A Quick Look at Oil Wettability Progression in Carbonate Formations

March 2026

Illustrations Modified After:

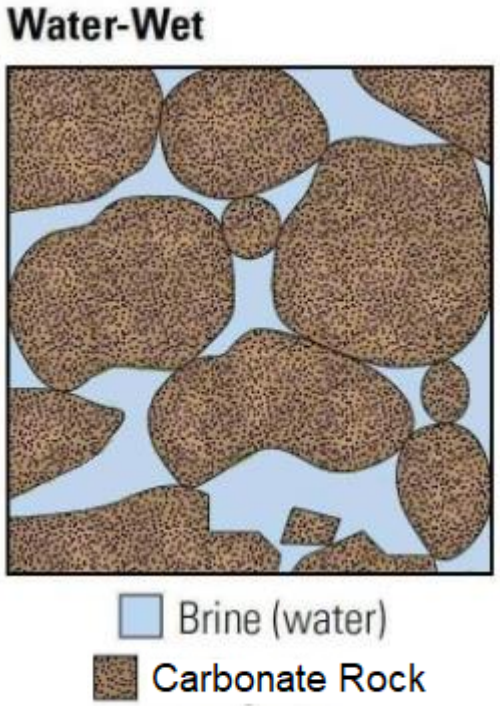
https://www.slb.com/resource-library/oilfield-review/defining-series/defining-wettability#:~:text=In%20Dalmatian%20wetting%2C%20the%20solid,surface%20film%20(Figure%202).

Melzer CO2nsulting

Wettability in Carbonates

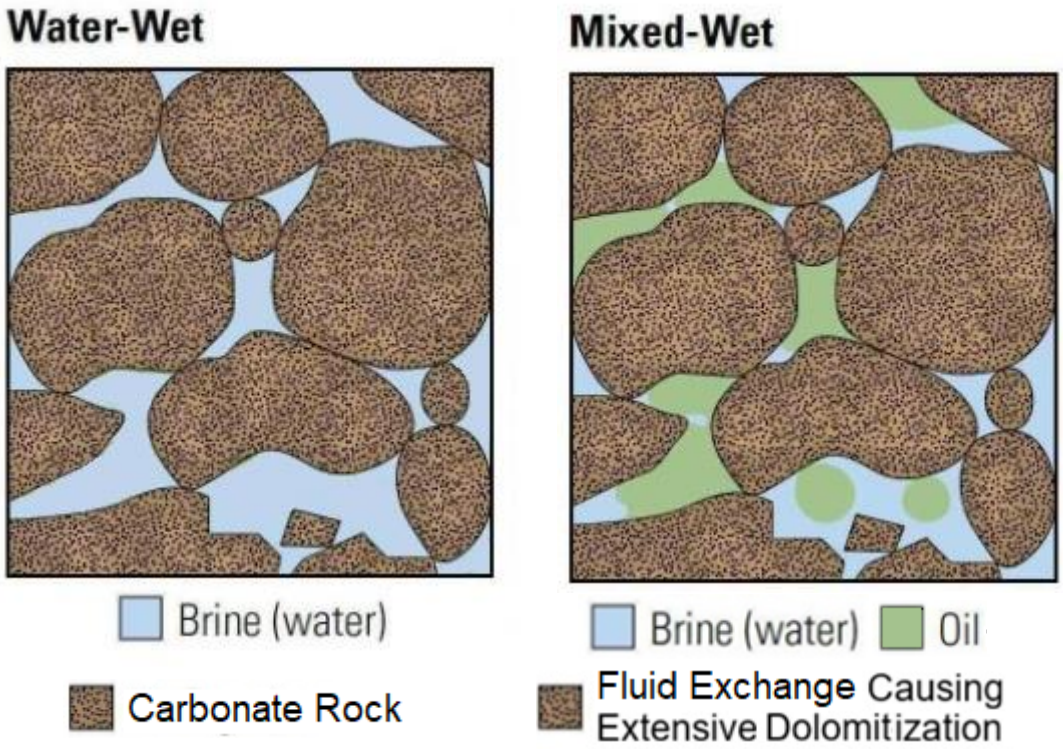
- Recent Research Conducted in the San Andres formation of the Permian Basin has added new insights to the development of mixed- and oil-wet reservoir development.
- The research conducted proposes that indigenous anaerobic processes we are calling bio-geochemical alterations have influenced wettability in very important ways.
- The attraction of oil molecules to newly formed solid surfaces while in the presence of partially biodegraded oil (providing polar functional groups) are the keys.
- The following slides outline the processes involved.

Original Carbonate Reservoir (Prior to Oil or Gas Generation)



Oil Influx to an Original Carbonate Reservoir

Oil Entrapment Phase

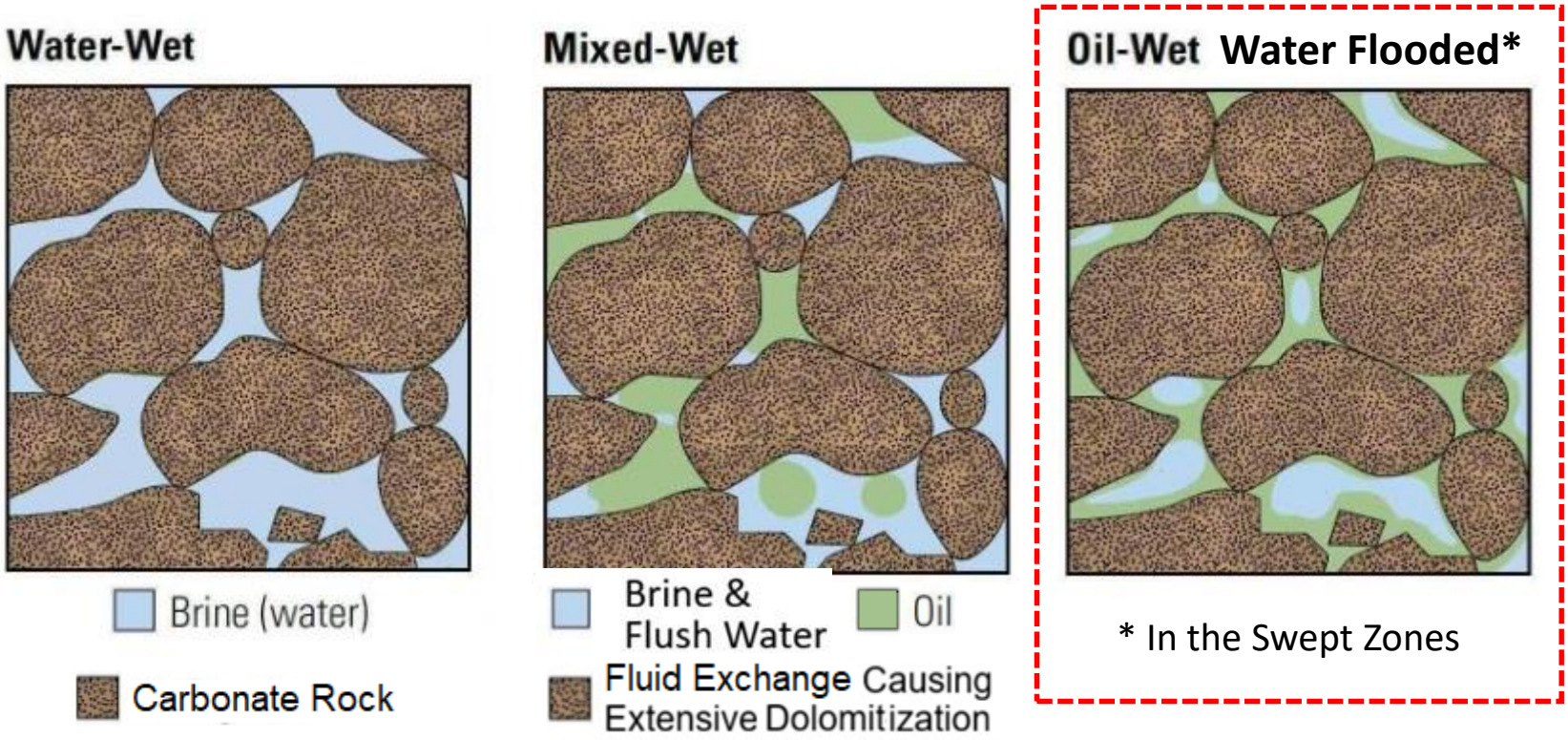


- Oil Moves in and Displaces Most of the Brine (Connate Water)
- The Flowfield and Newly Arriving Oil Allows the Microbial Geochemistry to Advance
- New Dolomite Rock Surfaces are Created and H_2S byproduct Results
- The H_2S Builds up and Microbes go Inactive (MSL*)
- New Dolomite Surfaces Preferentially Attract Oil Creating Mixed-wet Conditions

** Microbial Self Limitation*

After Primary Depletion, Man Initiates a Water Flood

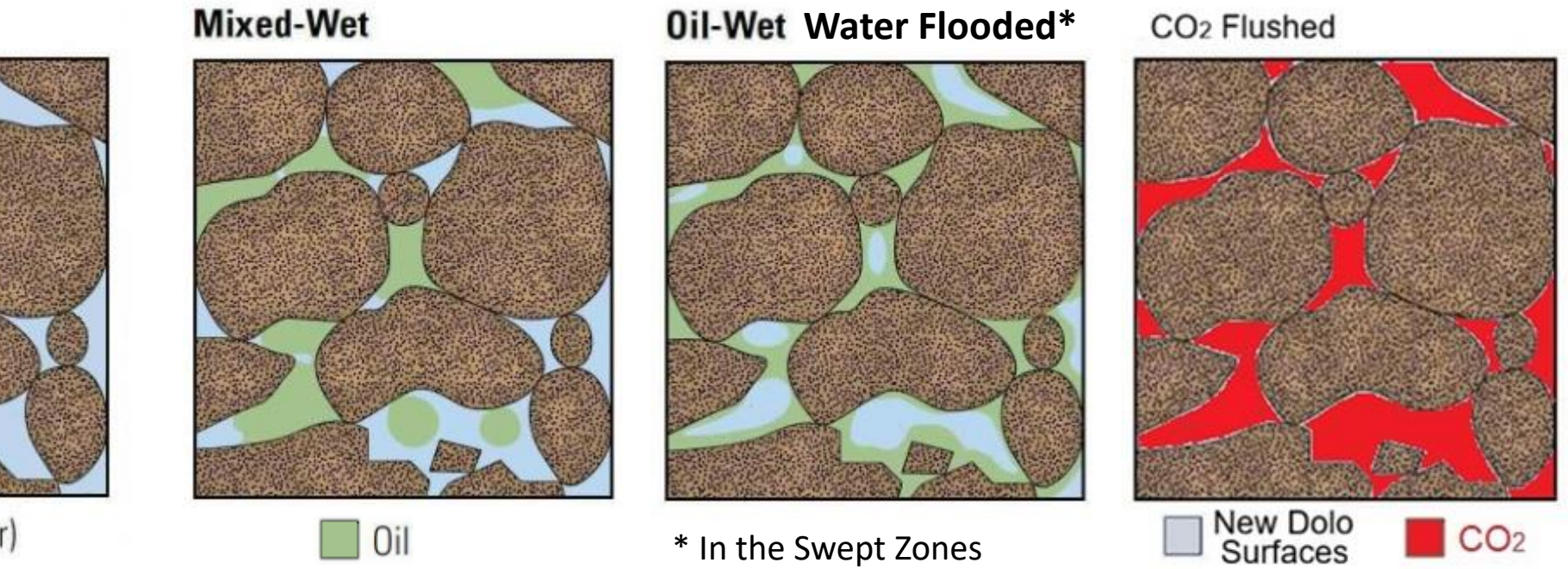
Oil Entrapment Phase



- Injected Water Displaces the Mobil Oil
- The Flow Field Reactivates the Microbes
- Oil Wettability is Enhanced
- Sweep by-passes the immobile Oil

Tertiary CO_2 Flooding

Oil Entrapment Phase

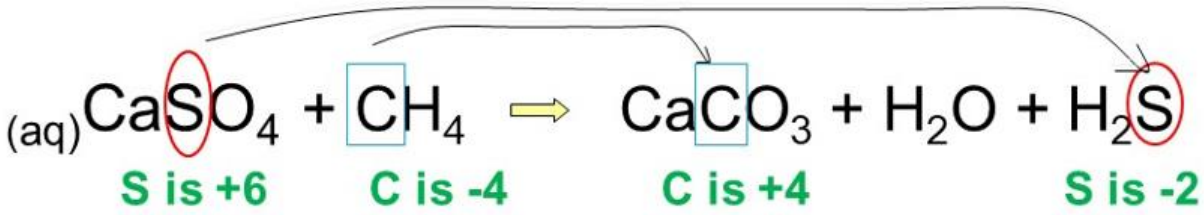


* In the Swept Zones from Man's WF and Enhanced Oil Wetting

* Sweep with Further Enhanced Oil Wetting & Pervasive Dolomitization

The CO_2 Swept Zones are Effectively Cleaned of all Oil

The Bio-GeoChemistry
Key Biogenic (Redox) Reaction



Will also Create Saturated SO_4 Conditions in the Water

We are showing Methane here as the source of carbon but… ..there is evidence it can be other hydrocarbon molecules also

- **Microbes remove 8 Electrons from the Carbon and transfer them to the Sulfur**
- **H_2S is Created and Can Inhibit Future Activity (But…A Flowfield Can Disperse)**

Souring the Oil and Gas

- **Dolomitization Typically Follows as Well**

$$CaCO_3 + Mg \Longrightarrow MgCa(CO_3)_2$$

New Dolomite Surfaces Attract Oil over Water, Re: Oil Wettability

Re: from Vance, David (2012), RPSEA II Project Chapter 4;
https://residualoilzones.com/wp-content/uploads/2019/01/RPSEA-II-ROZ-Report-10123-17-12_final-report_pdf.pdf

Summary

- The Life Processes of Indigenous Microbes are at Work Leaving:
  - Evidence of Carbon and Sulfur Electron Swaps forming:
    - New Surfaces of Late-stage Dolomite (aka 'Late-stage Diagenesis')
    - Polarized Oil Attracted to the Positively Charged Rock Surfaces
    - Pervasive Dolomitization in Continuing Flowfields
- These Processes Can be Applied to:
  - Mixed-wet Conditions formed during the Initial Entrapment's Flowfield Stage
  - When Flow Conditions Cease in Main Payzones, Further Oil Wetting also Ceases
- We are Seeing Analogous Processes that can be Applied to:
  - Mixed-wet Conditions in Arkosic and Carbonate Cemented Clastic Reservoirs
  - Mixed-wet Conditions in Reservoirs with Post Entrapment Stage Authigenic Clay formation