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The Rosetta Resources CO_2 Storage Project — A WESTCARB Geologic Pilot Test

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ABSTRACT

WESTCARB, one of seven U.S. Department of Energy partnerships, identified (during its Phase I study) over 600 gigatonnes of CO_2 storage capacity in geologic formations located in the Western region. The Western region includes the WESTCARB partnership states of Alaska, Arizona, California, Nevada, Oregon and Washington and the Canadian province of British Columbia. The WESTCARB Phase II study is currently under way, featuring three geologic and two terrestrial CO_2 pilot projects designed to test promising sequestration technologies at sites broadly representative of the region's largest potential carbon sinks. This paper focuses on two of the geologic pilot studies planned for Phase II — referred to collectively as the Rosetta Resources CO_2 Storage Project. The first pilot test will demonstrate injection of CO_2 into a saline formation beneath a depleted gas reservoir. The second test will gather data for assessing CO_2 enhanced gas recovery (EGR) as well as storage in a depleted gas reservoir. The benefit of enhanced oil recovery (EOR) using injected CO_2 to drive or sweep oil from the reservoir toward a production well is well known. EGR involves a similar CO_2 injection process, but has received far less attention. Depleted natural gas reservoirs still contain methane; therefore, CO_2 injection may enhance methane production by reservoir repressurization or pressure maintenance. CO_2 injection into a saline formation, followed by injection into a depleted natural gas reservoir, is currently scheduled to start in October 2006.

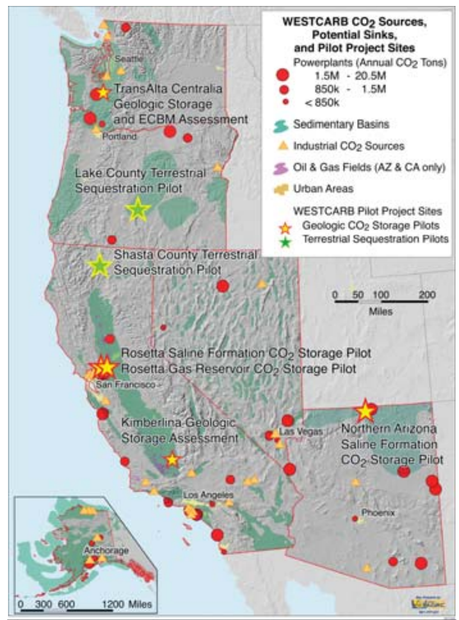

Figure 1. WESTCARB geologic pilot test locations.

PHASE II PROJECT GOALS

The primary goals of the 3-year pilot program include:

• Demonstrate the potential for safe CO_2 storage in depleted gas reservoirs and regionally extensive saline aquifers;

• Study the feasibility of using CO_2 to enhance production of natural gas from depleted gas reservoirs;

• Gain experience and establish procedures for permitting, public outreach, and monitoring and verification in WESTCARB states.

INTRODUCTION

Two of the three geologic pilot studies planned for Phase II will be performed in the Southern Sacramento Valley Region of California (Figure 2) and are collectively referred to as the Rosetta Resources CO_2 Storage Project. Rosetta Resources, Inc. is an oil and gas exploration and production company and a WESTCARB industry partner. Rosetta is the unit operator, leaseholder and partial land owner of the Rio Vista Gas Field, the largest on-shore gas field in California. Since 1936, the Rio Vista Gas Field has produced over 9.3 x 10^{10} m^3 (3.3 Tcf) of natural gas. The formations at Rio Vista are representative of 128 smaller gas-producing fields in California, the cumulative storage capacity of which is estimated at 1.7 Gt. CO_2. A small abandoned gas field located near Rio Vista will be used for the Rosetta pilot tests.

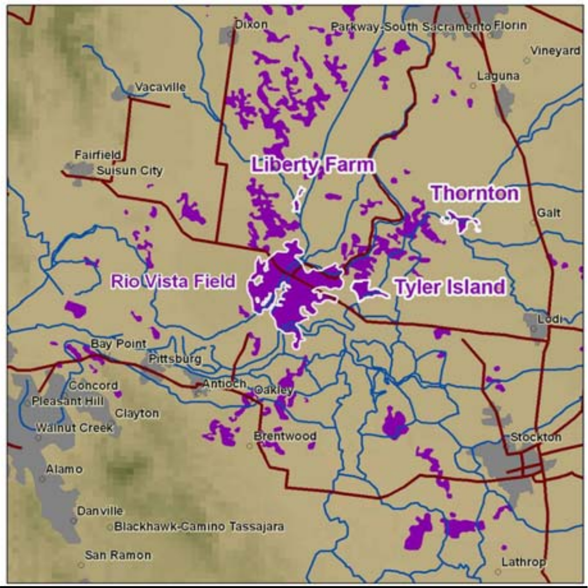

Figure 2. Southern Sacramento Valley California geologic pilot test location.

STACKED RESERVOIR TEST

A novel approach to testing, referred to as a stacked reservoir test, will be performed at the Rosetta Resources CO_2 Storage Project site. The stacked reservoir test consists of two experiments:

McCormick Sand — Saline Formation Pilot Test

The first experiment will involve injecting up to 2000 tons of CO_2 into a brine-filled zone in the McCormick sand, a very fine to medium grained, quartzitic sandstone (Figure 3). Two wells, a CO_2 injector and an observation well, will be installed in a saline zone located beneath the gas trap in the McCormick sand. Our current best estimate for the target depth of the saline test is 1067 to 1098 m (3500 to 3600 ft). Both wells will be drilled to approximately the same depth and the casing will initially be perforated in the saline zone. CO_2 injection will commence after logging and testing the wells.

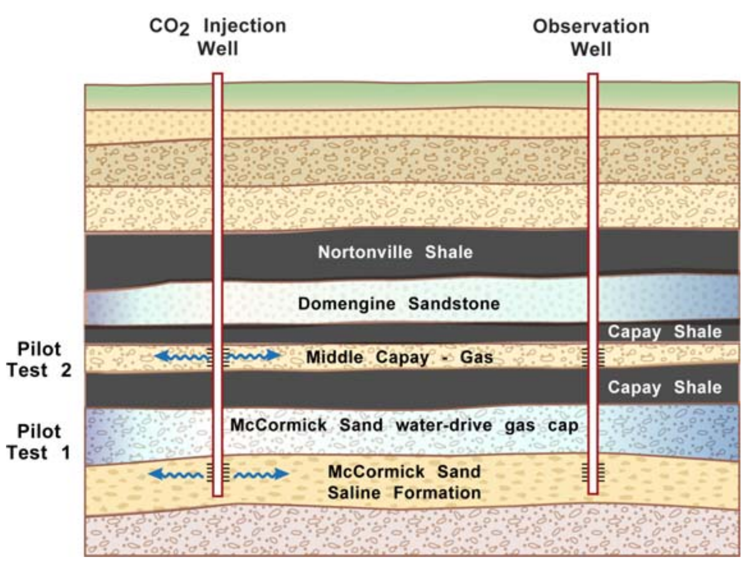

Figure 3. Typical geologic section showing stacked reservoir. Pilot Test #1 is in the lower McCormick sand and Test #2 is in the Middle Capay Shale.

Capay Shale — Gas Reservoir Pilot

The second experiment will involve injecting up to 2000 tons of CO_2 into a depletion-drive, depleted gas reservoir located within the Middle Capay shale at a depth of 928 m (3044 feet). The Capay shale represents a regionally extensive reservoir cap (Figure 3), containing pockets of natural gas in thin interbedded sand lenses. The top of the McCormick sand, a depleted water-drive reservoir at a slightly greater depth of 1003 to 1021 m, is an alternative location for the gas reservoir test if the Capay sand stringer is absent at the location of the new wells. The casing will be perforated in the gas zone after completing the first experiment and cementing the well perforations to shut in the lower saline zone. CO_2 will be purchased from a local supplier and trucked to the site for both pilot tests.

ENHANCED GAS RECOVERY

The second experiment consists of injecting CO_2 into the depleted gas zone to assess the nature and extent of reservoir pressurization and displacement of methane by CO_2. The Rosetta Resources CO_2 Storage Project will be the first field-scale test used to demonstrate CO_2 Storage with Enhanced Gas Recovery (CSEGR). Depleted petroleum reservoirs are especially promising targets for CO_2 storage because of the potential to use CO_2 to extract additional oil or natural gas. The benefit of enhanced oil recovery (EOR) using injected CO_2 to swell and mobilize oil from the reservoir toward a production well is well known. CSEGR involves a similar CO_2 injection process, but relies on sweep and methane displacement and has received far less attention. Depleted natural gas reservoirs are not entirely devoid of methane, therefore, CO_2 injection may enhance methane production by reservoir repressurization or pressure maintenance.

PRELIMINARY RESULTS IN SUPPORT OF TEST DESIGN

Preliminary computer simulations were conducted using TOUGH2/EOS7C in support of the pilot tests at the conceptual design level. The questions addressed at the conceptual design level include the following:

1. How much CO_2 should be injected and at what rate?

2. What are the expected pressure and temperature changes in the reservoir associated with the injection?

3. What kind of monitoring and sampling should be conducted in the observation well?

Using preliminary estimates of homogeneous formation properties (permeability 10^{-12} m^2 and porosity 35%), and boundary and initial conditions, preliminary simulations showed that breakthrough of supercritical CO_2 will occur during the saline test within 10 days at an observation well located 39 m from the injector (Figure 4). Approximately 1800 tonnes of CO_2 injected at a rate of 2 kg/s into the upper-most 4 m of the McCormick Sand is required to produce this result. In contrast, breakthrough of CO_2 gas will occur in the 2-3 m thick Capay Shale gas interval containing methane at the same 39 m distance within a couple of days (Figure 5) using far less CO_2 (1000 tonnes injected at a rate of 1.2 kg/s). Pressure changes caused by injection are small in both cases (<0.3 bars) and temperature effects are minimal.

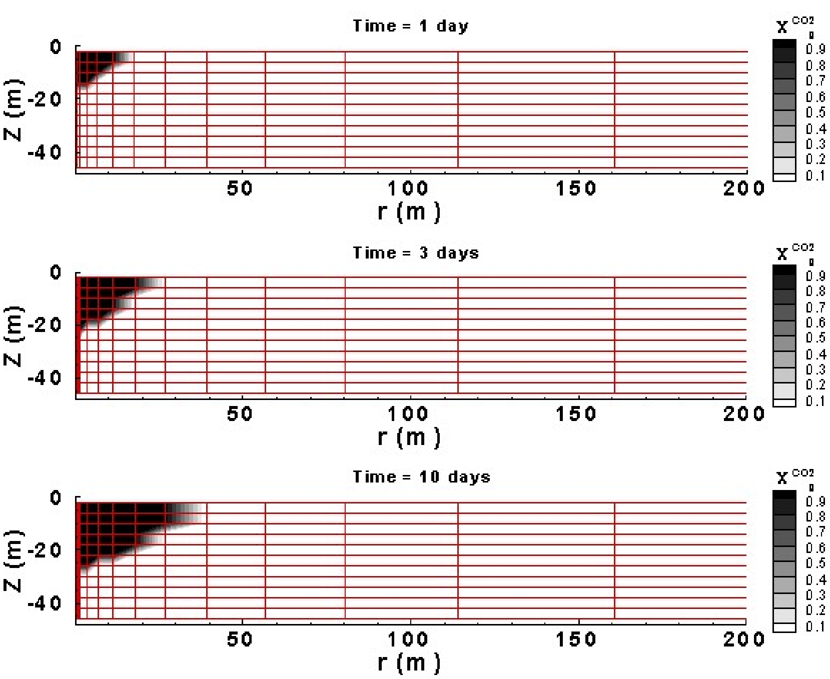

Figure 4. Mass fraction of CO_2 in the gas ($X_g^{CO_2}$) at three times after injection into the upper-most 4 m of the McCormick saline formation at a rate of 2 kg/s, assuming radial symmetry.

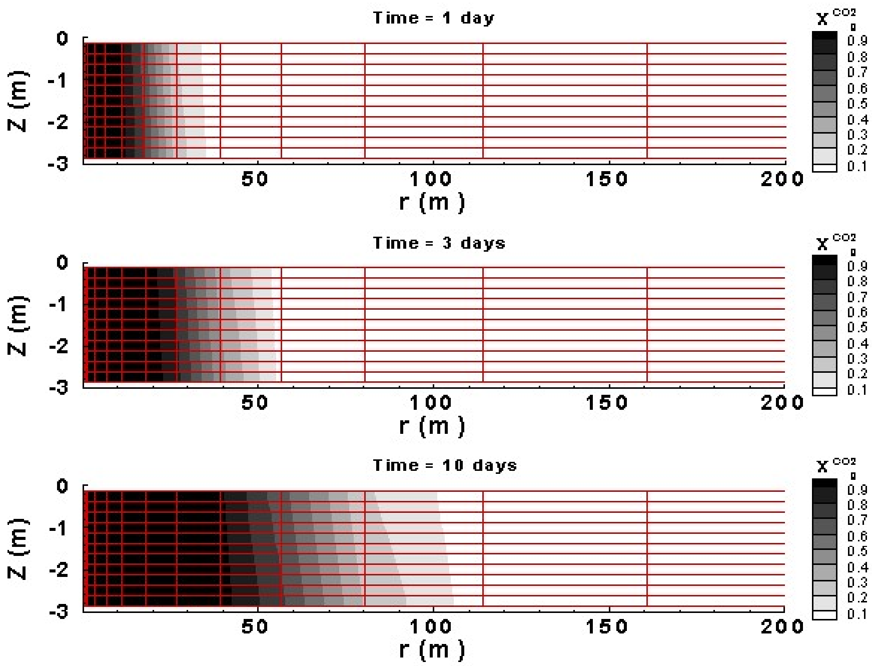

Figure 5. Two-dimensional *r*-*z* results showing CO_2 mass fraction in the gas phase (X_g^{CO2}) at three times after injection into the Capay gas reservoir, assuming radial symmetry.

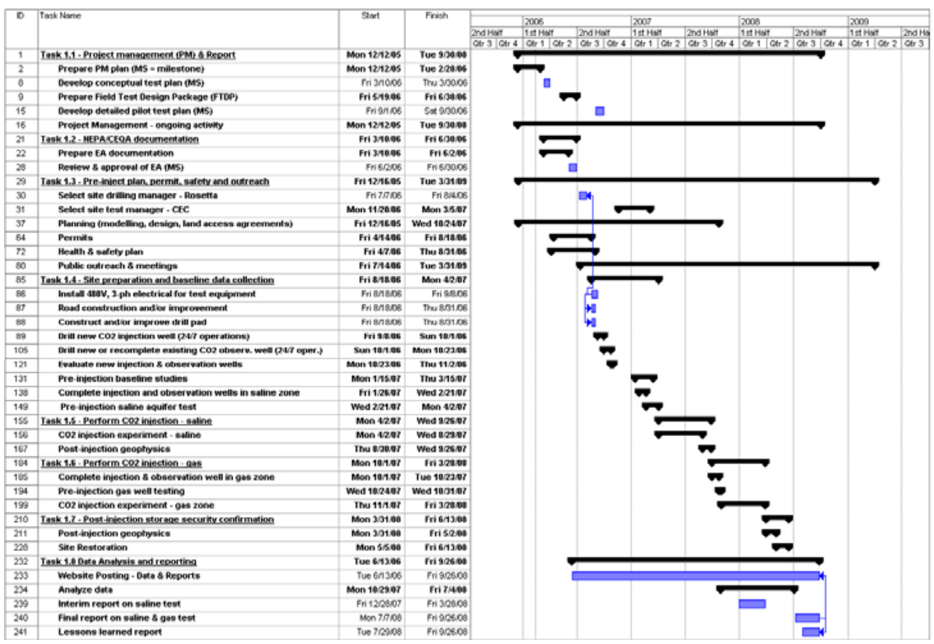

Figure 6. Rosetta Resources CO_2 Storage Project

CONCLUSION

A detailed project management plan and schedule (Figure 7) have been developed describing the proposed pilot Tests and defining the sequence of test activities. Implementation of the field program will begin in August 2006 starting with site preparation activities and well installation. Injection of CO_2 into the saline zone will begin in Spring 2007 and into the gas zone in Fall 2007.

ACKNOWLEDGMENT

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