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Quantification of Uncertainty in Recovery Efficiency Predictions: Lessons Learned from 250 Mature Carbonate Fields

The most prominent aspects of carbonate reservoirs are their heterogeneity, viable wettability and dual pore network, which collectively contribute to complex fluid flow and uncertainty in reservoir performance and recovery efficiency predictions. A review of ultimate recovery efficiency in 250 mature carbonate fields from around the world provides constraints for quantifying uncertainty in recovery efficiency predictions. Key determinants of ultimate recovery are fluid type/viscosity, pore network, reservoir geometry, drive mechanism and wettability. Development strategies and reservoir management techniques play crucial roles in maximizing expected ultimate recoveries for given reservoir/fluid parameters. Six main fluid type/carbonate reservoir classes, with characteristic ultimate recovery distributions and controls are: (1) heavy and viscous oil reservoirs, in which RF is controlled by fluid viscosity variations, field size and application of horizontal drilling; (2) karstic/fractured macroporous oil reservoirs, in which RF is controlled by matrix permeability and drive mechanism; (3) fractured microporous oil reservoirs, in which RF is controlled by fracture density and wettability; (4) conventional oil reservoirs, in which RF is controlled by reservoir quality/heterogeneity and mobility ratio; (5) organic buildup oil reservoirs, in which RF is controlled by nature and size of organic buildups and diagenetic modifications; and (6) gas/condensate reservoirs, in which RF is controlled by aquifer encroachment and condensate drop-out. Examination of actual case histories reduces uncertainty in predevelopment recovery efficiency predictions and shows what is possible in new or old fields.