TIME-LAPSE MODELING AND INVERSION OF CO2 SATURATION FOR SEQUESTRATION AND ENHANCED OIL RECOVERY

Quarterly Report for the Period January 1, 2004 – March 31, 2004

Date Issued: May 10, 2004

Mark A. Meadows

4TH WAVE IMAGING CORPORATION
16A Journey, Suite 200
Aliso Viejo, California 92656

PREPARED FOR THE U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Work Performed Under DOE Award Number DE-FC26-03NT15417

FULL LEGAL DISCLAIMER

ABSTRACT

In the second quarter of this DOE NETL project, we have continued Phase I and Phase II activities for researching and developing new technology to quantitatively model the rock physics effects of CO_2-oil-water systems. These activities included completing a literature search of currently available equation-of-state methods, initiating work in molecular dynamics modeling, and building a prototype seismic modeling code for predicting time-lapse CO_2 changes in well-log models. We have also received permission to use the Sleipner time-lapse CO_2 data set from the North Sea for the current NETL project, and have issued a formal request for the data.

TABLE OF CONTENTS

Page

I. EXECUTIVE SUMMARY

In the second quarter of this DOE NETL project, we have continued Phase I and Phase II activities for quantitatively modeling the rock physics effects of CO_2 injection (both miscible and immiscible) in porous reservoir/aquifer rock systems containing oil-water phases. These activities have included completing a literature search of currently available equation-of-state methods, initiating work in molecular dynamics modeling, and building a prototype seismic modeling code for predicting time-lapse changes from well-log data during CO_2 injection. We have also received permission to use the Sleipner time-lapse CO_2 data from the North Sea for our project work, and have formally requested the data.

II. EXPERIMENTAL

No experimental methods were used during this reporting period.

III. RESULTS AND DISCUSSION

We have completed our literature search for calculating CO_2-oil and CO_2-brine properties via equation-of-state (EOS) methods. We also initiated research into applying molecular dynamics modeling for calculating properties (such as bulk modulus and density) of CO_2-oil-brine mixtures. Molecular dynamics modeling is a numerically intensive modeling approach that is able to generate macroscopic properties of a specific mixture of molecular components at equilibrium. The two-pronged approach of using both equation-of-state methods and molecular dynamics modeling in our fluid modeling effort should result in novel methodologies that improve upon current, state-of-the-art techniques, particularly for problematic zones near phase transitions in supercritical CO_2 solutions.

Other work accomplished during this quarter involved the prototyping and refining of a seismic modeling code for predicting time-lapse changes in well-log data (Vp, Vs, and density) during CO_2 injection (see Figure 1). This code will eventually use our fluid modeling methodology developed in Phase I to generate time-lapse changes in seismic traces resulting from CO_2 saturation and pressure changes.

Lastly, we obtained permission to use the Sleipner CO_2 time-lapse data set for this NETL project, and have already requested the data. This industry-standard data set consists of four vintages of 3D seismic data recorded over a shallow saline aquifer during CO_2 injection, and should prove very useful for testing our inversion methods in Phase III.

IV. CONCLUSIONS

In the next quarter, we will complete our analysis of the most promising equation-of-state methods found in the literature, and will use this information to work towards a derivation of the best theoretical approach for modeling oil-water-CO_2 mixtures. This effort, coupled with continued work in molecular dynamics modeling, should result in a novel, accurate, and robust fluid modeling capability that can be used for seismic data modeling in Phase II, as well as for inversion of CO_2 pressure and saturation changes in Phase III.

V. FIGURES

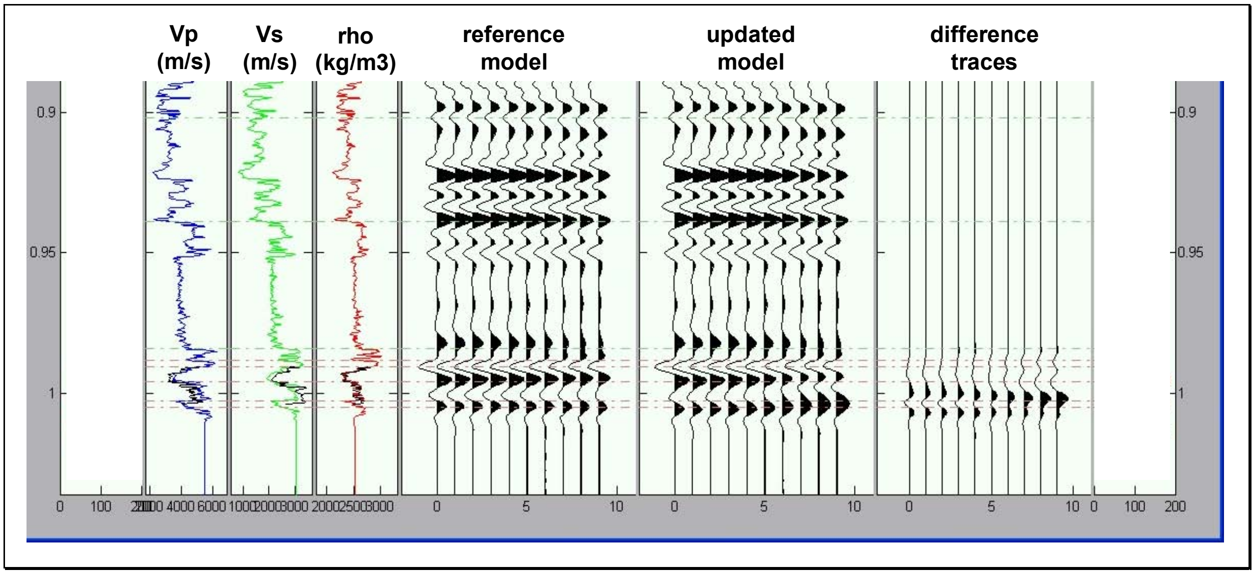

Figure 1 Example of time-lapse seismic modeling of well-log velocities and densities during CO_2 injection.