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Relative Permeability Damage in Undersaturated Reservoirs

Many reservoirs in the western Mid-Continent and Rocky Mountain regions are not in pressure equilibrium. They are hydrodynamic and underpressured, not hydrostatic and normal pressured. Recent work has also shown that the reservoirs are in non-equilibrium with respect to capillary pressure in the subsurface (Bennion, et al, 2000); the reservoirs are undersaturated with water for their present capillary pressure. These underpressured and undersaturated reservoirs are related because the same mechanisms that cause the underpressuring cause the undersaturation.

The sub-capillary pressure equilibrium nature of the reservoirs causes the reservoirs to have different production characteristics than would be expected if they were at capillary pressure equilibrium. Relative permeability to hydrocarbons is higher than would be predicted from standard capillary pressure and relative permeability work. These reservoirs are also easily damaged by the presence of water in any drilling and completion operations. It has been recognized that reservoir permeability can be reduced by damage induced by drilling, cementing, and completion operations. What has not been generally recognized is that these operations can also alter relative permeability, greatly reducing the hydrocarbon production from a reservoir and greatly increasing the water production.

Even though an area may contain all sub capillary pressure equilibrium reservoirs, some of the fields or reservoirs in fields may still produce when drilled with water based fluids. There are several factors that can mitigate or inhibit water imbibition and the reservoir damage that it causes. This can allow completion of the reservoirs for commercial production, but not always optimal production. The results are an interaction of reservoir architecture, wettability, initial water saturation, pressure, and permeability to different fluids.