Petroleum Charge Analysis of the Southern San Joaquin Basin, California: Implications for Future Exploration*

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Abstract

Southern San Joaquin Basin petroleum charge was analyzed to evaluate basin prospectivity in areas with low exploration success. Cuttings data were used to map SPI and to calibrate transformation. Petroleum generation was calculated from SPI and transformation maps. Migration was evaluated using structural configuration and stratigraphic focusing. Petroleum charge was then compared to oil-in-place and leakage to determine areas with significant charge, but little discovered petroleum. Generation from Tertiary source rocks is restricted to the Maricopa subbasin, Buttonwillow depocenter, Valley Syncline and Avenal Syncline. All significant petroleum accumulations are located where focused charge from these areas is probable.

Oil generation is Pliocene to Recent, with mostly Pleistocene generation. Tertiary source rocks in the deepest parts of the basin are barely in the gas window. Structural noses shield the east-central part of the basin from most charge and focus this oil towards the Bakersfield nose and Helm Field area. Generation occurs east of these barriers, but structural traps are absent and stratigraphic trapping is rare due to unfavorable orientation of known sandstone pinchouts. Essentially no Tertiary oil was generated in the western disturbed belt, so charge to the western part of the disturbed belt requires an older (Cretaceous?) source rock or a migration pathway from the east destroyed by subsequent deformation. Unassociated thermogenic gas potential is limited to the deepest parts of the basin by thermal maturity. Deep-basin oil potential is limited to fractured reservoirs because deeply buried sandstones have matrix permeability too low for economic oil production rates.
PETROLEUM CHARGE ANALYSIS OF THE SOUTHERN SAN JOAQUIN BASIN, CALIFORNIA: IMPLICATIONS FOR FUTURE EXPLORATION

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ABSTRACT

Approaches to Basin-Scale Exploration Evaluation

A broad exploration framework is used to assess the conditions for charge and a role for exploration evaluation. The process is applied to the southern San Joaquin basin to illustrate the approach.

The process is simplified in two parts: (1) characterize the basin and petroleum systems, and (2) evaluate basin potential for charge. The first part is a straightforward and rapid mapping exercise. The second part can be more sophisticated, using charge analysis models with parameters estimated from the first part.

Approaches to Basin-Scale Exploration Evaluation

1. Characterization of the basin and petroleum systems

1.1. Stratigraphic Framework

- System fill in the basin is represented by a stratigraphic map showing the thickness of different rock units.
- Shale thicknesses are also shown.
- Regional unconformities and fault patterns are illustrated.

1.2. Charge Analysis Methodology

- Charge analysis was performed to evaluate the amount of petroleum generated in an area and the factors controlling efficiency and direction.
- Transformation ratio vs. temperature relationships were calculated.

1.3. Burial History and Transformation Kinetics

- Transformation ratio vs. temperature relationships were calculated for different rock units.
- Transformation map of the basin center was generated.

2. Evaluation of charge potential

2.1. Estimating Transformation

- Transformation was estimated for the basin center, Avenal Syncline, and Point of Mabury.

2.2. Characterization of the basin and petroleum systems

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EVALUATION OF FRONTIER EXPLORATION POTENTIAL

INTRODUCTION

The southern San Joaquin basin has three major exploration frontiers: deeper objectives along the central-basin axis, the northeastern basin flank, and the western fringe of the basin in Antelope and Bakersfield Fields. The central basin axis has major stratigraphic traps, and the northeastern basin flank lacks major stratigraphic traps but has large, late Cenozoic structural elements. Antelope and Bakersfield Fields are potential sources of late Miocene structural elements.

FUTURE DEEP BASIN POTENTIAL

POTENTIAL RESERVOIR DISTRIBUTION

The stratigraphic section of interest is the Early Jurassic San Joaquin Group of the Mesaverde and San Andres formations and the Early Cretaceous of the Laramide group. These formations are commonly named the Lower Jurassic, Late Jurassic, and Cretaceous.

THERMAL MATURATION AND PETROLEUM TYPE

The stratigraphic section of interest is the Lower Jurassic, Late Jurassic, and Cretaceous.

RESERVOIR QUALITY EVOLUTION

The stratigraphic section of interest is the Lower Jurassic, Late Jurassic, and Cretaceous.

CRITERIA FOR SUCCESSFUL EXPLORATION

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FUTURE EAST-SIDE POTENTIAL

Parts of the east side of the southern San Joaquin fields have received sufficient charge for large, economic petroleum accumulations. However, large accumulations have not been discovered on the east side of the field.

TRAP LIMITATIONS

Structural deformation in the Holdenville trend on the opposite of the Holdenville trend, so the most likely trap types are synclinal or listric, and are relatively unfilled at multiple levels of maturity. Model stratigraphic traps are unlikely. Structural marine fans are shows, and no reliable fans have five sealing horizons.

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CHARGE LIMITATIONS

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FUTURE WEST-SIDE POTENTIAL

Most structures in the western basin are either not fully charged, or are charge associated with over-compensation. The charge indicators indicate good charge into structural elements and the Late Jurassic strata are charge indicators.

DISTRIBUTION OF MATURE SOURCE ROCK

Reservoir quality (oil and gas) is present to the west of the field, but the eastern basin is a reasonable charge area.