Modification of Seal Capacity by Carbonate Diagenesis at Peace River, Alberta, Canada - A Seal Quality Evaluation for Acid Gas Injection

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Seal capacity evaluation is important in prospect characterization for hydrocarbon exploration and for derisking acid gas injection into subsurface reservoirs. Dawson et al. (2005) showed that siliciclastic shale seal quality and capacity depend not on thickness, but on fabric, texture, organic content, mineralogy and capillary pressure of the seal. Subsequently Chevron expanded their method and applied it using eight Shale Types and six Seal Types based on fabric and petrophysical properties. Chevron linked them to the sequence stratigraphic framework, with Seal Types 1 and 6 (TSTs and condensed sections) forming the best seals.

The mixed lithology Late Devonian Ireton Formation is a regional flooding surface that is the primary seal for the Leduc carbonate shelf complex at Peace River, Alberta, Canada, which is proposed for acid gas injection. However, the Ireton is not a TST or condensed section. Shell compared seal quality in mixed carbonate-siliciclastic systems at Peace River to seals elsewhere using Chevron's methodology and calculated maximum column heights of acid gas.

Petrography and laboratory analyses indicate that Ireton shale-rich beds are excellent seals at Peace River. They vary from Chevron's six siliciclastic Seal Type classes by extensive diagenesis (dolomite cementation and recrystallization). In particular, although the Ireton was deposited as Shale Types 3 and 4 that originally probably had characteristics of Seal Types 3 or 4 (moderate to poor), diagenesis enhanced its seal capacity to Type 6 (excellent), with capillary entry pressures at 10% intrusion of 12,000 to 13,000 psi. This was also the case for Ireton samples analyzed from the currently active Leduc acid gas injector in the analog Puskwaskua Field (14,200 psi).

The overlying Mississippian Exshaw shale (upper TST deposit) is a secondary top seal for Leduc injection. Results indicate it is organic-rich, micaceous, highly laminated, clay-rich, with high entry pressures (8640 psi), and locally cemented by calcite and pyrite. It is consistent with Chevron's Seal Types 1 and 6.

This work showed that Chevron's classification scheme is a viable approach for calcareous as well as siliciclastic seals. However, care should be taken in linking the depositional system to the seal capacity interpretation. Even if the seal was not deposited as an upper TST or condensed section (Seal Type 1 or 6), later diagenesis can enhance it and provide excellent sealing capacity.