Understanding Seismic Anisotropy in Exploration and Exploitation: *Hands on*

A four-day course, covering all areas of seismic anisotropy

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Course description

All rock masses are seismically anisotropic, but we often ignore this in our seismic acquisition, processing, and interpretation. The anisotropy nonetheless does affect our data, in ways that limit our effectiveness in using it, if we ignore that anisotropy. In this short course, we will understand why this inconsistency between reality and practice has been so successful in the past, and why it is less successful now and in the future, as we acquire better seismic data, and correspondingly higher expectations of it. We will further understand how we can modify our practice so as to more fully realize the potential inherent in our data, through algorithms which recognize the fact of seismic anisotropy. To use the seismic data for subsurface physical characterization, we will require the application of anisotropic rock physics. This more realistic basis for seismic exploration and exploitation is particularly important (naturally!) for the shale resource. We will see that the anisotropy, although always weak (when defined as a rock property), has weak effects on some seismic data, strong effects on other seismic data, and sometimes completely novel effects. The course is accompanied by numerous class exercises, presented in .xls format.

1. Physical principles (Day 1)
    - A. Definition of anisotropy
    - B. Anisotropy *vs.* heterogeneity
    - C. Anisotropy as a function of scale
        - *i. Exercise: Thin layers*
    - D. Elasticity and Symmetry
        - ii. Polar anisotropy
            - *a. Exercise: Plane wave velocities*
        - iii. Azimuthal Anisotropy
    - E. The Power of Notation

2. P-waves: imaging (Day 1, 2)
    - A. Polar anisotropy
        - *I. Exercise: Wavefronts*
        - *II. Exercise: Effective eta*
    - B. Azimuthal anisotropy
        - I. Tilted polar anisotropy
            - *a. Exercise: Tilted polar anisotropy*
        - II. Orthorhombic anisotropy
        - III. Monoclinic anisotropy
    - C. Slowness ellipses
        - *I. Exercise: Azimuthal NMO*

3. P-waves: characterization (Day 2, 3)
    - A. Polar anisotropy
        - I. Velocities: lithology, geomechanics, fluids, pore pressure
            - *a. Exercise: Compliance anisotropy*
            - *b. Exercise: Fluid dependence of anisotropy*
        - II. Amplitudes: lithology, fluids
            - *a. Exercise: P-AVO*
    - B. Azimuthal anisotropy
        - *I. Exercise: P-AVOAz*
    - C. Stress and Fractures

4. S-waves: (Day 3)
    A. Polar anisotropy
        I. *Exercise: SV Triplication*
    B. Azimuthal anisotropy: S-wave splitting
        I. *Exercise: 2Cx2C rotation*
    C. Crossed-dipole sonic data

5. C-waves: (Day 4)
    A. C-wave basics
        I. *Exercise: C-waves*
    B. Polar anisotropy
    C. Azimuthal anisotropy: C-wave splitting
        I. *Exercise: Vector infidelity*
        II. *Exercise: 2C rotation*

6. Epilogue: (Day 4)