

**Water-Shutoff Technology
Critically Needed for
Deep Water Production,
Unconventional Gas
Production, & Small Producers**



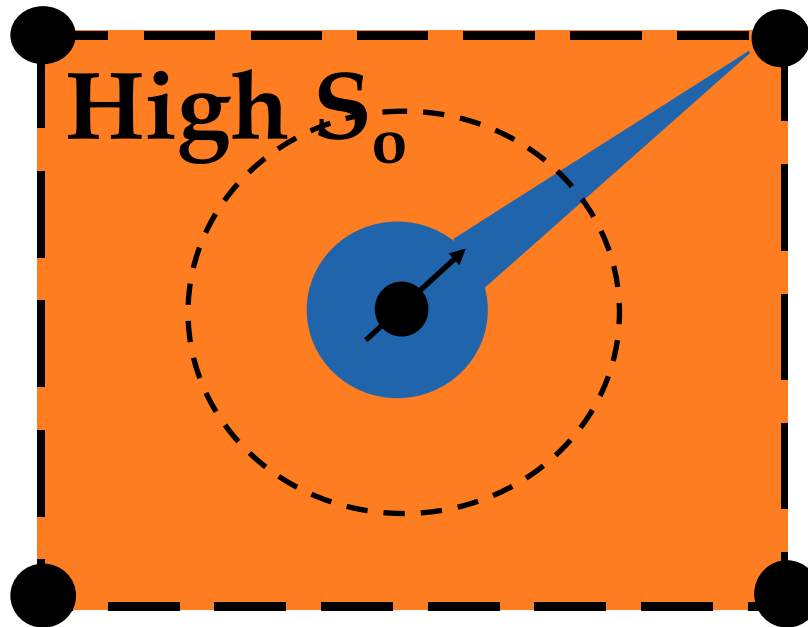
***RPSEA Talk
Albuquerque
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Services



Domain in
this talk of
RPM/DPR WSO

Vertical
(radial flow)



Areal

Often
Fractures
(linear flow)

Reservoir Water

The Best Option

If Feasible & Cost Effective

Keep It in the Reservoir

Especially
If the Water Production
Is Directly Competing
With Oil or Gas
Production

Aqueous Crosslinked Polymer Gels

- **Are a very cost & functionally effective material for use in oilfield WSO treatments**
- **Are probably the presently most widely applied chemical WSO technology**
- **Are integral to this presentation**

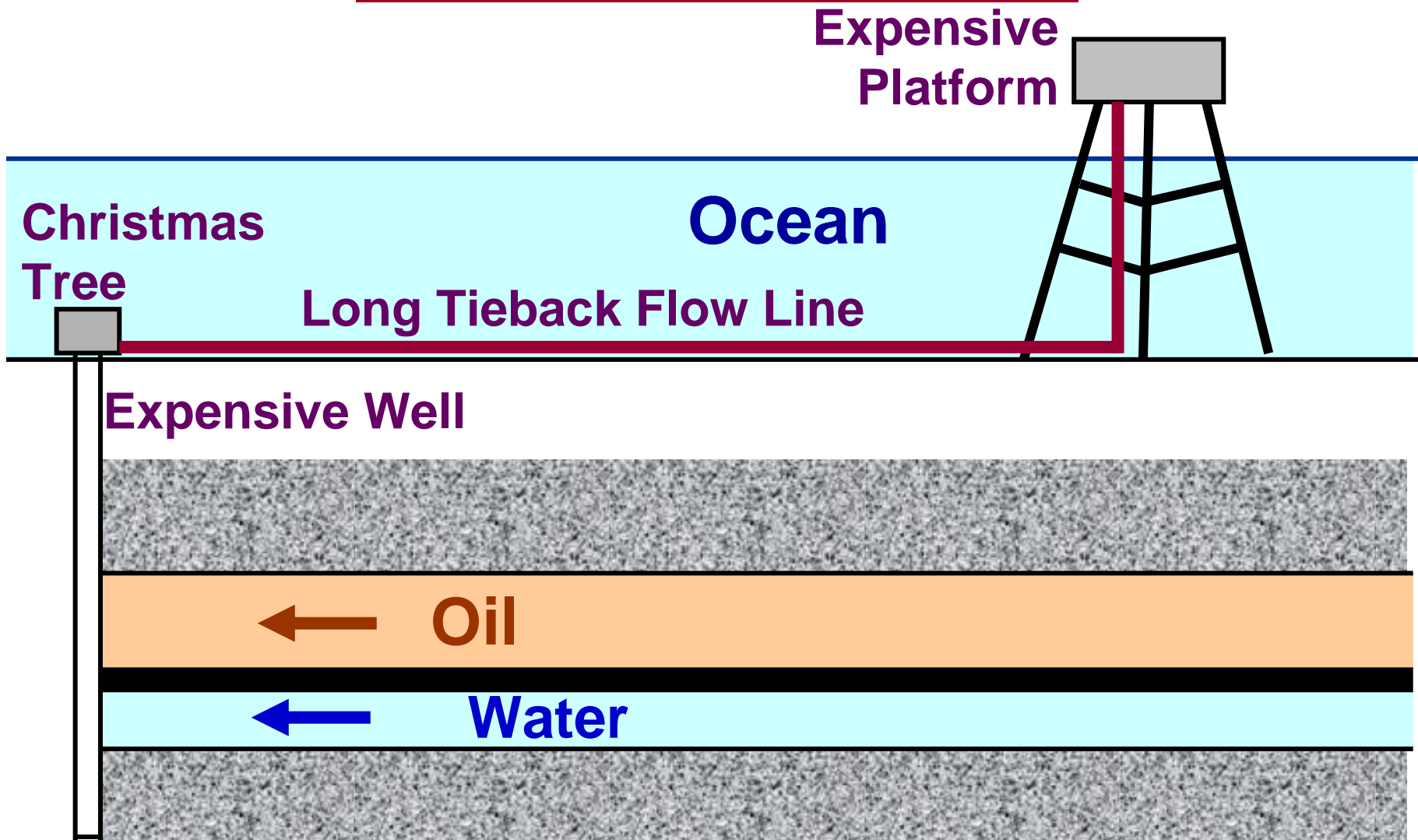
Water Shutoff

- **Historical perspective**
 - **Water production can only be viewed as an economic & operational detriment**

- **Possible paradigm shift – futuristic scenario**
 - **Water production can create economic value or partially pay for itself by being put to beneficial uses**
 - **Economics & attractiveness will be location specific**

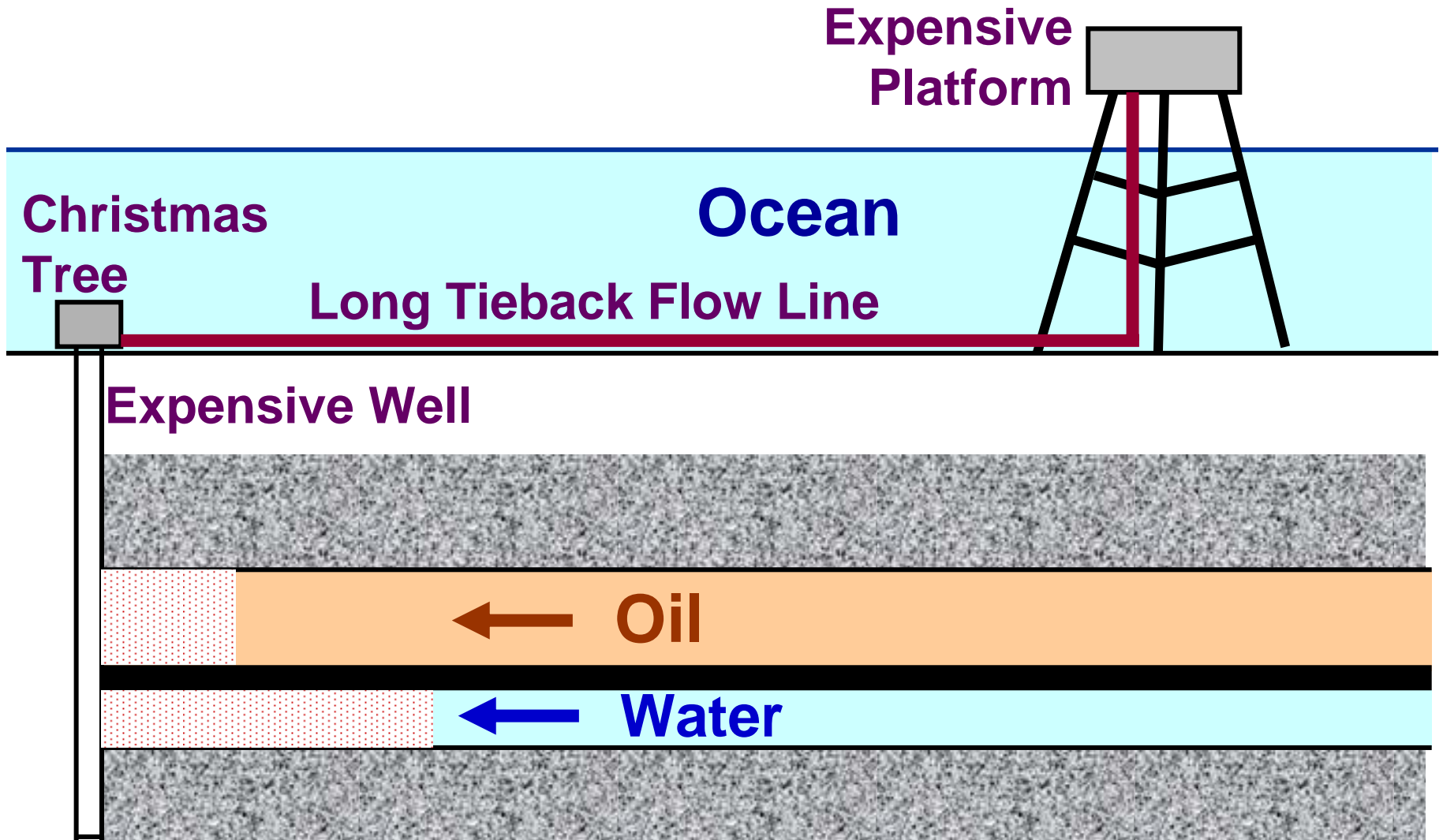
**Deep
Water
Production**

Deep Sea Well Producing Excessive Water



**Deep Water
WSO Treatments
Essentially
Require
RPM/DPR**

Bullheaded RPM/DPR Gel WSO Treatment



Essentially all existing chemical WSO technologies:

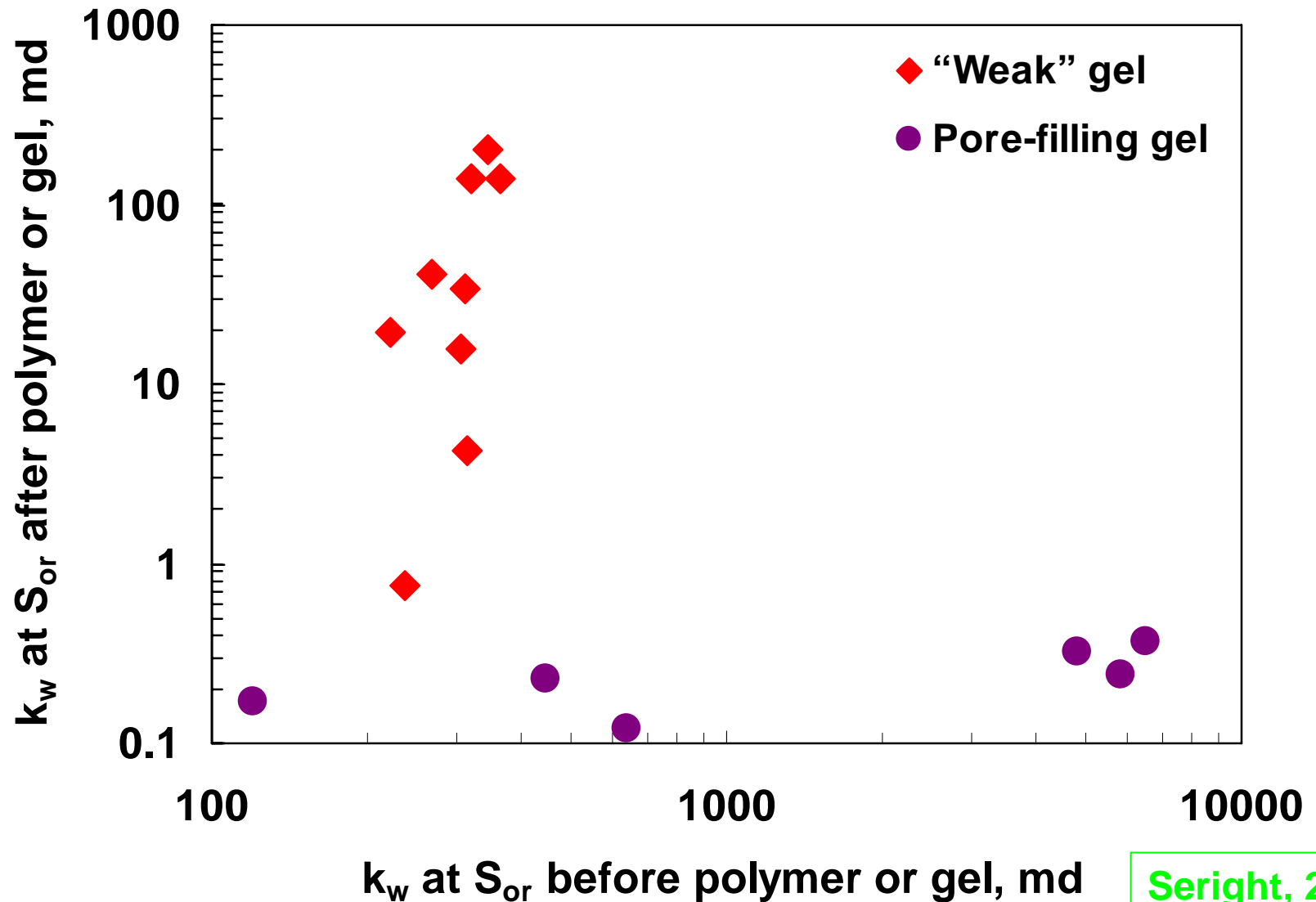
- Can not be successfully
applied to deep-water
production wells**
- Including traditional (presently
available commercially)
RPM/DPR WSO technologies**

New & critically needed for deep-water wells

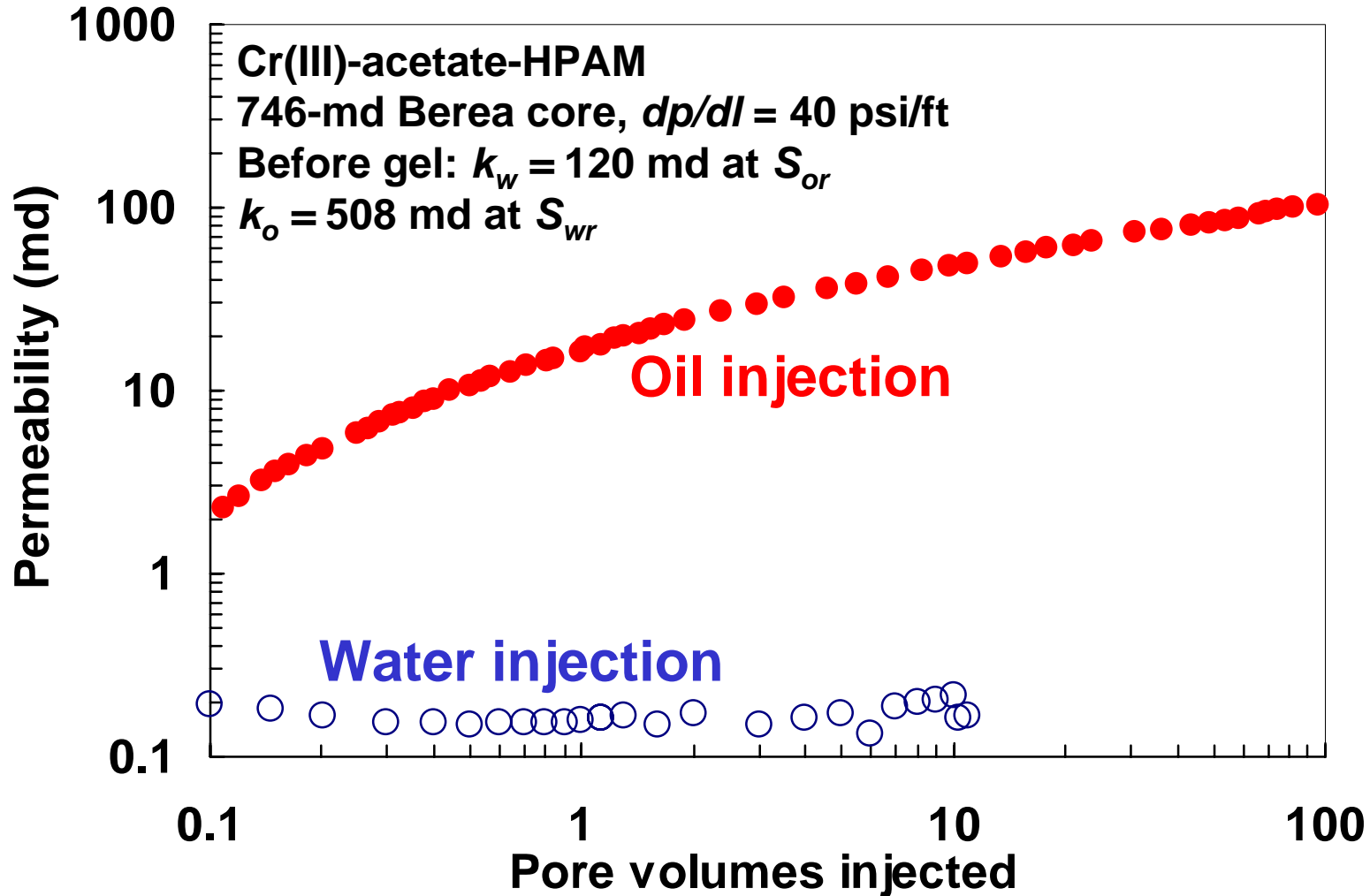
Pore-Filling RPM/DPR Matrix-Rock WSO Treatments

- **Recently developed & advocated by New Mexico Tech (Seright)**
- **Use same popular, robust, & strong bulk gel chemistry & type as applied extensively & successfully in fracture-problem WSO treatments**
 - **Not a weak gel or a polymer alone as used in traditional RPM/DPR WSO treatments**

Pore filling gels are more reliable than adsorbing polymers or weak gels.



Oil Permeability “Cleanup” for CC/AP Gel in Berea Sandstone Core



A recent lab data set showed for the studied experimental conditions and the 0.5%-polymer CC/AP gel placed in various high-perm. porous media:

- **All post-gel-placement $k_w \sim 200 \mu d$**
- **All restoration times for post-gel-placement oil flow to reach 50% of the initial k_o was <1 day**

A quantitative model has been developed (at NMT) to predict, under field conditions, the restoration time required to attain 50% of the initial k_o after 0.5%-polymer CC/AP gel placement in an oil-producing zone.

- R.S. Seright (NMT) 2006 DOE project report**

Further Laboratory Study & Development

- **Required to:**
 - **Develop gel formulations with appropriate gel onset times**
 - **Reduce the pore-filling gel WSO concept to deep-water field practice**
 - **Demonstrate commercial viability**

Deep-Water RPM/DPR WSO Treatments Must Truly Be

- **Robust**
 - Chemically
 - Functionally
- **Absolutely dependable**
- **Full proof**

- **No current RPM/DPR WSO technology meets these criteria**
- **Pore-filling gels are a candidate**
 - **Recent NMT work offers hope**

Unconventional Gas Production

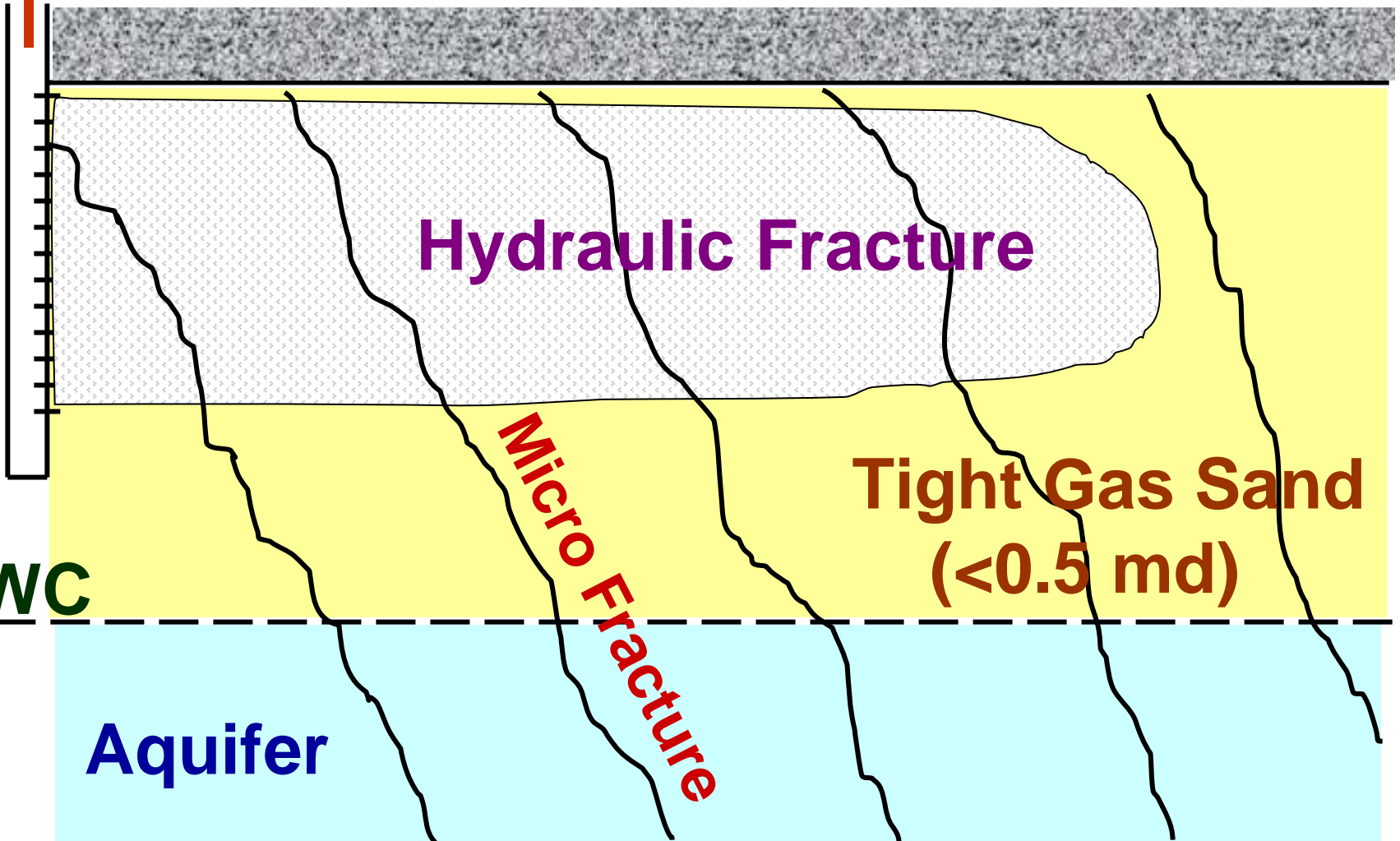
A Leading Cause of Tight-Gas-Sand Well Abandonment

- **Is water production**
 - **Can be a relatively *small amount or rate***
 - **Causes well to become uneconomic**
 - **Leads to *premature abandonment* of gas reserves surrounding the well**
 - **Leads to large volumes of stranded *recoverable* gas reserves**
 - **Much of water production to these wells occurs via fractures**

- **Development of effective water-production-abatement technology for tight-gas-sand wells could add huge amounts of U.S. gas reserves from proven & existing tight-gas-sand reservoirs**
 - **This possibility is not being actively pursued**

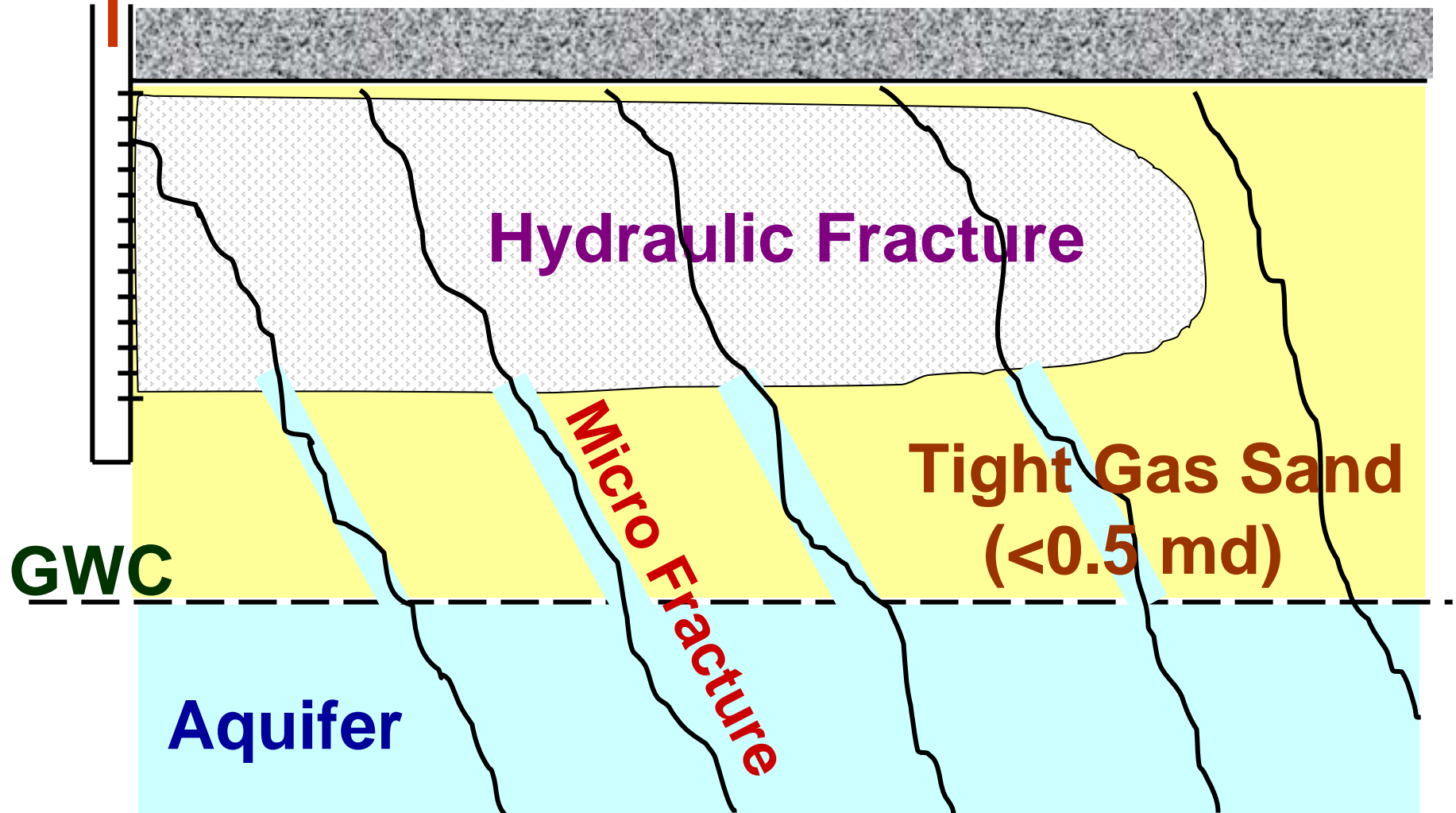
Well in a Naturally Fractured Tight Gas Sand Overlying an Aquifer

Gas well production



Watered Out Well in a Naturally Fractured Tight Gas Sand

↑ Gas well production



**Classical WSO
fracture-problem
bulk polymer gels
are *not* applicable!**

Low-Concentration CC/AP Gel in Micro Fractures

R.S. Seright, 2006

(Alcoflood 935 HPAM, 41°C, $L_f = 4$ ft, 1-day-old gel,
gel $q = 2,000$ cm³/hr, brine $q = 100$ cm³/hr)

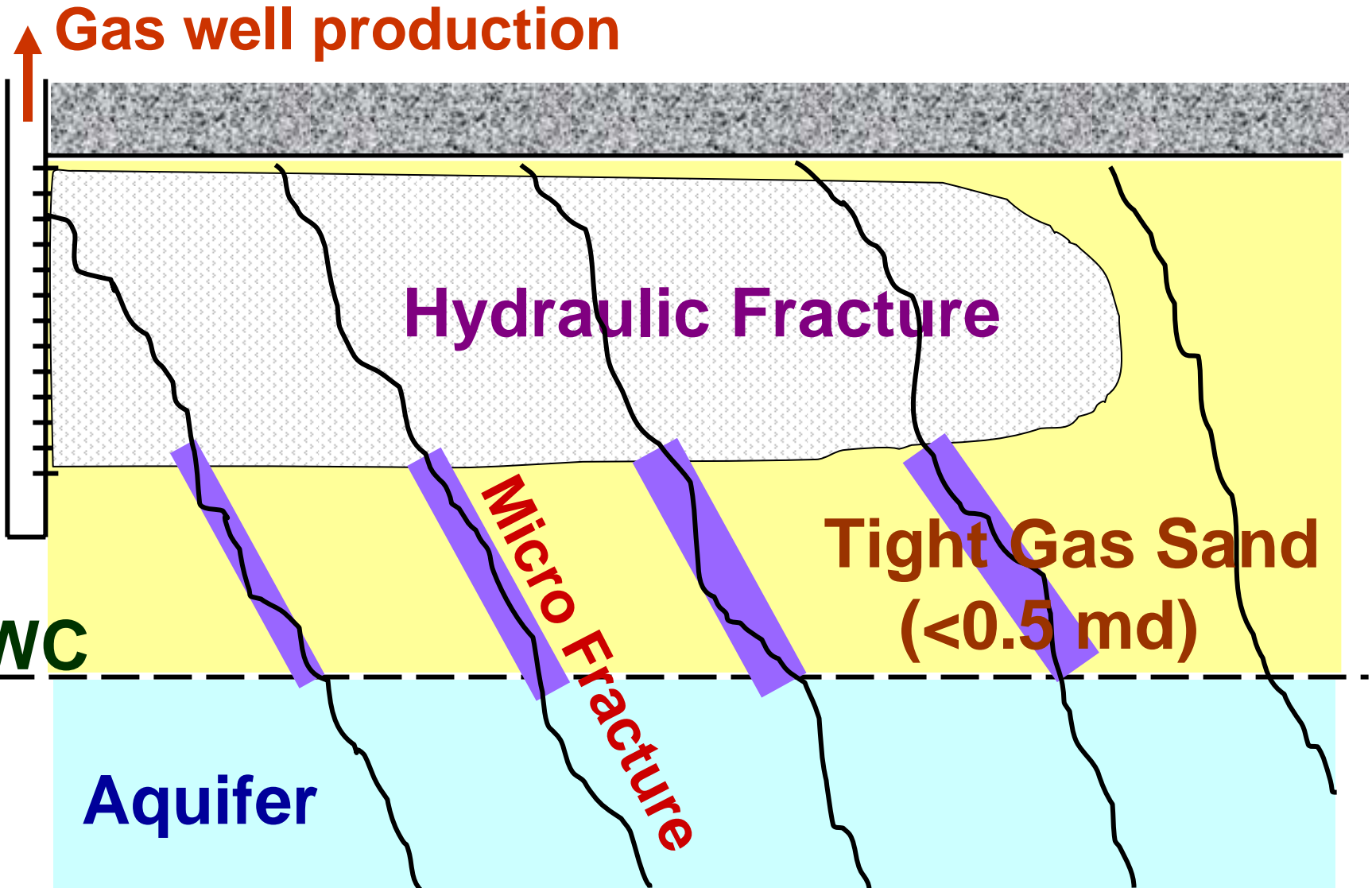
HPAM (%)	0.2	0.25
Crosslinker (%)	0.0167	0.0209
w_f (μm)	100	80
Gel placement dp/dl (psi/ft)	27.8	71.8
Effective μ in fracture (cp)	5.4	7.2
Brine breaching dp/dl (psi/ft)	29.7	72.1
Final % of flow through matrix	100	100

New & critically needed for tight gas sands

Challenges & Needed Studies

- **How to obtain proper & needed placement of the gel**
 - **So as to reduce water production, without reducing gas production**
- **How to be sure to not damage gas productivity**
 - **Avoid inducing any water-block problems**
 - **Avoid any gel leakoff into matrix rock**

Gel-Treated Well in a Naturally Fractured Tight Gas Sand



Water production abatement
is the *key* to being able to
greatly increase the
recovery factor for wells in
many *existing & proven*
tight-gas-sand reservoirs!

Thank You