Combined Seismic Attribute Analysis and Structural Restoration as Effective Tool for Prediction of Fault Geometry at Depth and Fracture System Modeling: Case Study From the Lublin Basin (South East Poland)

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ABSTRACT

Modern techniques of seismic acquisition and processing provide high quality images of geological structures at depth. In areas characterized by complex tectonic setting, (steep folds limbs and fault surfaces), application of structural seismic attribute analysis coupled with restoration techniques may improve the interpretation quality. The main goal of our research was to constrain geometry and kinematics of basement fault within the 'Wierzbica 3D' survey located in the eastern part of the Lublin Basin (LB). LB extent is defined by the present-day occurrence of Carboniferous deposits that rest uncomfortably on older Paleozoic strata under flat-lying Mesozoic cover. The LB has been focus of hydrocarbon exploration for several decades, including recent intense shale gas exploration. Its sub-Carboniferous structure formed in latest Devonian - earliest Carboniferous (Bretonian phase) due to NW-SE compression and development of high angle, reverse basement faults. The Late Carboniferous (Variscan) SW-NE compression did not overprint structures in the studied area. 'Wierzbica 3D' survey reveals tight fold in Devonian strata, cut in part by post-Bretonian erosion and covered by generally flat-lying Carboniferous sequence. Ca. 1 km of Silurian shales underlies Devonian strata and rest on thin (~100 m) Ordovician carbonates and > 600 m Ediacaran-Cambrian siliciclastics. Distinct Ordovician and crystalline basement top reflections end abruptly below the preserved SW fold limb. Faults and fractures interpretation from structure-oriented filtered 3D cube was based on coherence and curvature attributes. Volumetric geometrical attributes provided information about fractures distribution and orientation. The main reverse ENE-striking fault zone and associated fault splays resembling horsetail structure cut Precambrian-Ordovician strata. Trishear model has been chosen to take into account mechanical contrasts between relatively brittle Precambrian-Ordovician and Devonian strata separated by ductile Silurian shales. Presence of these shales led to development of fault-related fold within the Devonian strata above the high-angle basement fault. Formation of fracture sets was related to the two mechanisms operating during the Bretonian tectonic phase: fractures within the Ediacaran-Ordovician section developed due to reverse and strike-slip motion on the main fault, while in the Silurian and Devonian section they propagated within the trishear zone due to increased shear.