TWO-COMPONENT RECORDING WITH A P-WAVE SOURCE TO IMPROVE SEISMIC RESOLUTION

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Abstract. In two-component seismic observations with vertical and in-line horizontal geophones, the compressional (P-) wave amplitudes, as well as the vertically polarized shear (SV-) wave amplitudes, are observed on both vertical and horizontal geophones. In our case, we use a P-wave source, while the SV waves are the result of mode conversion. The mode-conversion mechanism considered here is related to the near-surface layers, i.e. we have a P-leg from the source and mode conversion at/in the weathered layer. The resulting SV waves therefore will show lateral variations because the elastic parameters of the near-surface layers vary along the seismic line, but these variations will be consistent at the surface. This effect is demonstrated by a synthetic example based on elastic parameters representative of the actual seismic line being considered. To separate the individual P and SV arrivals, we apply a two-dimensional convolution filter designed to meet the wavenumber-frequency ($k$-$f$) domain transfer function for P-SV separation which can be derived from the $k$-$f$ domain geophone-receiving characteristic and the near surface P- and S-wave velocities. The reason for P-SV separation filtering in the offset-traveltime ($X$-$T$) domain instead of directly filtering in the $k$-$f$ domain, is a great saving in computer time, as $X$-$T$ filters, with few coefficients, can be used. In this paper, after a short summary of the $k$-$f$ domain P-SV separation filters and their transformation to the $X$-$T$ domain, we apply the $X$-$T$ filters to synthetic data in order to demonstrate that our design is correct. We also work on actual data and discuss the problems being faced, which mainly originate from the different geophone groups and, as a consequence, the different scalings of vertical and horizontal geophones. The main advantage of two-component seismic observations is two-fold: firstly, a clean P-wave section is obtained (SV-energy arriving at the receivers is cancelled by applying theforesaid separation filter) and, secondly, we obtain an additional SV-wave section at almost no cost to data acquisition. These two sections contribute towards distinguishing between true and false bright spots, so they are used as direct hydrocarbon indicator tools.

1. Introduction

The advantages gained by recording more than only the vertical component of a P-wave source are well known. However, a Full-component recording would consist of nine components, i.e.

(a) P-wave source, recorded with three components,
(b) SV-wave source, recorded with three components, and
(c) SH-wave source, recorded with three components.

In theory, only this $3 \times 3$-component data acquisition would allow us to deal with phenomena, as there are shear-wave-splittings due to anisotropy for example, but despite the fact that drilling is expensive and data is difficult to process, this effort
of acquiring a full-component data set will only be justified under very specific circumstances.

In this paper, we discuss a simplified data-acquisition scheme, which is based on a P-wave source and two-component recording. The underlying principle is depicted in Figure 1. Two separate recordings, one with a P-wave source and the second one with a SV-wave source, can be replaced by a single P-wave source and a two-component recording. Some specific properties related to such data sets, including possible problems and solutions, will be discussed.

Finally, an actual data example will show that sufficient information to distinguish between ‘true’ and ‘false’ amplitude anomalies in terms of direct hydrocarbon indicators (DHI) (Neidell, 1985) can be derived. This result has to be seen in the light of the statement given by Errico et al. (1981) who describe the general geo-