UTSA Earth and Planetary Sciences

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Institute for Water Research Sustainability and Policy (IWRSP)

Seminar Presentation

By

Dr. Yipeng Zhang
Hydrogeologist, Meadows Center for Water and the Environment
Texas State University

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"Impact of Pleistocene Continental Glaciations on Pore Pressure Evolution, Brine Migration, Rock Failure, and Earthquake Triggering for Integrity Assessment of Nuclear Waste Storage in High Latitude Countries"

Abstract

The effects of Pleistocene glacial loading on rock failure, permeability increases, pore pressure evolution, and brine migration within two linked sedimentary basins (the Illinois and Michigan Basins) were evaluated using a multi-physics, control volume finite element model (CVFEM). We applied this model to a generic cross section that extends across the continent of North America from the Hudson Bay to the Gulf of Mexico. Our analysis considered glacial-induced lithosphere stress changes ($\sigma yy > 35$ MPa) in response to 10 cycles of ice sheet loading. Hydrologic boundary conditions, lithosphere rheological properties, and aquifer/confining unit configuration were varied in a sensitivity analysis. We used a metric called Coulomb Failure Stress change ($\Delta CFS > 0.1$ MPa) to evaluate the potential of fault failure, and we will increase formation permeability by a factor of 100 in some simulations.

Simulation results suggest that a build-up of anomalous pore pressures up to about 3 MPa occurred in confining units during periods of glaciations, but this had only a second-order effect on triggering rock failure compared to glacial-induced stress disturbances. In regions prone to failure, permeability increases during glaciations help to explain observations of brine flushing in sedimentary basin aquifers. During the Holocene to present day, deglaciation resulted in underpressure in confining units primarily along the northern margin of the northern basin. Holocene-modern glacial-induced stress fields dissipated very rapidly and became much smaller (<0.6 MPa) compared to glacial loading periods. In contrast, the remnant pore pressures preserved in low-permeable confining units after glacier retreated, especially when a basal sedimentary basin aquifer is present, became the dominant factor in inducing rock failure and seismicity, with epicenters located up to 150 km beyond the terminus of the ice sheet.