Gas-hydrate Petroleum System Modeling in the Eastern Nankai Trough, Japan*

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Introduction

Gas hydrates are pressure/temperature controlled accumulations of mostly methane which occur in sediments at relatively shallow depths. They have not yet been proven commercially, but recent progress in developing appropriate exploration/production methods has provided encouraging results. JOGMEC is conducting long-term feasibility studies to assess the available gas-hydrate resources and offshore production methods in the Eastern Nankai Trough, Japan.

Study: Methodology and Preliminary Results

More than 10 gas-hydrate-concentrated zones have been delineated by 2D/3D seismic interpretation and petrophysical analysis of multiwell drilling surveys in this area. However, the accumulation mechanisms and gas-hydrate petroleum systems in this area are not yet well understood. In order to understand gas-hydrate accumulations and their spatial distribution and controls by complex geological/geochemical processes and factors, a gas-hydrate petroleum systems modeling study had been conducted using advanced 2D/3D petroleum systems modeling simulators with gas-hydrate modeling capabilities (Figures 1 and 2).

The study area is 70km from the coast in water depths of 800+m. The first study based on 2D type-sections was conducted using models based on 11 key geologic horizons with ages measured by oxygen isotope measurements from foraminiferal shells and volcanic ash of core samples. Pressure and temperature distributions were modeled as they are the basic factors which control the Gas-Hydrate Stability Zone (GHSZ). High-resolution seismic facies analysis and interpretations were also used to define facies distributions in the 2D and 3D models. In the second phase, 3D petroleum systems modeling is used to determine not only the extent of the GHSZ through geologic time, but also to directly

simulate the generation of methane from biogenic sources and the formation of gas hydrates in the available pore space in the GHSZ as well as the resulting effects of the gas hydrates on the physical properties of the sediments. Recent developments in 3D technology, such as high-resolution local grid refinements and time steps, provide significant benefits, such as improved resolution and accuracy of generation and formation of gas hydrate.

2D modeling results suggested that the setting of biogenic-methane-generation depth is one of the important controlling factors for gas-hydrate accumulation. If we set methane generation peak in lower temperature (i.e., shallower depth within or just below GHSZ), hydrate accumulation can be simulated relatively easily. Furthermore, preliminary 3D modeling results suggested that the direction of sediment supply (i.e., distribution of sandy sediments) and formation dip direction can be important controlling factors of gas-hydrate accumulation.

The methodology can then be applied to frontier areas in Japan, and it will enable predictions of gas-hydrate resources to be based on better understanding of the controlling factors and with greater confidence, even in areas with sparse data.

(a) Depth converted horizon data

(b) Constructed 3D facies model

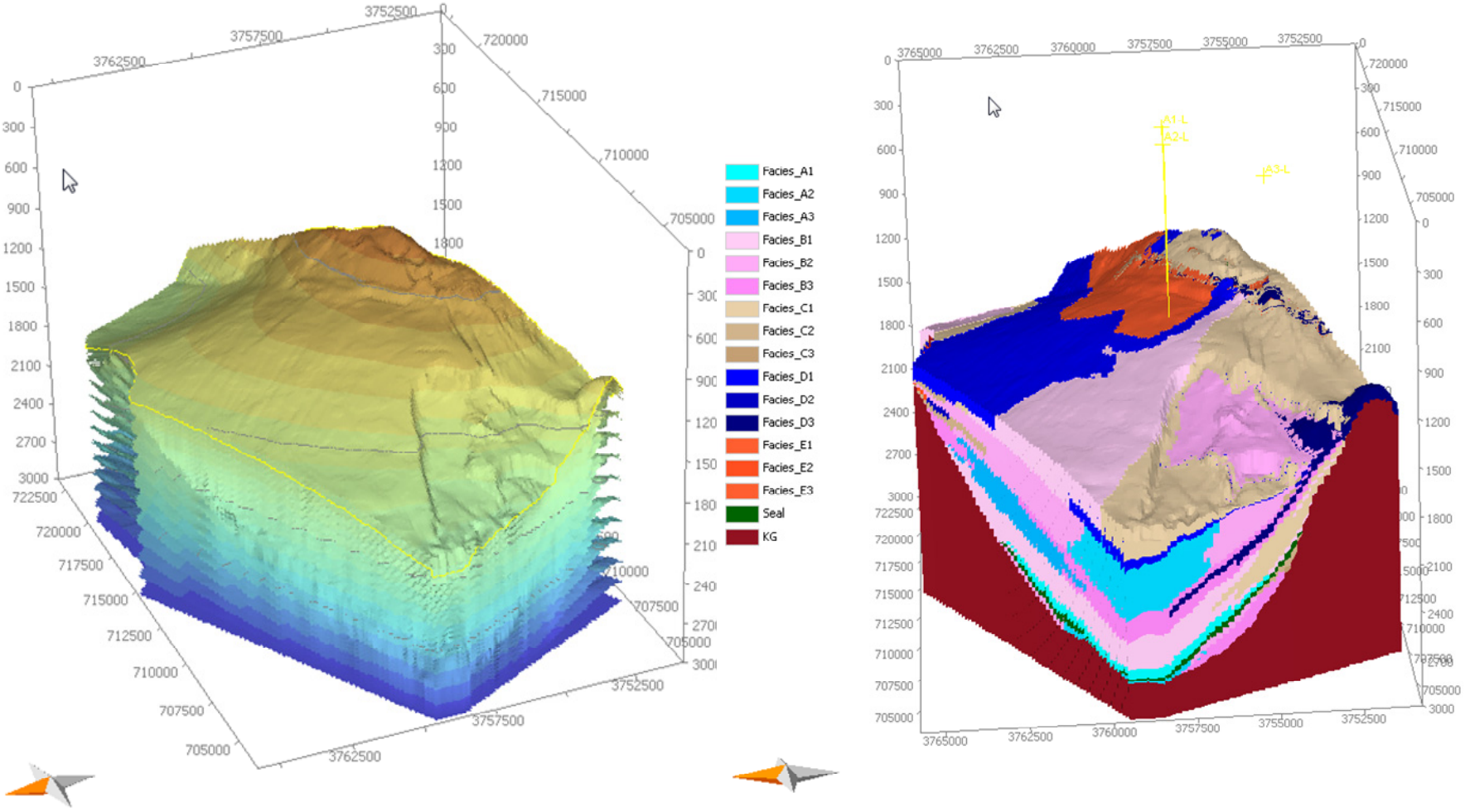

Figure 1. Example of 3D model construction (model input).

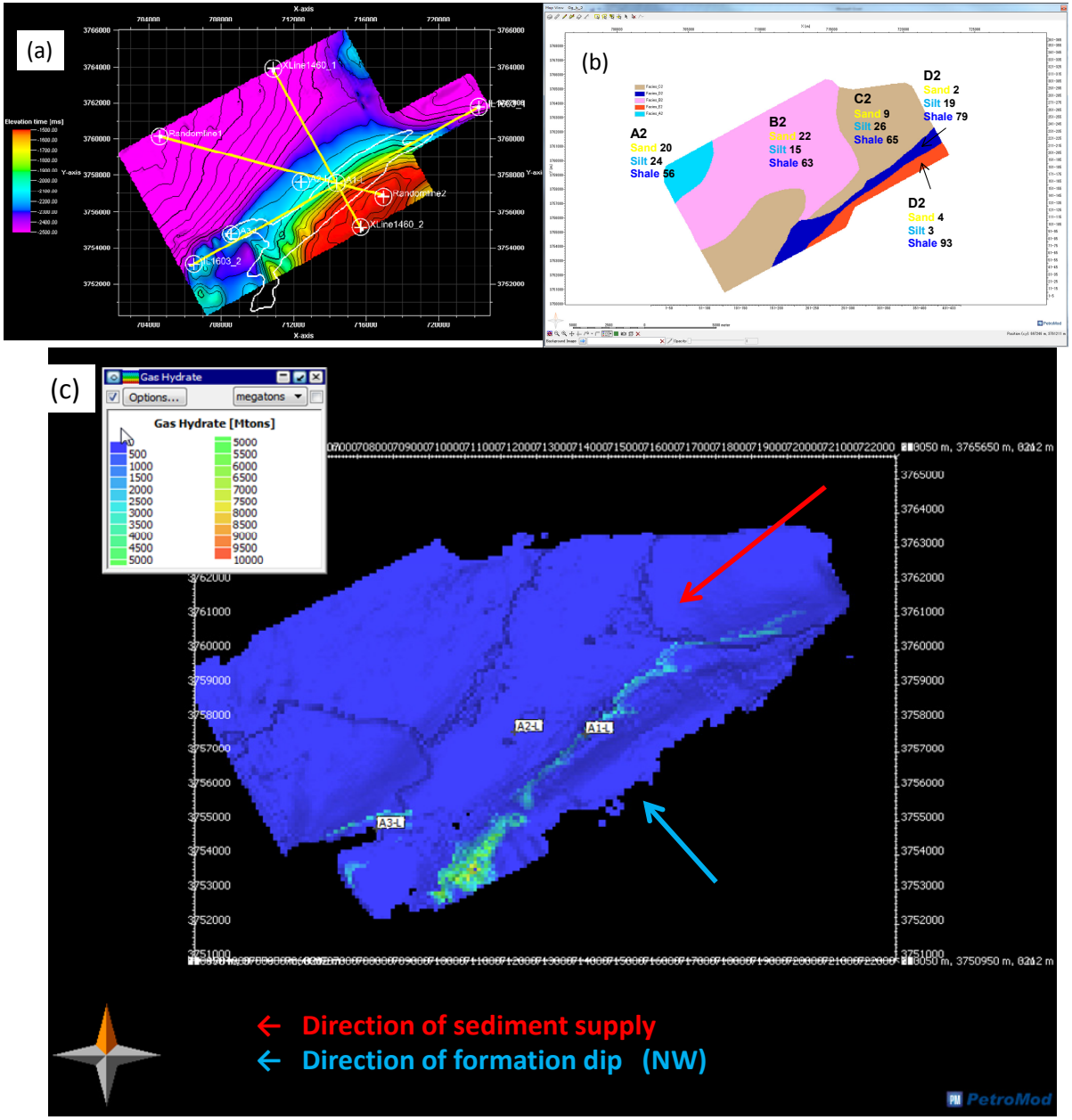

Figure 2. Preliminary 3D modeling results. (a) Time structure map of gas-hydrate concentrated zone and its spatial distribution (white line), which was interpreted from 3D seismic data. (b) Facies distribution map (Facies Og_b_2) constructed by seismic facies interpretation. (c) Gas-hydrate mass distribution in lower part of gas-hydrate concentrated zone(Facies Og_b_2).