Abstract Proof

CONTROL ID: 1775705

TITLE: Fault stability and CO2 storage in the Early Paleozoic sedimentary basin of the St. Lawrence Lowlands (Quebec, Canada): insight from coupled reservoir-geomechanical modeling

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ABSTRACT BODY: A coupled reservoir-geomechanical (TOUGH-FLAC) modeling is applied to evaluate the potential shear failure along pre-existing high-angle normal faults and tensile failure in the caprock units (Utica Shale and Lorraine Group) associated with CO2 injection into the sandstone reservoir (Covey Hill Formation) of the Early Paleozoic sedimentary basin in the St. Lawrence Lowlands (Quebec, Canada). Field and subsurface data are used to estimate sealing properties of the faults. The spatial variations in fluid pressure, effective minimum horizontal stress and shear strain are calculated for different injection rates using a simplified 2D geological model of the Becancour area between Montreal and Quebec City. The simulation results show that the likelihood of reactivating two reservoir-bounding faults (Yamaska and Champlain Faults) strongly depends on reservoir pressure at the faults, which in turn depends on injection rate, hydrological properties of aquifers and the distance between the faults and the injection well. The Yamaska Fault, which is located closer (1.5 km) to the injection zone is easier reactivated than the more distant (4.4 km) Champlain Fault. In addition, fault permeability affects the timing, localization, rate and length of fault shear slip. If the fault is sealing, shear slip occurs later in time and it is localized along the fault segment (230 m) below the caprock units. If the fault is permeable, the fault reactivation starts earlier and shear slip is nucleated along the fault segment (50 m) in the caprock units subsequently progressing up to the surface. Sealing fault behaviour causes asymmetric fluid pressure build-up and lateral migration of CO2 plume away from the closer-to-injection Yamaska fault that reduces the overall risk of CO2 leakage along faults. The fluid-pressure induced tensile fracturing postdates shear failure along faults; it occurs only under extremely high reservoir pressure as a result of high injection rates, with fracturing being localized below the caprock units, which remain intact preventing upward CO2 migration.

KEYWORDS: 1822 HYDROLOGY Geomechanics, 1847 HYDROLOGY Modeling, 8010 STRUCTURAL GEOLOGY Fractures and faults, 8118 TECTONOPHYSICS Dynamics and mechanics of faulting.

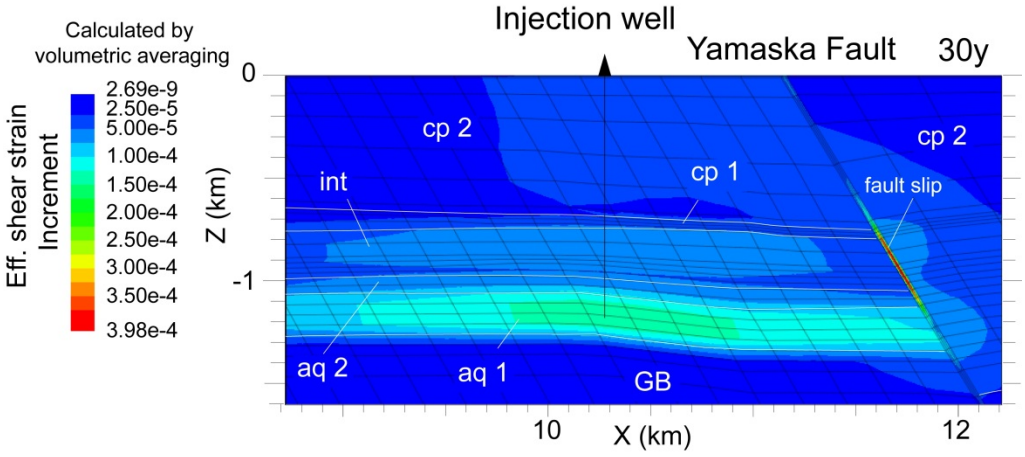

Fig. 1. Changes in effective shear strain occurred around the injection zone and along the Yamaska Fault during subsequent steps of experimental run, low injection rate, sealing fault behaviour. Fault slip occurs after 22.5 years of continued injection.