

Fracture and Carbonate Reservoir Characterization using Sequential Hybrid Seismic Rock Physics, Statistic and Artificial Neural Network: Case Study of North Tiaka Field*

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Abstract

Tiaka field is located in the Senoro-Toili block at the eastern arm of Sulawesi, Indonesia. The main hydrocarbon-bearing reservoir is a lower Miocene carbonate sequences which possess a dual porosity system, both matrix and fracture. Actually, the carbonate rock characterization is quite complex because of their matrix, pore system, chemical reaction produced from fluid interaction in interior walls of their pores space; also to be considered is the wave propagation system through carbonate reservoir. This carbonate complexity has required special treatment to characterize precisely the reservoir.

In this article, the very latest technology for carbonate complex reservoir characterization using hybrid seismic rock physics, statistic and artificial neural network will be presented. This methodology enables the integration of a huge size of various data sets to produce coherence correlation among input data and their target. The data set consists of core (i.e., lithology, lithofacies, fracture intensity, fracture width, porosity), well log (i.e., gamma ray, density, Sw, porosities, sensitivities, etc.), multi-attribute seismic (either pre-stack or post-stack) of different vintages of 2 D seismic lines, and seismic rock physics. The whole array of input data was trained together using natural workflow which is also combined with statistic and artificial neural network. Afterwards it is used to predict several reservoir parameters.

This method is applied at North Tiaka field to predict the lateral lithofacies, fracture, porosity, and fluid or hydrocarbon distribution. In addition, the whole process of reservoir parameter prediction is performed by using natural algorithm based on lithofacies prediction; therefore, the determination of lithofacies is the first task that should be made before characterizing the other properties of reservoir. By using this approach, it can produce high accuracy in reservoir parameter prediction. The accuracy of the testing process shows that the predicted parameter of the reservoir on an average is a 90 percent match with the reservoir parameter in the existing wells.

References

Hasanusi, D., R. Abimanyu, E. Artono, and A. Baasir, 2004, Prominent Senoro Gas Field Discovery in Central Sulawesi: IPA-AAPG Deepwater and Frontier Symposium, p. 177-197.

Satyana, A.H., 2006, New insight on tectonic of central Java, Indonesia and its petroleum implications: Search and Discovery Abstract #90061. Web accessed 26 March 2012,
http://www.searchanddiscovery.com/abstracts/pdf/2006/intl_perth/abstracts/ndx_satyana.pdf

**CARBONATE RESERVOIR CHARACTERIZATION
USING SEQUENTIAL HYBRID SEISMIC ROCK
PHYSICS AND ARTIFICIAL NEURAL NETWORK :
CASE STUDY OF NORTH TIKA FIELD, INDONESIA**

Deddy Hasanusi¹, Rahmat Wijaya¹, Indra Shahab²
Bagus Endar B. Nurhandoko³

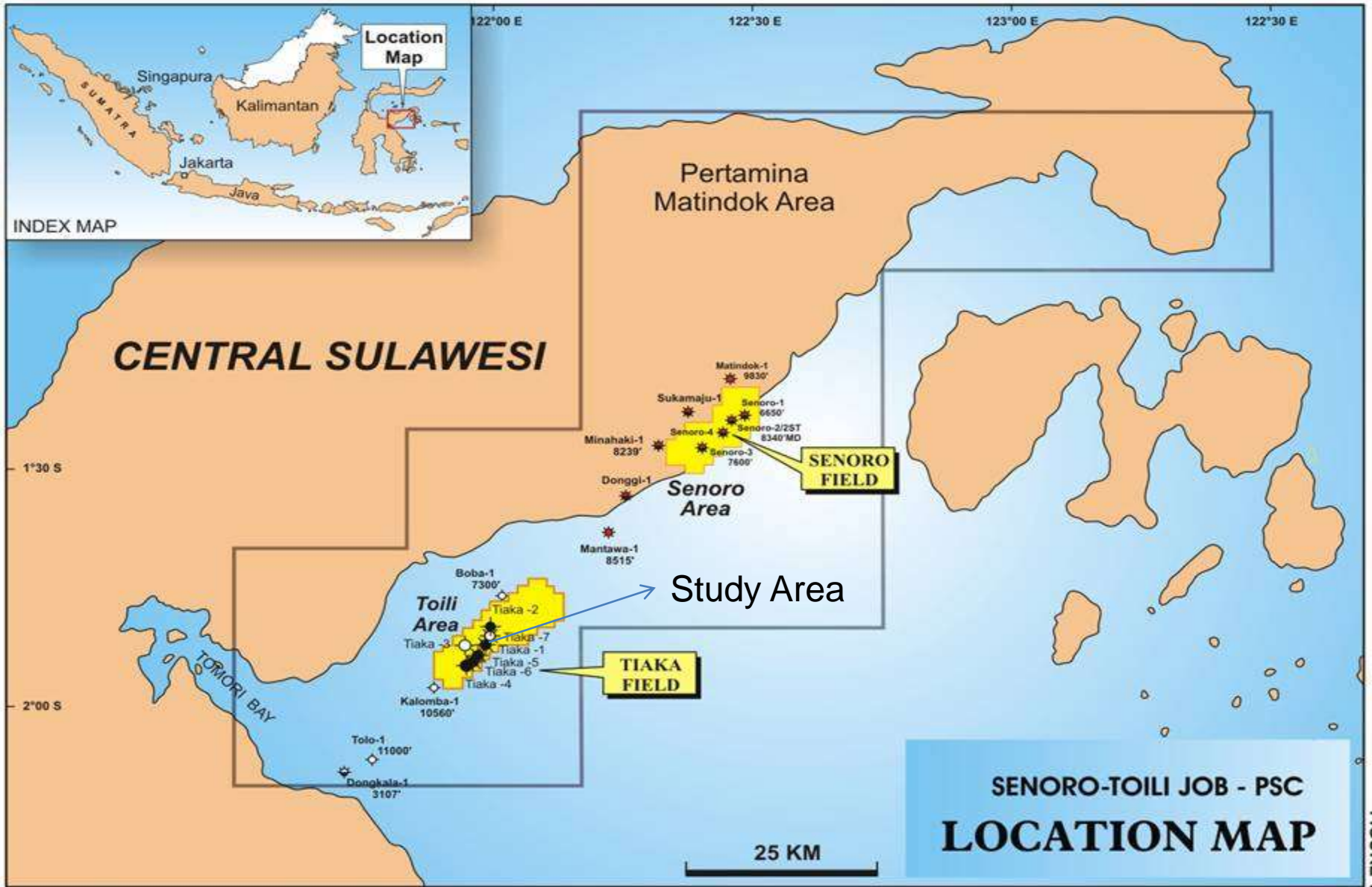
OUTLINE

- **INTRODUCTION**
 - Background
 - Objective
- **METHODOLOGY**
- **RESERVOIR CHARACTERIZATION**
 - Carbonate Facies Prediction
 - Fracture Prediction Analysis
 - Porosity Prediction (Matrix and Fracture Porosity)
 - Fluid Prediction
- **CONCLUSION**

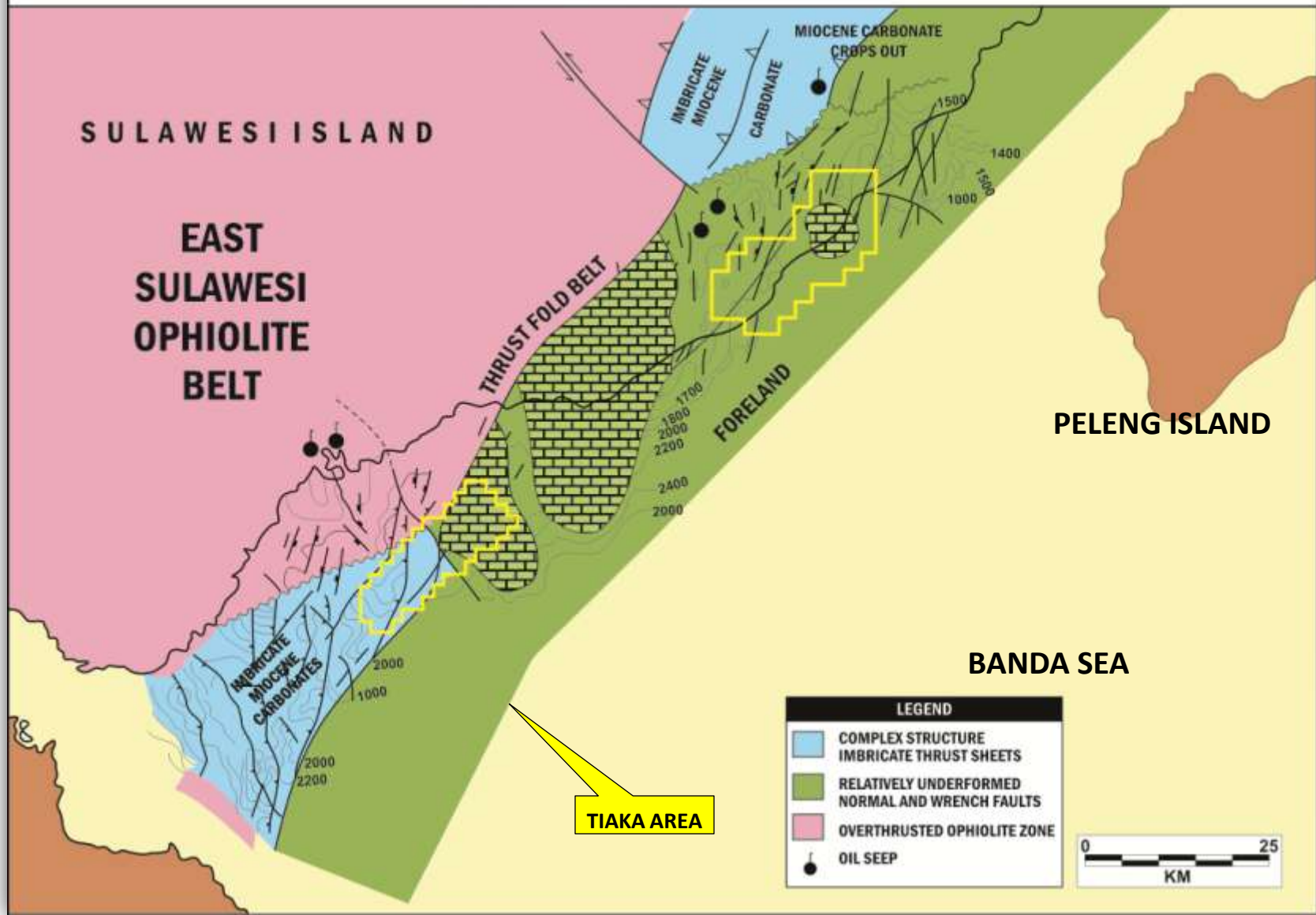
INTRODUCTION

Field Location



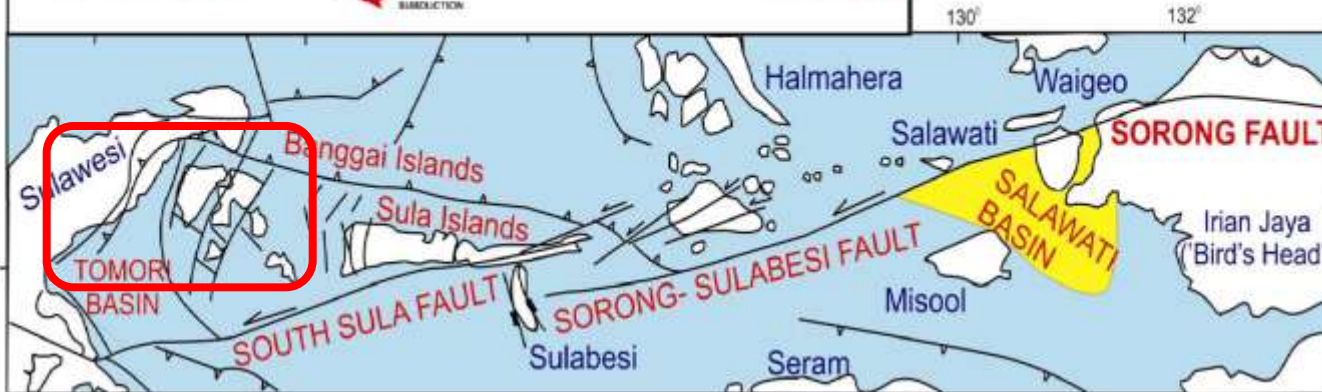
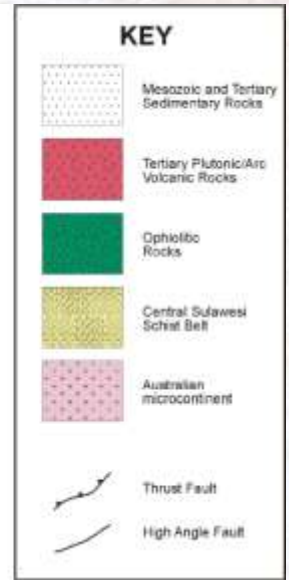
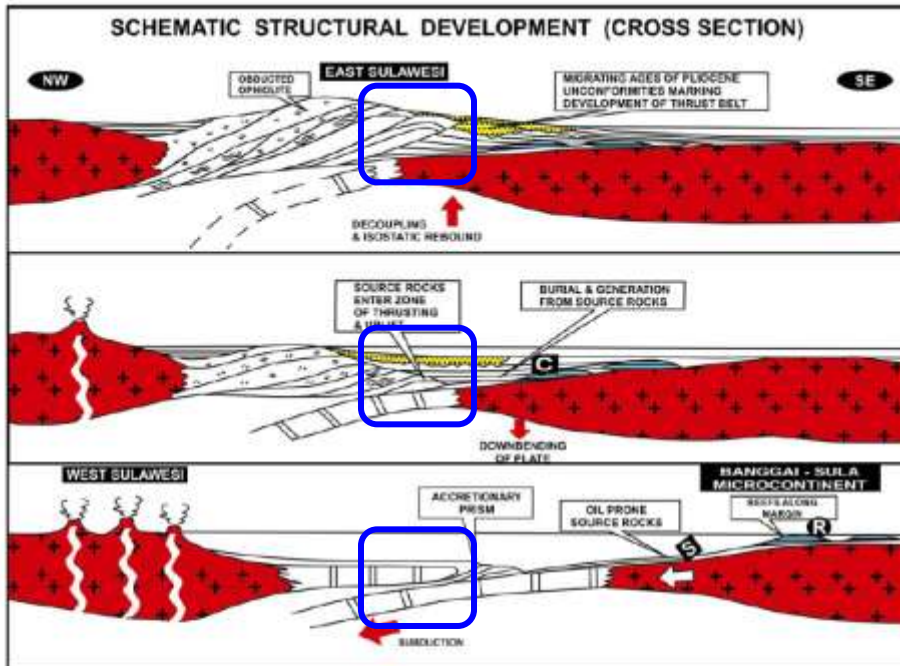


TECTONIC ELEMENT EAST SULAWESI

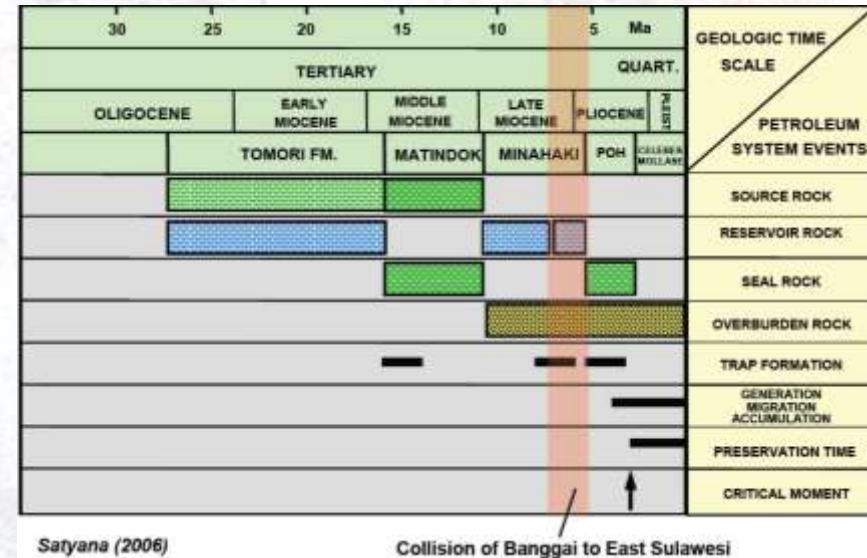
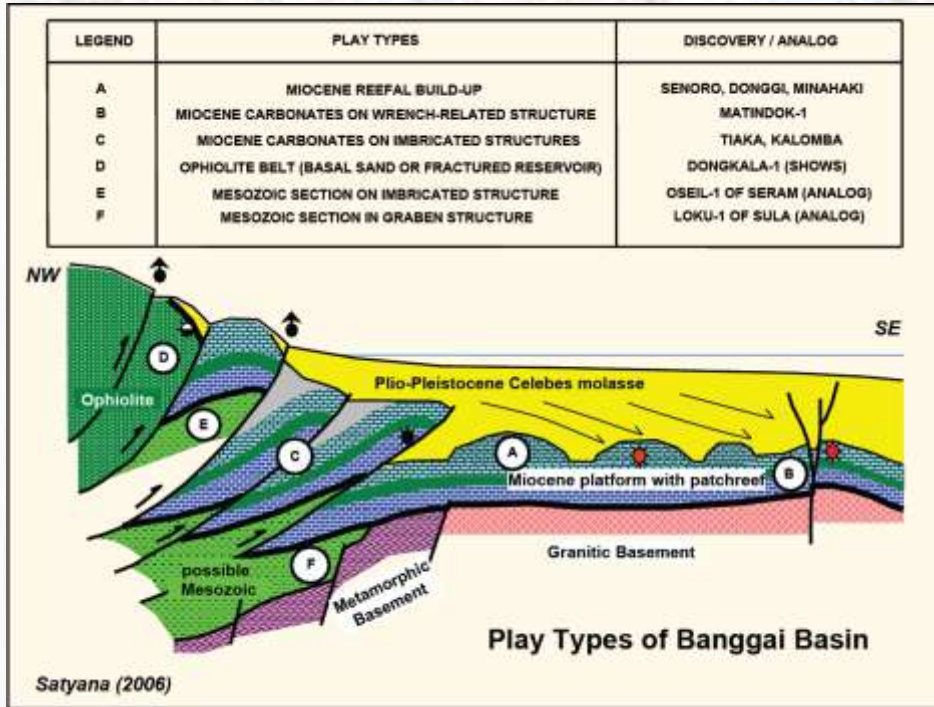


After Hasanusi et al., 2004

Tectonic Setting and Regional Structure



Petroleum System



- Tiaka field is Miocene fractured carbonate play type within Late Miocene – Pliocene imbricated thrust structures.
- Petroleum system indicated hydrocarbon generation, migration and accumulation in structural trap during Pliocene – Pleistocene time.

Regional Stratigraphy

Source Rock:

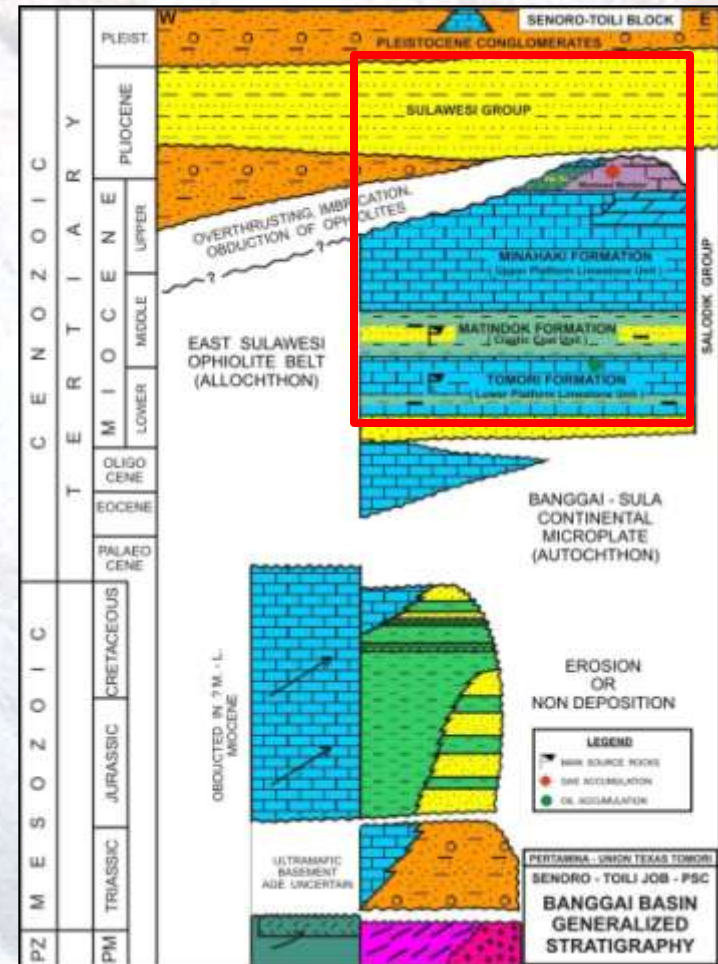
- Tomori Formation
- Matindok Formation

Reservoir:

- Tomori Formation
- Minahaki Formation and Mantawa Member

Seal:

- Matindok Formation
- Kintom Formation (Sulawesi Group)



::: INTRODUCTION :::

BACKGROUND

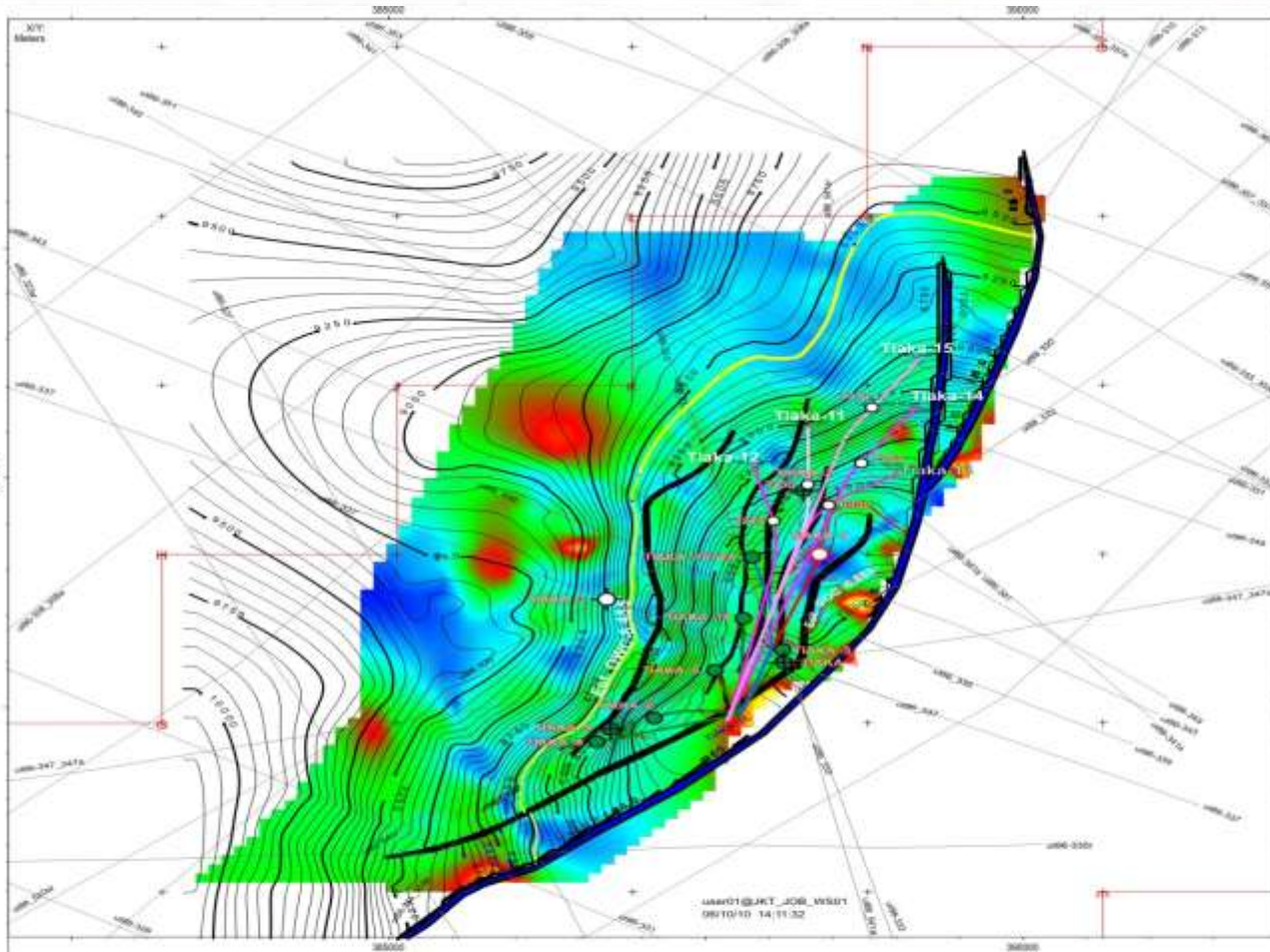
Tiaka field is located in the Senoro-Toili Block , eastern arm of Sulawesi. The main reservoir in this field is platform carbonates. To characterize the carbonate rock usually using conventional analysis, however, is quite complex. This complexity of carbonate needs special treatment to precisely characterize the reservoir.

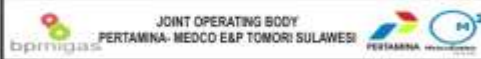
Moreover, this main producing hydrocarbon reservoir has been defined from previous study as fractured carbonate reservoir.

Technical limitations of this reservoir characterization are:

- 1. Pre-stack seismic data set is very limited .**
- 2. No FMI**
- 3. No Shear wave log**

To handle this limitation, core observation as well as core measurement should be carried out during this project.



	
TIKA FIELD TOP TOMORI DEPTH & TOTAL POROSITY MAP CI: 50 FEET	
Author : A.A.B	Date : June, 2010

::: INTRODUCTION :::

OBJECTIVE

The main objective is reservoir characterization enhancement in Northern part of Tiaka field by Integrating Seismic Rock physics and artificial neural network to predict :

- 1. Facies of carbonate reservoir,**
- 2. Fractured reservoir,**
- 3. Porosity distribution**
- 4. Distribution of Fluid type in pores as well as in fracture.**

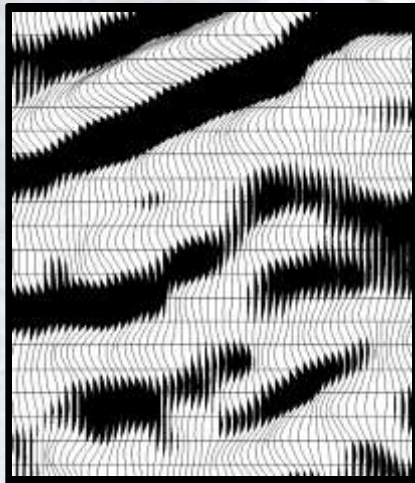
METHODOLOGY

::: METHODOLOGY :::

- **Reservoir characterization applies latest technology using Hybrid Statistical Rock Physics and Artificial Neural Network.**
- **This methodology is able to integrate all of following G&G data resolution into Reservoir Prediction System, i.e.:**
 - **Core data (lithology, lithofacies, fracture intensity, fracture width, porosity)**
 - **Well log data (gamma ray, density, Sw, porosity, resistivities, etc.)**
 - **Multi-attribute seismic , pre-stack as well as postack data,**
 - **Seismic rock physics data.**
 - **Petrophysics data**
- **Reservoir properties are predicted by sequential flow; it means that porosity, permeability and fluid saturation prediction are based on lithofacies information.**

WHAT IS SEISMIC ROCK PHYSICS?

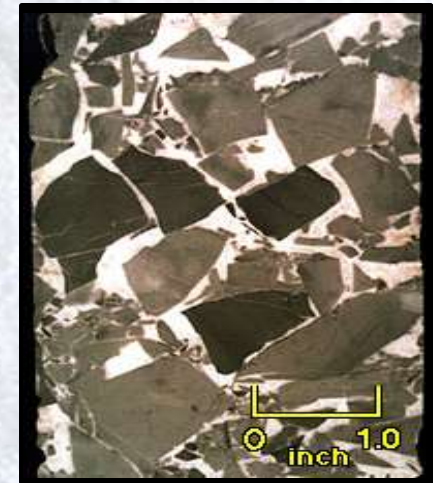
Method to translate seismic wave into Reservoir parameters
(Petrophysics and Lithofacies)



Parameter Seismic wave



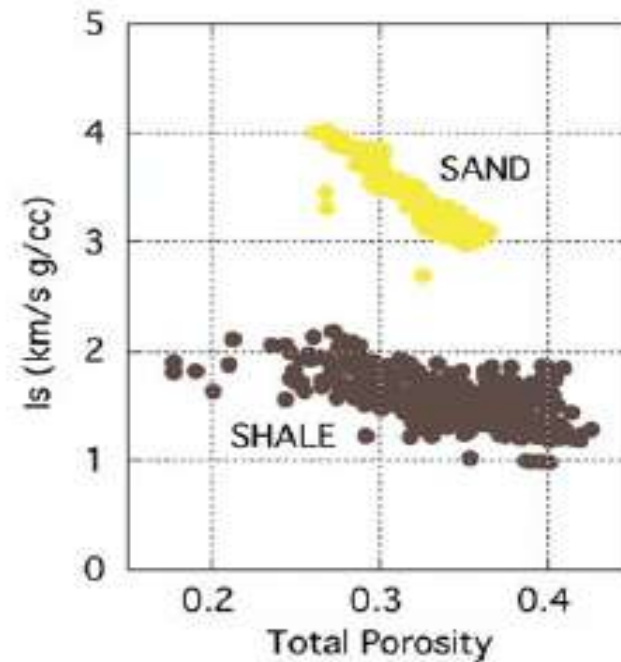
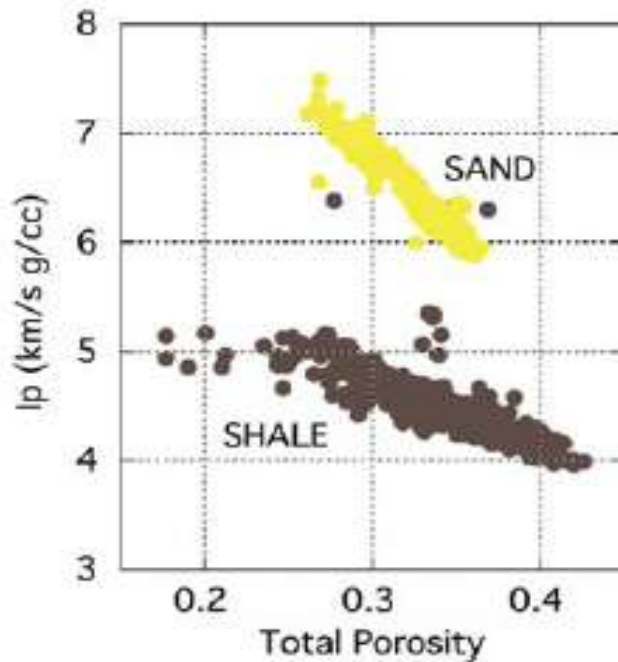
ROCK PHYSICS



Parameter reservoir

EXAMPLE SEISMIC ROCK PHYSICS APPLICATION

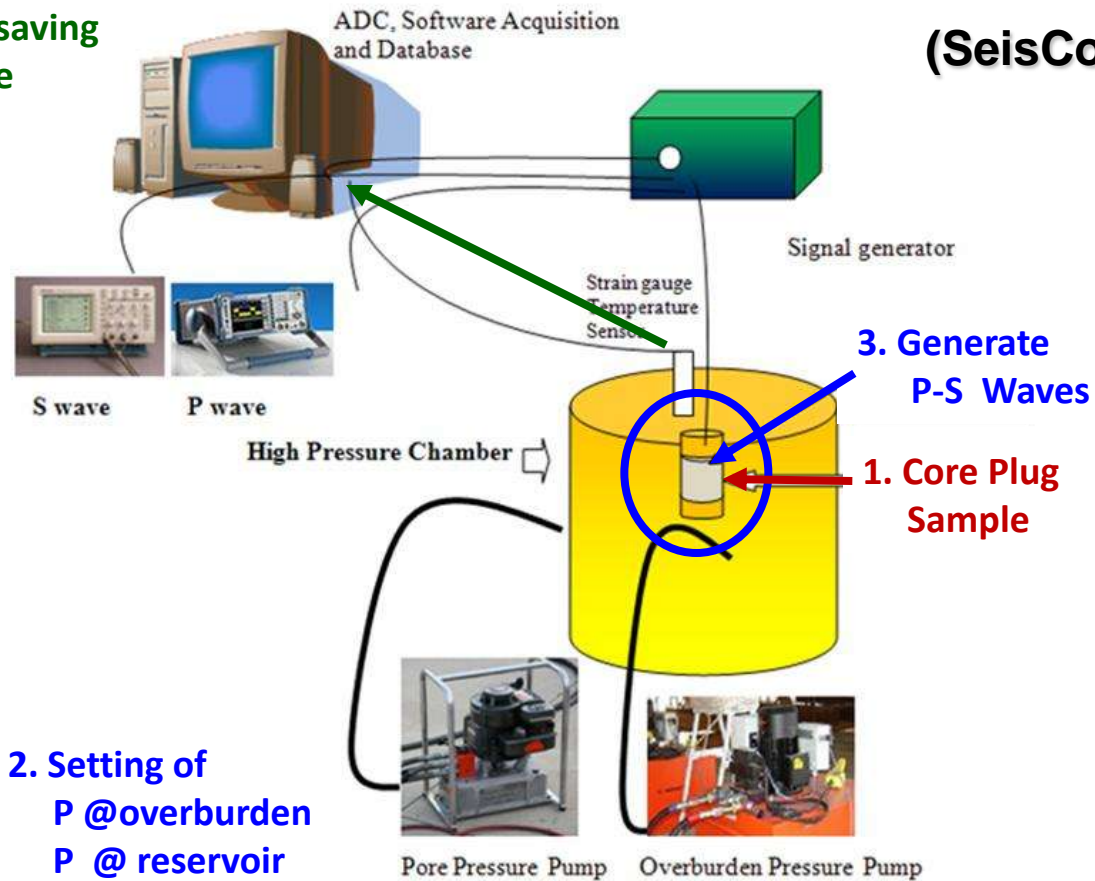
Identification of sand and shale lithology using Acoustic Impedance (IP) and Shear Impedance (IS)



METHODOLOGY :

SEISMIC ROCK PHYSICS MEASUREMENT

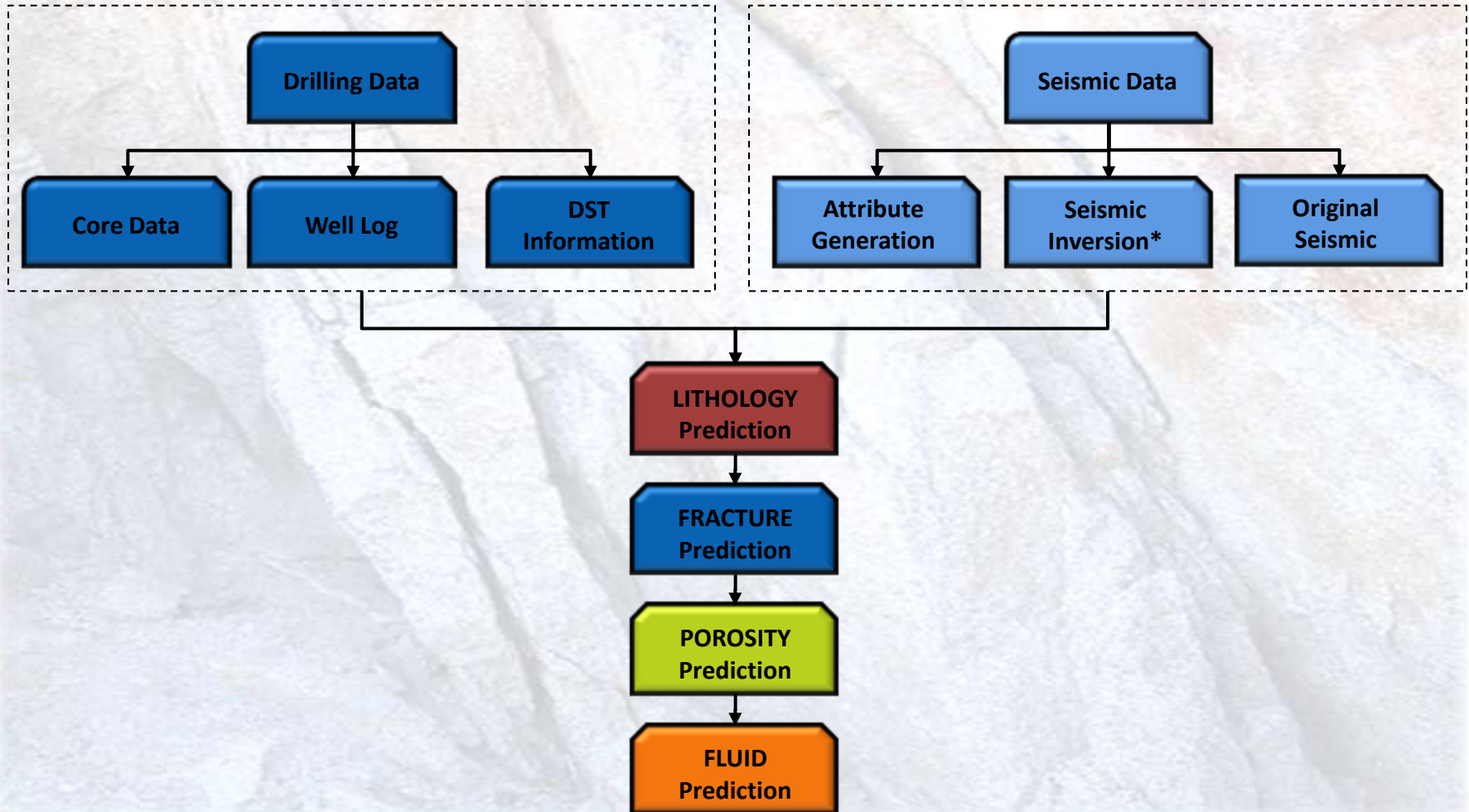
4. Recording and saving Wave Response



2. Setting of
P @ overburden
P @ reservoir

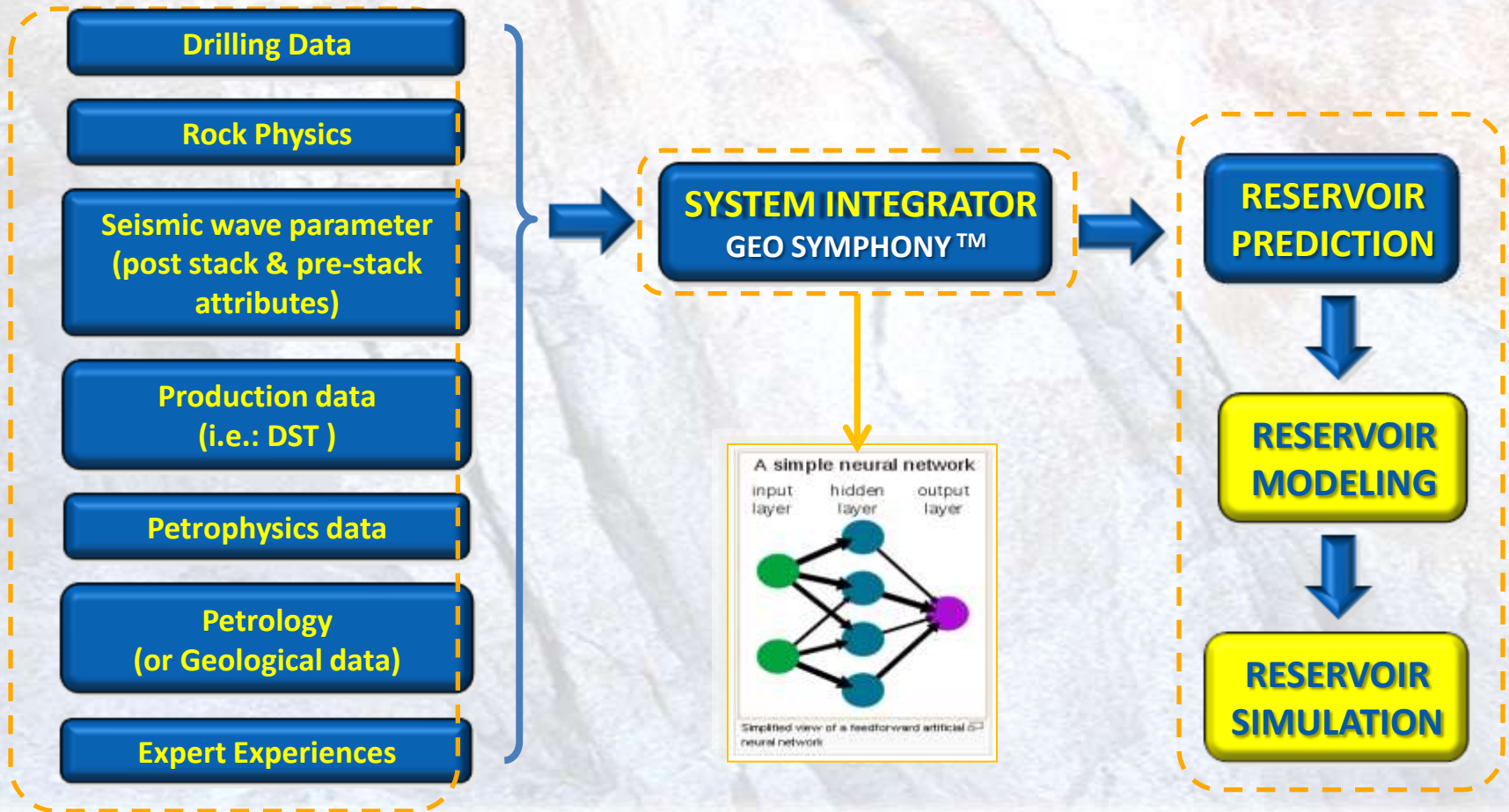
::: METHODOLOGY :::

GENERAL WORKFLOW



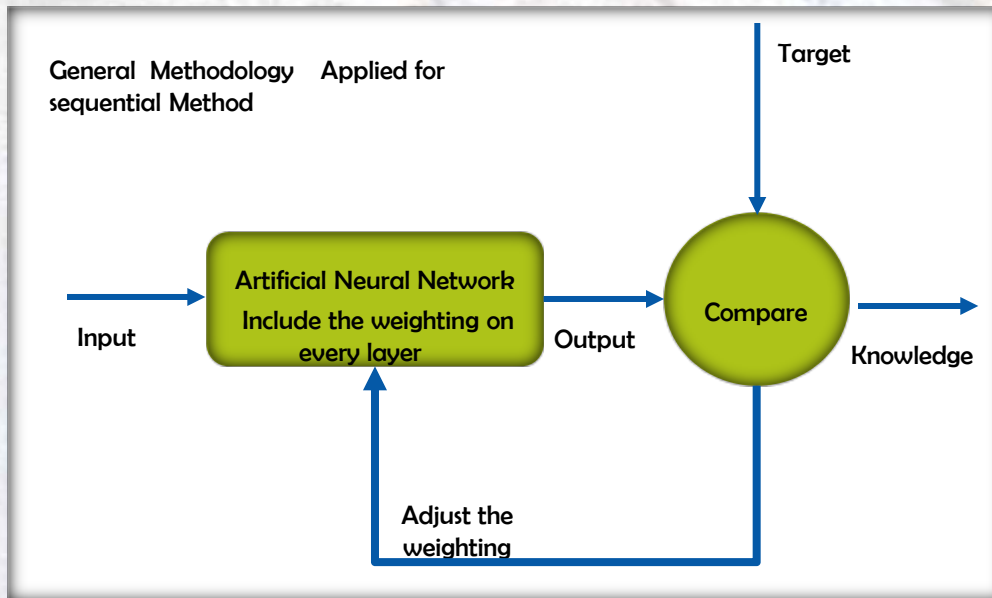
METHODOLOGY :

RESOURCES ILLUSTRATION WORKFLOW



::: METHODOLOGY :::

ARTIFICIAL INTELLIGENCE PRINCIPLE WORKFLOW

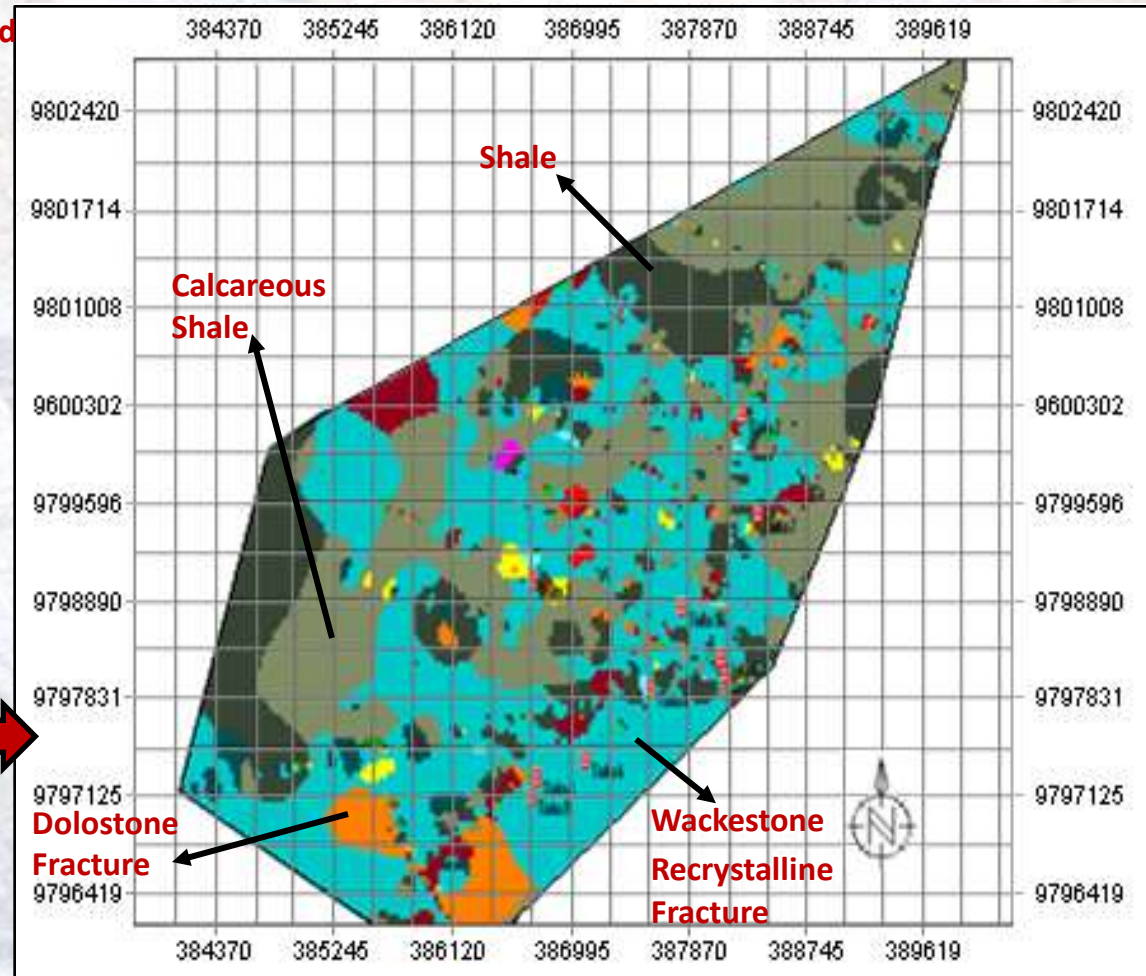
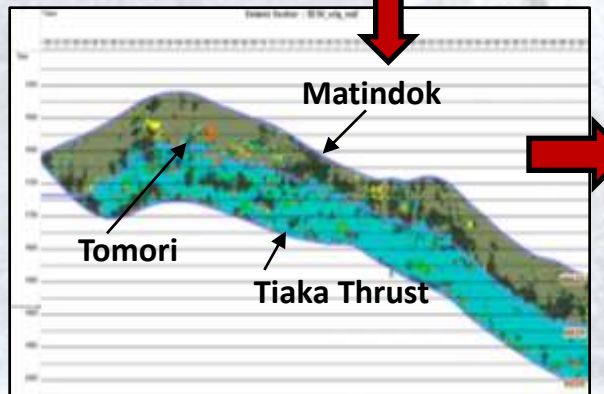
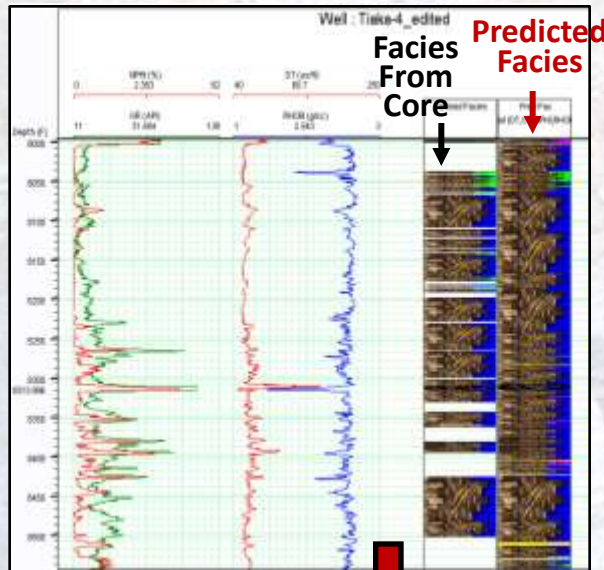


An artificial neural network is data processing system that has special characteristic which mimic the human brain to analyze and come out with results.

In addition, a combination of artificial intelligence and rock physics is a must because of its capabilities to handle complex problems, huge data (many attributes, many correlations) and non-linearity.

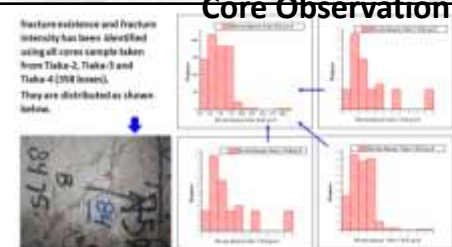
RESERVOIR CHARACTERIZATION RESULTS

LITHOFACIES PREDICTION TOMORI RESERVOIR

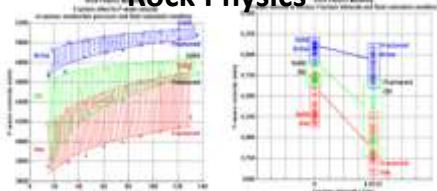


FRACTURE PREDICTION TOMORI RESERVOIR

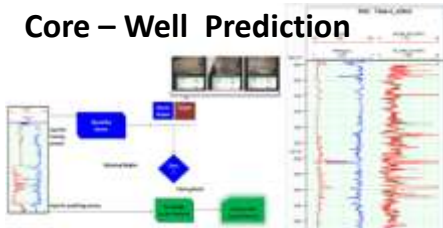
Core Observation



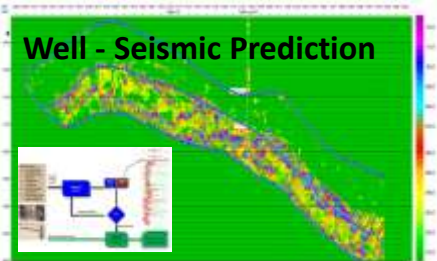
Rock Physics



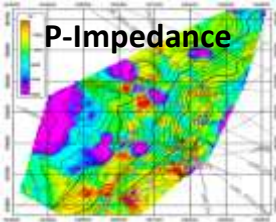
Core - Well Prediction



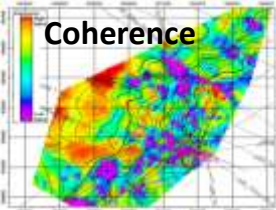
Well - Seismic Prediction



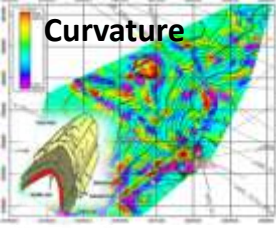
P-Impedance



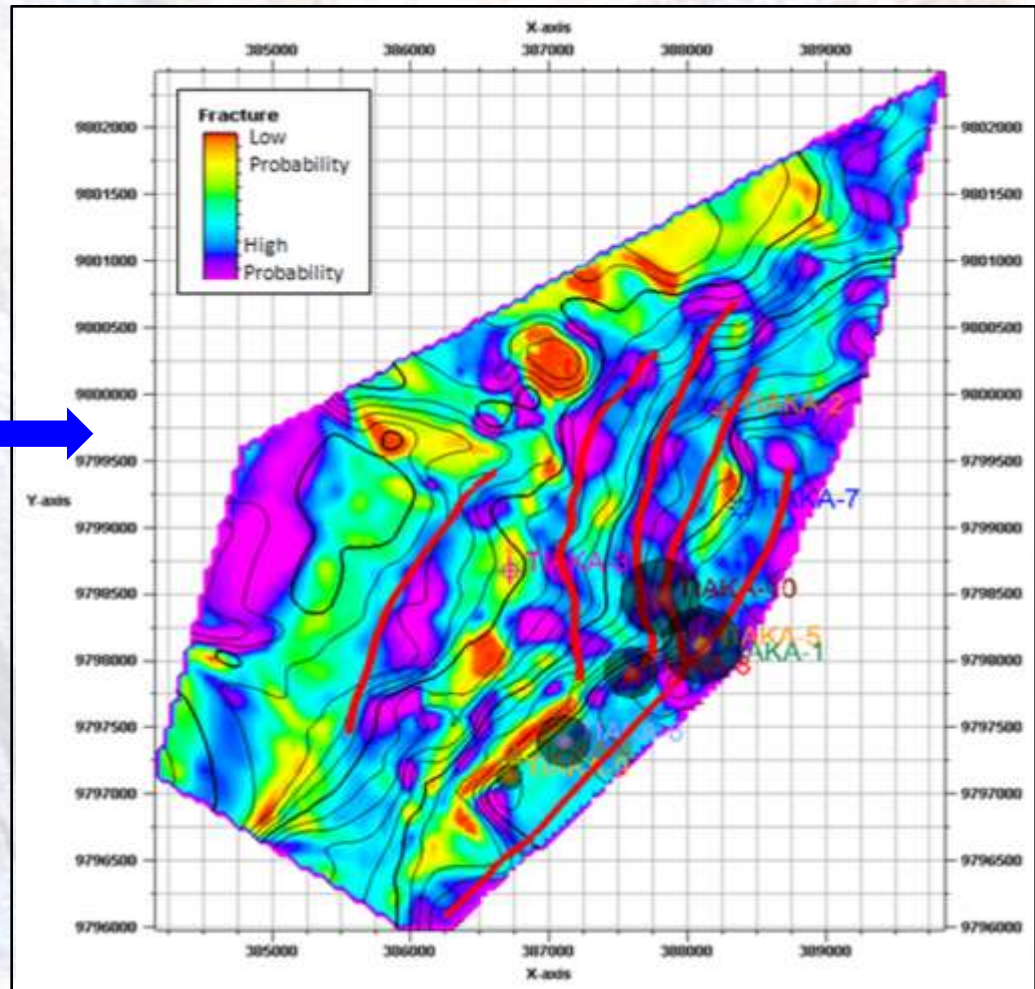
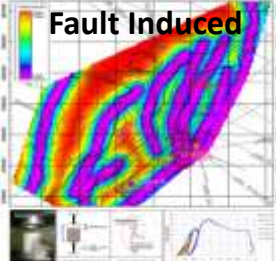
Coherence



Curvature

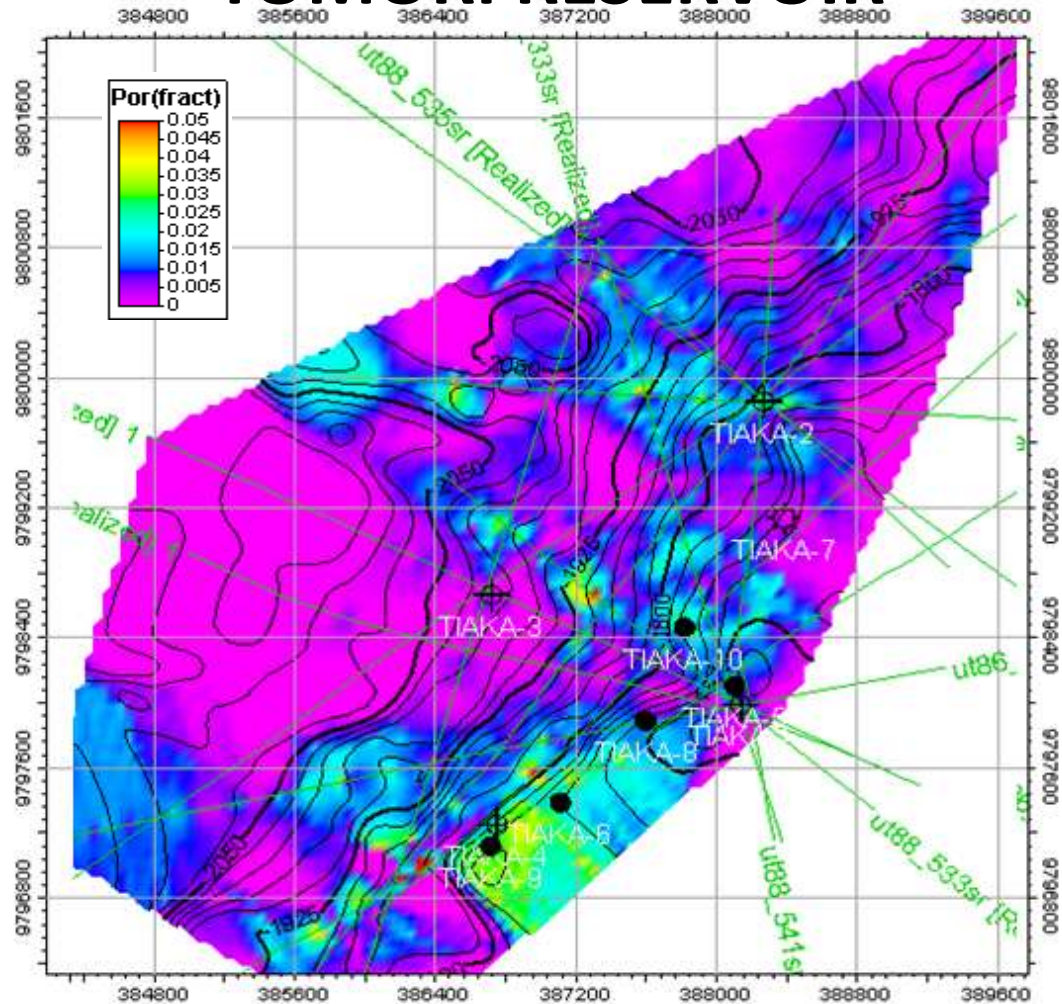


Fault Induced



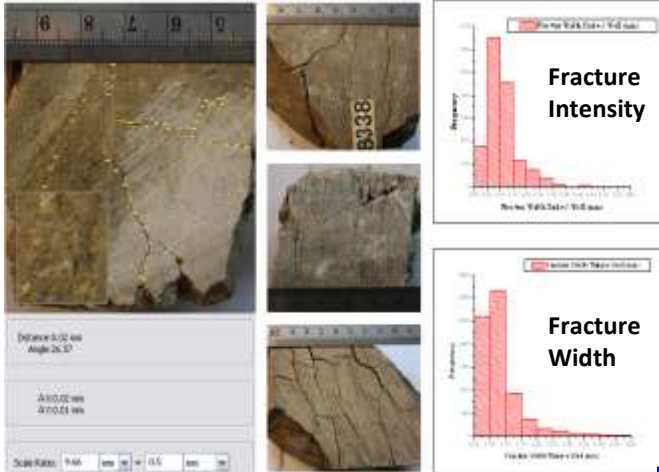
EFFECTIVE POROSITY PREDICTION

TOMORI RESERVOIR

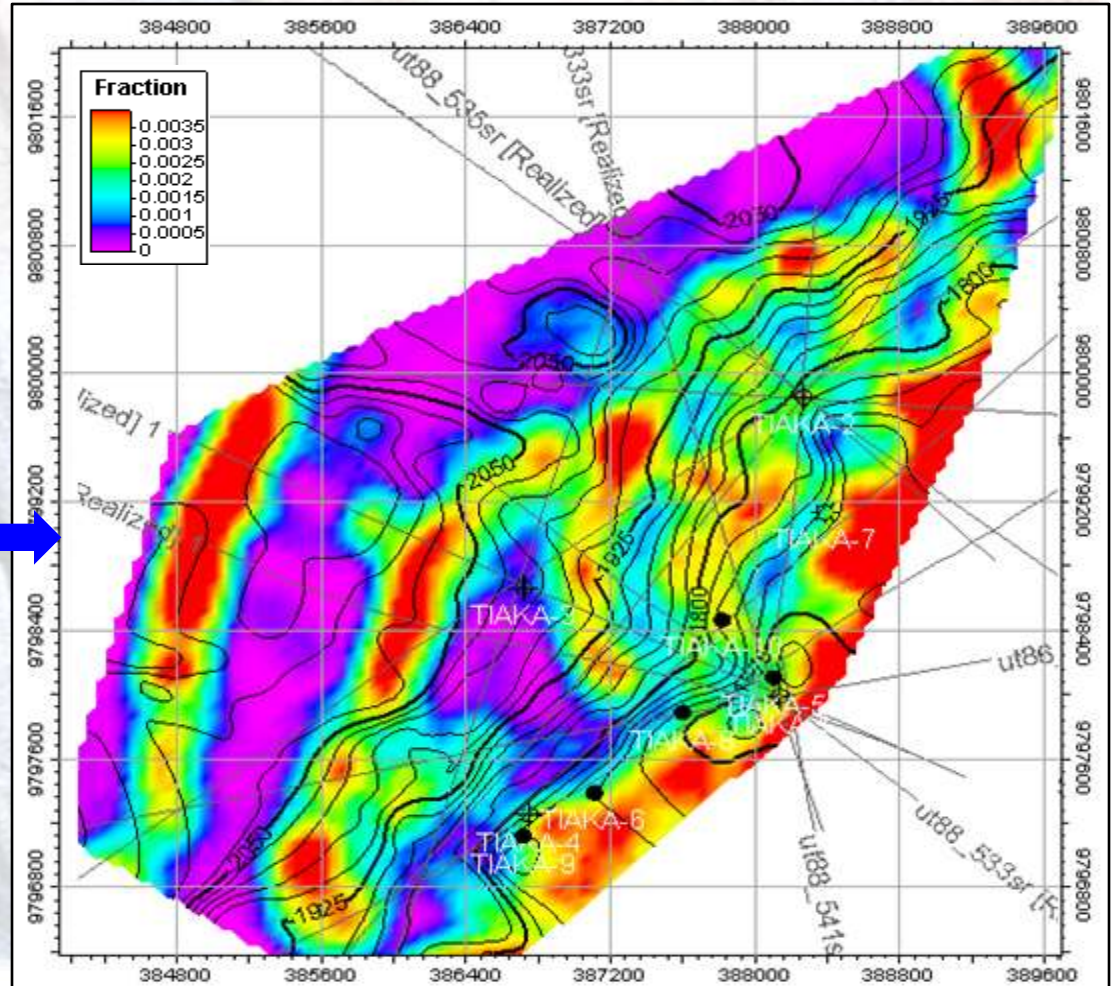
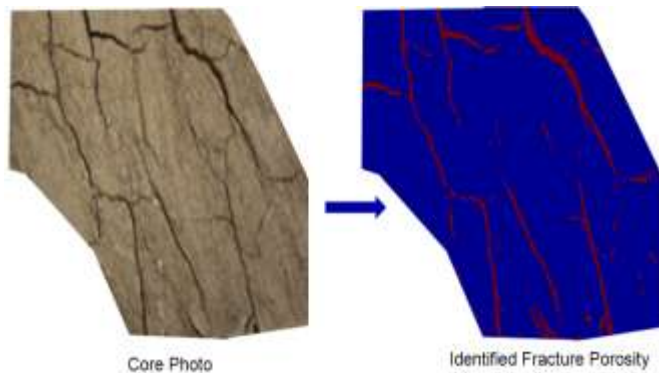


FRACTURE POROSITY PREDICTION TOMORI RESERVOIR

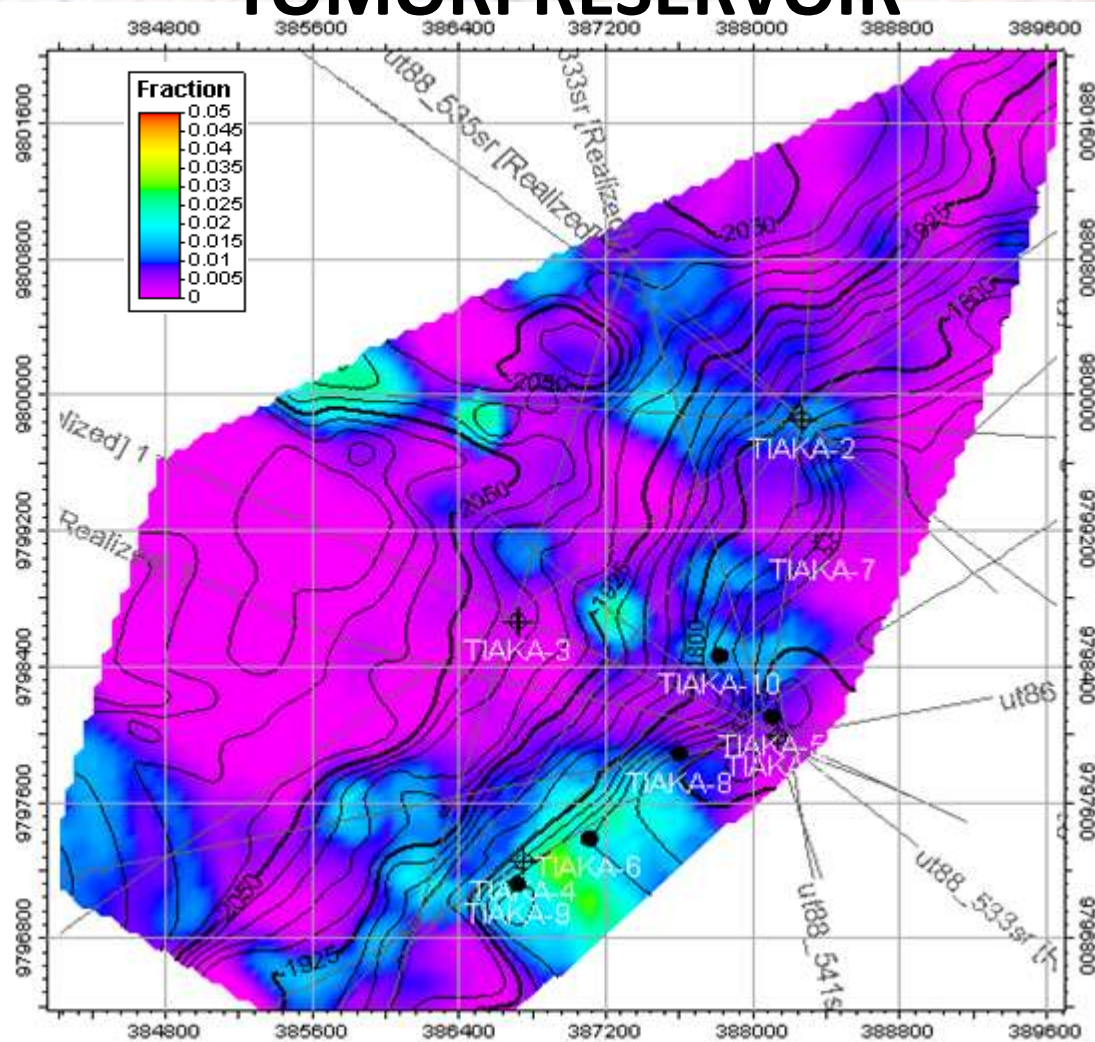
Core Observation



Porosity Image Processing



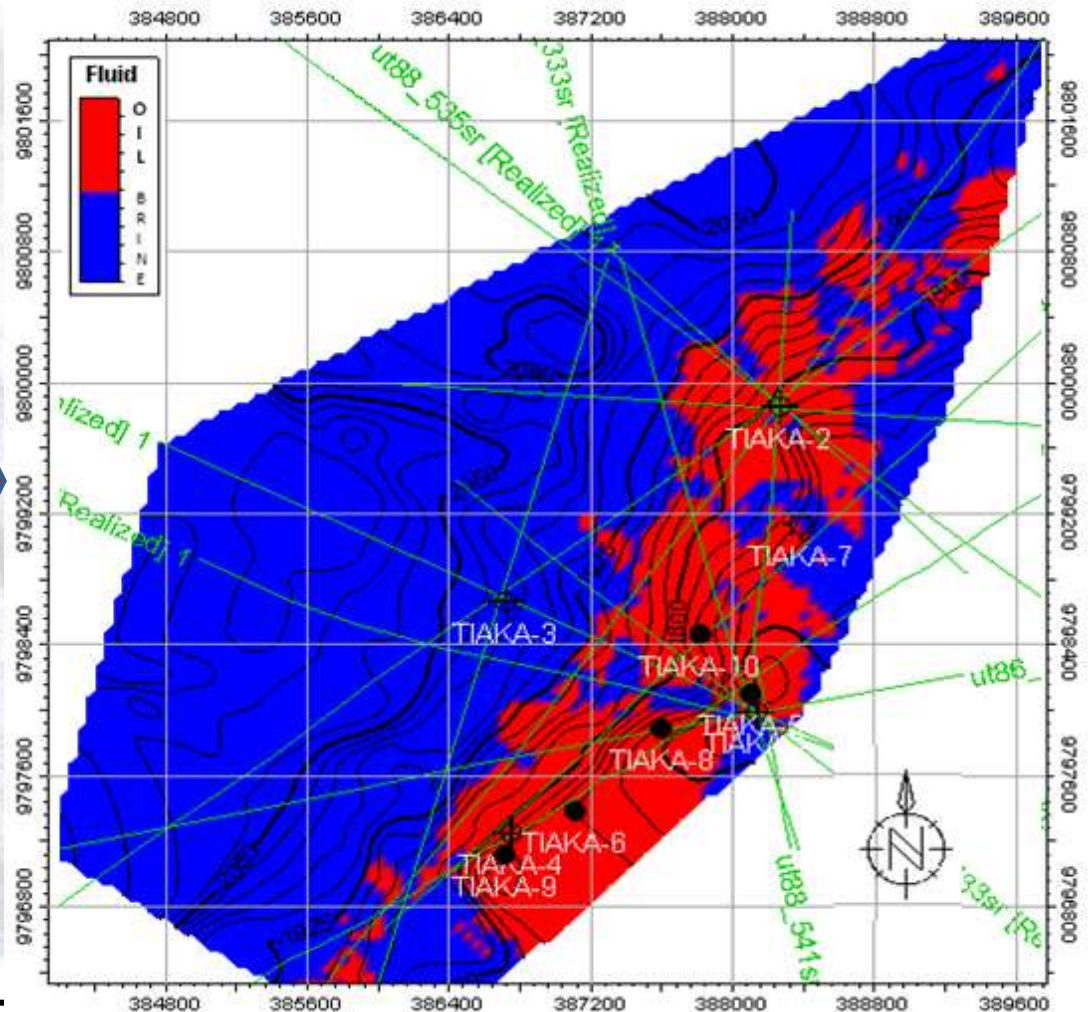
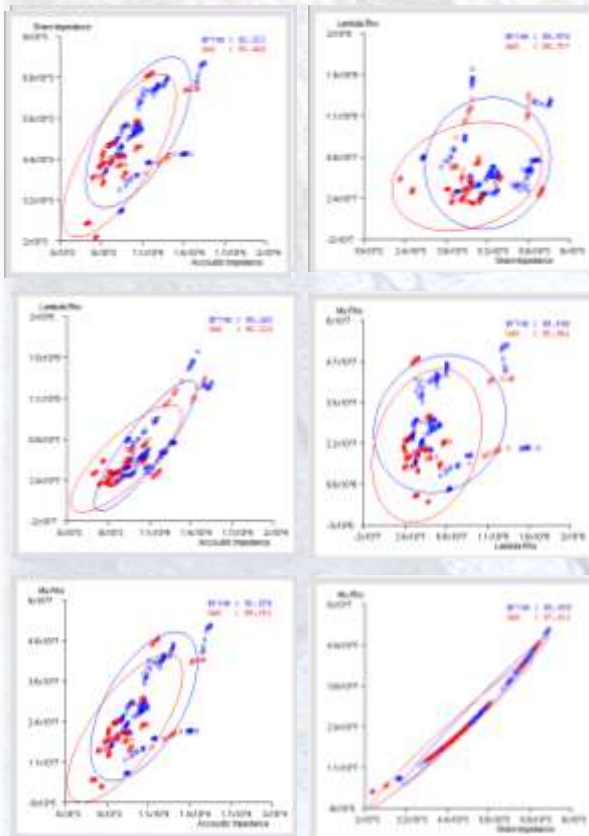
MATRIX POROSITY PREDICTION TOMORI RESERVOIR



FLUID PREDICTION

TOMORI RESERVOIR, TIAKA FIELD

Rock Physics



CONCLUSIONS

1. This technology had been used for characterizing North Tiaka field by integrating seismic rock physics, statistics, and artificial neural network.
2. This methodology can integrate a large number of data sets for obtaining coherent correlation between input data consisting of derivatives of core data set (lithology, lithofacies, fracture intensity, fracture width, porosity), well log (GR, density, resistivity, Sw, Porosity), seismic data (multi-attribute from pre-stack and post stack), and seismic rock physics data. Then, whole data were trained using natural method combined with statistic and artificial neural network in order to predict several reservoir parameters.
3. The application of this method at North Tiaka field is used to predict lithofacies , fracture, porosity, and fluid distribution.
4. Reservoir properties are accurately predicted which average correlation between predicted value and well information around 90 %.

ACKNOWLEDGMENTS

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Thank you