Phase decomposition and its applications

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Summary

Phase decomposition is a novel technique that decomposes a composite seismic signal into different phase components, which can improve reservoir characterization. The technique is particularly useful in those areas where thin-bed interference causes the phase of the input seismic response to differ from the phase of the embedded wavelet in the data. For a zero-phase wavelet in the data and thin low-impedance layers below tuning thickness, the waveform phase response generated after carrying out phase decomposition is found to be -90^o, which stands out anomalously. A correspondingly high-impedance thin layer exhibits a similar +90^o phase waveform response. By generating a synthetic response with use of well data and a zero-phase wavelet, such observations for thin reservoir layers can be understood with confidence and correlated with real seismic data. Phase decomposition can help immensely in direct interpretation of seismic data in terms of reservoir and non-reservoir zones, amongst other applications.

Another important aspect that may be mentioned is that the seismic waveform is amplitude, phase, and frequency dependent. Consequently, for thin layers below tuning, the frequency content of the associated seismic response must be monitored for targets with variable thicknesses. Phase decomposition does not use well data for the generation of phase components, but the synthetic traces generated from well data can be used to establish the relationships between amplitude/phase/frequency that may be desirable for a given problem. In this context, application of spectral decomposition to a synthetic trace could produce a frequency gather and provide the required frequency dependent behavior. Likewise, the application of phase decomposition to the generated synthetic gather will provide a set of phase component gathers. Thus, between the spectral and phase decomposition applications, the desired amplitude/phase/frequency information can be sought.

Phase decomposition could serve as a tool for direct interpretation of data in terms of impedance variations as well as a reconnaissance tool. For doing these interpretations, not only the phase gathers but the individual phase components can also be generated, the ones at 0^o, 180^o, -90^o and +90^o appearing to be more useful. The first two phase components can be combined into an 'even' component volume, and the latter two into an 'odd' component volume. Thin-bed seismic anomalies associated with hydrocarbons can be conveniently analyzed by interpreted these two data volumes.

In many regions around the world the production is expected from thin sandstone or carbonate reservoirs. Because the seismic waves are bandlimited with low-frequency content, a thin reservoir implies that the thickness of the reservoir is at or less than a quarter wavelength of the seismic waves. In such thin reservoirs the reflection response would comprise interference of reflections from the top and the base of the thin layers. Exercises aimed at characterizing thin reservoirs frequently neglect such interference effects, resulting in inaccurate reservoir characterization. The phase decomposition discussed above finds useful applications subject to some caveats in that the seismic data being considered have a zero-phase embedded wavelet, the thicknesses of the zones of interest are at or below tuning at the CWT frequency used and the seismic response has absence of interference from adjoining reflectors.