Lessons Learned as Multidisciplinary Team Investigates Poor Injectivity to Optimise Current Development And Design Future Waterflood Expansion in Raudhatain-Zubair in North Kuwait

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In Raudhatain-Zubair Phase1 injection at matrix conditions started in mid-2001. The primary objective was to provide near-term pressure maintenance, understand injection characteristics, evaluate pressure response to better understand subsequent Phase2 injection and recovery of secondary reserves. Unfortunately, Phase1 injection performance was poor. Consequently, systematic investigations were undertaken to understand the cause of this poor injectivity.

Various well remedial actions have in general, been unsuccessful. Lab studies indicated that the sand was prone to progressive plugging due to the inherent small pore throat size, thus declining matrix injectivity. This highlighted that the injection water specification is a key factor for matrix injectivity. Analogs, peer reviews suggested that maintaining such rigid specification was impractical. Successively, Step Rate Tests (SRTs) indicated that desired injectivity is achievable above fracture conditions. The earlier Phase2 expansion plan had envisaged requirement of injection above fracture pressures to sustain desired injection targets. However, the SRTs indicated that the fracture gradient was greater than that assumed in the previous Phase2 plan. Therefore, Phase2 surface injection pressure requirements were redefined, resulting in significant changes to the existing design. Poor Phase1 injectivity affected pressure maintenance thus slowed production ramp-up to prevent secondary-gas production. A unique zonal depletion-plan has been developed through detailed full-field model studies to optimize current development and arrest production decline.

This paper summarizes the systematic field and laboratory investigations undertaken by an integrated team to understand Phase1 injectivity decline, the impact of higher fracture gradient on future Phase2 waterflood expansion and the unique depletion-plan that optimizes current development.