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Estimating Effective Seismic Anisotropy Of Coal Seam Gas Reservoirs from Sonic Log Data Using Orthorhombic Buckus-style Upscaling

Lutz Gross (1) and Stephen Tyson (1,2)

(1) The University of Queensland, School of Earth Sciences, St Lucia, Australia (l.gross@uq.edu.au), (2) The University of Queensland, Center for Coal Seam Gas, St Lucia, Australia (s.tyson@uq.edu.au).

Fracture density and orientation are key parameters controlling productivity of coal seam gas reservoirs. Seismic anisotropy can help to identify and quantify fracture characteristics. In particular, wide offset and dense azimuthal coverage land seismic recordings offers the opportunity for recovery of anisotropy parameters. In many coal seam gas reservoirs (eg. Walloon Subgroup in the Surat Basin, Queensland, Australia (Esterle et al. 2013)) the thickness of coal-beds and interbeds (e.g mud-stone) are well below the seismic wave length (0.3-1m versus 5-15m). In these situations, the observed seismic anisotropy parameters represent effective elastic properties of the composite media formed of fractured, anisotropic coal and isotropic interbed. As a consequence observed seismic anisotropy cannot directly be linked to fracture characteristics but requires a more careful interpretation. In the paper we will discuss techniques to estimate effective seismic anisotropy parameters from well log data with the objective to improve the interpretation for the case of layered thin coal beds.

In the first step we use sonic log data to reconstruct the elasticity parameters as function of depth (at the resolution of the sonic log). It is assumed that within a sample fractures are sparse, of the same size and orientation, penny-shaped and equally spaced. Following classical fracture model this can be modeled as an elastic horizontally transversely isotropic (HTI) media (Schoenberg & Sayers 1995). Under the additional assumption of dry fractures, normal and tangential fracture weakness is estimated from slow and fast shear wave velocities of the sonic log. In the second step we apply Backus-style upscaling to construct effective anisotropy parameters on an appropriate length scale. In order to honor the HTI anisotropy present at each layer we have developed a new extension of the classical Backus averaging for layered isotropic media (Backus 1962) . Our new method assumes layered HTI media with constant anisotropy orientation as recovered in the first step. It leads to an effective horizontal orthorhombic elastic model. From this model Thomsen-style anisotropy parameters are calculated to derive azimuth-dependent normal move out (NMO) velocities (see Grechka & Tsvankin 1998).

In our presentation we will show results of our approach from sonic well logs in the Surat Basin to investigate the potential of reconstructing S-wave velocity anisotropy and fracture density from azimuth dependent NMO velocities profiles.