Role of 3-D Seismic Data in Prediction of High Potential Areas within Pre-Tertiary Fractured Granite Basement Reservoir in Cuu Long Basin, Vietnam Offshore*

Nguyen Huy Ngoc[1], Nguyen Quoc Quan[1], Hoang Ngoc Dong[1], Nguyen Do Ngoc Nhi[1]

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[1]Thang Long Joint Operating Company, Ho Chi Minh City, Vietnam (nhngoc@tljoc.com.vn)

Abstract

Cuu Long Basin, which is located in the South-East Vietnam offshore (Figure 1), is a main oil-producing province in Vietnam. Currently oil is producing from Lower Miocene and Oligocene sandstones and Pre-Tertiary fractured granite basement reservoirs. The fractured granite basement is considered the primary objective, which contributes more then 70% of oil produced. The Pre-Tertiary basement consists mainly of granitic rocks belonging to three complexes: Hon Khoai, Dinh Quan and Ankroet, which are different in ages and rock types varying from granodiorite to granite (Figure 1). Younger Oligocene and Miocene dikes cut these granitic complexes.
Because the fresh granite has almost zero porosity, the granite basement becomes a reservoir only if it was fractured by tectonic activities. To explore and develop hydrocarbons from this particular reservoir type, we are faced with many difficulties especially how to predict fracture systems and their characteristics inside the granite basement.

Based on exploration, appraisal and production from this particular reservoir type, the following main fracture characteristics will play roles in the potential for the fractured basement reservoir and will contribute to success of the wells: top basement structure, fracture density, aperture and direction of opened fractures, continuity and connectivity of different fracture systems. Besides these main fractured characteristics, the basement rock types, their contacts and the existence of younger dikes also play some additional roles in reservoir potential. Prediction of these fracture characteristics in the granite basement is a very complicated problem. The application of new 3D seismic data processing technology, seismic imaging of faults and associated fractures inside the granite basement has been significantly improved. Consequently, the prediction of fracture characteristics using seismic data integrated with geological and

logging data has achieved some encouraged results. The workflow to predict high potential fracture reservoir areas within a certain basement structure is presented in Figure 2.

In this paper, the authors would like to present the role of 3D seismic data, especially seismic attributes, in prediction of high potential areas within the Pre-Tertiary fractured granite basement.

The modern 3D seismic data applying state of the art acquisition and processing technology such as Kirchhoff and Beam Anisotropic Pre-stack Depth Migration could provide good imaging not only for top of the basement but also for faults inside the basement. Good quality 3D seismic data combined with seismic attributes such as Coherency Cube (Variance Cube), secondary derivative and amplitude attributes permits us to map the top basement and faults inside the basement with high detail and certainty. Figure 3 shows the 3D seismic data interpretation results for granite basement of oil field A in the Cuu Long Basin.

To predict high fracture density areas inside the granite basement, many seismic attributes have been tested and acoustic impedance (AI) was considered the best attribute which provided reasonable correlation with the well data. Figure 4 shows the difference in AI calculated from log data for fractured granite and fresh granite. Distribution of low AI areas reflected high fractured density at levels of 275 ms below the basement top.

Recently, prediction of existing of large aperture fractures inside the fractured granite basement based on seismic data has not been achieved. For this purpose, we have used “From seismic interpretation to tectonic reconstruction” method, which was presented with more detail in our poster presentation in the November 2009 AAPG IEC in Rio de Janeiro, Brazil to reconstruct the main tectonic phase and to predict the fault systems with high potential of generating the large aperture (Macro) fractures. Figure 5 shows the main deformation phases in the study areas as well as the fault systems (Sub E-W direction fault systems) which could create large aperture fractures. Well data confirmed the prediction results. (Figure 5)

Continuity and connectivity of different fracture systems inside the fracture granite basement could be predicted by seismic dip attributes as well as the reflection magnitude attribute. (Figure 6)

Prediction of high potential areas within the Pre-Tertiary fractured granite basement reservoirs was performed based on integration of the above fracture character predictions by numeric code method. The first number reflects potential of the area in the basement structure, the second number in fracture density character, the third number based on potential of existing of large aperture fractures and the forth one reflects the continuity and intersection of different fracture systems. Value of 1 is the highest potential and the

potential gradually reduces to a value of 4. A four-digit number will characterize every seismic anomaly area and the lowest value (i.e. 1111) reflects the highest potential area (Figure 7). So far, the potential fracture areas predicted in Figure 7 is consistent with the results of six drilled wells.

In this paper, the authors also would like to present some prediction results of rock type boundaries and existing young dikes within the fracture granite basement in oil field A by seismic attributes combined with well data.

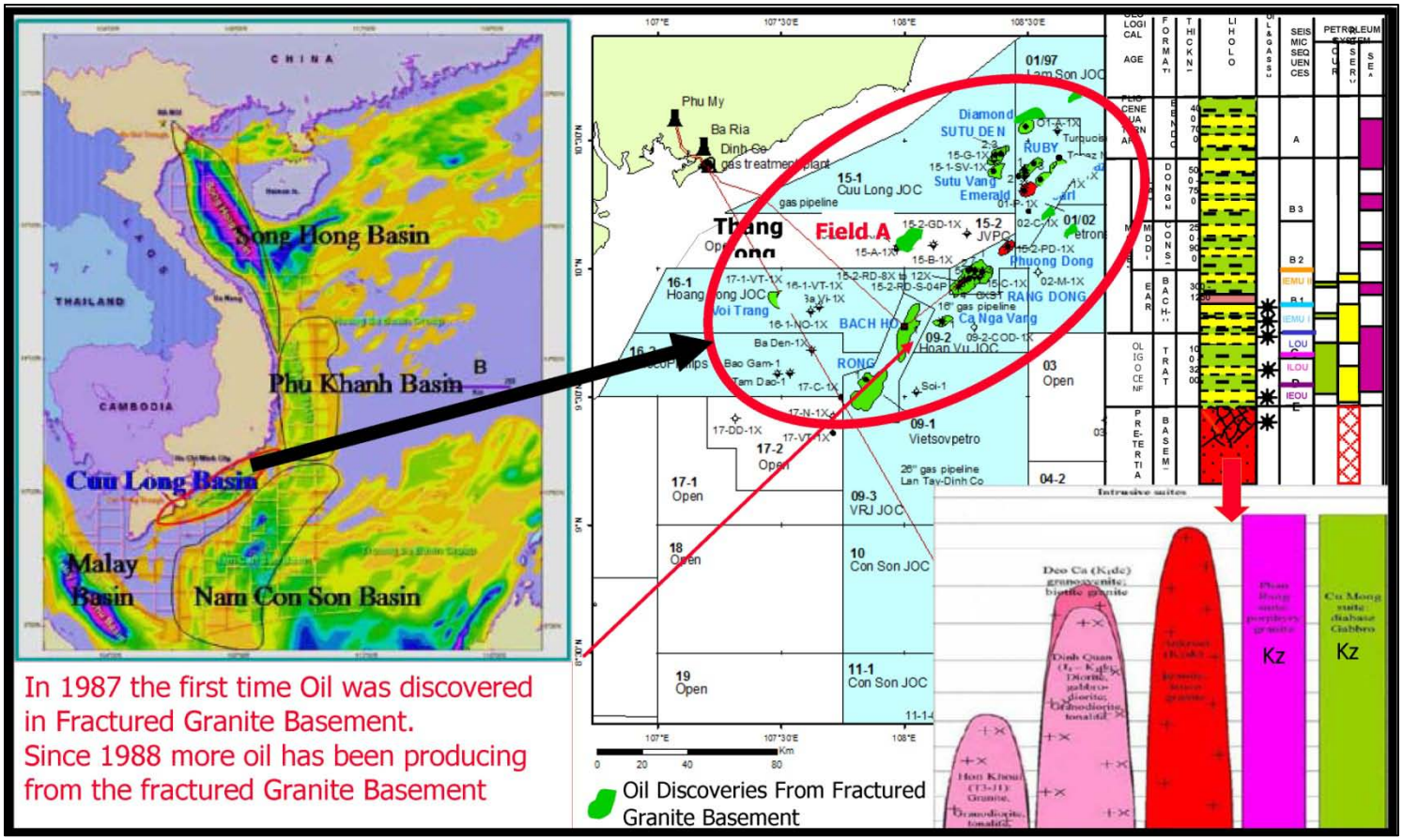

Figure 1. Location Map of Cuu Long Basin with Oil Discoveries from Pre-Tertiary fractured granite Basement.

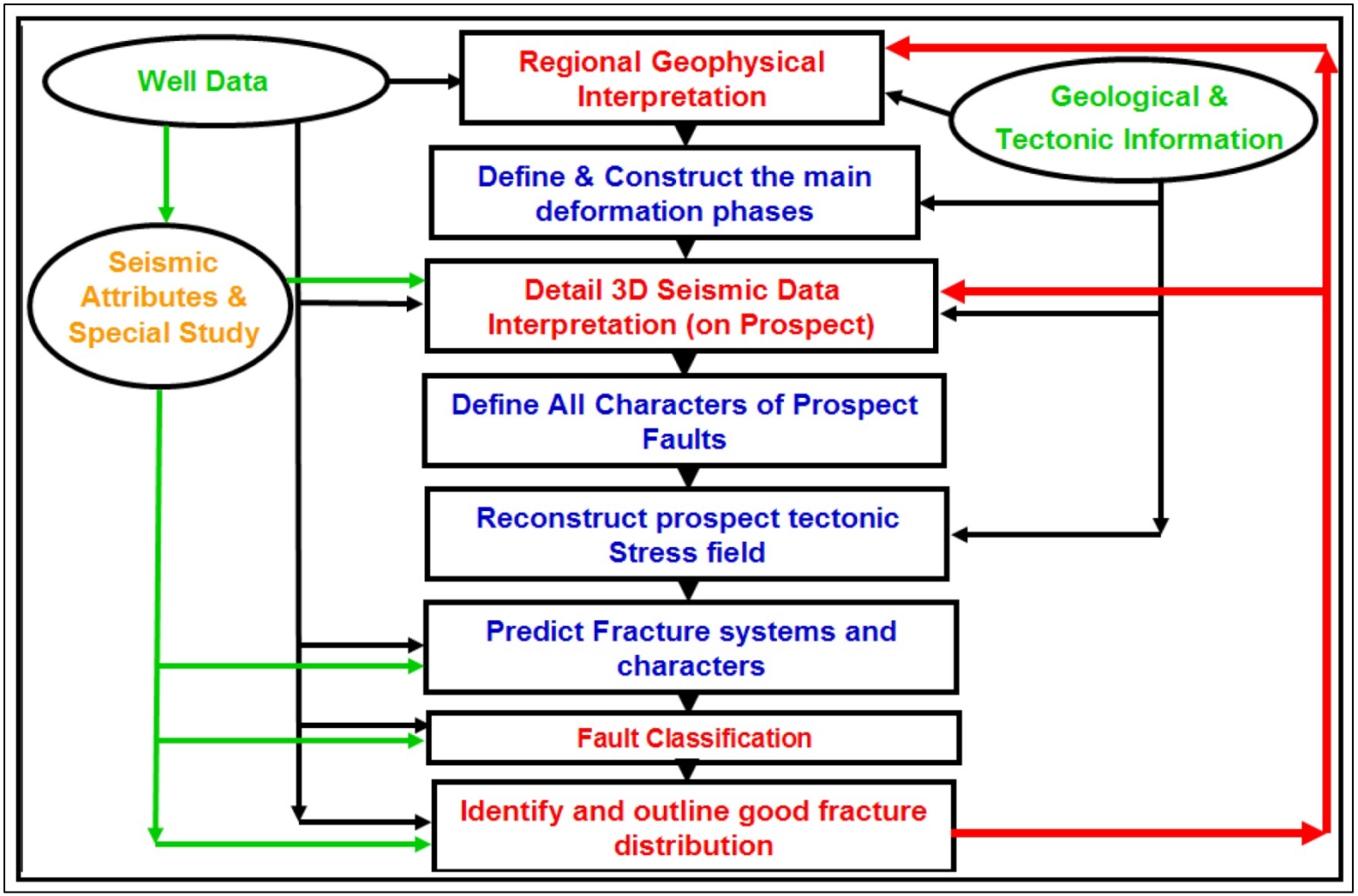

Figure 2. Workflow of 3D seismic data interpretation for prediction of high potential fracture areas inside the Pre-Tertiary fractured granite Basement.

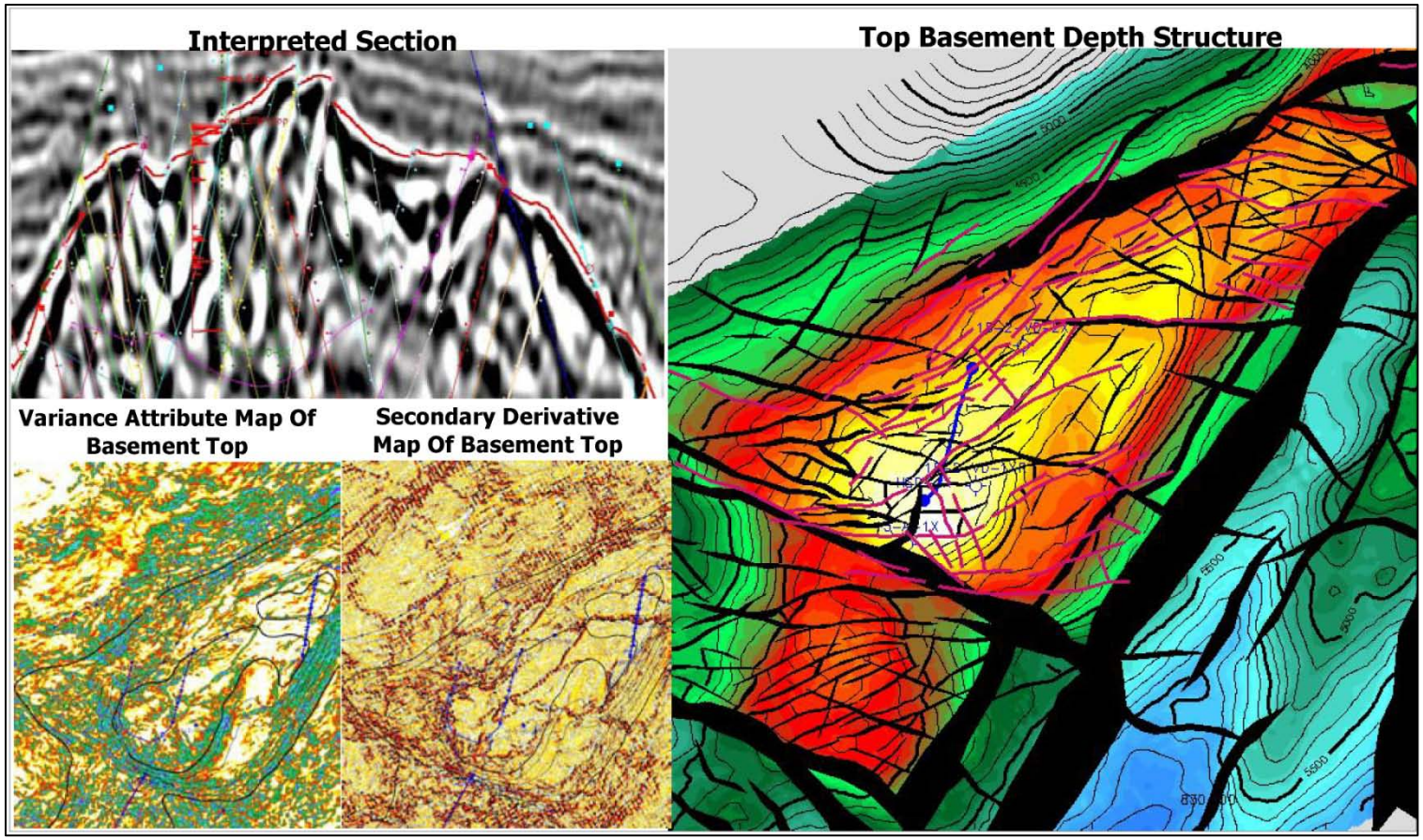

Figure 3. Results of structural 3D seismic data interpretation for the Pre-Tertiary Granite Basement of Oil field A in the Cuu Long Basin.

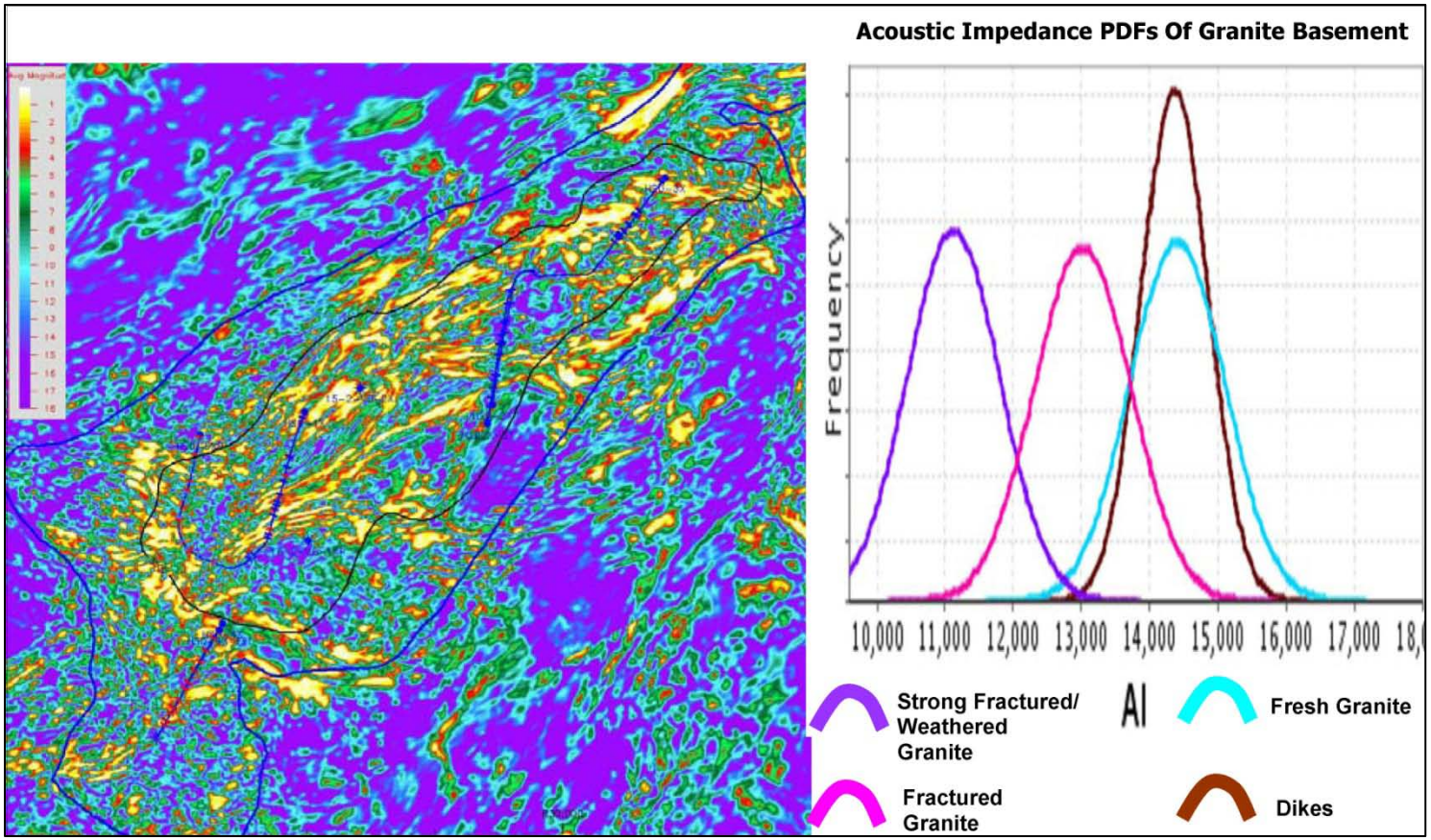

Figure 4. Distribution of low AI areas (Possible high fracture density) at level of 275 m below top of the Pre-Tertiary Granite Basement of Oil field A in the Cuu Long Basin.

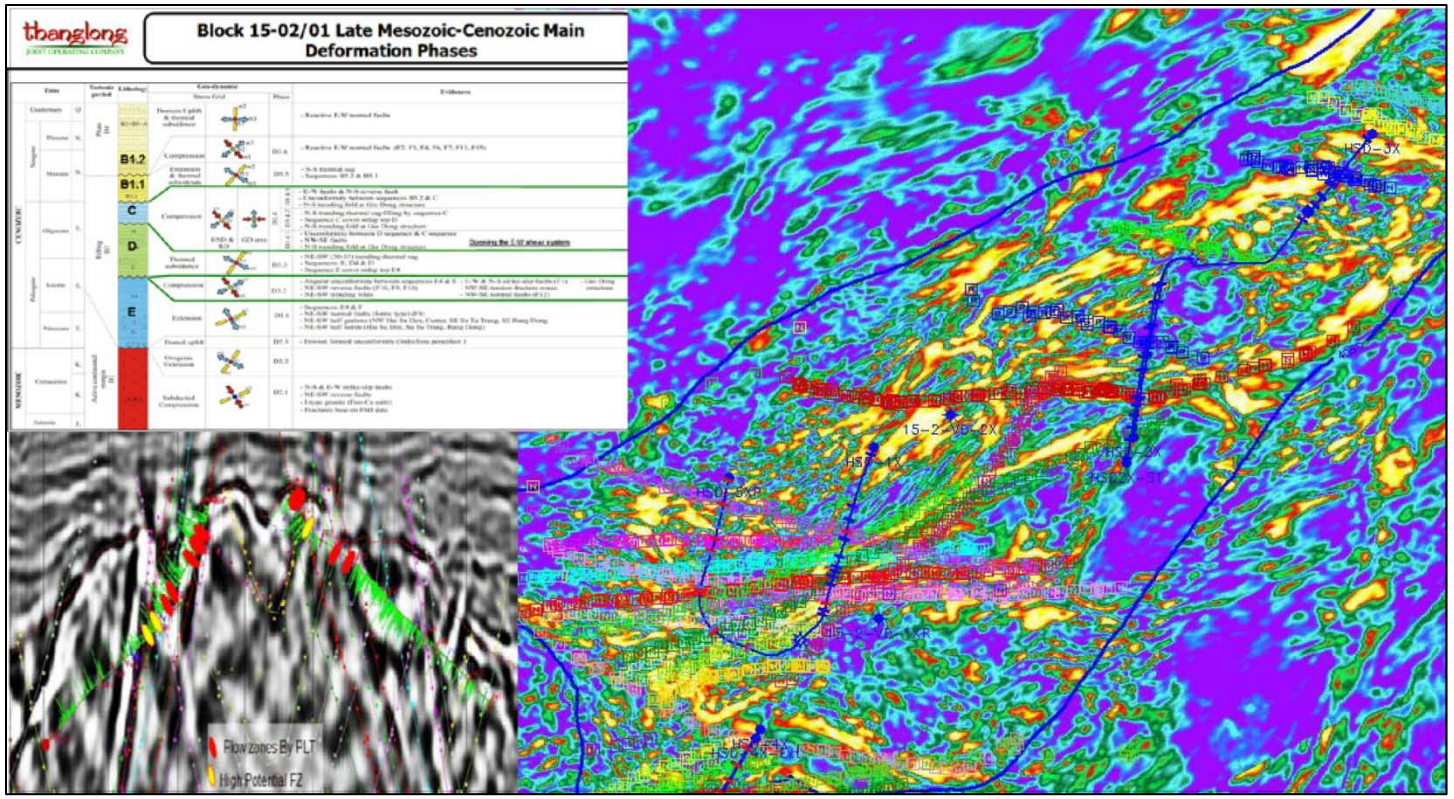

Figure 5. Main deformation phases and predicted fault systems which have high potential of creating of large aperture fractures inside the Pre-Tertiary Granite Basement of Oil field A in the Cuu Long Basin.

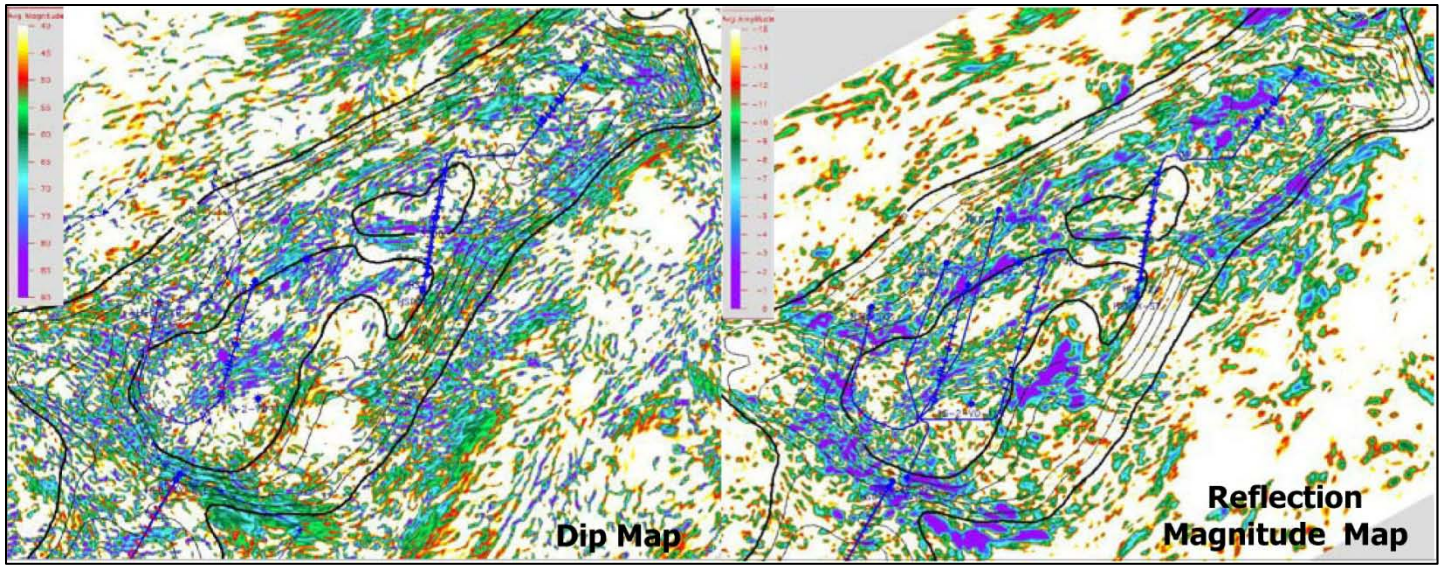

Figure 6. Prediction of continue & intersection between different fracture systems by seismic dip & Reflection magnitude at level of 275 m below top of the Pre-Tertiary Granite Basement of Oil field A.

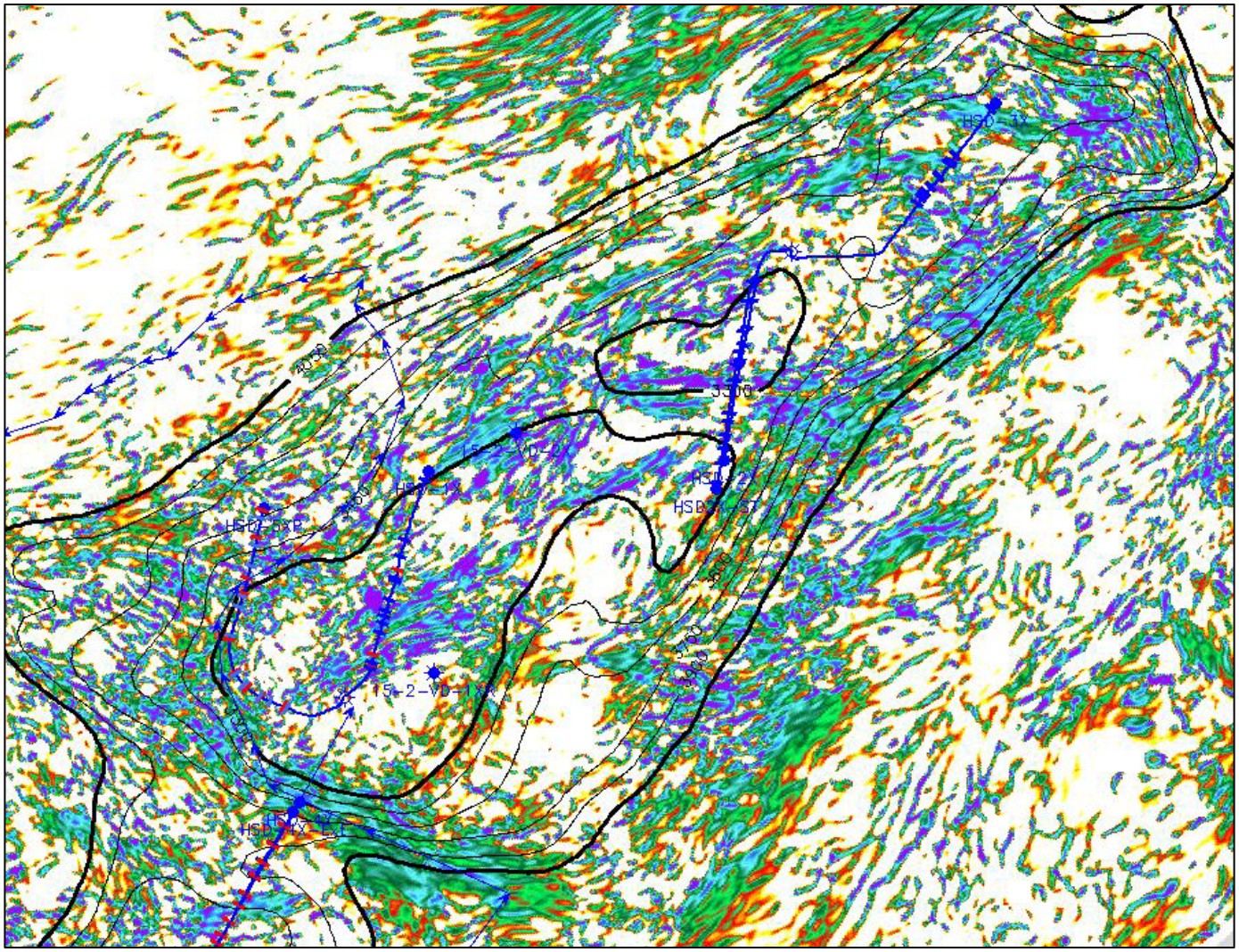

Figure 7- Prediction of high potential areas at level of 275 m below top of the Pre-Tertiary Granite Basement of Oil field A in the Cuu Long Basin.