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Identification and characterisation of seismic anomalies associated with the gas hydrates in the Southern Hikurangi Margin, New Zealand

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Summary

The Hikurangi Margin, east of the North Island of New Zealand, contains a significant gas hydrate province. However, the distribution, concentration and dynamics of hydrate accumulations in the southern portion of the margin (the Pegasus Sub-Basin) off the northeastern coast of the South Island are poorly constrained. In late 2009 and early 2010, a seismic dataset consisting of approximately 3000 km of 2D seismic data was collected in the Pegasus Sub-Basin. The Pegasus Sub-basin is located in the zone of transition between the tectonic regimes of North Island subduction and South Island transpression. The seismic data were acquired using a 12-km-long streamer, providing a grid of data over an area of ~35,000 km2, and providing acquisition geometries that facilitate studies based on amplitude variations with offset. Bottom-Simulating Reflections (BSRs) are abundant in the data, and they are supplemented by other features that may indicate the presence of free gas and gas hydrates in zones of high concentration. We present initial observations and results from the study, including the identification of specific features such as blanking, bright spots (high-amplitude anomalies) and flat spots (indicating potential fluid contacts).

Keywords: *Gas hydrates, active margin, seafloor fluid flux, bottom simulating reflections, multi-channel seismic reflection.*

Introduction

Characterisation of the gas hydrate province on the Hikurangi Margin east of New Zealand's North Island has been primarily based on analysis of multi-channel seismic data from regional and focused surveys (e.g., Henrys et al., 2003, Barnes et al., 2010, Crutchley et al., 2010, Pecher et al., 2005, Pecher et al., 2010). The data presented here come from a New Zealand government (Crown Minerals) survey that was undertaken in late 2009 and early 2010 in the Pegasus Sub-basin to stimulate exploration in this region for conventional hydrocarbons. (Fig. 1).

The Pegasus Sub-basin is located in the zone of transition between the tectonic regimes of North Island subduction and South Island transpression. Roughly 3000 km of multi-channel seismic reflection data were acquired using a 12-km-long streamer, providing a grid of data over an area of ~35,000 km2. In addition to helping characterise the conventional hydrocarbon potential of the basin, these new data also provide us with unique opportunities to examine New Zealand's continental margin in this region for gas hydrates (Fraser et al., 2011). In particular, the acquisition geometries used facilitate studies based on amplitude variations with offset.

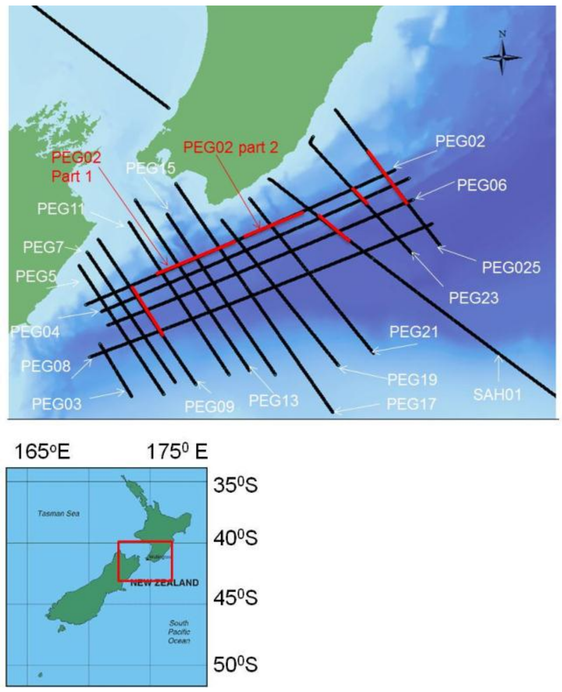

Figure 1: Location of Pegasus survey lines acquired in late 2009 and early 2010 in the southern part of the Hikurangi Margin. Locations of seismic data shown here are indicated in red.

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Initial Observations and Analyses

The primary seismic indicators of a gas hydrate systems are Bottom-Simulating Reflections (BSRs). These are abundant in the Pegasus data. A classic example (Fig. 2) shows how the phase change from hydrate to free gas and water at the base of hydrate stability can result in striking amplitude changes in a clastic sedimentary system. In particular, note how the seismic response of an inferred porous sand unit changes from a strong trough-peak-trough below the BSR to a strong peak-trough-peak above the BSR, corresponding to gas charged and hydrate filled porosity, respectively. Other units show high-amplitudes below the BSR, but no significant change above the BSR, which suggests that the concentration of hydrate in these units is limited.

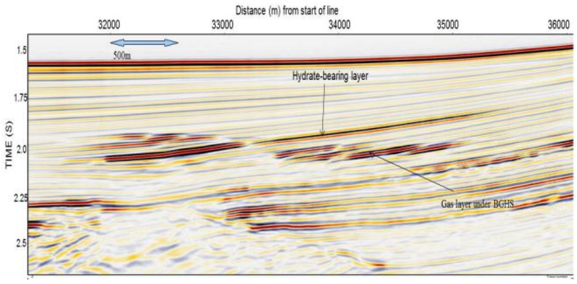

Figure 2: Part of line PEG25 highlighting the amplitude response of gas and hydrate saturation of sediments at the base of the hydrate stability zone.

Another striking example of a BSR co-incides with an extensive region of suppressed amplitudes at the base of the hydrate stability zone within a regional anticlinal feature (Fig. 3). This has been interpreted as a zone where hydrate has partially filled the pore space. Below the BSR, amplitudes are increased, which is interpreted to be the result of trapped gas in the sediments. Distorted reflections in the centre of the feature, co-incident with the apex of the anticline, may indicate a central chimney structure where focused upwelling of fluids may have occurred.

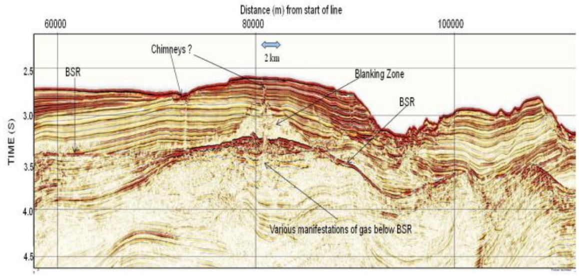

Figure 3: Part of line PEG02 highlighting a reduced amplitude anomaly in the lower half of the hydrate stability zone.

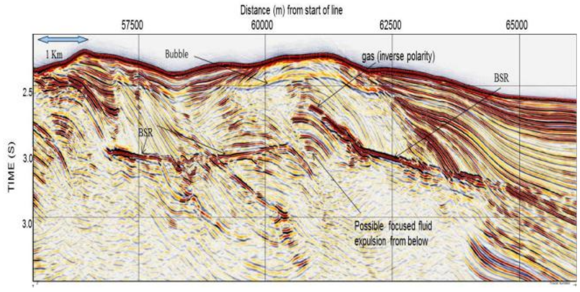

Figure 4: Part of line PEG23 highlighting a locally raised BSR.

Increased upward fluid flow should result in a locally raised base of the hydrate stability zone, and therefore a raised BSR as well. The seismic data show several examples of this, particularly in locations where focused fluid flow may occur through anticlines (Fig. 4), stacked stratigraphic packages or fault systems.

BSRs are supplemented by other features that may indicate the presence of associated free gas and highly-concentrated zones of gas hydrates. One example is a possible pull-down effect resulting from a low-velocity gas-filled unit trapped beneath an anticlinal ridge and capped by a BSR (Fig. 5). Another example contains bright spots and flat spots at the base of the hydrate stability zone (suggesting potential fluid contacts) similar to those seen in conventional hydrocarbon provinces (Fig. 6).

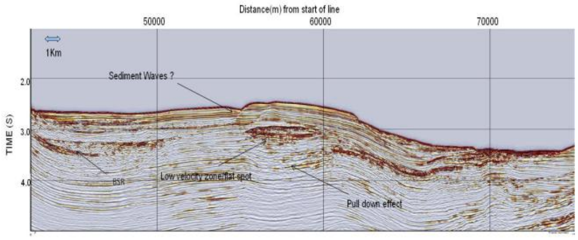

Figure 5: Part of line PEG09 showing a possible gas- charged anticlinal feature and sediment waves geometries that may control vertical fluid flow.

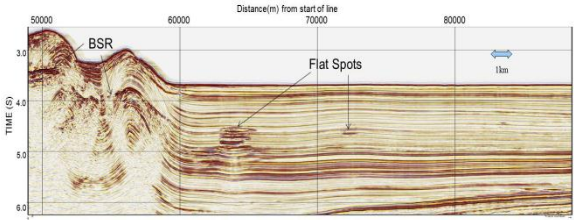

Figure 6: Part of line SAH01 highlighting high-amplitude features within or below the hydrate stability zone, and possible flat spots beneath them.

Ongoing Analysis

Analysis of these features is ongoing and most recent results will be presented. Primary goals are to characterise gas and hydrate occurrences based on interpretations of background lithology, stratigraphy and structure.

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