Synthetic Wide-angle Seismic Data in Gas Hydrate and Free Gas Bearing Sediments: A Virtual OBS Case Study

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ABSTRACT

In the last decade, vast areas of sediments bearing gas hydrates and free gas have been discovered offshore southwestern Taiwan. Until samples of these hydrates can be recovered, much of our ability to propose estimates of free gas and gas hydrate saturation values relies on the analysis of seismic data. Thus, we conduct a theoretical investigation in order to comprehend the seismic wave propagation in gas hydrate and free gas saturated sediments. Variations of the compressional velocity, shear wave velocity, and density are examined with respect to the host sediment's composition, porosity, cementation, and the concentration of hydrates and free gas. Amplitude versus offset behavior at the base of the hydrated zone and at the top of the free gas zone is reviewed. Hence, a far better estimate of the hydrate saturation is available when both compressional and shear wave velocities are measured. These elastic properties can be retrieved from the inversion of acoustic and P-S converted seismic data, recorded by four component OBS stations. In the second part of this paper, we present a series of synthetic case studies consistent with OBS surveys conducted in Taiwan's vicinity. Thus, we describe the seismic wave propagation within a set of original tools, such as ray tracing and full elastic forward modeling. Ray paths, amplitudes, reflection and transmission, as well as the complex conversion modes arising from hydrate and free gas bearing layers are studied. Hence, the characteristics of the arrivals in the synthetic seismograms are quantified with respect to variations in the models. We then introduce methods to estimate the shear velocities above the BSR and the thickness of the free gas layer. This study constitutes a "play ground" to improve our comprehension of the seismic wave propagation in the presence of gas hydrates and free gas, and test the interpretations of OBS records in natural environments within a virtual OBS.

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