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## Stress field and natural fracture systems in Lower Paleozoic shale belt in Poland based on borehole images

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Borehole images from wells at Syczyn, Berejow, Gozdzik, Streczyn, Uscimow and Stoczek along the East European margin in Poland were investigated for structural features. Wellbore instability features were used to calculate earth stress, borehole stability and fracture stress.

At Uscimow, basinal tilt to SW during Cambro-Ordovician was followed by straight subsidence during Silurian, and post-Silurian (Hercynian?) tilt *en-bloc* as seen at Syczyn and Berejow. At Stoczek, a N basin tilt before Silurian deposition is likely. WSW dipping faults were found in all 4 wells. At Streczyn, a conjugate shallow ENE set was also found. These faults are not seen on seismics. They can be assigned a Hercynian origin with general tectonic transport towards ENE, but recently reactivated, as we note stress-deflection at Streczyn.

Densely spaced NNE-SSW trending subvertical fractures are found in Uscimow, Streczyn and Berejow wells. Steep ENE dipping fractures were found in addition at Berejow and Streczyn, whereas at Syczyn and Stoczek, this set dominates. NNE dipping steep fractures were also found in lower part of the Silurian at Uscimow. All steep fractures seem to constitute a strike-slip set in response to a general N-NNE horizontal stress; alternatively, they formed by hydraulic tension and later slipped tectonically. The fractures remain sensitive to strike-slip in the current stress field with the exception that at Stoczek, the stress is aligned with the fracture strike.

Both principal horizontal stresses are high, placing the area in strike-slip regime. There is high horizontal stress anisotropy but due to rock strength and low fluid pressure, the vertical wells are quite stable to drill. The regime is favourable for drilling horizontal wells along the minimal stress axis. An FEM model with anisotropic material further explains the compressional and tensional stability of Syczyn and Berejow laterals.

There are no obvious low-ν zones in Silurian to constrain upward escape of artificial fractures apart from some thin tuff horizons, but the strong anisotropy of shale should favour horizontal propagation. The Ordovician limestone is also very stiff, hence fracture prone, so fractures may also escape downwards. These facts are supported by microseismics from fracturing of a Syczyn bed-parallel lateral. There is some evidence of overpressure in the lower part of the Silurian, which would make it more prone to fracturation and help constrain artificial fractures to the lower (prospective) horizon.