FOSSIL ENERGY

DOE/BC/15310-1
(OSTI ID: 795618)

GEO-ENGINEERING THROUGH INTERNET INFORMATICS (GEMINI)

Annual Report
October 1, 2000-September 30, 2001

By:
W. Lynn Watney
John H. Doveton
John R. Victorine
Geoffrey C. Bohling
Saibal Bhattacharya
Alan P. Byers
Timothy R. Carr
Martin K. Dubois
Glen Gagnon
Willard J. Guy
Kurt Look
Mike Magnuson
Melissa Moore
Ricardo Olea
Jayprakash Pakalapadi
Ken Stalder
David R. Collins

Date Published: June 2002

Work Performed Under Contract No. DE-FC26-00BC15310

The University of Kansas Center for Research Inc.
Lawrence, Kansas

National Energy Technology Laboratory
National Petroleum Technology Office
U.S. DEPARTMENT OF ENERGY
Tulsa, Oklahoma

DOE/BC/15310-1
Distribution Category UC-122

Geo-Engineering through INternet Informatics (GEMINI)

By
W. Lynn Watney
John H. Doveton
John R. Victorine
Geoffrey C. Bohling
Saibal Bhattacharya
Alan P. Byers
Timothy R. Carr
Martin K. Dubois
Glen Gagnon
Willard J. Guy
Kurt Look
Mike Magnuson
Melissa Moore
Ricardo Olea
Jayprakash Pakalapadi
Ken Stalder
David R. Collins

June 2002

Work Performed Under DE-FC26-00BC15310

Prepared for
U.S. Department of Energy
Assistant Secretary for Fossil Energy

Dan Ferguson, Project Manager
National Petroleum Technology Office
P.O. Box 3628
Tulsa, OK 74101

Prepared by
The University of Kansas Center for Research Inc.
2385 Irving Hill Road
Lawrence, KS 66045

Table of Contents

1. Introduction

This is a status report on the first year of development of the GEMINI Project. The goals of this report include:

1) Describe year 1 developments of the GEMINI project
2) Discuss role of participating companies
3) Describe steps to facilitate project review and feedback
4) Review plans and schedule for the remainder of the project

2. Project Description

Background: Utilization of improved recovery technologies could add significantly to the U.S. energy supply. In reservoir management, consistent, quantitative characterization and modeling of reservoirs are essential to make decisions on application of the most appropriate technology. Implementing this type of modeling is often not practical because of limitation of software, staff, and expertise. GEMINI (Geo-Engineering Modeling through Internet Informatics) will harness existing expertise and resources of the Kansas Geological Survey to provide efficient, interactive access to data and software modeling tools when and wherever it is needed. GEMINI will integrate extensive petroleum and petrophysical databases associated with the DOE-funded Northern Mid-Continent Digital Petroleum Atlas (DPA) (http://crude2.kgs.ukans.edu/DPA/dpaHome.html). GEMINI is being built on experience gained in software development provided through the DOE-funded PfEFFER (Petrofacies Evaluation of Formations for Engineering Reservoirs) software (http://crude2.kgs.ukans.edu/PRS/software/pfeffer1.html. GEMINI will resolve reservoir parameters that control well performance; characterize subtle reservoir properties important in understanding and modeling hydrocarbon pore volume and fluid flow; expedite recognition of bypassed, subtle, and complex oil and gas reservoirs at regional and local scale; differentiate commingled reservoirs; build integrated geologic and engineering model based on real-time, iterative solutions to evaluate reservoir management options for improved recovery; provide practical tools to assist the geoscientist, engineer, and petroleum operator in making their tasks more efficient and effective; enable evaluations to be made at different scales, ranging from individual well, through lease, field, to play and region (scalable information infrastructure); and provide training and technology transfer to elevate capabilities of the client.

Work to be Performed: The proposed program, for development and methodologies, is a 3-year interdisciplinary effort to develop an interactive, integrated Internet Website named GEMINI (Geo-Engineering Modeling through Internet Informatics) that will build real-time geo-engineering reservoir models for the Internet using the latest technology in Web applications. The client would 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, 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

3. GEMINI Schedule

The schedule for the GEMINI Project as proposed is divided into five tasks as described in Figure 1.

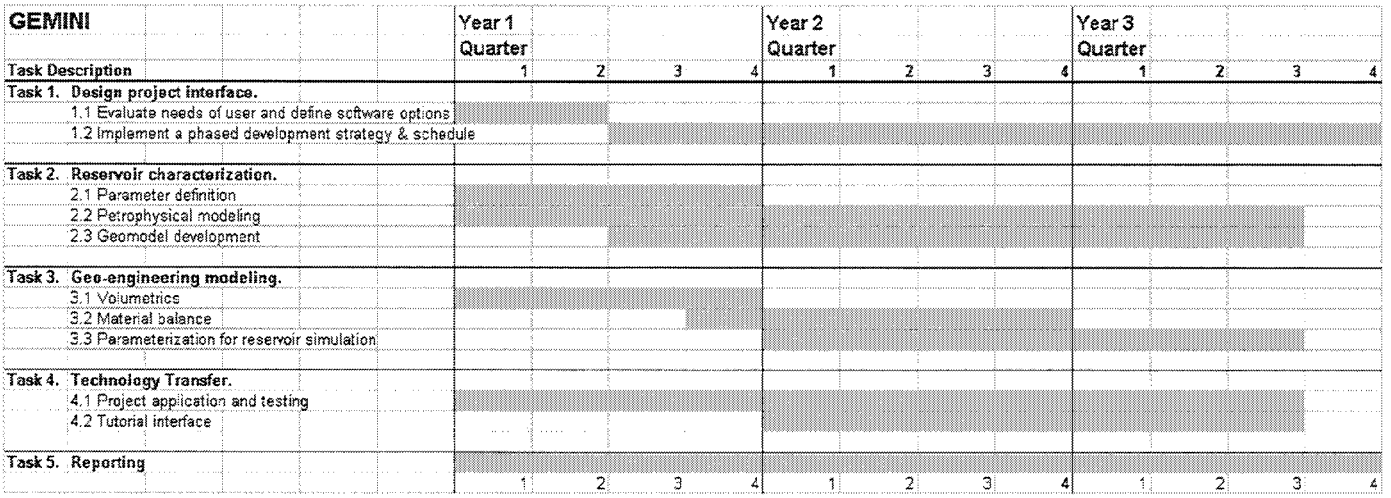


Figure 1. GEMINI schedule as proposed.

4. Task 1. Design Project Interface

4.1. Evaluate needs of users and define software options

The GEMINI project was presented to industry as mid-year and year-end summary workshops and two presentations, one to a professional society and another to an industry association. Brochures and an electronic slideshow were made available at a national meeting of AAPG. Those contacted were encouraged to visit website and provide feedback. No major changes to plans have been suggested. Rather, feedback has been positive and suggestions minor. Summary of results of the year-end summary workshop and other technology transfer activities are provided in Section 7 below.

The target user of GEMINI as the independent oil and gas industry was confirmed, in particular, for those companies working in mature oil and gas provinces such as Kansas where high-end integrated software tools are not practical due to smaller project size, However, major integrated companies are interested in GEMINI as evidenced by their active participation. The integrated, web-based applications of GEMINI makes it attractive to industry as a novel means to manage and analyze both large and small digital databases.

GEMINI will provide means to integrate enterprise and user data with analytical software tools for use in basic reservoir characterization and modeling. In particular, independent oil and gas industries need for low-cost means to assemble data from

disparate sources and access software that permits basic modeling of petroleum reservoirs. Data and software applications will be shared between operators, partners, and consultants when and where they are located. Such web resources can provide low-cost, but effective integration to accomplish day-to-day tasks in reservoir characterization. This entrance into quantitative reservoir modeling will help improve evaluation of reservoir performance and help users in identifying appropriate reservoir management options. Exporting results from GEMINI can permit pursuit of advanced methods in reservoir modeling such as use of geostatistical approaches. These are essential components to keep mature areas competitive.

GEMINI builds on the success of the Kansas' Digital Petroleum Atlas and is consistent with the objectives in utilization of the computing resources of the Kansas Geological Survey. The infrastructure is in place to make such as undertaking feasible including extensive web-accessed data, web-enabled relational databases, large flexible computer servers, large data storage capability, and expertise in building web application tools such as Java. Moreover, GEMINI expand on expertise gained in software development under previous DOE support, the successful commercial software PFEFFER (Petrofacies Evaluation of Formations for Engineering Reservoirs) -- http://crude2.kgs.ukans.edu/PRS/software/pfeffer1.html. Gemini provides a rationale pathway for future software development in delivery of software applications and organized data to the user in a very efficient, low-cost manner.

Ongoing education and training in reservoir characterization and modeling and associated technologies are important ongoing efforts of geological surveys, universities, and DOE, e.g., via PTTC. Concepts, technology, and methodologies continue to change and improve and basic software tools in reservoir modeling can allow the user to spend a greater proportion on the analysis and evaluation of results from a business or academic perspective. It is clear in working with users in previous software development that GEMINI needs to be user-friendly to encourage use and allow users to enhance insight into reservoir development. Accordingly, a versatile, integrated tutorial module is also essential for GEMINI's success.

The reassessment of GEMINI in Task 1 with industry feedback has refined the original objectives including:

- Develop projects consisting of single and multiple wells that can be accessed over time by the project team; also standalone modules and databases for quick access
- Combine information and analytical software tools in user-friendly manner
- Facilitate more robust, quantitative modeling of the reservoir volume
- Upload data from user as well as accessing web-based data
- Download results for further analysis or report assembly
- Mine digital information based on what has been learned from analyses
- Facilitate integrated studies and nurture entrepreneurial teams
- Keep Kansas & mature oil and gas producing provinces competitive

4.2. Implement a phased development strategy and schedule

The basic components of GEMINI remain the same as proposed including: 1) individual and multi-well analysis focused on quantitative characterization of pore types utilizing wireline log petrofacies integrated with a relational digital core catalog and DST analyzer, 2) correlative modeling module including cross section and mapping, 3) volumetrics and material balance calculations, and 4) parameter and data file assembly to conduct fluid flow simulation. System informatics, consisting of the network, software, data, and tutorial components will permit development of projects with varied spatial scales and complexity. The products include building a simple, validated petrophysical reservoir model and assembling key parameters for reservoir simulation for multiple wells or simply analyze an individual well, access a database, or use a software calculator. Accordingly, the schedule (Figure 1) and operational flow chart showing the path of negotiating GEMINI (Figure 2) remains as originally proposed.

The phased development strategy developed was developed after the arrival of the Lead Programmer. Java servlets and applets were determined the program of choice to develop GEMINI (Figure 3). The coding is fundamental Java and Swing and its operation is not dependent on 3rd-party software. The source code documentation meets Level 2 Certification, making it easier for other programmers to review and modify.

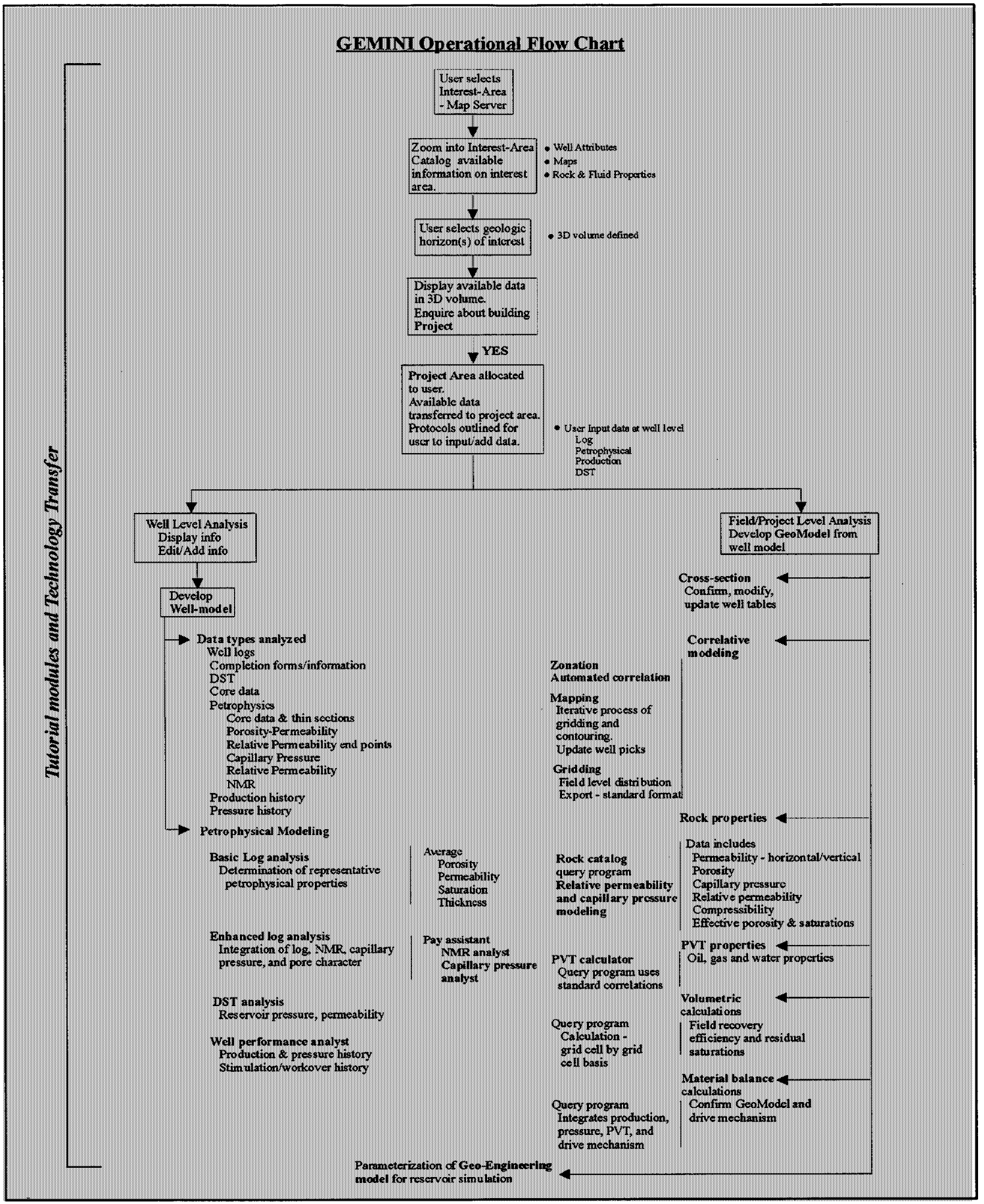


Figure 2. Operational flow chart of GEMINI.

A software development schedule was created at the close of Year 1. This does not replace the official project schedule, but compliments it in terms of implementing the programming tasks. The software development schedule provides specific resources and times needed to develop individual program modules to fulfill the stated tasks in GEMINI, namely reservoir characterization, geo-engineering modeling, and technology transfer. A summary of the programming schedule delineated at the end of the first year is included in Figure 4. The chart shows the Well Profile, PfEFFER, Rock Catalog, and Map Server modules made notable progress in Year 1. The work done using ERSI mapserver will be replaced by a simplified, but very functional Java applet that will eliminate the need for expensive 3rd-party software.

Major and independent companies involvement was confirmed. They will provide expertise, projects to test, and feedback to insure that the site is practical and useful. A tutorial module was also confirmed to instruct clients on theory, application of analytical tools, and operation of GEMINI.

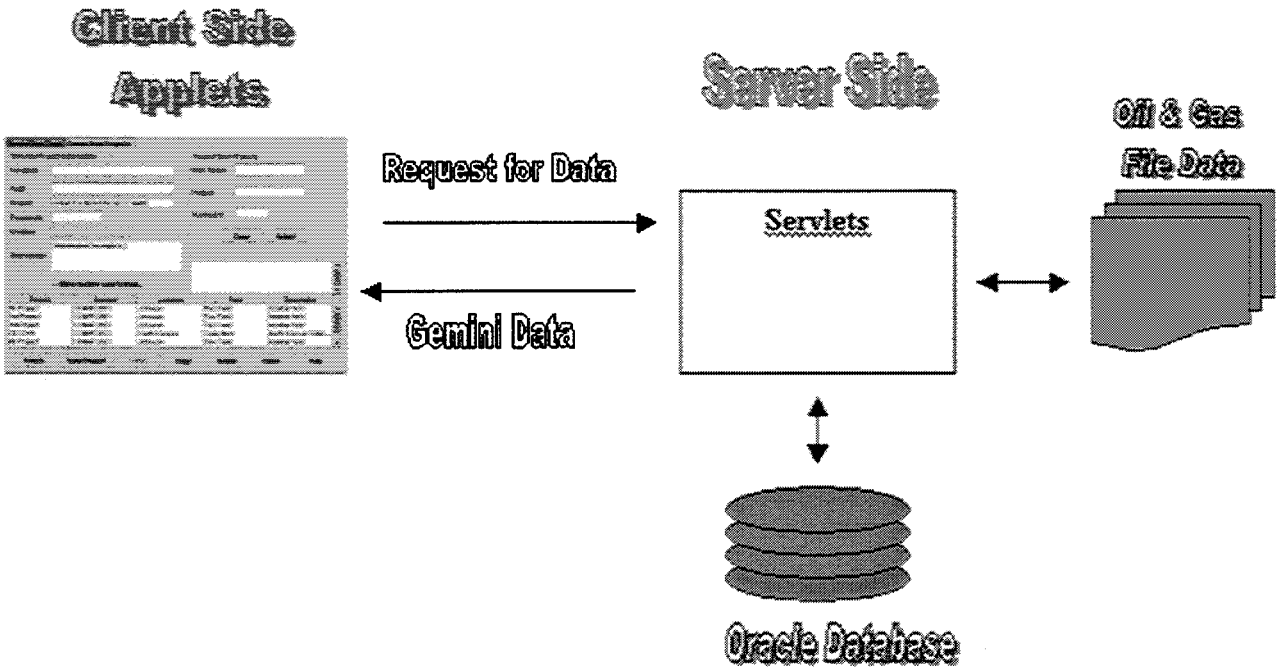


Figure 3. Java programming structure used in GEMINI.

A)

Module	Duration (days)
I. User/Project	32
upload well data	22
II. Well Profile	98
III. PfEFFER	
GUI, Servlets, etc.	
Pickett Plot	
IV. Volumetrics	
V. Production	
Produc-Volum. (mapping)	
2D - Lease/Field (time plot)	
VI. DST	
VII. Rock Catalog	
VIII. Cross Section	
IX. PVT	
X. Material Balance	
XI. Fluid Catalog	
XII. Synthetic Seismogram	
XIII. KHAN (Ks. Hydrocarbon Assoc. Nav.	239
GUI, Servlets, etc.	92
Plots	27
Math	112
XIV. Tutorial	279
Design/Prototype – TBD	10
Write Tutorials	
Fluid Catalog	20
Well Profile	20
DST	21
User/Project	20
PVT	21
PfEFFER	20
Volumetrics-Production	20
Rock Catalog	21
Synthetic Seismogram	20
Cross Section	20
Material Balance	20
KHAN	20
XV. ESRI Map Server	130
GEMINI - Integration and Testing	

Module	Duration (days)

B)

Gemini Java Applets

- User Project
- Well Level Analysis
  - Well Profile
  - PfEFFER (log analysis)
  - Synthetic Seismogram
  - KHAN (Kansas Hydrocarbon Association Navigator)
- Field Level Analysis
  - Cross Section
  - Mapping
  - Volumetrics
  - Material Balance
- Catalogs and Calculators
  - Digital Rock Catalog
  - DST
  - Production
  - PVT
  - Fluid Composition

Figure 4. A) Simplied version of software development schedule (without monthy breakdown) designed to meet GEMINI project schedule. B) Java Applets organized by function and scale.

A useful diagram of program modules organized by function has been used in presentations to convey what GEMINI does. This is included in Figure 5.

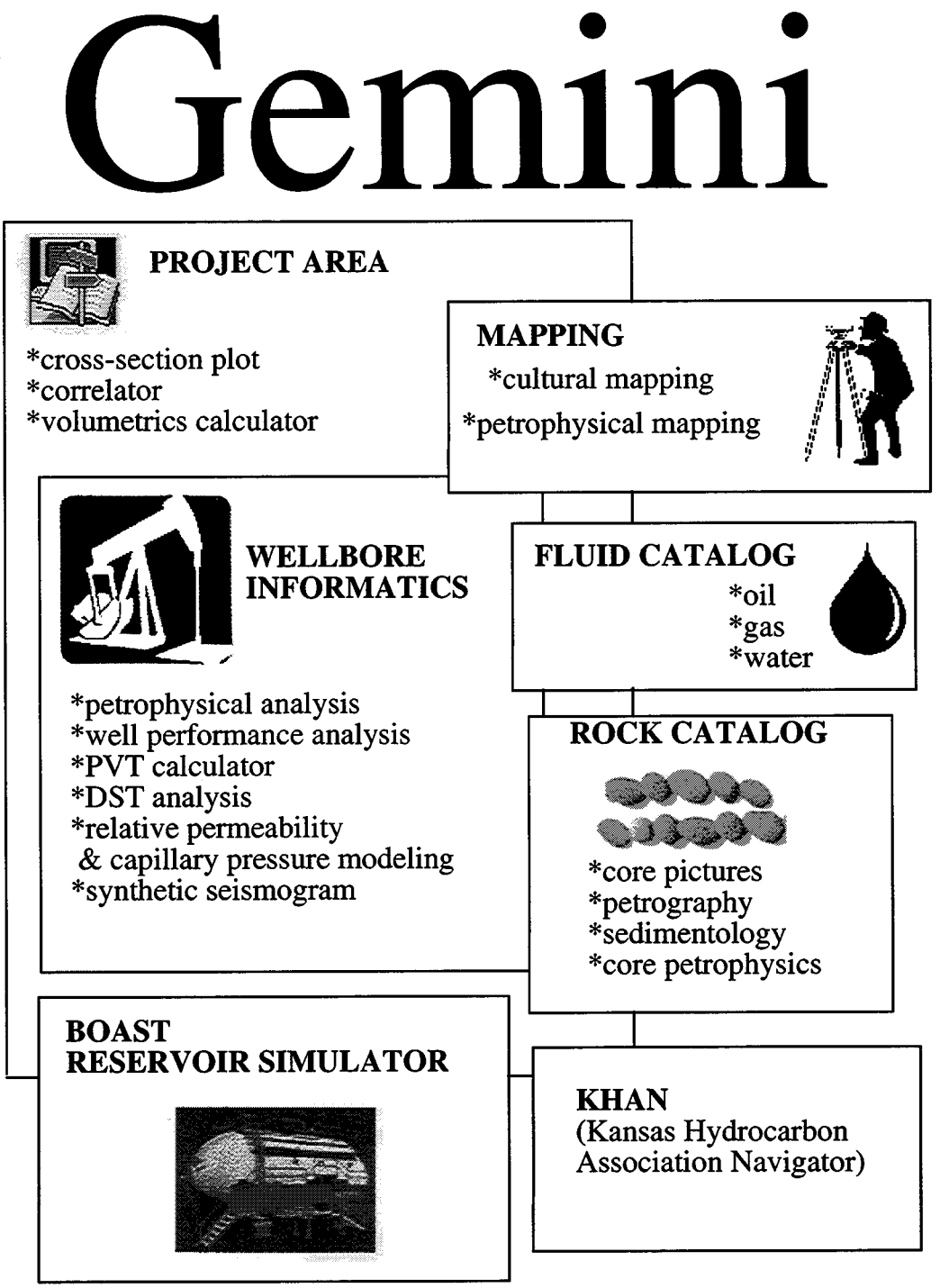


Figure 5. Diagram showing GEMINI Project by function.

5. Task 2. Reservoir Characterization

5.1. Parameter Definition

5.1.1. GEMINI and the Digital Petroleum Atlas. The Midcontinent Digital Petroleum Atlas (DPA) is a primary source of fundamental data utilized by GEMINI. Five years of data collection, web building, database development, and field studies made GEMINI feasible. All of the DPA information is accessible via a web-browser. Since the data is primarily stored in Oracle tables, this information is also accessible to GEMINI. The input data includes:

- **Well Header**
  - location, completion, status, formation (reservoir) tops, perforations, tests
- **Production**
  - Fluid properties, cumulative & monthly volumes by lease, well, reservoir, and zone
- **Test results**
  - DST, production delineated by reservoir and depth
- **Core analysis**
  - rock information and analyses, petrofacies & pore type classifications
- **LAS files**

Figure 6 depicts the sources of web-based data at the Kansas Geological Survey and the projects that have contributed to the data.

Specific databases that have been enhanced in the first year by the GEMINI project include: core analysis, core photos and images, fluid catalog, drill stem test results, and digital well log data. A table defining wireline log tool names and synonyms is being developed to improve access to the digital log data. Attributing wells to lease production is another activity undertaken during the first year. In Kansas, oil production is only reported by lease and commingling of production is permitted, so individual well and zone production cannot be obtained in public records.

Digital well data is increasingly available and it is projected that by the end of the project, a considerable amount of new digital data will be available.

5.1.2. User Project. The User Project Module is being designed to:

- Establish a project
- Assemble data for the project
- Launch software tools
- Provide functionality ranging from managing single well to multiple wells

Status of Petroleum Databases at the KGS

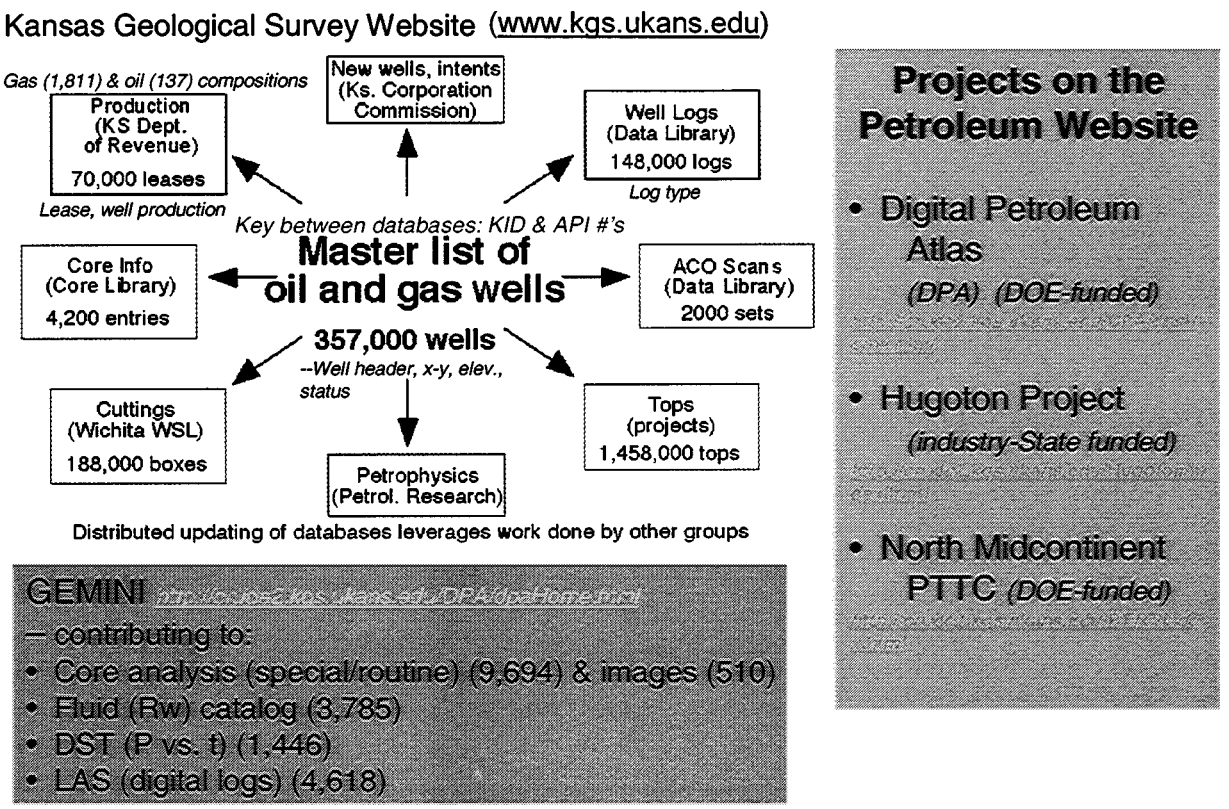


Figure 6 depicts sources of digital data at the Kansas Geological Survey and projects that have contributed to the database.

The User Project provides options to upload data from the Kansas Geological Survey, but eventually other data will be uploaded from the user's computer. Input options for data, for example, digital well log data called LAS files, are accessed either by a dialog box where the user filters through the database or via an interactive map interface. A Java applet showing a map of LAS wells in Kansas (Figure 7) is a first attempt to build a map interface to access data. Figure 8 A) and B) are two dialogs in

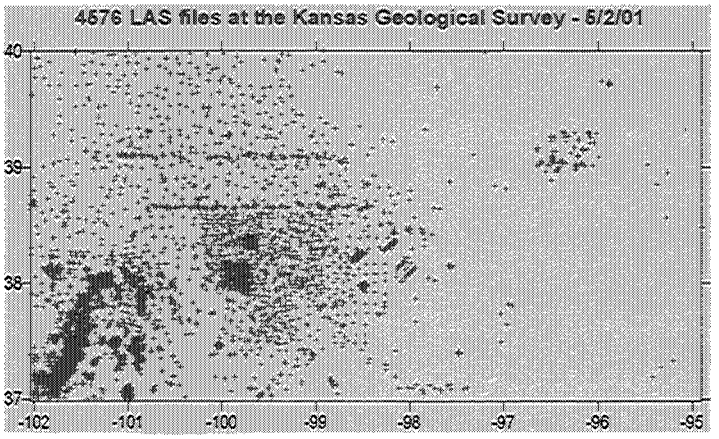
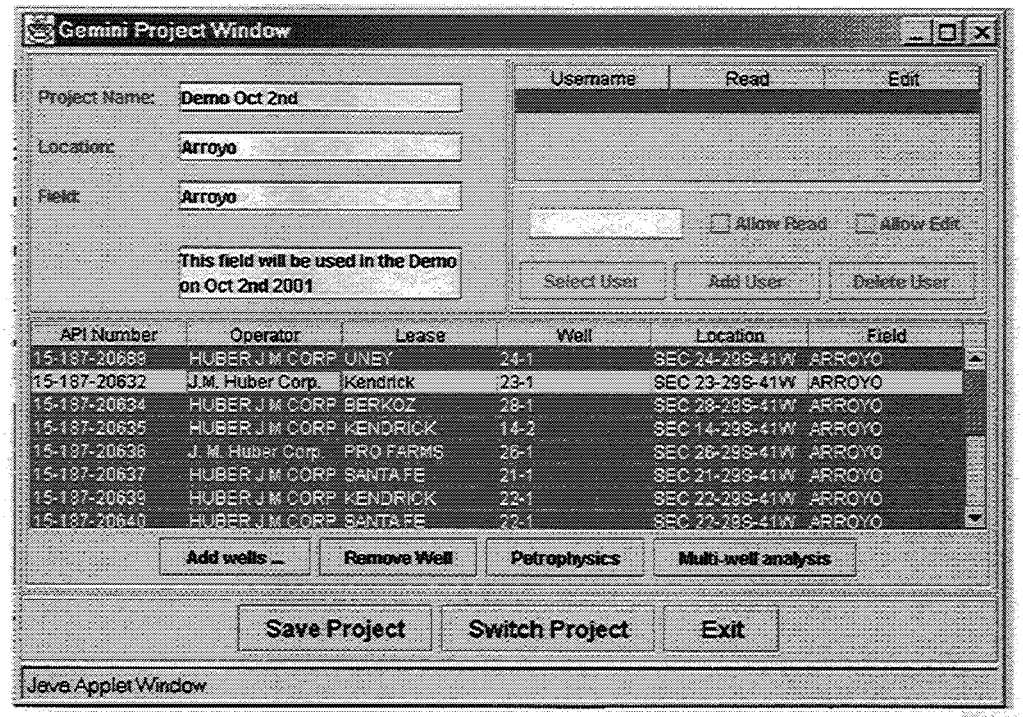


Figure 7. View of LAS-format digital well log data for Kansas. Prototype maps are applets that are served to user to choose wells and information for their project.

The User Project, A) showing means of adding wells to a project and B) a dialog showing buttons to access working prototype modules at the end of Year 1 of GEMINI.

A)



B)

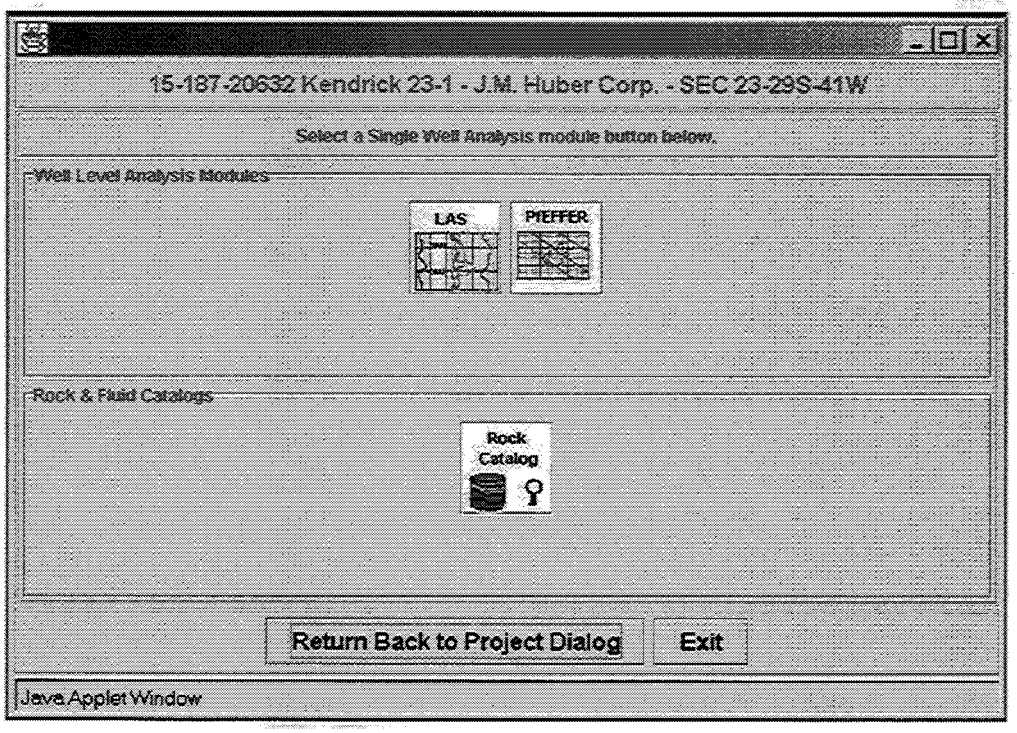


Figure 8. A) Dialog (Java applet) showing list of wells selected for project and means to add additional wells to existing project or access single well (Petrophysics button) or multi-well analysis. B) Dialog to launch single well applications including LAS viewer, PfEFFER log analysis, and Rock Catalog.

5.1.3. Catalogs and Calculators. Specific reference and paths to access data catalogs are provided via the User Project Dialog. The user can also access information outside a project. The only catalog or calculator in prototype after year 1 is the rock catalog that is described below. Other catalogs and calculators will include fluid catalog, DST analyst, and PVT calculator.

5.1.4. Rock Catalog. A digital rock catalog was conceived to be able to present a wide range of rock petrophysical data for a range of lithologies, organized on the premise that individual "type" core samples exhibit petrophysical properties that are representative of a class of rocks of similar lithology. The rock catalog concept originated by Shell in the early 70's was designed to present rock petrophysical properties for major rock types worldwide. The first catalog contained 80 samples. Their fundamental paradigm, as it is in this digital rock catalog, is rocks of similar lithology and basic properties exhibit similar petrophysical properties. In contrast to earlier rock catalogs, our digital version is presented in relational context, not limited to categorical data as previous attempts. GEMINI's rock catalog is project specific and relational in that type sample properties are shown within the context of other samples of similar type or within context of all samples for study. In other words, a sample can be compared to others to determine correlations and permit use of data models, e.g., permeability vs. porosity.

The petrophysical data are related to wells by depth, location, field, and formation. The comparisons can be either categorical or relational. The relational context specified is by user. The database is flexible and can grow continuously, and can be modified. The attractiveness of the digital catalog is its versatility and integration with other applications for fully integrated utilization in petrophysical characterization. Core data can be shown by itself or integrated with rock photos and shown alongside corresponding well log data. The rock catalog module can also be accessed separate from a GEMINI project.

The user accesses the digital core catalog via Oracle tables that are called by GEMINI software to accomplish the interactive analysis. The current data structure of this prototype software is shown in Figure 9.

The digital rock catalog is composed of petrophysical data including:

- Porosity
- Permeability
- Capillary Pressure Properties
- Electrical Properties
- Mechanical Properties
- Lithologic Properties
- Geologic Properties

These data are what is often referred to as both routine and special core analyses. GEMINI has identified over 9000 core analysis entries and 500 core images during the first year of the project. New core analyses are being acquired. Core images are being

routinely uploaded into the Oracle database for newly viewed core and cores described for new projects.

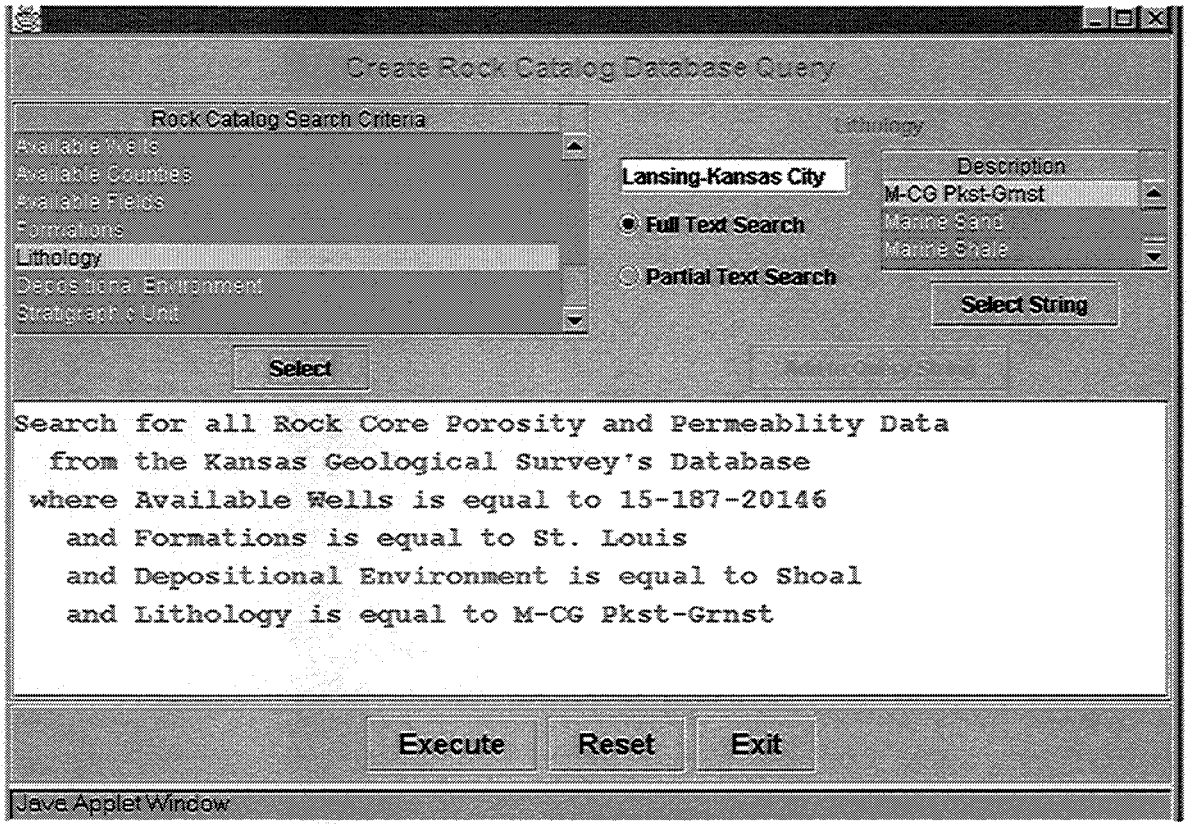
Modifications to the digital core catalog will occur, but included here are several

API_NUMBER	CORE_NUMBER
WELL_HEADER_KID	G
OPERATOR_NAME	ORIGINAL_SAMPLE_NUMBER
WELL_NAME	FRACTURES
LEASE_NAME	POROSITY_WHOLE_ROUTINE_PCT
TOWNSHIP	POROSITY_PLUG_ROUTINE_PCT
TOWNSHIP_DIRECTION	POROSITY_PLUG_800PSI_PCT
RANGE	POROSITY_PLUG_INSITU_PCT
RANGE_DIRECTION	PERMEABILITY_WHOLE_MAX_MD
SECTION	PERMEABILITY_WHOLE_90_MD
FIELD_NAME	PERMEABILITY_WHOLE_VERT_MD
STRATIGRAPHIC_UNIT	PERMEABILITY_PLUG_ROUTINE_MD
STRATIGRAPHIC_NAME	PERMEABILITY_PLUG_KLROUTINE_MD
DEPTH_TOP_LITH_FT	PERMEABILITY_PLUG_INSITU_MD
DEPTH_BASE_LITH_FT	PERMEABILITY_PLUG_KLINSITU_MD
DEPTH_TOP_CORE_FT	PERMEABILITY_PLUG_VERT_MD
DEPTH_BASE_CORE_FT	SATURATION_OIL_PCT
LITHOLOGIC_DATA_SOURCE	SATURATION_WATER_PCT
ROCK_TYPE	GRAIN_DENSITY_GCC
LITHOLOGIC_CLASSIFICATION	DESCRIPTION_REMARKS
CONSOLIDATION_FRACTURING	DATA_MODIFIER
ARGILLACEOUS_CONTENT_PCT	COMMENTS
GRAIN_SIZE	LABORATORY
PRINCIPAL_PORE_TYPE	ANALYSIS_DATE
SUBSIDIARY_PORE_TYPE	DATA_SOURCE
CEMENT_POREFILLING_MINERAL	DATA_PUBLIC
BEDDING	ADVANCED_PROPERTIES
WATER_DEPTH	CAPILLARY_PRESSURE
FAUNAL_ASSEMBLAGE	NMR
COLOR	PROPERTIES_UNDER_STRESS
DEPOSITIONAL_ENVIRONMENT	ARCHIE_CEMENTATION_AMBIENT
LITHOFACIES	ARCHIE_CEMENTATION_INSITU
THIN_SECTION	ARCHIE SATURATION AMBIENT
DIGITAL_IMAGE	ARCHIE_SATURATION_INSITU

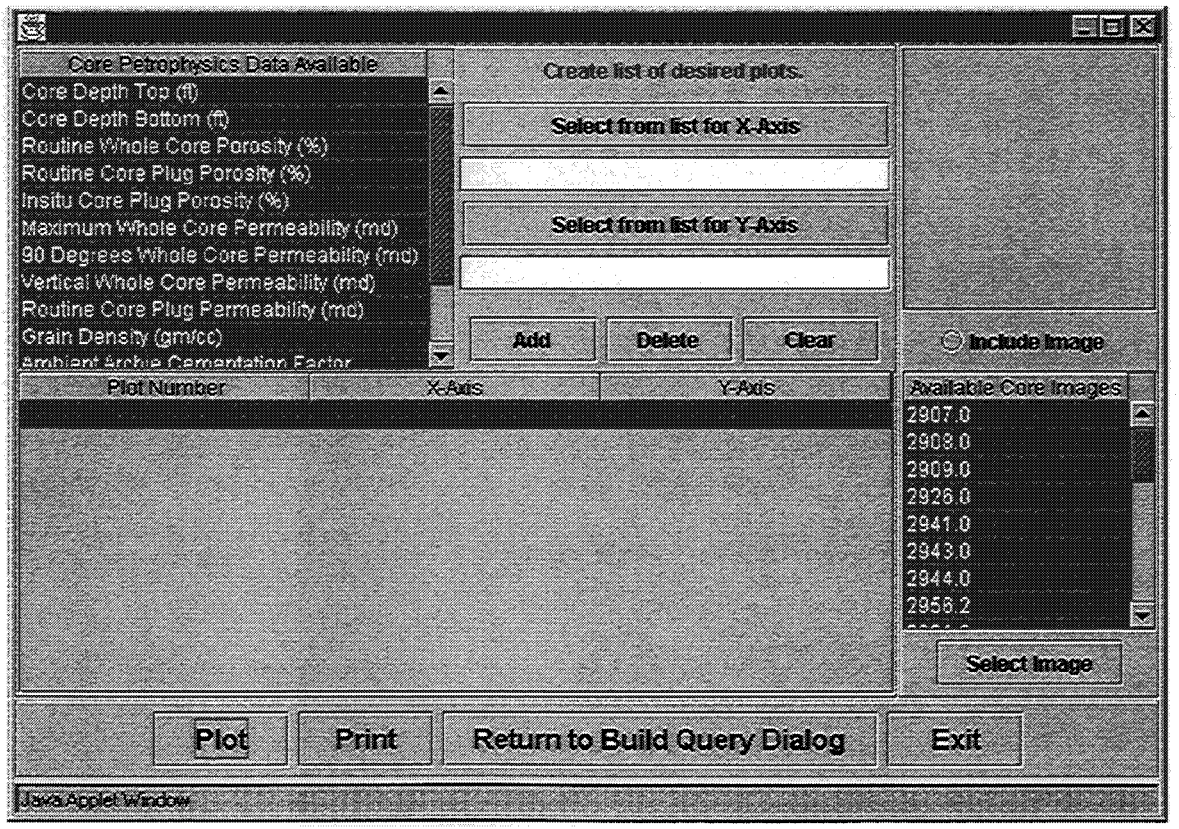
Figure 9. List of data categories in GEMINI's prototype digital rock catalog.

Figures that depict the current dialogs once the Rock Catalog application is launched (Figure 10 A, B, and C).

A)


Create Rock Catalog Database Query
Rock Catalog Search Criteria
Available Wells
Available Counties
Available Fields
Formations
Lithology
Depositional Environment
Stratigraphic Unit
Select
Lithology
Lansing-Kansas City
Full Text Search
Partial Text Search
Description
M-CG Pkst-Grnst
Marine Sand
Marine Shale
Select String
Search for all Rock Core Porosity and Permeablity Data
from the Kansas Geological Survey's Database
where Available Wells is equal to 15-187-20146
and Formations is equal to St. Louis
and Depositional Environment is equal to Shoal
and Lithology is equal to M-CG Pkst-Grnst
Execute
Reset
Exit
Java Applet Window

B)


Core Petrophysics Data Available
Core Depth Top (ft)
Core Depth Bottom (ft)
Routine Whole Core Porosity (%)
Routine Core Plug Porosity (%)
Insitu Core Plug Porosity (%)
Maximum Whole Core Permeability (md)
90 Degrees Whole Core Permeability (md)
Vertical Whole Core Permeability (md)
Routine Core Plug Permeability (md)
Grain Density (gm/cc)
Create list of desired plots:
Select from list for X-Axis
Select from list for Y-Axis
Add
Delete
Clear
Include Image
Plot Number
X-Axis
Y-Axis
Available Core Images
2907.0
2908.0
2909.0
2926.0
2941.0
2943.0
2944.0
2956.2
Select Image
Plot
Print
Return to Build Query Dialog
Exit
Java Applet Window

C)

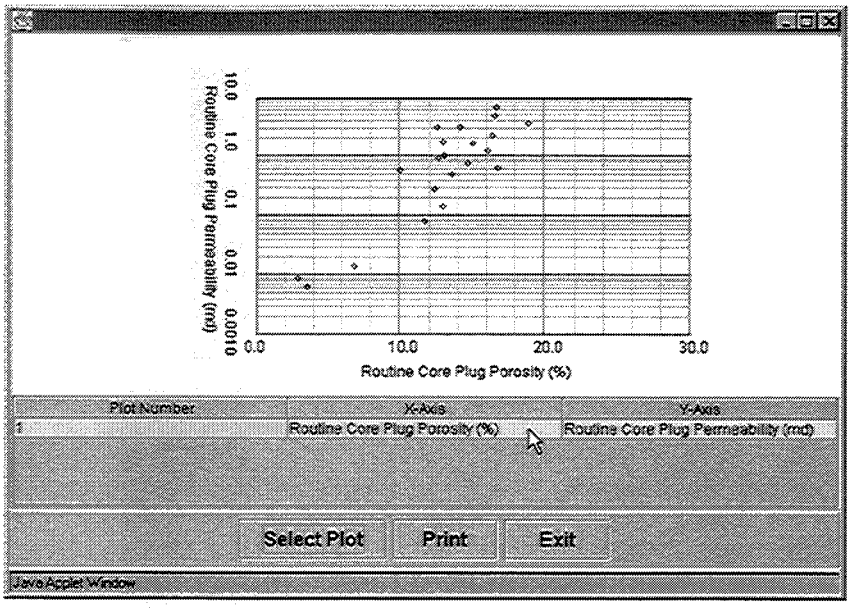


Figure 10. A) Java applet dialog for a database query, in this case selecting porosity and permeability data from the St. Louis Limestone formation, shoal depositional environment, and a medium to coarse grained packstone-grainstone lithology. B) user is instructed to select the core petrophysics data to be plotted and the core images to view. C) User-selected plot of porosity vs. permeability is shown.

Ultimately, the user will be able to assemble a series and plots and images that characterize a particular type of rock (Figure 11). The user can currently include core analysis within a well profile with wireline logs. This is discussed in the next section under Well Profile.

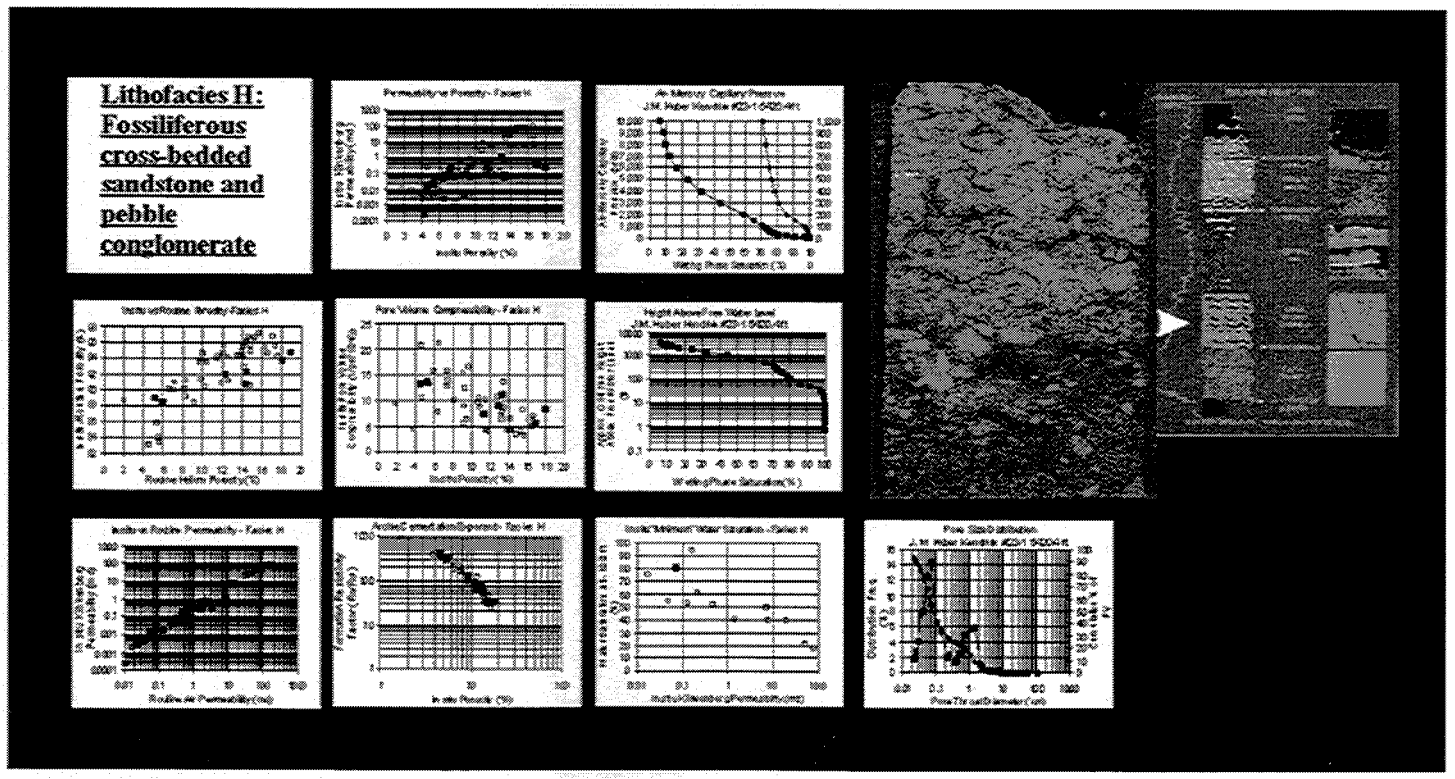


Figure 11. Excel version (mock up) of an anticipated set of core petrophysics plots, core image, and diagram characterizing a lithofacies to be constructed in the digital core catalog.

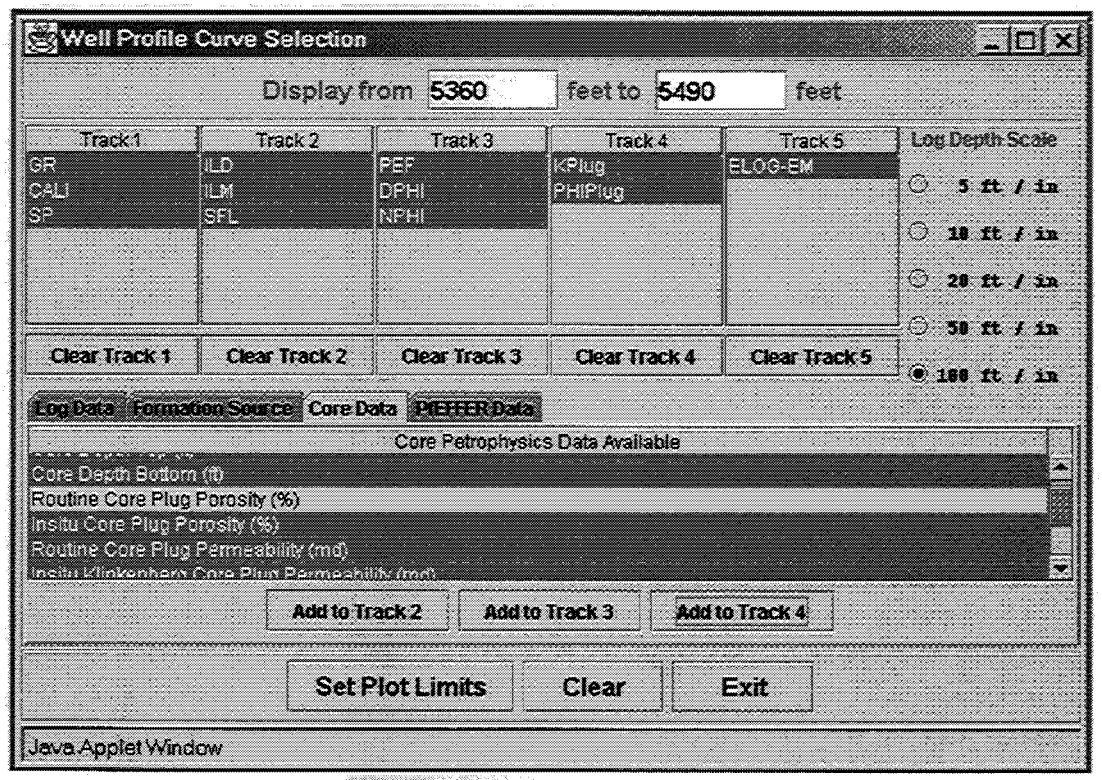
5.2 Petrophysical Modeling

Two design-prototypes of modules under the Subtask Petrophysical Modeling were developed in year 1, Well Profile and several tasks within PfEFFER log analysis software. Year-end results are described below.

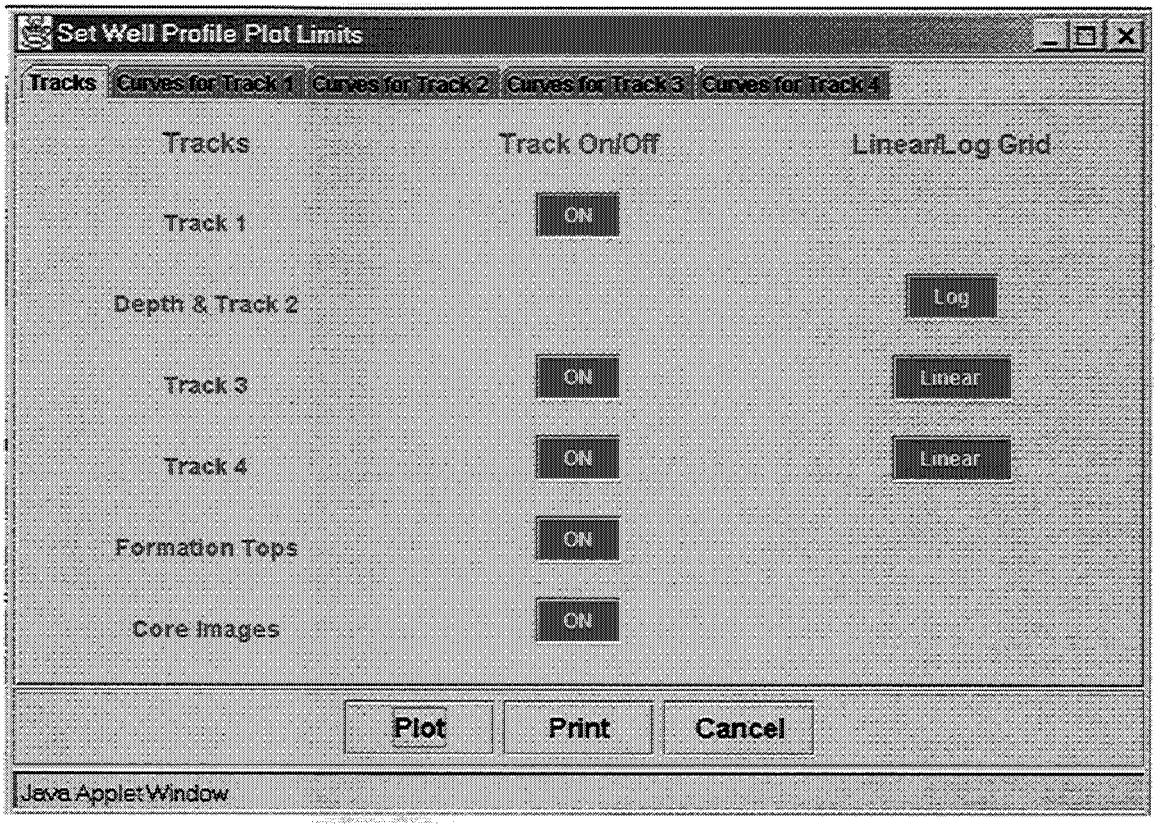
5.2.1. Well Profile. Well Profile module permits viewing LAS digital log files and other depth-related information including quick look PfEFFER data, core analysis, and locations of core photos. Well Profile is also the primary location to set depths and names of formation tops and select depth intervals and names for PfEFFER analysis and correlative modeling, and volumetrics (Figure 12). The intervals are selected by the user with increasing sophistication as the user conducts petrophysical analysis and reviews test and production information. The objective in the reservoir analysis is that the interval chosen here reflects the reservoir pay, either gross or net, and thus approximating flow units. It is up to the user to incorporate both static rock data and dynamic fluid data to come to a decision on this critical element in reservoir characterization.

Well Profile settings including data entered by the user are saved in a project for later use and reference. The user controls what curves are placed in what tract, whether a log or linear scale is used, scale range of depicted log, colors of curves, and depth scale of copy when printed in inches per foot of log depth. The user is able to access the module as a stand-alone application as well as through the User Project setup module (as LAS).

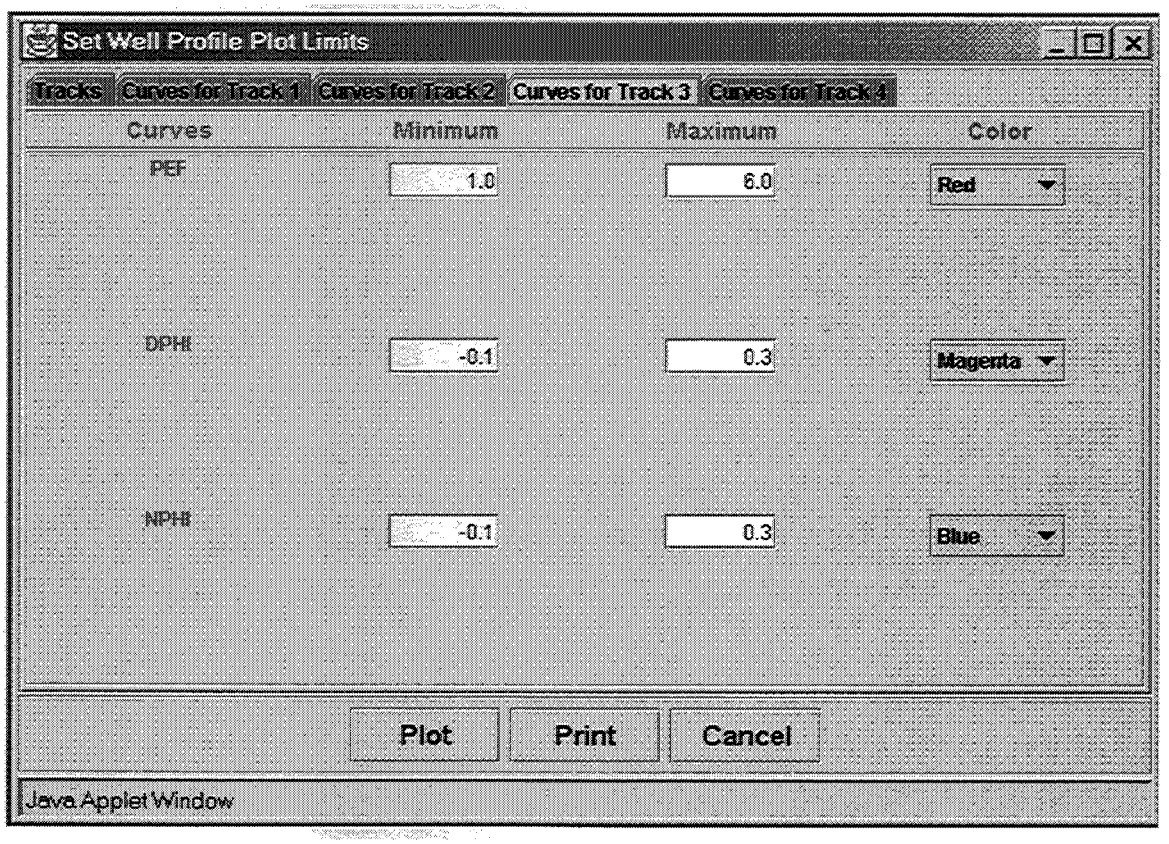
A)



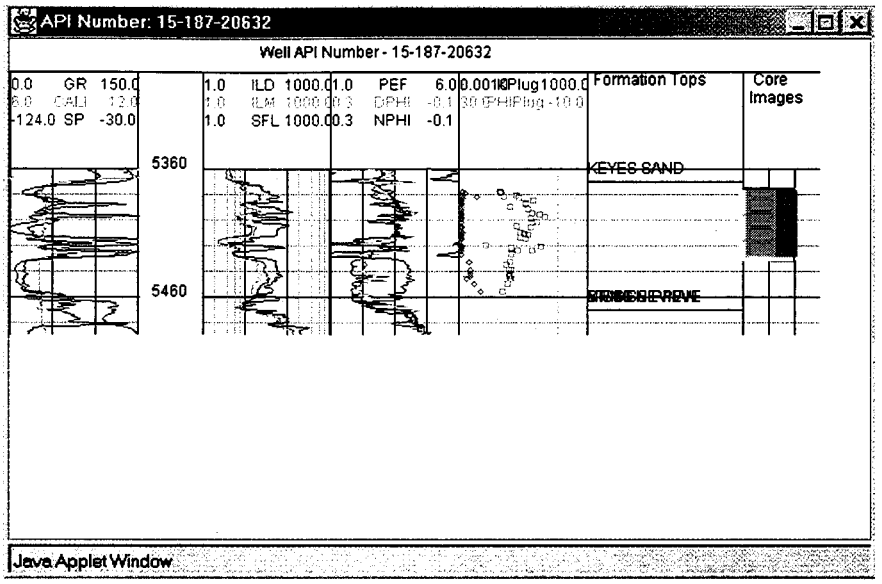
B)


Set Well Profile Plot Limits
Tracks
Curves for Track 1
Curves for Track 2
Curves for Track 3
Curves for Track 4
Tracks
Track On/Off
Linear/Log Grid
Track 1
ON
Depth & Track 2
Log
Track 3
ON
Linear
Track 4
ON
Linear
Formation Tops
ON
Core Images
ON
Plot
Print
Cancel
Java Applet Window

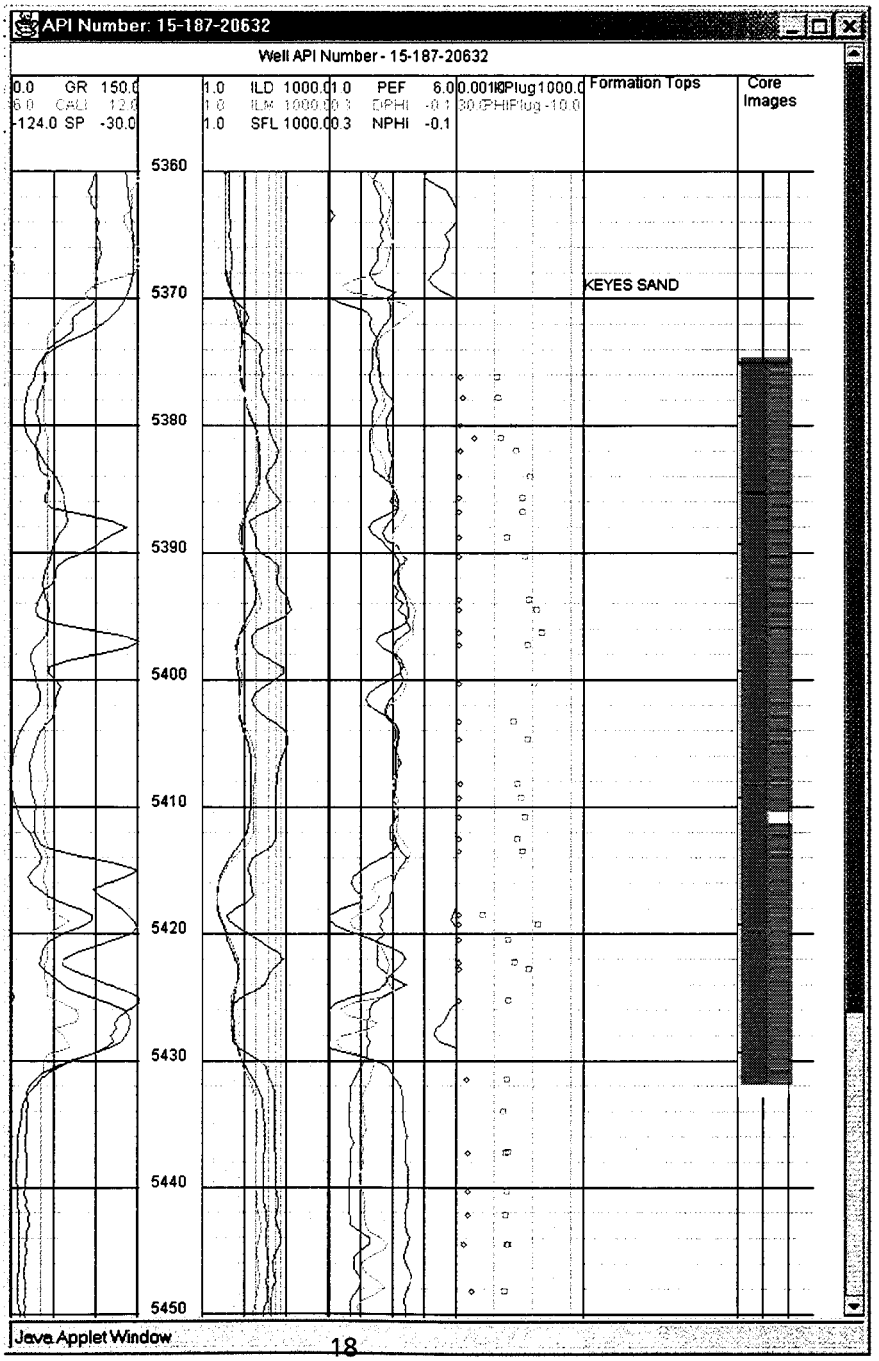
C)


Set Well Profile Plot Limits
Tracks
Curves for Track 1
Curves for Track 2
Curves for Track 3
Curves for Track 4
Curves
Minimum
Maximum
Color
PEF
1.0
6.0
Red
DPHI
-0.1
0.3
Magenta
NPHI
-0.1
0.3
Blue
Plot
Print
Cancel
Java Applet Window

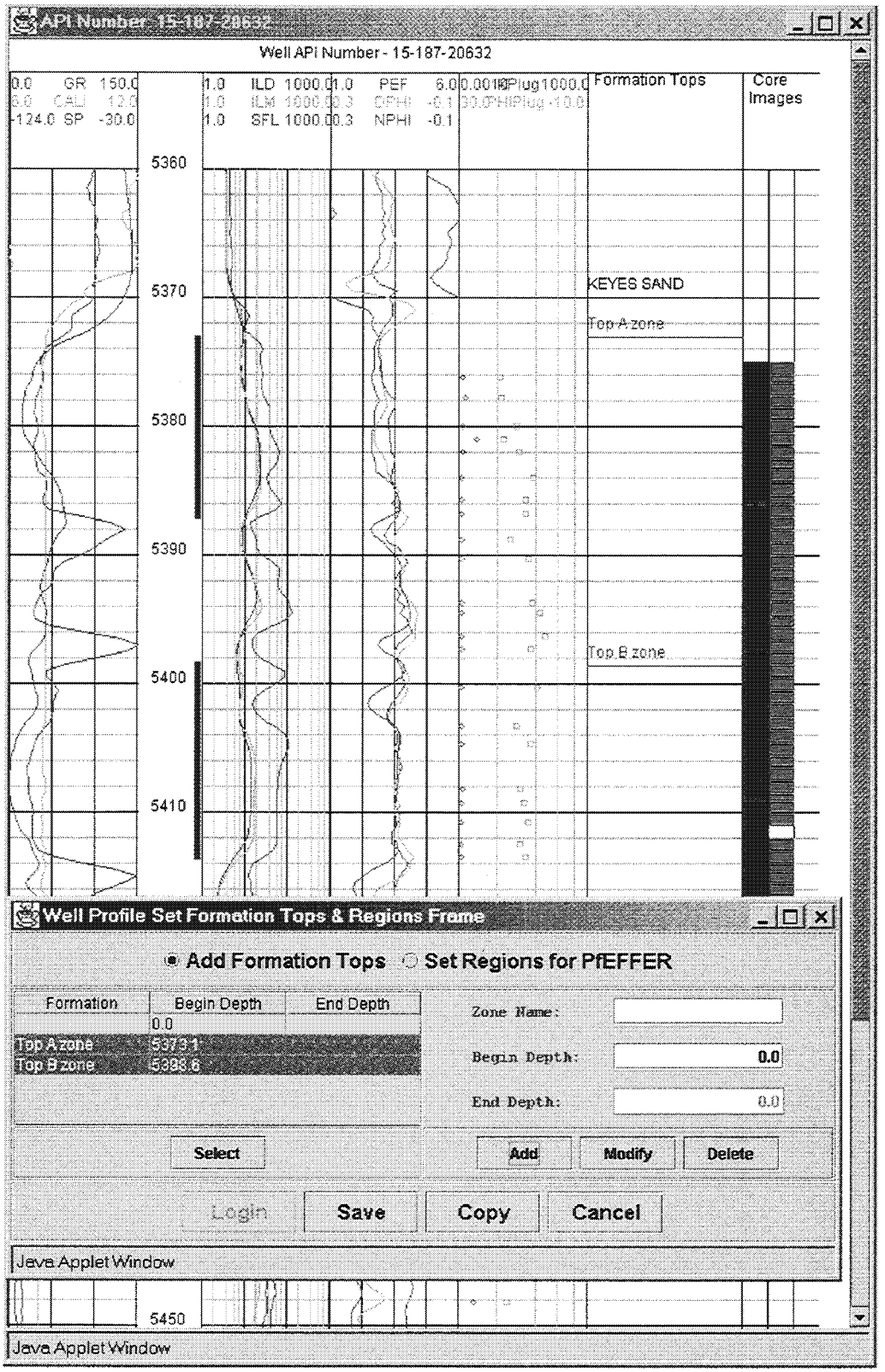
D)


API Number: 15-187-20632
Well API Number - 15-187-20632
0.0 GR 150.0
-124.0 SP -30.0
1.0 ILD 1000.0
1.0 SFL 1000.0
0.3 NPHI -0.1
6.0 PEF
Formation Tops
Core Images
5360
5460
KEYES SAND
Java Applet Window

E)


API Number: 15-187-20632
Well API Number - 15-187-20632
0.0 GR 150.0
-124.0 SP -30.0
1.0 ILD 1000.0
1.0 SFL 1000.0
0.3 NPHI -0.1
6.0 PEF
Formation Tops
Core Images
5360
5370
5380
5390
5400
5410
5420
5430
5440
5450
KEYES SAND
Java Applet Window

F)


API Number 15-187-20632
Well API Number - 15-187-20632
GR
CALI
SP
ILD
ILM
SFL
PEF
CPHI
NPHI
Plug
PHIPlug
Formation Tops
Core Images
5360
5370
5380
5390
5400
5410
5450
KEYES SAND
Top A zone
Top B zone
Well Profile Set Formation Tops & Regions Frame
Add Formation Tops
Set Regions for PfEFFER
Formation
Begin Depth
End Depth
Top A zone
Top B zone
Zone Name:
Begin Depth:
End Depth:
Select
Add
Modify
Delete
Login
Save
Copy
Cancel
Java Applet Window
Java Applet Window

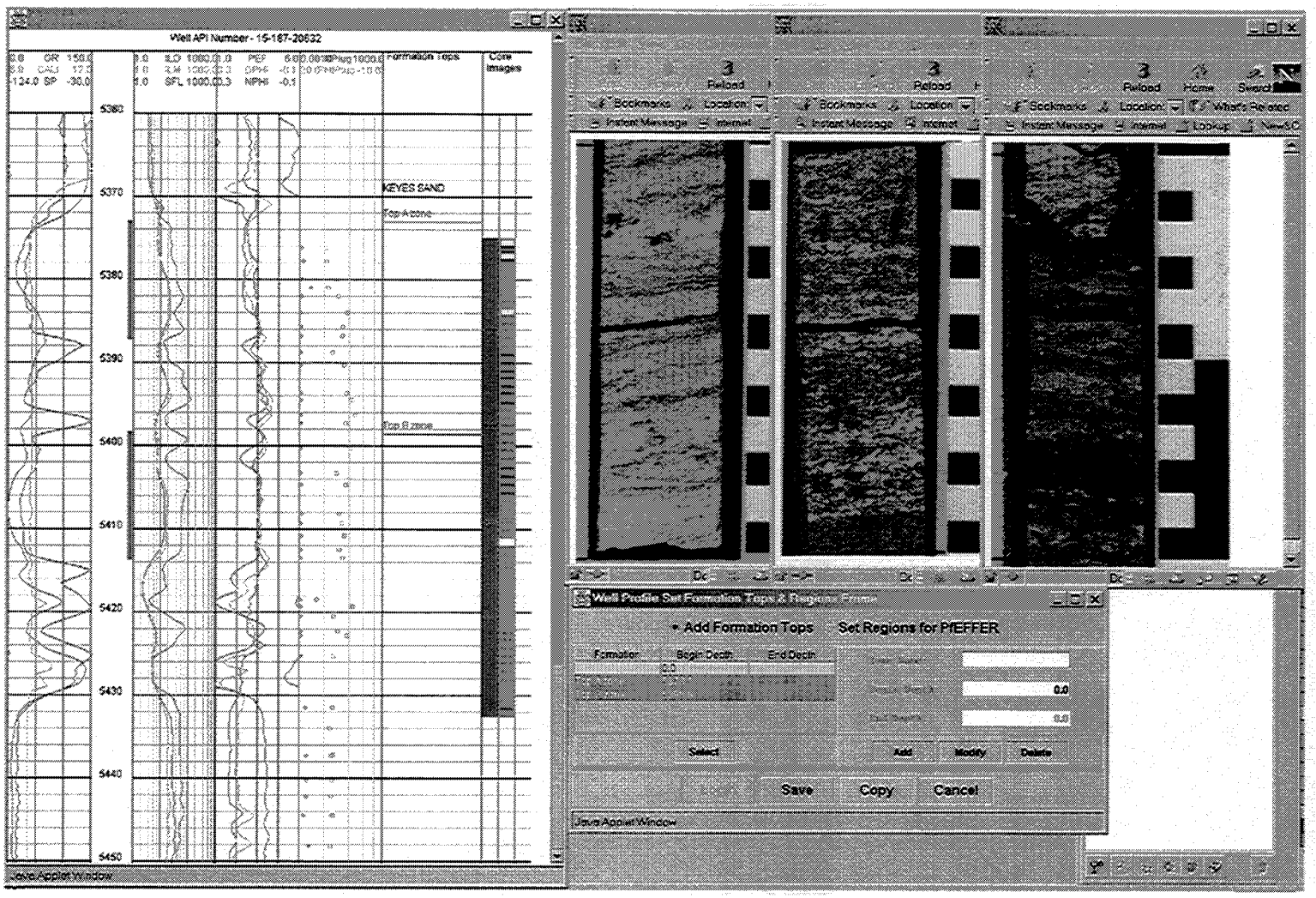


Figure 13. A) Once Well Profile is activated, the well profile curve selection dialog (applet) appears on the screen. The user is able to select the depth interval to be shown; choose log curves from the LAS files; load formation tops that are already part of a particular database; add PfEFFER pay, Sw, BVW by entering pay cutoffs; select core data to plot (as shown in this figure); and choose scale of viewed and printed copy. B) User then sets plot limits, first with a dialog that selects tracts and type of grid. C) User then checks minimum/maximum of curves and color of curves. User can plot as applet for additional annotation or Print to a web browser. D) and E) Two plot scales are shown for same log interval. F) Applet plot of well profile showing pop-up dialog to add or edit formation tops and set intervals (regions) for PfEFFER analysis. The added formations are shown, as are intervals, the later indicated by vertical blue bars in the depth tract. G) Well profile with pop-up dialog and core photo corresponding to depth of white-colored rectangle on right margin of well profile.

5.2.2. PfEFFER Log Analysis. PfEFFER is an extensive log analysis program that was developed with partial assistance from DOE in 1997. The program currently runs as a Visual Basic add-in to Excel. Java code is being written for all of the PfEFFER log analysis modules. Cross section and mapping modules are being redeveloped in GEMINI outside of what was accomplished earlier in PfEFFER.

PfEFFER log analysis operations in GEMINI will have the look of a spreadsheet, an aspect that is familiar for current users of PfEFFER. The focus of Java programming during year 1 was to establish the basic spreadsheet with LAS data and petrophysical parameters, calculate water saturation, and prepare a prototype of the Pickett cross plot of log porosity vs. resistivity with water saturation and bulk water volume contours.

The user enters PfEFFER through the User Project. A dialog appears (Figure 14) that contains well name and parameters that were read from the LAS digital log file. The user can also enter the parameters here if this information was not previously available. The user also is presented three choices, entering PfEFFER directly or Well Profile and Interval Section. The former two options are provided if the user needs to view the logs and determine the interval(s) to be analyzed by PfEFFER. User saves information to continue with the session or return at a later time to complete the tasks.

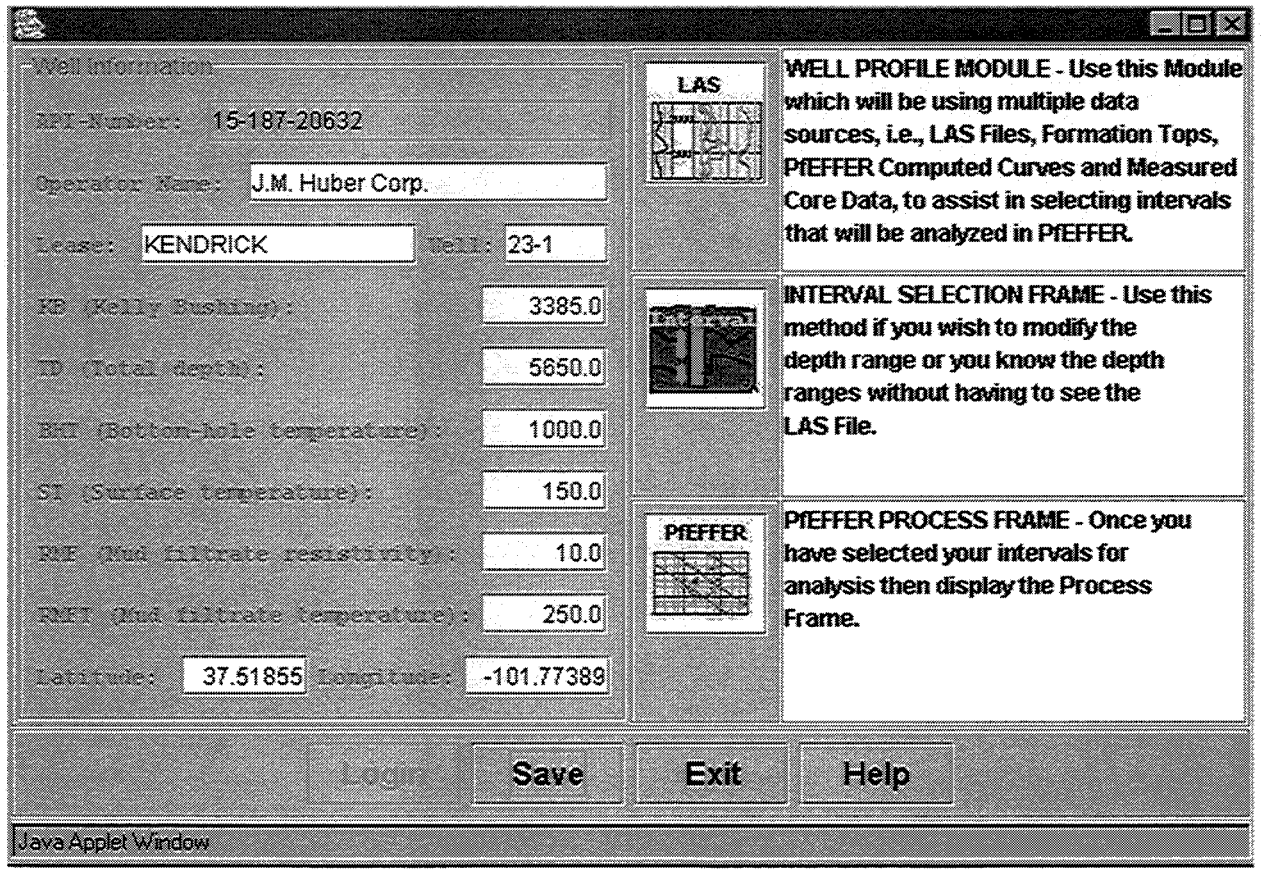
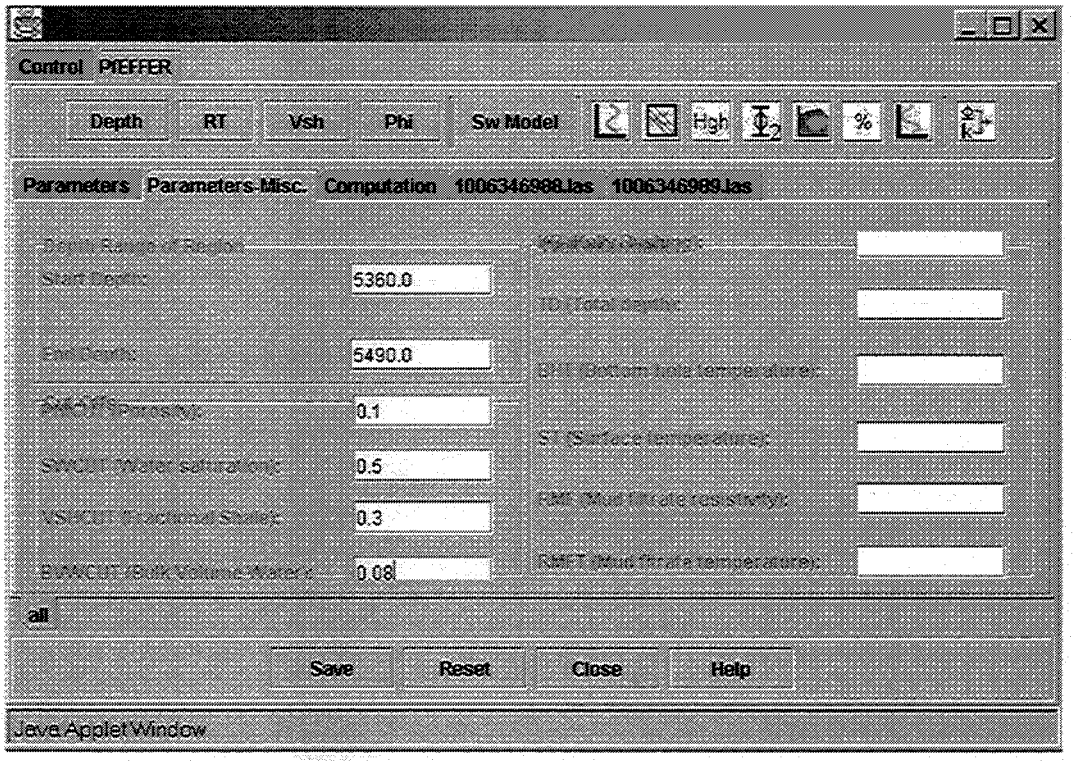


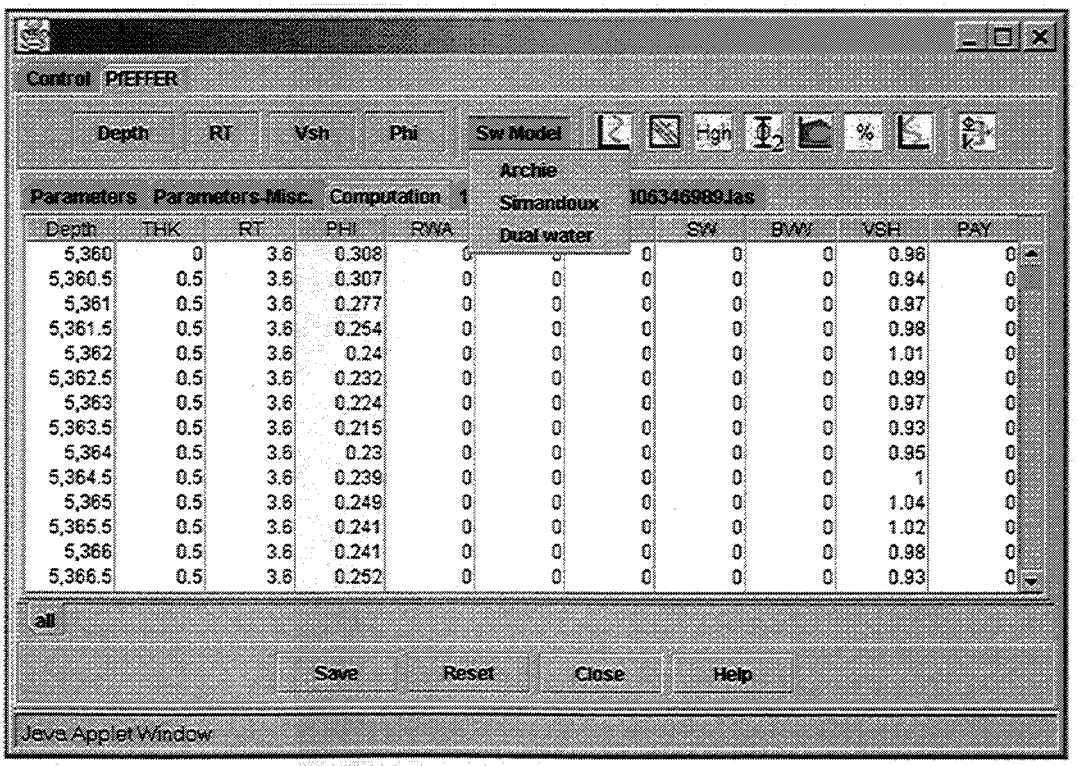
Figure 14. Java applet dialog box at the opening of PFEFFER provides well information read from LAS file and options to enter PfEFFER directly or to use other modules to view logs and define intervals for analysis.

The Java version of the PfEFFER spreadsheet is divided into areas for parameters, computations, and well log (LAS) data. Rather than a large single sheet as in the Excel version of PfEFFER, these spreadsheet areas in GEMINI are accessed by tabs (Figure 15). The result is still the same.

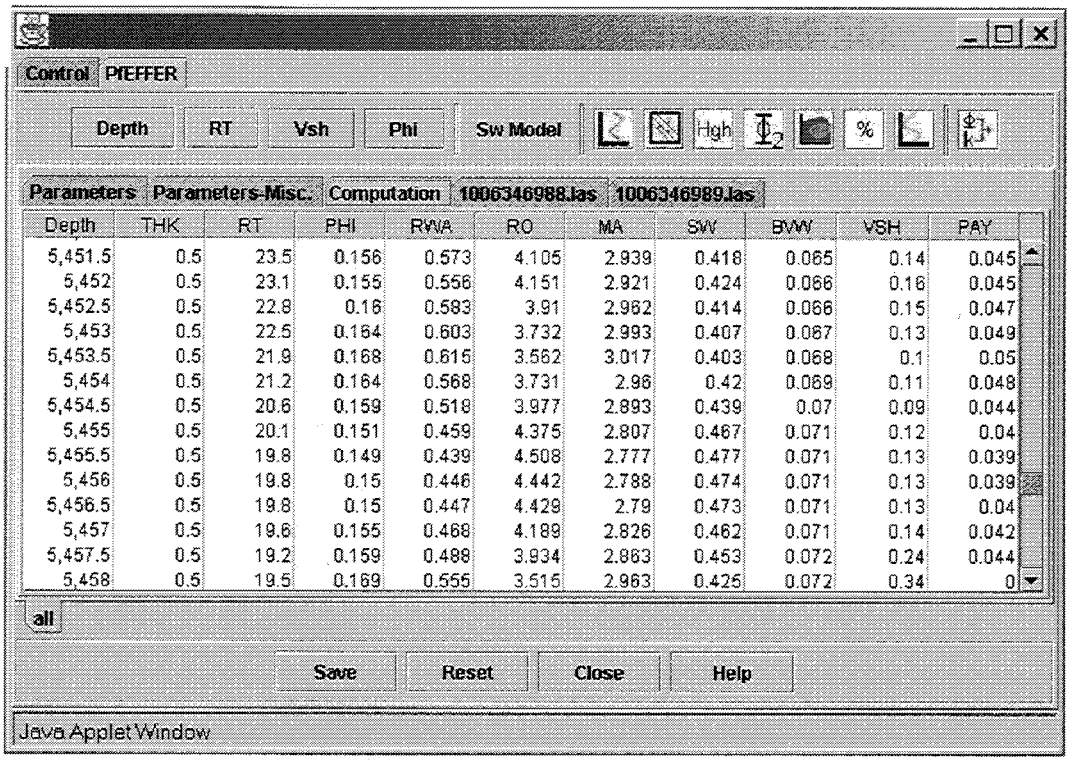
A)



B)



C)



Depth	THK	RT	PHI	RWA	RO	MA	SW	BVW	VSH	PAY
5,451.5	0.5	23.5	0.156	0.573	4.105	2.939	0.418	0.065	0.14	0.045
5,452	0.5	23.1	0.155	0.556	4.151	2.921	0.424	0.066	0.16	0.045
5,452.5	0.5	22.8	0.16	0.583	3.91	2.962	0.414	0.066	0.15	0.047
5,453	0.5	22.5	0.164	0.603	3.732	2.993	0.407	0.067	0.13	0.049
5,453.5	0.5	21.9	0.168	0.615	3.562	3.017	0.403	0.068	0.1	0.05
5,454	0.5	21.2	0.164	0.568	3.731	2.96	0.42	0.069	0.11	0.048
5,454.5	0.5	20.6	0.159	0.518	3.977	2.893	0.439	0.07	0.09	0.044
5,455	0.5	20.1	0.151	0.459	4.375	2.807	0.467	0.071	0.12	0.04
5,455.5	0.5	19.8	0.149	0.439	4.508	2.777	0.477	0.071	0.13	0.039
5,456	0.5	19.8	0.15	0.446	4.442	2.788	0.474	0.071	0.13	0.039
5,456.5	0.5	19.8	0.15	0.447	4.429	2.79	0.473	0.071	0.13	0.04
5,457	0.5	19.6	0.155	0.468	4.189	2.826	0.462	0.071	0.14	0.042
5,457.5	0.5	19.2	0.159	0.488	3.934	2.863	0.453	0.072	0.24	0.044
5,458	0.5	19.5	0.169	0.555	3.515	2.963	0.425	0.072	0.34	0

Figure 15. A) Prototype dialog frame in GEMINI's version of PfEFFER in the Parameters-Misc. "sheet" that includes values for pay cutoffs. Note that the tab "all" in lower left refers to the depth interval called "all" that is being analyzed. Multiple reservoir intervals would have separate tabs at this position. Consistency of spelling and correlation of reservoir intervals between wells will be assisted by correlative modeling modules, namely cross section and mapping. B) User defines depth, Rt, Vsh, and Phi columns in the LAS section to determine water saturation, bulk volume water (BVW), and pay in the computation area. A drop down menu for the water saturation equations is provided. Once selected the computation "sheet" is completed real time as shown in C.

The PfEFFER dialogs shown in Figure 15 have a series of icon buttons which are the same as those included in the Excel version of PfEFFER. The Pickett cross plot button is the only active button in the GEMNI prototype at the end of year 1. The initial version of the Pickett cross plot of log porosity vs. resistivity is interactive, permitting the user to add contours for Sw and BVW (Figure 16). As in the Excel version of the Pickett cross plot, the data points are connected. Currently, the points are not colored by a third variable such as depth or some other attribute (ATT button), e.g., gamma ray, PEF. The buttons above the cross plot allow the user to filter by depth, Rt, and Phi. Permeability (k) using the Timur equation and capillary pressure (CAPS) will be activated in a later phase of development of the cross plot.

Two petrophysical Java programs were available at the end of year 1 that were undergoing testing before being linked to the PfEFFER module. These programs are Rhomma-Umma and user-selected log solution of lithology and depth-constrained cluster analysis (Figure 17). Buttons in the PfEFFER module that will eventually become active once they are linked to GEMINI represents the programs. The resulting Java applets are interactive, allowing the user to change parameters and obtain results – plots of composition including depth. These additional depth-related petrophysical solutions

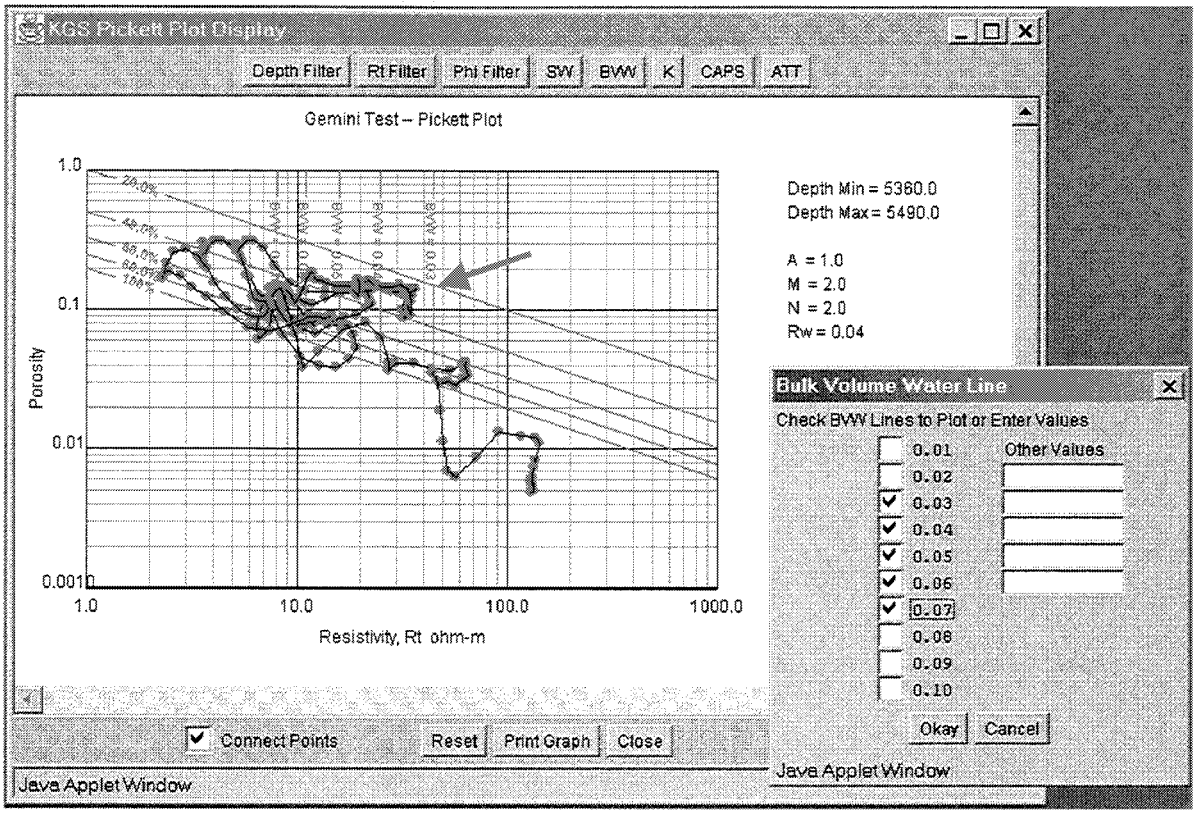
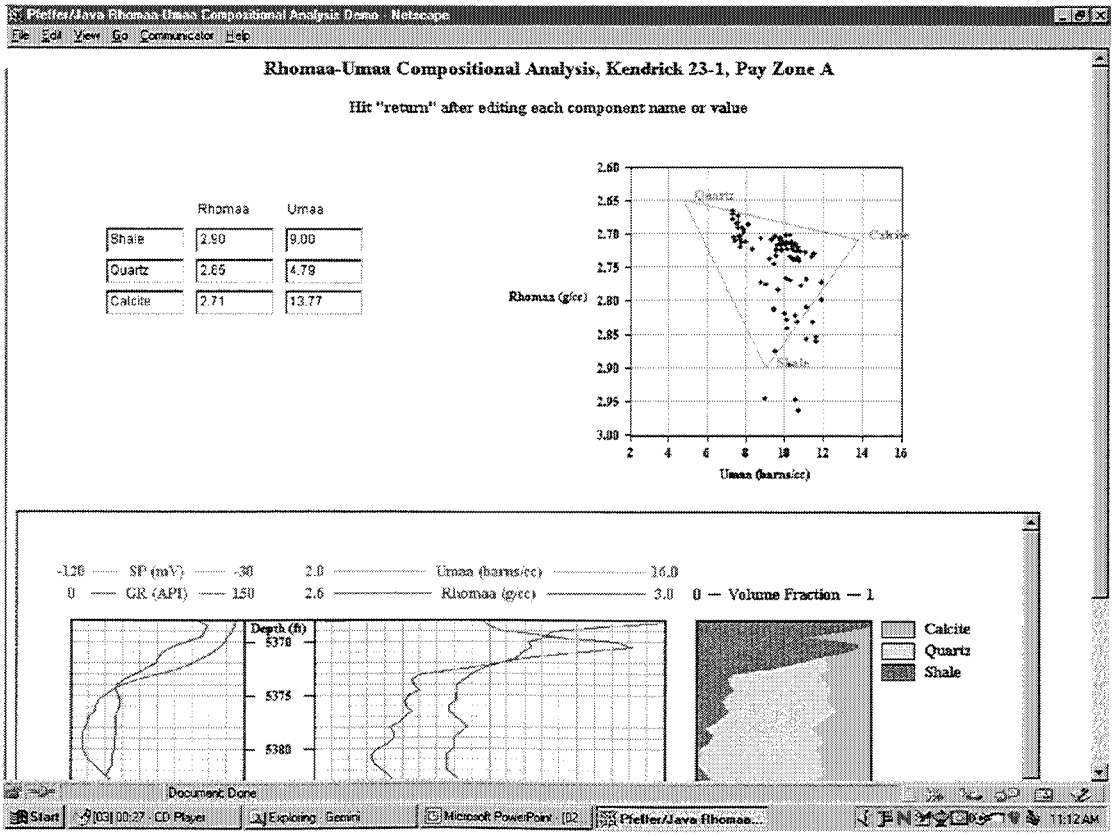


Figure 16. Prototype of Pickett cross plot Java applet that presents means to interactively modify plot to suit user objectives toward discriminating hydrocarbon pay within a defined reservoir interval. Hydrocarbon pay in this productive Morrow reservoir (Arroyo Field in Stanton County in southwest Kansas) is indicated by the clustering of points around a minimum BVW (0.035) and porosity above 10% (see green arrow). The points to the left of the arrow with increasing BVW are believed to reflect changes in pore type rather than an oil-to-water transition zone since the interval is known to produce water free. Applet continues to be developed and refined.

A)



B

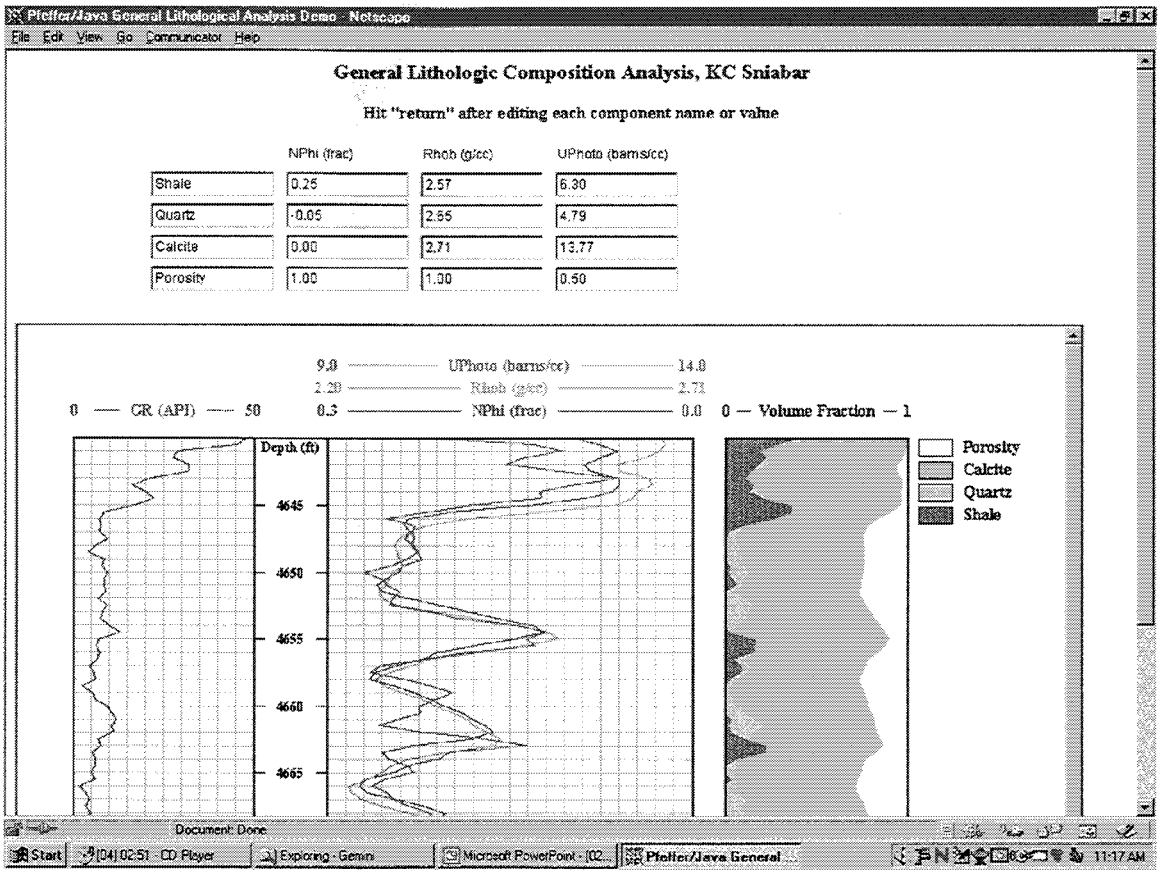


Figure 17. A) Rhomma-Umma lithology solution for reservoir interval in Morrow Sandstone in Arroyo Field. Parameters can be changed interactively with concurrent changes in Rhomma-Umma cross plot and composition depth plot. B) General lithology solution with logs and parameters selected by user. Applet is again interactive. General lithology option is useful when a Pe curve is unavailable for rhomma-umma solution.

will be available to print as scaled copy as in Well Profile. Results will also be available for use in cross sections to help establish and verify correlations.

Depth-constrained hierarchical cluster analysis provides an independent means to group comparable divisions of a PfEFFER interval using a selected suite of logs chosen by the user (Figure 18). The user selects the number of divisions of the resulting dendrogram and number of intervals in the corresponding blocked logs. The user is able to refine results by adding and deleting logs interactively. The user might first chose a gross interval of the reservoir for initial analysis in PfEFFER and then uses this clustering software to further define subdivisions in the gross reservoir interval. Ultimately, the user determines the final reservoir intervals and the software only assists in this important procedure.

The logic used to select logs for cluster analysis is determined by the user, but hydrocarbon pay discrimination could be best facilitated by selecting gamma ray or Vsh, porosity, Sw, and BVW. These are the same variables used to define cut offs for hydrocarbon pay in PfEFFER calculations. Pay and non-pay divisions arrived at here can provide objective means, if the user wants to use them, or at least present options to subdivide the reservoir. Combining cluster results with other geological and engineering

information such as depositional environment, sequence stratigraphy, and drill stem test results will further refine reservoir subdivisions so critical to reservoir modeling.

5.3. Geomodel Development

The objective of a full-fledged reservoir characterization is to establish an accurate and useful quantitative petrophysical geomodel. Intervals and subintervals defined in PfEFFER need to be evaluated in perspective of vertical conformance (flow communication), lateral correlatability and property continuity and fluid flow connection. Ideally, static reservoir properties and dynamic flow properties are brought together to confirm the geomodel and obtain an integrated geo-engineering model. The modules in GEMINI are integrated to access all available, potential solutions to characterize flow units including volumetric calculations to compare to what has been produced. The challenge in developing GEMINI is to provide user-friendly software integration at critical stages such as moving from single well to multi-/inter well space. The user should be able to seamlessly access and analyze essential geologic and engineering information for the wells in question.

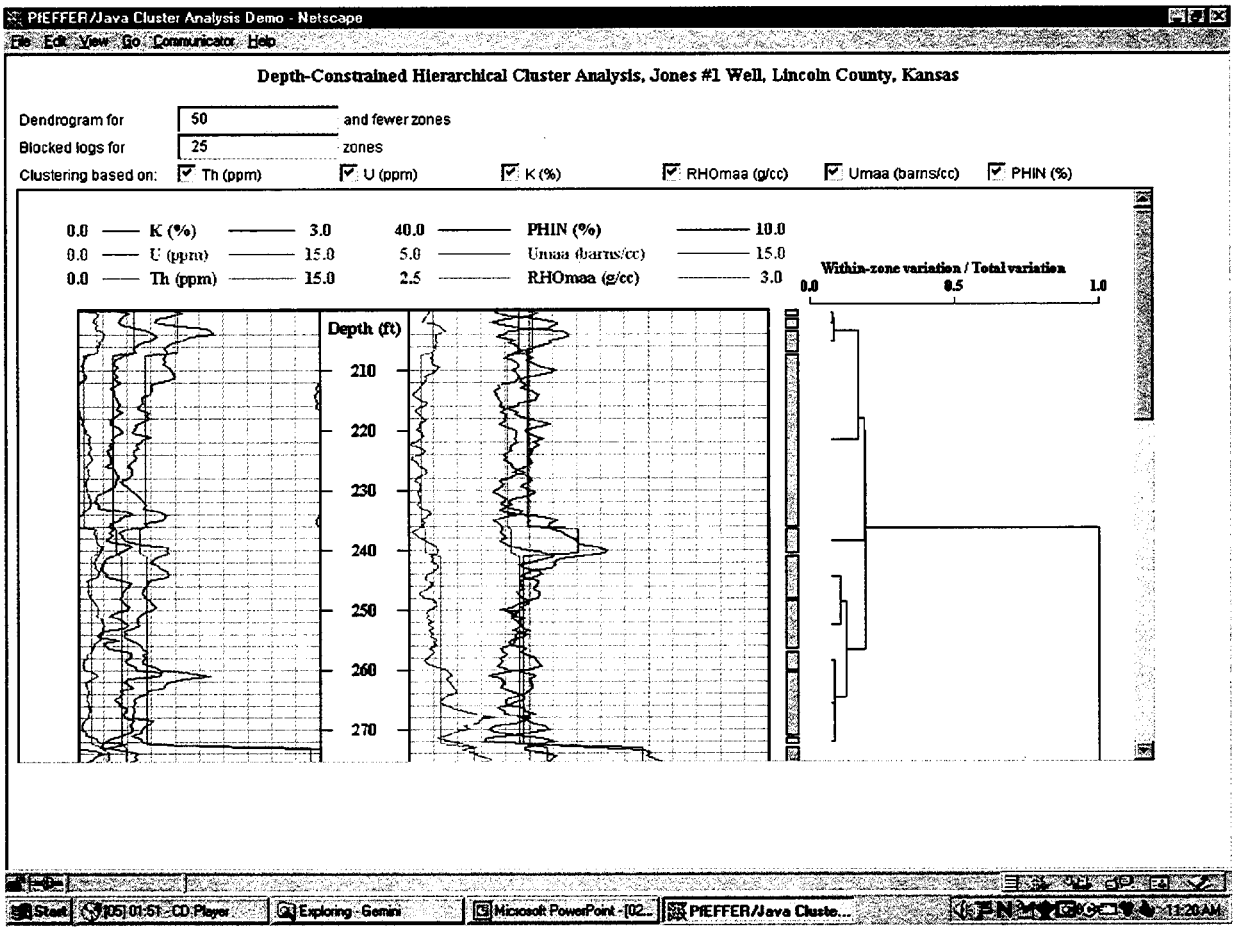


Figure 18. Java applet dialog for depth-constrained hierarchical cluster analysis. Cluster analysis is based on Ward's Method (Gill et al., 1993, Numerical zonation of log suites and log facies recognition by multivariate clustering, AAPG Bulletin v. 77, no. 10, p. 1781-1791).

Other modules such as Core Catalog, DST analysis, Production, Cross Section, Mapping, and Volumetrics need to be easily accessible to create a geomodel, test it, and hopefully verify it. We view this as an iterative process where the individual user or the project team revisits the project as new information becomes available and as new reservoir management opportunities arise. Furthermore, results must be downloadable for integration into reports and use in other applications.

Geomodel development encompasses several modules, namely those involved in correlative modeling – Cross Section, Gridding, and Mapping. These modules extend results from the single well analysis to a multi-well or 3-D model volume of the reservoir. User should also be able to go back and modify the single well analyses as needed. Conceivably, the user will define reservoir intervals and sub intervals well by well and these divisions must then be correlated between wells. Then reservoir interval and subinterval attributes/variables, as the case might be, including elevation, thickness, net/gross pay, porosity, permeability, water saturation, etc. are interpolated between wells included in the project.

Java coding of the Cross Section module is left to year 2 after the PfEFFER module is fully implemented. The concept to be used in cross section is that any depth-related variable can be included. Wells will be selected from a simple, but effective interactive map running as a Java applet. It is also envisioned that the cross section will be scaled vertical and horizontal and focused at the reservoir scale.

5.3.1. Grid and Map Modules. Prototype development of the Gridding and Mapping modules was realized in year 1 of GEMINI in the context of the Volumetrics module in Task 3 (Geo-Engineering Modeling). Thus, more details related to gridding and mapping is discussed under the Volumetrics module in the following section of this report.

The design of the gridding and mapping will accommodate control over grid size and dimensions and permit wells to be shown in the context of the grid elements to facilitate development of a geo-engineering model of the reservoir that is optimized for fluid flow simulation. The gridding used in GEMINI is simple inverse-distance with control over the weighting function, nearest neighbors, and number of sectors of the search. Design specs for mapping will allow the user to download well data as a plot file to use in more complex gridding or geostatistical modeling of reservoir properties.

Mapping in GEMINI is limited to basic color-coding of grid cells assigned by the magnitude of the parameter being mapped. The design considerations include establishing maximum and minimum range in color similar to what will be used to illustrate variables in the Cross Section module and coloring points for a third variable in the Pickett cross plot.

5.3.2. Automated Correlation Module. While depth-constrained clustering is used to define subintervals in reservoirs in single wells, automated correlation will assist

the user in establishing correlations between wells paralleling the cross section module. The user will ultimately determine the correlation, more or less assisted by the techniques available in this module. The Automated Correlation Module will be implemented in year 2 of GEMINI, but progress in its design continues to follow two approaches:

- Statistical correlation of log responses marking boundaries between zones (Olea, 1994, Mathematical Geology, v. 26, no. 8.)
- Markov chain analysis of transition characteristics (Collins and Doveton, 1993, in Computers in Geology: 25 Years of Progress, Davis and Herzfeld, eds., Oxford U. Press.)

The first automated correlation method involves correlation of surfaces at a high resolution (at the sampling level of the digital log data). The technique has been demonstrated to resolve internal stratal architecture significant in sequence stratigraphic interpretation at levels well below that which can be correlated manually (Watney, W.L., Olea, R.A., and Davis, J.C., 1999, Regional Stratigraphic Analysis of A Pennsylvanian Carbonate Shelf and Margin in Kansas, *in*, Merriam, D.F., ed., Transactions, AAPG Mid-Continent Meeting, p. 52-62).

. The software called Correlator is currently written in Fortran with input/output accomplished through UNIX software. This program will be rewritten in Java. The objective of this correlation method in GEMINI will be to resolve internal stratal or depositional surfaces of a reservoir such as shingling/lateral accretion surfaces (Figure 19).

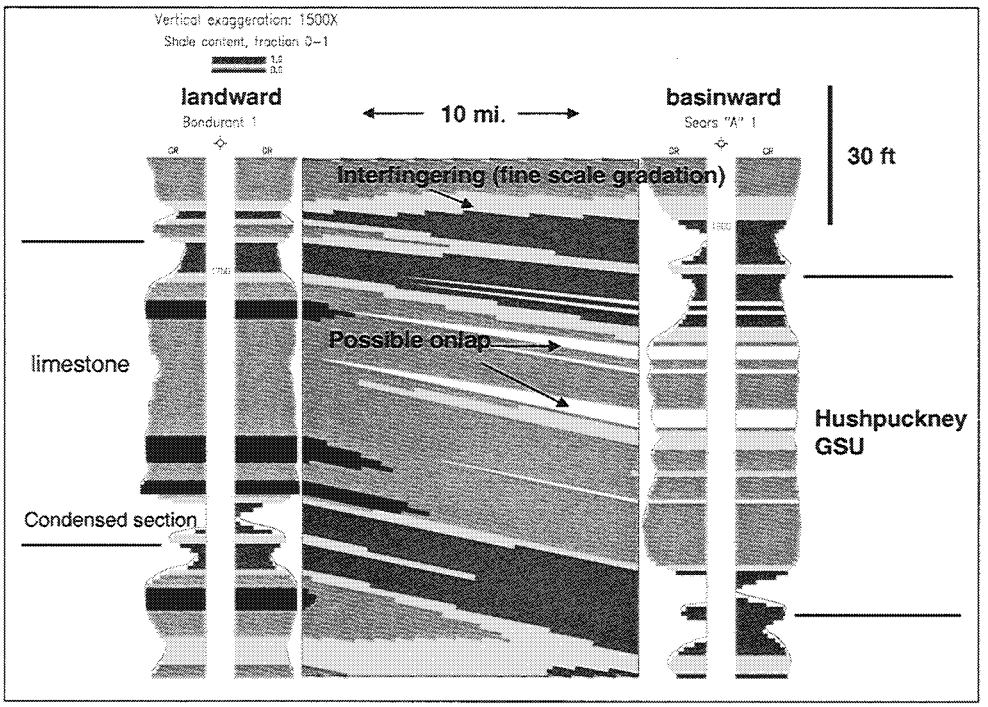


Figure 19. Correlation of genetic stratigraphic units with Correlator software currently written in Fortran that will reprogrammed in Java for GEMINI (Olea, 1994). Illustration from (Watney et al., 1999). Software will provide high-resolution correlation of internal stratigraphic architecture useful in gauging reservoir compartmentalization.

The second method for autocorrelation will also begin in year 2 to provide a means to independently correlate intervals and subintervals originally defined in PfEFFER for individual wells. A Markov chain analysis will determine similarities of properties and succession among selected wells, accommodating both lateral variation in intervals and their pinch out (Figure 20).

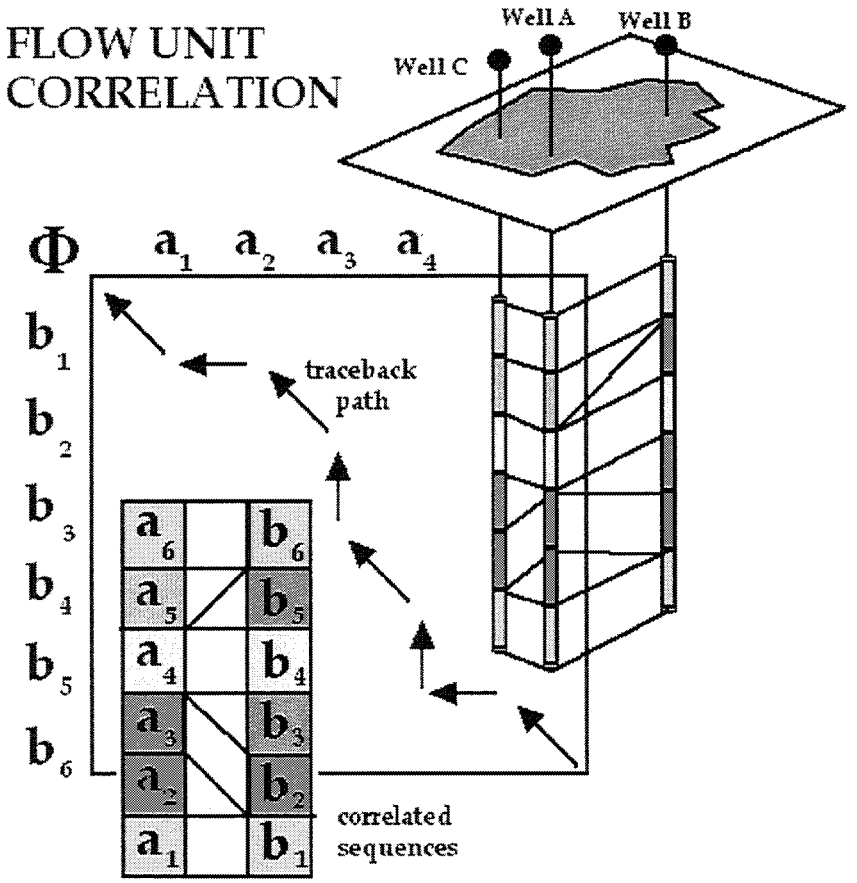


Figure 20. Conceptual diagram of how flow units/intervals will be correlated using Markov chain analysis of transition characteristics (Collins and Doveton, 1993). Automated correlation method will accommodate lateral variation of intervals and truncation/truncation as depicted.

6. Task 3. Geo-Engineering Modeling

The Geo-engineering modeling task contains three subtasks including volumetrics, material balance, and parameterization for reservoir simulation. From the

programming standpoint, the engineering software has been extended to include the following:

- Production data analyst - well, lease, field
- DST analyst - well level
- Volumetrics - field level
- Material Balance - field level
- PVT calculator
- Parameter and file assembly for simulation

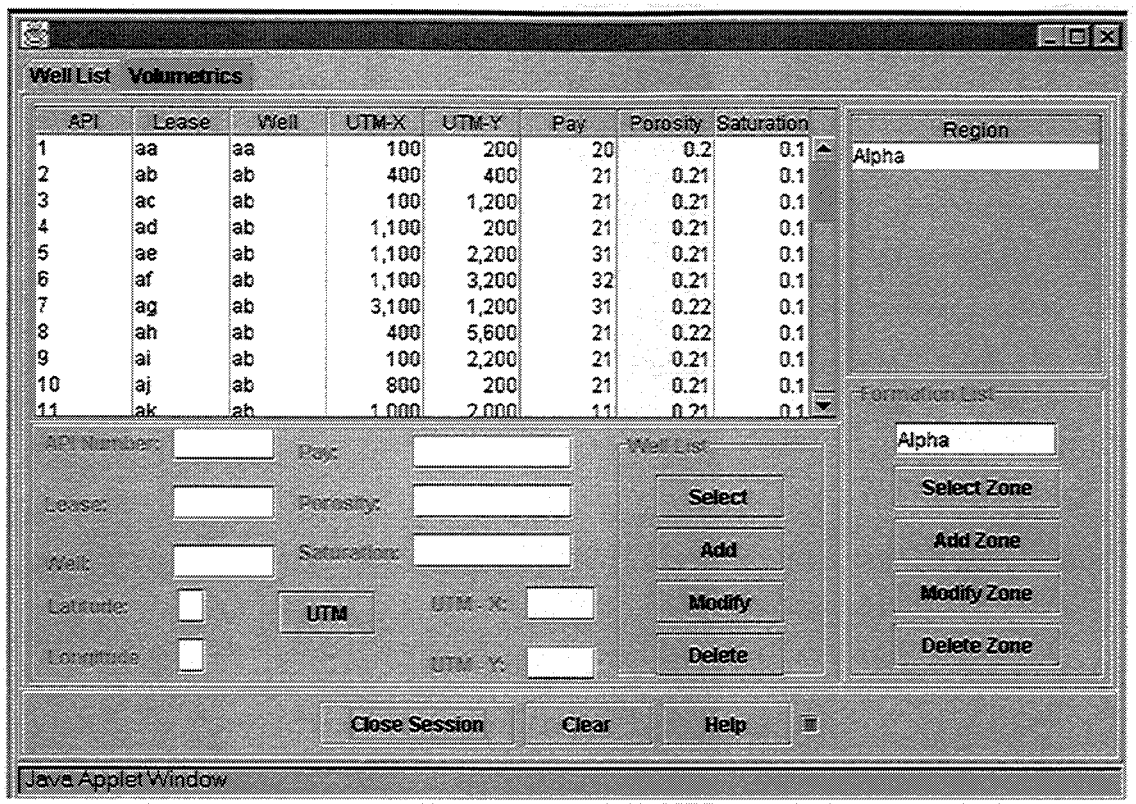
The production and DST analysts and the PVT calculator serve to augment volumetrics and material balance where the production analyst provides a means to compare with volumetric and material balance computations. Also, information can help to ascertain development potential and recovery efficiency. The DST analyst provides a means to obtain formation pressure, estimate permeability, and assess production contribution of a reservoir interval. The PVT calculator computes parameters for volumetric, material balance, and DST computations. Only the Java prototype for the volumetrics module was addressed during the year 1 of GEMINI and is discussed in more detail below. Parameterization and file assembly for simulation while not a programming issue in year 1 underwent discussion and initial design considerations and is further described below.

6.1. Volumetrics

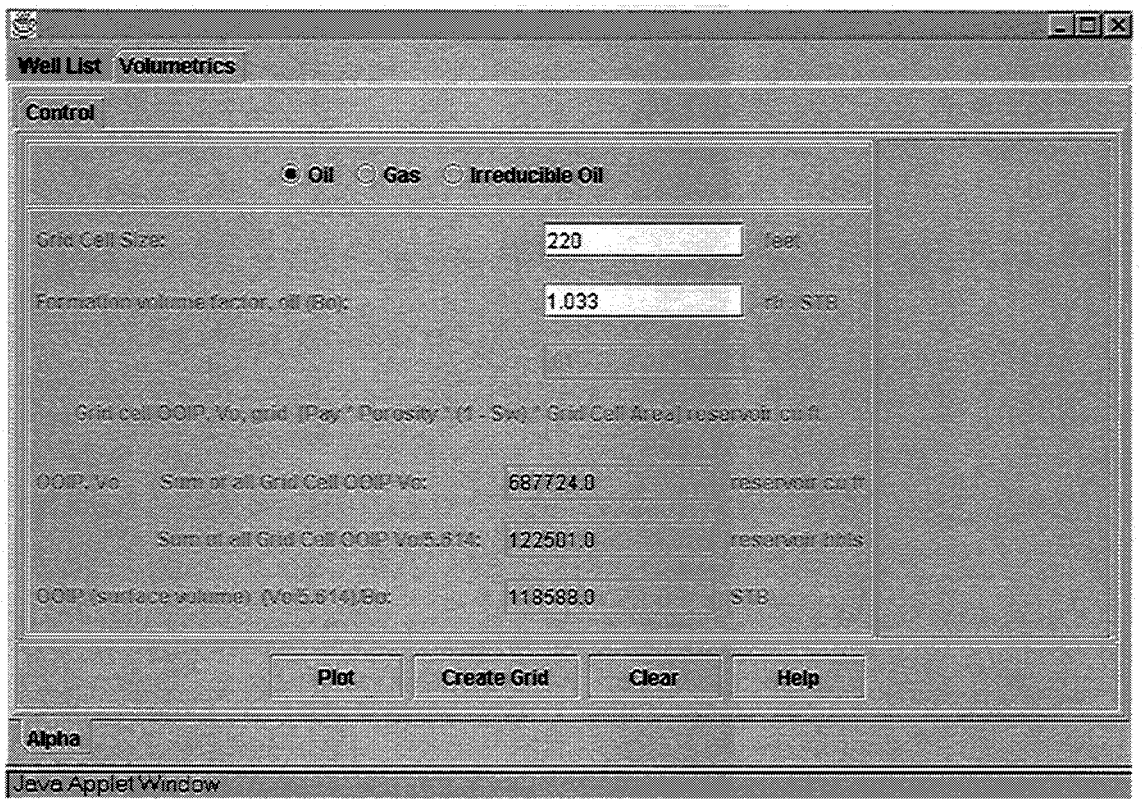
Volumetric analysis module was undertaken in year 1. Prototype Java applets were developed to allow well and interval selection for analysis, grid definition and gridding, calculation of oil and gas in place, and mapping of oil and gas in place. Figure 21 (A) shows list of wells (abbreviated names) in Arroyo Field selected for volumetric analysis. A region/interval called Alpha is also shown. Each reservoir interval could have computed volumetrics. As wells are selected values for net pay thickness, porosity, and water saturation are shown for the interval of interest. Average properties used in volumetrics are computed in PfEFFER as the pay is defined. Latitude and longitude are also shown. We will include UTM coordinates conversion in the applet computed from the lat-long values. UTM coordinates allow better visual scaling of the map and computed grid cells. However, UTM calculation was not done in year 1. Volumetric calculations are computer in the applet shown in Figure 21 (B). User enters the grid cell size and the formation volume factor, Bo. Original-oil-in-place, OOIP, is computed for all grid cells in reservoir cubic feet, reservoir barrels, and surface stock tank barrels (STB).

Well locations are also shown from this example. Values in each cell are delineated by color. Eventually, the range of color and data values will be included as options to customize the map. Maps of variables used in the volumetric calculation will also be available to the user.

A)


Well List
Volumetrics
API
Lease
Well
UTM-X
UTM-Y
Pay
Porosity
Saturation
1 aa aa 100 200 20 0.2 0.1
2 ab ab 400 400 21 0.21 0.1
3 ac ab 100 1,200 21 0.21 0.1
4 ad ab 1,100 200 21 0.21 0.1
5 ae ab 1,100 2,200 31 0.21 0.1
6 af ab 1,100 3,200 32 0.21 0.1
7 ag ab 3,100 1,200 31 0.22 0.1
8 ah ab 400 5,600 21 0.22 0.1
9 ai ab 100 2,200 21 0.21 0.1
10 aj ab 800 200 21 0.21 0.1
11 ak ab 1,000 2,000 11 0.21 0.1
Region
Alpha
Formation List
Alpha
Select Zone
Add Zone
Modify Zone
Delete Zone
API Number:
Lease:
Well:
Latitude:
Longitude:
Pay:
Porosity:
Saturation:
UTM
UTM - X:
UTM - Y:
Well List
Select
Add
Modify
Delete
Close Session
Clear
Help
Java Applet Window

B)


Well List
Volumetrics
Control
Oil
Gas
Irreducible Oil
Grid Cell Size:
220
feet
Formation volume factor, oil (Bo):
1.033
rb / STB
Grid cell OOIP, Vo, grid (Pay * Porosity * (1 - Sw) * Grid Cell Area) reservoir cu ft
OOIP, Vo
Sum of all Grid Cell OOIP, Vo:
687724.0
reservoir cu ft
Sum of all Grid Cell OOIP, Vo/5.614:
122501.0
reservoir bbls
OOIP (surface volume), (Vo/5.614) Bo:
118588.0
STB
Plot
Create Grid
Clear
Help
Alpha
Java Applet Window

C)

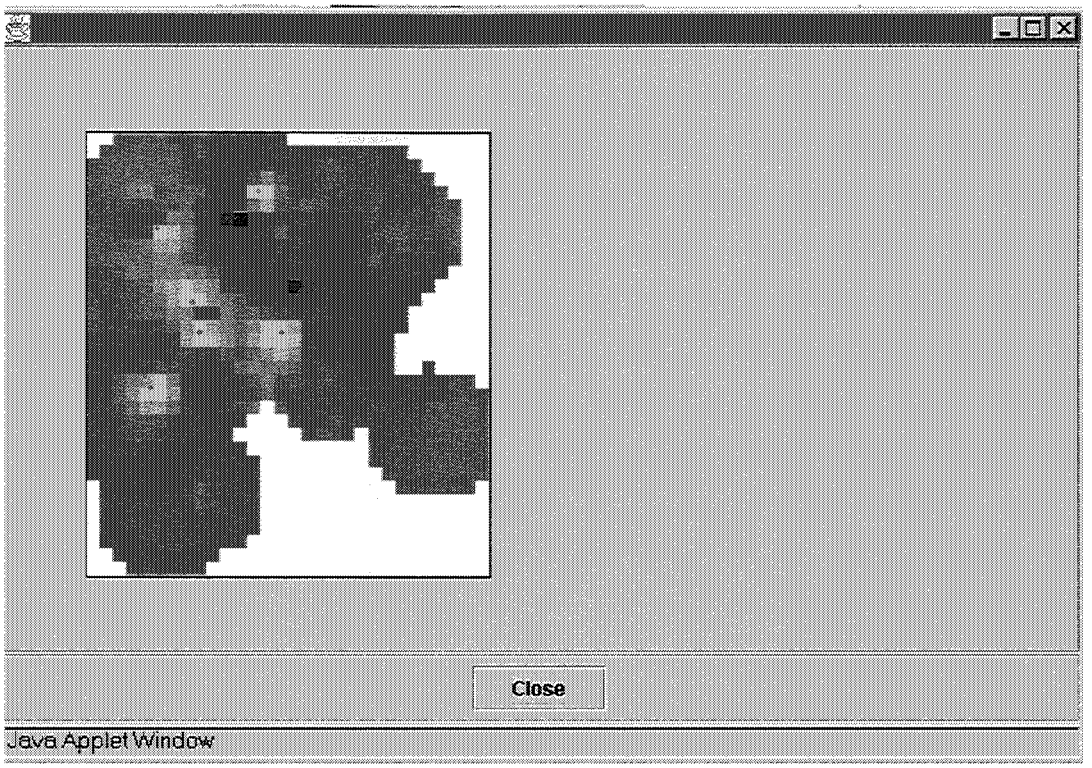


Figure 21. A) Prototype of the initial volumetric Java applet used in selecting wells from a project. Then the user defines the reservoir region/interval previously defined in the PfEFFER module and perhaps corroborated by correlative modeling modules. User can examine values to ensure a quality check before the computation is done. B) The subsequent volumetric screen in which the volumetric calculation is performed. The grid cell size is set and the formation volume factor, Bo, is entered. A separate PVT model under development will derive Bo. Reservoir surface volumes are computed. C) Map of oil volume for cells gridded with data from project wells defined in A).

The volumetrics module can be updated as new wells are added, intervals are redefined or re-correlated, or criteria for input variables are modified in PfEFFER. This will be an iterative process. Volumetric calculations will also be compared with production to examine recovery efficiency and identify areas that have too much or too little oil or gas produced. These anomalies may be real and represent development opportunities or are indications that the user must return to other modules to modify the geomodel in order to rectify results.

6.2. Parameterization for Reservoir Simulation (now referred to as Parameterization and File Assembly for Simulation)

Assembly and export of information derived from GEMINI is vital to the success of the project. Fluid flow simulation is a possible avenue users will pursue and all the steps taken in GEMINI are directed toward developing a robust geo-engineering model suited for reservoir simulation. Organization of the reservoir information will also encourage users to employ reservoir simulation because of the time and effort saved in the data assembly procedure. The basic export format to be followed for simulation will correspond to that required by DOE's BOAST black oil simulator. Moreover, we also

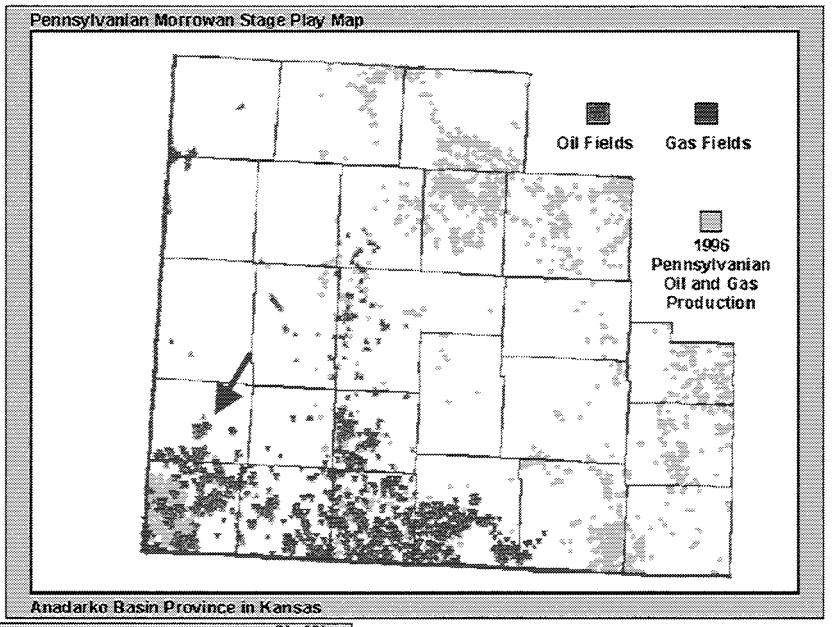
envision making a generalized data export module that will allow the user to see and select what data is available to export.

7. Task 4. Technology Transfer

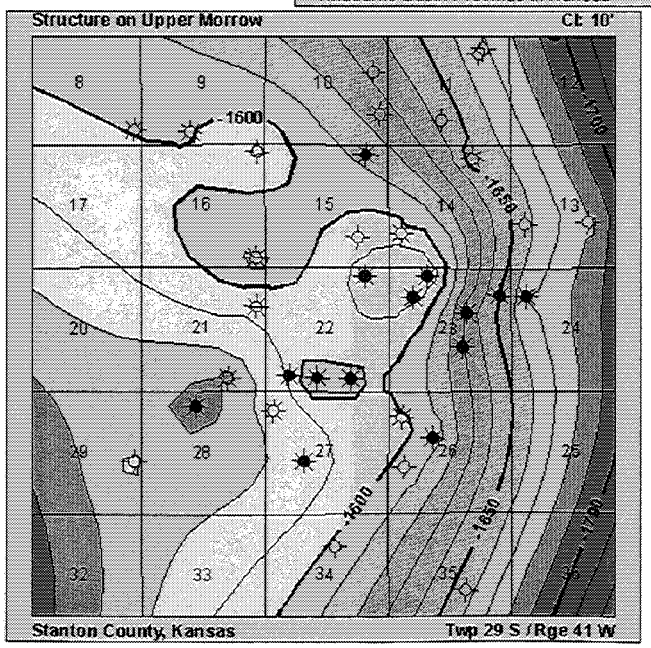
7.1. Project Application and Testing

GEMINI testing sites include company data and information from the Arroyo Field, Stanton County, Kansas. Company data were being assembled in year 1, basically getting companies familiar with GEMINI and its potential to assist them in their day-to-day operations. Arroyo Field data are part of the Kansas' Digital Petroleum Atlas and much of the information needed to test GEMINI has been assembled in this digital field study. The previous reservoir characterization of the Morrow Sandstone in Arroyo Field provides an excellent framework from which to compare results. Since its discovery in 1990 the Arroyo Field has produced nearly a million barrels of oil and over 30 BCF of gas from a total of 22 producing wells. Figure 22 below provides information on Arroyo Field

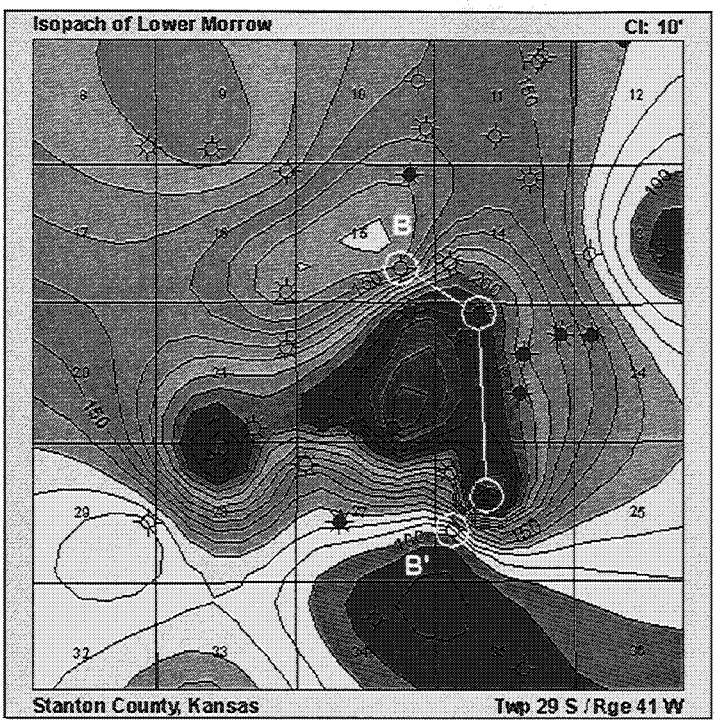
A)



B)



C)



D)

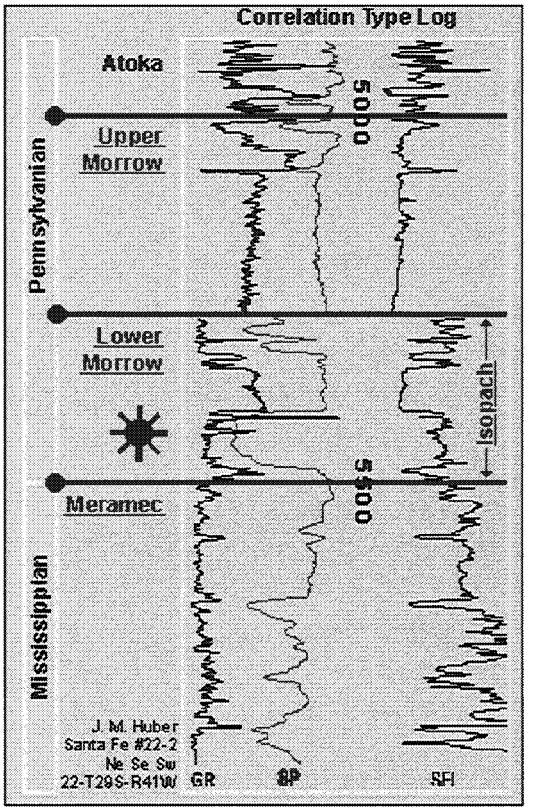


Figure 22. A) Regional map of wells producing from Morrow Formation in southwestern Kansas. Blue arrow shows location of Arroyo Field. B) Structure map of Upper Morrow in Arroyo Field. C) Isopach of Lower Morrow containing producing Morrow Sandstone in Arroyo Field. D) Type correlation log of identifying productive Lower Morrow Sandstone in Arroyo Field.

7.2. Tutorial Interface

Specifications for the GEMINI tutorial were refined during year 1. The tutorial will consist of: 1) "help" dialogs accessed by help buttons on applets used in the program modules; 2) a step-by-step manual written in HTML accessed at any point in the operation of GEMINI. In addition, the manual will be downloadable as a pdf file. The manual will present the overall design of GEMINI, options to access modules, typical workflows, managing results, concepts behind modules, and examples. Accessing elements of the manual will be assisted by links to GEMINI. The goals of the tutorial are user-friendly operation; a logical, intuitive organization; and basic training for users in reservoir modeling.

Feedback from representatives of participating companies and seminar and workshop participants are an important component to evaluate and suggest features in GEMINI that will be most useful to them. Also, participating companies have been asked to test developing modules and obtain their feedback before prototype programming becomes an official release. Issues such as being able to upload their own data early in the development schedule have been addressed. During year 1, the GEMINI Project team has maintained contact with company representatives and encouraged presentations to

industry. A daylong workshop at the end of year 1 was designed to obtain feedback (see summary below).

The GEMINI website is steadily being modified to encourage users and obtain their feedback. As the project advances and becomes more useful, we expect increasing feedback. The organization and accessibility of the website are issues that will be an increasing priority in year 2.

7.3. Technology Transfer Activities

Technology transfer activities in year 1 include:

- Developed website for GEMINI to access prototype software and review progress: http://crude2.kgs.ukans.edu/Gemini/index.html; also included are reports and presentations

- GEMINI introduced to the Kansas petroleum independents on May 2001 with an invited presentation to the Kansas Geological Society in Wichita

- Brochures and demo made available at AAPG/SEPM Annual Meeting in Denver in June 2001

- Presented workshop on GEMINI and Digital Petroleum Atlas to BP-Amoco in Houston in July 2001

- Presented an invited seminar on GEMINI to Kansas Independent Oil and Gas Association Annual Meeting in Wichita in August 2001

- Held day-long GEMINI Workshop in Lawrence for participating companies and DOE describing progress and developments – October 2001

Many of the presentations have been posted on the GEMINI website with newer ones often superseding earlier talks. We have discussed GEMINI design, demonstrated prototype modules, and encouraged visiting the site and obtaining feedback. In the process, we have become aware of other's efforts to handle digital data on the web and have discussed mutual interests.

7.4. Summary of Year One Review Workshop – October 2, 2001

A daylong workshop was held for participating companies and DOE on October 2, 2001 to review progress and seek feedback. The following are comments from participants.

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 interactiveness 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.

8. Future Plans

GEMINI's programming schedule is on track so that all the modules as proposed can be delivered (Figure 4). Team members will continue to participate in the design of modules in keeping with their expertise. The primary issues encountered to date in development have been obtaining finalized program specifications, controlling flow of user access to modules and appearance of applets realizing need to integrate the modules, optimizing code creation that can be shared between modules, saving project information, printing, uploading user data, formatting data types to fit Java specifications, getting timely feedback, and limiting modules to intended functions. These will continue to be issues and opportunities in subsequent years of the project, primarily addressed by optimizing, but not overwhelming communication among the team members. Testing of software will increasingly rise in importance as more prototype modules become available. Testing will include use of Arroyo Field data and that provided by participating companies to ensure usefulness and accuracy of results.

Two modules that were not addressed will be undertaken in years 2 and 3. These modules include KHAN – Kansas Hydrocarbon Association Navigator and Synthetic Seismogram Builder. The former software will permit the user to process "raw" log data (LAS files) directly to detect hydrocarbon pay. The user sets criteria or the user can incorporate information in a pay database designed for a particular region. The software will serve as a guide in assessing shows in an exploration mode or more precise reservoir pay in a field study. The results are necessarily limited to the criteria that are included in the database. It is anticipated that database for basin, plays, and provinces will evolve over time and become increasingly refined and robust. First, the usefulness of this module needs to be demonstrated and established through the development and testing phases. Initially, the pay database that is developed will be applicable for the Hugoton Embayment in southwestern Kansas.

The synthetic seismogram builder will provide a means to extend the results in GEMINI's petrophysical results to seismic information. Many types of software are available to make synthetics, but a simple version included in GEMINI can facilitate quick extractions.

Additional workshop, presentations, and papers are in planning including a 2nd-year review workshop.