

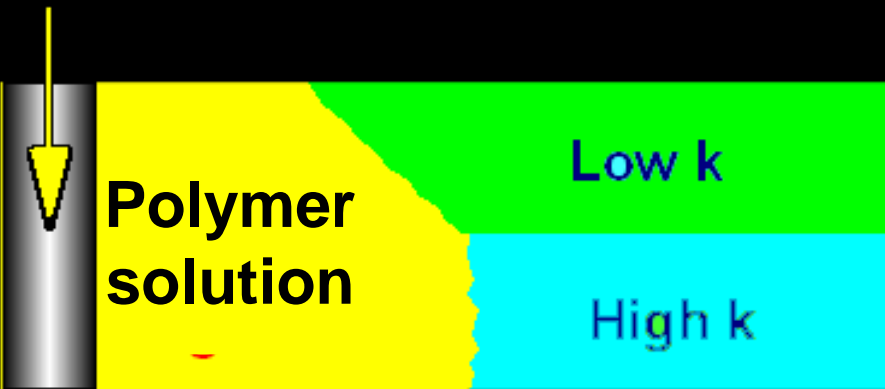
POLYMER FLOODS VERSUS GEL TREATMENTS

Polymer floods use polymer solutions. Gels add a crosslinker to the polymer solution.

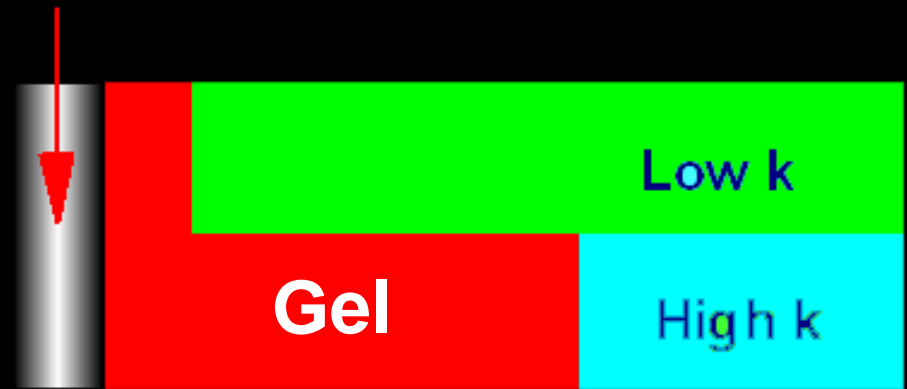
- The “Windfall Profits Act of 1980” encouraged grouping the two methods together as “polymer augmented waterfloods”.
- The Oil and Gas Journal does not distinguish the two methods in their biannual EOR survey.

What is the difference?

Distinction between a gel treatment and a polymer flood.



- For a polymer flood, polymer penetration into low-k zones should be maximized.



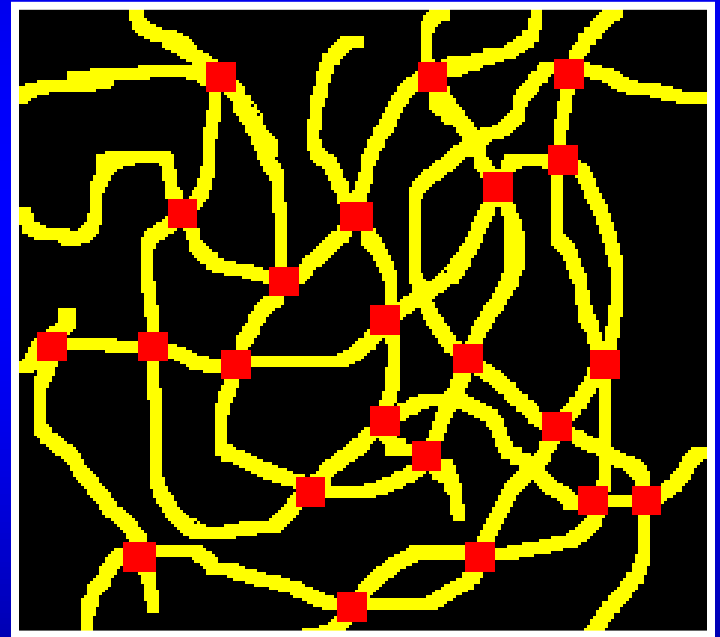
- For a gel treatment, gelant penetration into low-k zones should be minimized.

**VISCOUS
POLYMER
SOLUTION**



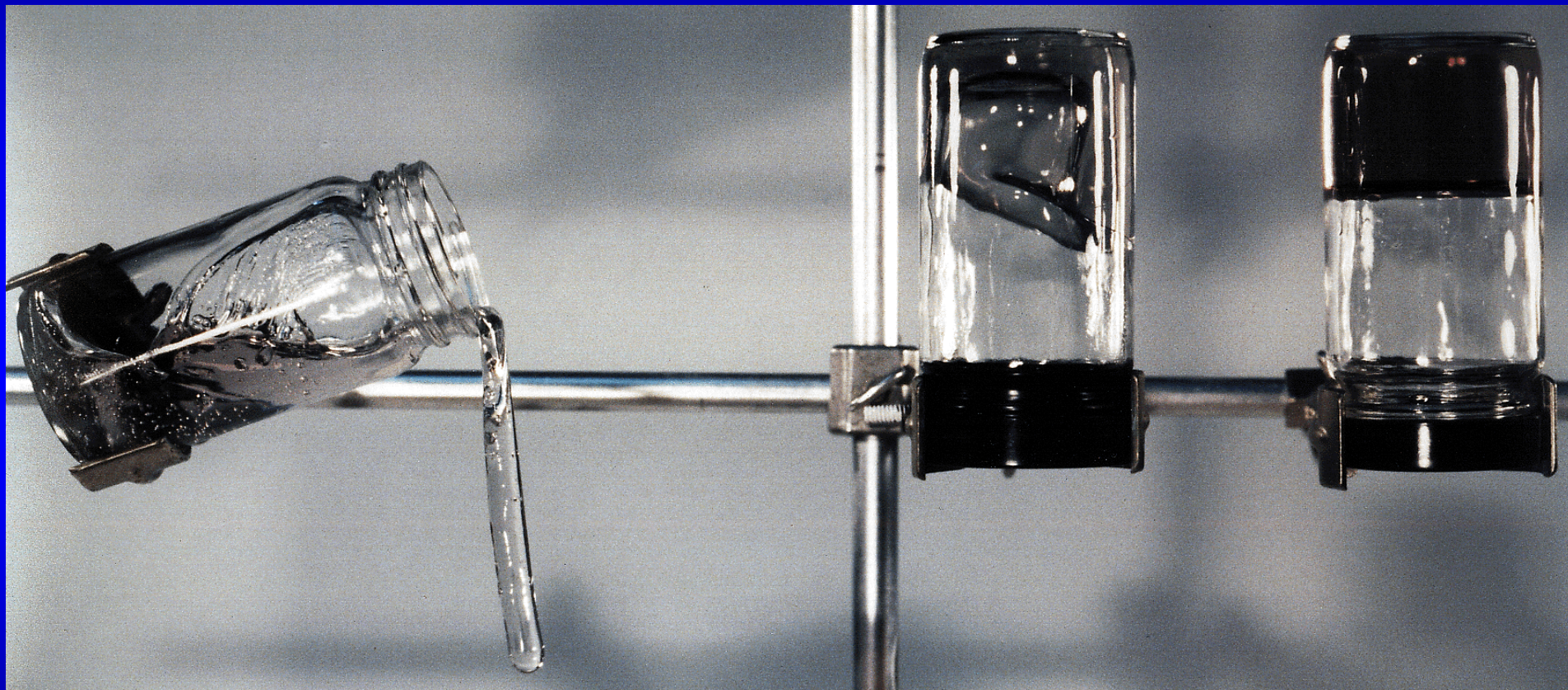
**CROSSLINKED
POLYMER
(GEL)**

■ Crosslink site



Gelant = Polymer + crosslinker solution before gel formation.
Gel = Crosslinked structure after reaction.

Higher polymer & crosslinker concentrations yield stronger gels



If not enough polymer or crosslinker is present, no gel forms.

GEL TREATMENTS ARE NOT POLYMER FLOODS

Crosslinked polymers, gels, gel particles, and “colloidal dispersion gels”:

- Are not simply viscous polymer solutions.
- Do not flow through porous rock like polymer solutions.
- Do not enter and plug high-k strata first and progressively less-permeable strata later.
- Should not be modeled as polymer floods.

POLYMER FLOODING is best for improving sweep in reservoirs where fractures do not cause severe channeling.

- Great for improving the mobility ratio.
- Great for overcoming vertical stratification.
- Fractures can cause channeling of polymer solutions and waste of expensive chemical.

GEL TREATMENTS are best treating fractures and fracture-like features that cause channeling.

- Generally, low volume, low cost.
- Once gelation occurs, gels do not flow through rock.

WHY DO WE WANT TO REDUCE WATER PRODUCTION?

REDUCE OPERATING EXPENSES

- Reduce pumping costs (lifting and re-injection):
~\$0.25/bbl (\$0.01 to \$8/bbl range).
- Reduce oil/water separation costs.
- Reduce platform size/equipment costs.
- Reduce corrosion, scale, and sand-production treatment costs.
- Reduce environmental damage/liability.

INCREASE HYDROCARBON PRODUCTION

- Increase oil production rate by reducing fluid levels and downhole pressures.
- Improve reservoir sweep efficiency.
- Increase economic life of the reservoir and ultimate recovery.
- Reduce formation damage.

MAIN POINTS I THINK YOU NEED TO KNOW

1. What polymers, gelants, and gels can/cannot do.
2. Why determining whether flow is radial (into matrix) or linear (through fractures) is critical in EVERY application.
3. A strategy for attacking problems.

PROPERTIES OF AVAILABLE GELANTS/GELS

- 1. Early in the gelation process, gelants penetrate readily into porous rock.**
- 2. After gelation, gel propagation through porous rock is extremely slow or negligible.**
- 3. The transition between these two conditions is usually of short duration.**

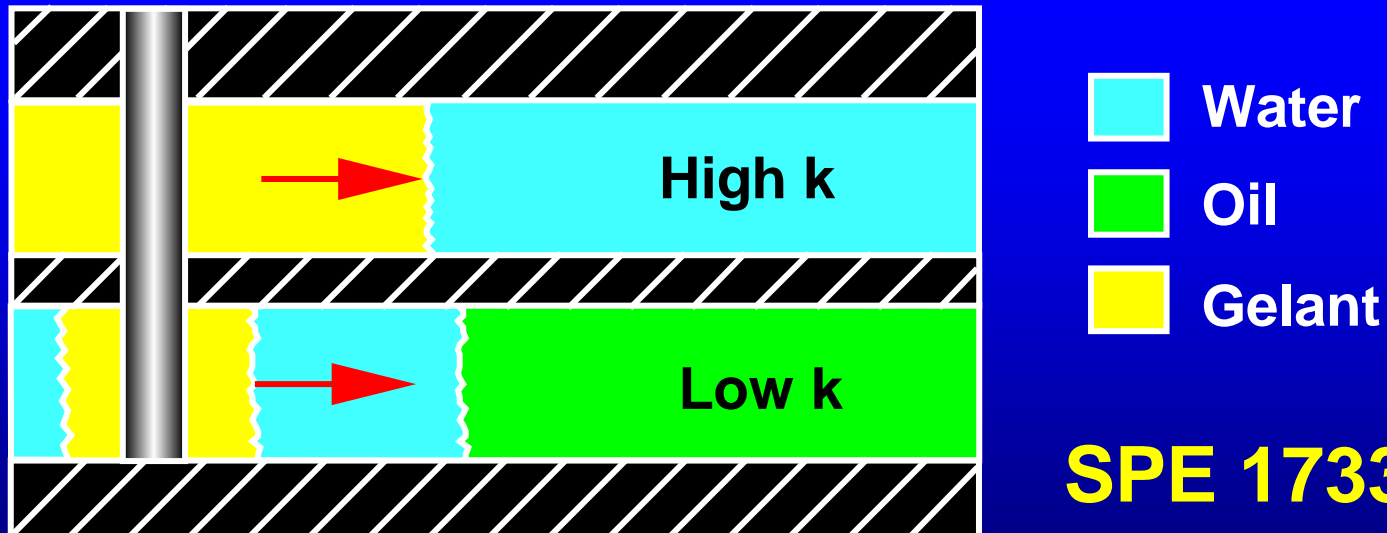
***SPE*RE (Nov. 1993) 299-304; *IN SITU* 16(1) (1992) 1-16; and *SPE*PF (Nov. 1995) 241-248.**

BASIC CALCULATIONS

Gelants can penetrate into all open zones.

An acceptable gelant placement is much easier to achieve in linear flow (fractured wells) than in radial flow.

In radial flow (unfractured wells), oil-productive zones must be protected during gelant placement.



KEY QUESTIONS DURING BULLHEAD INJECTION OF POLYMERS, GELANTS, OR GELS

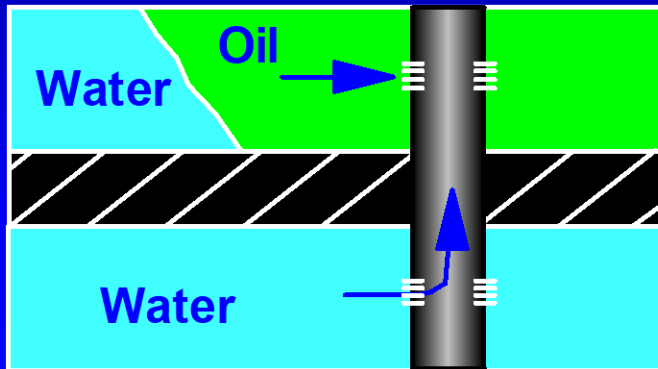
- **Why should the blocking agent NOT enter and damage hydrocarbon productive zones?**
- **How far will the blocking agent penetrate into each zones (both water AND hydrocarbon)?**
- **How much damage will the blocking agent cause to each zone (both water AND hydrocarbon zones)?**

A STRATEGY FOR ATTACKING EXCESS WATER PRODUCTION

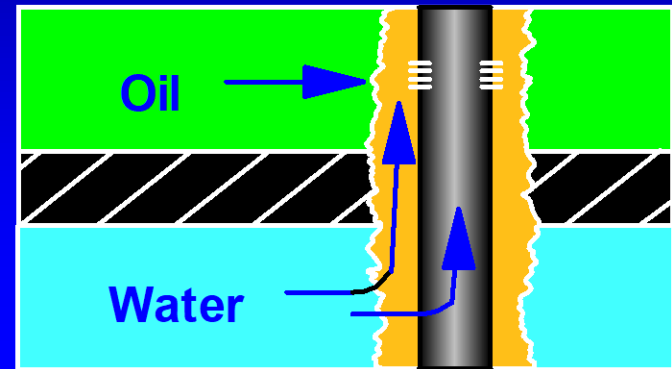
- 1. Consider and eliminate the easiest problems first.**
- 2. Start by using information that you already have.**

CAUSES OF EXCESS WATER PRODUCTION

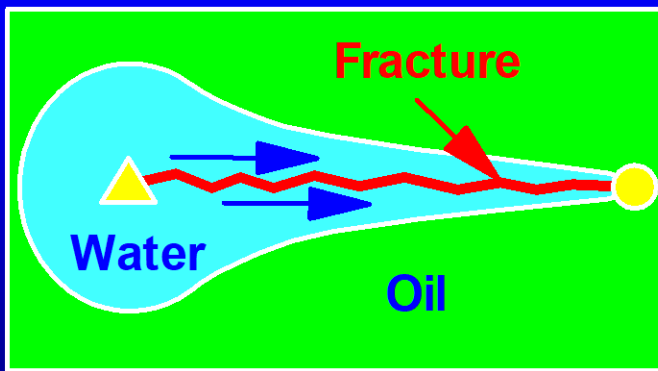
Open Water Zone



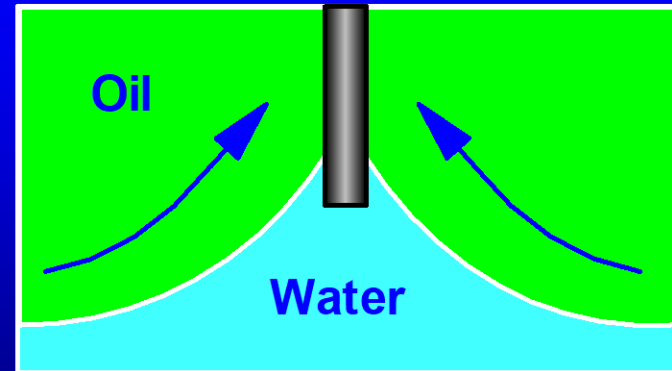
Flow Behind Pipe and Casing Leaks



Channeling from Injectors



Coning or Cusping



MAIN POINTS

Many different types of excess water production problems exist.

Each problem type requires a different approach (e.g., different blocking agent properties) for optimum solution.

Problem types should be adequately diagnosed before attempting a solution.

WATER CONTROL METHODS

- Cement, sand plugs, calcium carbonate.
- Packers, bridge plugs, mechanical patches.
- Pattern flow control.
- In fill drilling/well abandonment.
- Horizontal wells.
- Gels.
- Polymer floods.
- Resins.
- Foams, emulsions, particulates, precipitates, microorganisms, nanoparticles.

SOME MATERIALS FOR WATER SHUTOFF

CEMENTS

- + Have excellent mechanical strength.
- + Have good thermal stability (up to 450°C).
- Do not penetrate readily into tight areas.
- Do not always form a good pipe-formation seal.

RESINS

- + Can penetrate into rock matrix and tight areas.
- o Stability depends on the particular resin (up to 250°C).
- Chemistry can be very temperamental.
- Are not reversible.
- Are expensive.

GELS

- + Can penetrate into rock matrix and tight areas.
- + Reliability of gelation chemistry depends on the gelant.
- Have lower thermal stability than other materials (<175°C).
- Have low mechanical strength outside rock matrix.