Development of Kern County’s Rose Oil Field*

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Search and Discovery Article #20316 (2015)**
Posted July 20, 2015

*Adapted from oral presentation given at Pacific Section AAPG, SEG and SEPM Joint Technical Conference, Oxnard, California, May 3-5, 2015
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Abstract

We provide a data-rich update for Kern County's Rose oil field after reviewing the play, reservoir properties and a tiltmeter evaluation of frac propagation, as were documented in a cluster of publications ca. 2003. Our recent synthesis and themed evaluation is drawn from publically accessible online DOGGR data through early 2015. It includes both production information and well histories that include directional surveys, completion information and geologic markers. A “heat map” is presented showing incremental and cumulative production posted over completion intervals and not wellheads. We also present 3-D visualizations showing completion intervals. Decline curves are presented. A discussion of trends in completion and frac programs is presented. The Rose oil field is an unconventional play discovered in 2000. It was indicated by seismic modeling and drill data extrapolated from the nearby North Shafter field. The play is a burial-induced permeability increase attributed to the diagenetic transformation of opal-CT to quartz diatomite within the McLure shale member of the Monterey Formation. The field is structurally simple; the McLure dips gently SW in an apparently unfaulted homocline. The play was confirmed in mid-2000 when EOG Resources recompleted, fraced and flow-tested the Tulare 25-1 in the McLure, previously untested in the area. Shortly after, EOG spudded the discovery well Goodshow 1H to confirm commercial production from the McLure and establish the pattern for developing the field. Rose production wells are vertical drills to approximately 7500 ft TVD, builds of ~86 degrees or ~94 degrees and laterals of ~2500 to ~5500 ft length toward the NNE or SSW. Rose field has a cumulative production >4 Mbbl BOE. Current production is from ~52 wells with a GOR of ~430 cf/stb and watercut of ~70%. Completion of production wells is as follows: ~20 wells in 2000-2003, ~3 wells in 2004-2006, none in 2007-2010 and ~22 in 2011-2014. Produced water is injected at depths of ~2500 to 6000 ft into the Etchegoin and San Joaquin Formations. There are ~15 open permits for new wells of all types within or associated with the field.

References Cited

Development of Kern County’s Rose Oil Field

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Presented to PSA-AAPG, May, 2015, Oxnard, CA
Overview – Rose field

• Field discovered in 2000, all production has been from hydraulically fractured horizontal completions
• Central Kern County: monotonous, SSW – dipping homocline
• Diagenetic play (opal-CT to quartz) within McLure (Monterey Fm) shale
• Play identified by reprocessed seismic & extrapolated along-trend from drill success ~6 mi SSE in North Shafter field
• Target ~ 30 feet vertical thickness
• Typical completion ~ 3500 ft long
Rose field was presented by EOG Resources team in 2003 publications:

- Two SPE papers
- > 4 conference & meeting presentations
- Topics addressed:
  - The play
  - Drilling & completion including hydraulic fracturing
  - Reservoir characteristics
  - First 3 years production.
  - Microseismic evaluation of hydraulic fracturing
<table>
<thead>
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<th>Property</th>
<th>Value</th>
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<td>RES. PRESSURE</td>
<td>6200-6300 PSI</td>
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<tr>
<td>RES. TEMP</td>
<td>190-195 F</td>
</tr>
<tr>
<td>RES. THICKNESS</td>
<td>20-40 FT</td>
</tr>
<tr>
<td>PERM</td>
<td>0.04-0.06 mD</td>
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<tr>
<td>POROSITY</td>
<td>0.3</td>
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<td>INITIAL WATER SAT.</td>
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<tr>
<td>OIL COMPRESSIBILITY</td>
<td>7.8 E-06 PSI⁻¹</td>
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<tr>
<td>OIL VISCOSISTY</td>
<td>2.8 cP</td>
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<tr>
<td>BHP LIMIT</td>
<td>3360-3800 PSI</td>
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*Source: Ganong, et al, 2003 (SPE paper 83501)*
Ownership & Overall Production

- Entire field operated by EOG until transfer to Oxy (a.k.a. Vintage, California Resources Corporation) (October 2009)
- Placed on artificial lift by Oxy (early 2010)
- ~58 wells drilled through spring 2014
- 4.5m BBL total production through end-2014
Production & injection wells from DOGGR’s Well Finder Web Mapping Application

Feb 2015:
• 37 wells producing oil
• 7 wells injecting produced water

Active & Permitted Wells April 20, 2015:
• 65 “active status” oil & gas wells
• 14 “active status” water disposal wells
## Annual oil, natural gas, and water production

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<td>435</td>
<td>74.8%</td>
<td>1,680</td>
<td>6,439</td>
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Monthly production vs production well count
(March 2000 - December 2014)

EOG to Oxy (10/2009)
Oil Production – Decline Curve Analysis

Decline curve analysis
(20-50 Month vs. 63-135 Month)

Production decline equations (Arps):
- Exponential decline: \( q = q_i \exp (-D \cdot t) \)
- Hyperbolic decline: \( q = q_i (1+bD \cdot t)^{-1/b} \)
- Harmonic decline: \( q = q_i (1+D \cdot t)^{-1} \)
7.4% decline rate during 20-50 month time period
Oil Production – Decline Curve Analysis

1.6% decline rate during 63-135 month time period
Oil Production – Estimated Ultimate Recovery (EUR) Forecast for 10 years

- Cumulative Production - Harmonic
- Cumulative Production - Exponential
- Actual Production

(3.6 % decline rate)

Production (Bbl) vs. Time (months)

- 1.3 Million Bbls
- 2.3 Million Bbls
Wellbore surface traces

Directional data from 52 wells:
- EOG Resources – 30 wells
- Vintage – 22 wells
3D image of horizontal completion intervals
3D image of geologic markers
Initial Production Rates – Chart and Map

(20-50 Month vs. 63-135 Month)
References

- Publicly – available DOGGR data:
  - Well Finder http://www.conservation.ca.gov/dog/Pages/Wellfinder.aspx
  - Online Production & Injection data http://opi.consrv.ca.gov/opi/opi.dll

- Public – domain publications of others:
  - Grau, A. Sterling, R., and Kidney, R., 2003 AAPG, Search and Discovery Article #20012, adapted for online presentation from poster presentation at AAPG annual convention, May 2003, Salt Lake City, UT.
  - Kydney, R., Arestad, J., Grau, A. and Sterling, R., 2003 AAPG, Search and Discovery Article #20011, from oral presentation to AAPG annual convention, May 2003, Salt Lake City, UT.
Acknowledgements -
We thank the following organizations & persons for encouragement, support, review & suggestions:

State of California:
- Department of Conservation
- Division of Oil, Gas and Geothermal Resources:
  - State Oil and Gas Supervisor Steve Bohlen
  - District Deputy Bruce Hesson
  - Program Development Manager Marilu Habel
  - Associate Oil & Gas Engineer Aaron Stewart

California Resources Corporation
Jessica Stibor
Matt Stikes
our wives