The Direct Indicators for Predicting Gas Hydrate Occurrences in the Deep-Water Areas of Vietnam's Continental Shelf*

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Abstract

Besides the traditional petroleum resources that have an important role in industrialization and modernization, gas hydrate is the resource that can add to fossil fuels in the future and can existent in deep water areas on the continental shelf of Vietnam.

This paper presents several examples of gas hydrate prediction from seismic data in deep water areas of Vietnam. It appears that Bottom Simulating Reflector (BSR) distribution and Gas Hydrate Stability Zone (GHSZ) may be the best indicators for gas hydrate occurrence. In this case BSRs are absent, the amplitude anomalies may be a good proxy of gas hydrate.

Following these indicators, we determined the presence of strong reflective surfaces, continuous parallel to the sea floor (BSR) within the blank zones, gas chimneys, and anomalies amplitude on the seismic section in the deep water of the southern part of Song Hong Basin, the eastern part of the Phu Khanh Basin, as well as of the Nam Con Son and Tu Chinh - Vung May Basin.

From the results of Vietnamese seismic data analysis, there are many indicators of gas hydrates in the deep-water area of the Vietnam continental shelf.

Introduction

The Vietnamese margin is floored by a number of sedimentary basins: Song Hong, Phu Khanh, Nam Con Son, Cuu Long, Tu Chinh - Vung May, Ma Lai - Tho Chu, Hoang Sa, and Truong Sa with a considerable petroleum potential (Figure 1). Besides the traditional petroleum resources that have an important role in industrialization and modernization, gas hydrate is the resource that can add to fossil fuels in the future and can existent in deep water areas on the continental shelf of Vietnam.

Gas Hydrate (GH) is found in the ocean because of a coincidence of rising pressure and diminishing temperature with increasing water depth. The same areas are covered by huge quantities of seismic data but very sparse well data. One of the primary issues for gas hydrate research is the interpretation of seismic data to determine the possible existence of gas hydrates.

GH can be detected from seismic data by observations of Bottom-Simulating Reflectors (BSR), chimney or vents, and mounds and mud volcanoes. The BSR is defined as a seismic reflection originating from the impedance contrast between a layer of sediment containing GH and a free gas layer below. The associated contrast from high to low velocity gives the BSR a polarity which is opposite to that of the sea floor reflection. Free gas deposits tend to either remain trapped below the GHSZ or to pass through it and vent into the sea through gas chimneys that often pass along faults. Chimneys can be modeled as relatively narrow, open channels lined with gas hydrates which separates the internal gas from the groundwater in the surrounding strata. Vents are associated with both pockmarks and mud volcanoes, as well as venting of large volumes of gas which resolves from solution as the fluid mass rises adiabatically and coalesces. Mounds and mud volcanoes cannot form without the lifting power of ascending water. The gas hydrates commonly found associated with them forms on the sea floor owing to rapid chilling at the seawater/seafloor interface.

In this presentation, we present the above indicators by seismic reflection data that predicted viability of gas hydrates in deep-water areas of the Vietnam continental shelf.

Data and Method

Data: The seismic data used for this study are 2D and 3D seismic reflection data of many vintages of acquisition (Figure 1). The seismic data displayed used zero phase, SEG normal polarity, the study interval from 0 to 2000ms TWT below sea floor, and the interval velocity ranges between 1500 – 3000 m/s.

Method: Gas hydrates can be detected from seismic data by:

1. Recognize BSR, is a reflection that parallels the sea floor and cuts through reflections from strata; the BSR is a reflection from the base of the gas hydrate-cemented layer where free gas is present beneath it;
2. Using Amplitudes, seismic velocities, and AVO analysis.

Results

Based on the seismic data analysis as well as integrated analysis allows prediction viability of gas hydrates on deep-water areas in the continental shelf of Vietnam (Figure 1). On some seismic sections in the study area (Figure 2, Figure 3, and Figure 4), the presence of strong reflective surfaces, that continuously parallel the sea floor (BSR) within the blank zones, gas chimneys, and amplitude anomalies can be related to gas hydrates.

From the seismic data with the gas hydrate indicators as presented, in combination with related geological data, several abnormal amplitude objects, which have been subjected to AVO analysis, predict the existence gas hydrates (Figure 5). Beneath the BSR layer there is a flat spot

which is indicative of a change of phase from the accumulated free gas to water. AVO analysis shows undefined Gradient, which is scattering around 0 (Figure 5 - Right), while in the EEI analysis, the lithology impedance data (EEI -58) is dim, showing similar value across the flat spot which implies a similar lithology. On the other hand, a large increase in the fluid impedance (EEI 10) can be observed which is indicative of a change in in the infilling fluid from Gas to Water.

Conclusions

The BSR indicates the likely Direct Seismic Detection of Gas Hydrate. From seismic interpretation results, we can determine the layer occurs at a contact between higher acoustic impedance above and lower acoustic impedance below, it produces a phase reversal in a reflected acoustic wave compared to the reflection from the seafloor. This BSR is distributed in the southeast of the Phu Khanh Basin and northeast of the Tu Chinh - Vung May Basin. AVO analysis for the seismic data of the Phu Khanh Basin shows that the product parameter is a nice attribute to distinguish BSR-related bright spots. The Gas chimney, Vents, and Blanking zones mapped as the free gas zone over the eastern part of the Phu Khanh Basin may be related to the gas hydrate.

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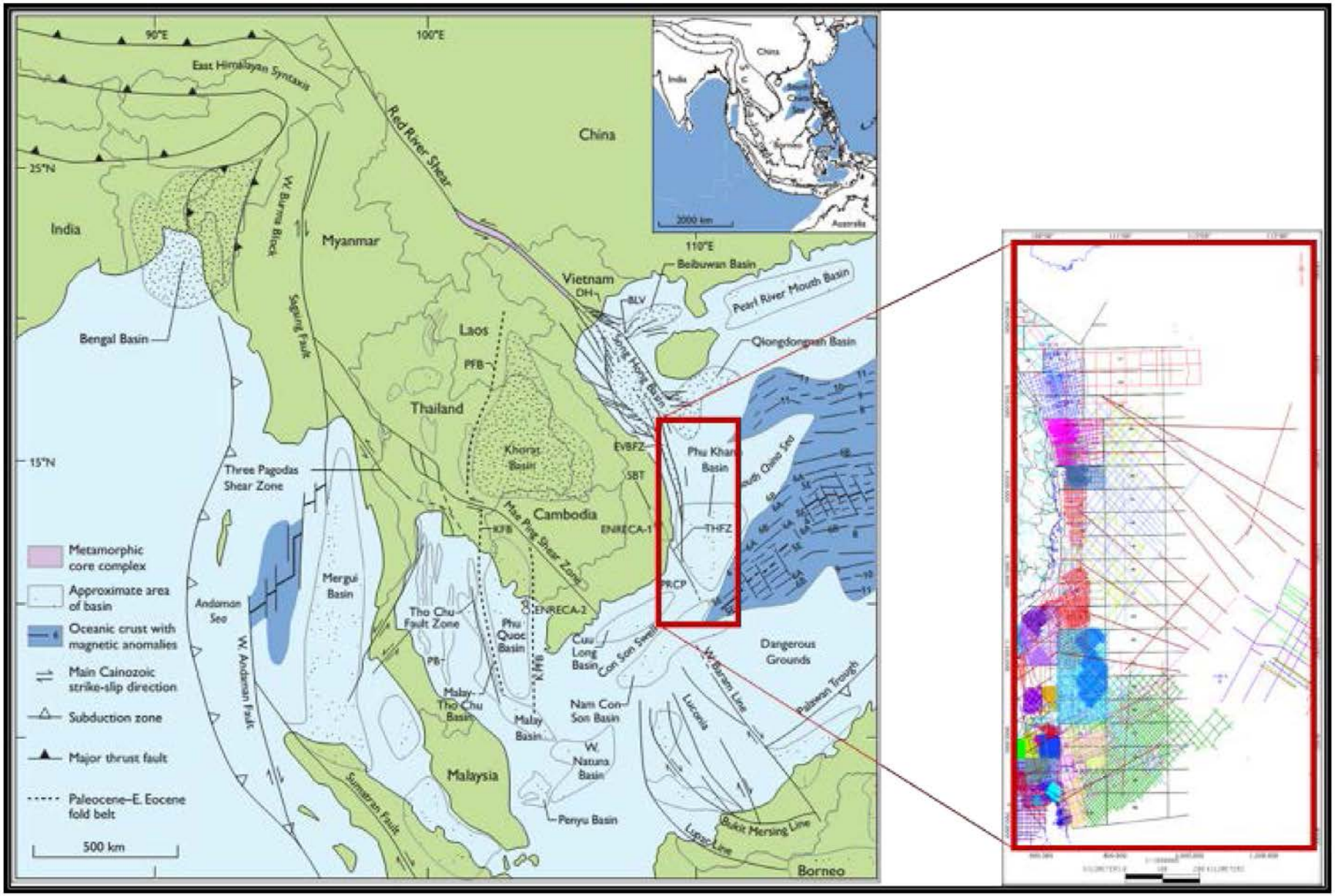

Figure 1. Location map of major Cenozoic basins with the main morphological features of the Asia-Pacific Sea (left). The study area outlined in the red box is shown in detail (right).

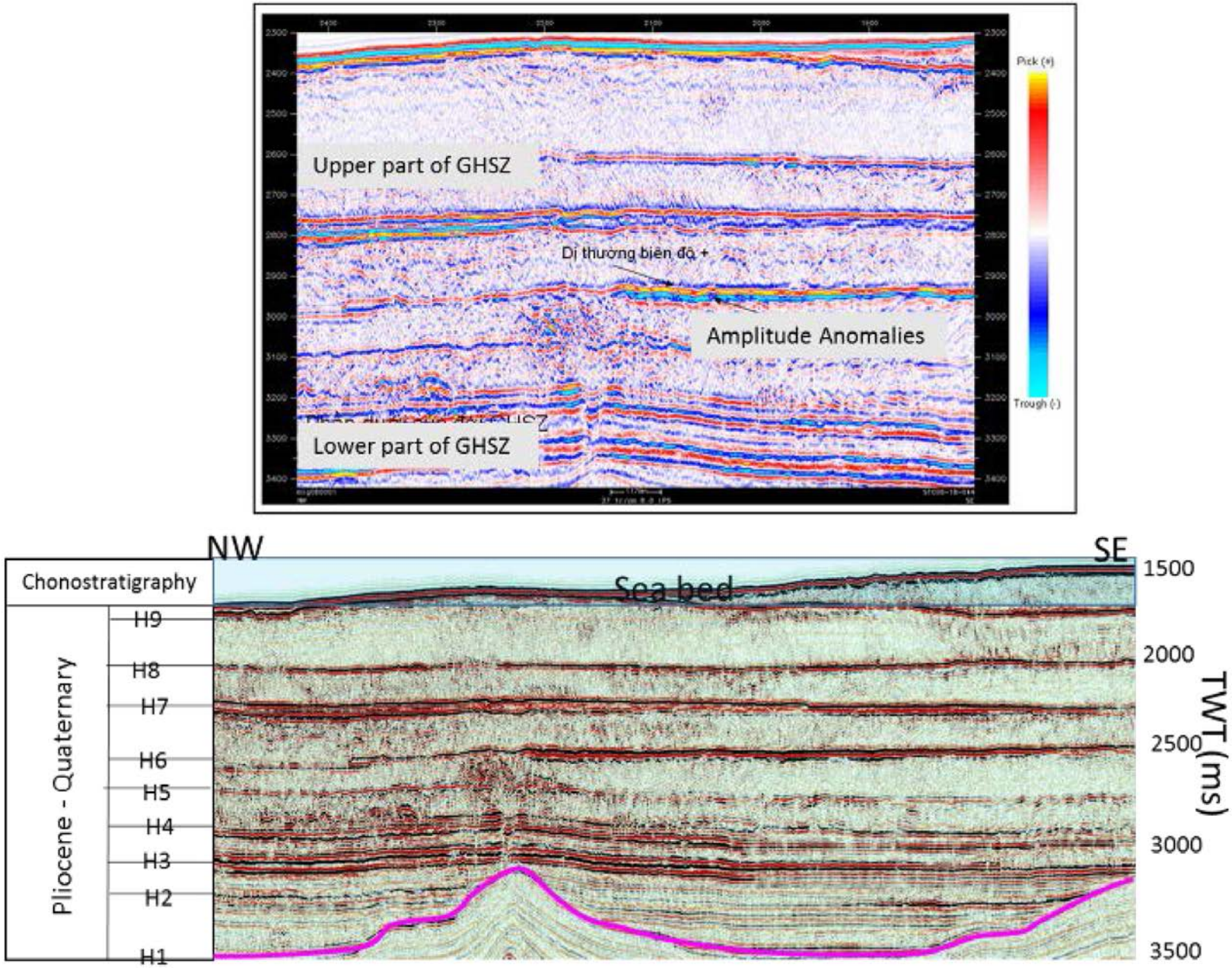

Figure 2. Estimate the Gas Hydrate by analyzing amplitude anomalies and seismic section in the Eastern Phu Khanh Basin.

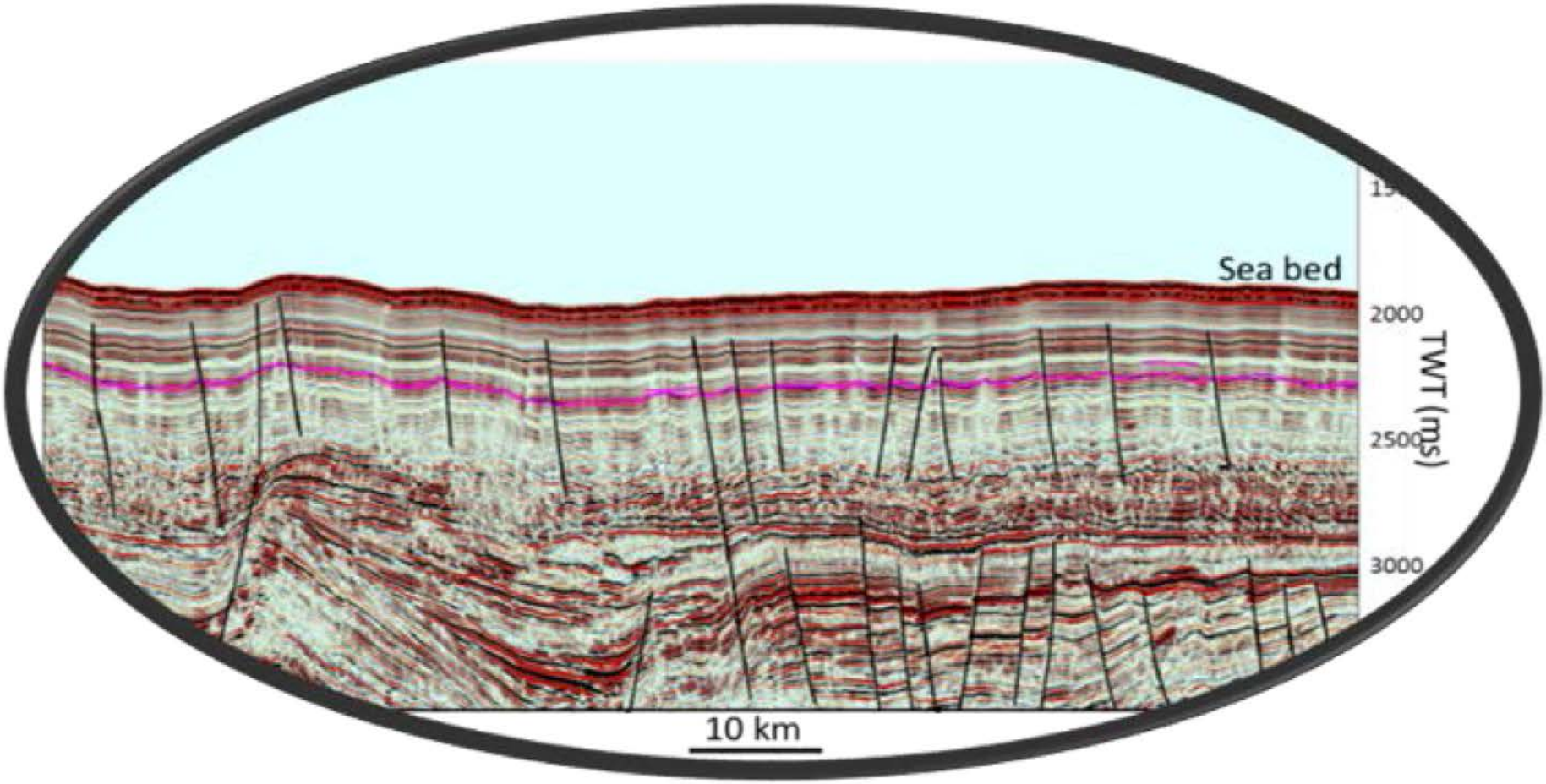

Figure 3. The anomalous reflection which seems to follow a stratigraphic unconformity, may represent free gas within the HSZ, perhaps fed by gas migration along a system of faults in the TC-VM Basin.

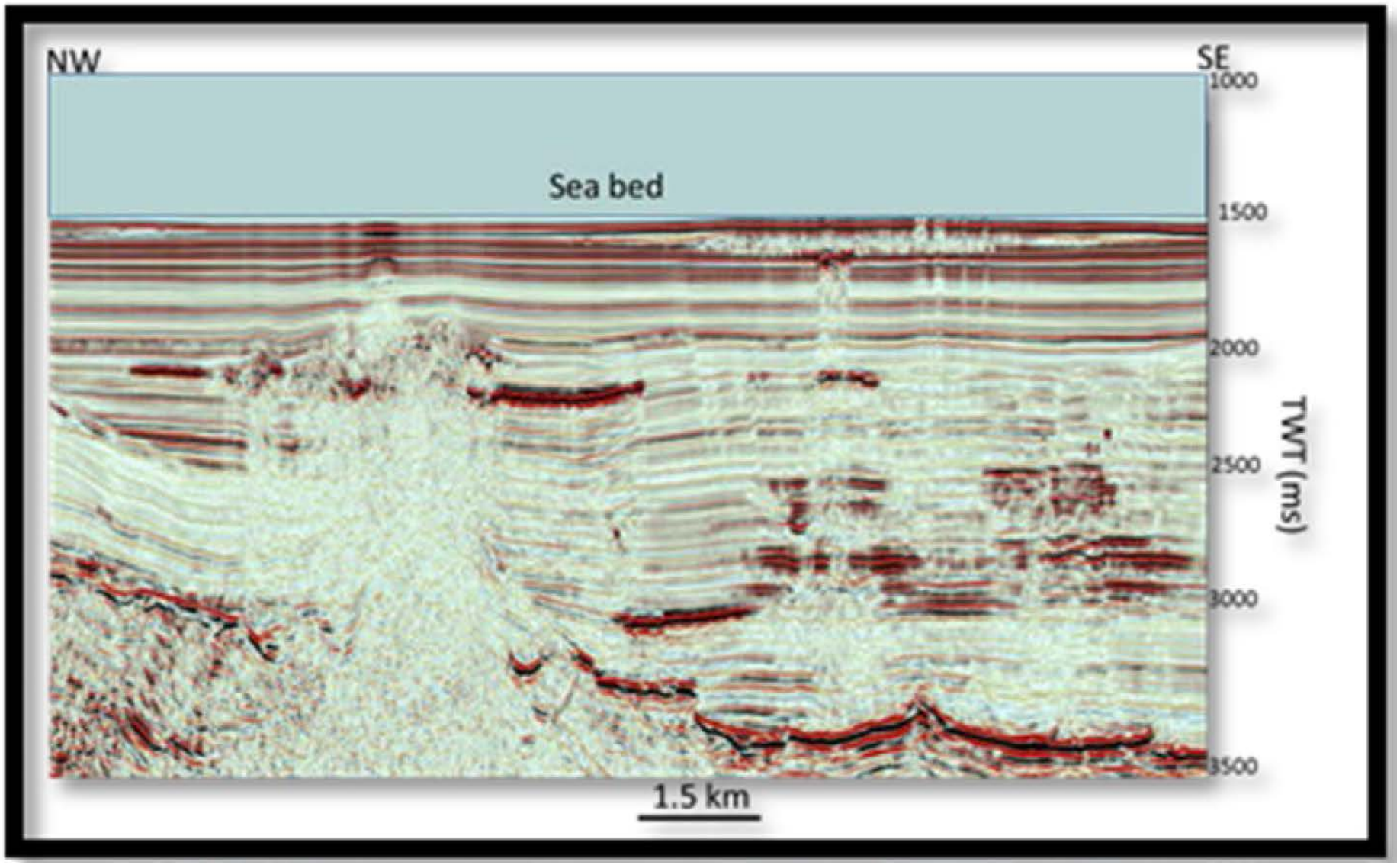

Figure 4. “Blanking", appears in deep water of the study area. It occurs as a function of gas hydrate development where gas hydrate displaces water in pore spaces and causes a Diminution of the reflection coefficients of strata.

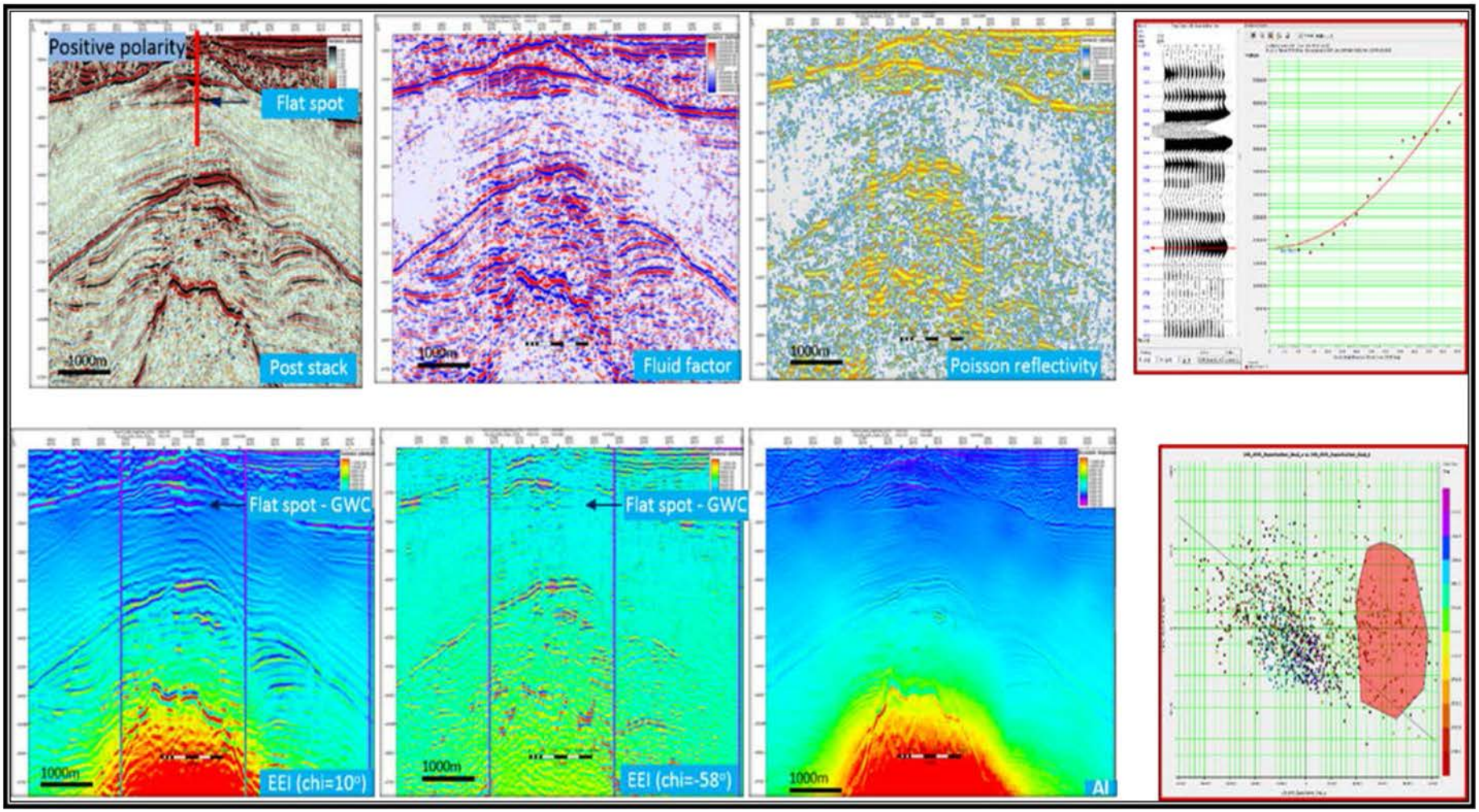

Figure 5. AVO attribute analysis for gas hydrate prediction in the Phu Khanh Basin.