SPE 146087

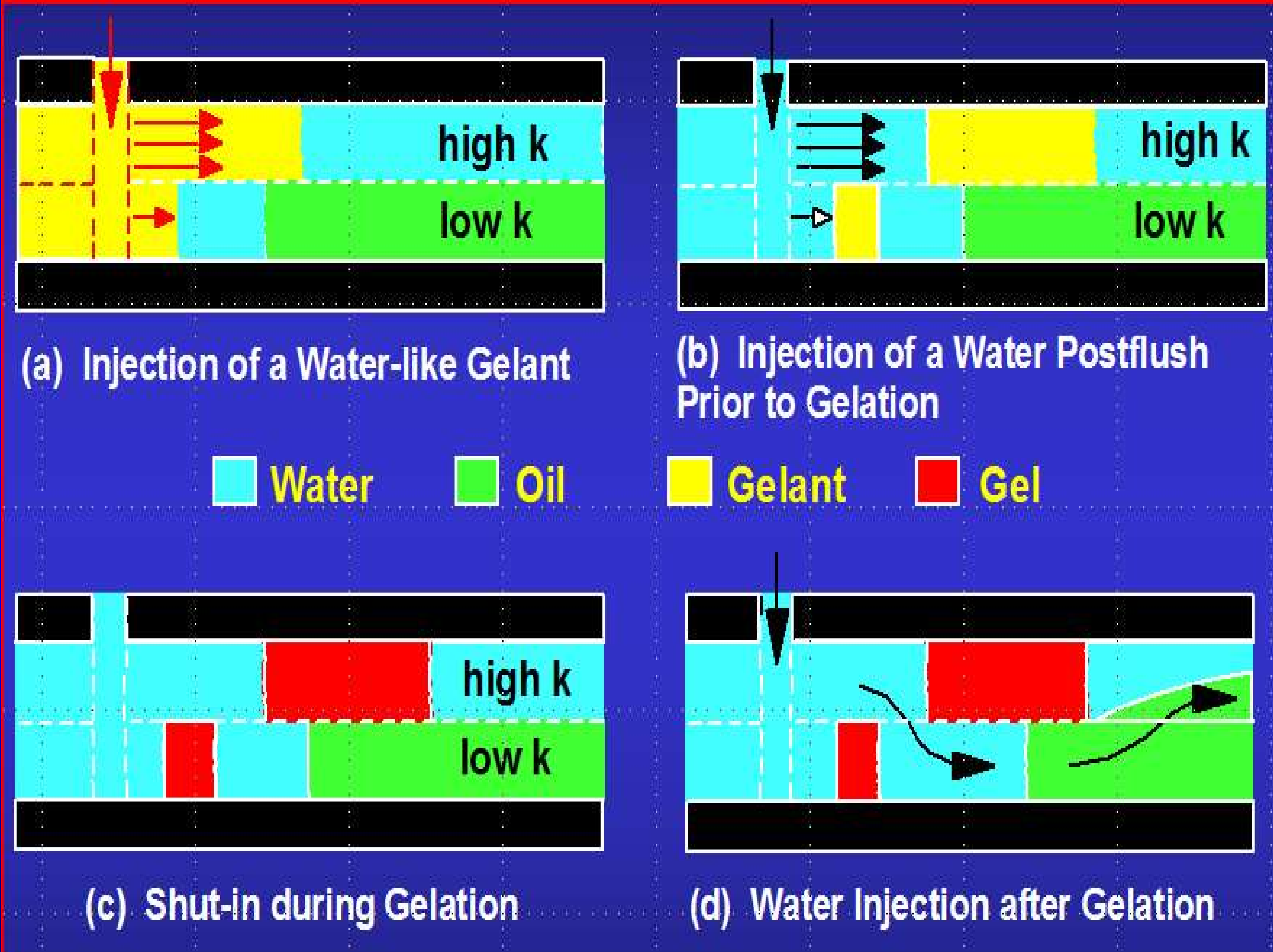
A COMPARISON OF POLYMER FLOODING WITH IN-DEPTH PROFILE MODIFICATION

BOTTOM LINE

1. In-depth profile modification is most appropriate for high permeability contrasts (e.g. 10:1), high thickness ratios (e.g., less-permeable zones being 10 times thicker than high-permeability zones), and relatively low oil viscosities.
2. Because of the high cost of the blocking agent (relative to conventional polymers), economics favor small blocking-agent bank sizes (e.g. 5% of the pore volume in the high-permeability layer).
3. Even though short-term economics may favor in-depth profile modification, ultimate recovery may be considerably less than from a traditional polymer flood. A longer view may favor polymer flooding both from a recovery viewpoint and an economic viewpoint.
4. In-depth profile modification is always more complicated and risky than polymer flooding.

IN-DEPTH PROFILE MODIFICATION

A specialized idea that requires use of a low-viscosity gelant.



ADVANTAGES AND LIMITATIONS

ADVANTAGES:

1. Could provide favorable injectivity.
2. “Incremental” oil from this scheme could be recovered relatively quickly.

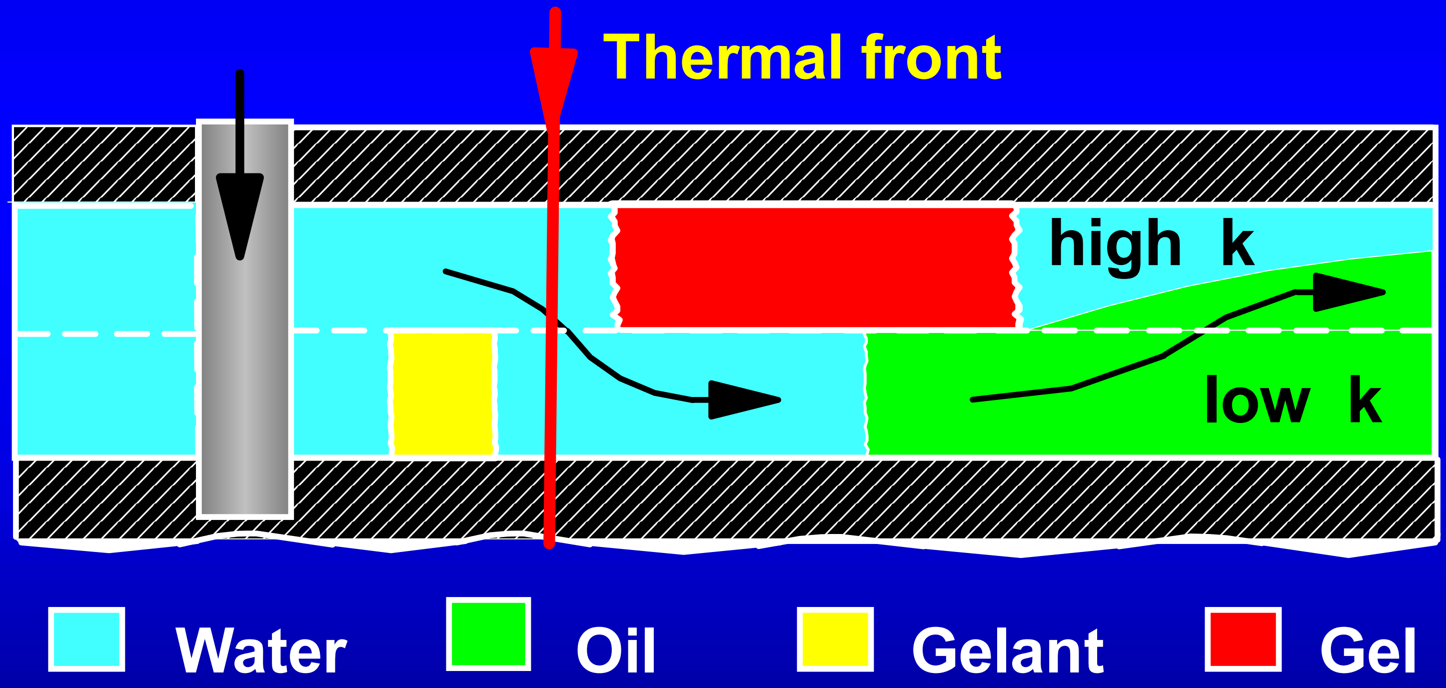
LIMITATIONS:

1. Will not improve sweep efficiency beyond the greatest depth of gelant penetration in the reservoir.
2. Control & timing of gel formation may be challenging.
3. Applicability of this scheme depends on the sweep efficiency in the reservoir prior to the gel treatment.
4. Viscosity and resistance factor of the gelant must not be too large (ideally, near water-like).
5. Viscosity and resistance factor of the gelant should not increase much during injection of either the gelant or the water postflush

Sophisticated Gel Treatment Idea from BP

In-depth channeling problem, no significant fractures, no barriers to vertical flow:

- BP idea could work but requires sophisticated characterization and design efforts,
- Success is very sensitive to several variables.



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BRIGHT WATER—A VARIATION ON BP's IDEA
(SPE 84897 and SPE 89391)

- Injects small crosslinked polymer particles that "pop" or swell by ~10X when the crosslinks break.
- "Popping" is activated primarily by temperature, although pH can be used.
- The particle size and size distribution are such that the particles will generally penetrate into all zones.
- A thermal front appears necessary to make the idea work.
- The process experiences most of the same advantages and limitations as the original idea.

BRIGHT WATER

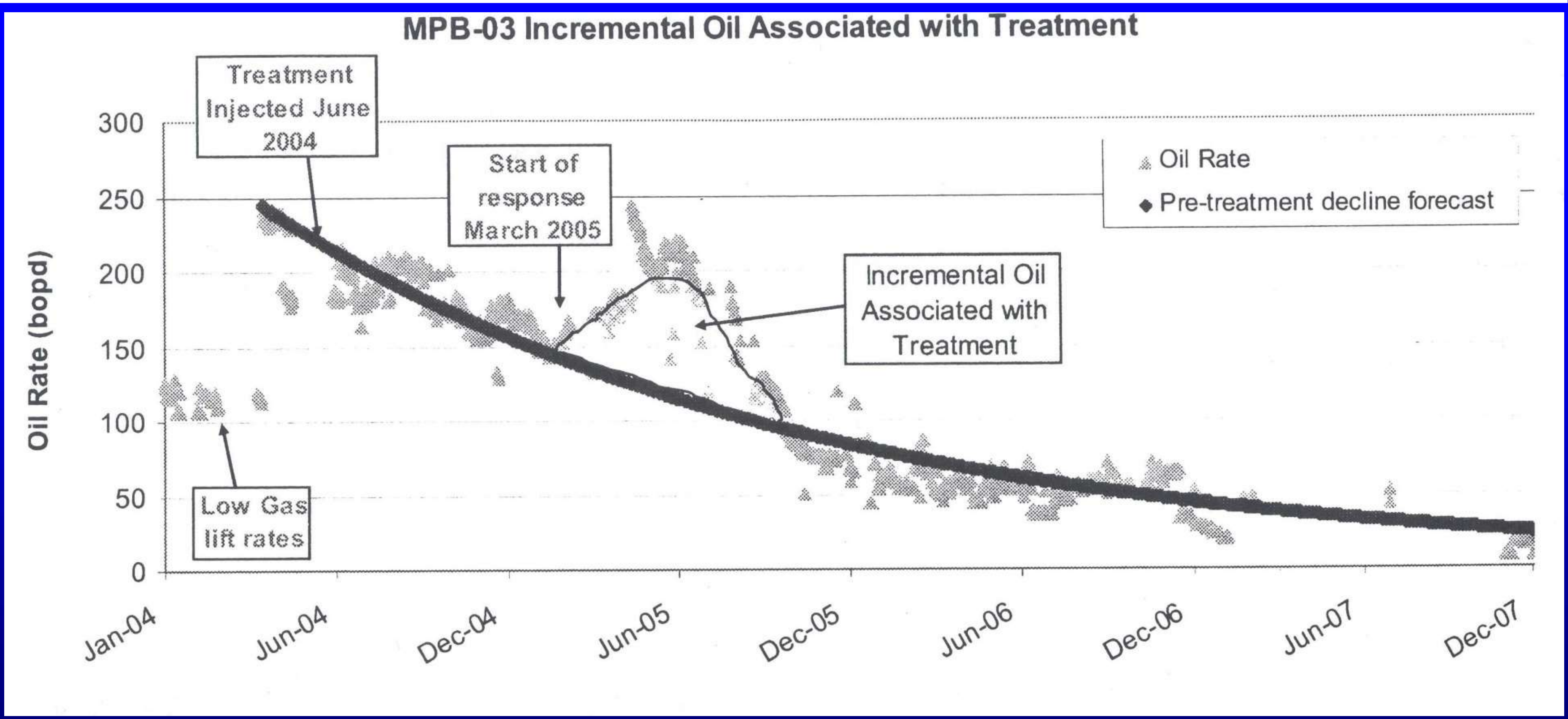
Had it origins ~1990.

Had an early field test by BP in Alaska.

Was perfected in a consortium of Mobil, BP, Texaco, and Chevron in the mid-1990s.

BRIGHT WATER—RESULTS (SPE 121761)

- BP Milne Point field, North Slope of Alaska.
- Injected 112,000 bbl of 0.33% particles.
- Recovered 50,000 bbl of incremental oil.
- 0.39 bbl oil recovered / lb of polymer (compared with ~1 bbl oil / lb polymer for good polymer floods).



ADDITIONAL CONSIDERATIONS

1. For small banks of popping-agent, significant mixing and dispersion may occur as that bank is placed deep within the reservoir—thus, diluting the bank and potentially compromising the effectiveness of the blocking agent. .
2. Since the popping material provides a limited permeability reduction (i.e., 11 to 350) and the popped-material has some mobility, the blocking bank eventually will be diluted and compromised by viscous fingering (confirmed by SPE 174672, Fabbri et al.). High retention (130 µg/g) is also an issue (SPE 174672).
3. If re-treatment is attempted for a in-depth profile-modification process, the presence of a block or partial block in the high-permeability layer will (1) divert new popping-agent into less-permeable zones during the placement process and (2) inhibit placement of a new block that is located deeper in the reservoir than the first block. These factors may compromise any re-treatment using in-depth profile

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