Fine-Scale Gas Hydrate Distribution at Porangahau Ridge, Hikurangi Subduction Margin, New Zealand

S. J. Toulmin[1,2], I. A. Pecher[1,2], K. Schwalenberg[3], J. Underhill[1,4], A. Curtis[1,4]

suzannah.toulmin@pet.hw.ac.uk

1) Edinburgh Collaborative of Subsurface Science and Engineering (ECOSSE), 2) Institute of Petroleum Engineering, Heriot-Watt University, EH14 4AS, UK. 3) Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany. 4) School of GeoSciences, Grant Institute, University of Edinburgh, EH9 3JW, UK

INTRODUCTION

Is gas hydrate at Porangahau Ridge distributed within pore-space, or is it concentrated in fractures? Does it occur on the flanks of the anticline, or in the core? Knowledge of the fine-scale distribution of gas hydrate at Porangahau Ridge will provide vital clues for understanding the structures and processes controlling fluid flow and hydrate formation along the wider Southern Hikurangi Subduction Margin. This knowledge would also allow for more accurate estimates of hydrate saturation.

Here we show the methods we will use to accurately locate gas hydrate sweetspots, and to estimate hydrate saturation.

STAGE 1: Image structure and stratigraphy

High-resolution seismic data reveals detailed internal structure within the anticline at Porangahau Ridge (Fig 1). Enhanced seismic processing will:

- produce a high-resolution velocity model for identifying velocity anomalies associated with localised concentrations of gas hydrate.
- resolve steeply dipping features (e.g. faults) through dip move-out, pre-stack time migration
- remove multiples and acquisition artefacts through tau-p demultiple

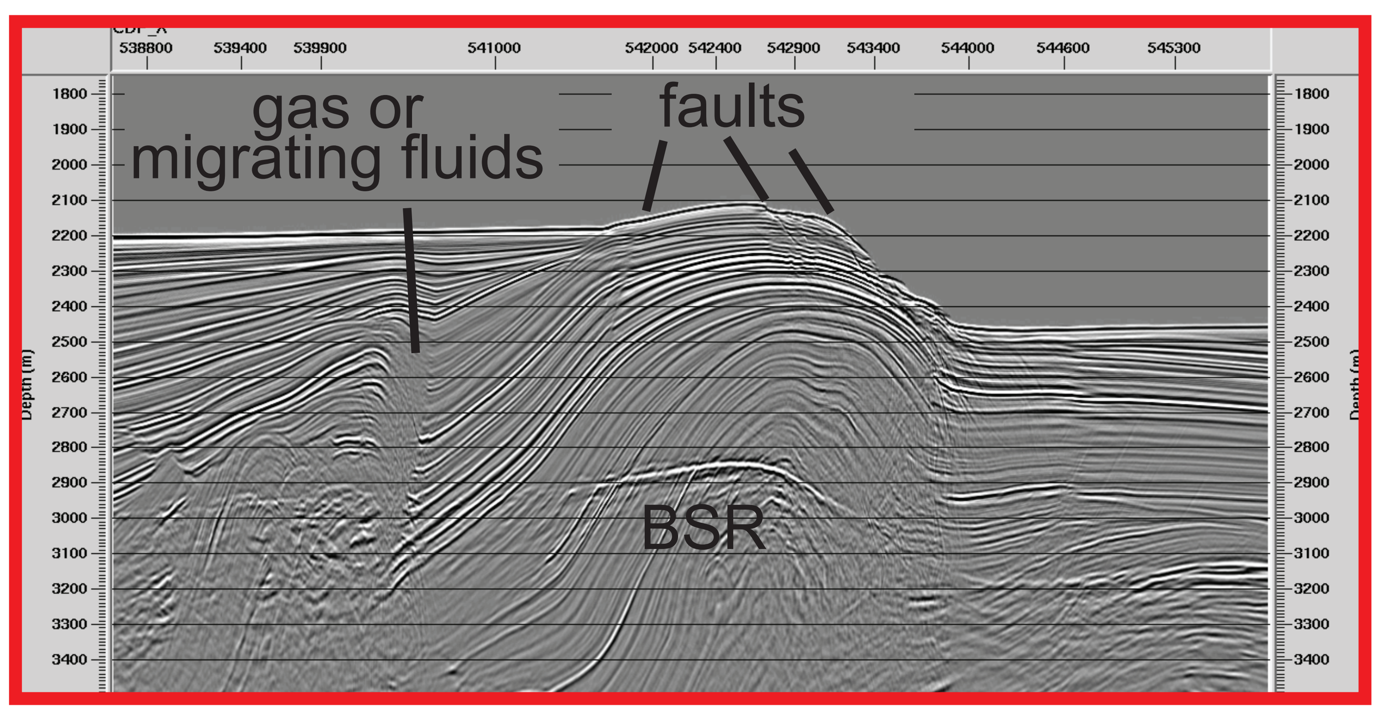

Fig. 1: Depth converted migrated seismic data (05CM-38) clearly resolves a BSR, extensional faulting in the upper layers of an anticline due to tension and wipe-out zones due to migrating fluids.

STAGE 2a: Interpret Geology

- Identify key layers and structures
- provide constraint for resistivity modelling
- relate resistive bodies to geology

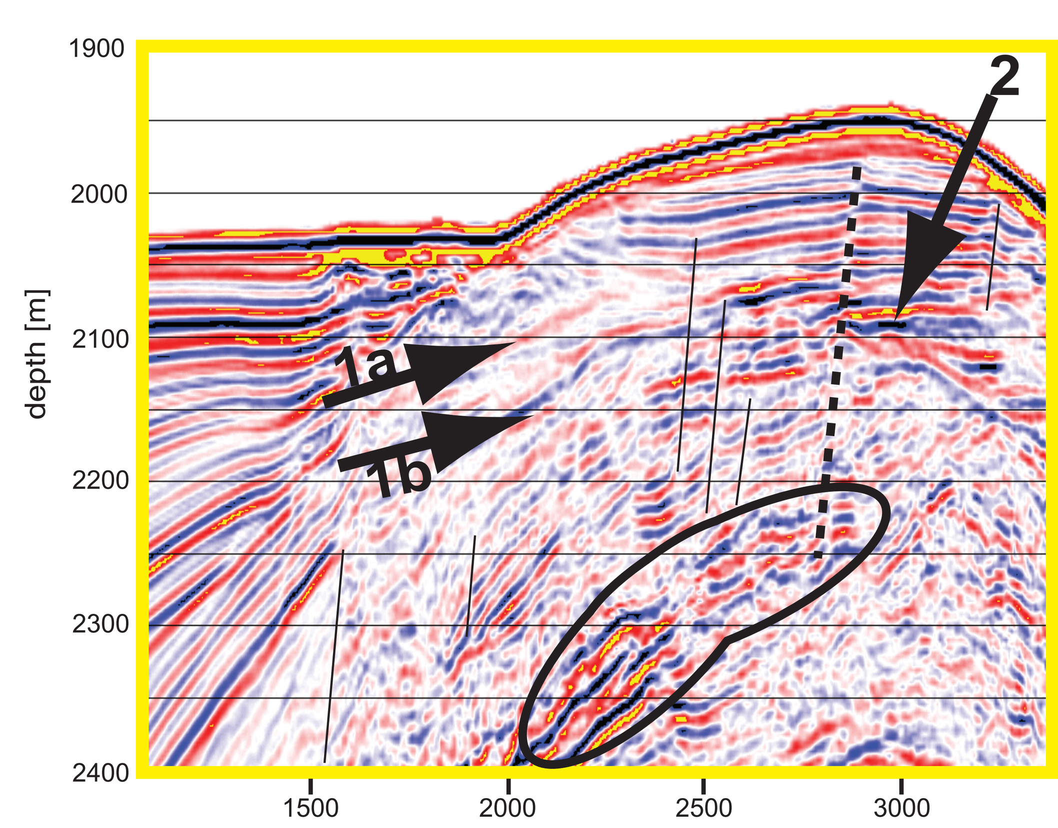

Fig. 2: Resistivity anomalies superimposed on depth converted seismic data with initial interpretation. (See Toulmin et. al. 2008 - AGU poster for more detail)

Detailed seismic interpretation and an accurate resistivity model will be useful for:

- accurately locating gas hydrate sweet-spots
- identifying structure/stratigraphy hosting gas hydrate sweetspots
- determining if hydrate is distributed in pore space, or concentrated in fractures

STAGE 2b: Determine position of resistivity anomalies

Reduce spatial uncertainty of resistivity anomalies by:

- Smoothing Receiver 2 using spline-interpolation and perform joint-inversion
- Adding geological information obtained from seismic interpretation to constrain inversion starting model

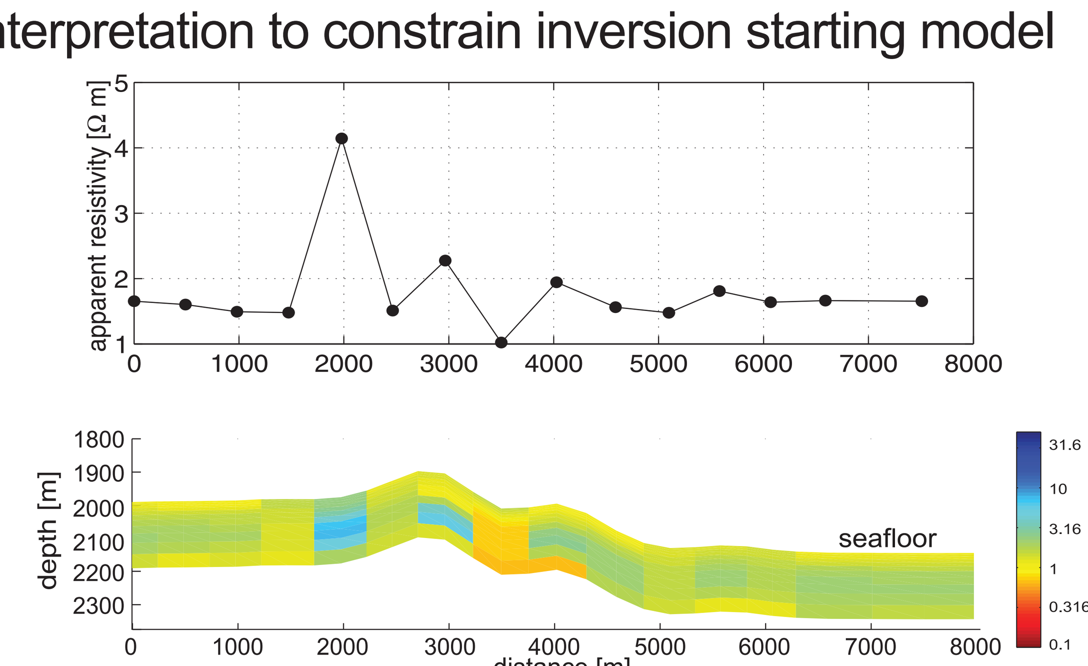

Fig. 3: Resistivity profile and stitched 1D resistivity models can be used to identify highly resistive zones of gas hydrate.

STAGE 3: Determine Hydrate concentration

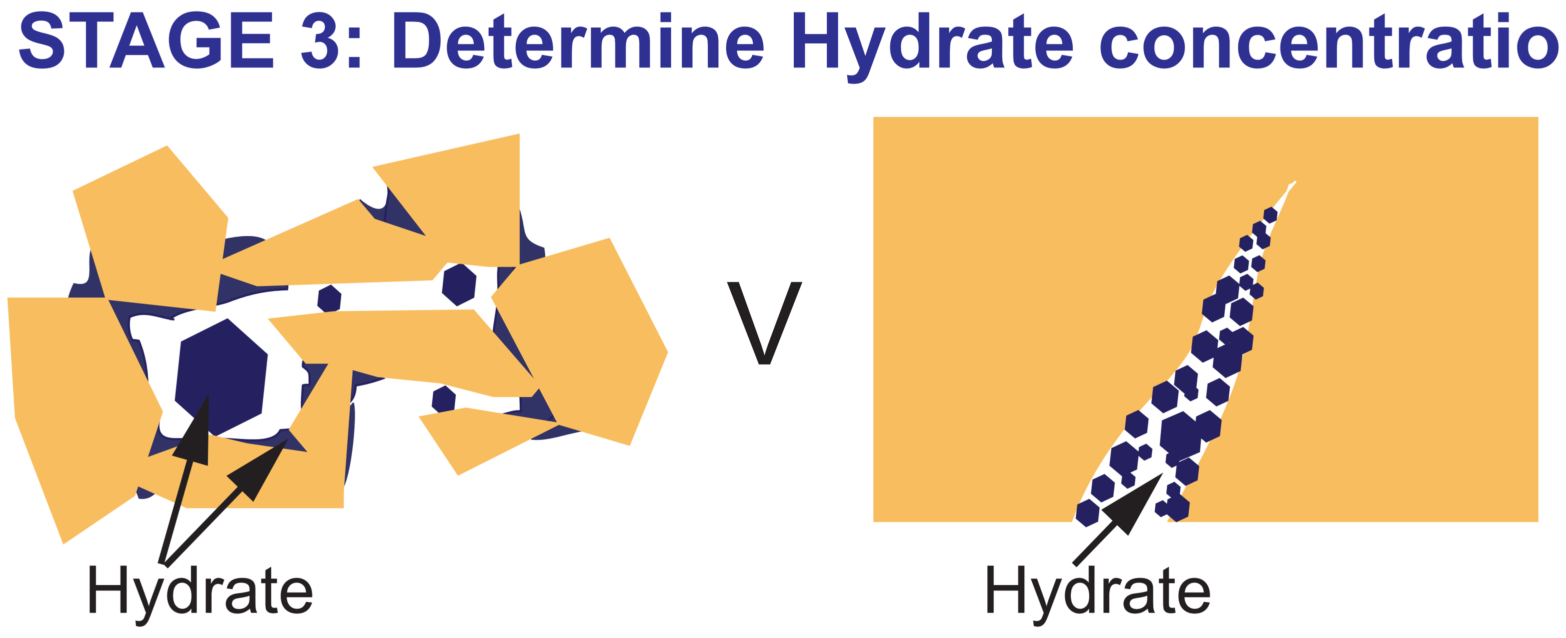

Fig. 4. Hydrate can float in pore space between sediment grains and cement grains together (left), or fill fractures (right). It is unkown how these different modes of hydrate distribution affect apparent resistivity measurements.

- Archie's Law is commonly used to estimate saturations from apparent resistivities
  - *assumes an isotropic distribution of hydrate in pore space.*
  - *assumption fails if hydrate is concentrated in near-vertical, aligned fractures*
- use resistivity rock physics modelling to test the limitations of Archie's Law, Hashin-Shtrikman bounds and other effective medium models

OUTPUTS

- Cross-section showing distribution of gas hydrate at Porangahau Ridge (PR)
- Knowledge of how hydrate is distributed through fractures and pore space at PR
- Accurate estimates of gas hydrate saturation