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Fault reactivation and seismicity risk from CO_2 sequestration in the Chinshui gas field, NW Taiwan

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The Chinshui gas field located in the fold-thrust belt of western Taiwan was a depleted reservoir. Recently, CO_2 sequestration has been planned at shallower depths of this structure. CO_2 injection into reservoir will generate high fluid pressure and trigger slip on reservoir-bounding faults. We present detailed in-situ stresses from deep wells in the Chinshui gas field and evaluated the risk of fault reactivation for underground CO_2 injection. The magnitudes of vertical stress (Sv), formation pore pressure (Pf) and minimum horizontal stress (Shmin) were obtained from formation density logs, repeat formation tests, sonic logs, mud weight, and hydraulic fracturing including leak-off tests and hydraulic fracturing. The magnitude of maximum horizontal stress (SHmax) was constrained by frictional limit of critically stressed faults. Results show that vertical stress gradient is about 23.02 MPa/km (1.02 psi/ft), and minimum horizontal stress gradient is 18.05 MPa/km (0.80 psi/ft). Formation pore pressures were hydrostatic at depths 2 km, and increase with a gradient of 16.62 MPa/km (0.73 psi/ft). The ratio of fluid pressure and overburden pressure (λp) is 0.65. The upper bound of maximum horizontal stress constrained by strike-slip fault stress regime (SHmax>Sv>Shmin) and coefficient of friction (μ=0.6) is about 18.55 MPa/km (0.82 psi/ft). The orientation of maximum horizontal stresses was calculated from four-arm caliper tools through the methodology suggested by World Stress Map (WMS). The mean azimuth of preferred orientation of borehole breakouts are in $\sim$65[U+3002]N. Consequently, the maximum horizontal stress axis trends in 155[U+3002]N and sub-parallel to the far-field plate-convergence direction. Geomechanical analyses of the reactivation of pre-existing faults was assessed using 3DStress and Traptester software. Under current in-situ stress, the middle block fault has higher slip tendency, but still less than frictional coefficient of 0.6 a common threshold value for motion on incohesive faults. The results also indicate that CO_2 injection in the Chinshui gas field will not compromise the stability of faults.