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Seismic Anisotropy of Sedimentary Rocks: A Unique Probe of Rock Fabric

Seismic anisotropy in sedimentary rocks arises from the partial alignment of anisotropic minerals, grains, microcracks, fractures, bedding planes and heterogeneities on a length scale smaller than the seismic wavelength. An anisotropic rock fabric also leads to permeability anisotropy which must be accounted for in order to optimize production from hydrocarbon reservoirs. The relative importance of the different components of the rock fabric in determining the seismic anisotropy of sedimentary rocks is discussed. For shales, the seismic anisotropy results primarily from the partial alignment of anisotropic clay minerals, and is a function of the fluid content and compaction of the rock. In reservoir rock, the most important cause of seismic anisotropy results from discontinuities such as microcracks, fractures and grain contacts. The compliance of such discontinuities change with changes in applied stress and pore pressure, resulting in variations in seismic anisotropy during production. The seismic anisotropy arising from the presence of partially aligned discontinuities can be written in terms of a second and fourth rank tensor. These expressions allow the components of these tensors to be obtained by inverting measurements of seismic anisotropy. This opens up the possibility of predicting permeability anisotropy from seismic anisotropy. Examples where this is and is not possible are discussed by comparing the permeability and elastic stiffness tensors for an anisotropic interconnected network of fractures, and for a partial alignment of unconnected fractures in a permeable background medium.