PROJECT facts

Petroleum Exploration and Production

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U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY
STRATEGIC CENTER FOR NATIONAL GAS AND OIL

RESERVOIR CHARACTERIZATION OF ANTELOPE SHALE AND BELRIDGE DIATOMITE

Analysis of Potential for CO_2 Flooding of Siliceous Shales

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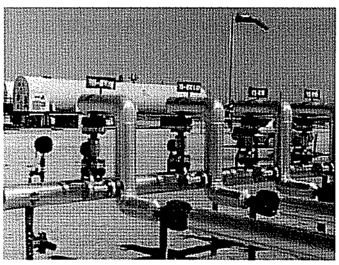
MAIN SITE

Buena Vista Hills Field
Lost Hills Field
Kern County, CA

DE-FC22-95BC14938



CO_2 gauging facilities at Lost Hills field.

Background/Problem

Buena Vista Hills and Lost Hills oil fields in Kern County, California have large volumes of remaining oil in bypassed zones after over forty years of primary and secondary production. The Monterey Formation siliceous shales at the two fields; the Antelope and Brown Shales at Buena Vista Hills and the Belridge Diatomite at Lost Hills pose unique problems for enhanced oil recovery. The Buena Vista Hills reservoir produced 9 million barrels of oil between 1952 and 1995, but this represented only 6.5% of the estimated 130 MMB of the original-oil-in-place. By 1995 production was in decline, and several wells were in danger of abandonment. At Lost Hills field the small pore size, high porosity and low permeability has led to low primary recovery (3-4% OOIP), and after 10 years of waterflooding production is in decline.

Project Description/Accomplishments

The project conducted extensive reservoir characterization to evaluate the potential for CO_2 flooding of the reservoirs. Phase I focused on reservoir characterization of the Antelope and Brown shales, however the results indicated that very low oil saturation at Buena Vista Hills field did make it a viable candidate for CO_2 recovery. Phase II was conducted at Lost Hills field. The application of state-of-the-art reservoir characterization and reservoir management techniques attempted to establish the viability of CO_2 enhanced oil recovery.

The reservoir characterization phase at Buena Vista Hills field produced several firsts. The first coreflood analysis of siliceous shales compiled data from 160 wells into a database. The first high-resolution crosswell reflection images of any oil field in the San Joaquin Valley were made. The project demonstrated the first successful application of the TomoSeis acquisition system in siliceous shales. The study at Buena Vista Hills was the first detailed reservoir characterization of the Brown and Antelope siliceous shales in the San Joaquin Valley. Chevron made numerous Technology Transfer workshops, presentations and publications making knowledge of the siliceous shales available to the public for the first time.

Transfer of the project to Lost Hills Field for Phase II provided the opportunity to conduct and publish a detailed reservoir characterization of the Belridge Diatomite. The Belridge Diatomite has an unusual composition and characteristics. It has high oil saturation (50%) and high porosity (45%-70%), but low permeability (< 1 millidarcy). CO_2 flood production forecasts generated by Chevron's proprietary reservoir simulation software suggested that CO_2 injectivity is two to three times greater than water or steam.

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Reservoir Characterization of Antelope Shale and Belridge Diatomite

Analysis of Potential for CO_2 Flooding of Siliceous Shales

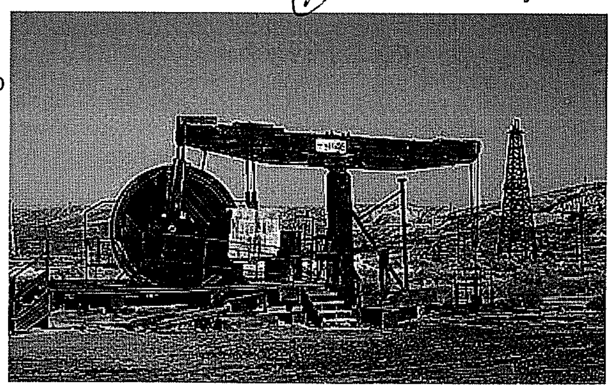
The project evaluated the economic uncertainties for CO_2 flooding of the Belridge Diatomite. Part of the project involved identification and demonstration of several systems to monitor CO_2 flood movement within the reservoir and to image the CO_2 migration. Implementation of the CO_2 flood at Lost Hills field resulted in installation of a four- pattern, 2.5 acre pilot, upgrading facilities, reworking several injection wells and drilling two new injection wells, and construction of CO_2 facilities and lines, and setting up a CO_2 monitoring system. All construction was completed and CO_2 injection began in August 2000. The study evaluated how injection of a very low viscosity gas differed from injection of water into the diatomite in terms of fracture azimuth, injectivity, and areal and vertical sweep.

Over 2½ years a total of 375,113 Mcf of CO_2 was injected into the diatomite. An initial oil response was observed in one well as a result of CO_2 injection. However, sanding problems eventually caused shutting in that well and finally termination of the CO_2 injection pilot. Remedial work on the wells to correct subsidence related casing damage and exhaustive analysis suggested that CO_2 injection played a major role in the sanding problems in the Belridge Diatomite.

Monitoring demonstrated that CO_2 flowed through natural fractures, faults and induced hydraulic fractures, and that neither injection rates nor corrosion were issues for the project. CO_2 injection profiles were able to display lateral and vertical flow.

Benefits/Impacts

Reservoir characterization of the Antelope and Brown shales at Buena Vista Hills field and the Belridge Diatomite at Lost Hills fields added extensively to the knowledge of these formations and understanding of how siliceous shales react to enhanced oil recovery processes. Because the siliceous shales are widespread in the San Joaquin Valley and hold millions of barrels of remaining oil in place publication of the reservoir characterization will assist future projects targeted at enhanced oil recovery from these reservoirs.



Westside Oil Field, Buena Vista Hills, north of Taft, CA

The lessons learned in the demonstration show that CO_2 is capable of increasing oil recovery from diatomite, and that CO_2 is very good at finding the path of lest resistance and by-passing matrix oil.

Although the CO_2 flood was not an economic and technical success, the pilot monitoring and surveillance program at Lost Hills field was a huge success. Technologies for monitoring and imaging CO_2 floods conducted by Lawrence Livermore and Lawrence Berkeley National Laboratories were demonstrated and proved highly effective.

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TOTAL ESTIMATED COST

$9,699,000

COST SHARING

DOE	- $4,849,000
Non-DOE	- $4,850,000

WEBSITE

www.netl.doe.gov