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Characteristics of gas hydrate and free gas offshore southwestern Taiwan from a combined MCS/OBS data analysis

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Abstract

In this study, we present the results of the combined analyses of ocean bottom seismometer and multi-channel seismic reflection data collection offshore southwestern Taiwan, with respect to the presence of gas hydrates and free gas within the accretionary wedge sediments. Estimates of the compressional velocities along EW9509-33 seismic reflection profile are obtained by a series of pre-stack depth migrations in a layer stripping streamlined Deregowski loop. Strong BSR is imaged over most of the reflection profile while low velocity zones are imaged below BSR at several locations. Amplitude versus angle analysis that are performed within the pre-stack depth migration processes reveal strong negative P-impedance near the bottom of the hydrate stability zone, commonly underlain by sharp positive P impedance layers associated with negative pseudo-Poisson attribute areas, indicating the presence of free gas below the BSR. Ray tracing of the acoustic arrivals with a model derived from the migration velocities generally fits the vertical and hydrophone records of the four ocean-bottom seismographs (OBS). In order to estimate the Poisson's ratios in the shallow sediments at the vicinity of the OBSs, we analyze the mode-converted arrivals in the wide-angle horizontal component. P-S mode converted reflections are dominant, while upward P-S transmissions are observed at large offsets. We observe significant compressional velocity and Poisson's ratio pull-down in the sediment below the BSR likely to bear free gas. When compared to Poisson's ratio predicted by mechanical models, the values proposed for the OBSs yield rough estimates of gas hydrate saturation in the range of 0–10% in the layers above the BSR and of free gas saturation in the range of 0–2% just below the BSR.

Introduction

Gas hydrates are ice-like non-stochiometric crystalline solids composed of a hydrogen bonded water lattice entrapping low-molecular weighted gas molecules commonly of methane. Gas hydrate form under specific conditions of relative high pressure and low temperature, when the gas concentration exceeds those which can be held in solution, both in marine and on-land permafrost sediments (Sloan, 1998). Commonly, gas hydrates occupy more than 1% of the bulk sediment volume, resulting in 5–15% saturation of the pore space depending on the porosity (e.g. Paull et al., 1996; Dickens et al., 1997; Guerin et al., 1999). A thick stratum bearing free gas often underlies the hydrated layer.

Gas hydrates have been recovered at numerous locations, from shallow cores as well as on-land (permafrost) and offshore drill sites (Booth et al., 1998). Gas hydrate often occur as segregate bodies in the form of lenses, nodules, pellets, or sheets where the hosts sediments are fine grains (clay and silts), and only display an interstitial or cementing feature in coarser grained lithologies. At the Cascadia margin, ODP Leg 141 Sites 889, 890 and 892 penetrated the gas hydrate stability zone and underlying free gas layer (MacKay et al., 1994). While small pellets and occasionally massive pieces of hydrates were recovered in the shallow silt clays, gas hydrate appeared concentrated at several horizons, often characterized by coarser grained sediments, within the tectonized strata of the accretionary wedge (Kastner et al., 1996;