
Using Low-Frequency Ambient Seismic Vibration Spectra to Detect Hydrocarbon Reservoirs – a Numerical Approach

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Ambient vibration measurements are successfully applied to identify and characterise low-velocity surface layers (Nakamura, 1989). The method is based on the analysis of characteristic features of the ratio between the amplitude spectra of the horizontal and vertical ground motion (H/V-ratios) caused by the ambient vibration.

Similar to such features in the Nakamura H/V-ratios, characteristic signatures can occur in the spectra of the ambient vibration, which are likely to be caused by hydrocarbon bearing structures in the subsurface. During several measurement campaigns conducted by Spectraseis Technologie AG at different oil field locations throughout the world, the presence of such signatures was observed and a high degree of correlation to the presence of hydrocarbon reservoirs could be established.

In this paper the impact of hydrocarbon bearing structures on the surface velocity spectra is investigated by numerical simulations. The numerical algorithm is based on 2D explicit finite differences with staggered grids, and solves the elastodynamic equations which are formulated as a first-order hyperbolic system. The ambient vibration wave field is generated using the method proposed by the SESAME project (Site Effects Assessment Using Ambient Excitation). The model domain consists of a 3 km wide and 2.5 km deep elastic body. The hydrocarbon bearing structure is represented by a 100 m thick and 1000 m wide layer, located in 500 m depth, which has different geophysical properties than the surroundings.

Results show significant pattern changes of the surface velocity spectrum depending on the magnitude of various parameters. The characteristic spectral patterns can therefore identify potential hydrocarbon bearing structures similar to the Nakamura H/V-ratio peaks for identifying low-velocity surface layers.
