

Enhancing Recovery From Mature Fields – Opportunities and Challenges for Chemical EOR Processes

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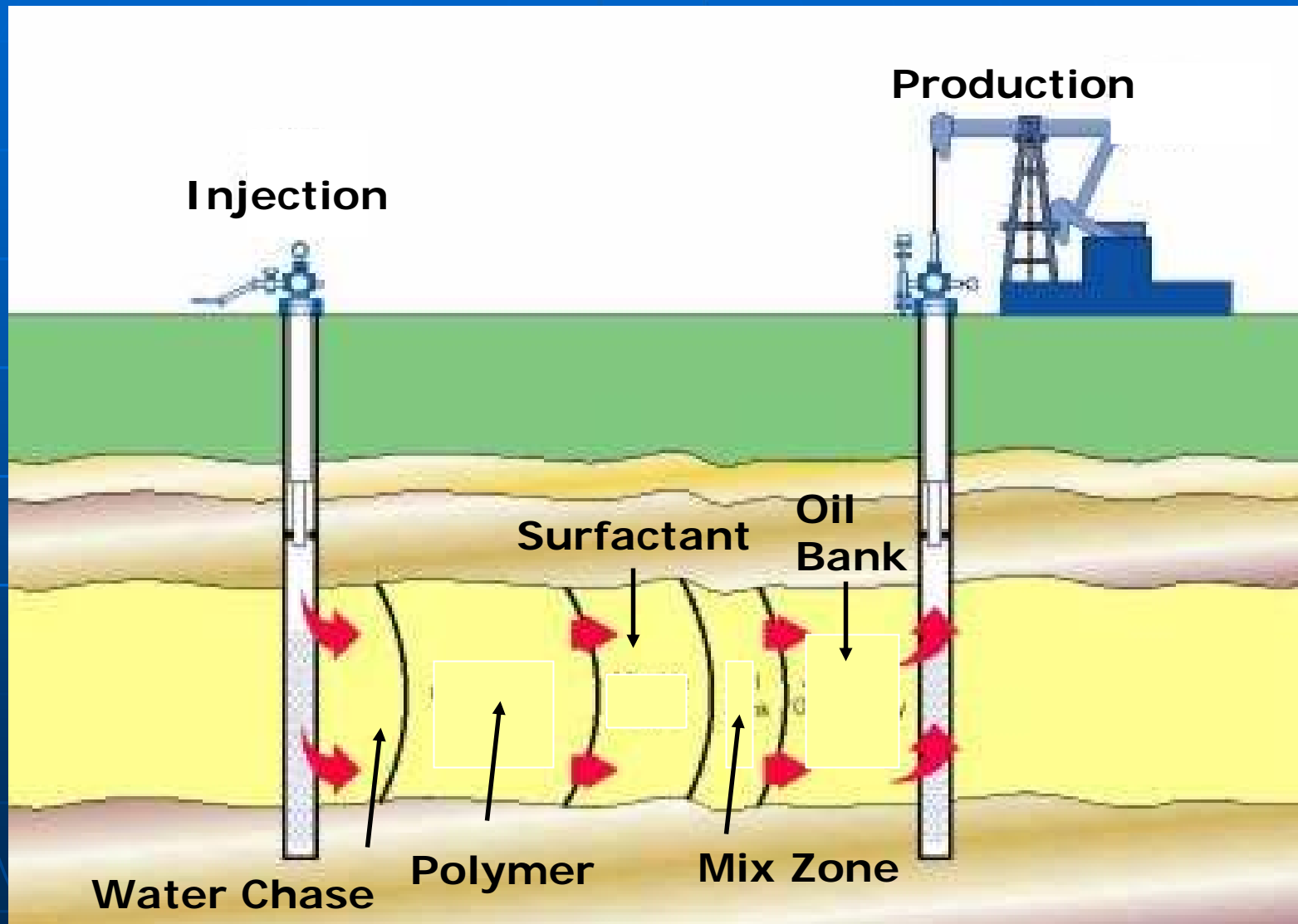


Opportunities and Challenges for Chemical EOR Processes

Main Points:

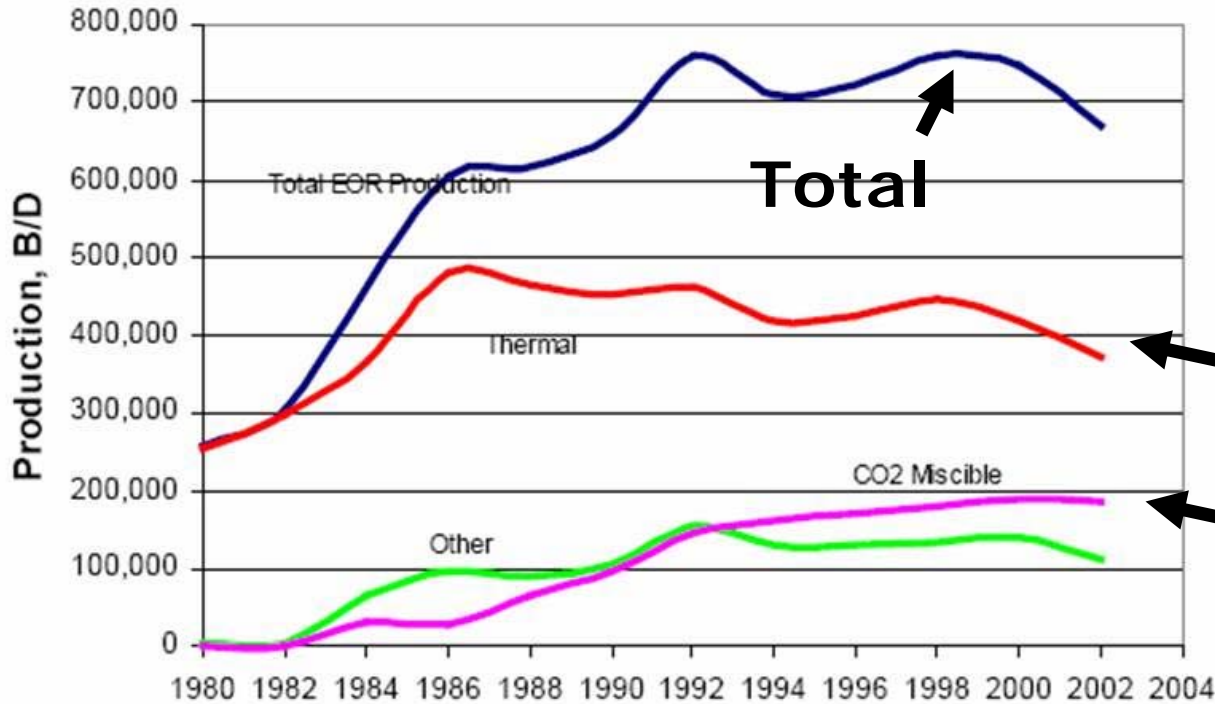
- Chemical EOR -- large opportunity for U.S.
- Challenges to implement (U.S.)
- New technologies favor chemical EOR
- Some new ideas – smaller profitable projects
“EOR on a dime” -- target smaller operators

“Traditional” Chemical EOR



EOR in U.S. Has Favored Thermal & CO2

U.S. EOR Production



U.S.

EOR in 2002
680,000 BPD
147 Projects

Thermal

CO2

Chemical EOR in U.S. –

1980's – projects low oil recovery

Recently – some small successful projects

Opportunities & Barriers for Chemical EOR

Opportunities for Chemical EOR:

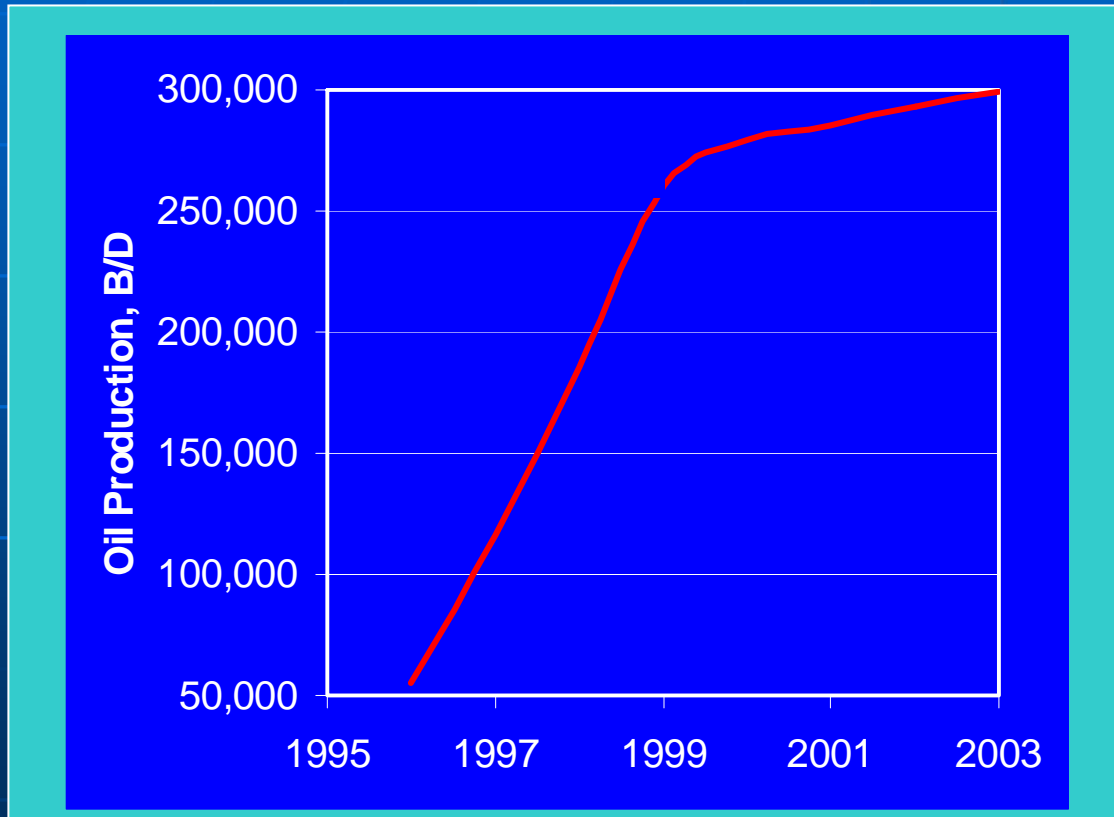
- DOE estimates EOR target in U.S. > 350 B bbl
- Perhaps > 30%; light oil, not accessible to CO₂

Barriers to Implementing Chemical EOR:

- Previous field experience in 1980's not good
- Complex engineering -- trained people??
- Project/Reservoir / geologic uncertainties
- Project logistics – esp. remote locations
- “Traditional” processes - Economic barriers
 - > High front end investment
 - > Long-term project and payout
 - > Oil recovery and oil price uncertainty

Chemical EOR in China – recent success -- indicates a large opportunity for U.S.?

Chemical EOR in China



China has improved the EOR technology created in 1970's and 1980's

China

Large-scale application of polymer flooding EOR -- starting in 1990's

EOR Outside U.S

In 2002 --
860,000 BPD
in 165 projects
(Major source of chemical & microbial EOR)

New Technologies Favor (Chemical) EOR

Improvements in Oil Field Technology Enable EOR:

- Reservoir simulation -- reduce uncertainty
- Geologic description -- reduce uncertainty
- Horizontal wells -- increase injectivity

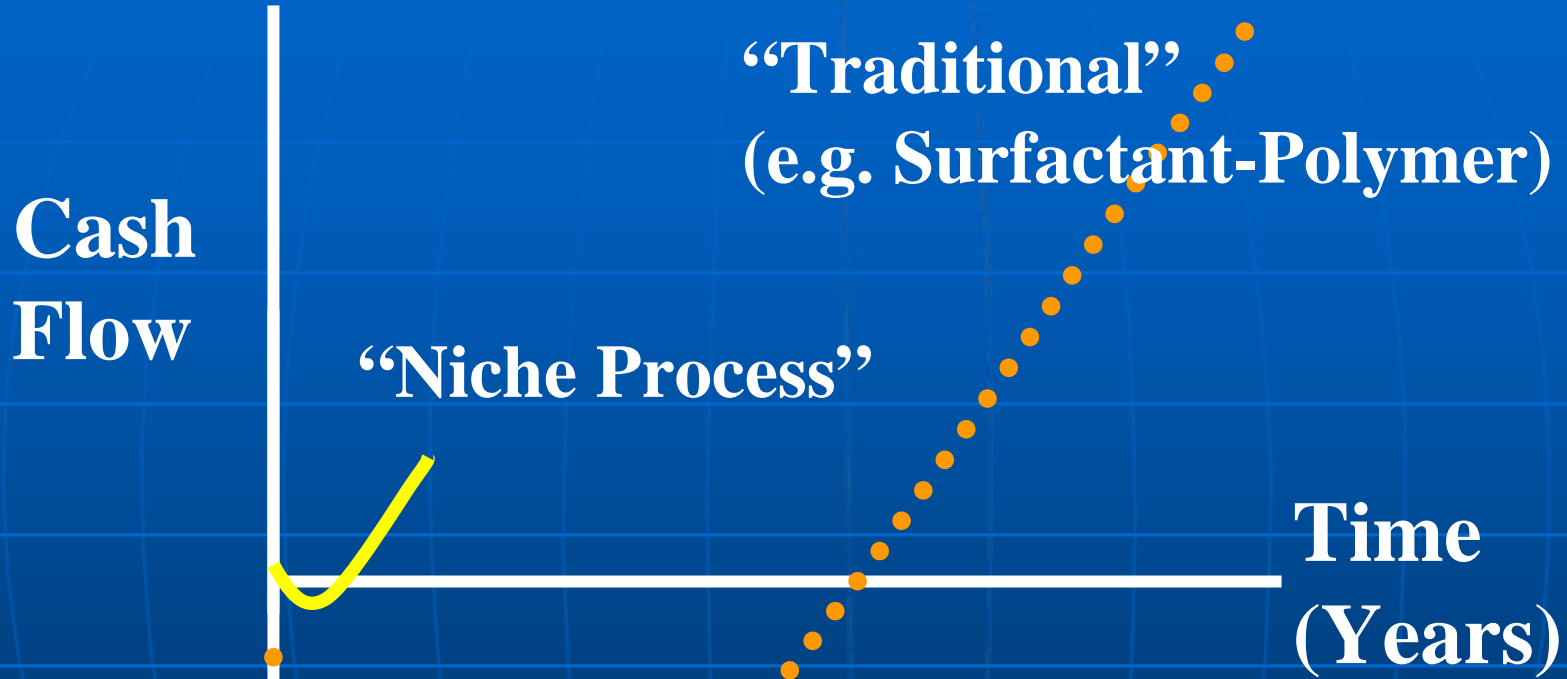


Improvements in Chemical EOR Technologies:

- New polymer & surfactants -- extend Temp/Salinity range that can apply
- New EOR processes { -- lower cost
-- new niche applications

Smaller, Niche Chemical EOR Processes --

Might be Better Match to Smaller Operators



	<u>Traditional</u>	<u>Niche Process</u>
Time	5 - 20 yr	<1 - 5 yr
%OOIP	10 - 20	1 - 5
Chemical Cost per bbl oil	<\$5 - \$10	<\$5 - \$10

Example -- In-Depth Conformance Control

Case – Before

Case - After

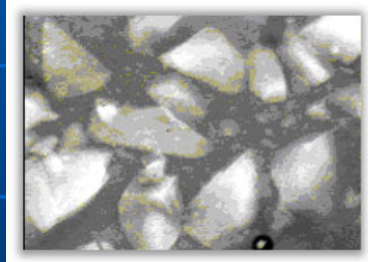
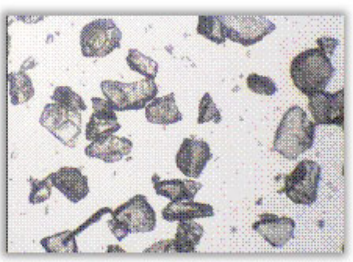
→ Thief Zone – high permeability

→ Homogeneous Portion

→ Ideal, Homogeneous

Soft particles to reduce perm in "Thief Zones" –
in injection water – reduces the heterogeneity

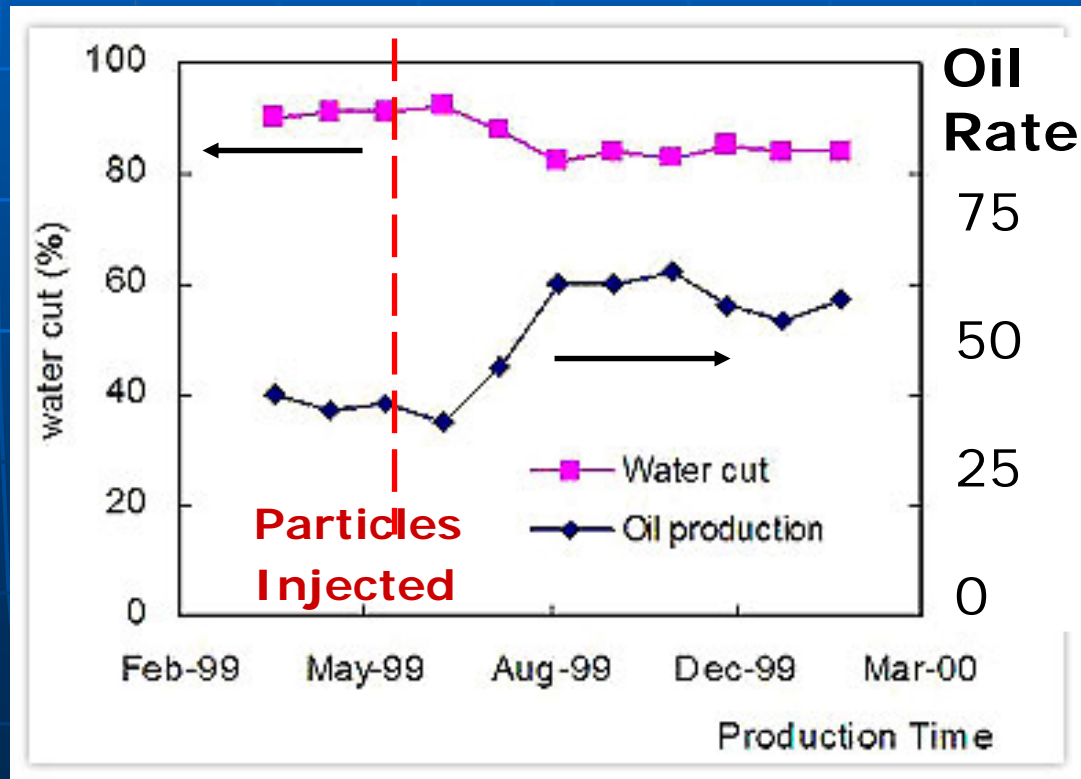
Example -- Particles



Before
Swelling

After
Swelling

Particle sized to
match Thief Zone



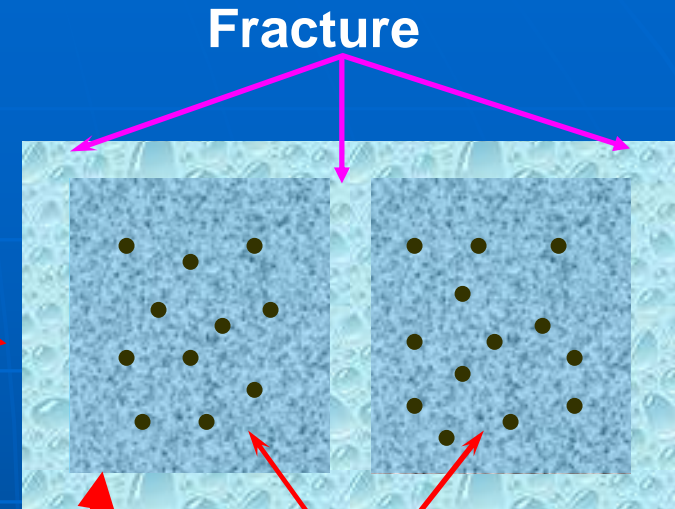
Surfactant EOR in Fractured Carbonate

Waterflood Only:

- Matrix is oil-wet
- Water only travels in fractures
- Oil recovery poor (<25%)



Oil forced out of core by imbibition of aqueous chemical solution --
NO OIL RECOVERY IF BRINE ONLY



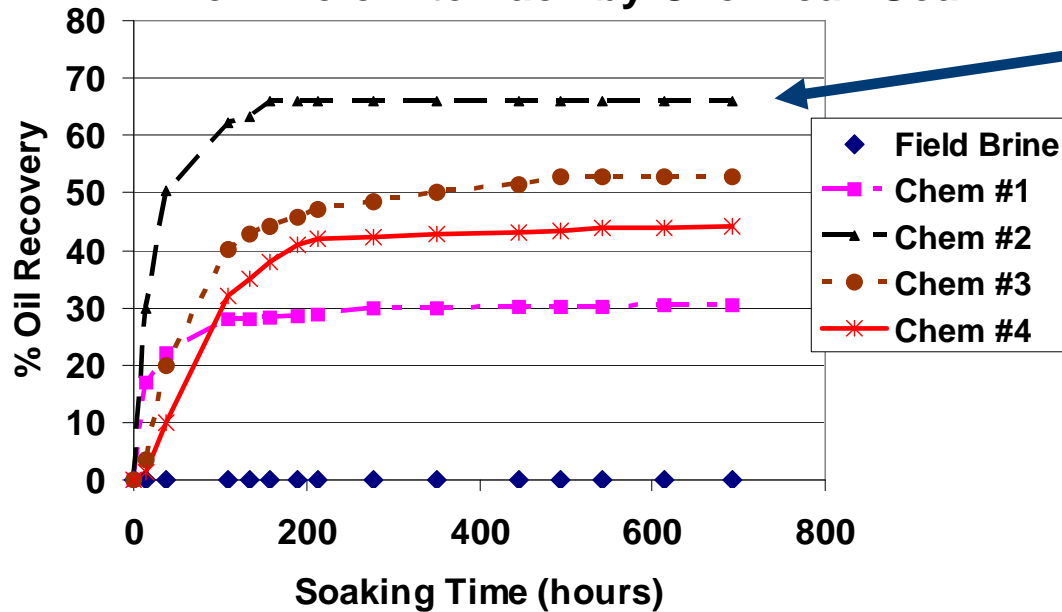
**Oil Trapped
in Matrix**

Surfactant Added:

- Surfactant enables water imbibition
- Mobilizes additional oil
- Oil goes into fractures and is produced

Surfactant EOR in Fractured Carbonates – A New Opportunity

Recovery of Light West Texas Crude
from Dolomite Pack by Chemical Soak



Oil Recovery by
Different Formulations

Surfactant formulation may be applied as –

- ➔ production well soak – “stimulation”
- ➔ add to injection water to improve pattern flood

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NOTE: The extra “dimes” can add up to a significant result
just 1% of 377 B bbl EOR target → ~ 4 Billion bbls oil
Almost 2 yr Domestic Production