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**ADVANCED RESERVOIR CHARACTERIZATION AND EVALUATION OF CO<sub>2</sub> GRAVITY DRAINAGE IN THE NATURALLY FRACTURED SPRABERRY RESERVOIR**

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**Parker and Parsley Petroleum USA, Inc.,  
303 West Wall  
Suite 101  
Midland, Texas  
79701**

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**Project Officer: Edith Allison, Bartlesville Project Office**

**Project Manager: Paul McDonald, Parker and Parsley Petroleum USA, Inc.**

**Principal Investigator: David Schechter, New Mexico Petroleum Recovery Research Center**

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**Objectives**

The objective of this research and the pilot project planned is to test the feasibility of CO<sub>2</sub> for recovering oil from the naturally fractured Spraberry Trend Area in the Midland Basin. This notoriously marginal reservoir has confounded operators for 40 yrs. with rapid depletion, low recovery during primary, disappointing waterflood results and low ultimate recovery. Yet, the tremendous areal coverage and large amount of remaining oil (up to 10 Bbbl) warrants further investigation to expend all possible process options before large numbers of Spraberry wellbores need to be plugged and abandoned.

CO<sub>2</sub> injection on a continuous, pattern wide basis has not been attempted in the Spraberry Trend. This is due to the obvious existence of a network of naturally occurring fractures. However, it has become clear in recent years that neglecting CO<sub>2</sub> injection as an option in fractured reservoirs [1, 2] may overlook potential projects which may be viable.

The 15 well pilot field demonstration and supporting research will provide the necessary information to quantify the conditions whereby CO<sub>2</sub> flooding would be economic in the Spraberry Trend.

**Summary of Technical Progress**

***In the field***

The E.T. O'Daniel #37, the central production well in the projected 15 well pilot, was spud by Parker and Parsley Petroleum Co. Sept. 27th, 1995. The objective was to core as much of the approximate 250 feet of the Upper Spraberry as possible. A sponge core was taken in one of the main pay zones (5U) while several rotary sidewall cores were retrieved in the other pay zone (1U). Fifteen feet of fluorescing sand were present in the 30 foot sponge barrel. The corresponding sections of sponge were also strongly fluorescent indicating solution gas drive of oil into the sponge as the core was raised to the surface and processed. The core analysis, including distinction between natural and induced fractures, is currently ongoing.

After the final core was recovered, the well was drilled-out and cleaned. Open hole logs, including Schlumberger's FMI log, were run in the Upper Spraberry, both for net pay correlations and fracture identification.

Paleomagnetic orientation was performed on three core samples within the 5U zone to verify orientation

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of logs and cores. Results from the whole cores, paleomagnetic orientation and the FMI log indicate:

1. Orientation of natural and drilling induced fractures from FMI as interpreted by Schlumberger are approximately N85°E as shown in Fig. 1 and 2 respectively.
2. Paleomagnetic orientation verifies the orientation obtained from the FMI.
3. Both natural and drilling induced fractures were oriented approximately N85°E in whole core samples.
4. The FMI log was not able to resolve some of the natural fractures observed in whole core.

It appears the FMI is an excellent tool for resolving fracture orientation yet less effective for one to one correlation of resistivity anomalies and fractures observed in whole core.

A micro-fracture treatment was performed by Halliburton after completion of open-hole logging. From micro-frac data, a large degree of stress anisotropy has been measured. The results of all the core, log and micro-fracture tests are being analyzed and will be available shortly.

Currently, the E.T. O'Daniel#37 has been stimulated and now is being produced. This well will serve as the pulse well in obtaining the local, in-situ fracture orientation prior to final orientation of the pattern.

Plans are now being prepared for a dual lateral horizontal core well in the spring/summer of 96 for the purpose of obtaining fracture density. Once the two pay zones are cored, the laterals will be extended and produced in order to establish the economic feasibility of current horizontal technology in the Spraberry Trend.

### ***In the Lab***

Experiments continue in order to understand transfer mechanisms between fractures and Spraberry matrix. A total of 40 cores from a well taken in preparation for the Class III submittal are being used to study imbibition and capillary pressure behavior. The permeability of the matrix is less than 1 md so the experiments are lengthy. This is exactly the reason that so little data on low permeability imbibition is available in the literature. These studies, over the course of this project, will provide much information on the parameters affecting imbibition in low permeability media, which is characteristic of many fractured reservoirs. Our initial results indicate that Spraberry matrix may not be strongly water-wet which could prove to be an important parameter in assessing waterflood performance.

A 2 foot whole core from the Spraberry Shackelford Unit 1-38A was preserved to test the ability of CO<sub>2</sub> to recover oil from Spraberry sand. The core is flooded with synthetic Spraberry brine and reduced to connate water by injecting Spraberry STO in a Hassler-type cell (all at reservoir temperature). The core is transferred to a gravity drainage cell with a small clearance between the cell wall and the core. The clearance allows free flow of gas through the annular region thus simulating dynamic gas injection into the high permeability fracture system. CO<sub>2</sub> is then injected into the cell and maintained at a pressure near the miscibility pressure as determined by slim tube experiments. CO<sub>2</sub> is continuously circulated through the cell and into a back pressure regulator, and is monitored along with oil production at the outlet.

Other work involves building a well database in order to simulate the pilot. We have approximately 100 well logs, both modern and old, from the Spraberry Trend Area. A 3-D seismic shoot from an area near the pilot and a 2-D seismic shoot over the pilot area have been donated to the project team. The use of seismic to extrapolate interwell heterogeneity and the potential for identifying more intensely fractured areas in the Upper Spraberry is being investigated.

### ***Technology Transfer***

Papers are being presented at the Permian Basin SPE meeting in Midland, March 96 (SPE 35469 and SPE 35224) and the DOE/SPE EOR meeting in Tulsa, April 96 (SPE 35170).

### **References**

- [1] Beliveau, D., Payne, D.A. and Mundry, M.: "Waterflood and CO<sub>2</sub> Flood of the Fractured Midale Field," *JPT* (Sept 1993) 45, 881-887.
- [2] Schechter, D.S., Zhou, D. and Orr, F.M., Jr.: "Low IFT Drainage and Imbibition," *J. Pet. Sci. and Eng* (1994) 11, 283-300.

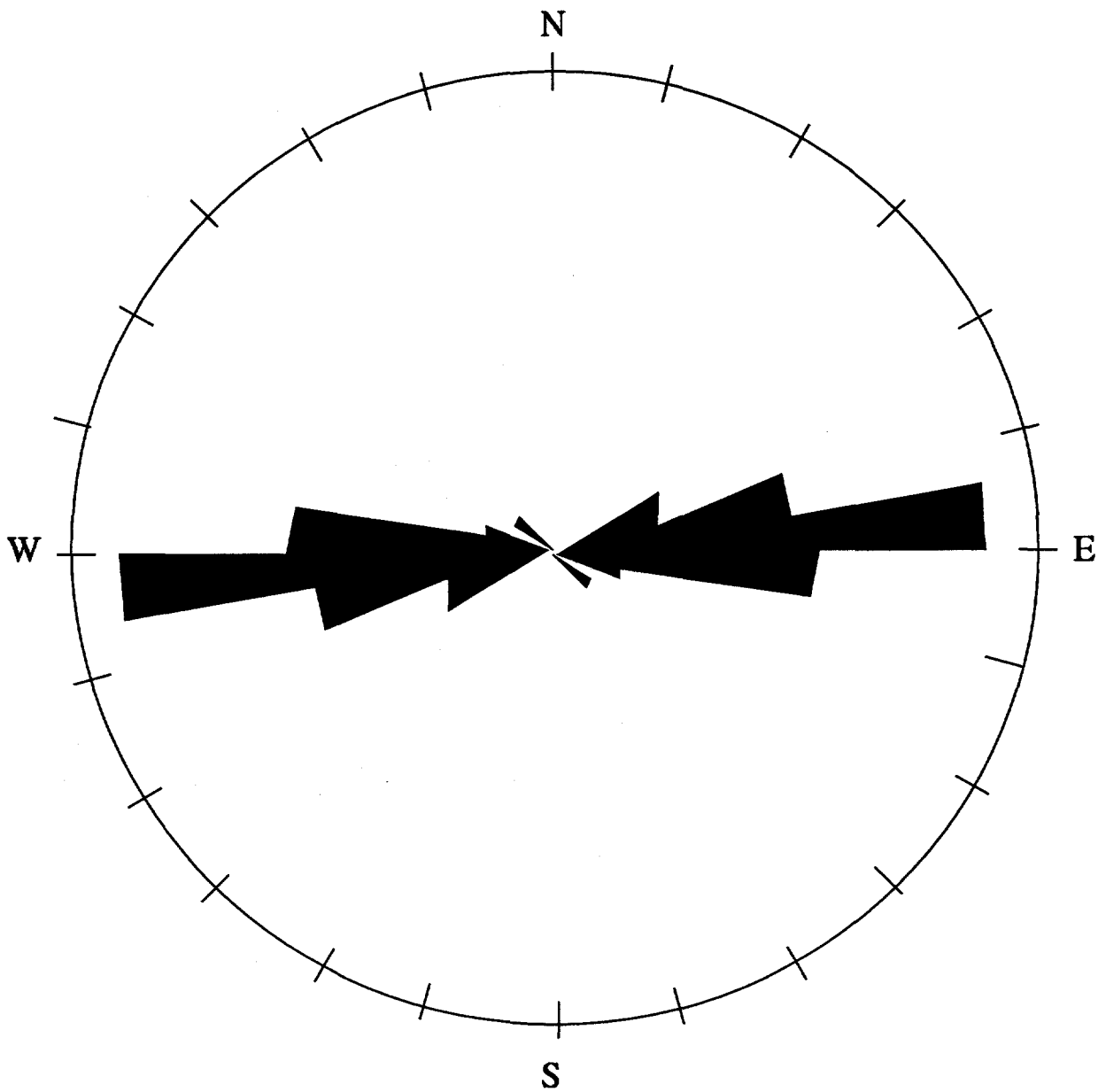


Fig. 1—FMI orientation of 53 drilling induced fractures, E.T. O'Daniel #37.

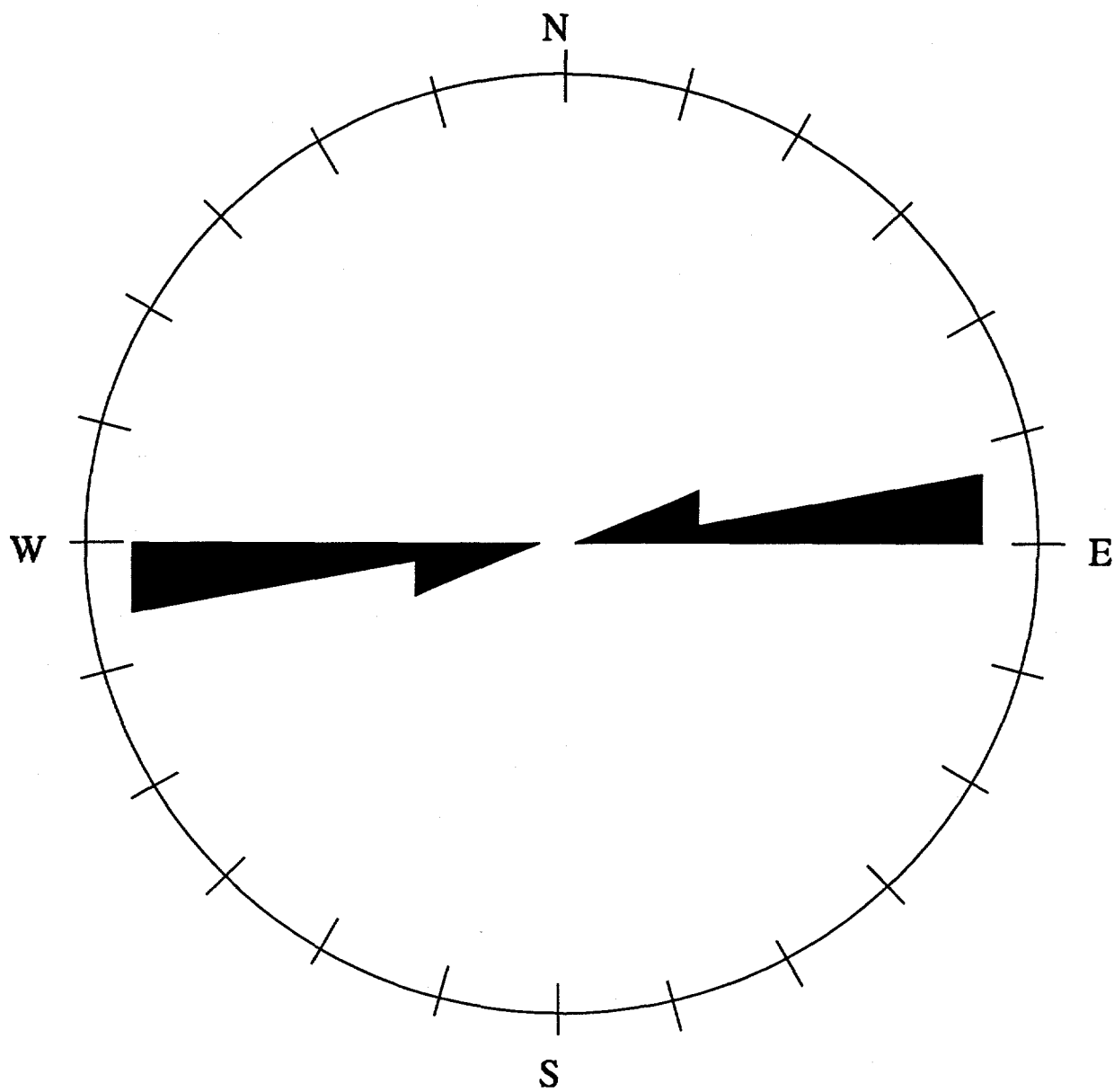


Fig. 2—FMI orientation of 4 natural fractures, E.T. O'Daniel #37.

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