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Tectonic context of the penetrative fracture system origin in the Early Paleozoic shale complex (Baltic Basin, Poland/Sweden).

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Characterization of natural fracture and fault pattern play significant role for reservoir stimulation design and evaluation of its results. Having structural observations limited to immediate borehole surrounding it is a common need to build up a fracture model of reservoir in a range of stimulation reservoir volume or even beyond. To do this we need both a 3D seismic model and a consistent concept of the regional tectonic evolution. We present the result of integrated tectonic study in several deep boreholes target the Lower Paleozoic shale complex of Baltic Basin (BB), combined with analysis of 3D seismic survey and outcrop screening in Scania (Swedish part of the BB).
During deposition of shale complex in the Ordovician and Silurian the research area was located 200-300 km away from the continental margin of Baltica involved in the Caledonian collision with the Eastern Avalonia. This distance allowed the shale complex to avoid significant tectonic deformation. Regional seismic cross section reveals the general pattern of the BB infill characteristic for the foreland basin underwent post-collisional isostatic rebound. Due to stress changes in collisional context the shale complex was cross-cut by steep, mostly inverse faults trending NW-SE and NE-SW. The fault zones oriented NW-SE are associated with an array of en echelon faults characteristic for strike-slip displacement. In our interpretation, these faults of Silurian (Wenlock) age create pattern of the regional pop-up structure, which is simultaneously involved in the plate flexure extension. Seismic attributes (e.g. curvature or ant tracking) highlight lineaments which mostly mimic the faults orientation. However, attributes show also some artefacts that come from regular array of seismic sources and receivers, which mimic the orthogonal joint system.
Structural observations on borehole core lead us to conclusion that regular, orthogonal fracture system developed after maximum burial of the complex, triggered by mechanism of natural hydraulic fracturing due to hydrocarbon generation. These fractures create veins filled with calcite that growth was controlled by mechanical layering and the TOC content of the shale complex. The main joint fracture pattern is stable across at least 300 hundred kilometers, from the Polish to Swedish portion of Baltic Basin. Therefore a major tectonic event is expected to govern its origin. The Late Carboniferous thin-skinned compression exerted at the edge of the East European Craton, is preferred tectonic fracture triggering factor. This age of jointing is confirmed by the strike of principal joint set characteristic for Variscan compression. In addition, principal joint system is sensitive (=younger) to a presence of the Caledonian-age faults in Pomerania but insensitive (=older) to the Mesozoic faults in Scania. Above genetic considerations should be taken into account while building the self-consistent discrete fracture network of faults and fractures for the purpose of shale reservoir stimulation.