CONF-960530--27

LA-UR- 96-0594

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Title: A Simulation-Based Reservoir Management System

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Submitted to: Society of Petroleum Engineers, Western Regional Meeting, May 22-24, Anchorage, AK

Los Alamos
NATIONAL LABORATORY

Form No. 836 R5
ST 2629 10/91

SPE 35703

A Simulation-Based Reservoir Management Program

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This paper was prepared for presentation at the Western Regional Meeting to be held on May 22-24, 1996, in Anchorage, Alaska.

Abstract

There are more than fifty-two hundred independent oil and gas producers operating in the United States today (based on current IPAA membership figures). These companies are playing an increasingly important role in production of hydrocarbons in California and elsewhere in the United States.
Pacific Operators Offshore, Inc. , in a historic collaboration with its government royalty owners, the California State Lands Commission and the Minerals Management Service of the U.S. Department of Interior, is attempting to redevelop the Carpinteria Offshore Field (see **figure 1**) after two-and-a-half decades of production and partial abandonment by a previous operator.

This paper will describe a project, funded by the Defense Programs Office of the Department of Energy and the participating companies and institutions, which focuses on the distribution of advanced reservoir management technologies (geological, petrophysical, and engineering) to independent producers like Pacific Operators Offshore, Inc. The evolving information highway, specifically the World Wide Web (WWW), serves as the distribution medium. The project to be described in the remainder of this paper is an example of the implementation of a reservoir management tool which

- is supported by distributed databases
- incorporates a shared computing environment
- integrates stochastic, geological, and engineering modeling .

Introduction

Reservoir management technologies[1] have the potential to increase oil recovery while simultaneously reducing production costs. These technologies were pioneered by major producers and are routinely used by them. Independent producers confront two problems adopting this approach: the high cost of acquiring these technologies and the high cost of using them even when they are affordable. Effective use of reservoir management tools requires, in general, a team approach and an environment which supports the sharing of information and technologies by professionals with backgrounds which include the geosciences, engineering, and business management.

This paper describes a project which aims to make these technologies available to the independent operator in a cost effective manner. The central

feature of our approach is the development of a simulation-based reservoir management tool which exploits the potential of the WWW[2,3,4] to deliver software and database access at low cost.

It should be emphasized that this is a low cost solution. The independent operator can control his cost of access to the reservoir management technology. He can contract for whatever services he cannot perform for himself. Moreover, the independent operator can access directly the modeling technology, for example, geological modeling, through interfaces which promote self-sufficiency and are intuitive. The more arduous tasks of data conditioning and model building can be contracted to local consultants or expert users. The hardware requirements are minimal: a PC, modem, Internet access, and a Web browser. At least two of these are probably already available. Some browsers are available as freeware and Internet access costs little more than Cable TV access.

Distributed Databases.

A reservoir management project, in general, involves the steps depicted in **figure 2**. The process usually begins with structural and stratagraphic modeling. Petrophysical data, such as well logs and core analyses, are used to flesh out the stratagraphic model to create deterministic or stochastic geological models. In turn these models provide the geological component of the input to a reservoir simulator which is used to forecast(optomize) hydrocarbon recoveries from competing production scenarios and to aid in risk assessment. Then the results are subjected to financial analyses. In our project the data available initially to support the process described above were

- primarily available only on paper
- inaccessible to any participant other than the original owner.

A significant effort has been invested in analyzing these data and converting them to electronic format. A reservoir database has been populated with numerous kinds of field measurements: structural picks, deviated well surveys, well logs, core measurements, production records, workover summaries, and completion records, to name a few. Some of these records are accessible over the WWW, for example, interpreted well logs (**figure 3**). These can be accessed on-line to support geological interpretation.

These databases are being organized to support the statistical, geological, engineering and financial software applications which form the heart of the reservoir management tools used in this project. We are attempting to make them compatible with the Petrotechnical Open Software Corporation (POSC) data model, Epicenter.

Shared Computing Environment.

The internet is on the verge of revolutionizing the way business and technology are being conducted. Essentially the internet is a very large group of computers connected together by a wide variety of links including the telephone network so that they can communicate with one another. The predecessor to the internet, the ARPANET, was designed with significant built-in redundancy for national security reasons. With the advent of low cost, powerful personal computers, the rapid increase in available communication speeds (28.8 kbaud modems are now the norm and significantly higher speeds expected in the future), and, most significantly, the availability to the general public, the internet has metamorphosed into a general purpose information "superhighway" that is being put to a large number of uses.

The WWW supports extremely user-friendly interpretation protocols (HTML, etc.) which facilitate the transmission of graphic images and movies as well as text. These protocols have lead to a new definition of "document". A *hypertext* document does not necessarily reside in a single computer. Parts of such a document may reside on computers distributed worldwide and bound together through dynamically established connections called "links". Such documents have extended the concept of a report to include databases, movies and even executable software. The document links to other documents manifest themselves as highlighted portions of text or figures which the viewer can invoke with the click of a mouse.

In the WWW, certain computers are servers which are configured to provide information and services to all who request it (our reservoir management software resides on one such server), while others are clients which access the information. The clients must have

"browser" software installed. This browser software allows the client to properly display the data as text, graphics or movies.

To access our server from a browser, open the link

http://ees-www.lanl.gov/EES5/gas_oil/ARM

Figure 4 displays the result of a successful link. From our server we expect to provide access to

- remotely distributed portions of our project database maintained by the various participants in our project
- software applications supported by on-line tutorials
- progress reports which are updated continuously
- information about the participating companies or institutions

This information can be accessed by the click of a button.

Integrated Reservoir Management System

The preceding section illustrates the concept of distributing reservoir management applications and data to independent operators over the WWW. This section will describe our approach to the development of integrated reservoir management software tools. The main goal of this effort is to guide the redevelopment of the field. A supporting goal is to characterize and reduce the risk inherent in the options available to Pacific Operators Offshore, Inc. The use of the WWW is an integral part of this strategy.

Integrated reservoir management software systems have received a lot of attention within the petrotechnical software market during this decade. In this porject the focus is on simulation-based planning and risk assessment. We seek to build a system comprising statistical applications, geological modeling software and reservoir simulation tools, illustrated in **figure 5**, which is

- heterogeneous, that is, comprised of the best-of-breed software from different vendors
- POSC-compliant to the extent feasible
- at least moderately integrated from the perspective of data sharing

The last bullet merits further explanation. The "ideal" reservoir management system might sit on top of a fully POSC-compliant realization of the Epicenter data model. All applications would share the same view of the data. Moreover, the applications themselves would also communicate with each other seamlessly. To the user a truly integrated system appears to be a single application. The industry has not yet reached this ideal state - especially for software from different, competing vendors.

Our goal is less ambitious, but achievable today. The ability of different applications to support common data formats and to inport/export data conveniently is paramount. The number of steps required to transfer data between applications needs to be small, but we recognize that the goal of zero steps is unachievable at present. There must also be a rough match between the modeling capabilities and limitations of different software applications in our reservoir management system. For example, the use of grids in stochastic simulation of reservoir attributes, geological modeling, and reservoir simulation must be compatible. Finally, the needs of different user communities,e.g. geologists, engineers and managers, must be supported as painlessly as possible.

Just as there is a distribution of data and applications, so there is also a distribution of effort. Expert users and local consultants will visit our web site from time to time to aid the independent operator. Unlike the case for the majors, these individuals are not employees of the independent producer. The use of the WWW facilitates this interaction. Web features like video-conferencing, electronic white boards and other forms of "virtual collocation" compensate for the fact that the project's participants are not working from the same location.

The independent operator addresses the reservoir management tools through an interface tailored to his needs to understand how various reservoir management operational parameters within his control impact profitability. He is not expected to assemble data or models. This is the domain of the expert user, whose services are used as needed.

Conclusions

This paper has described the beginning of a project with an ambitious goal: to bring the power of advanced reservoir management technologies, validated by the majors, to independent operators. The basic price of access is modest. Only a PC, modem, and web browser plus internet access are needed. Unlike the situation with the majors, full-time engineering and geological support is not required. Rather, the independent operator will contract with local consultants and expert users on a case-by-case basis. All will access the reservoir management technology over the WWW. The unique feature of this approach is that it places portions of the technology directly into the hands of the independent. The interface between the independent operator and powerful modeling applications is simple enough that the need for specialized training is minimized. The independent operator can control his costs by performing as much of the work as he is capable of and by limiting his use of outside resources to the greatest extent possible.

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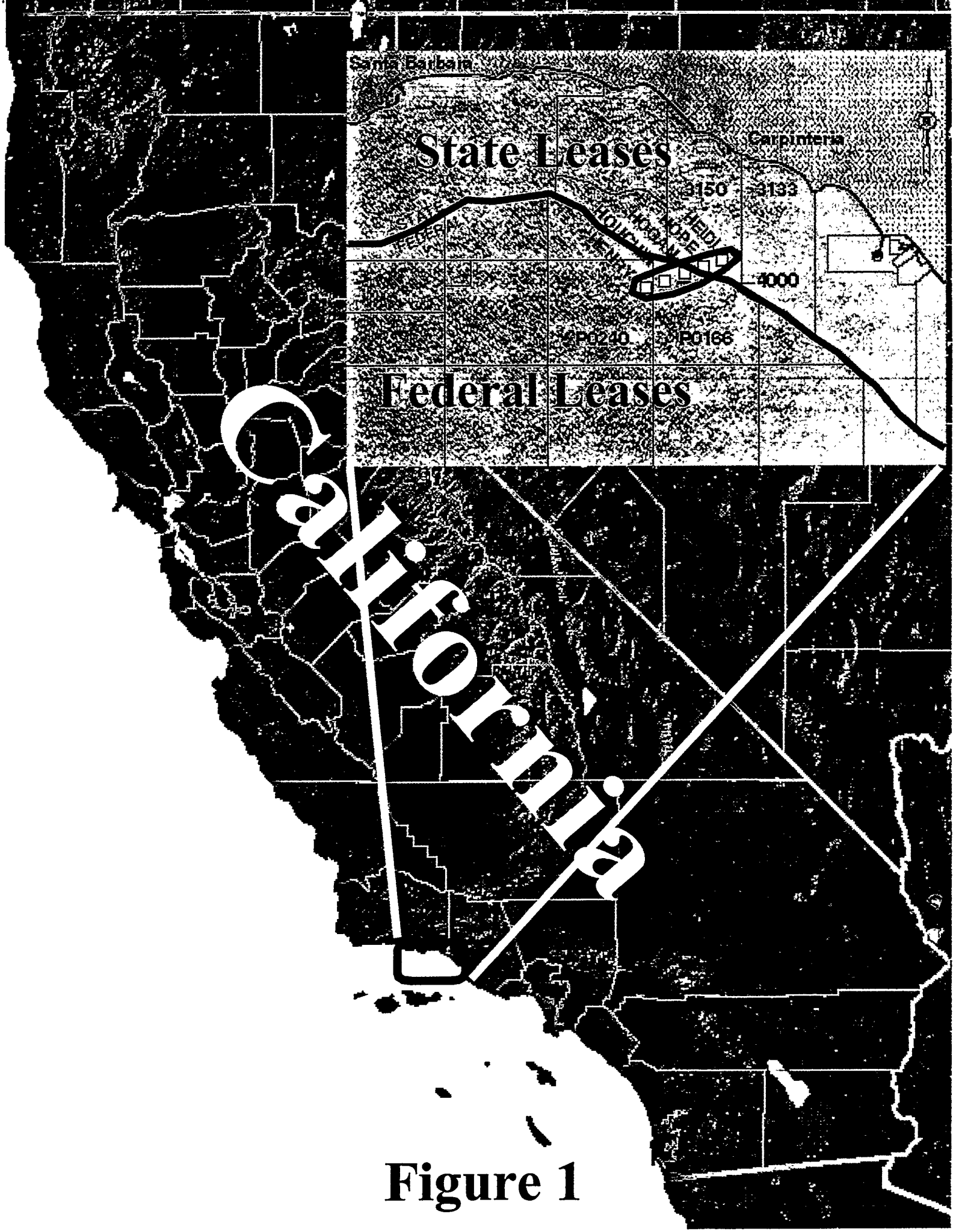
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3133
HEIDI
HOPE
4000
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Federal Leases
California

Figure 1

Project Tasks

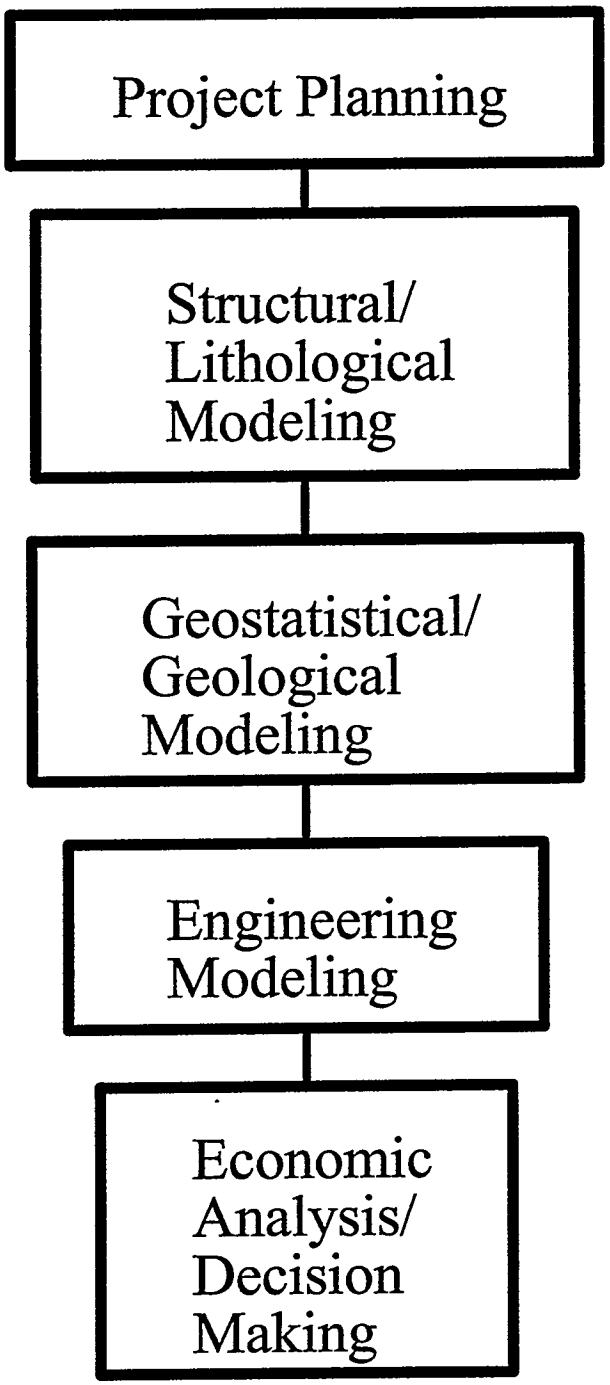
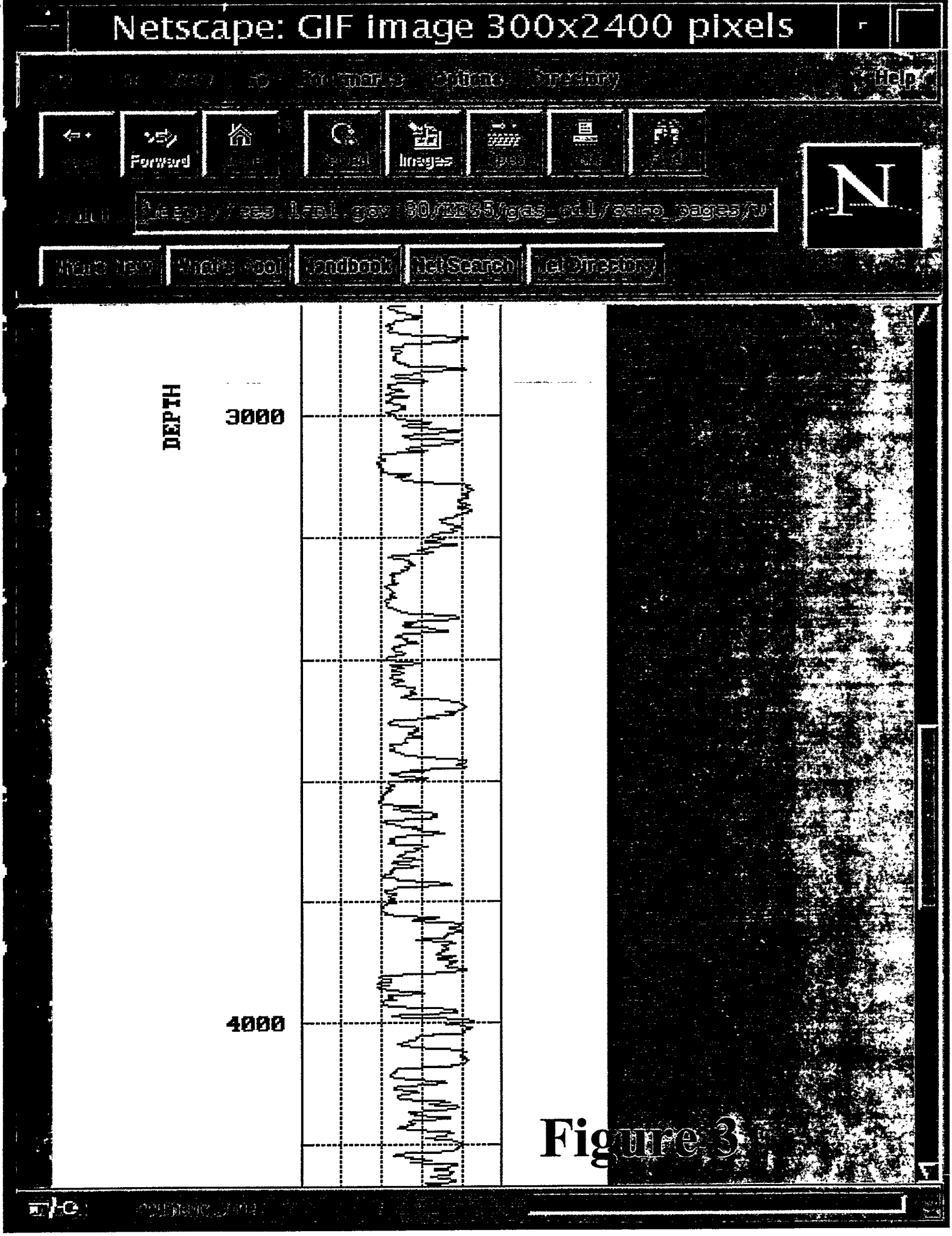


Figure 2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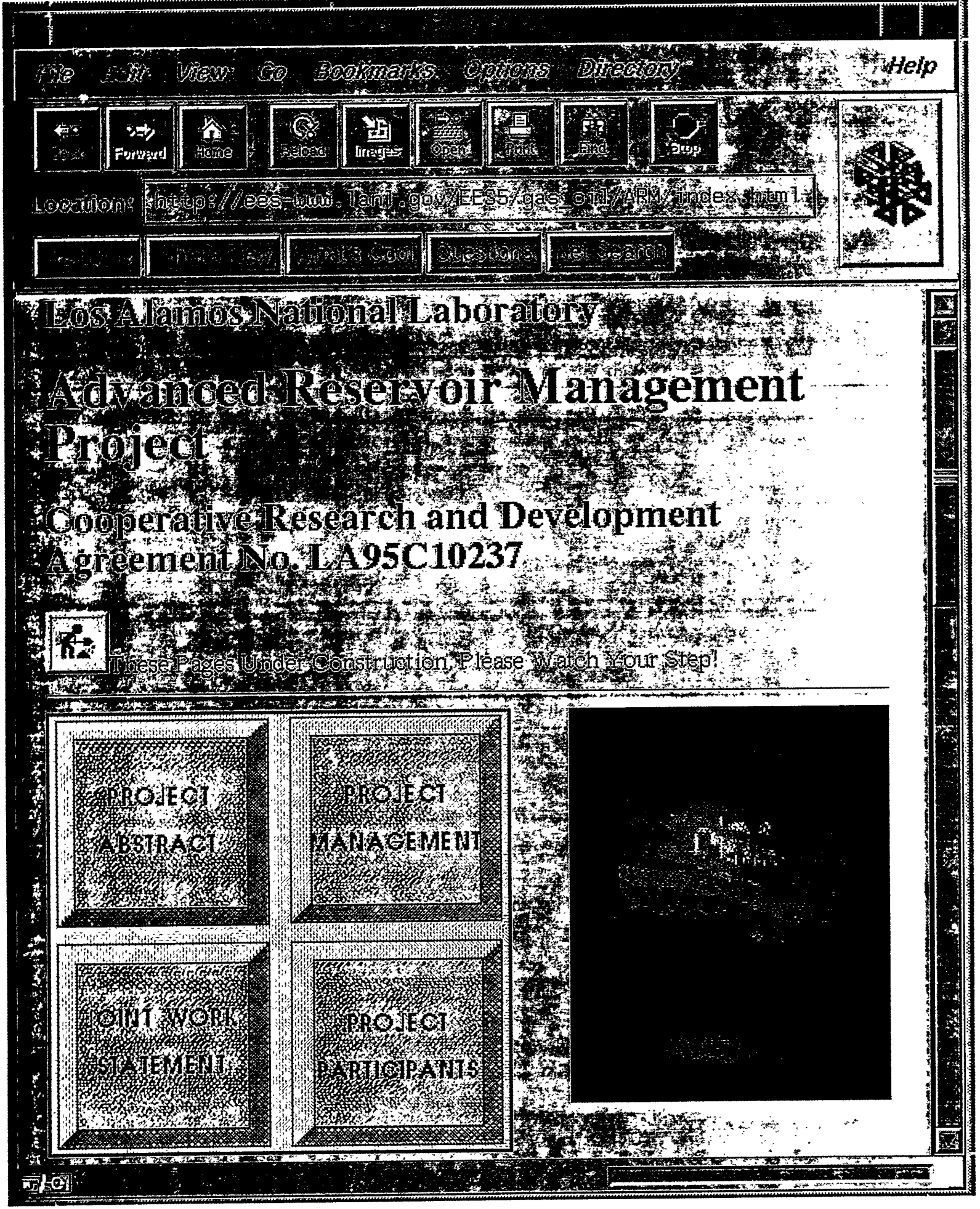
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What's Cool Questions Net Search
Los Alamos National Laboratory
Advanced Reservoir Management Project
Cooperative Research and Development Agreement No. LA95C10237
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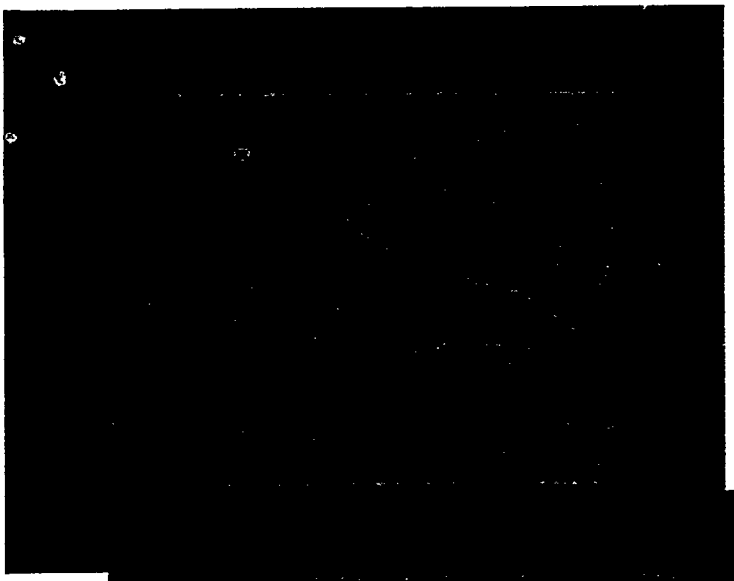
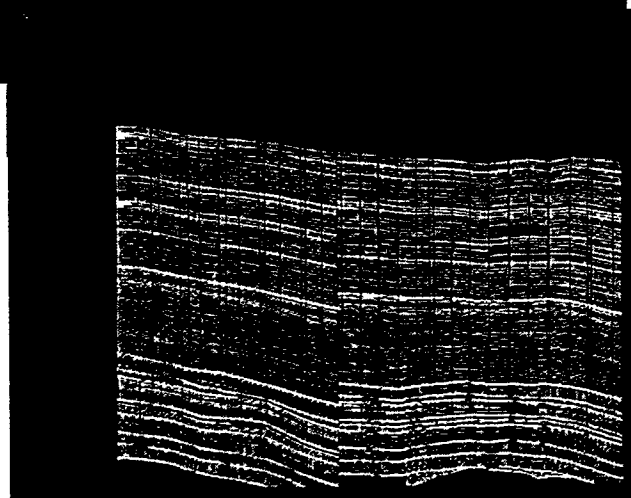
PROJECT ABSTRACT
PROJECT MANAGEMENT
JOINT WORK STATEMENT
PROJECT PARTICIPANTS

Figure 4

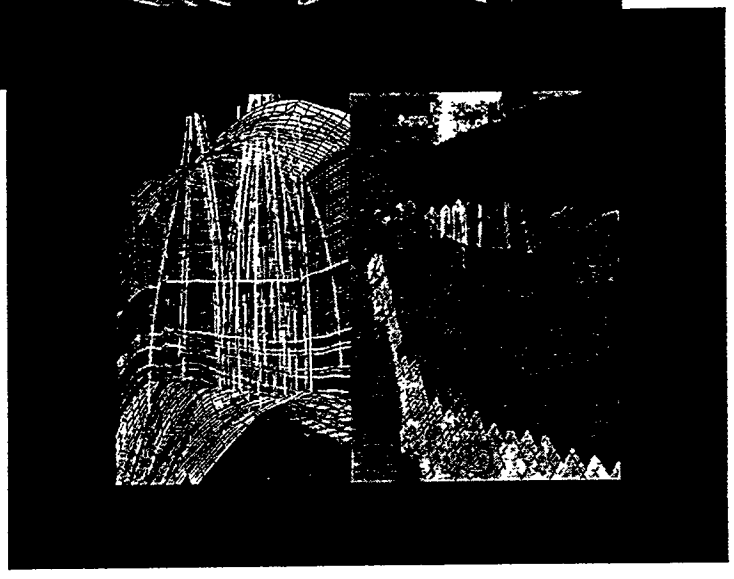


Structural Models

Stratigraphic Framework Models



Geological/ Geostatistical Models



Engineering/ Flow Simulation Models

Figure 5