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TITLE: Three-dimensional Seismic Reconstruction of the Anisotropic Tectonic Stress for Cap-rock Integrity in the Athabasca Oil Sands, Alberta, Canada

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ABSTRACT BODY:

Abstract Body: The present tectonic stress can be completely characterized by the magnitudes and directions of the three principal stresses (vertical, maximum horizontal and minimum horizontal). For crustal rocks, stresses are composed of two parts: one caused by the pressure of the water in the pore space (formation pore pressure), and one caused by the stress between solid particles (effective stress). In-situ stresses affect both elastic and mechanical rock properties.

In the Athabasca Oil Sands basin, the Lower Cretaceous McMurray Formation reservoir is overlain by the Clearwater Formation. The formation shales form the reservoir caprock and have the role of blocking the vertical migration of the steam by confining the stresses and the deformations induced during the thermal oil recovery process.

We present a new method for the prediction of the pre-production anisotropic stress, by integrating dipole sonic logs, pore pressure data and elastic properties obtained from multicomponent seismic inversion. This new method combines the generalization of Terzaghi's law of effective stresses with the Schoenberg and Sayers linear-slip elastic stiffness matrix and the anisotropic stress correction estimated from Backus averaging the elastic properties recorded at wells.

The pore pressure is modelled from local pressure measurements which show values below the normal hydrostatic regime indicating abnormal pressure in the Clearwater Formation. The predicted total and effective magnitudes of the three principal stresses indicated correctly that the Clearwater Formation is under a normal stress regime. There is excellent consistency between the minimum horizontal stress calculated with this method and minifrac values. This good agreement shows that, for the case study, this new method successfully aids in a deeper understanding of the in-situ anisotropic stress field, which is critically important for the assessment of caprock integrity.