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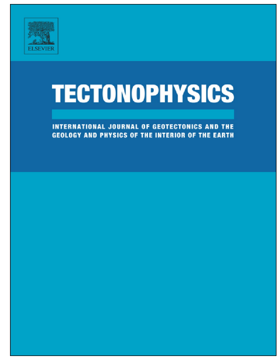

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The Correlation between Low Tectonic Stress and the Appalachian Basin Quiet Zone

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Abstract

In order to assess the nature of the Appalachian Basin Quiet Zone (ABQZ), a region of low seismic activity, a minimum horizontal stress profile from sonic logs was calibrated using hydraulic fracture stress measurements in a well from McKean County, PA. The calibrated minimum horizontal stress profile that best fits with the hydraulic fracture stress data was established using an extended Eaton's model that treats rock as a transverse isotropic material with a vertical symmetry axis (TIV). To achieve a best fit, several assumptions are introduced: (1) a constant tectonically-induced elastic strain of ε_{Hmax} = 3.3 x 10^{-4}, (2) an anisotropic velocity model ANNIE approximation for shales, and (3) a bimodal pore pressure distribution with abnormally high pore pressure in a gas shale. Other calibration methods assume an isotropic medium, a constant tectonic strain gradient corresponding to zero stress at ground surface, or constraints from sidewall core data to estimate stiffness constants. By testing four calibration methods, we find that stress profiles are slightly affected by multiple factors, including the ratio of maximum tectonically-induced elastic strain over minimum tectonic strain, pore pressure in Marcellus, Biot's coefficients, and elastic properties. Sensitivity analysis was conducted to analyze the influence of these parameters. Our stress profile is most influenced by pore pressure and tectonically-induced elastic strain while other factors had much smaller effects. Tectonically-included strain in the ABQZ is insufficient to achieve the critical stress necessary to induce frictional slip on favorably oriented faults in the sedimentary cover which presumably speaks to the lack of earthquakes in the basement of the ABQZ. However, induced earthquakes from deep disposal wells suggest that basement at the edge of the ABQZ may be decoupled from the sedimentary cover, in which case the cover has relaxed through a time-dependent deformation mechanism such as pressure solution creep.