National Central University Graduate Institute of Applied Geology 112-1 seminar

Geological Modeling of the Fractured Reservoir in Tuchang Geothermal Field

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Advisor: Prof. Chuen-Fa Ni

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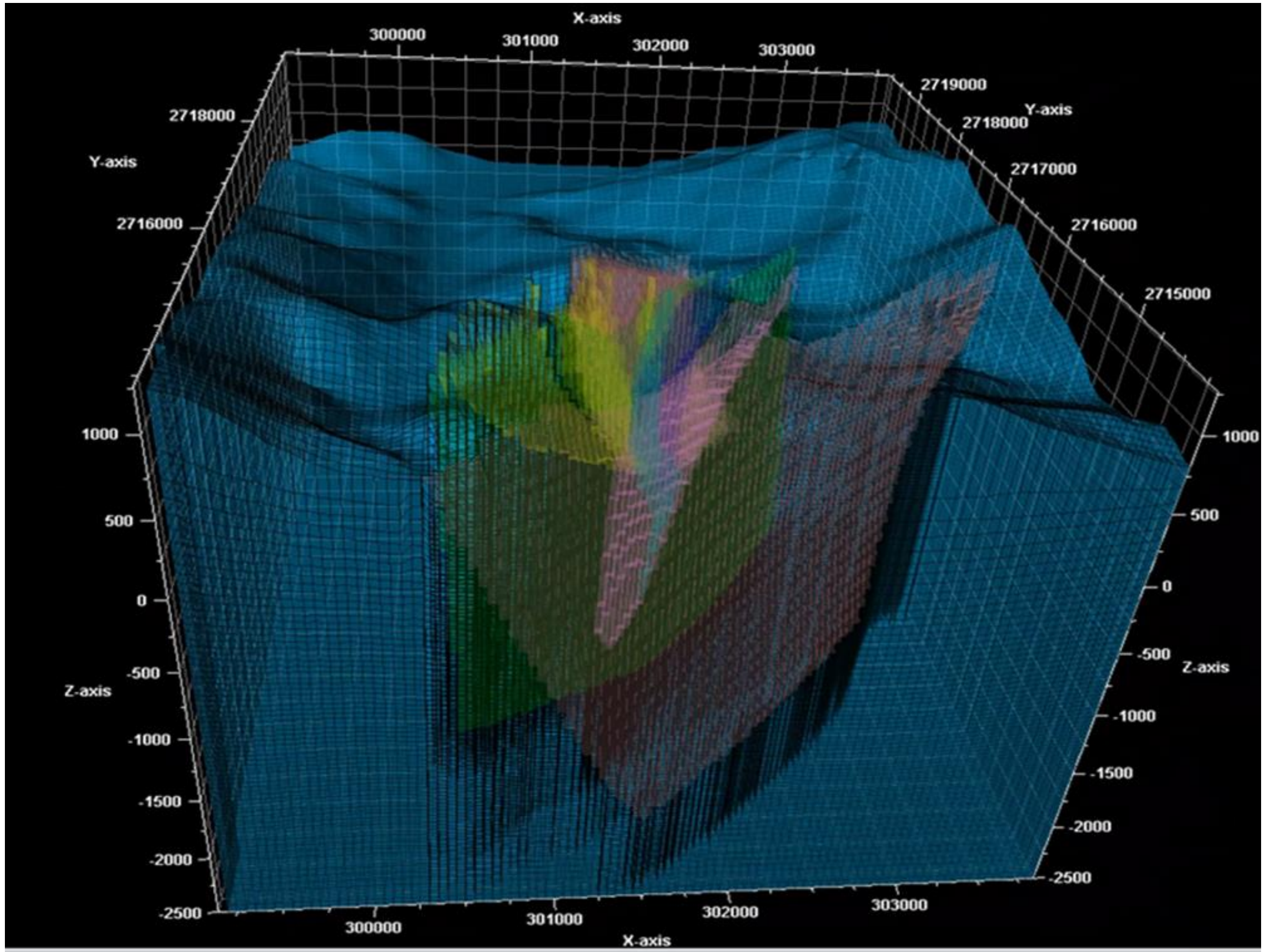
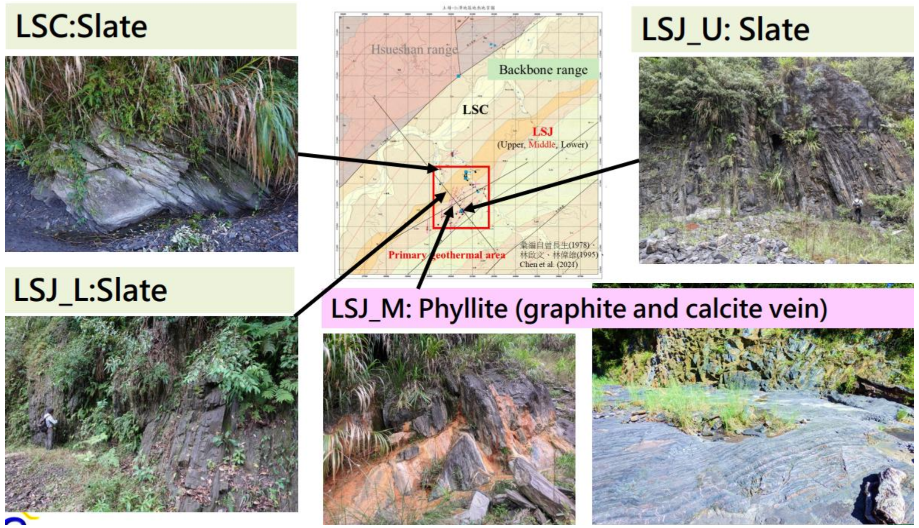
Outline

- Introduction
- method
- Data Preparation
- Modeling
- Conclusion

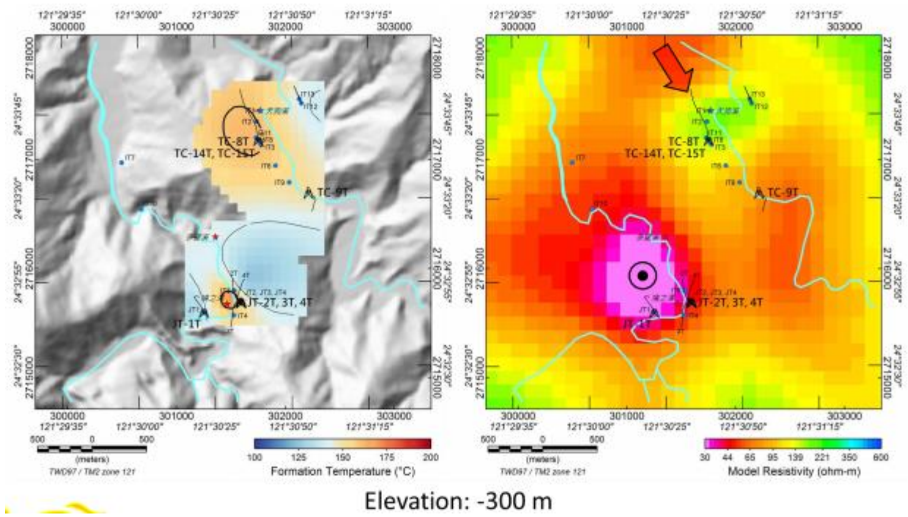


Subject of study

- This study integrates the results of surface geology, geophysics, and geochemistry surveys in the Tuchang-Jentse area in northeastern Taiwan to construct a three-dimensional geological model of fractured reservoirs in the Tuchang geothermal field.
- The completed geological model will be used in geothermal simulations to assist with the production evaluation and development planning of the Tuchang geothermal power station.

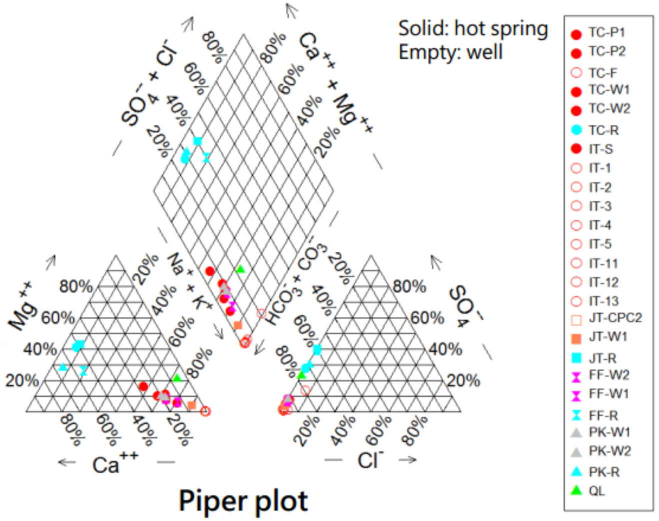


Surface survey



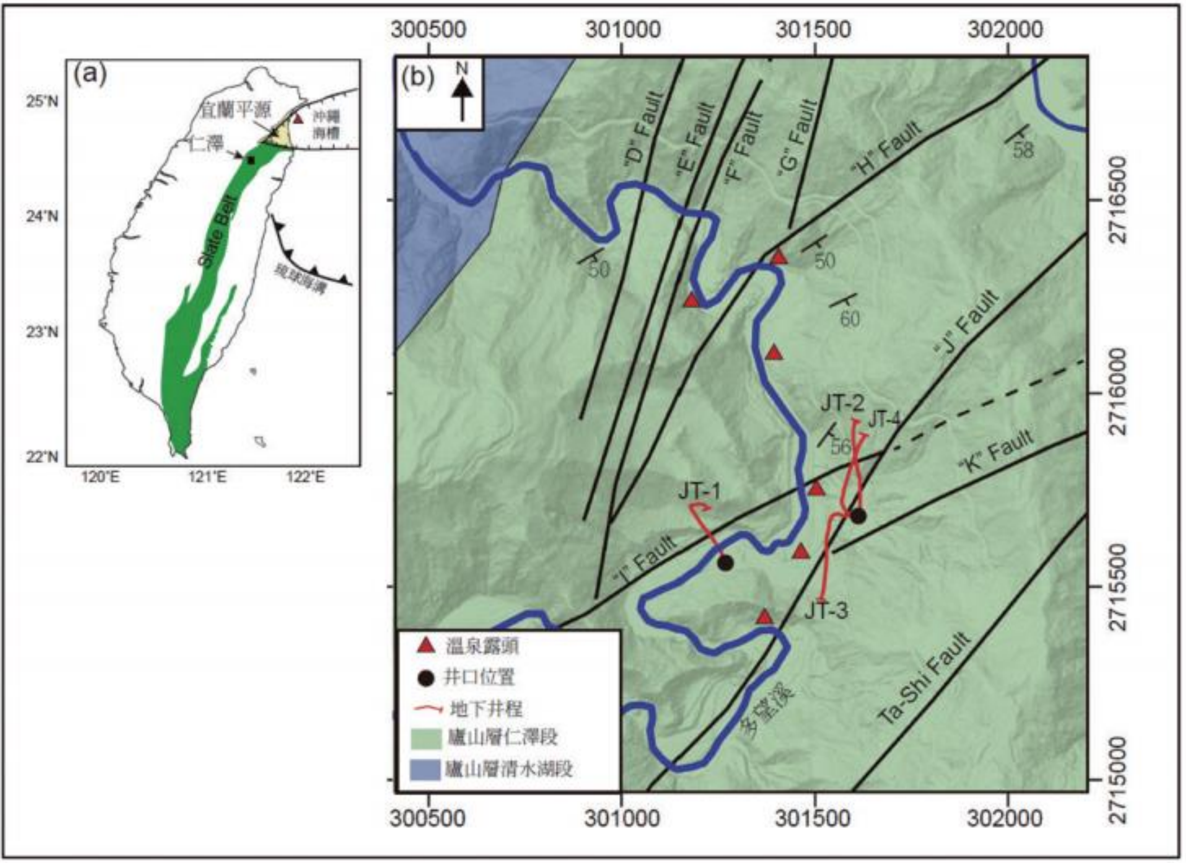
(Chiang et.al., 2015)

Temperature vs MT



Well and hot spring water characteristics

Background



(Chen et.al., 2021)

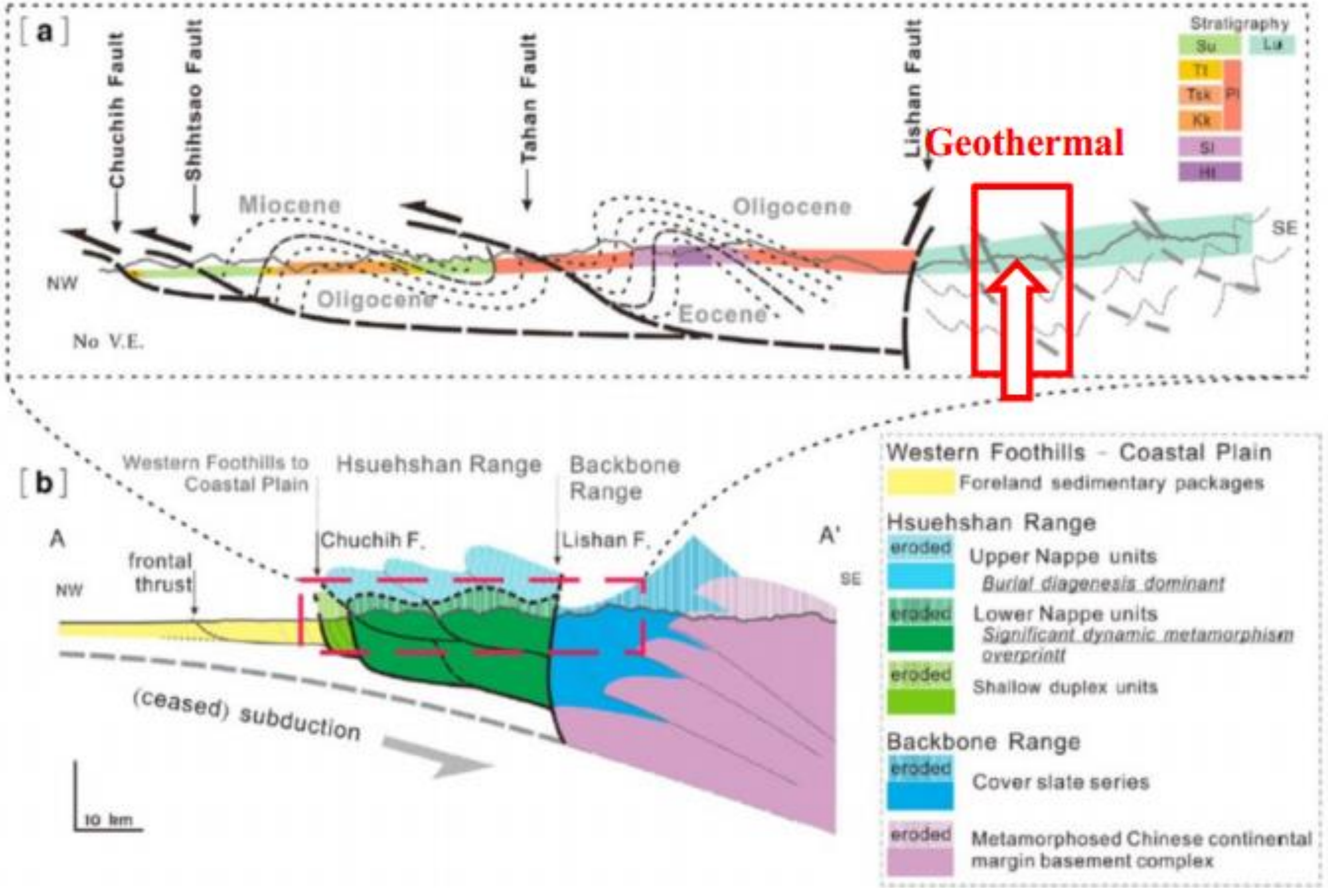


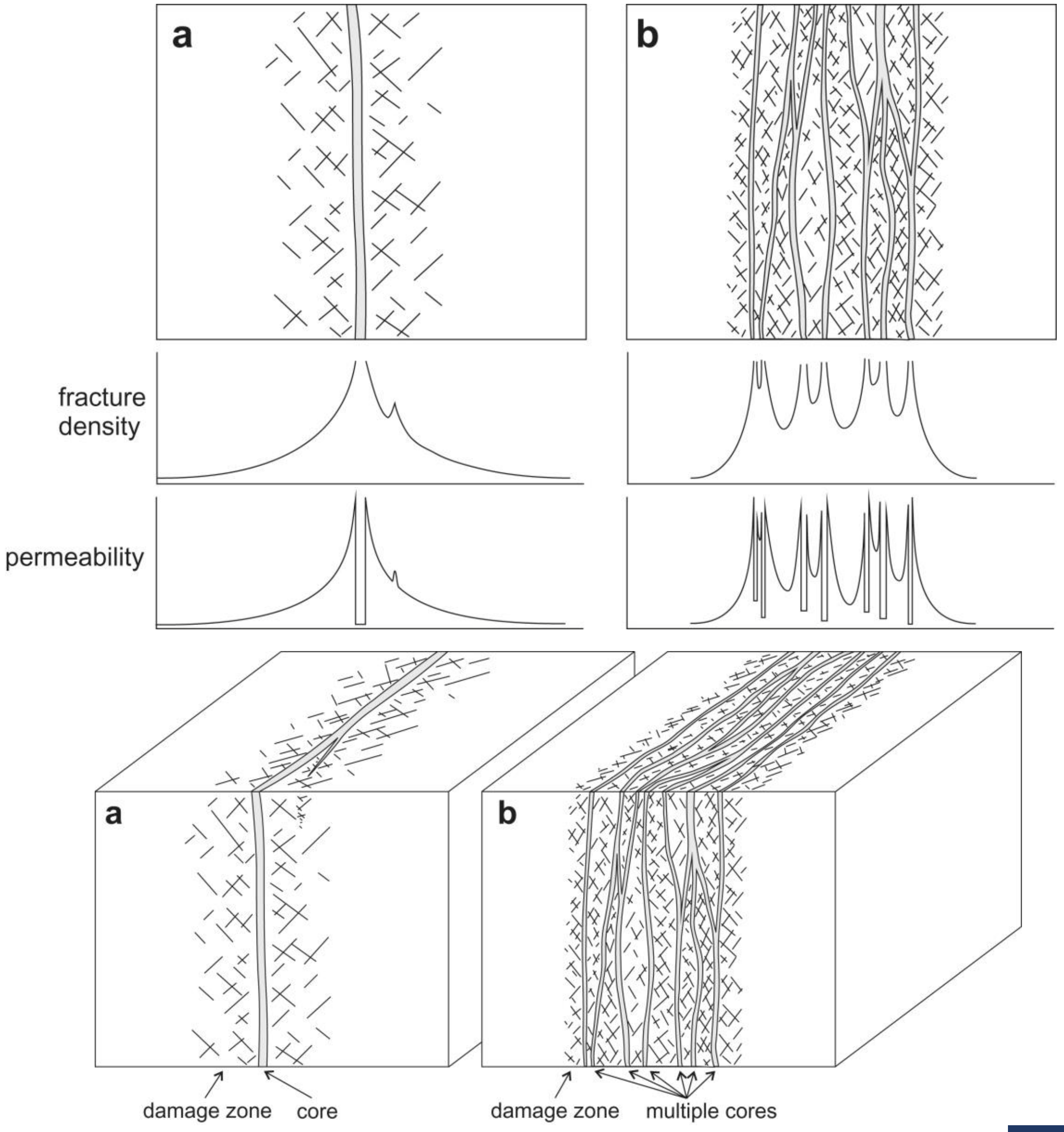
Plate subduction, rapid exhumation and denudation

(Chen et.al., 2019)

Background

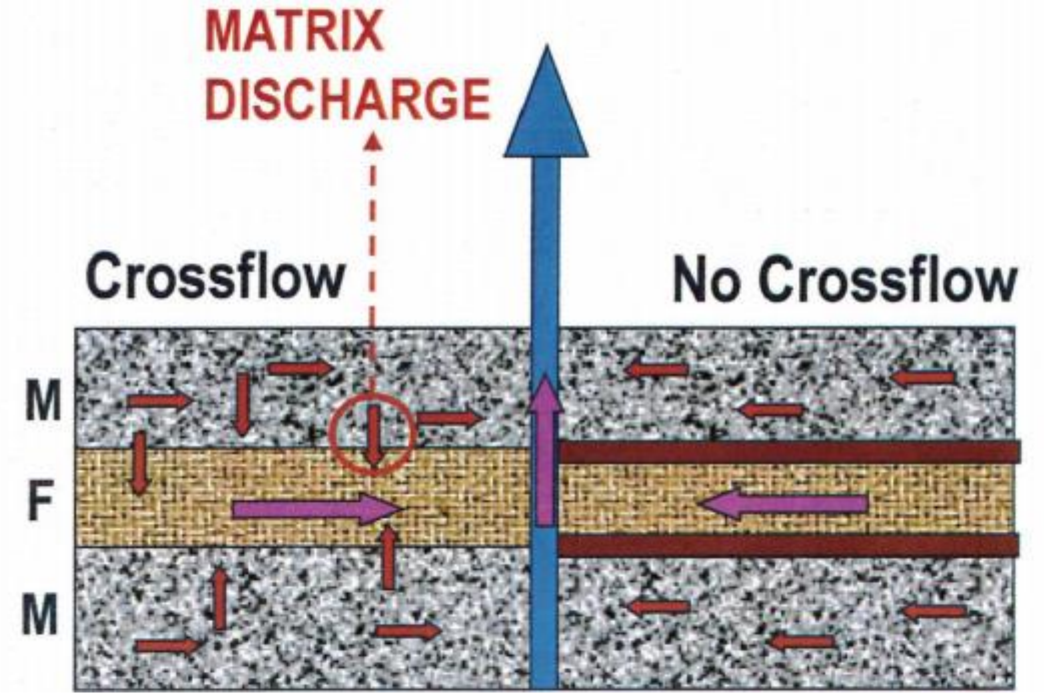
Geothermal pathways are all controlled by the fracture system

Fault with damage zone in Tuchang (CPC 2020)

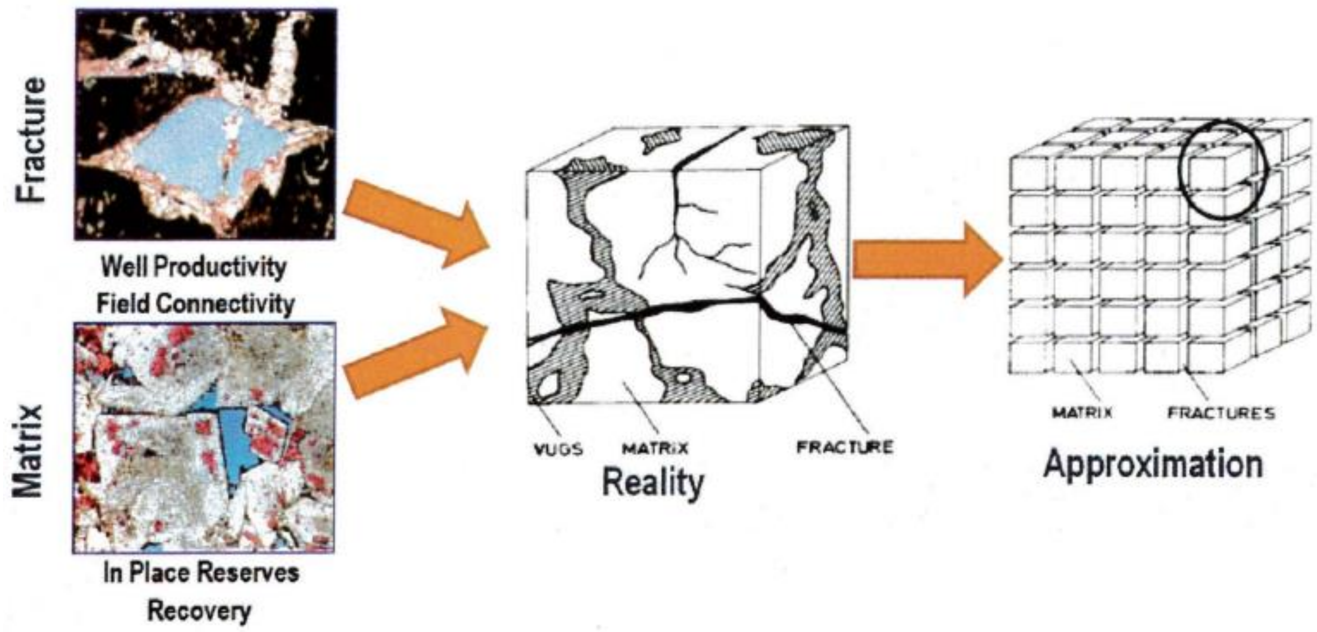


(Faulkner et.al., 2010)

Fracture Modeling



Dual-Porosity, Dual-Permeability



(Petrel Fracture Modeling 2014, Schlumberger)

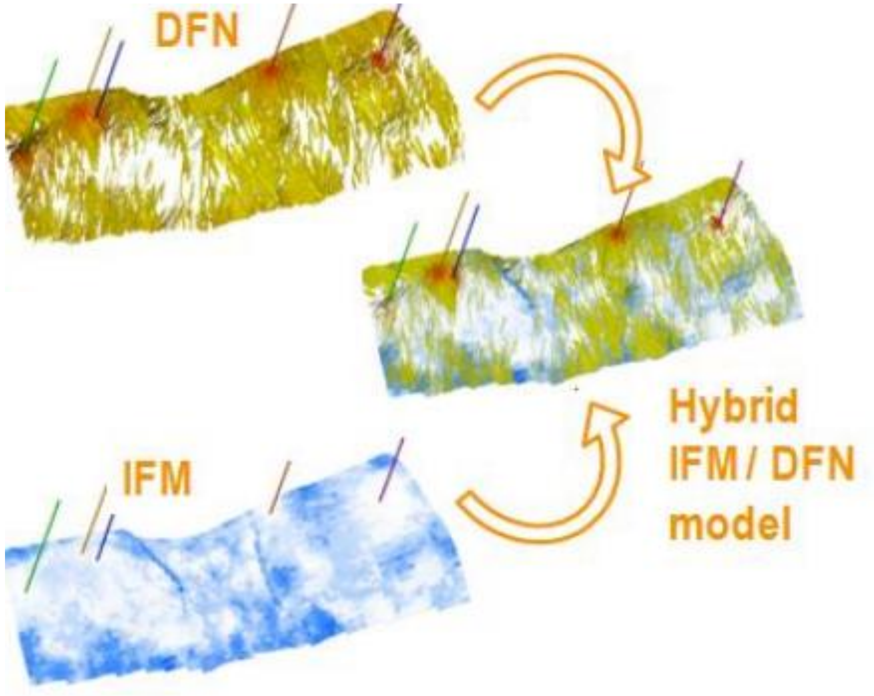
Fracture Modeling

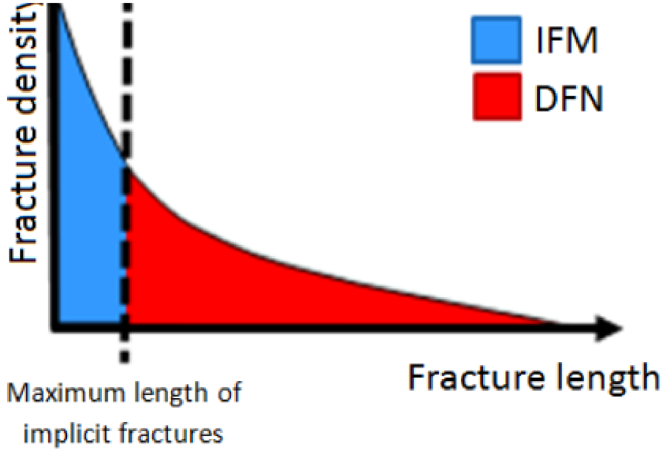
Discrete Fracture Network – DFN

- Faults
- Major fractures/joints
- Deterministic or stochastic
- planar surfaces in three dimensions

Implicit Fracture Model - IFM

- Minor fractures/joints
- Stochastic
- Intensity
- As a property of model

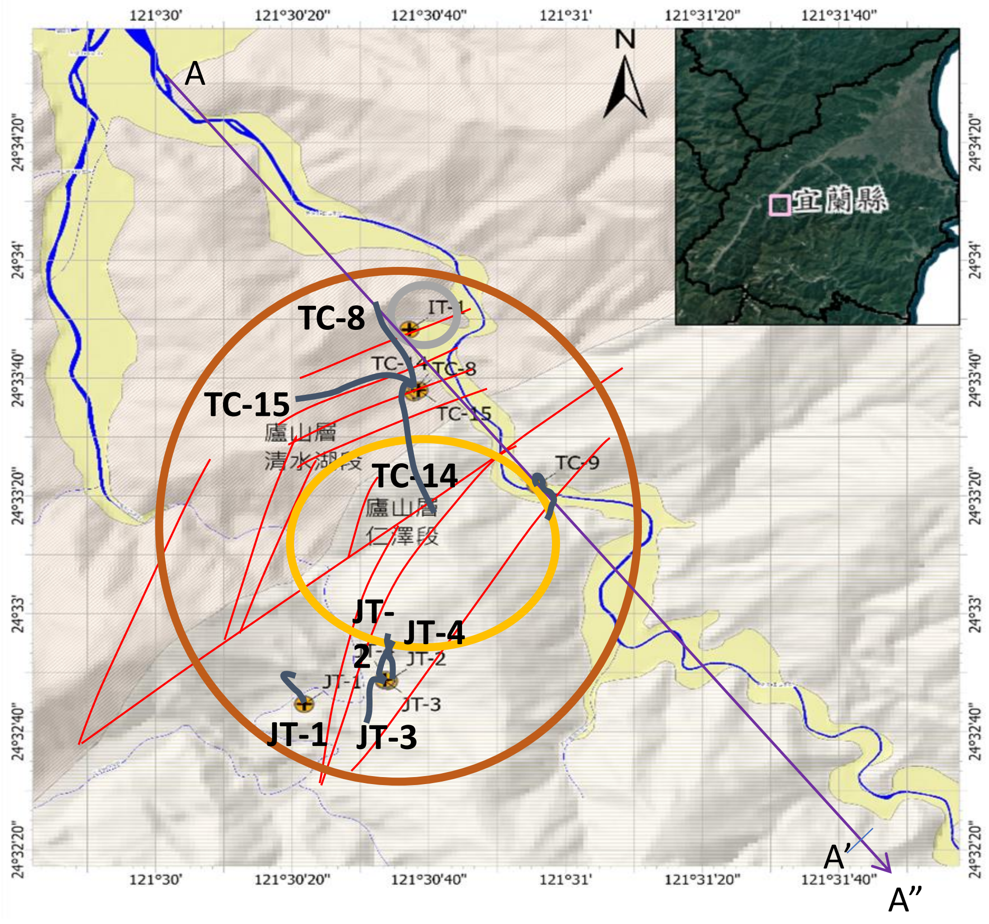


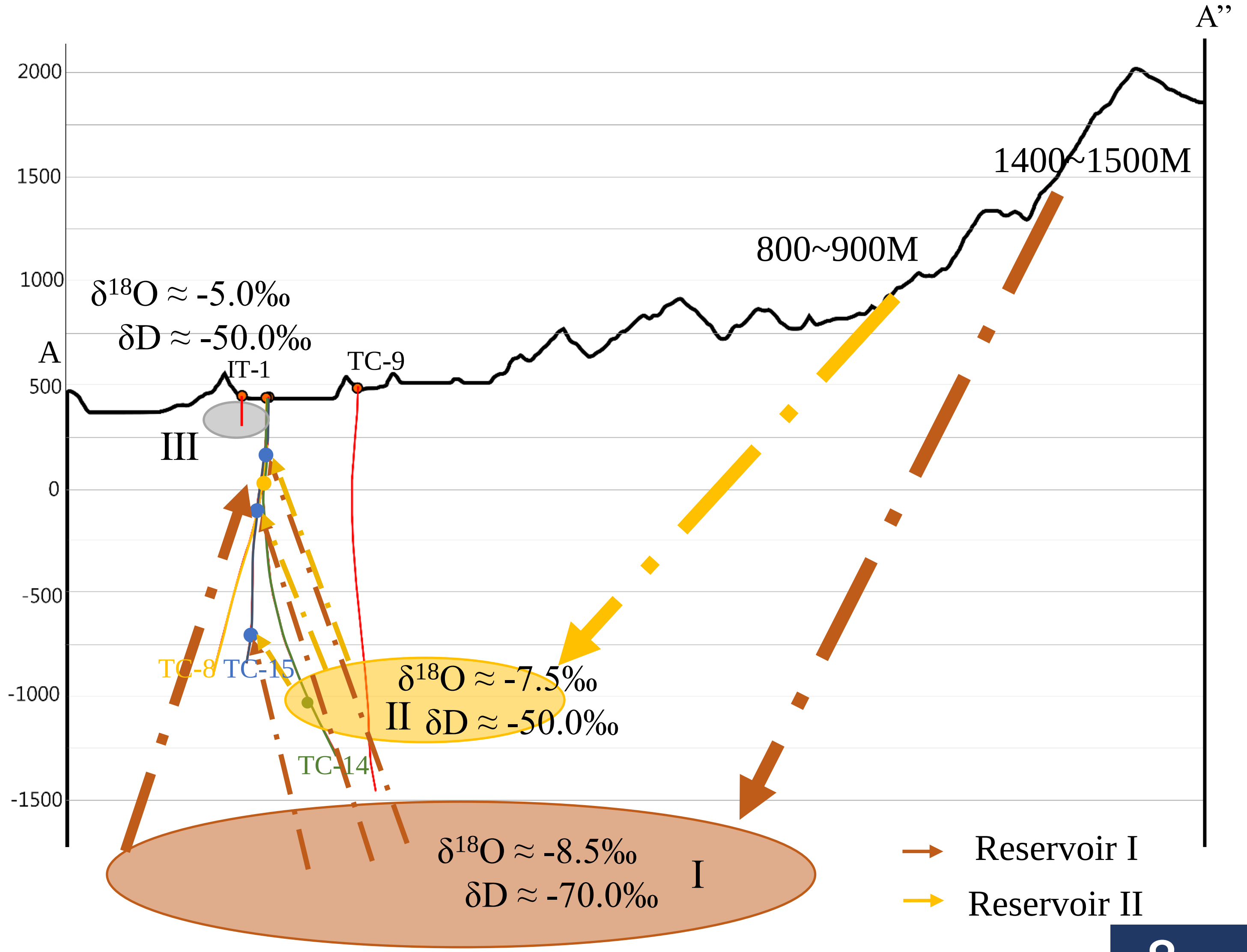


(Petrel Fracture Modeling 2014, Schlumberger)

Geochemistry

Well sample oxygen Isotope analysis





Geochemistry

- **SiO_2 Geothermometry:**
  - Eq.1: Chalcedony, 100℃ < T< 180℃,

    $$T = \frac{1112}{4.91 - \log(SiO2)} - 273.15$$ (Arnorsson, 1983)
  - Eq.2: Quartz, T> 180℃, **SiO_2 >266mg/L**

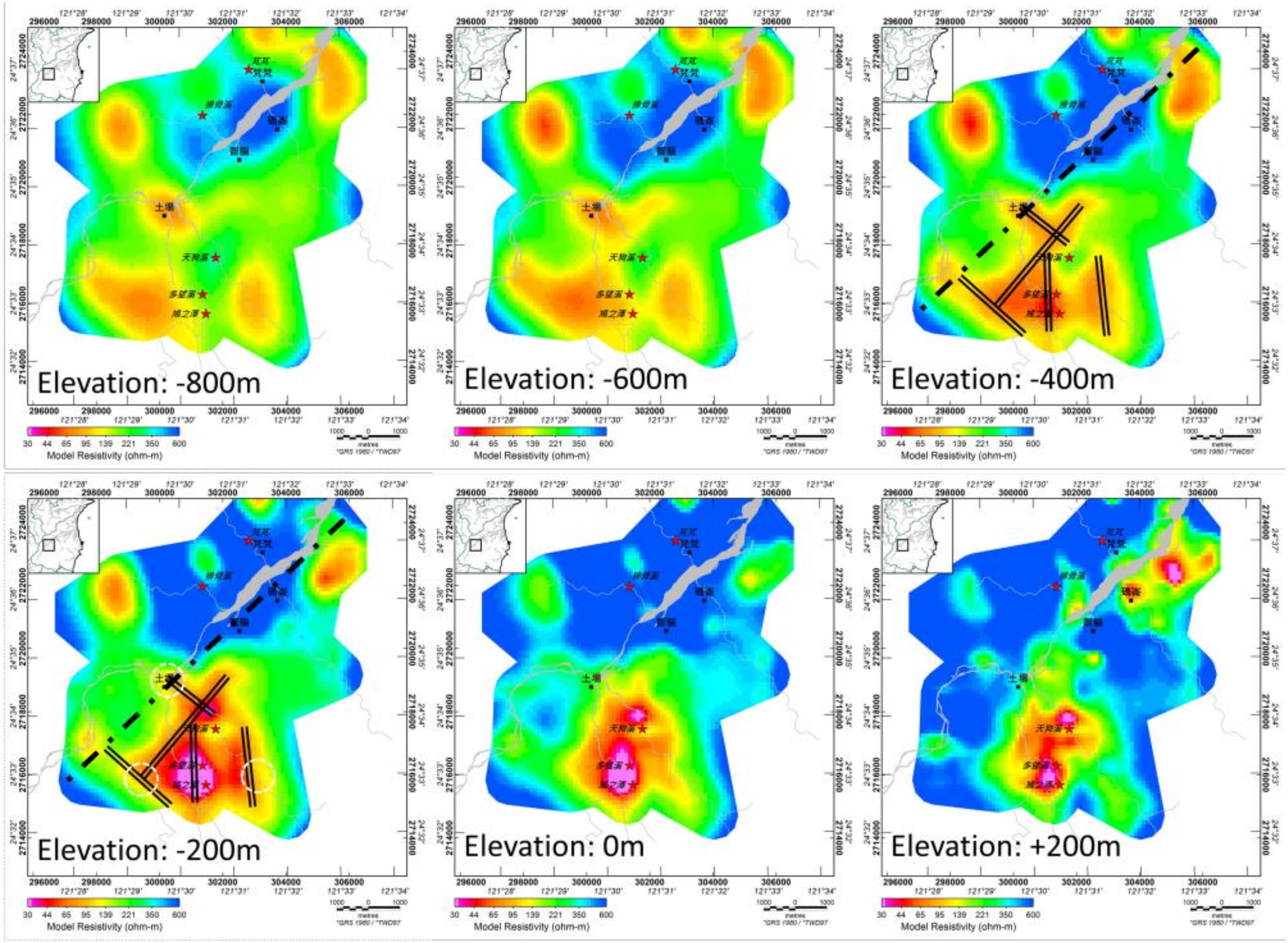
    $$T = \frac{1309}{5.19 - \log(SiO2)} - 273.15$$ (Fournier, 1977)
- **Tuchang-Jentse geothermal prospect:**
  - Estimated reservoir temperature via SiO_2 geothermometry.
  - Tuchang: max temp. 218℃
  - Jentse: max temp. 260℃

Region	Sample	T_{outlet}	BT_{well}	SiO_2 (mg/L)	$T_{SiO2\ Eq.1}$	$T_{SiO2\ Eq.2}$
Tuchang	TC-P1	68		158	137	165
	TC-P2	36		148	133	160
	TC-W2	57		100	109	137
	TC-F	70		**250**	169	196
	IT-1		163	**259**	172	198
	IT-2		171	236	165	192
	IT-3		173	**295**	183	208
	IT-11		146	**301**	184	210
	IT-12		140	**335**	193	218
	IT-13		151	217	159	186
Jentse	JT-W1	65		134	126	154
	JT-CPC2	80	194	**540**	238	260
	IT-4		144	189	149	176
	IT-5		143	180	146	173

Geophysics

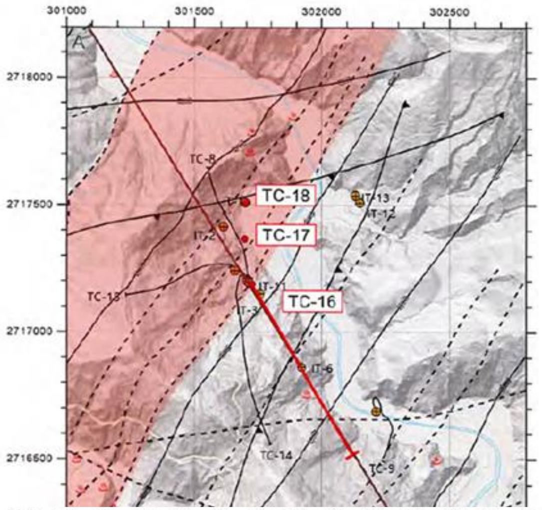
MT Survey

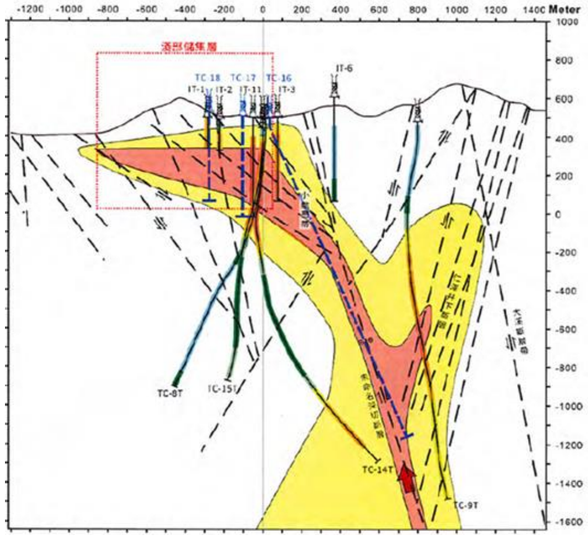
- Define reservoir boundary
- Flow pathway between Tuchang and Jentse

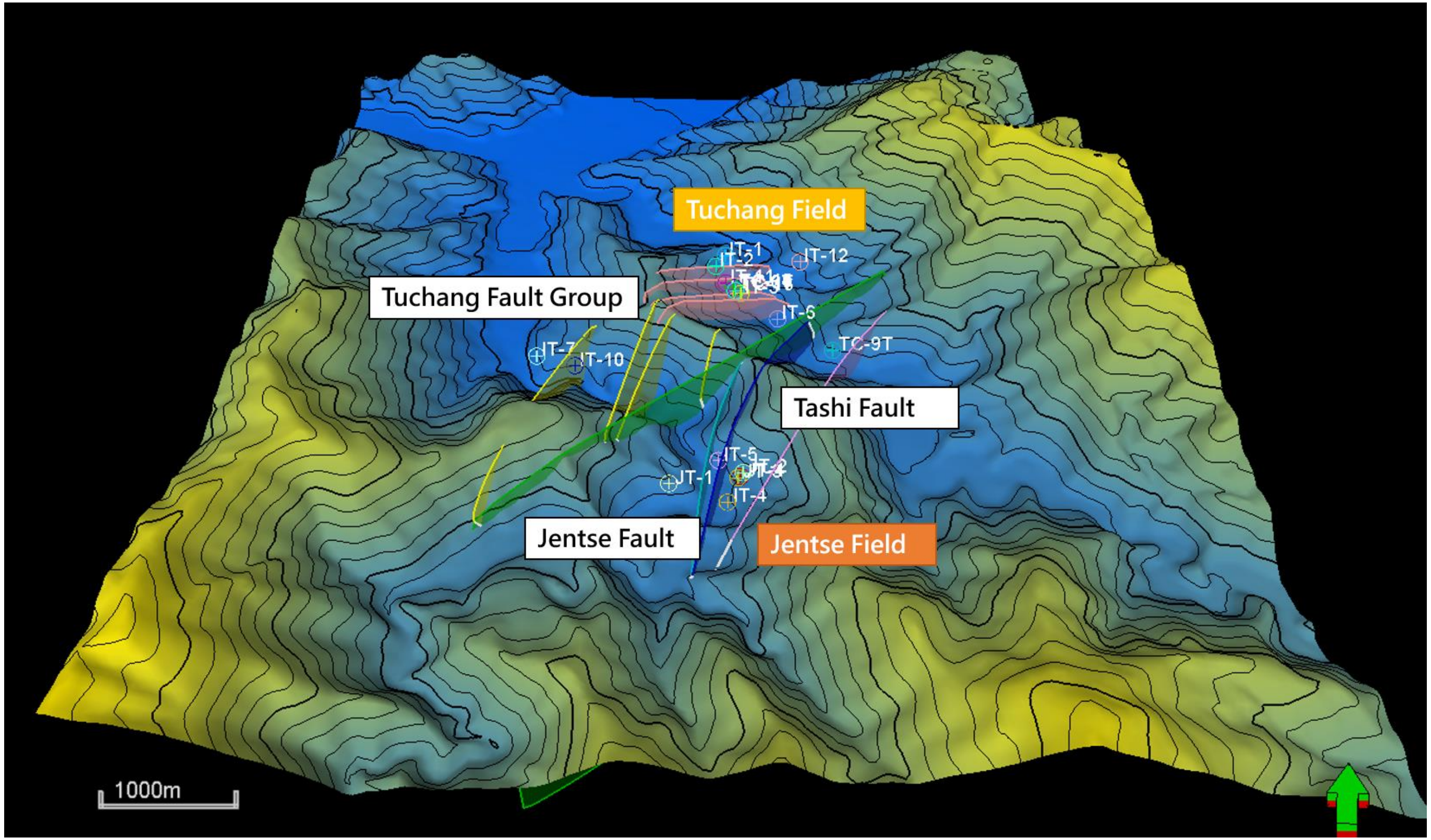


(Chiang et.al., 2015)

Surface geology

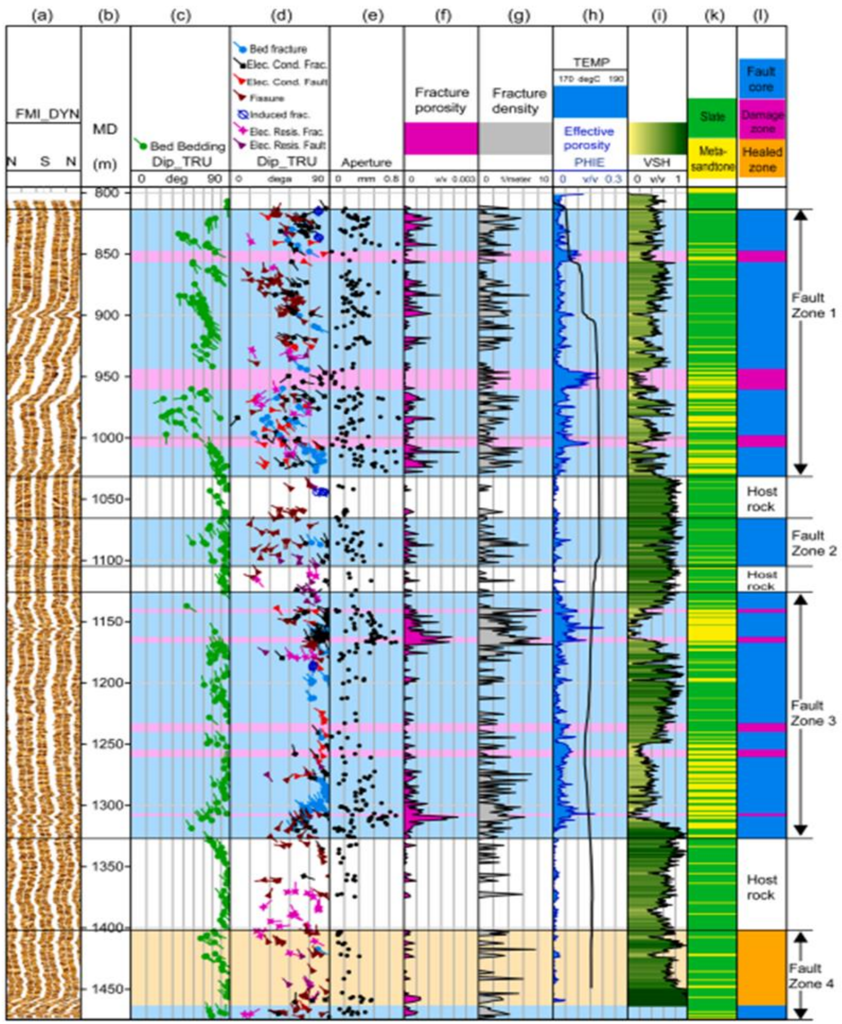




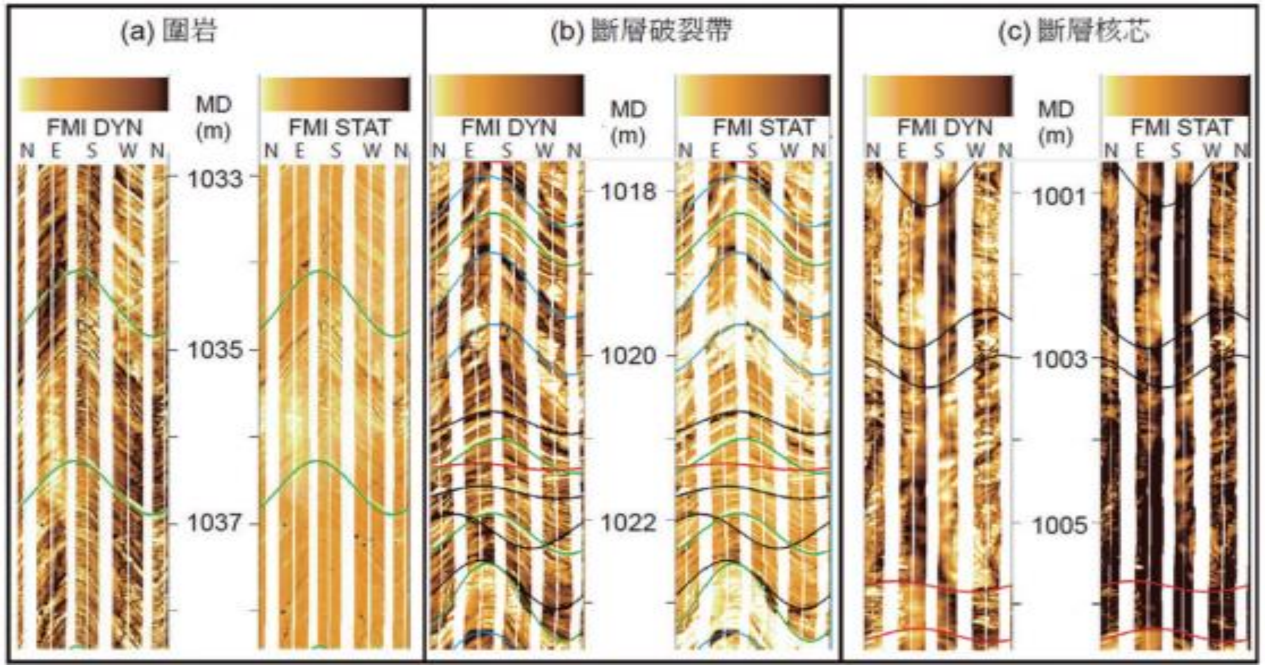


Faults interpretation in Tuchang (CPC, 2020)

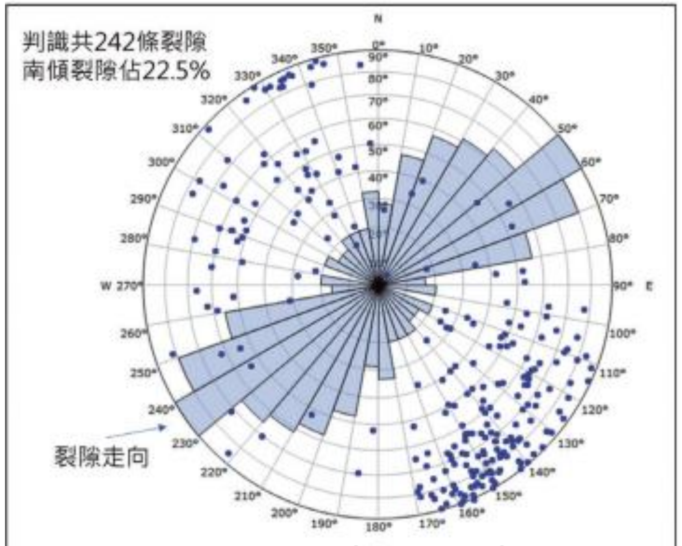
Well data



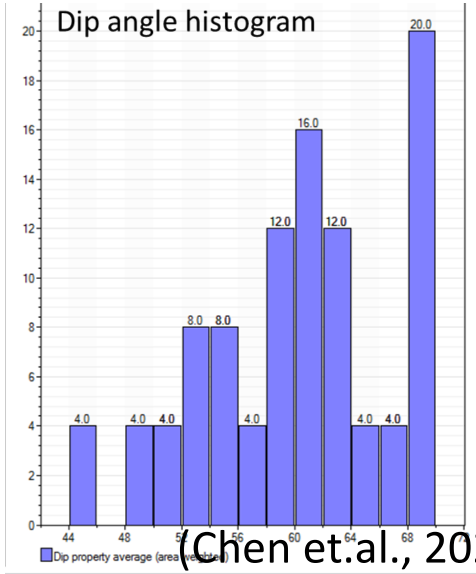
Well logging



Formation microresistivity imaging (FMI) (Chen et.al., 2021)

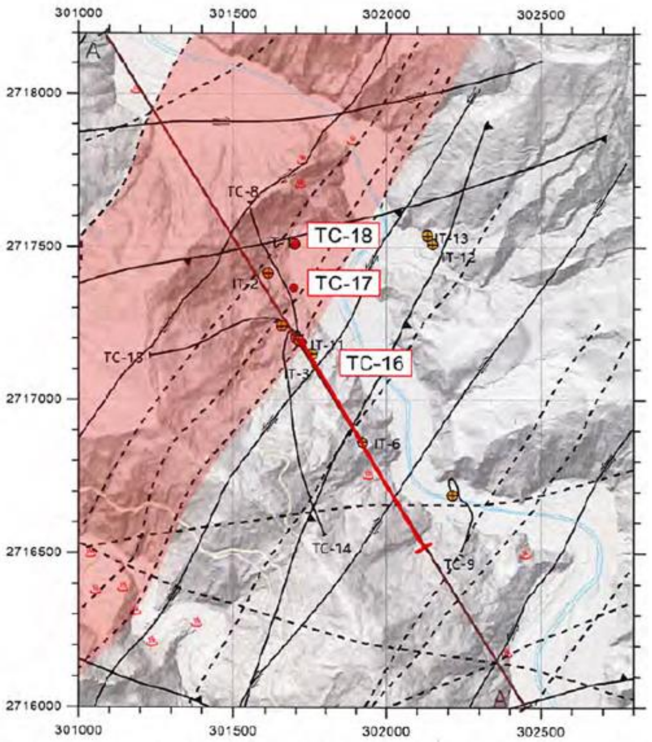


Stereonet & strike rose diagram

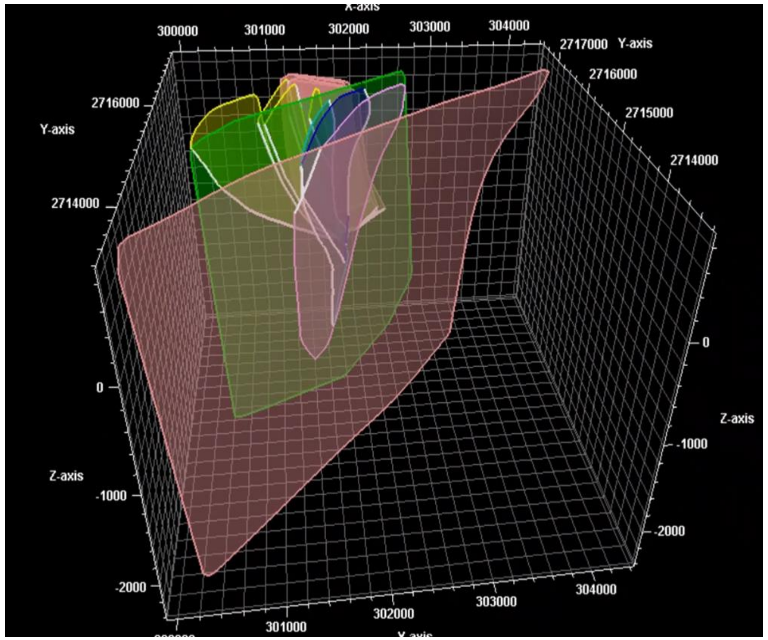


(Chen et.al., 2021)

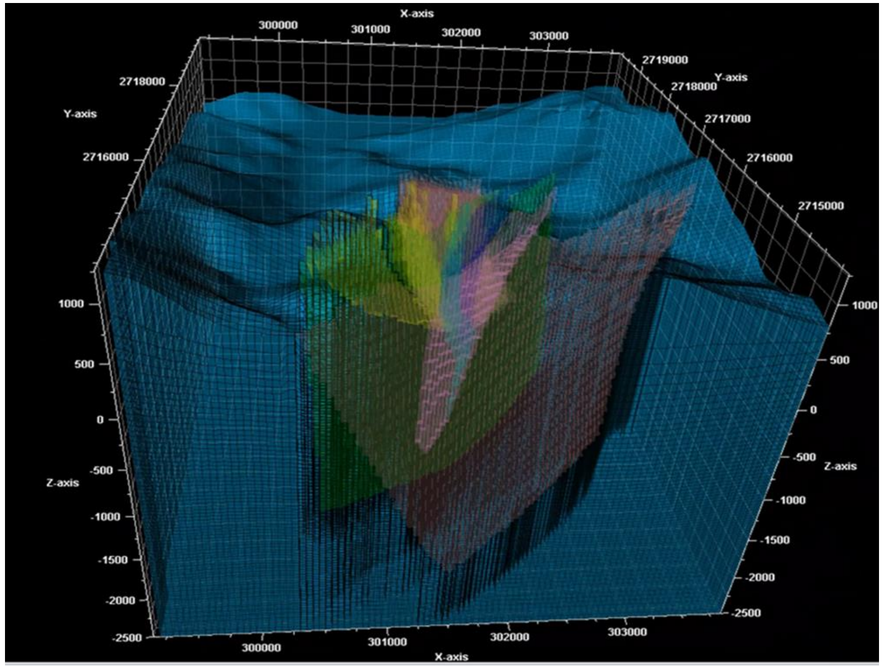
Structural Modeling



(CPC, 2020)



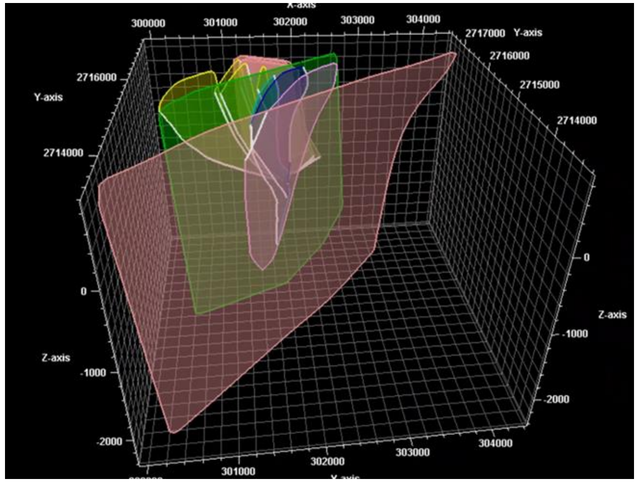
Digitalized fault polygon

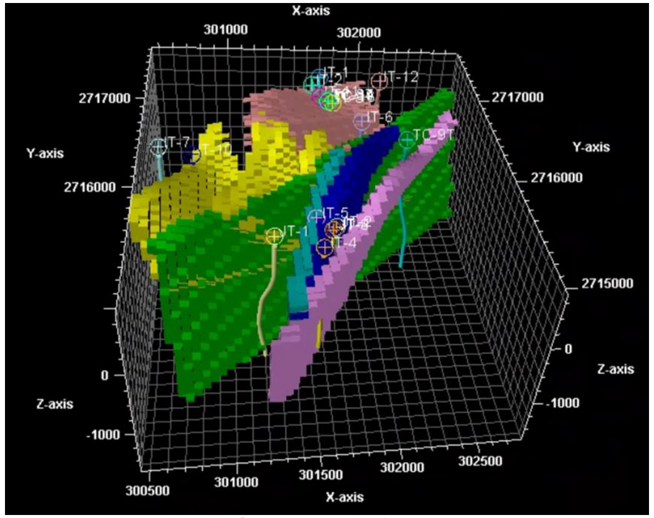


Structural Model

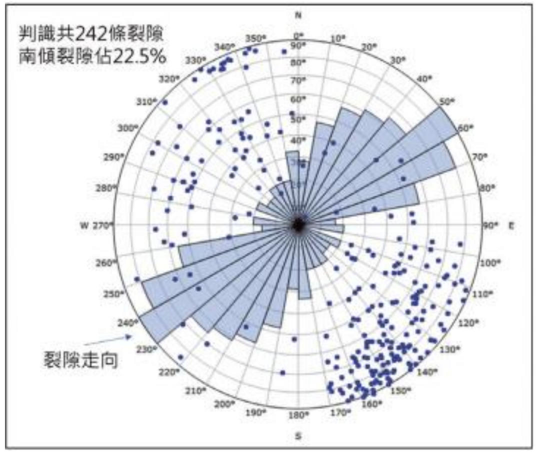
Grid size: 25m X 25m x 1m

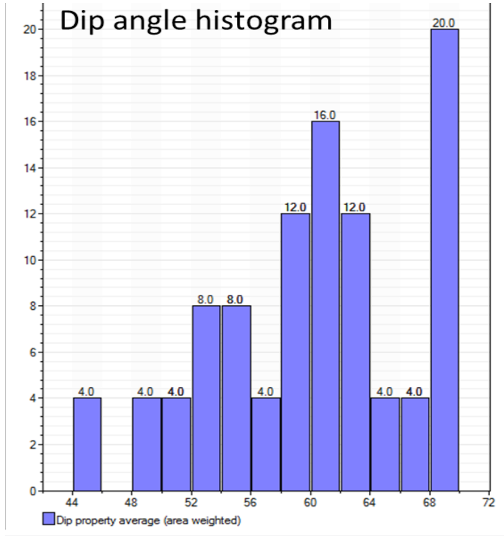
Property Modeling

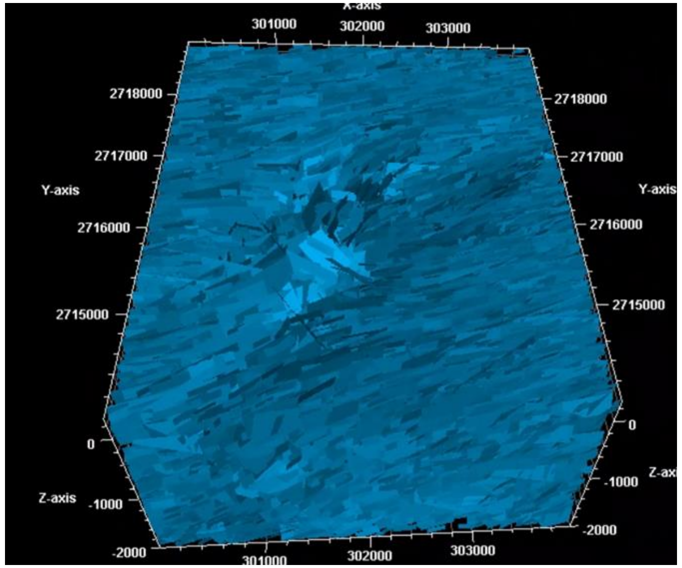




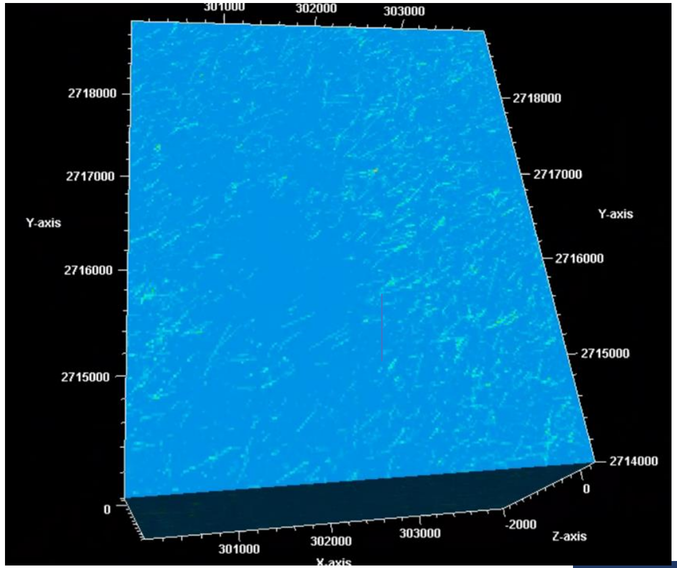
Fault gridding





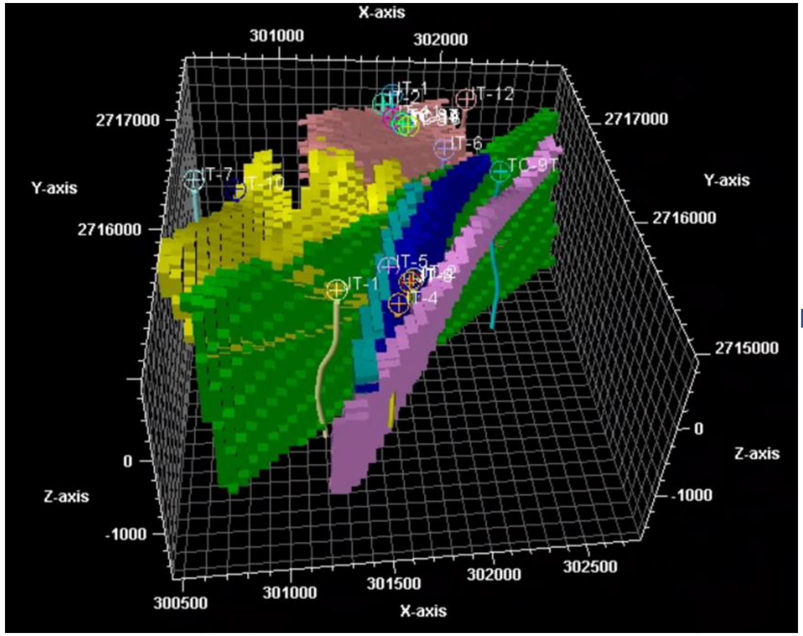


Major fractures/joints



Minor fractures/joints

Property Modeling



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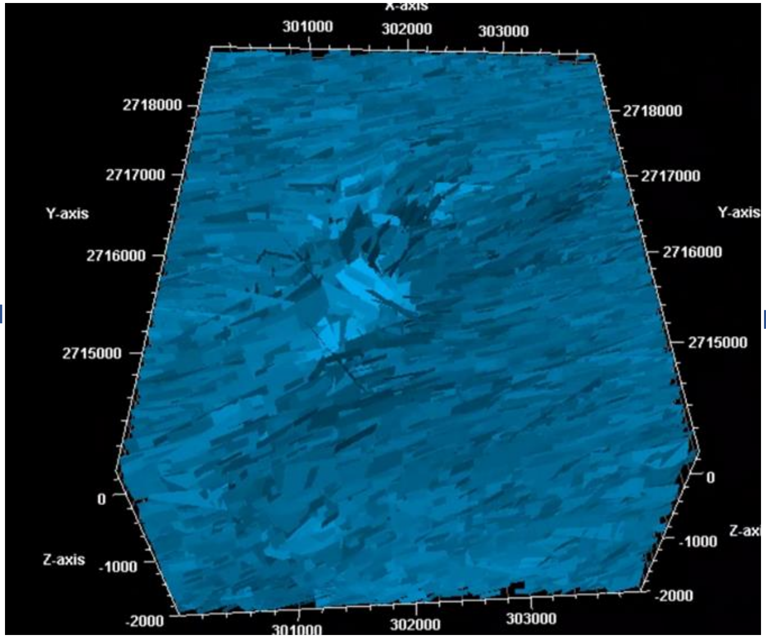

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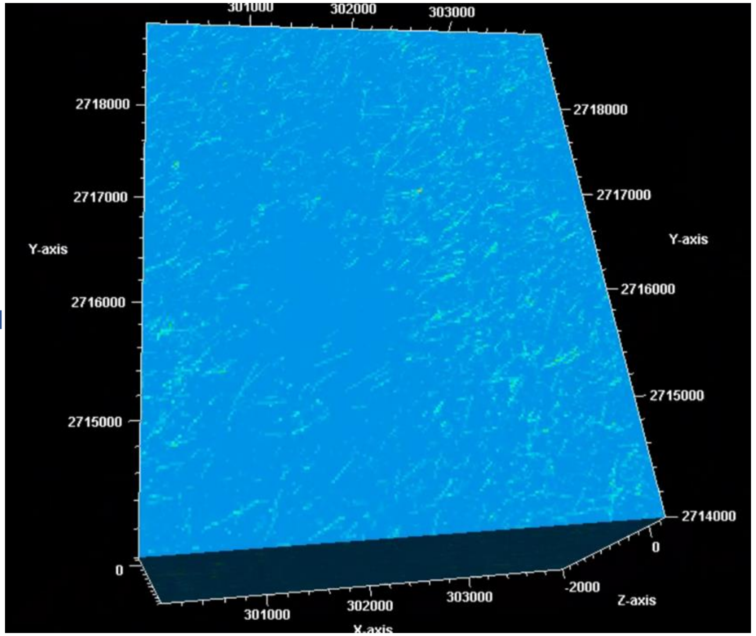


Faults

Major fractures/joints

Minor fractures/joints

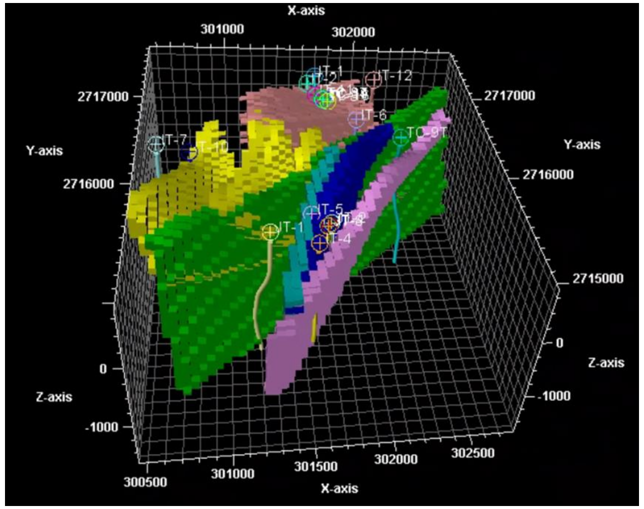
Discrete Fracture Network

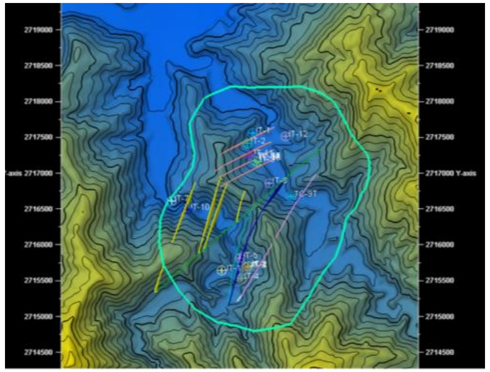
Implicit Fracture Model

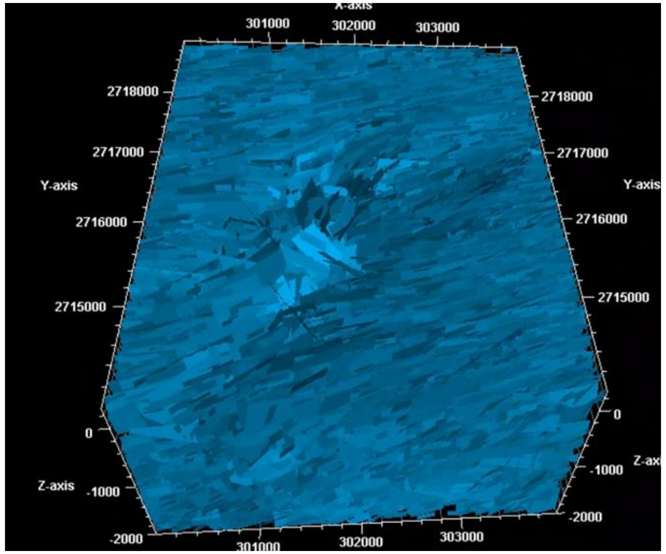
Deterministic

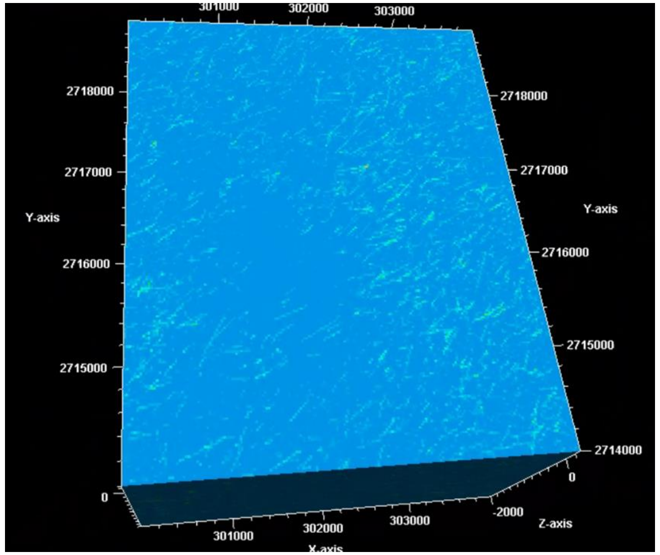
Stochastic

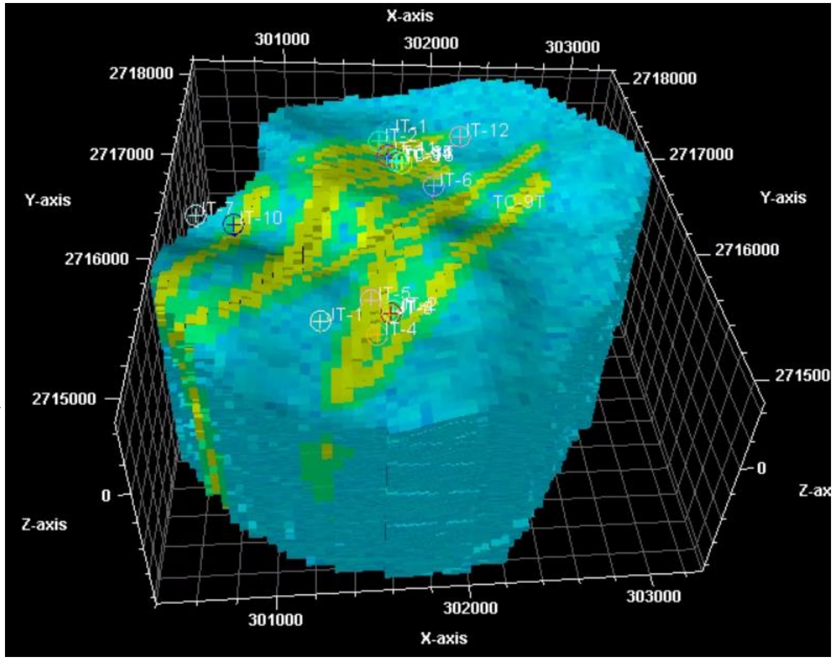
Property Modeling







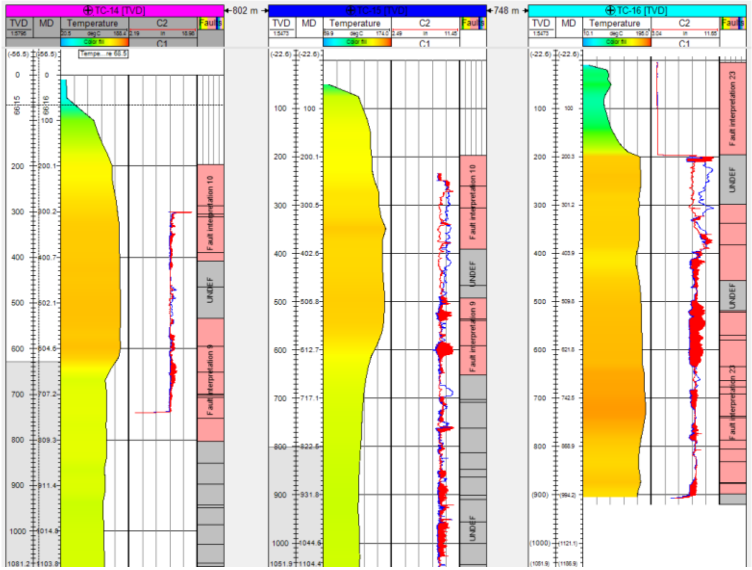


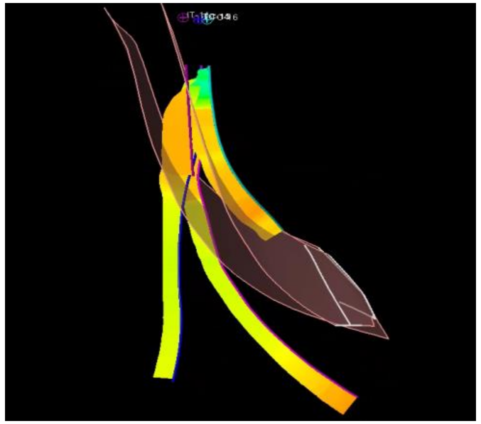


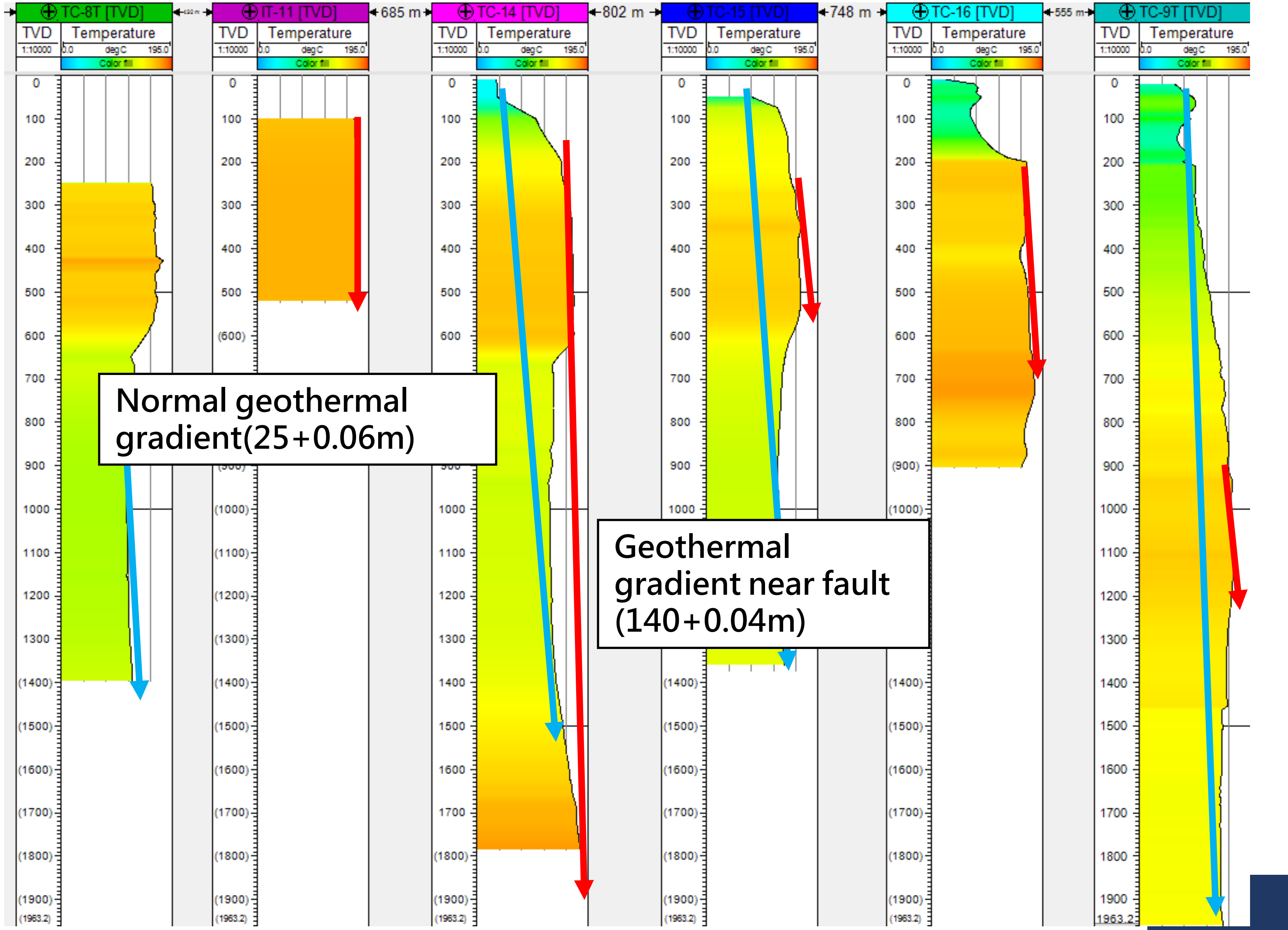
Grid size: 50m X 50m x 5m
Grid number : 0.93 Million

Property Modeling

Temperature distribution modeling

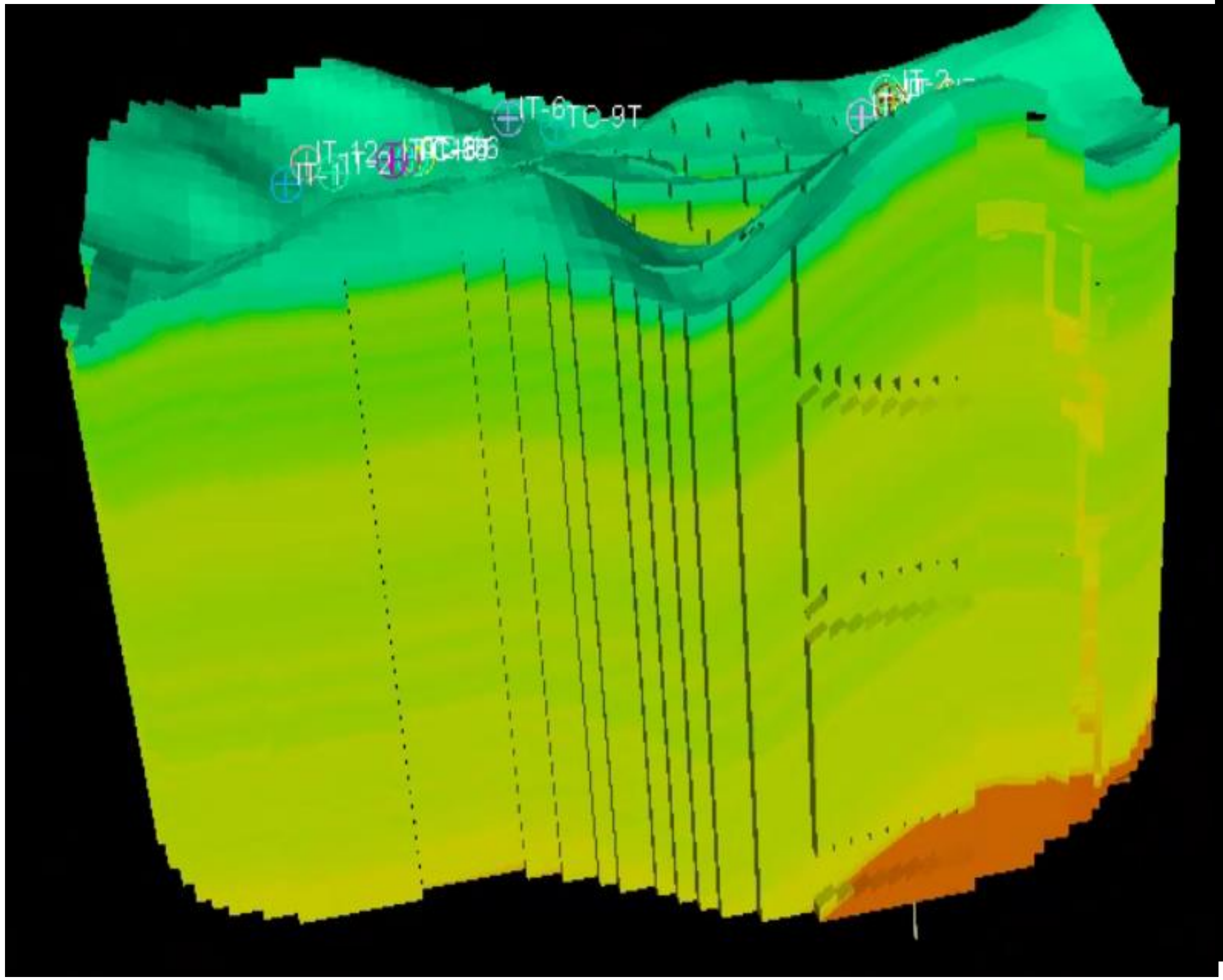


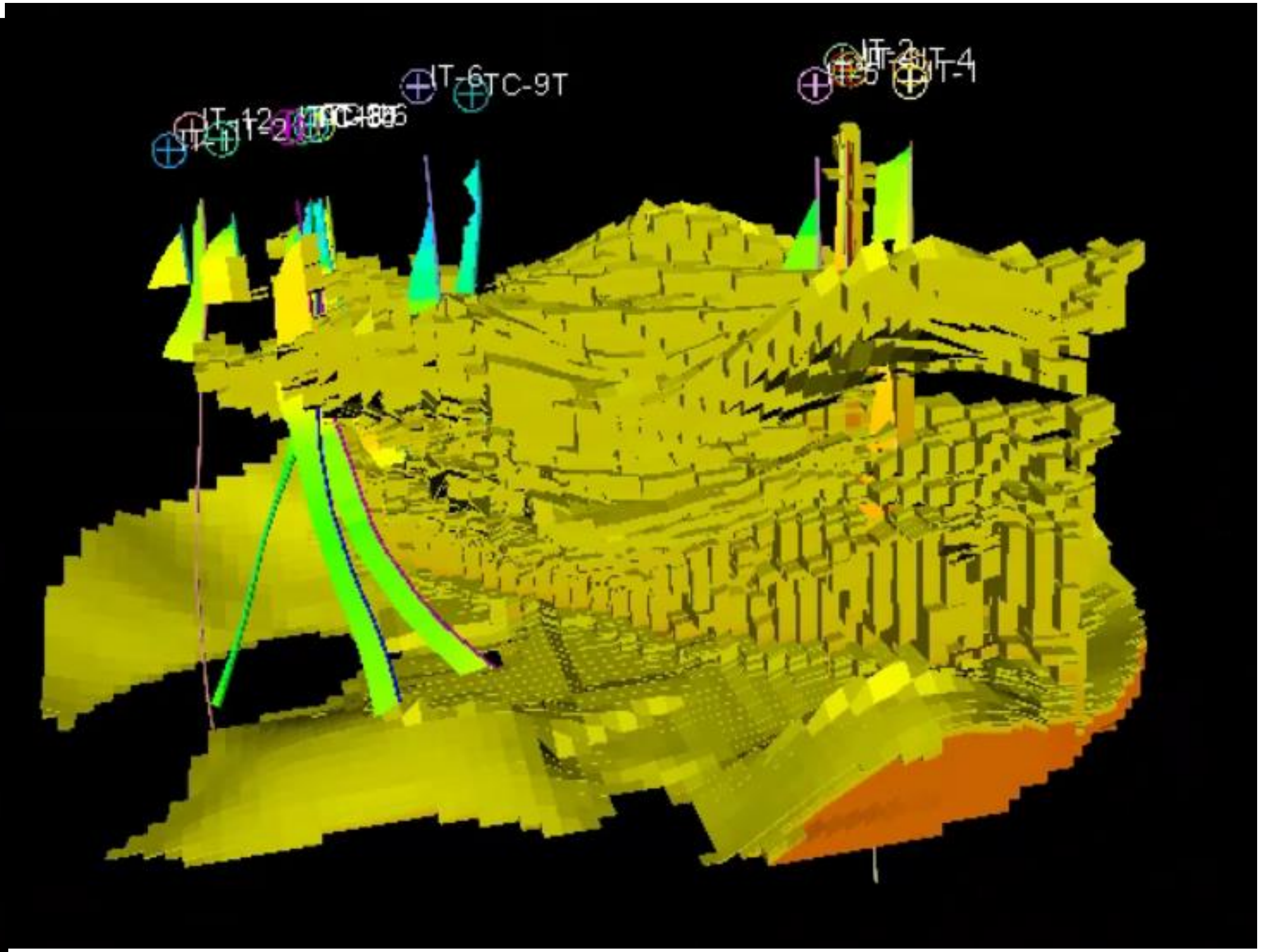




Temperature logging

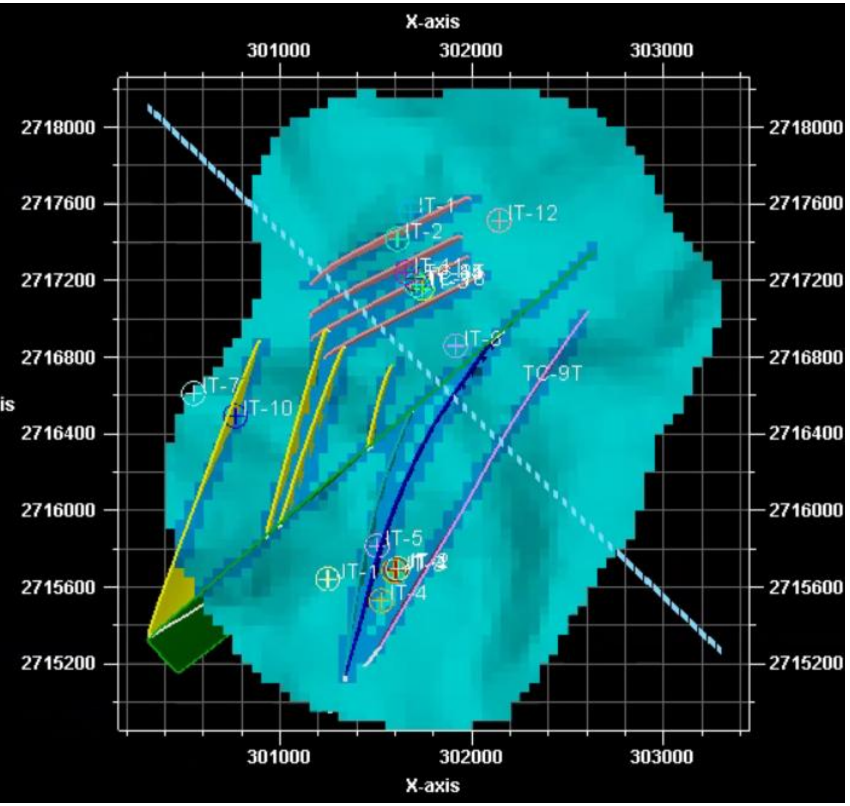
Property Modeling

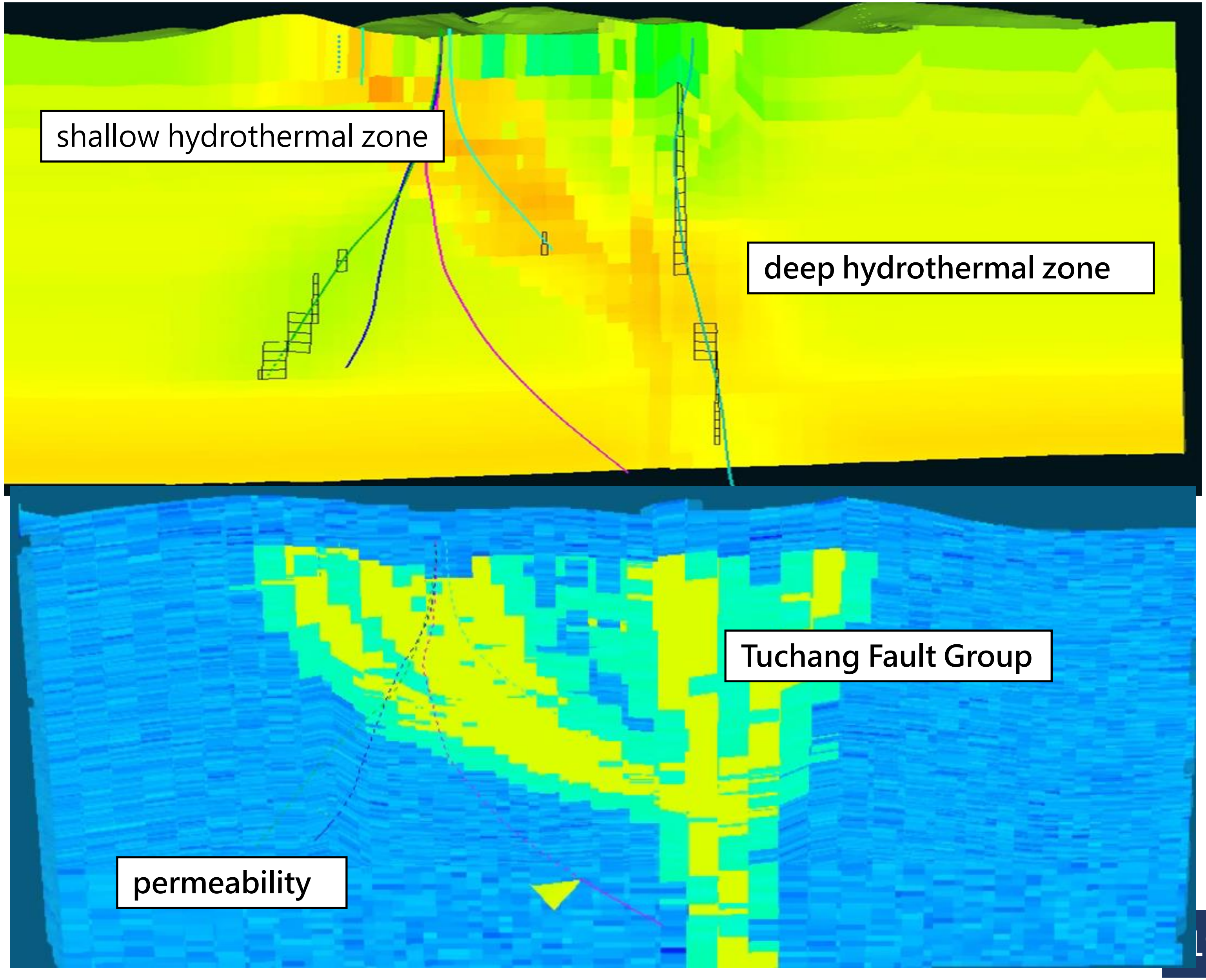




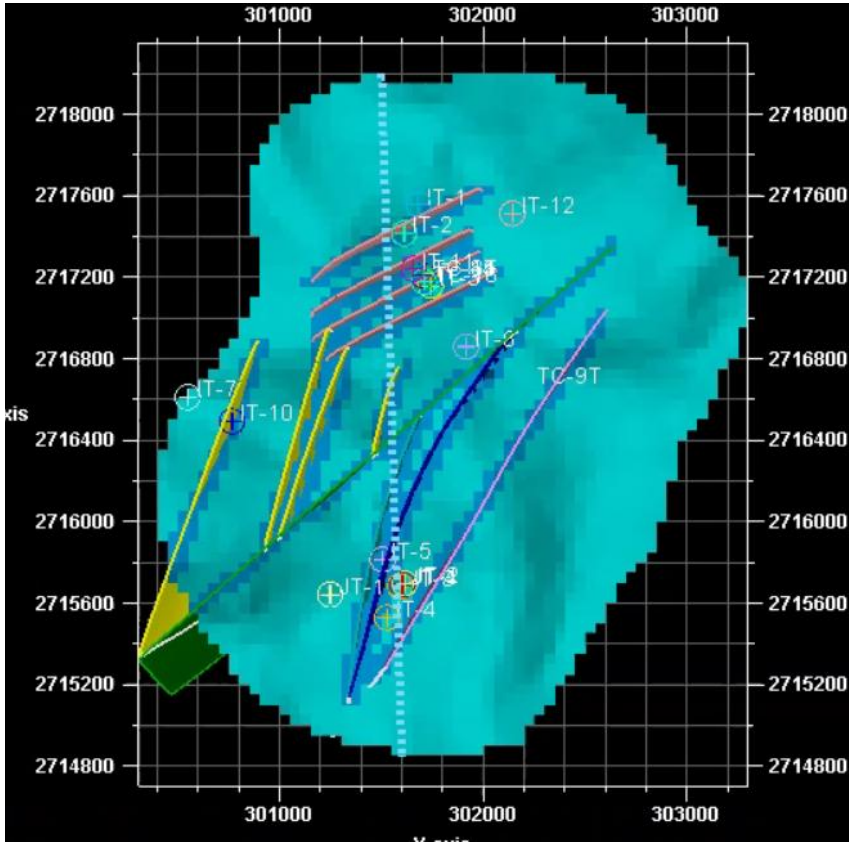
Property Modeling

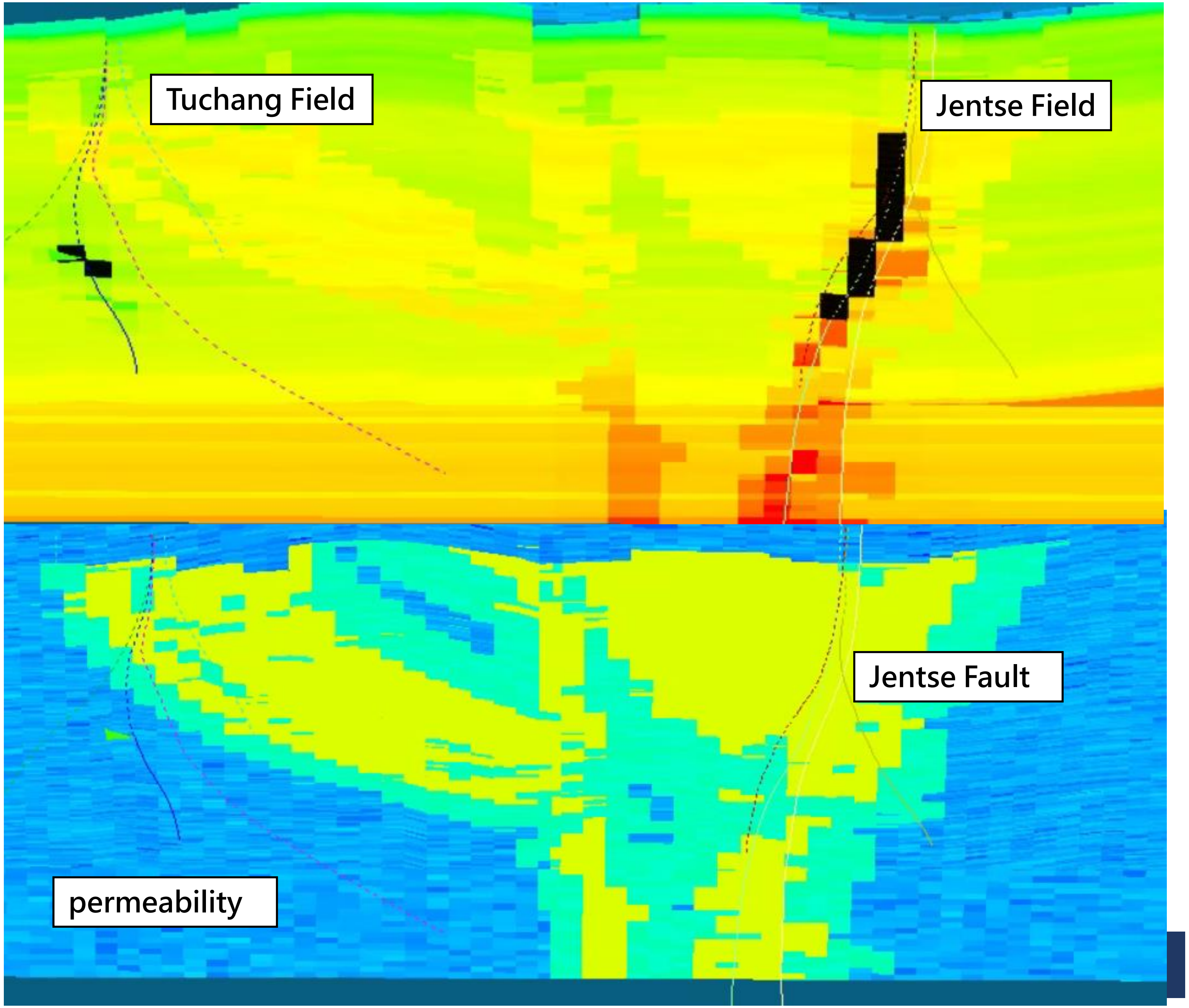
Shallow hydrothermal zone: 200m to 600m
Deep hydrothermal zone: 1,800m





Property Modeling





Conclusion

- Tuchang fractured reservoir can be divided into a shallow hydrothermal zone at depths of 200m to 600m and a deep hydrothermal zone at a depth of 1,800m.
- It is speculated that the hydrothermal fluids in Jentse field transport via Jentse faults to Tachang field.
- The completed model of the Tuchang fractured geothermal reservoir will facilitate further geothermal simulations.

References

- Chen, C. T., Y. C. Chan, O. Beyssac, C. Y. Lu, Y. G. Chen, J. Malavieille & H. C. Sun, 2019. Thermal History of the Northern Taiwanese Slate Belt and mplications for Wedge Growth During the Neogene Arc-Continent Collision. Tectonics, 38(9), 3335-3350.
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- Petrel Fracture Modeling, SLB, 2014

Thank you for listening