

# **PS New Chemical EOR Process for Bakken Shale\***

**Patrick Shuler<sup>1</sup>**

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<sup>1</sup>ChemEOR, Inc., Covina, CA ([patrick.shuler@chemeor.com](mailto:patrick.shuler@chemeor.com))

## **Abstract**

There is a new chemical EOR process available for the Bakken Shale. In this concept a custom surfactant agent may be incorporated into standard hydraulic fracturing treatments in these rock units to increase oil recovery. These are from the Late Devonian to Early Mississippian age occupying about 200,000 square miles (520,000 km<sup>2</sup>) of the subsurface of the Williston Basin, covering parts of Montana, North Dakota, and Saskatchewan. The rock formation consists of three members: lower shale, middle dolomite, and upper shale. The shales were deposited in relatively deep marine conditions, and the dolomite was deposited as a coastal carbonate during a time of shallower water. The middle dolomite member is the principal oil reservoir, roughly two miles (3.2 km) below the surface. Both the upper and lower shale members are organic-rich marine shale.

There are significant reservoirs of oil in the Bakken Shale. An April, 2008, USGS report estimated the amount of technically recoverable oil in the Bakken Formation at 3.0 to 4.3 billion barrels. Production from the Bakken has been limited in the past, but now has become a very active area of development with the widespread advent of drilling horizontal wells and large-scale hydraulic fracturing treatments. A key to the economic production rates of oil from these formations is to have an intense, well connected fracture system.

Laboratory experiments demonstrate that specialized surfactant formulations may be created that will interact with this mixed- to oil-wet low permeability formation to produce more oil. Specifically, including such a surfactant chemical formulation in an aqueous phase (e.g., hydraulic fracturing fluids) will promote the spontaneous imbibition of this fluid into the tight matrix containing high oil saturation. This promotes expulsion of oil otherwise trapped in place to appear in the fracture system and then be produced into the wellbore. Thus, including this surfactant agent in fracture fluids or in other aqueous-based well treatment fluids will produce additional oil.



# SURFACTANT ENHANCED OIL RECOVERY PROCESS FOR BAKKEN FORMATION

## HUGE UNTAPPED OIL RESOURCE IN BAKKEN FORMATION RESERVOIRS

### Bakken Formation Huge Oil Resource

- Location - North Dakota, Montana, Saskatchewan
- Estimate USGS (2008) 3.0 – 4.3 BBbls recoverable oil
- Recovery factor only about 1% OOIP!!

**AGE:** Late Devonian to Early Mississippi

**THICKNESS:** Up to 40 m

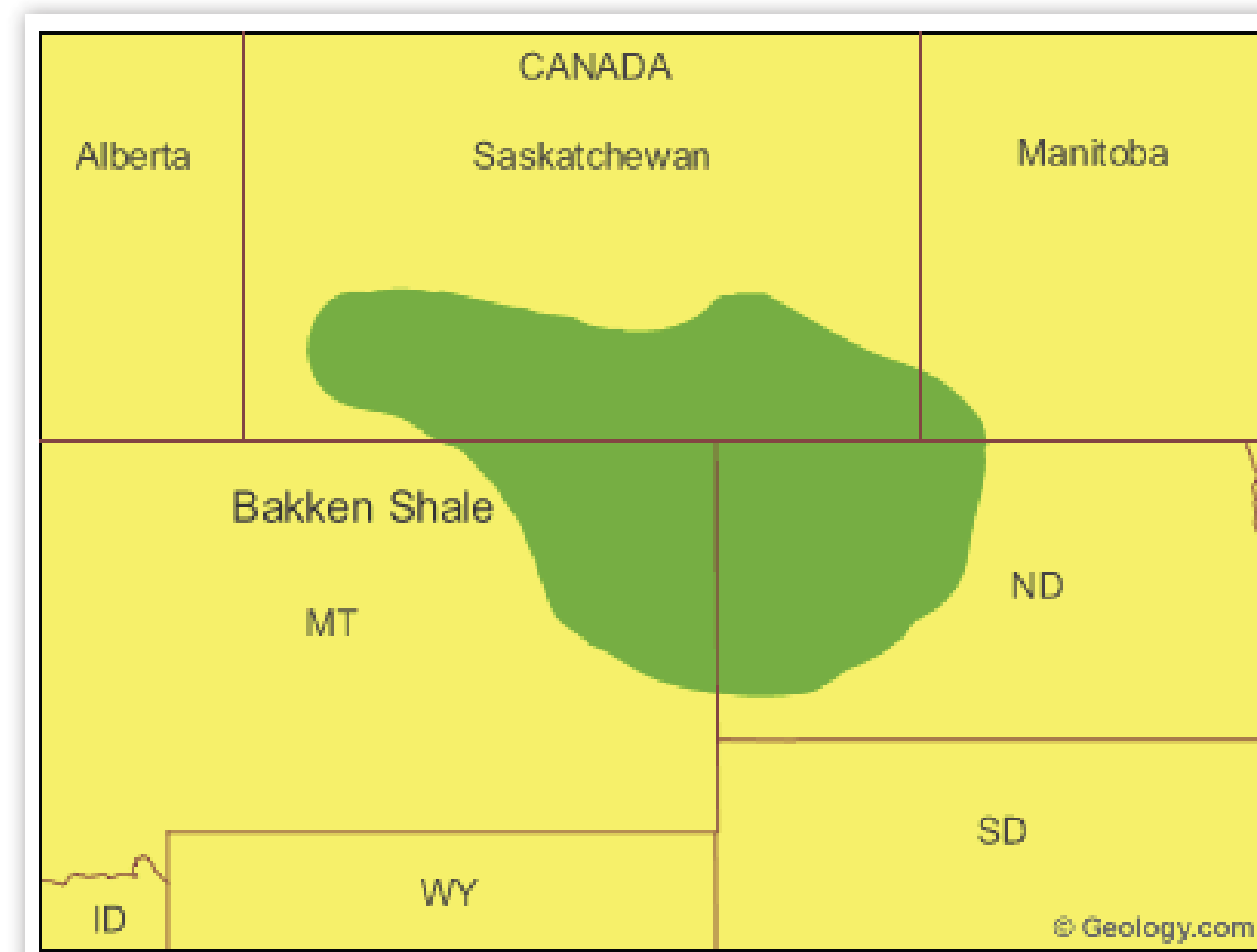
**3 MEMBERS:** Upper shale, Middle dolostone (main oil reservoir), Lower shale

**LITHOLOGY:** Shale, Dolomite, Sandstone, Siltstone

**POROSITY:** Typical 5%

**PERMEABILITY:** Typical 0.05 md

**OIL:** Typical API 42; 0.4 cp



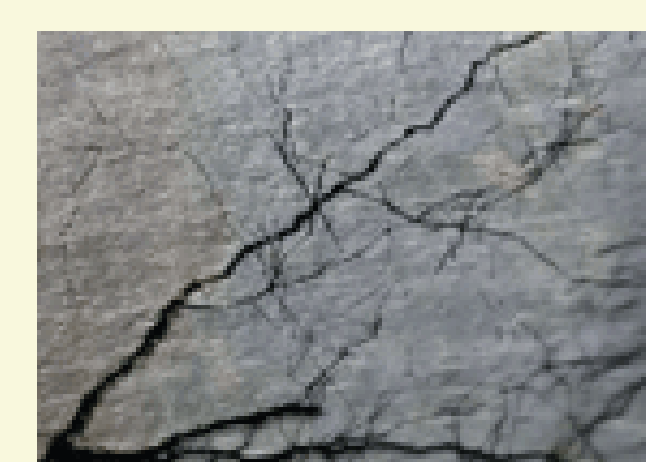
### Low Oil Recovery Factor - Low Matrix Perm

#### RESOURCE DEVELOPMENT:

- 1953 - 1987 vertical wells
- 1987 - 2000 horizontal wells
- 2000 - current massive hydraulic fracturing; higher rates; oil recovery still 1%

Intensive man-made and natural fracture systems and oil drainage from the tight matrix are key to higher oil recovery.

**A NEW TECHNOLOGY INCREASES  
OIL RECOVERY FROM THE MATRIX**



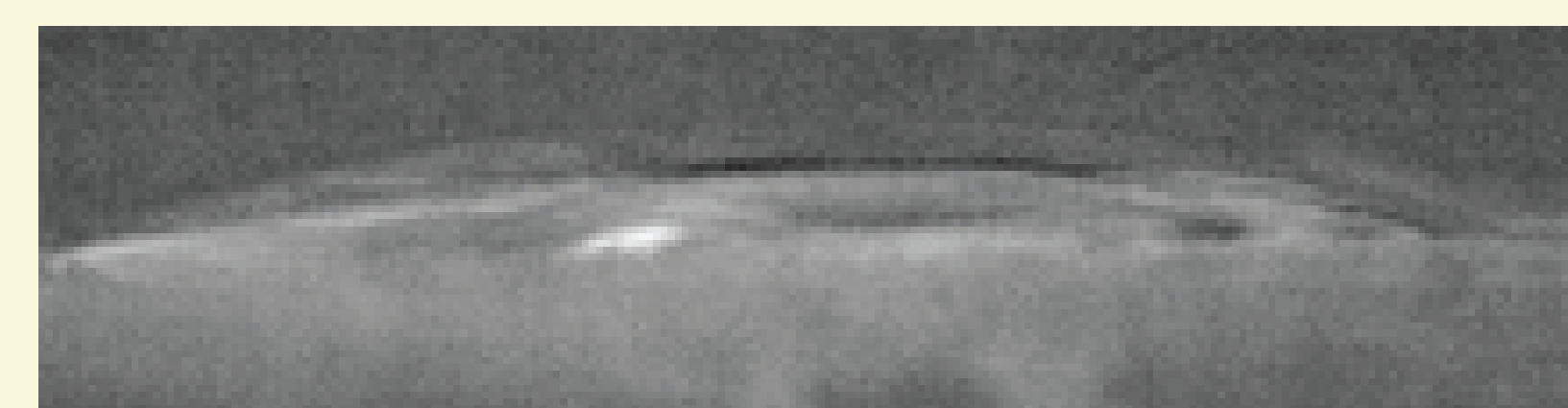
## CRS (CARBONATE RESERVOIR SURFACTANT) - PENETRATES MATRIX

### Crude Oils Mixed or Oil-Wet in Carbonates



Water alone does not wet a carbonate surface treated with Bakken crude

### CRS Aqueous Solution Now Water-Wetting



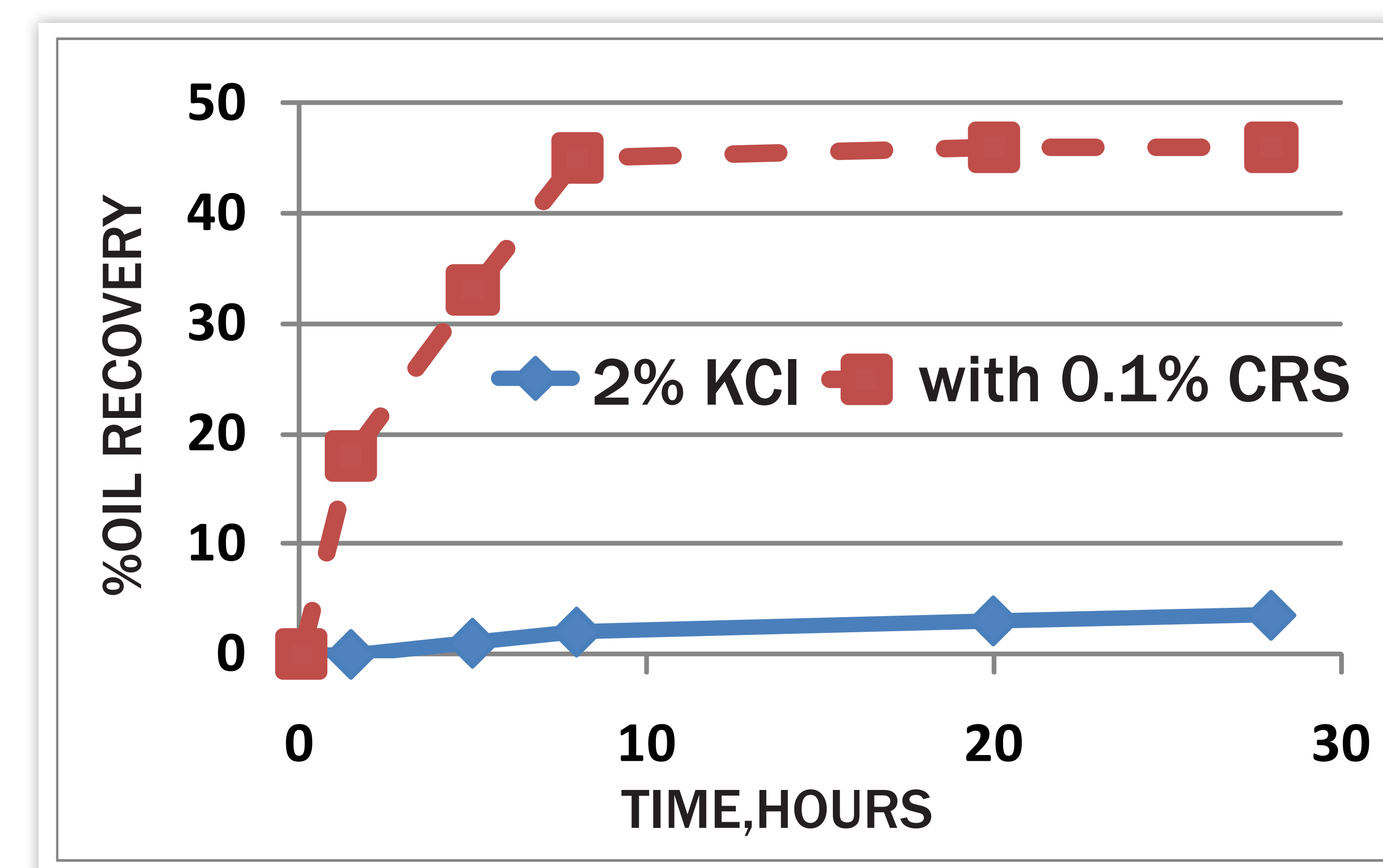
Water with CRS - surface now is water-wet

### Implication » CRS Will Penetrate into Matrix

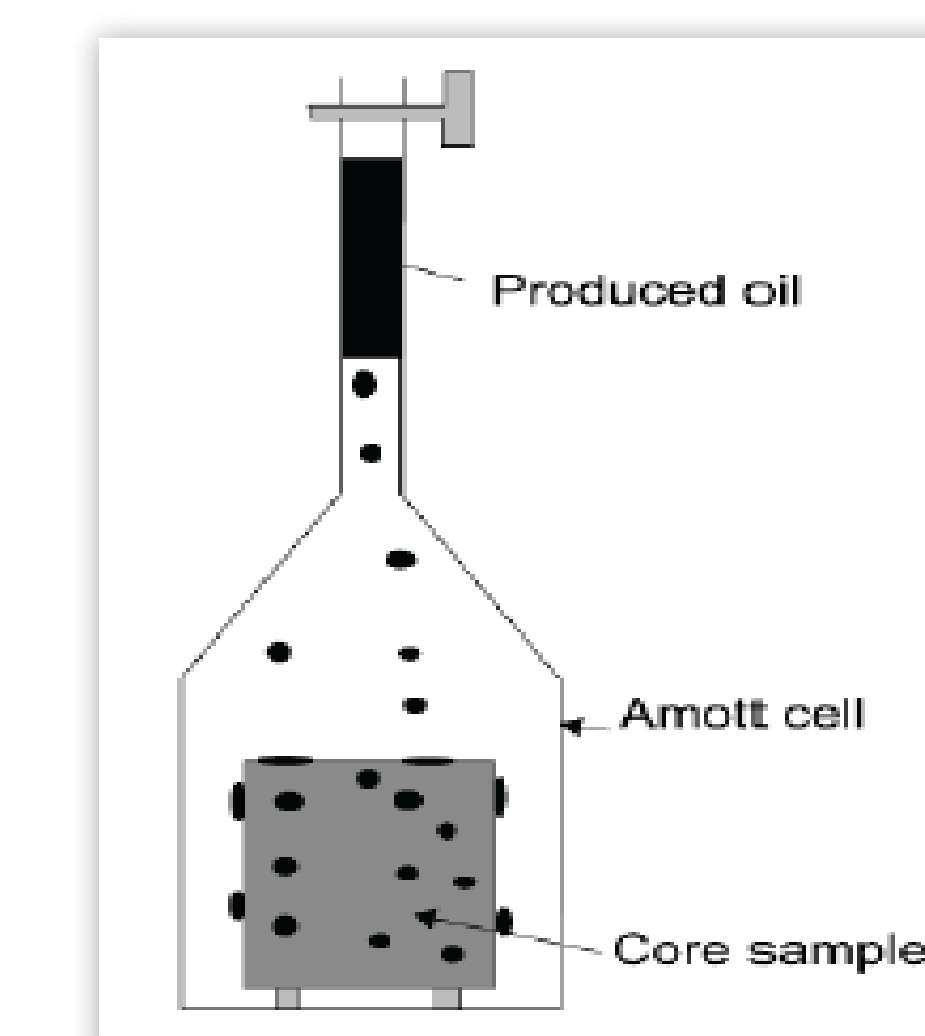
- CRS solution promotes spontaneous imbibition of aqueous phase into oil-rich matrix
- This action will force oil from matrix to fractures
- Oil travels to fracture system and is produced

## CRS - INCREASE OIL RECOVERY

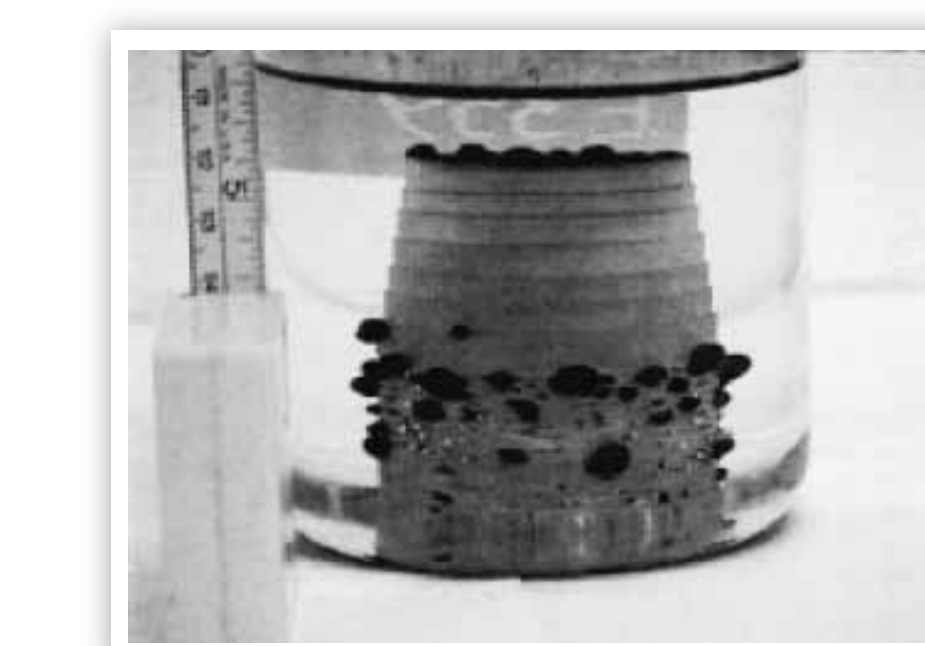
### Oil Recovery by Spontaneous Imbibition



Oil recovery from Bakken core versus soaking time in brine only and in a 0.1% CRS solution



Imbibition Cell with Core



Oil moves from matrix to surface

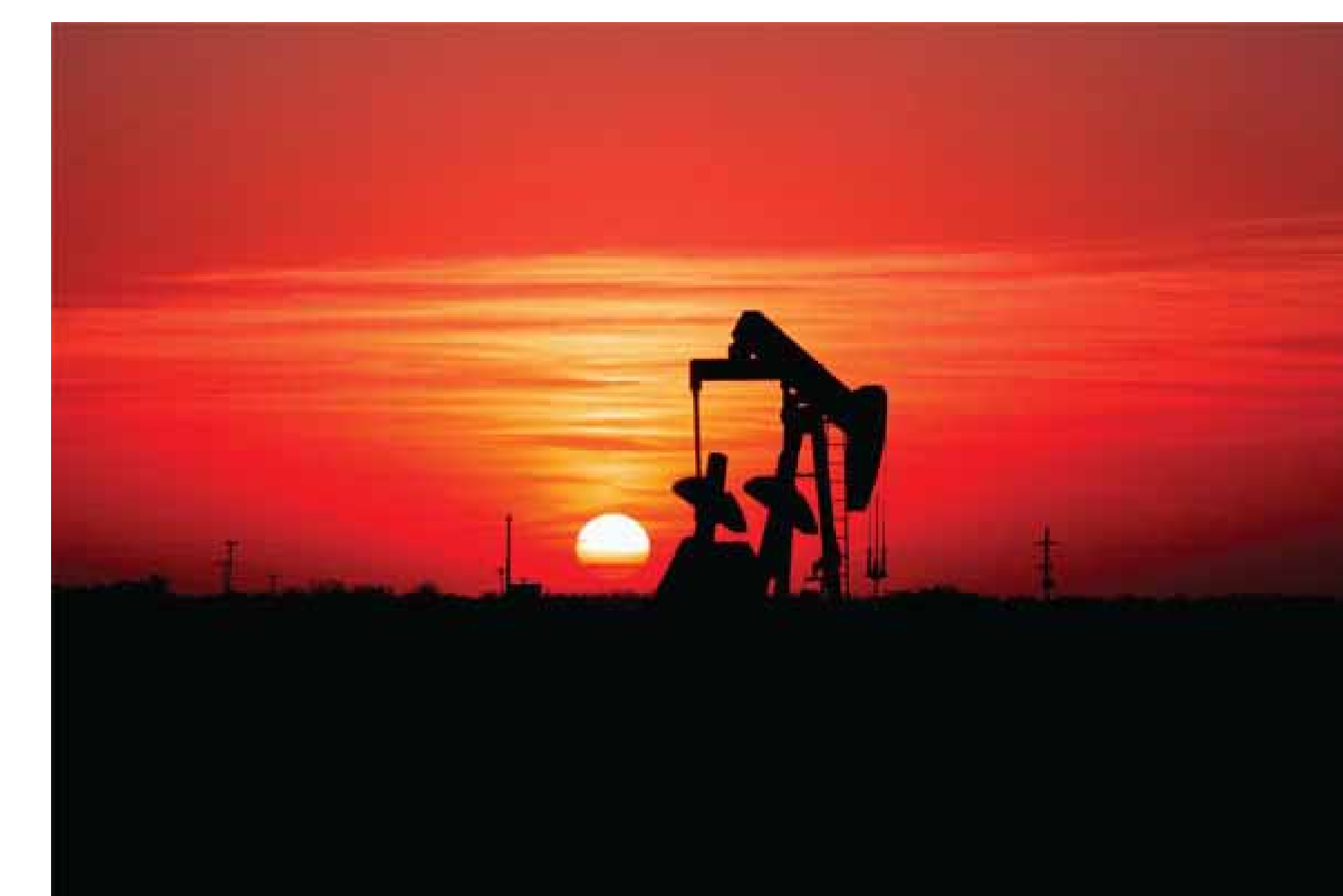
### Feature of CRS

- Water soluble and stable
- Compatible with stimulation fluids and produced water
- Low concentration is effective
- Customized formulation for Bakken crude oils

### Benefit of CRS

- Fast oil response and fast payout
- Attractive economics - low incremental cost for CRS
- Easy to implement – just add to fracture fluid recipe

## FIELD APPLICATION OF CRS



### Field Application of CRS

- As additive to fracturing fluids
- Promotes quick imbibition of aqueous phase - more oil recovery from matrix
- Perform fracture treatment as before
- Increase oil response beyond fracturing treatment without CRS