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Evaluation of Deeper Reservoir Capacity for Produced Water Disposal and CO_2 Storage Using 3D Geo-Cellular Model in Mangala Oil Field, India

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Abstract

The key oil fields in the northern Barmer Basin, currently undergoing tertiary recovery through polymer flooding, are being considered for potential full-field implementation of Alkali-Surfactant-Polymer (ASP) to further improve oil recovery. Given the consistently high-water cuts- often exceeding 90%- effective produced water management remains a key operational focus. To support this, a geo-cellular model spanning approximately 125 km^2 was developed for the Mangala field and surrounding aquifer system, aimed at assessing deep clastic reservoirs for safe water disposal and exploring the feasibility of CO_2 sequestration in the saline aquifer.

The Mangala field is a three-way fault structure, tilted approximately 10° SE. Due to limited well control in the flanks, 3D seismic interpretation played a key role in delineating structural features. Depth-converted seismic data was used to map key horizons and faults, which were integrated into a pillar grid-based structural framework. Detailed fault mapping was carried out to support dual objectives: produced water injection and long-term CO_2 storage assessment.

Reservoir property modelling involved upscaling facies and porosity logs across target intervals in Fatehgarh clastic reservoir. Facies populated using the Sequential Indicator Simulation (SIS) method, guided by depositional environment understanding and existing well data. Porosity was modelled with bias towards facies distributions and co-kriged with porosity-depth trends, which significantly influencing pore volume estimates- e.g., porosity decreases from 25% at the crest to 13% at the flank within a 1 km structural relief.

Simulation results reveal the long-term impact of 15 years of water and polymer injection, revealing notable pressure build-up in the aquifer area. This highlights the necessity for a dual strategy of water production and re-injection within the same formation to maintain pressure equilibrium. CO_2 injection simulations provide quantitative estimates of storage capacity, fault response, and CO_2 plume movement towards main field, guiding future carbon capture and storage (CCS) initiatives. The integrated modelling approach supports informed decision-making for sustainable water disposal and CO_2 storage strategies in mature hydrocarbon fields.