2nd Biennial CO2 for EOR
CO2 Conformance Controls

Chevron
Human Energy®

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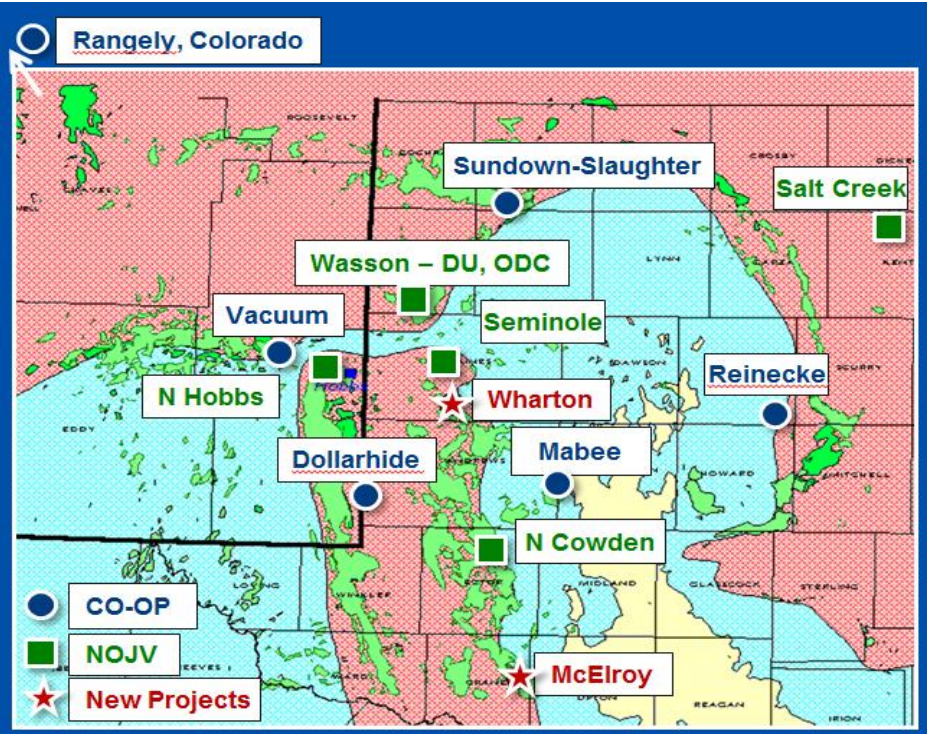
Chevron Energy Solutions

Significant operations & the longest history in the industry with large-scale CO_2 miscible EOR projects



- Chevron installed the first large-scale CO_2 miscible EOR flood in the Permian basin at the SACROC project in 1973 & has had continuous, significant CO_2 flood operations from 1973 to present.
- Chevron presently operates 6 floods, 5 in the Permian basin, 1 in Colorado & has interests in 5 floods operated by others.
- Chevron operates large-scale recycle compression & natural gas liquids recovery plants to support these projects.
- We consider CO_2 miscible EOR project design & execution a core competency & dedicate significant resources to maintain & enhance these capabilities.

We design & operate large-scale CO_2 floods in a variety of reservoir settings with a wide range of fluid properties & reservoir conditions

	Reinecke	Mabee	Sundown Slaughter	Vacuum	Dollarhide	Rangely
Depth (feet)	6,700	4,700	4,920	4,600	7,800	6,400
Lithology	Limestone/ Dolomite	Dolomite	Dolomite	Dolomite	Chert	Sandstone
Average Permeability (md)	170	4	5	22	17	8
Average Porosity (%)	10.4	9.1	12	12	13.5	12
API Gravity (degrees)	44	31	31	38	40	34
MMP (psi)	1,800	1,250	1,200	1,350	1,720	2,750
OOIP (MMBO)	180	430	429	470	146	2,200
Year Started	1995	1992	1994	1995	1985	1986
Total Fluid Production (STBPD)	6,500	45,500	56,900	67,000	10,600	238,000
Gas Injection (MMCFPD)	52	25	74	71	38	200
Water Injection (STBPD)	14,000	48,000	60,000	44,000	8,000	146

Key Elements of design and operation

CO2 Flood Execution

- Effective reservoir management is critical for economic success
- Flood strategies are field-specific
  - Manage reservoir pressure within a narrow window
  - Maximize recovery while minimizing CO2 utilization
- Flood Strategy
  - Initial optimization is done in the design phase
  - Most optimization is normally done during project execution
- Effective optimization is technically very challenging

MidContinent CO_2 Floods

- 4 WAG Floods
  - Rangely
  - Vacuum
  - Slaughter
  - Mabee
- 2 Continuous CO_2 Injection
  - Dollarhide
  - Reinecke

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SPE-175049
A New Perspective on Applying a Conformance Lookback Analysis for the Central Permian Basin Fields

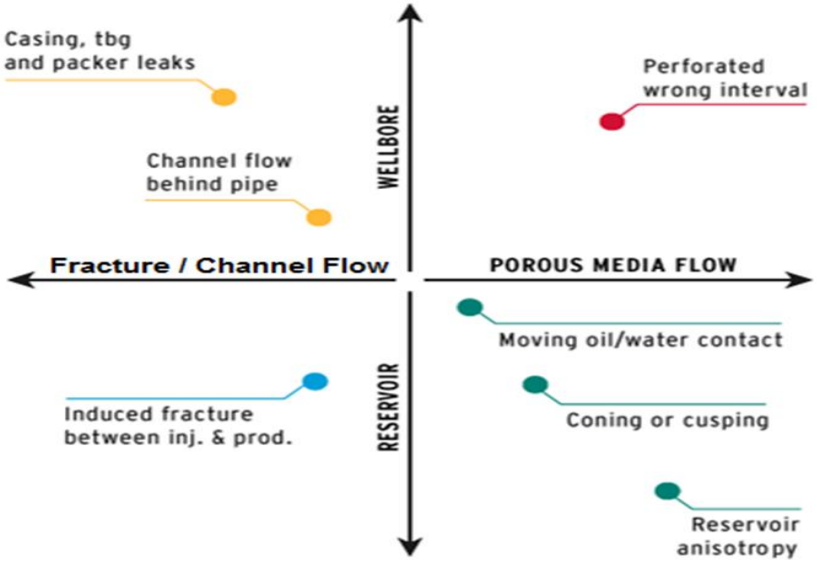
Carmen Hinds

Co Authors: Morteza Sayarpour & Adnan Hameed

- Chevron Corporation

Conformance and Associated Problems

Conformance: Non-uniform processing or any severe deviation from uniform volumetric sweep or depletion in a reservoir - areal or/and vertical



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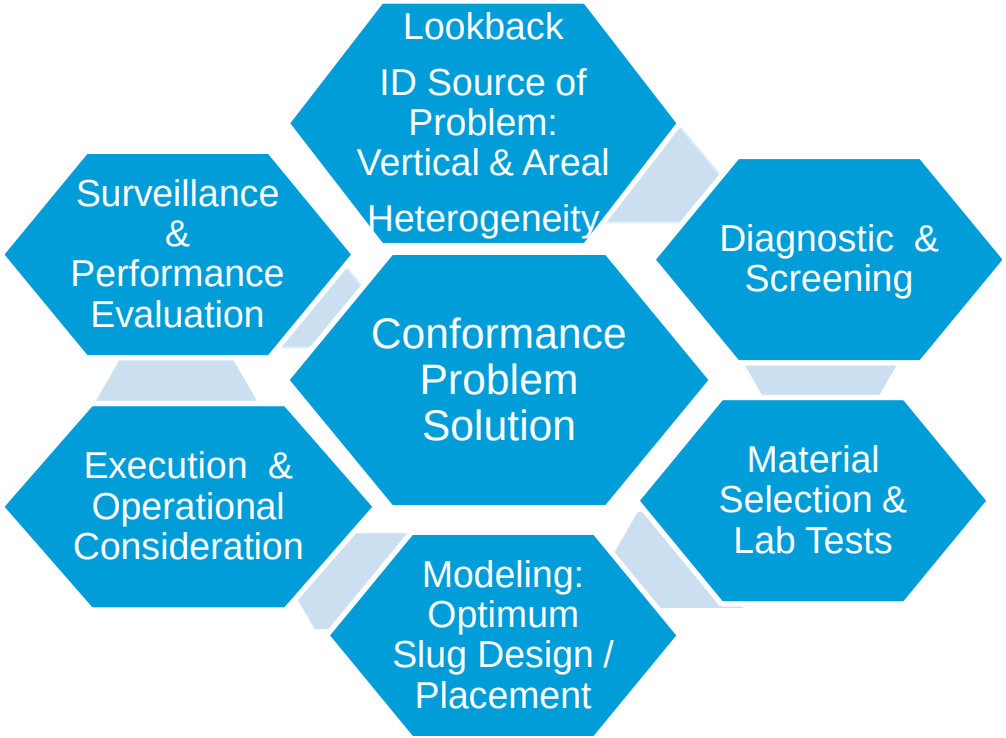
Why does It Matter to Us?

- Main cause of poor volumetric sweep efficiency
- 1/3 of OOIP not recovered due to conformance problems (Sydansk and Romero-Zeron, 2011)
- Even post tertiary recovery 35-65% of OOIP won't be contacted by injected fluid and remains unswept (DOE 2012 report)
- A successful conformance improvement program can add 8-20% incremental recovery

Conformance Workflow



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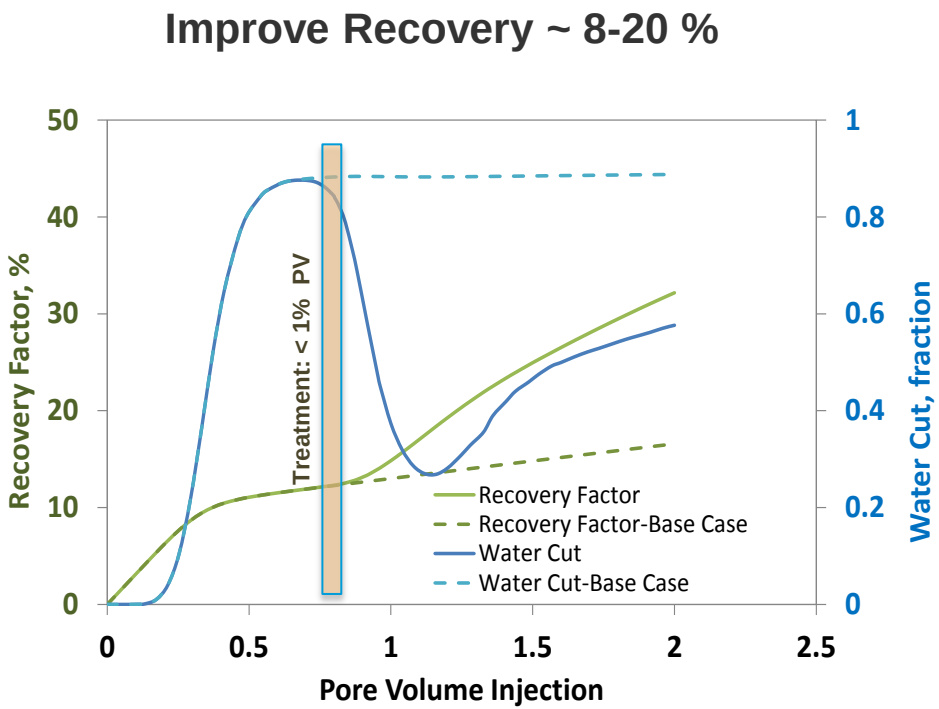
Conceptual Conformance Improvement Recovery



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Lookback Goals

- Identify any deviation from normalized baseline performance
  - Increase in normalized pattern oil production rate or oil-cut
  - Decrease in water or gas (CO_2) production,
  - Reduction of the decline rate
- Assess different types of conformance agents used and/or types of wells treated, treatment volumes and reservoir characteristic, etc.

How Could We Improve the Sweep Efficiency

- Improve reservoir management practices
- Historical effectiveness of conformance implementations
    - Review of 120 performed conformance jobs.
- Understanding of current conformance issues
- Execution!!!

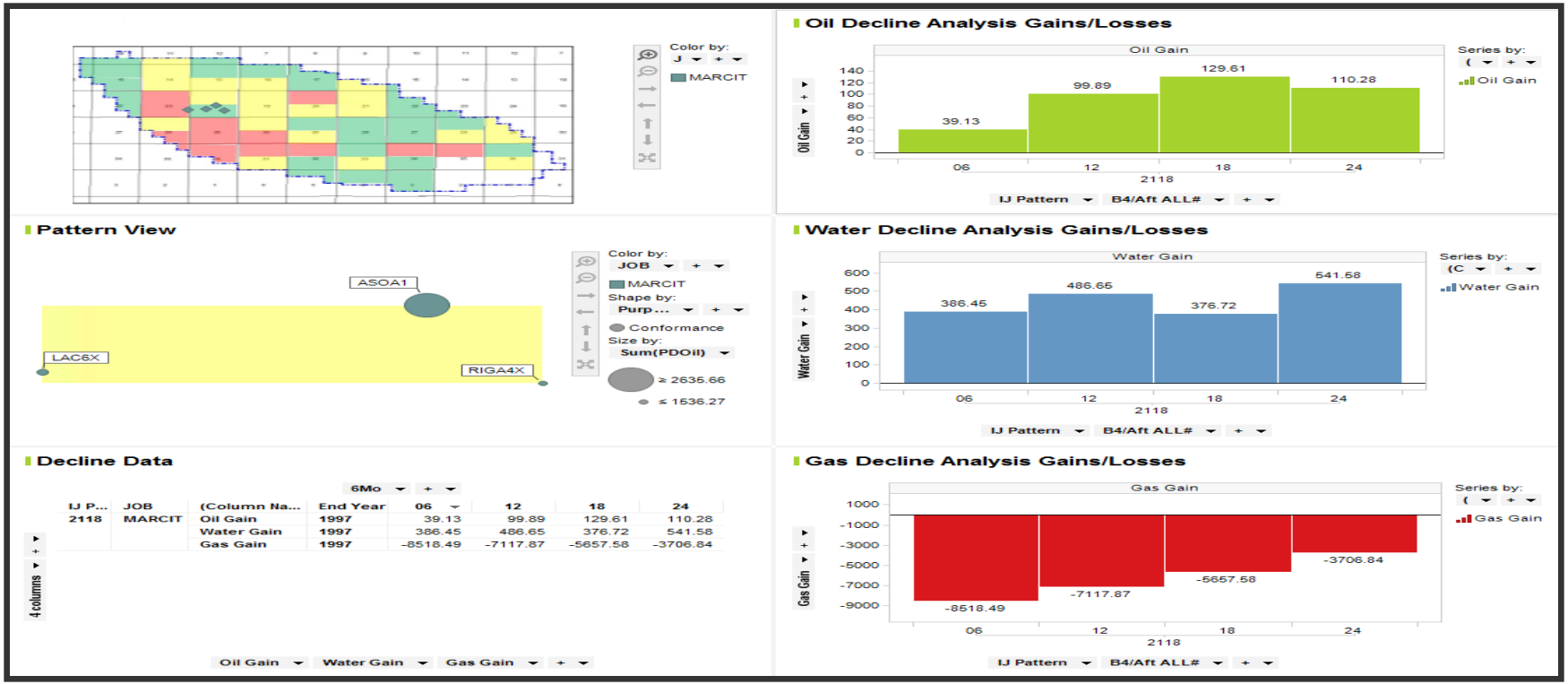
Approach

- Establishing an unbiased procedure was the key to achieve an objective estimate of the success or failure of performed conformance control workovers.
- Baseline procedure was created and utilized to review well/pattern level.
- Lookback dashboard in Spotfire was designed and utilized for analysis.

Performance Evaluation

- A total of 30 months (split in five 6-months intervals) production history was considered for analysis of all conformance control jobs.
- Performance of 6-months before the conformance job was used as baseline keeping a constant fluid-to-oil ratio
- Quantitative analysis was performed by normalized production and baseline decline rate to calculate incremental gains or losses after a conformance job.

Objective Approach



Pattern Results – Success Scenarios

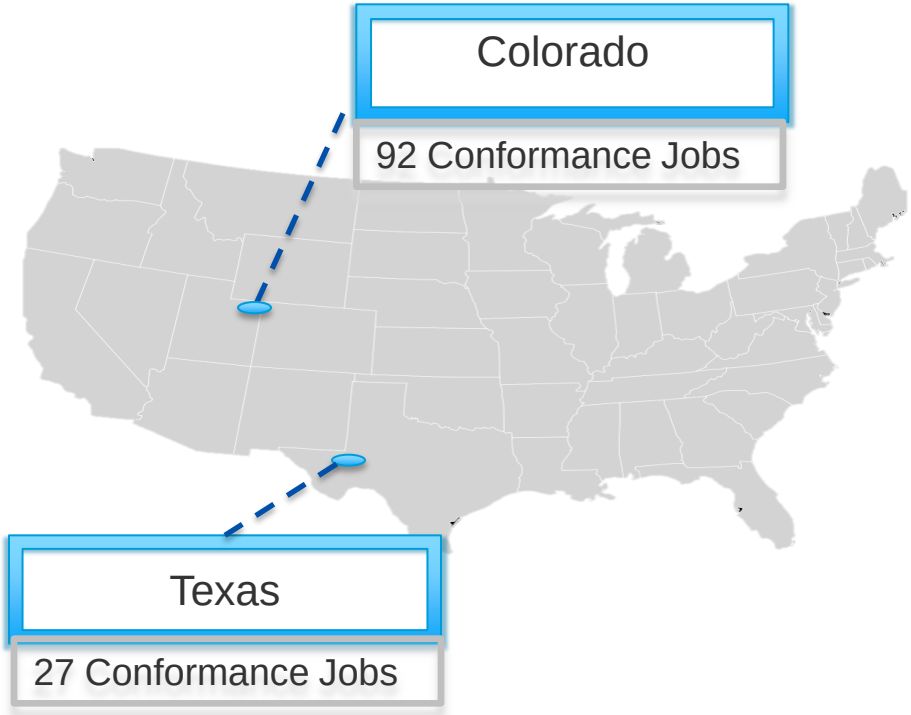
Overview of Fields

Clastic Field:

- ~2 billion bbls OOIP
- Produced ~ 800 MMBBLS, 12 MMBBLS NGL's. Over 1 BB left in place after WF
- Tertiary Recovery

Carbonate Field:

- Produced over 460 MMSTBO
- waterflood started in 1960
- RF ~26% of an OOIP of 1.8 BSTBO
- Secondary Recovery



Summary Distribution of Previous Conformance Jobs

Most of the jobs were Marcit type gel average job size ranges from 8,000 to 14,000 bbls of gel (5,000 ppm)

Clastic Reservoir

- Total of 92 conformance control jobs performed (1994- 1999).
  - 88 treated injectors
  - 4 treated producers

Carbonate Reservoir

- Total of 28 conformance control jobs with data available for analysis was performed 1980 – 2013. All jobs done on injectors.
- Reviews were done based on reservoir geological properties – High Quality Area and Low Pressure Area

Field Challenges

Clastic Reservoir

- Several separate sands each with its own geological characteristics
- Natural fractures that act as thief zones due to directional trends
- Breakthrough occurs in two weeks

Carbonates Reservoirs

- Lack of zonal separation
- Highly interconnected fractures and vugs
- Breakthrough occurs within days

Many open-hole completions & deteriorating wellbores

Conclusions

- Clastic and Carbonate reservoirs used the same Gel technology, (MARCIT gel) to block fractured and high-permeability flow paths.
- Utilizing unbiased workflow to evaluate past conformance work in both fields resulted in clear indications that MARCIT gel is more successful in fractured reservoirs.
- The analysis provides a deep insight on the importance of an integrated approach that requires standardized matching of technology to the right problem
- Geology and treatment selection plays a crucial part in explaining why some conformance jobs are more successful in certain parts of fields.

Acknowledgements

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