MENGGABUNGKAN SENI DAN TEKNOLOGI: STRUKTUR GEOLOGI DALAM 3D

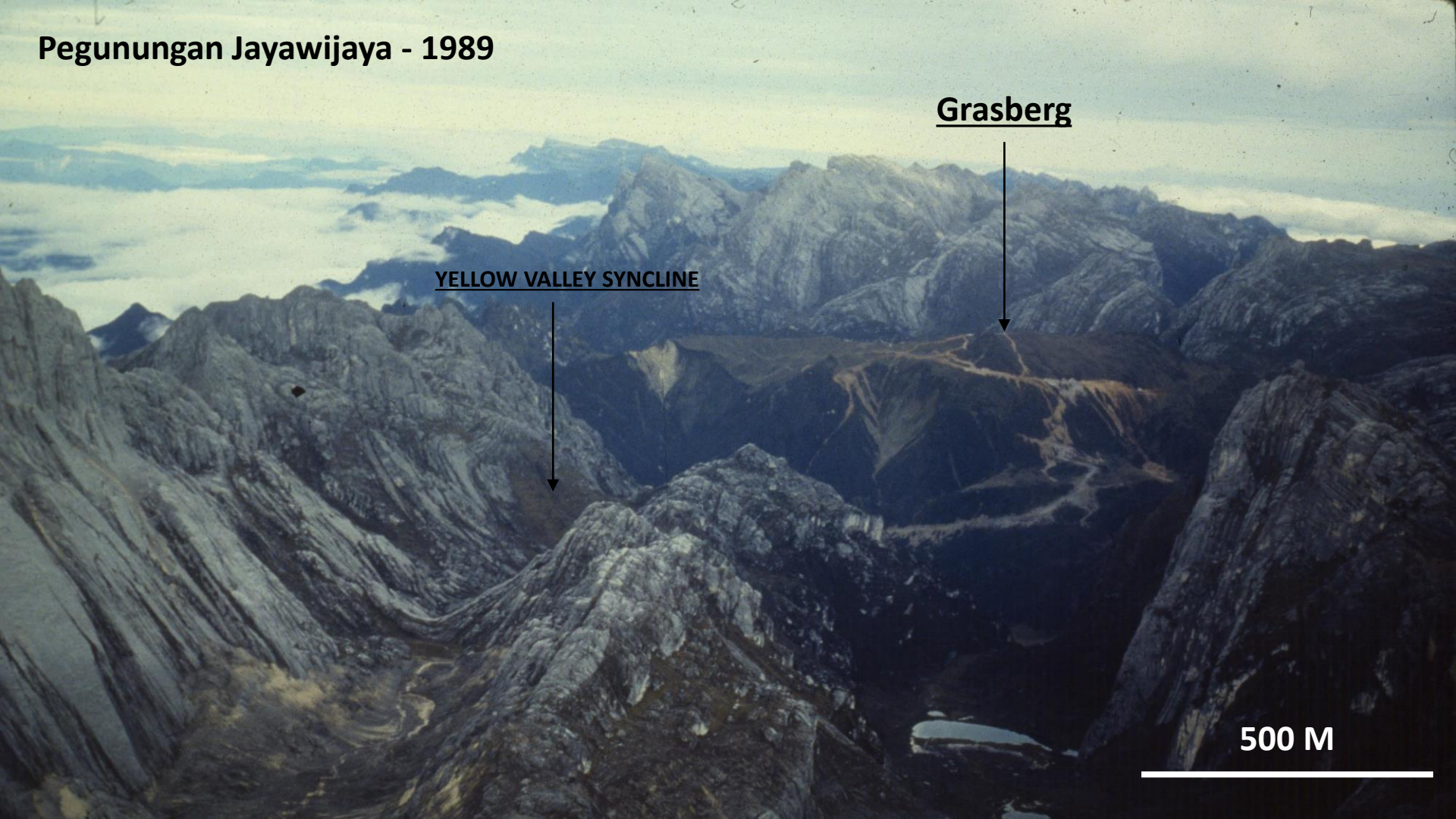
BENYAMIN SAPIIE

KK GEODINAMIKA DAN SEDIMENTOLOGI ITB

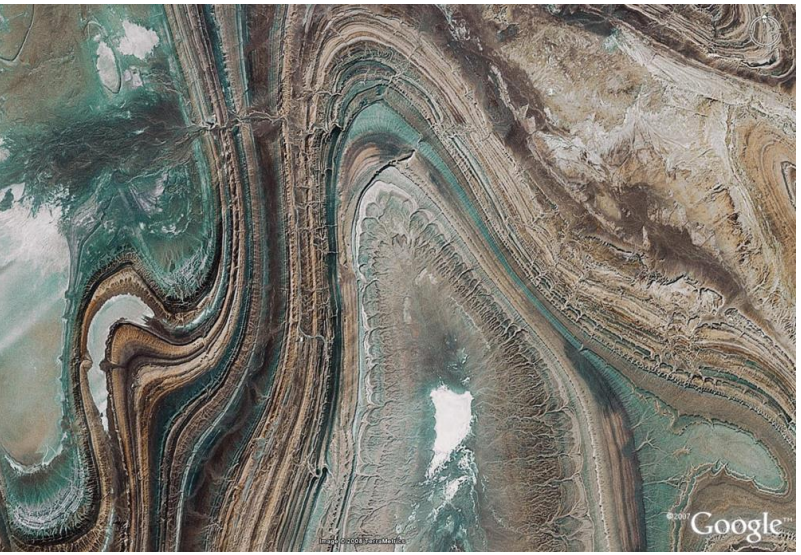
OUTLINE

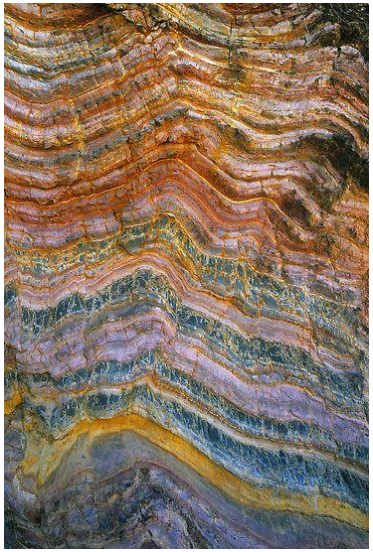
- PENDAHULUAN
- KONSEP STRUKTUR GEOLOGI MODEREN
- STUDI KASUS 3D STRUKTUR GEOLOGI
- ARAH DAN PERKEMBANGAN KE DEPAN
- DISKUSI DAN KESIMPULAN

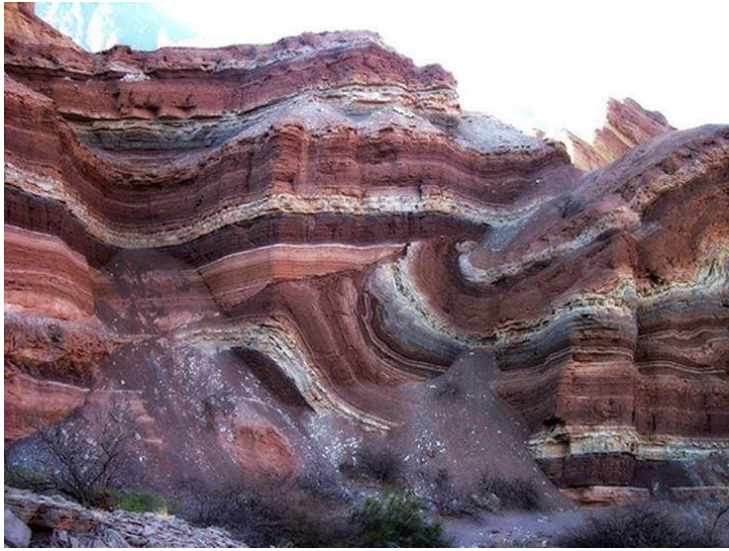
MENGAPA MEMPEJARI GEOLOGI STRUKTUR?


Pegunungan Jayawijaya - 1989
Grasberg
YELLOW VALLEY SYNCLINE
500 M

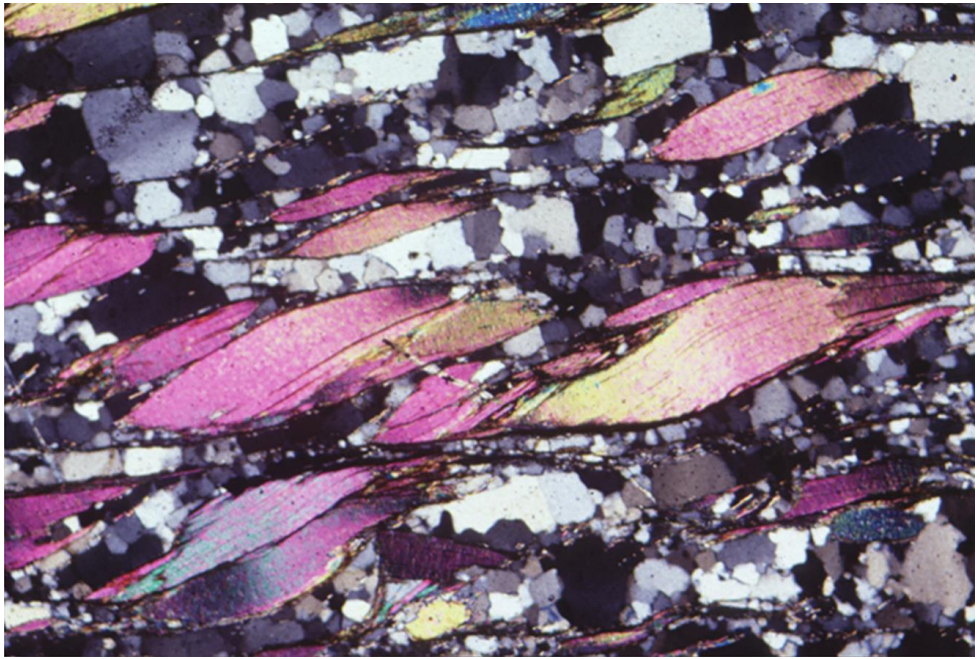

Dungun2 Valley - 2002
500 M







THE ART OF STRUCTURAL GEOLOGY OUTCROPS

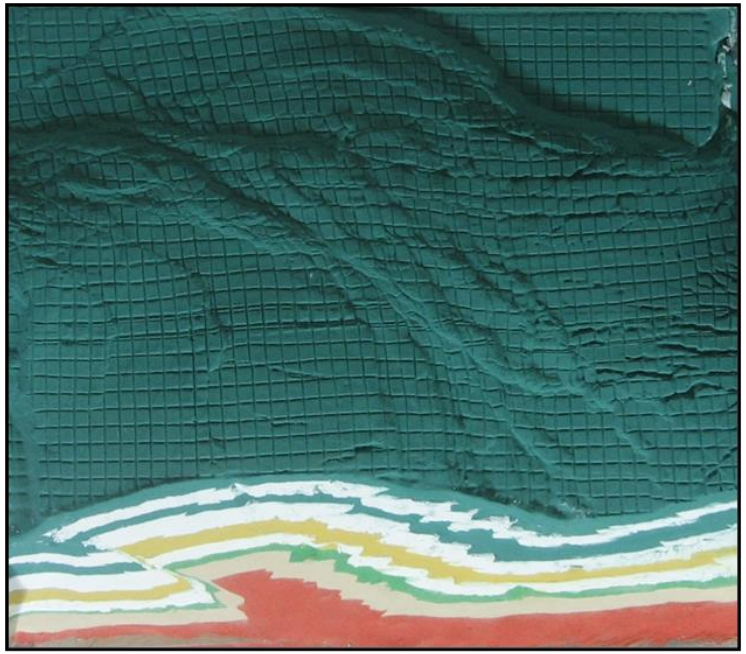


1 mm

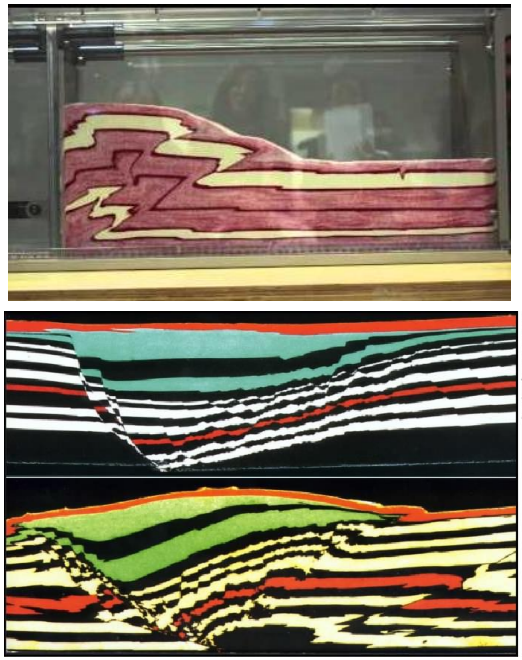
THE ART OF MICROSTRUCTURES

Natural Art - Laboratory

Rainbow Mountain - Peru

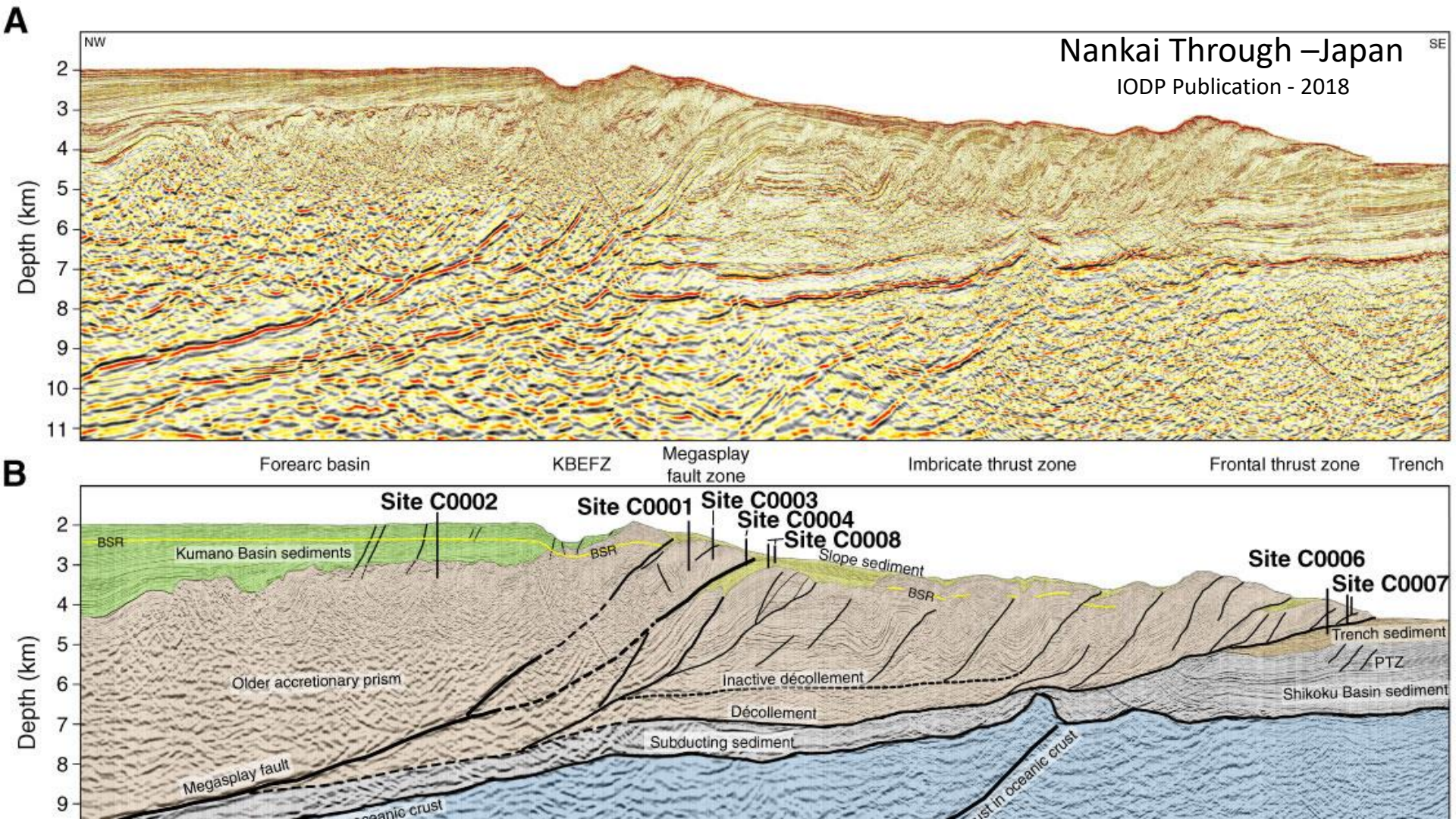


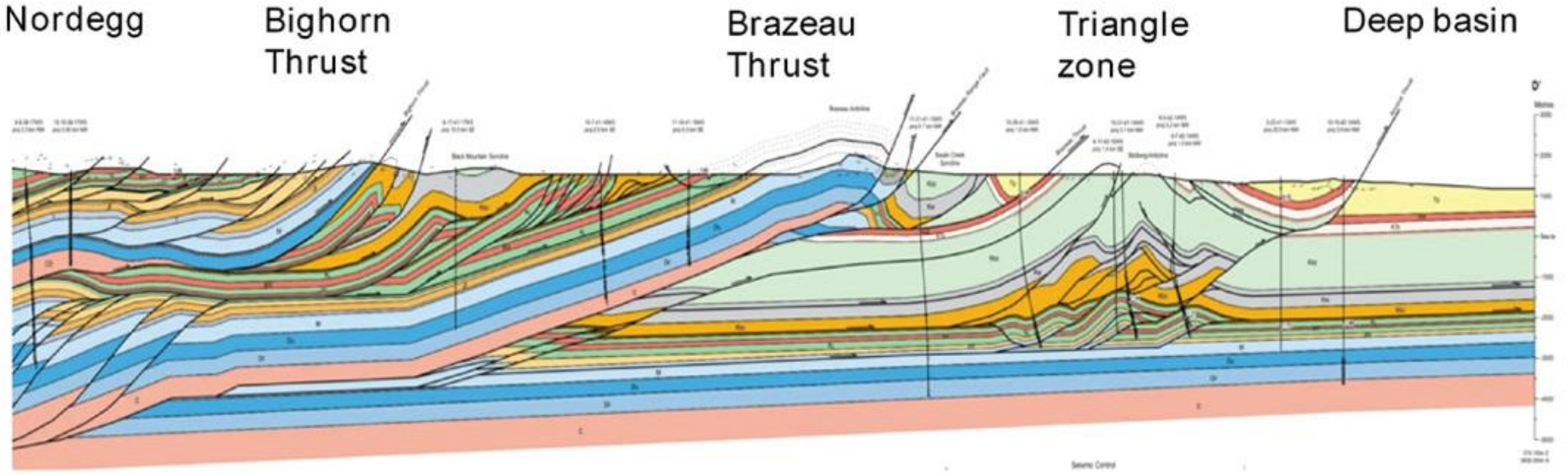
Sandbox modeling – GRG ITB



Clay modeling – Rutgers University

Eisenstadt & Withjack (1995)


A
NW
SE
Nankai Through –Japan
IODP Publication - 2018
Depth (km)
2
3
4
5
6
7
8
9
10
11
Forearc basin
KBEFZ
Megasplay fault zone
Imbricate thrust zone
Frontal thrust zone
Trench
B
Site C0002
Site C0001
Site C0003
Site C0004
Site C0008
Site C0006
Site C0007
BSR
Kumano Basin sediments
Slope sediment
Trench sediment
PTZ
Shikoku Basin sediment
Older accretionary prism
Inactive décollement
Décollement
Subducting sediment
Megasplay fault
Depth (km)

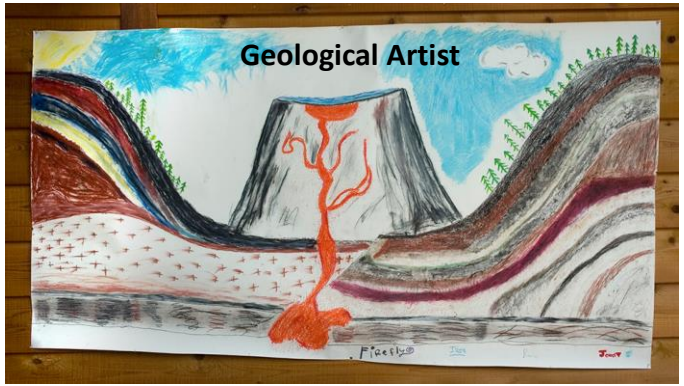


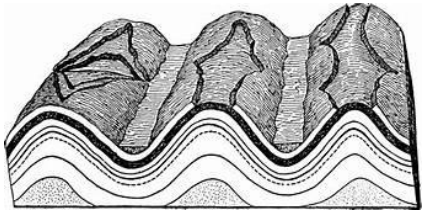
5 km

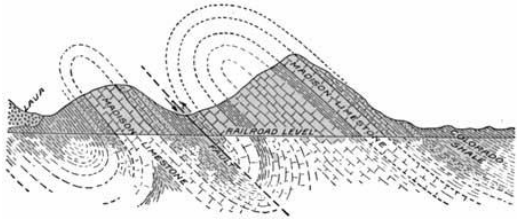
1:1

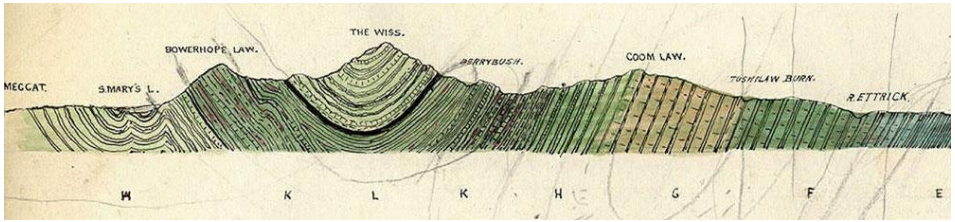
Newson (2015)

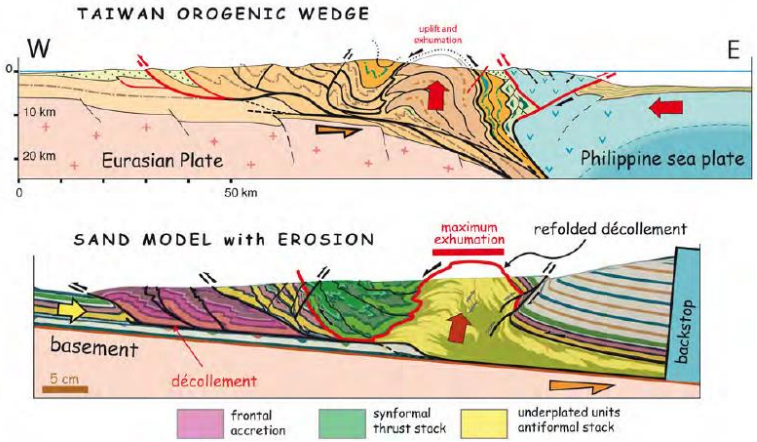
- **PENAMPANG GEOLOGI (STRUKTUR)**

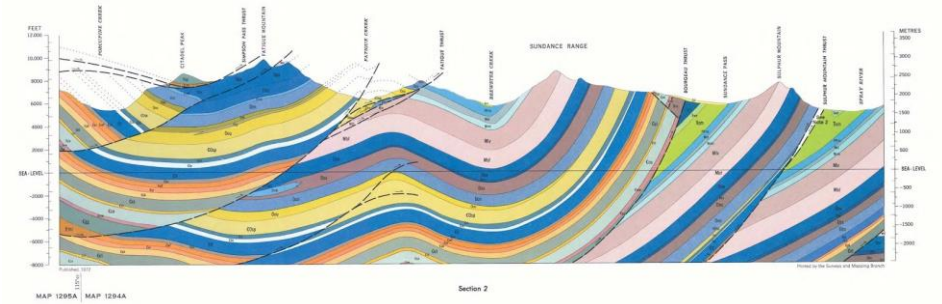




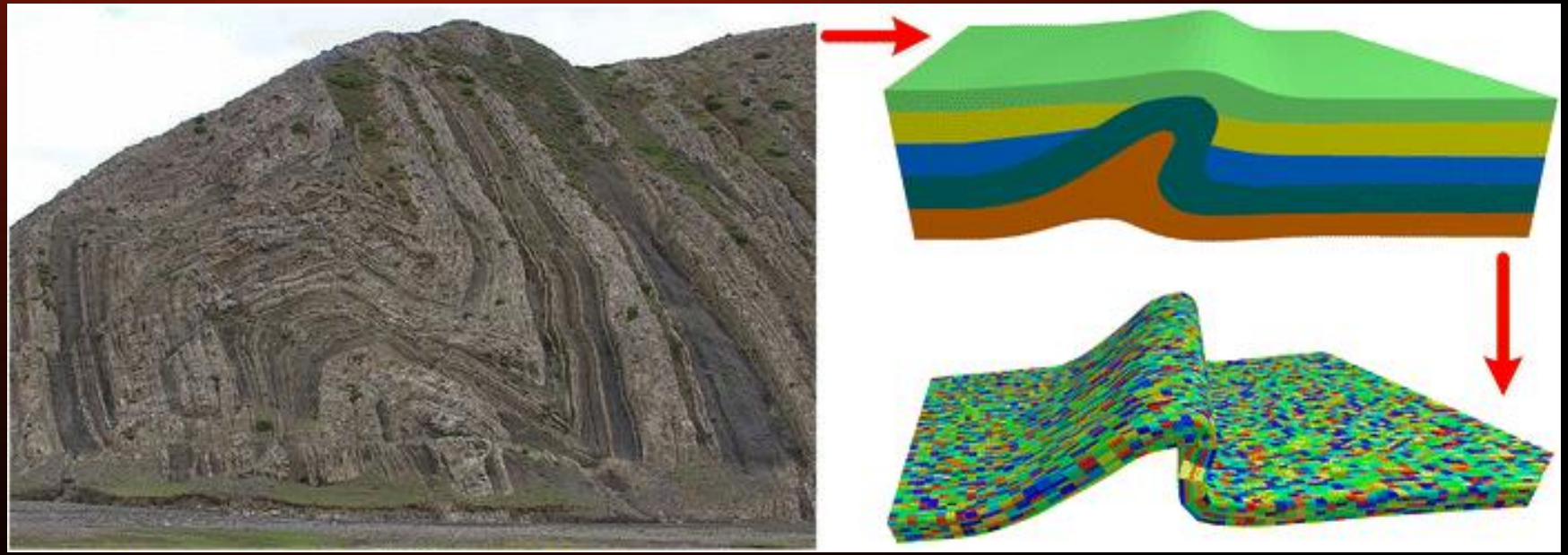








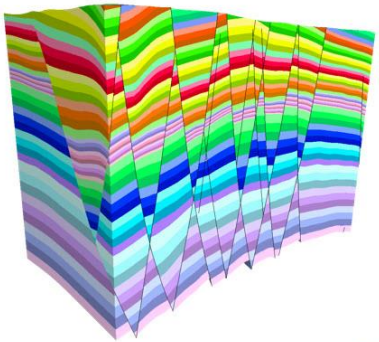
MEMODELKAN KOMPLEKS GEOLOGI

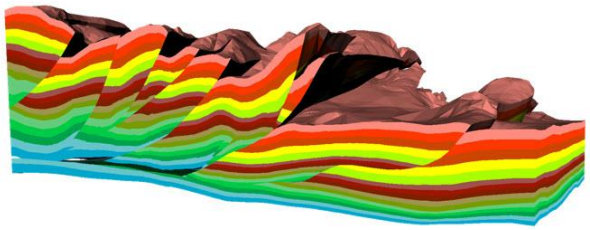


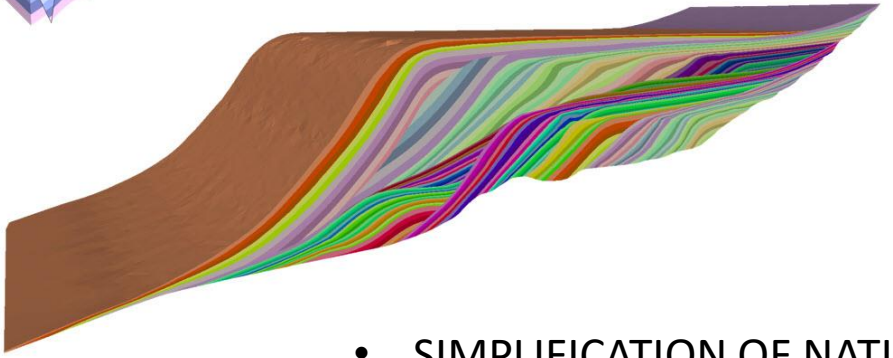
- A corner-point-grid-based voxelization method

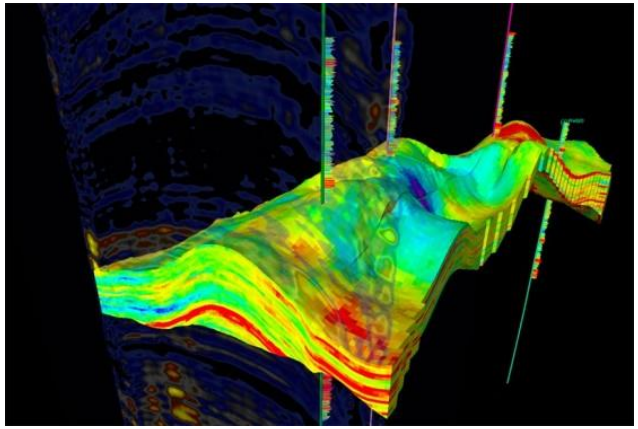
TECHNOLOGY - 3D STRUCTURAL MODELING

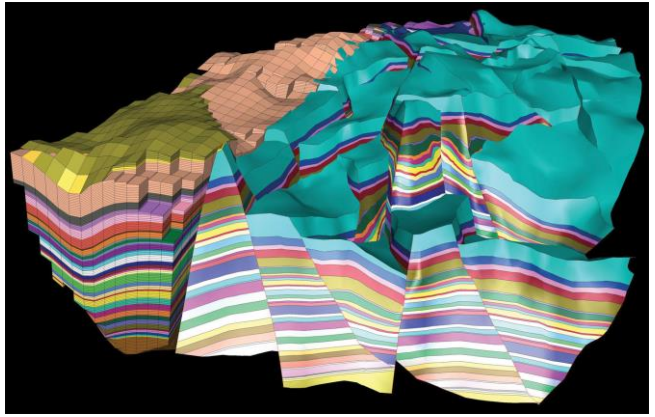
PETREL 2017





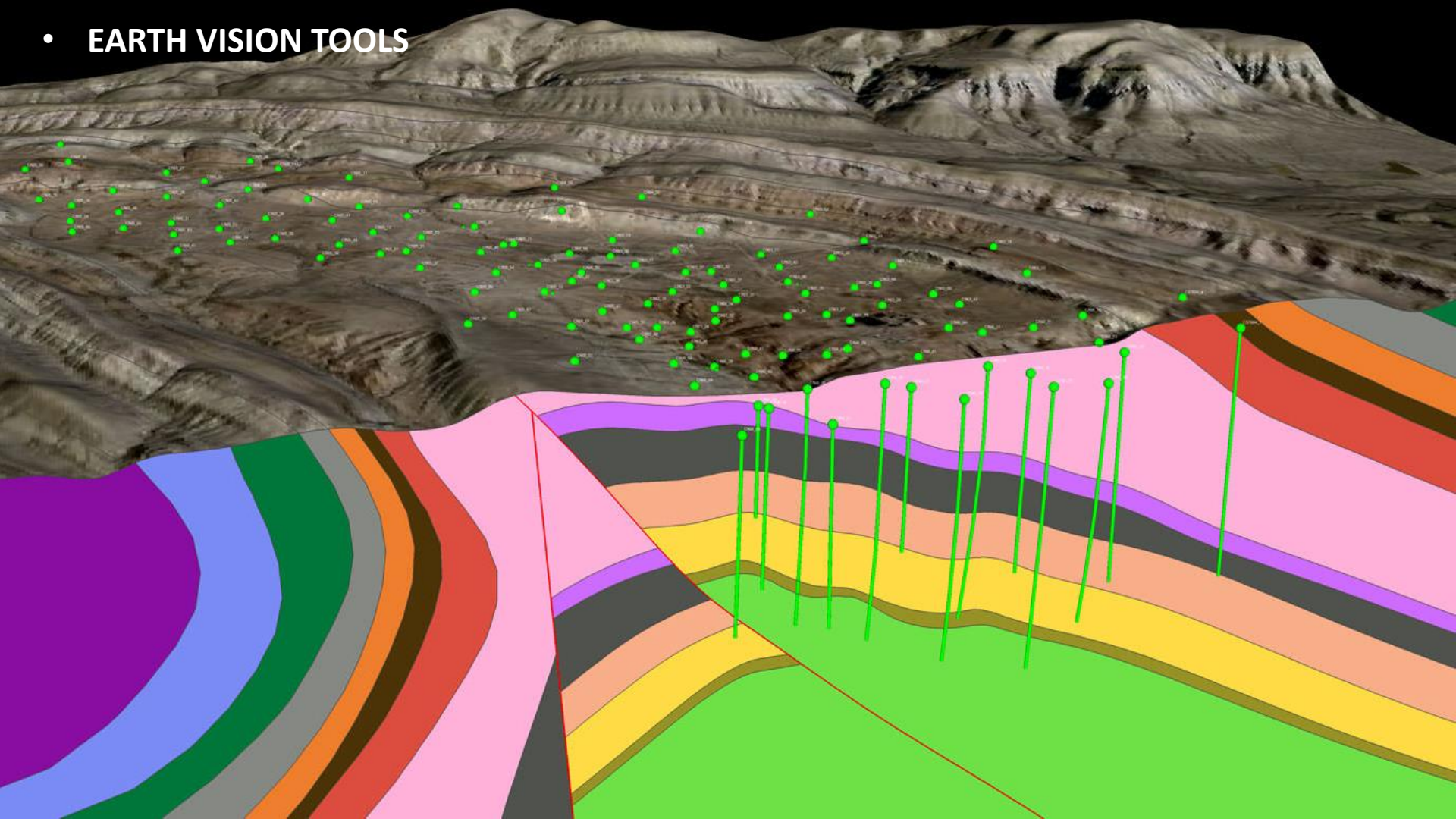


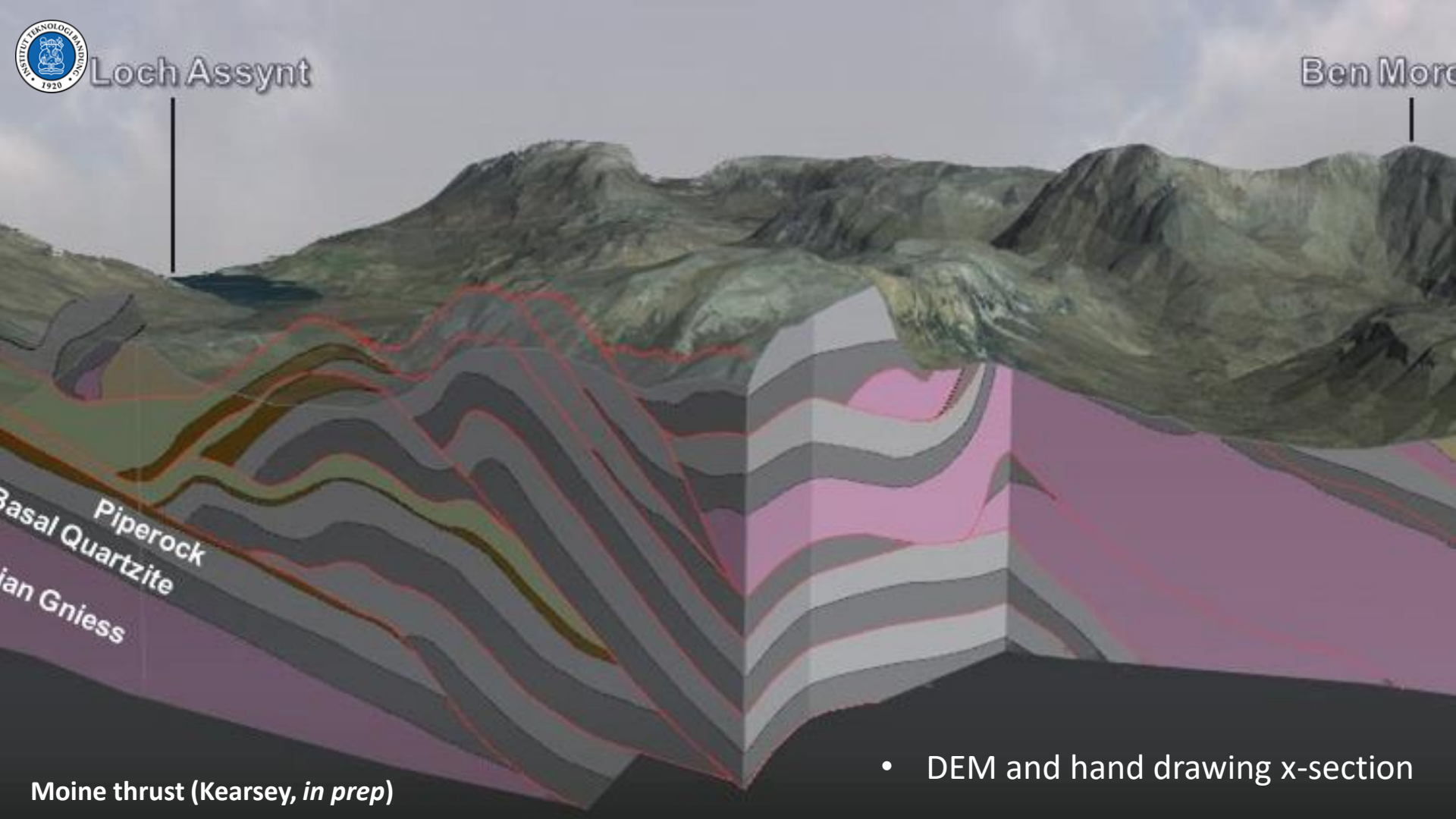




- SIMPLIFICATION OF NATURE

- **EARTH VISION TOOLS**





Moine thrust (Kearsey, *in prep*)

- DEM and hand drawing x-section

DEFINISI

- ***Structural geology*** *definition, the branch of geology dealing with the structure and distribution of the rocks that make up the crust of the earth (various Textbook).*

- ***Structural geology****, scientific discipline that is concerned with rock deformation on both a large and a small scale (Britannica).*

- ***Structural geology*** *is the study of the deformation of the surface and subsurface of the Earth and other planetary bodies (Nature, 1992).*

- ***Structural geology*** *is the study of the* ***three-dimensional*** *distribution of rock units with respect to their deformational histories (Wikipedia).*

- ***Structural geology*** *is the study of the* ***three-dimensional*** *distribution of large bodies of rock, their surfaces, and the composition of theirs inside in order to try and learn about their tectonic history, past geological environments and events that could have changed or deformed them (AAPG, 2010).*

DEFINISI

- ***Structural geology*** *is the study of the* ***three-dimensional*** *distribution of rock units with respect to their deformational histories.*

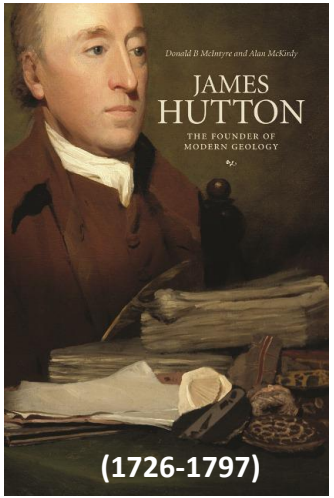
- *The primary goal of structural geology is to use measurements of* ***present-day rock geometries*** *to uncover information about the history of deformation (* ***strain****) in the rocks, and ultimately,* ***to understand the stress field*** *that resulted in the observed* ***strain and geometries****.*

(Wikipedia)

1638-1686

Nicolaus Steno

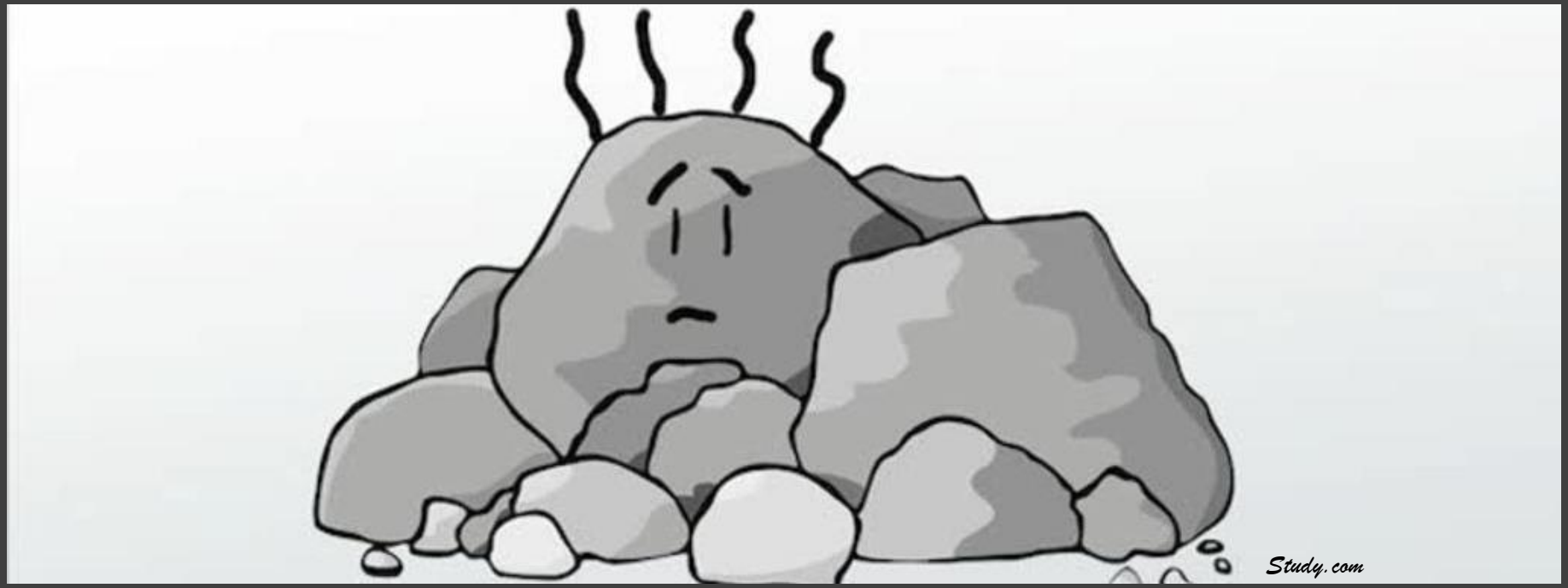
- **Original horizontality**
- **Lateral continuity**
- **Superposition**
- **Crosscutting relationship**



- **Theory of the Earth**
- **Uniformitarianism**

“THE PRESENT IS THE KEY TO THE PAST”

- **Geologi Struktur Moderen**: memfokuskan pada mekanisme deformasi **– *Forward Modeling***



KONSEP DEFORMASI BATUAN

- Deformasi akan **mengubah karaker dan konfigurasi** batuan
- Deformasi akan **mengubah bentuk dan ukuran batuan**
- Deformasi adalah **perubahan karakter, bentuk dan ukuran** batuan (***strain***) yang diakibatkan oleh ***stress***

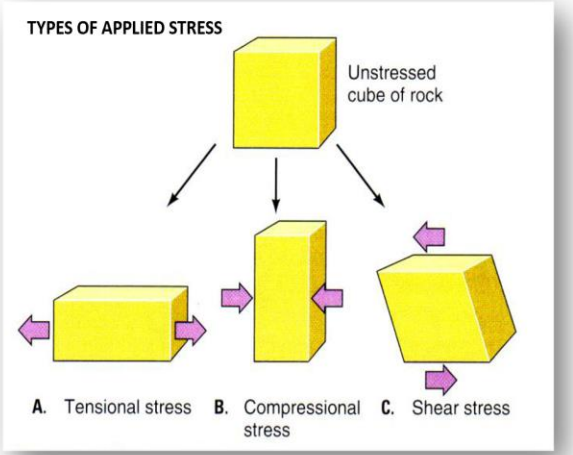
DEFINISI STRES vs. STRAIN

STRESS (σ)

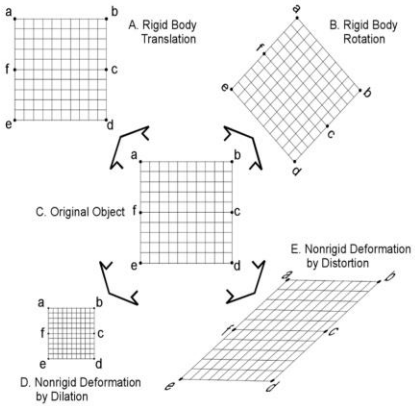
Stress defined as force per unit area:

$$\sigma = F/A$$

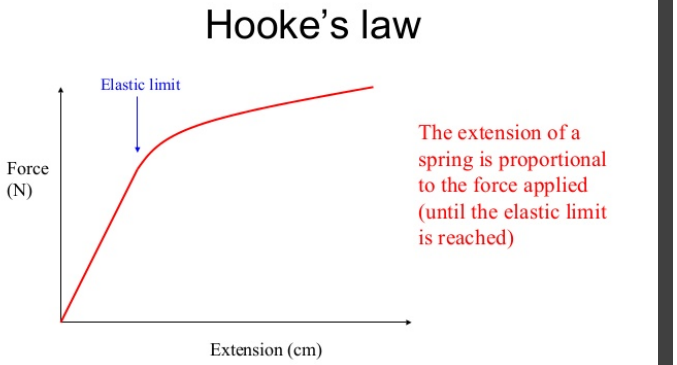
A = area, Stress units = Psi, Newton (N), Pascal (Pa) or bar (10^5 Pa)

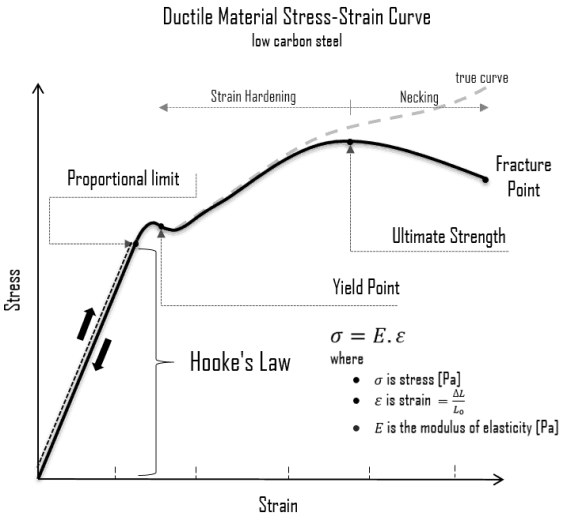


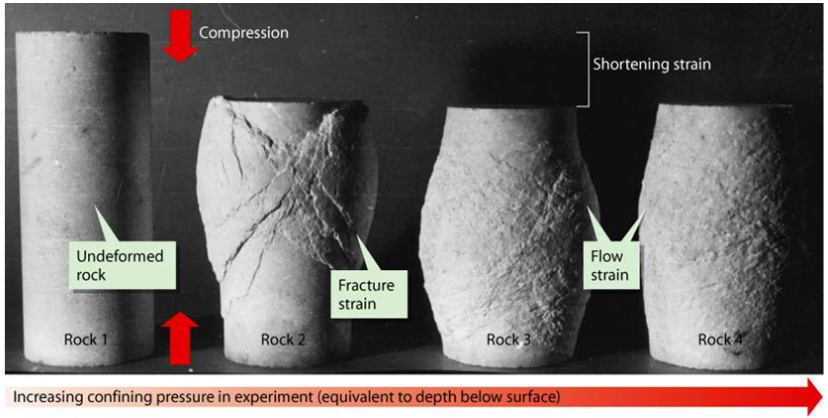
STRAIN (ε)

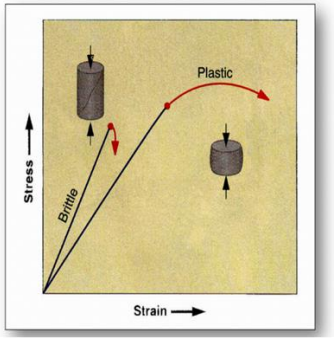


- Strain (e) = $(l_f - l_o)/l_o$
- Stretch (S) = $l_f/l_o = 1 + e$
- $\lambda' = 1/\lambda = 1/S^2 = 1/(1+e)^2$
- Shear Strain: $\gamma = \tan \psi$
- Dilation : $\Delta = (V_f - V_o)/V_o$



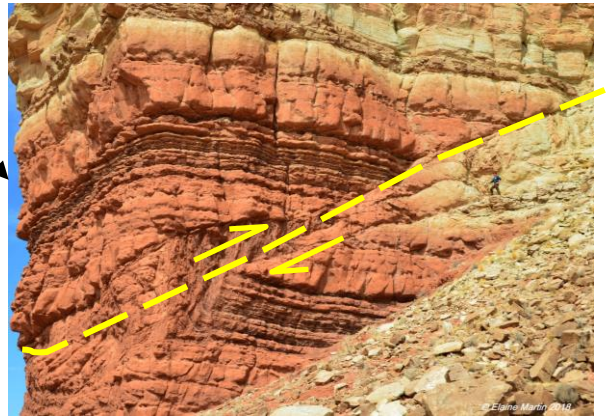






FAKTOR YANG MENGONTROL PROSES DEFORMASI?

KONSEP DEFORMASI BATUAN



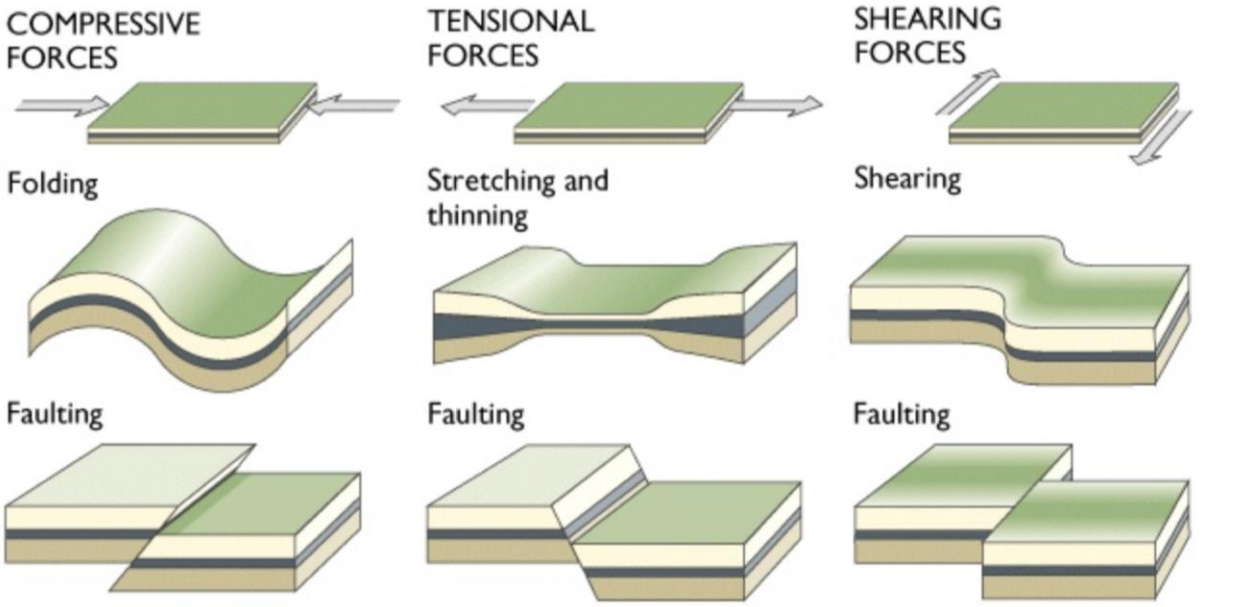
STRESS → **ROCKS** → **STRAIN**

- Faktor yang mengontrol deformation: **Stress, Strain (komposisi, texture, Por/Perm), P, T dan Fluida**

Stress	Strain
compression	shortening (contraction)
tension	lengthening (extension)

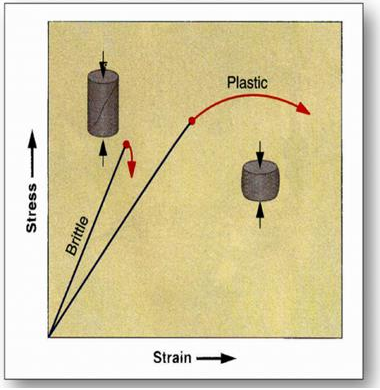
NOTE: Important distinction between two quantity !!!

STRESS DAN DEFORMASI

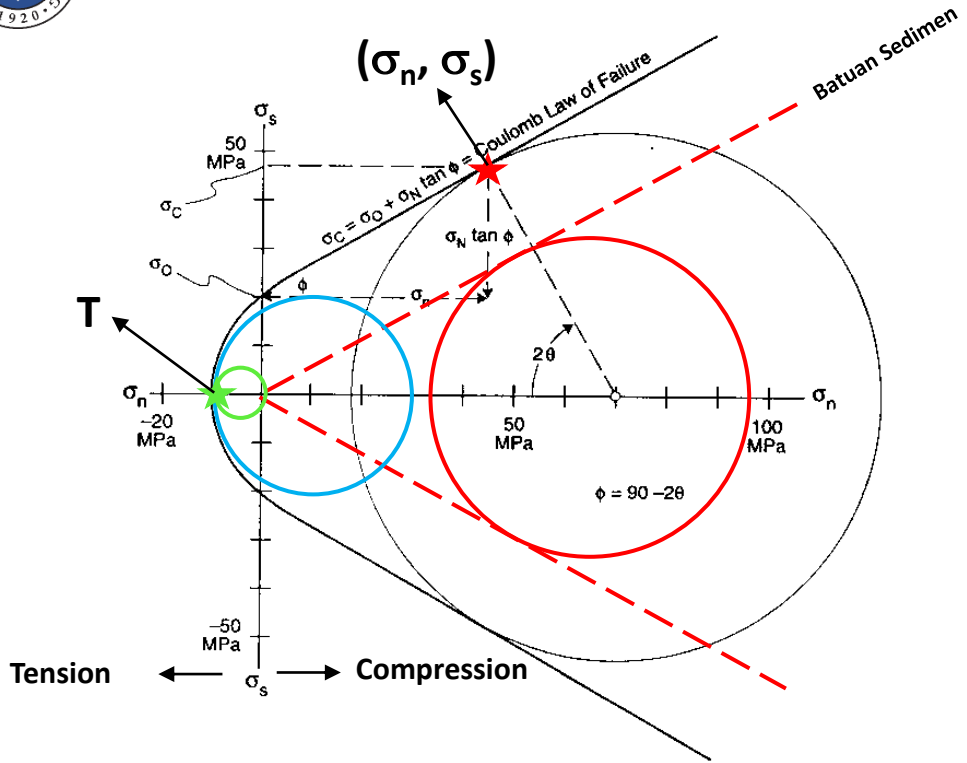


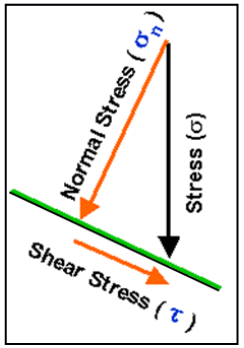
Skinner (1998)

SESAR NAIK **SESAR NORMAL** **SESAR GESER**



DEFORMASI *BRITTLE* - Coulomb (1773) dan Mohr (1900)





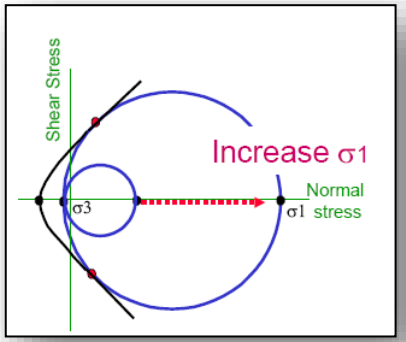
$\sigma_c = \sigma_o + \tan\phi\,(\sigma_n)$

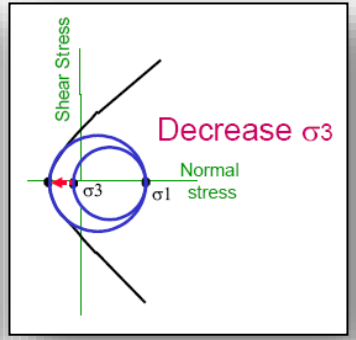
$\mu = \tan\phi$

$\sigma_c = \sigma_o + \mu\,\sigma_n$

For $\sigma_0 \sim 0$ (pasir lepas)

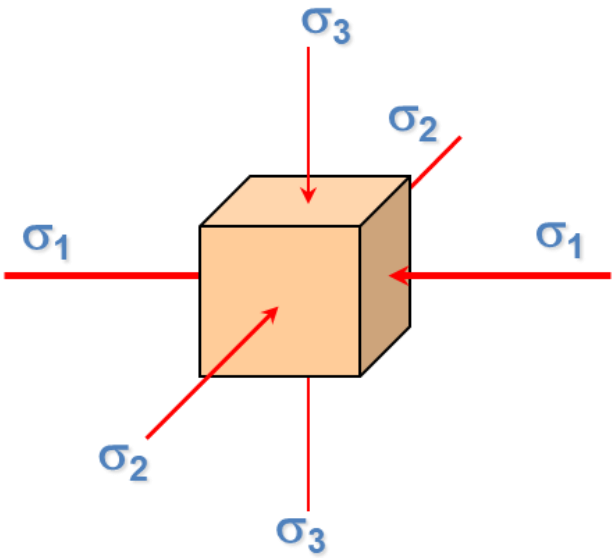
$\sigma_c = \mu\,\sigma_n$. , $\sigma_c = \tau$



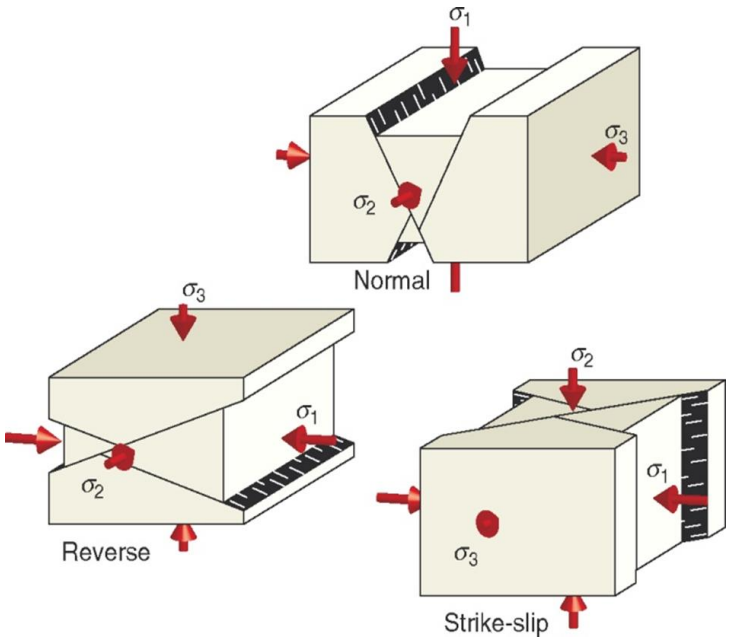


- σ_c adalah tegasan gerus kritis (*Critically-Stressed Fractures*), σ_o adalah kohesivitas (*shear Strength*), $\mu = \tan\phi$ = koefisien gesek dalam, dan σ_n adalah tegasan normal (positif=kompresi, negative = tensile)
- Diameter lingkaran adalah $\sigma_d = \sigma_1 - \sigma_3$ (*differential stress*)

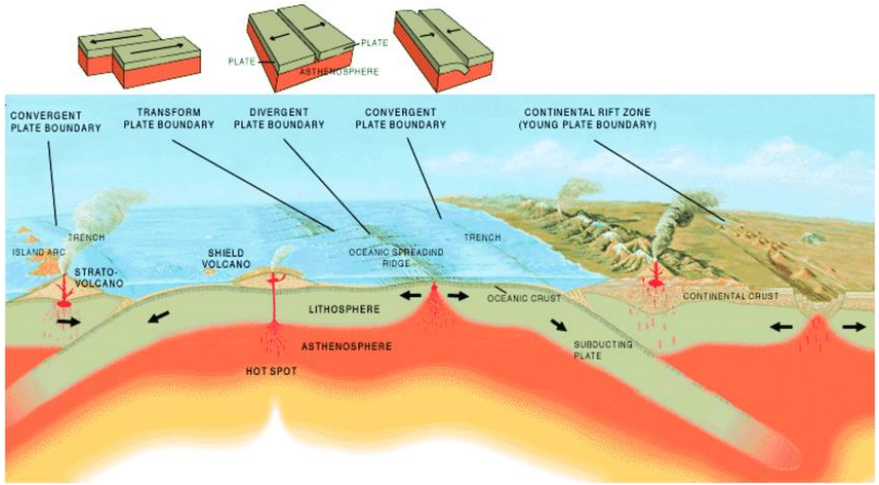
Teori Sesar **Anderson (1951)**



- $\sigma_1 > \sigma_2 > \sigma_3$

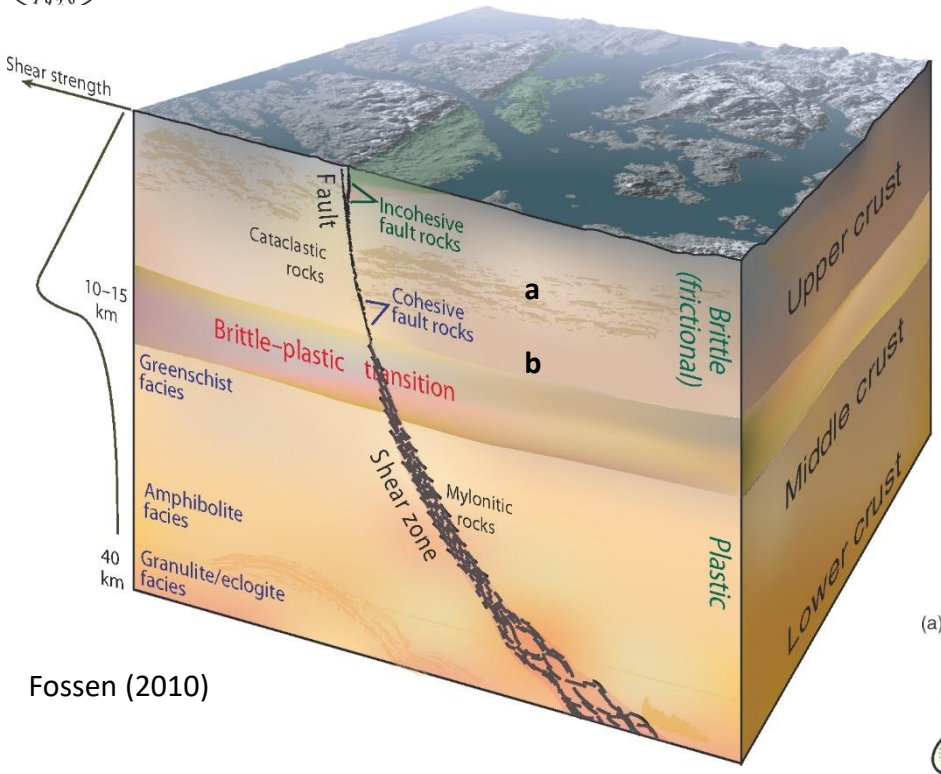


- **TEKTONIK LEMPENG (HORIZONTAL STRESS) – S_{Hmax}**
- **GRAVITASI (VERTIKAL) BY *LOADING/BURIAL* – BUYOANCY FORCE - S_V**
- **FLUIDA (TENSION) – KONSEP EFEKTIF STRESS – (σ_3)/ S_{hmin}**

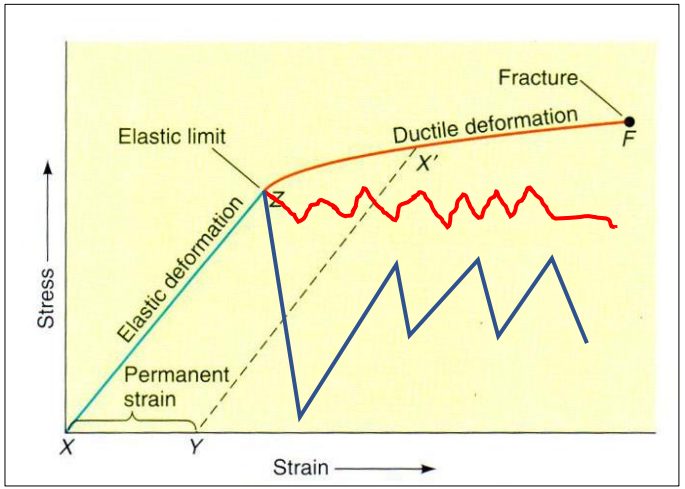


Present-day Earth Stress System (Geomechanics)

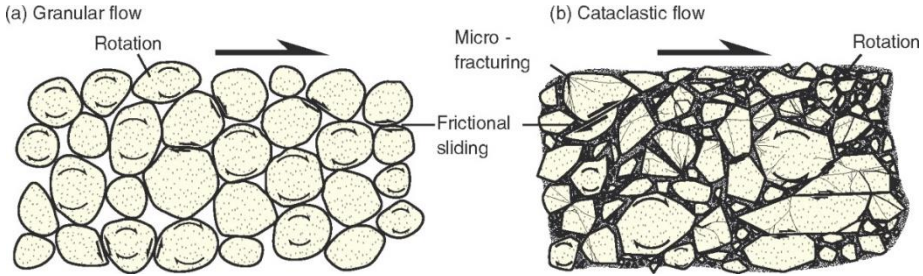
DEFORMASI BATUAN SEDIMEN (<~6 km)



Fossen (2010)

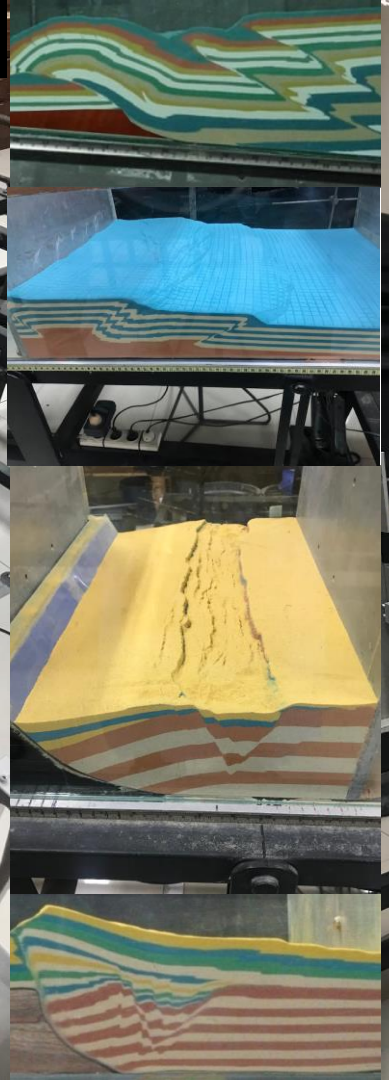


Poro-Elastic Brittle rocks



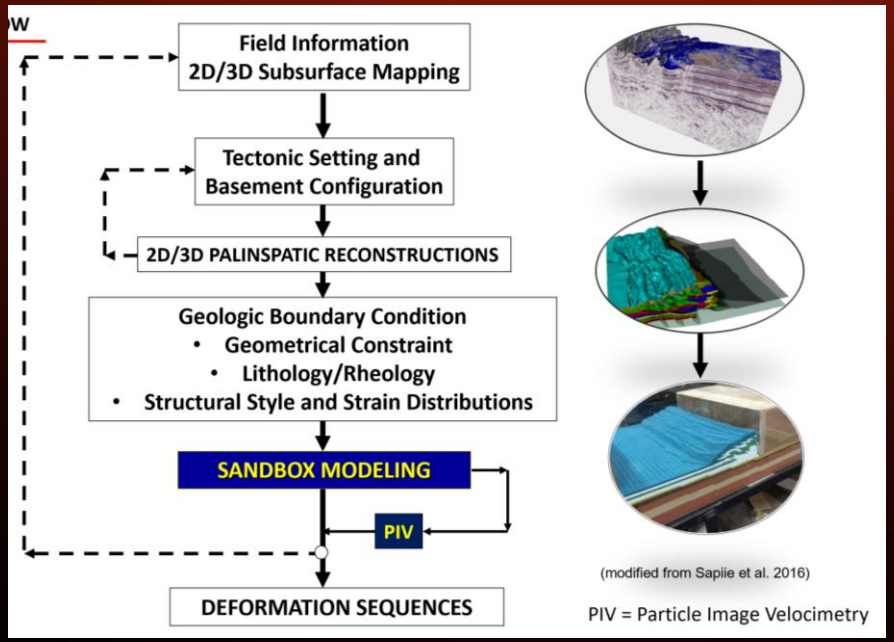
- Lithosfir terdiri dari mantle bagian atas, kerak dan sedimentary covers (~ 1-5 km)

PEMODELAN ANALOG SANDBOX ITB

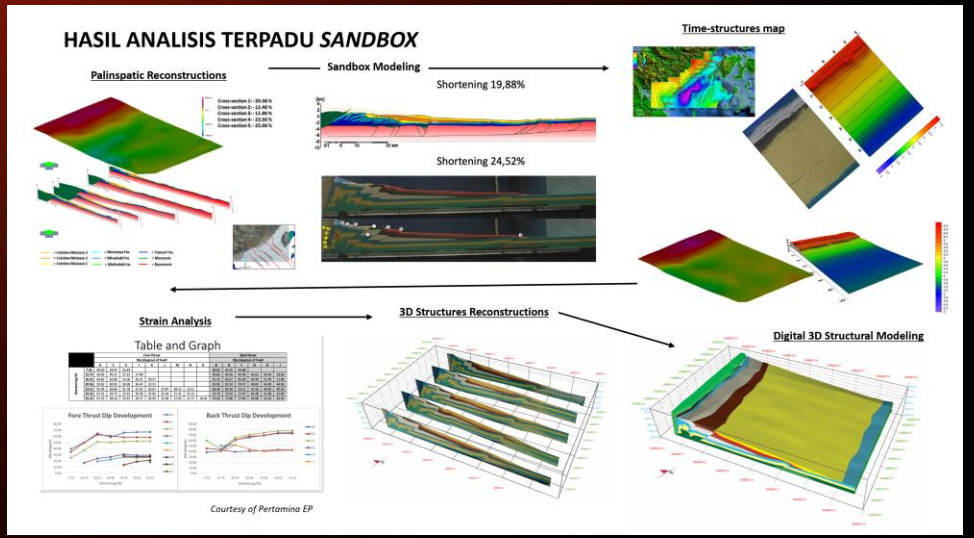


PEMODELAN ANALOG SANDBOX ITB

WORKFLOW



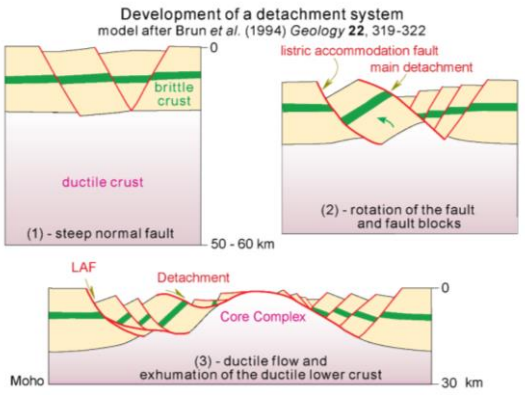
RESULTS

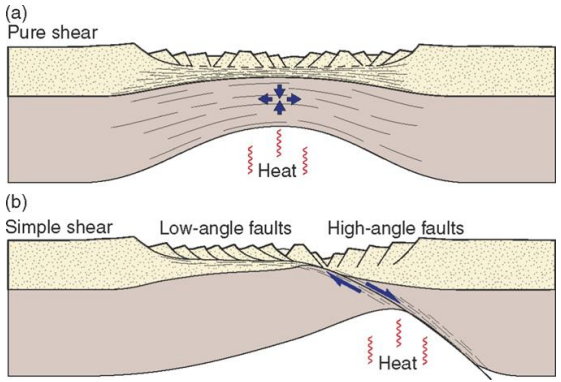


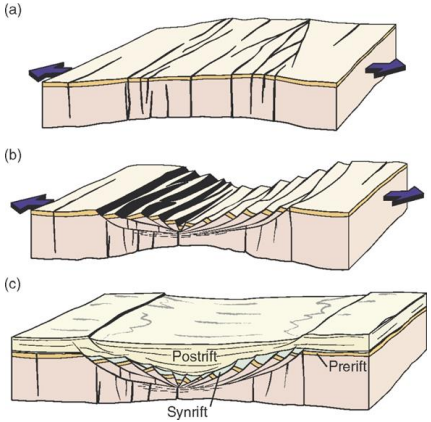
- METODA INTEGRASI

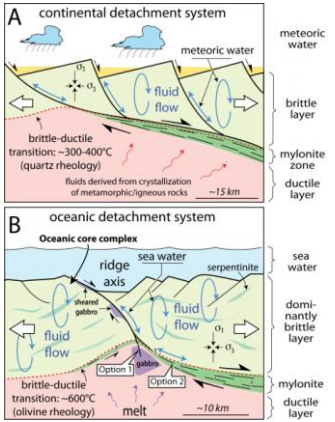
PENGEMBANGAN DAN PENELITIAN KASUS GEOLOGI STRUKTUR (2000-2020)

- ANALISA KINEMATIKA DAN SEJARAH DEFORMASI (2D/3D *PALINSPATIC RECONSTRUCTIONS*), TEKTONIK CEKUNGAN
- 3D MODELING STRUKTUR GEOLOGI; *STRUCTURAL FRAMEWORKS, 3D BASIN MODELING*
- SANDBOX MODELING – *NUMERICAL MODELING*
- SESAR DAN GEMPA (TEKTONIK AKTIF/GEOLOGI GEMPA); MEKANISME SESAR DAN KONSENTRASI STRESS , *MICROTECTONICS*
- RESERVOAR DAN ALIRAN FLUIDA (PERMEABILITY); *FAULT-SEAL-ANALYSIS* (FSA), *HYDRAULIC FRACTURING*
- REKAHAN ALAMI (*FRACTURED BASEMENT, FRACTURED CARBONATE*)
- RESERVOAR GEOMECHANICS – *IN-SITU STRESS MEASUREMENT*





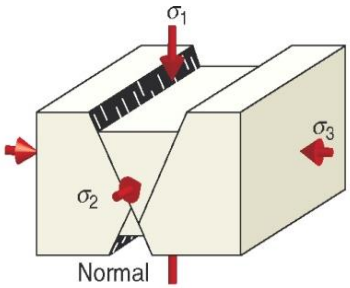


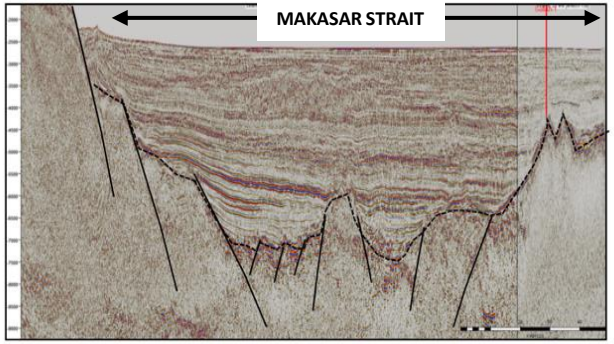


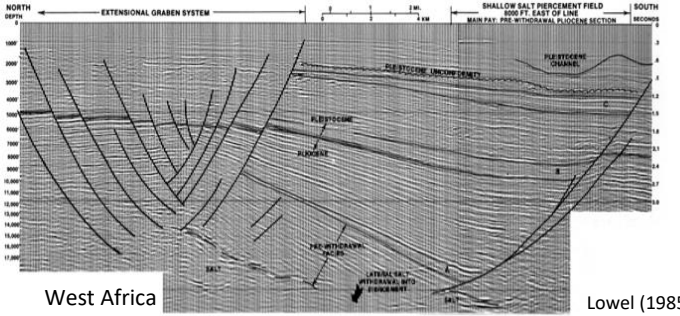
SYSTEM *DETACHMENT/DÉCOLLEMENT*
EXTENSIONAL FAULT SYSTEM

- DIVERGENT TECTONICS
- TENSION FORCE/PULL- APART

KASUS SESAR NORMAL – *EXTENSIONAL DEFORMATION*

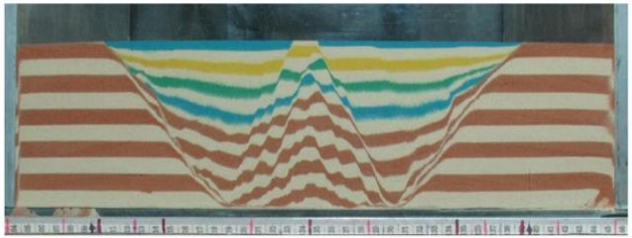


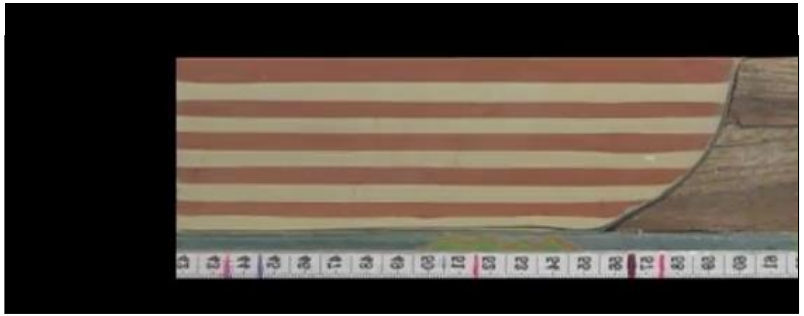




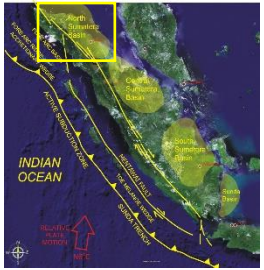
West Africa

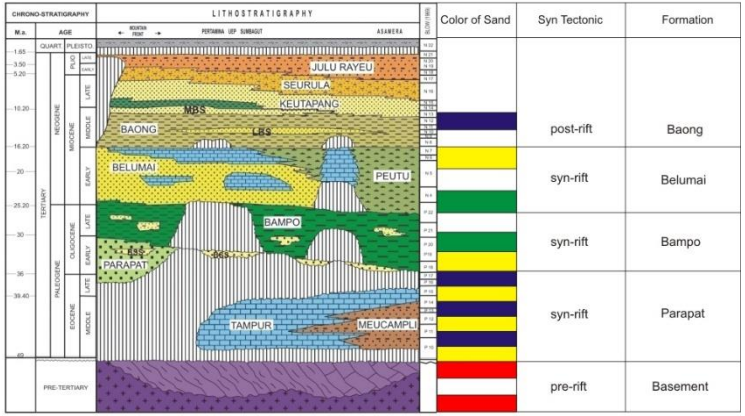
Lowel (1985)

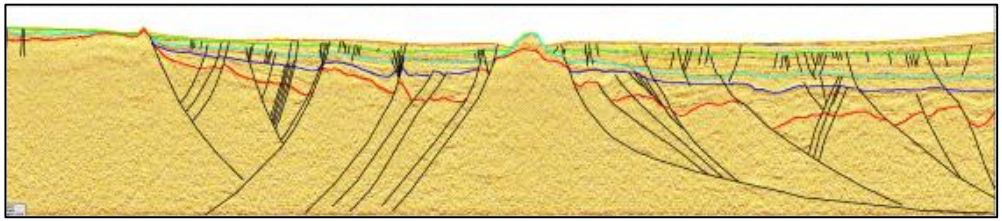


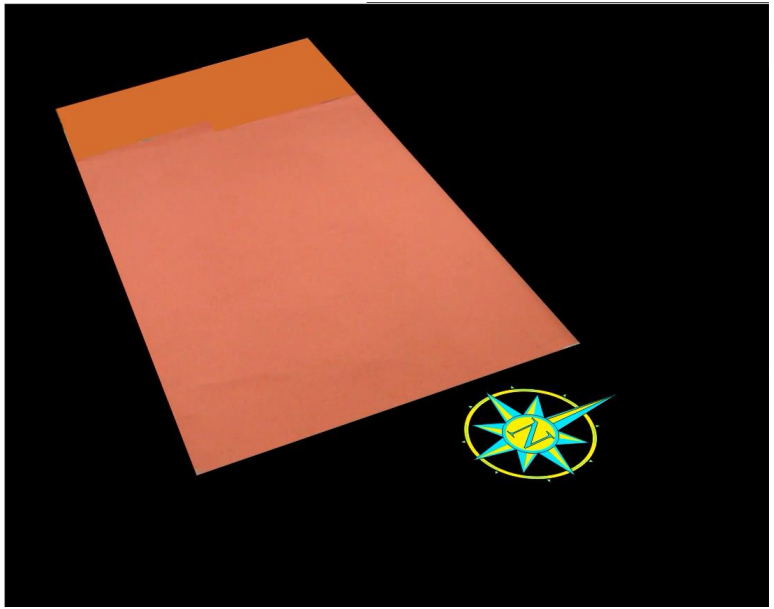


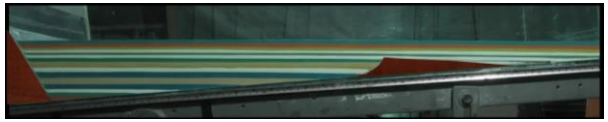
KASUS SESAR NORMAL – *North Sumatra Basin*

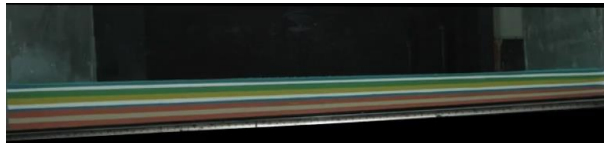


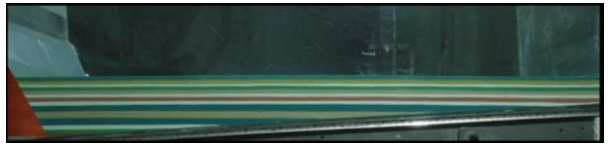


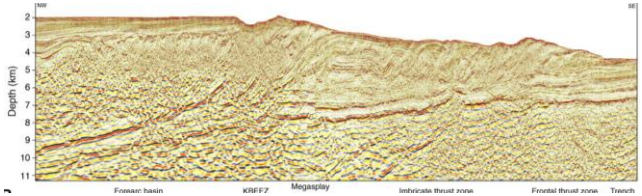


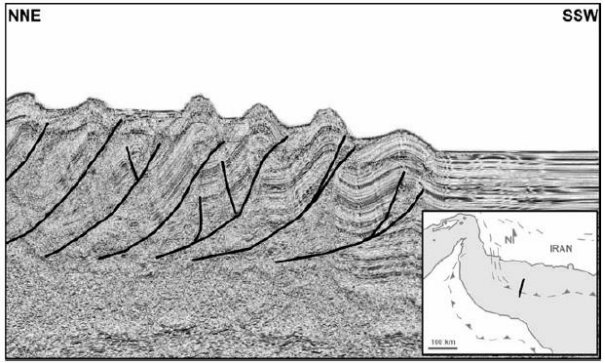


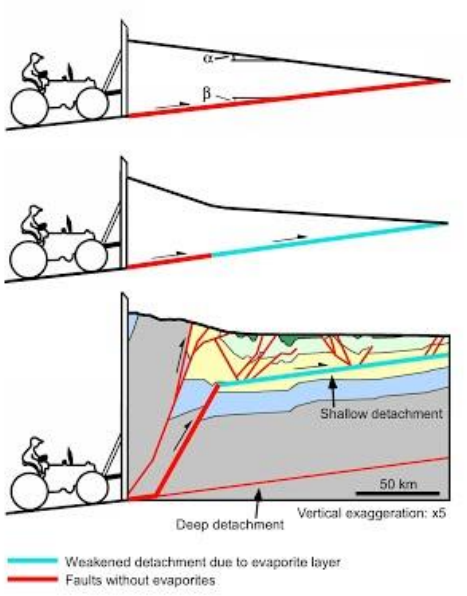








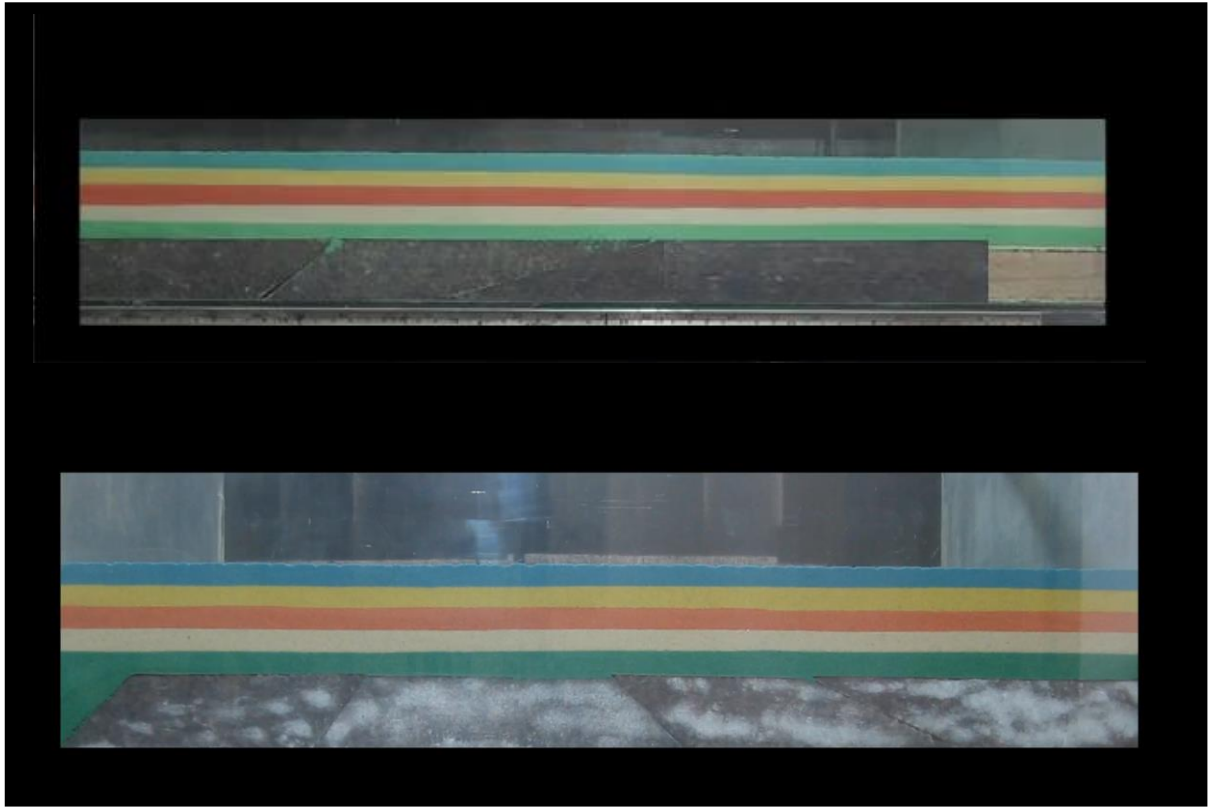


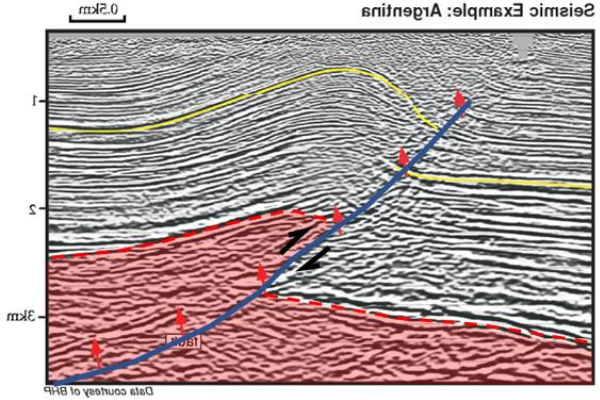


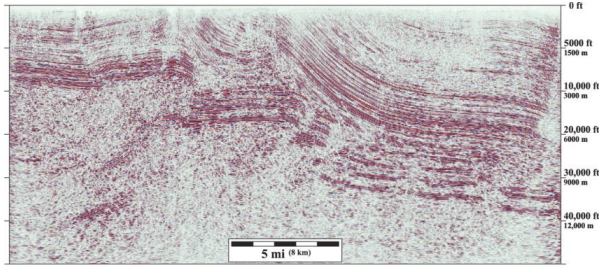
FOLD-THRUST-BELT

Decollement Concept for Thrust Wedge Growing

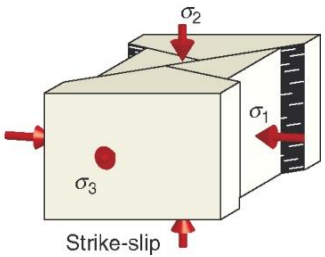
Basement Involved Deformation

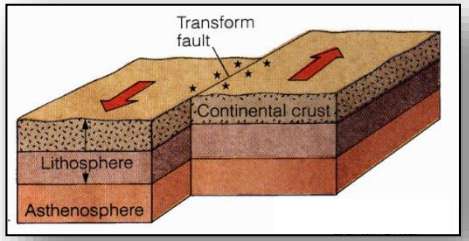


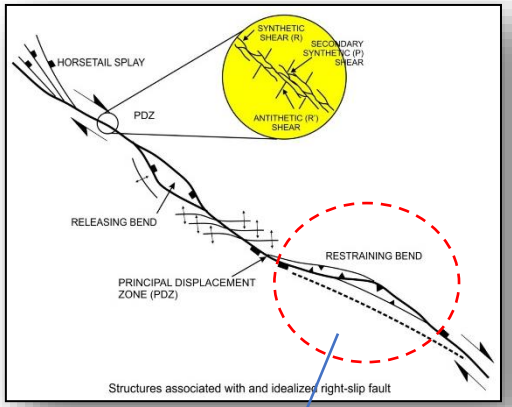


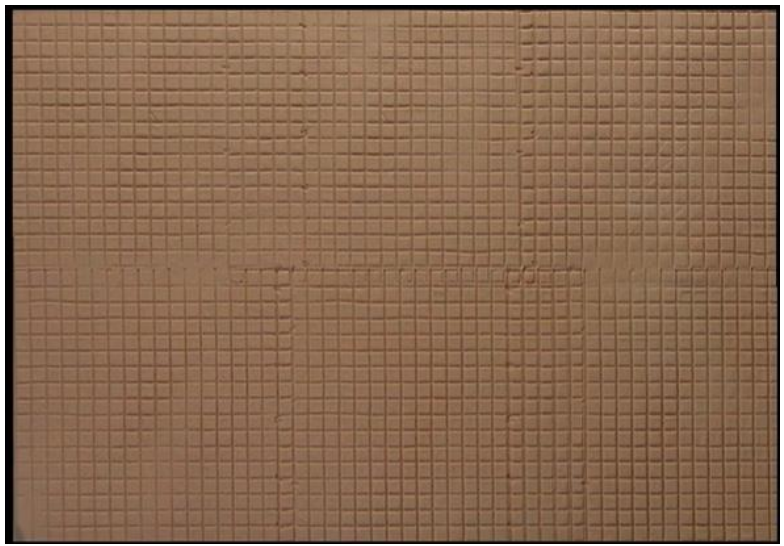


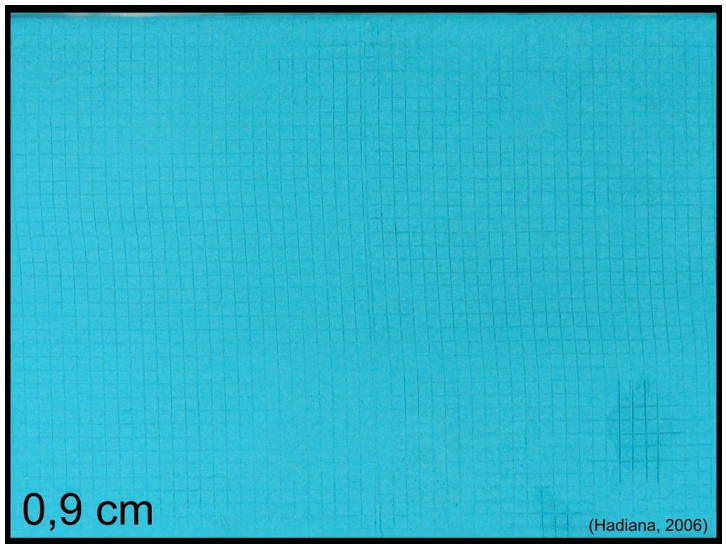
KASUS SESAR GESER – *STRIKE-SLIP DEFORMATION (WRENCH, OBLIQUE CONVERGENT/DIVERGENT)*



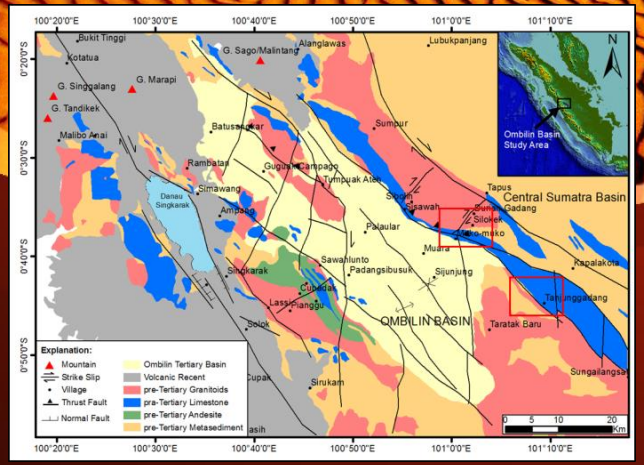




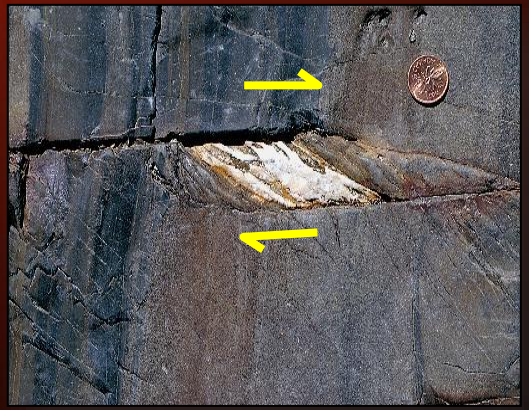


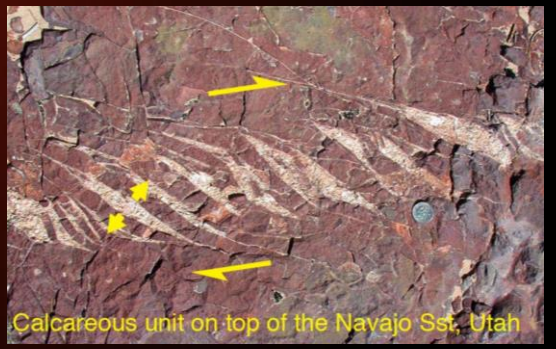


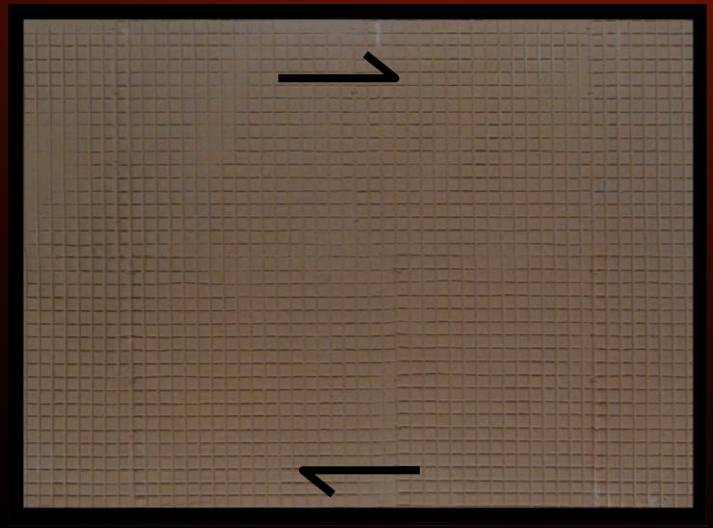
STRIKE-SLIP PULL-APART



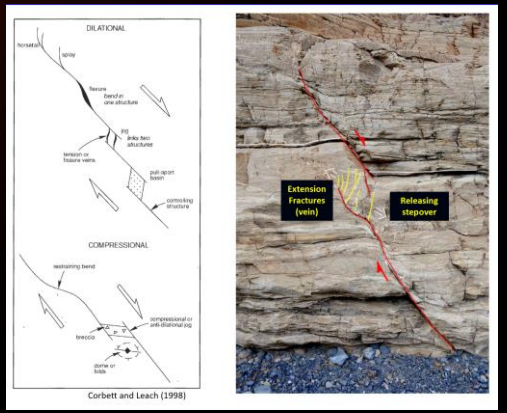
Pull-apart - *rhomboidal*



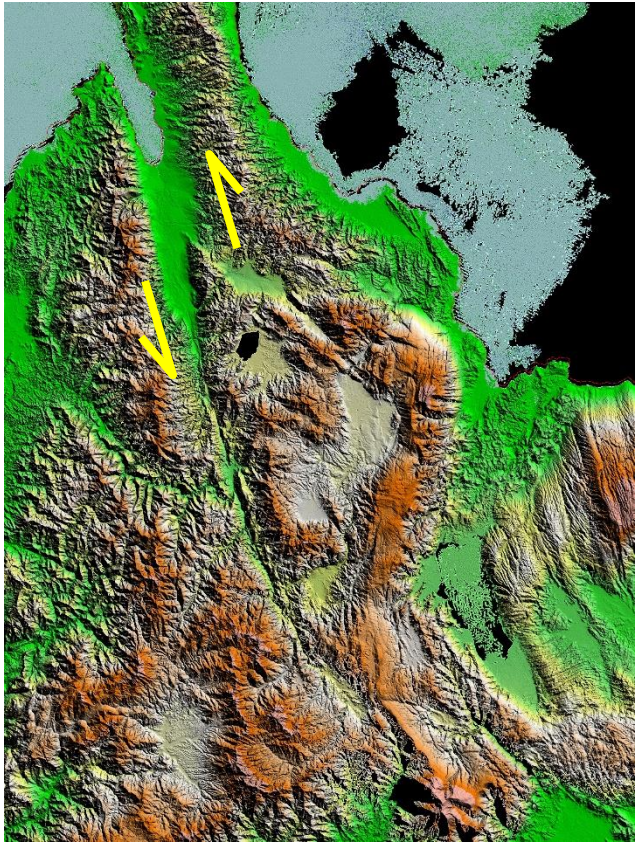


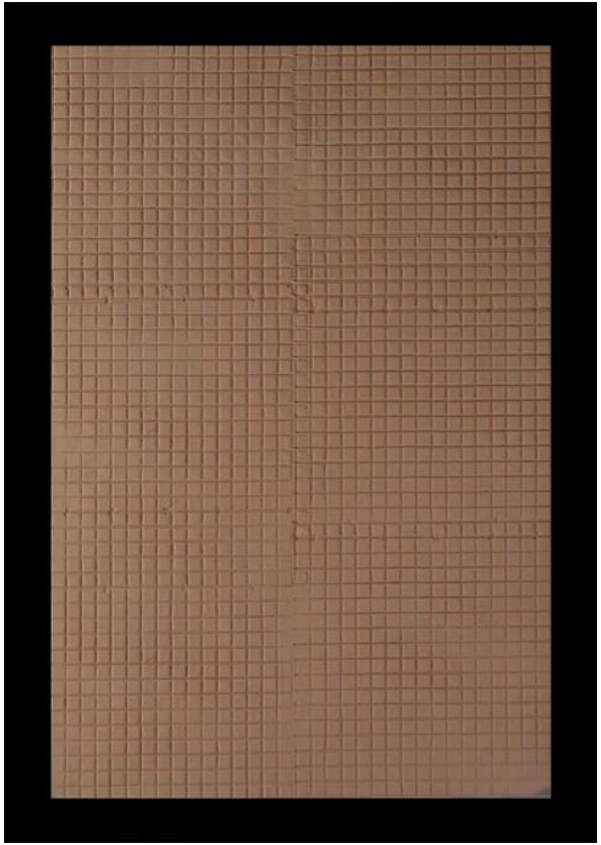


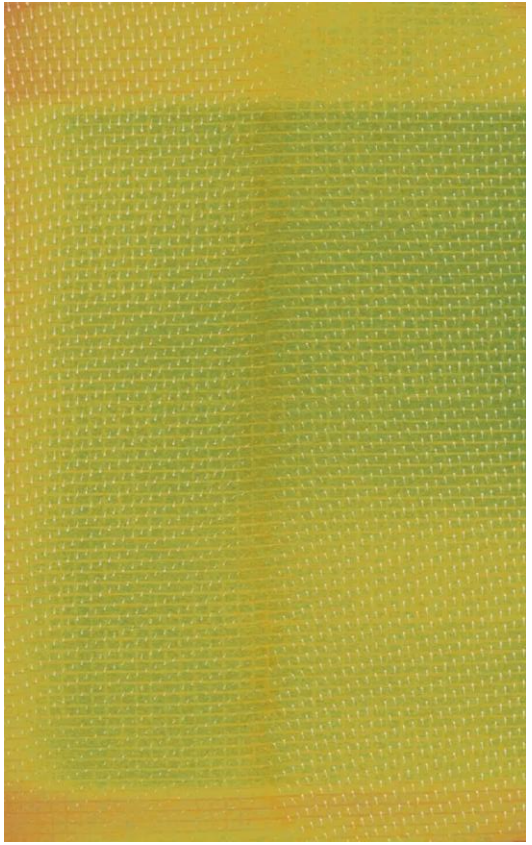
- Tension Stress



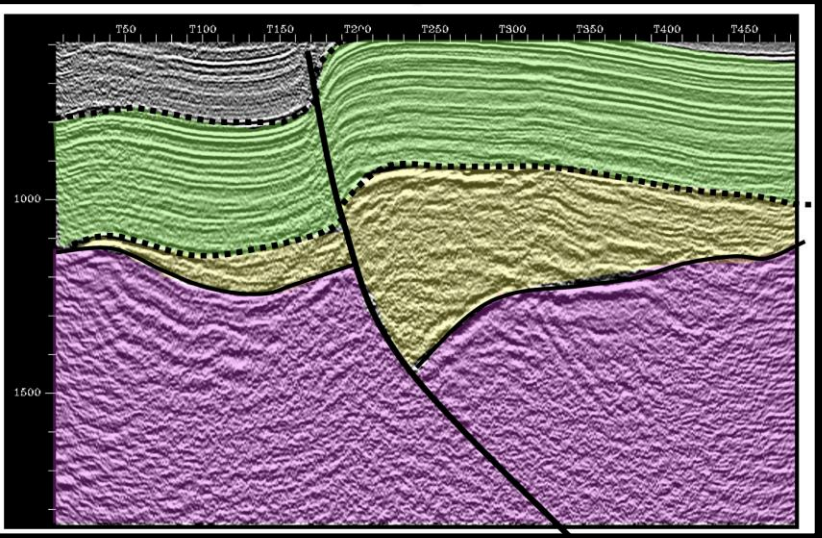
ANALISA *STRAIN* SESAR PALUKORO – *Sinistral Strike-Slip*



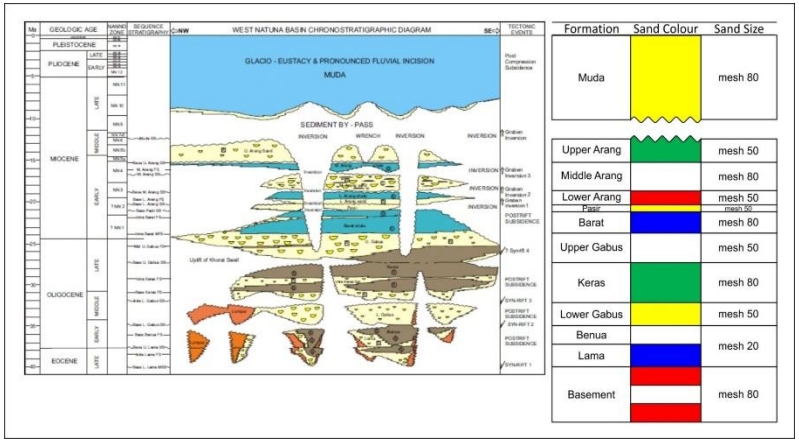


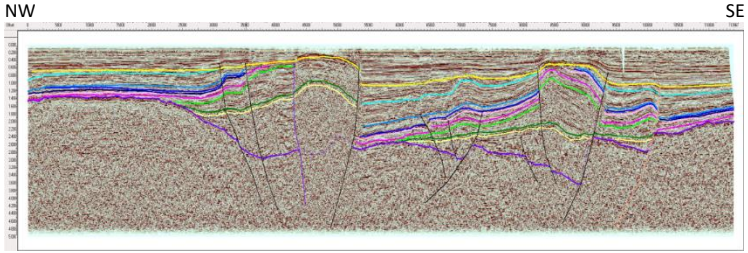


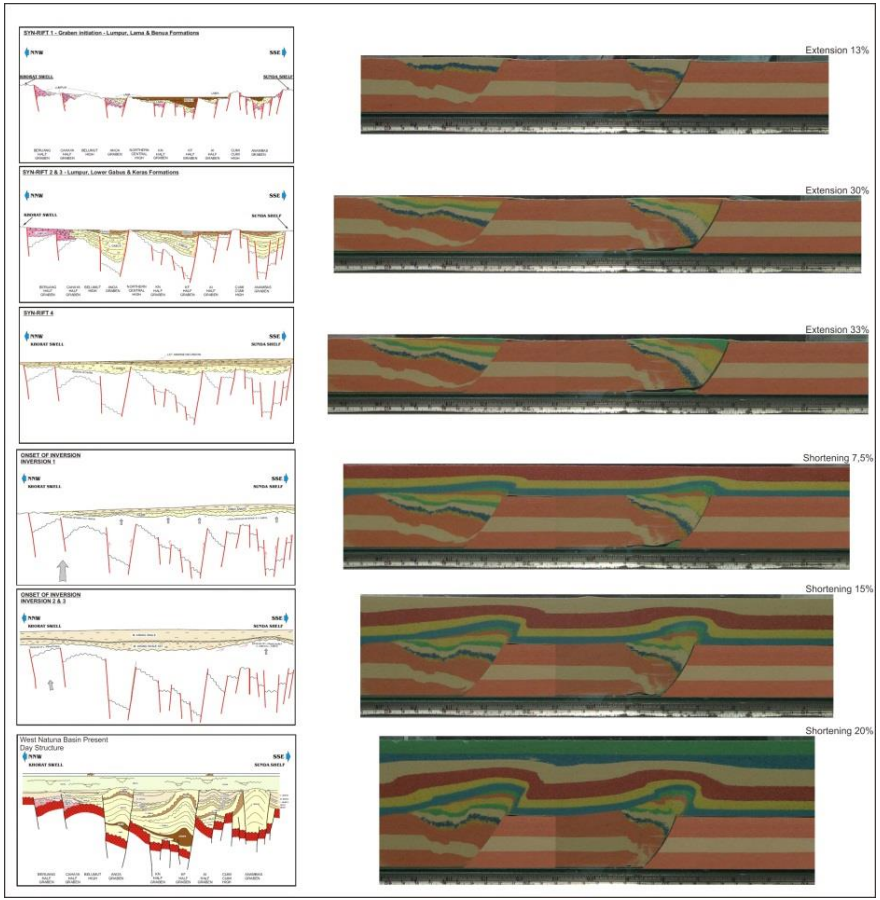
SESAR INVERSI



KOMPLEKS DEFORMASI SESAR INVERSI – WEST NATUNA

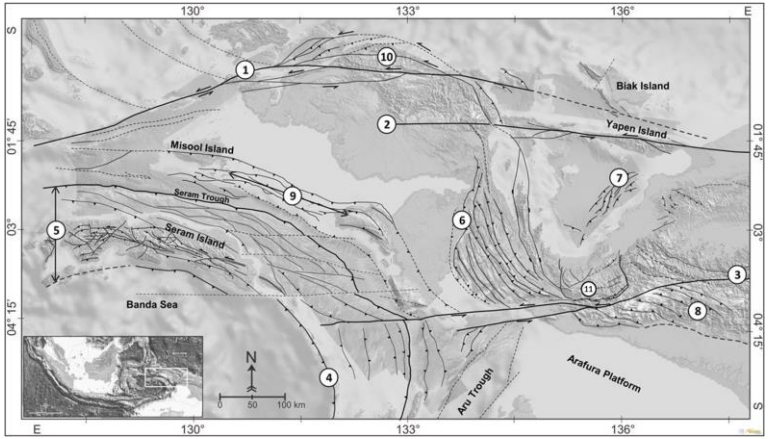


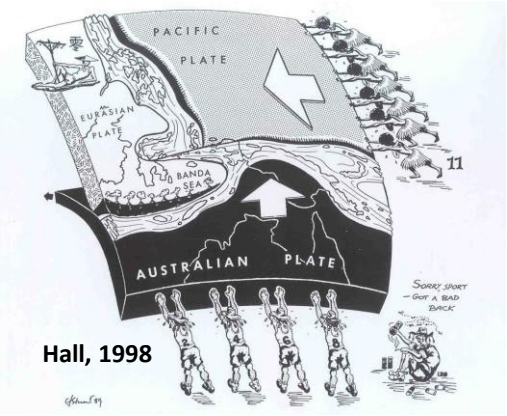




Courtesy of Premier Oil

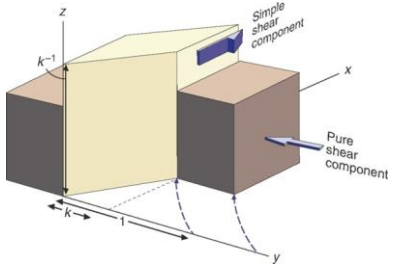
Kompleks 3D Deformasi – Seram Through





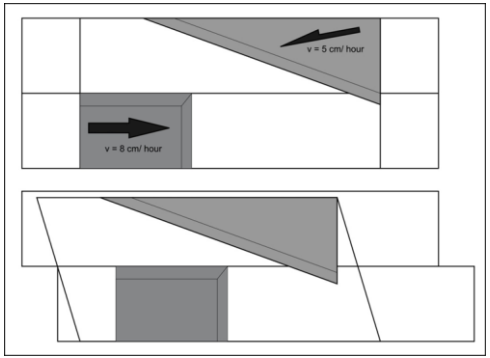
Hall, 1998

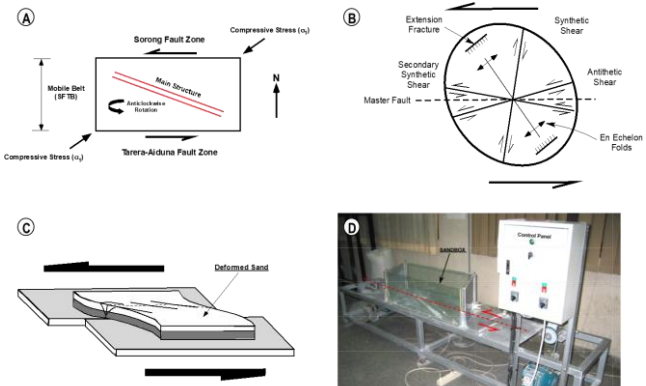
STRESS MODEL



Fossen (2010)

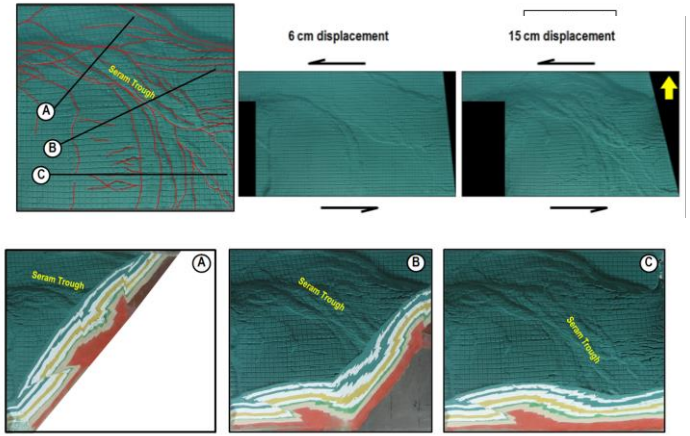
SANDBOX MODELING SETTING





Sapiie et al. (2012)

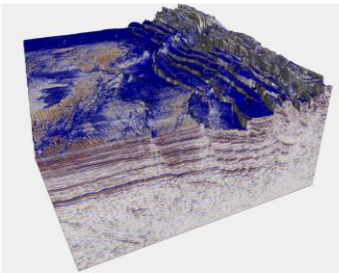
SANDBOX MODELING RESULTS

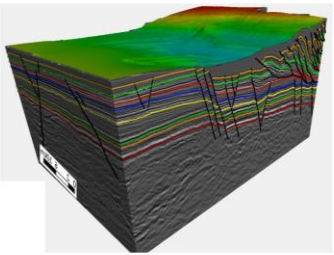


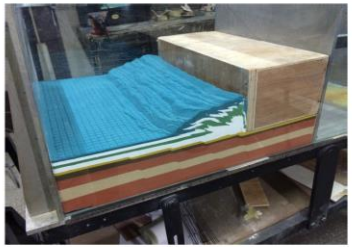
Structural Styles and Hydrocarbon Exploration Challenges in the Babar-Selaru Fold-Thrust-Belt, Banda Sea Region, Indonesia

B. Sapiie, A. Kurniawan, H. Danio, D. Daniel, M. Hadiana (*)
M. Ohara, M. Fujimoto, L. A. Perdana, A. Saputra (**)

(*) Geology Study Program, INSTITUT TEKNOLOGI BANDUNG, Indonesia
(**) INPEX CORPORATION, Japan





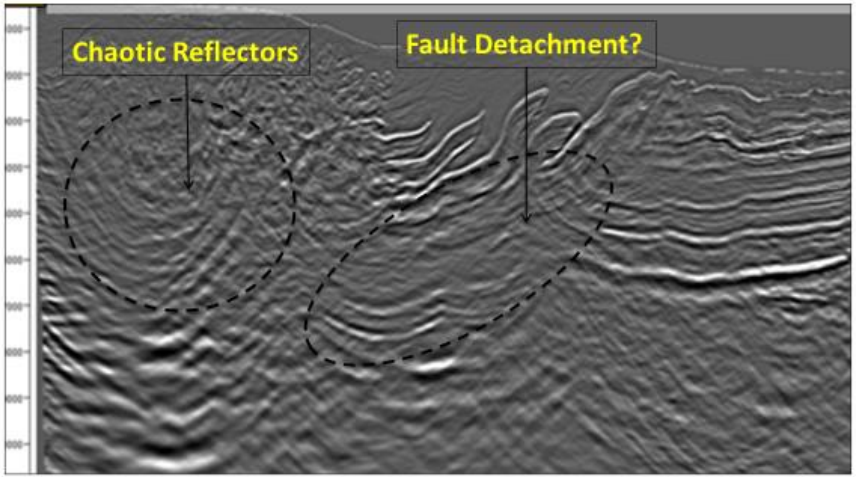


June 21, 2016 - Calgary, Alberta, Canada

AAPG Annual Convention & Exhibition 2016

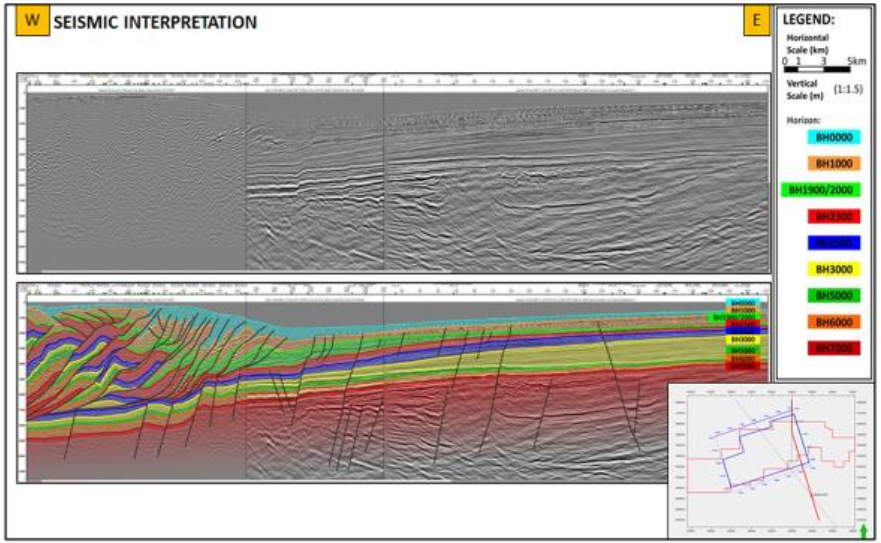
PERMASALAHAN (*RESEARCH QUESTION*)

STATE OF PROBLEMS? – looking for best interpretation



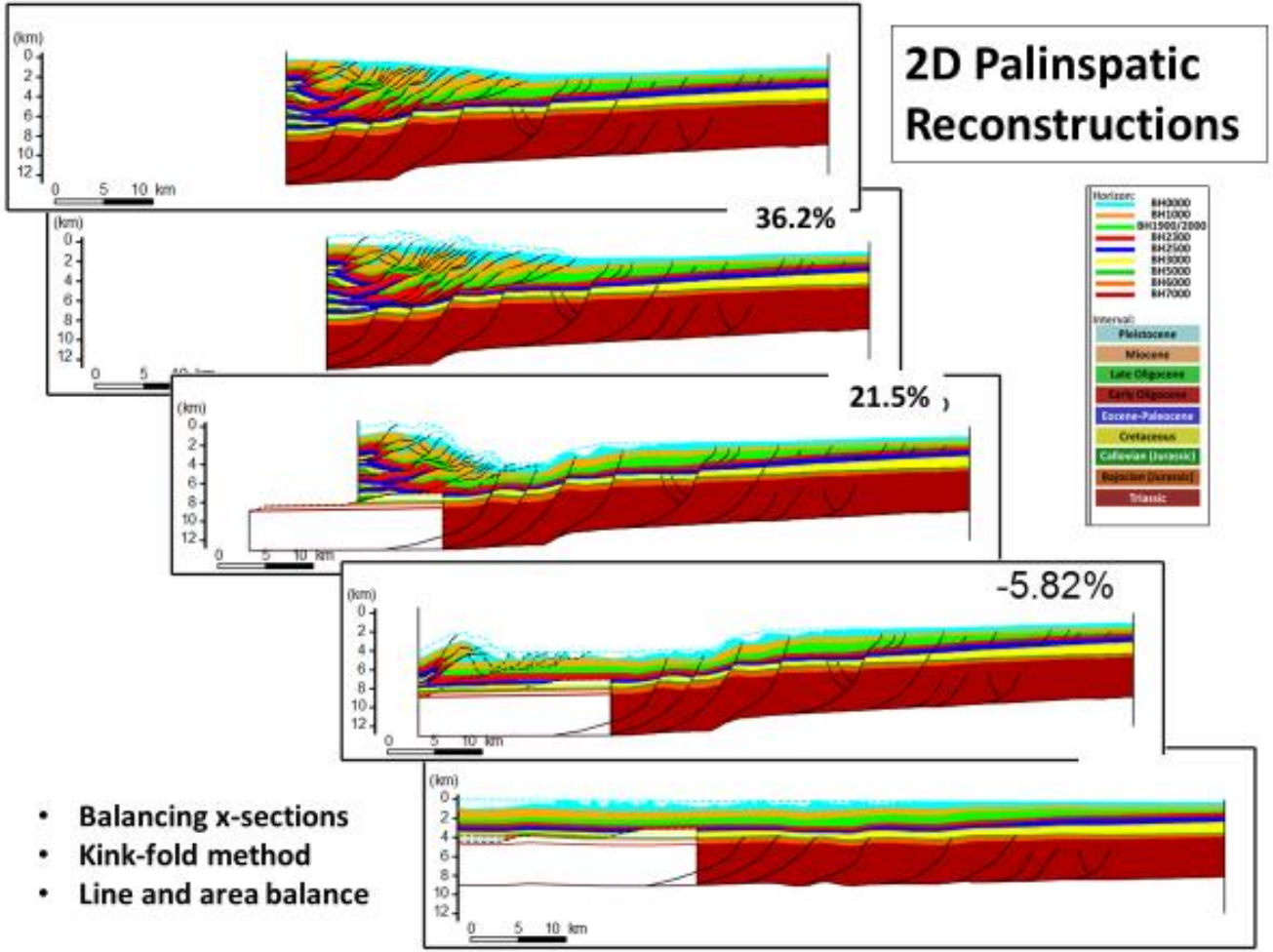
- Horizon mapping – continuing reflectors
- Detachment level? – weak reflectors

SEISMIC INTERPRETATION (REGIONAL LINE)

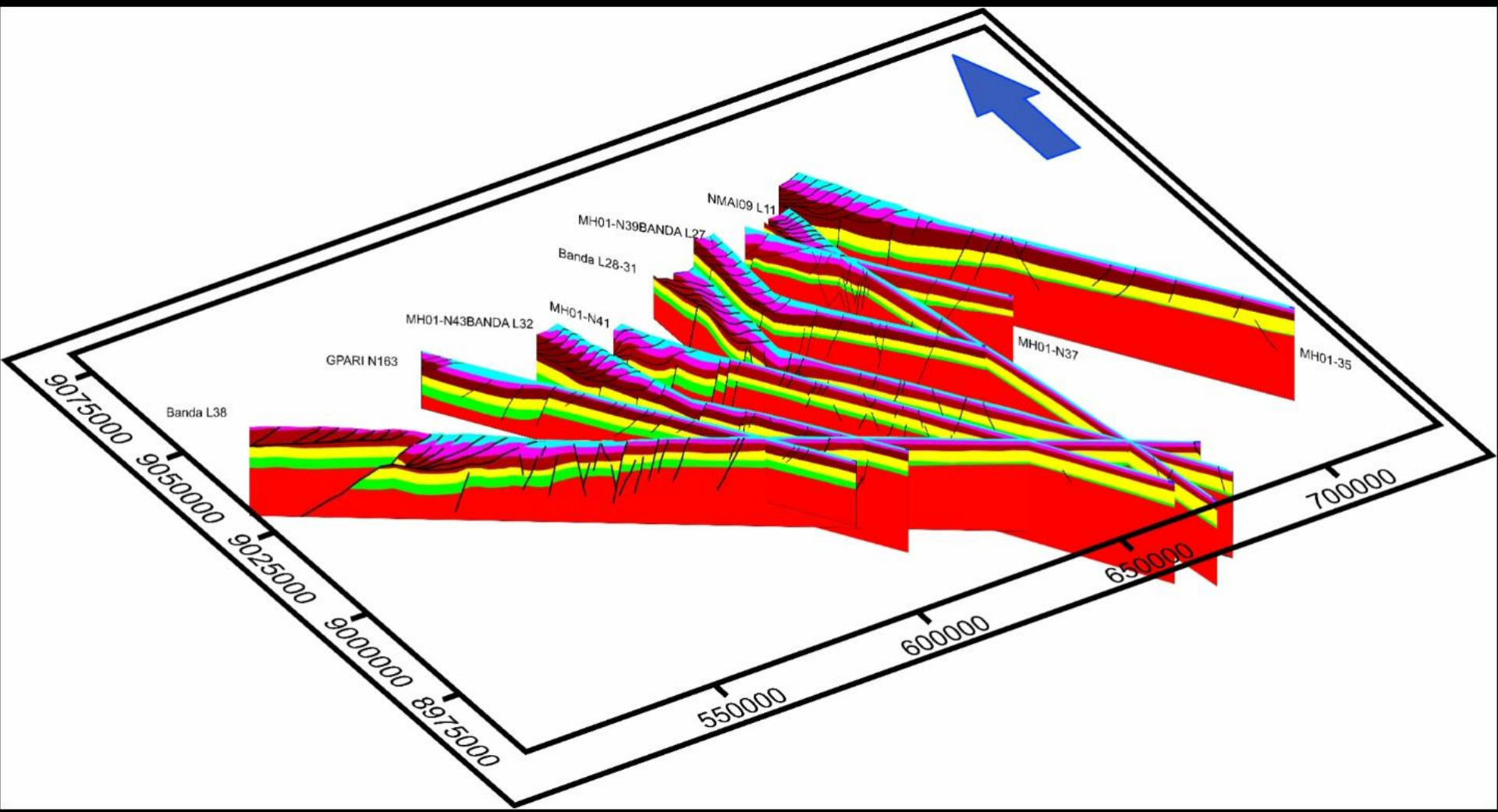


➢ **TEKNIK VALIDASI INTERPRETASI DAN MODEL STRUKTUR GEOLOGI?**

2D Palinspatic Reconstructions



- Balancing x-sections
- Kink-fold method
- Line and area balance


NMAI09 L11
MH01-N39BANDA L27
Banda L28-31
MH01-N41
MH01-N43BANDA L32
GPARI N163
Banda L38
MH01-N37
MH01-35
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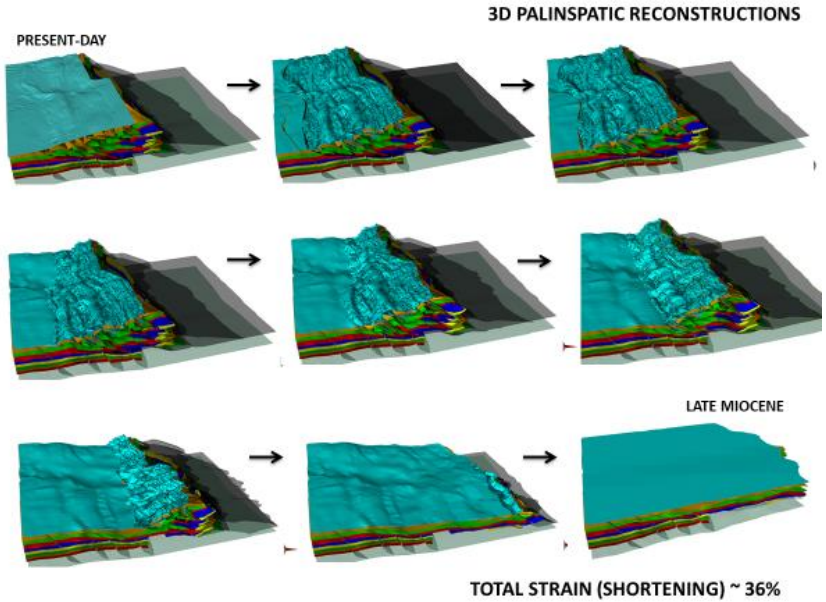
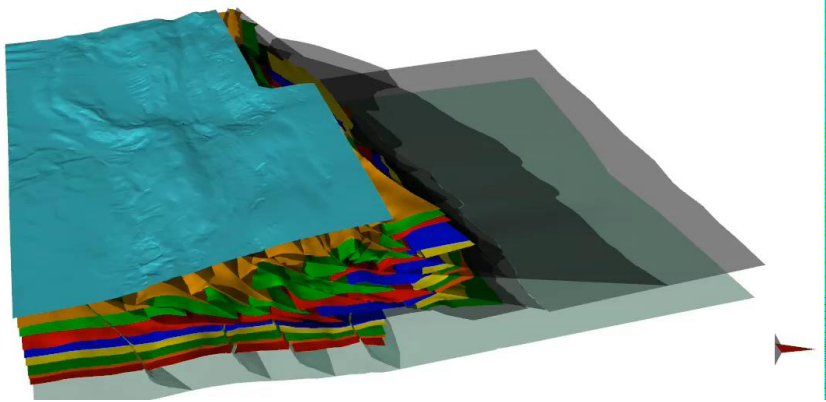
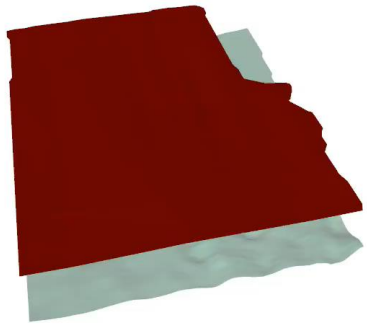
3D PALINSPATIC RECONSTRUCTIONS



Sapiie et al. (2016)



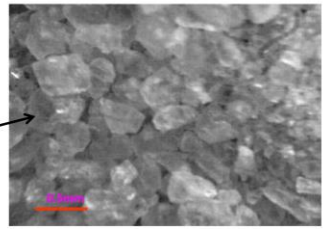


- Using 3D Moves Tools

VALIDASI MODEL STRUKTUR GEOLOGI

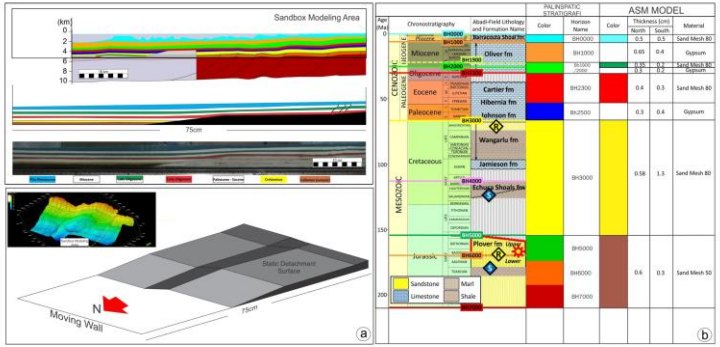
SANDBOX MODELING

- ITB SANDBOX APPARATUS WITH VARIABLES DISPLACEMENT RATE (~ 5 Cm/hr.)
- SIZE: 120 X 50X50 CM
- USING NATURAL MATERIALS
  - LOOSE DRY QUARTZ SAND GRAINS
  - GYPSUM POWDER (LIMESTONE)
- SAND SOURCE: NGRAYONG Fm. (EAST JAVA)
- COULOMB MATERIALS WITH ANGLE OF INTERNAL FRICTION (Φ) = 30^0, BULK DENSITY (ρ): 1.4-1.8 g.cm3

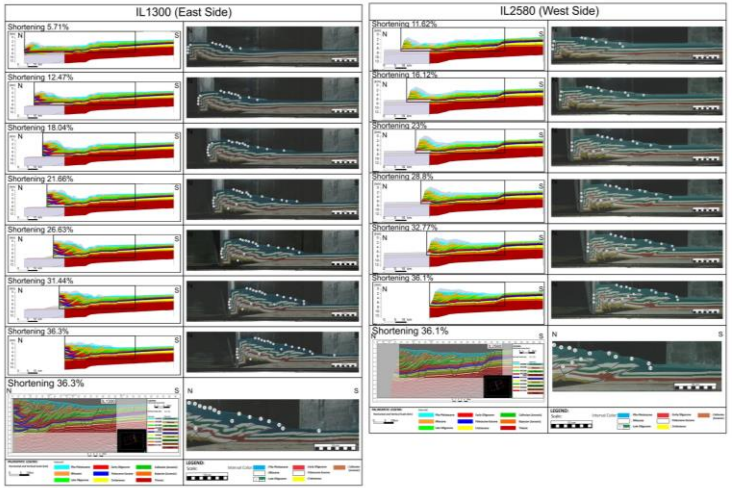


METHOD INTEGRASI

SANDBOX MODELING SETTING



SANDBOX MODELING RESULTS



OUTCROP SCALE FRACTURES CHARATERIZATION IN THE RAJAMANDALA LIMESTONE FORMATION, WEST JAVA, INDONESIA

Benyamin Sapiie *)
Maisi A. Riswanty *)
Adhipa Herlambang*)
Lisnanda A. Perdana *)
Astyka Pamumpuni *)
Eril Suhada Lanin *)
Isto Janata *)
Dwiharso Nugroho *)
Toni Simo **)

*) GEODYNAMIC RESEARCH GROUP, GEOLOGY ITB
**) URC EXXONMOBIL, HOUSTON, USA

Asia-Pacific AAPG-EAGE Joint GTW , Fractured Carbonate Reservoirs15-17 February 2012 , Bali, Indonesia

PENELITIAN RAJAMANDALA – *FRACTURED CARBONATE ROCKS*

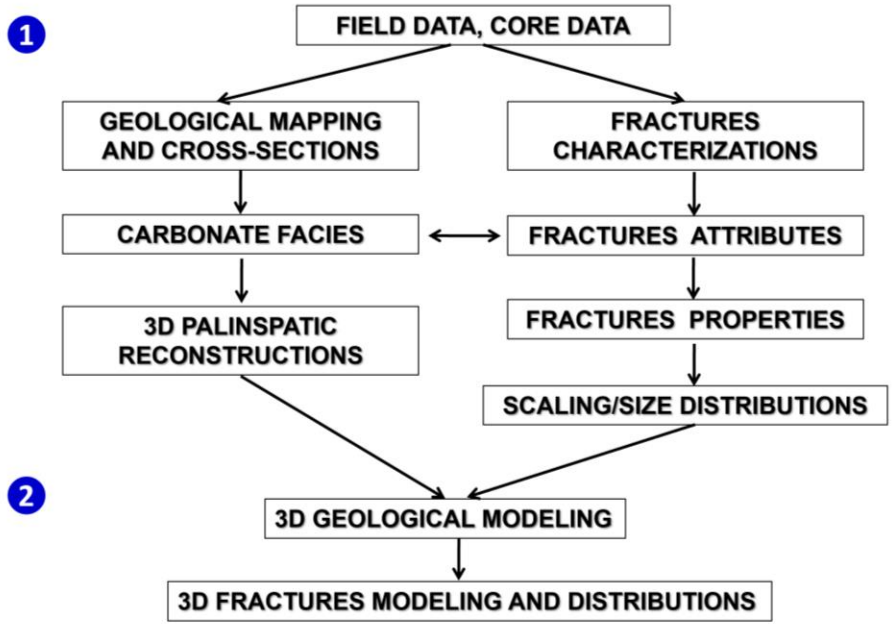
FRACTURES IN CARBONATE RESERVOIR

- Adding complexity in carbonate reservoir performance
- Complex styles and pattern (i.e. *Mechanical Stratigraphy*)
- Modified by secondary process (dissolution/karstification)

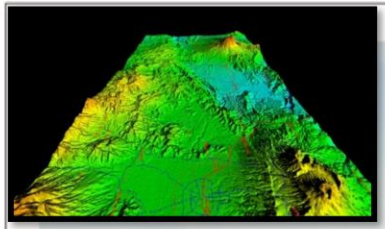
FRACTURES TYPES IN CARBONATE RESERVOIR

- FAULTS/SHEAR FRACTURES
- EXTENSION FRACTURES: JOINTS AND VEINS (HEALED FRACTURES)
- STYLOLITE (*PRESSURE SOLUTION*)
- VUGGY POROSITY (*SOLUTIONS ENLARGEMENT*)

FACIES – DEFORMATION - DIAGENESIS



bpmigas ExxonMobil



Gn. Gede

Gn. Guha

Gn. Bende

Gn. Bancana

Gn. Masigit

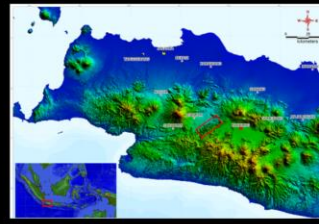
Gn. Paw

Gn. Pabeasan

Photo by : R.P.Koesoemadinata

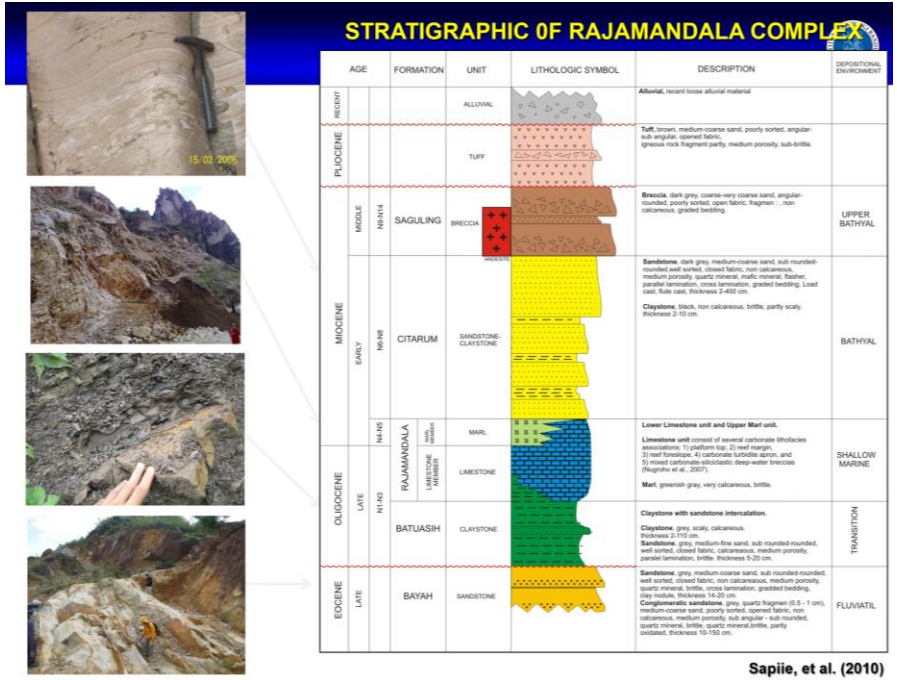
AERIAL PHOTO VIEW TO THE WES

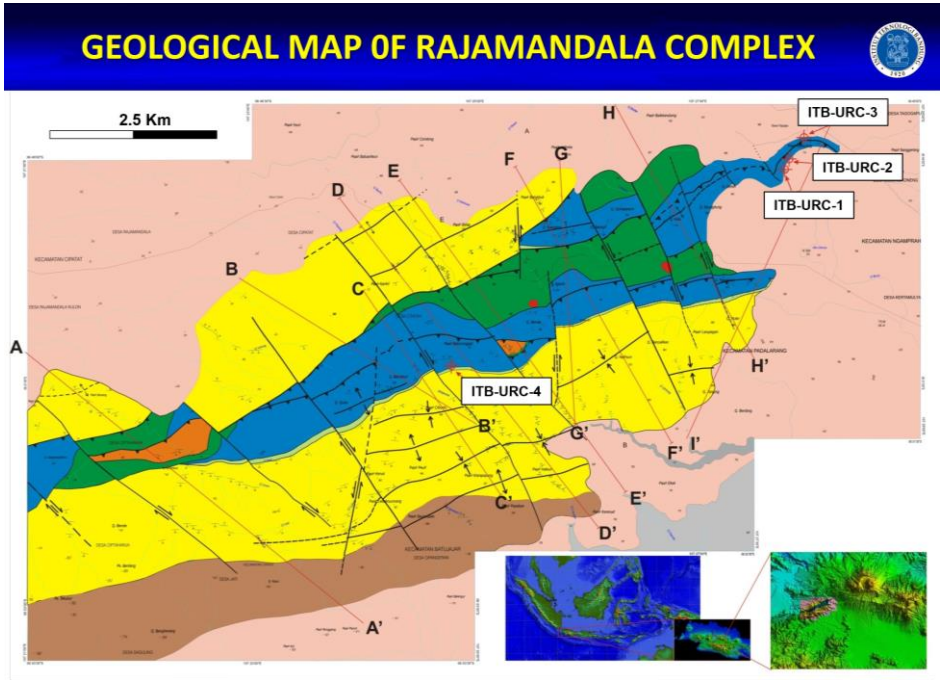
Gn. Gede



5 Km

GEOLOGI RAJAMANDALA CARBONATE COMPLEX

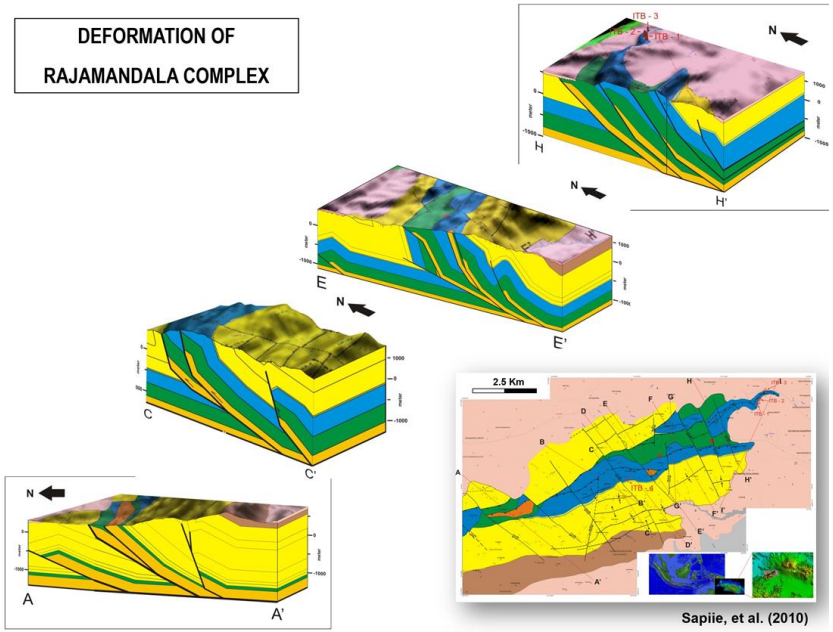




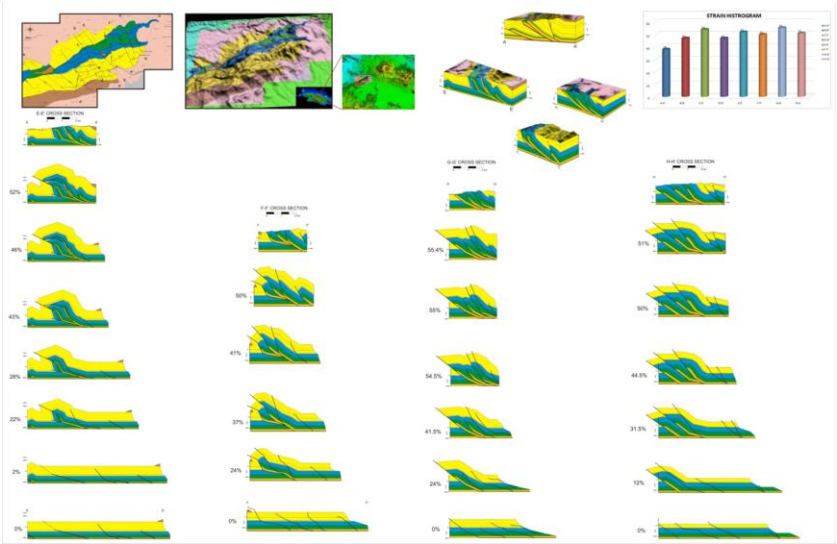
- FIELD GEOLOGICAL MAPPING
- 4 SHALLOW DRILLING SITE WITH CORE AND WIRELINE LOGS

DEFORMATION OF

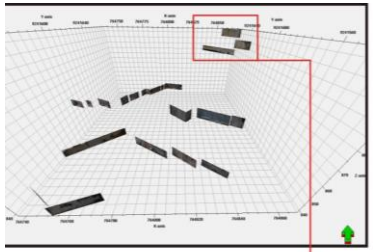
RAJAMANDALA COMPLEX

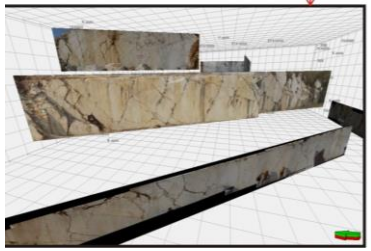


Sapiie, et al. (2010)



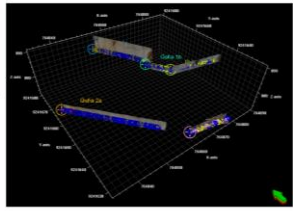
FRACTURES CHARACTERIZATIONS – *SCANLINE METHOD*





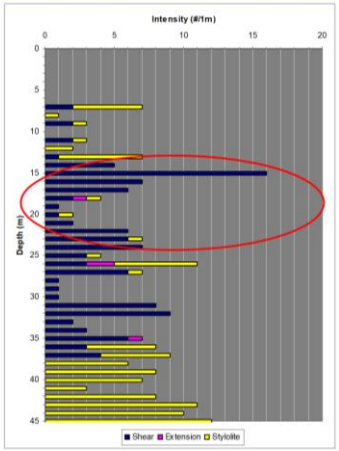
FRACTURE MODELING
PROPERTIES DISTRIBUTIONS

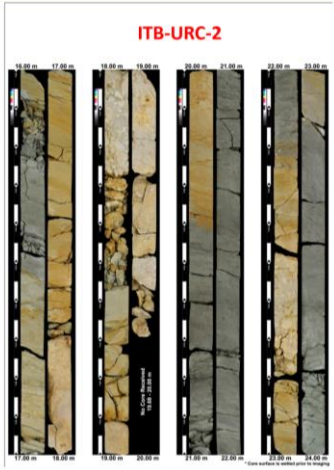
Fracture Characterization

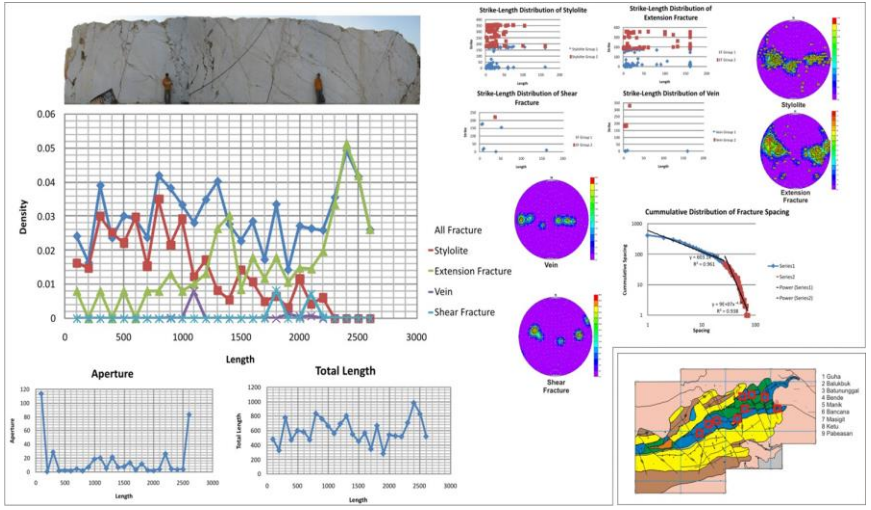


- BASED ON 2D SCANLINES
- STATIC MODELING

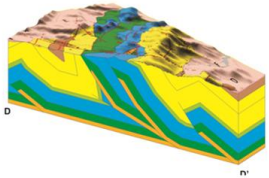
Sapiie, et al. (2011)

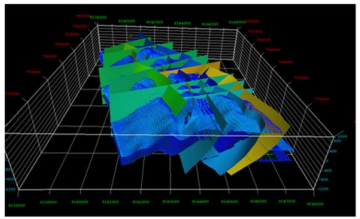




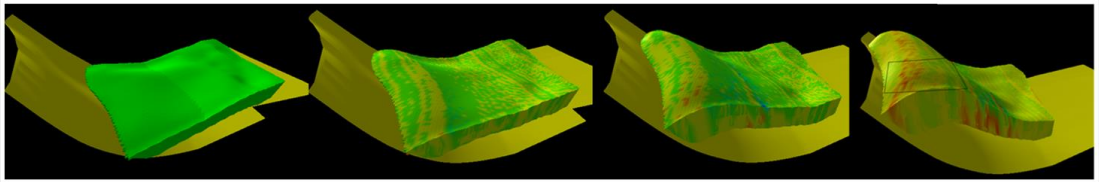


FIELD-BASED STRUCTURAL MODELING

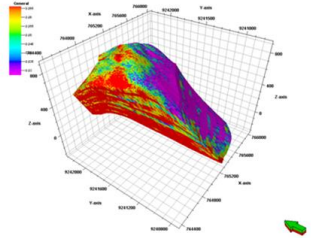




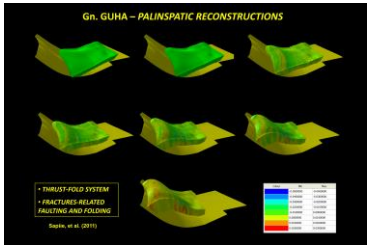
STRAIN MODELING/PALINSATIC RECONSTRUCTIONS

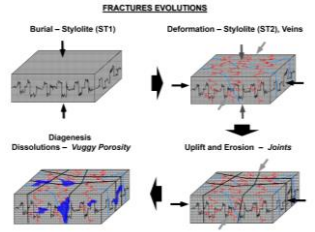


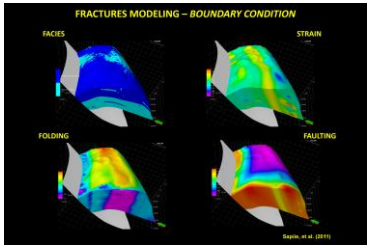
3D FRACTURES MODELING



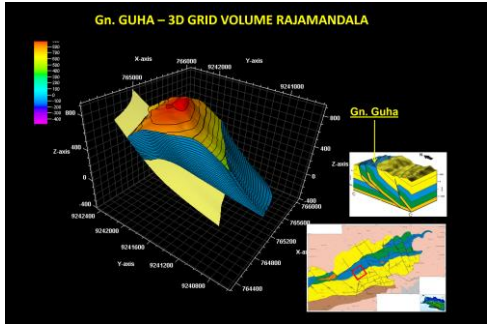
OUTCROP FRACTURES CHARACTERIZATION



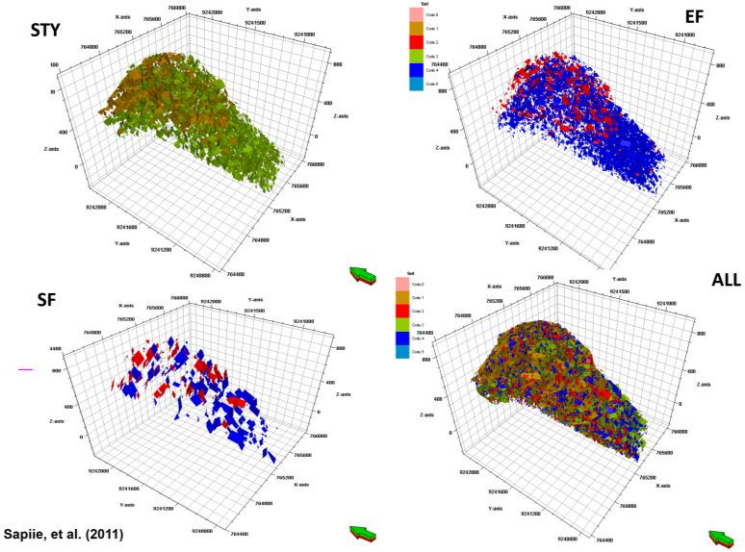




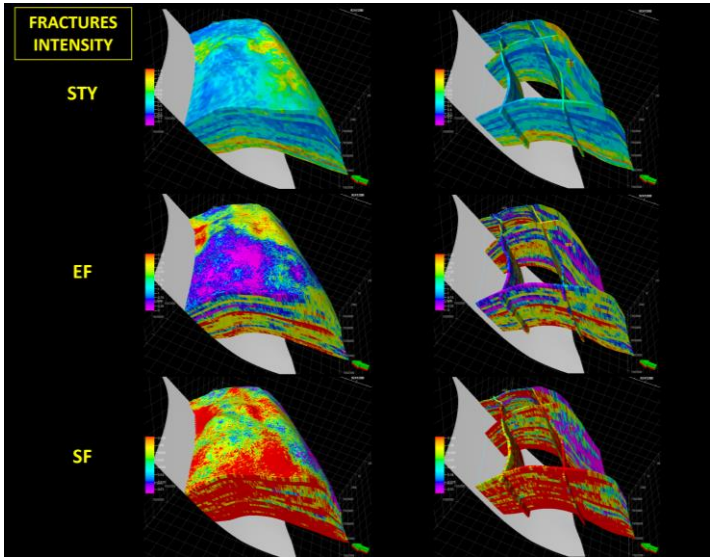
INTEGRASI DATA LAPANGAN DAN 3D MODELING

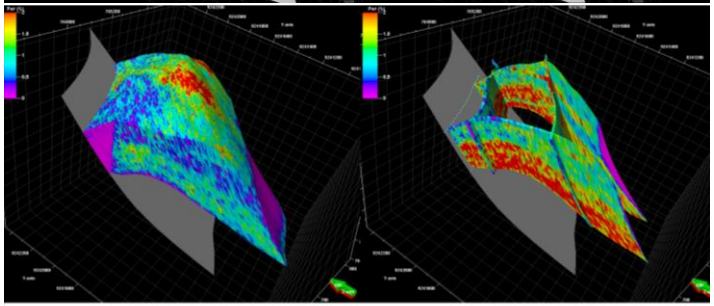


FRACTURES DISTRIBUTIONS – *DFN ALGORITHM*



Sapiie, et al. (2011)



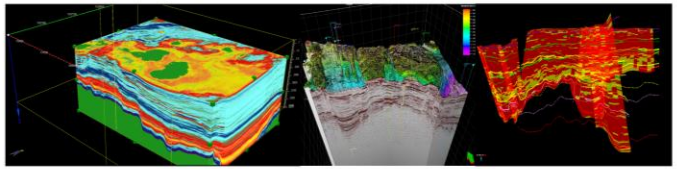


- DOMINANTLY CONTROL BY FACIES
- EXTENSION FRACTURES (LARGE APERTURE)
- DISSOLUTON OF STYLOLITES – *VUGGY POROSITY*
- RELATIONSHIP TO MAIN THRUST SYSTEM – *FOLDING*

FAULT-SEAL-ANALYSIS (FSA) IN CARBONATE ROCKS

Results of Using Different Petrophysical Approach in Controlling Fault Seal Analysis in Rengasdengklok Area, Northwest Java Basin, Indonesia

1) Benyamin Sapiie, Indra Gunawan, Risca Mustika Suciati, Eril Lanin,
2) Edward, Yosse Indra, Perdana Rakhmana Putra, Kharisma Winarswacesha, Mochamad Rasyid, Ricky Adi Wibowo



1. GEOLOGICAL ENGINEERING STUDI PROGRAM, ITB,INDONESIA
2. EXPLORATION DIVISION, PT. PERTAMINA, INDONESIA

PERTAMINA

JUNE 4 – MADRID, SPAIN
77th EAGE CONFERENCE & EXHIBITION 2015

FINAL REPORT
FSA RAJAMANDALA (FIELDWORK)
NOVEMBER 2016

FAULT SEAL ANALYSIS – RAJAMANDALA
2016

LAPI ITB PERTAMINA

STUDI PEMBORAN DANGKAL DAN CORING BATU GAMPING RAJAMANDALA UNTUK *ADVANCE FAULT SEAL ANALYSIS* RESERVOIR BATUGAMPING

Benyamin Sapiie, Astyka Pamumpuni
Febriana F. Rizky , Luthfi N. H. Saifudin

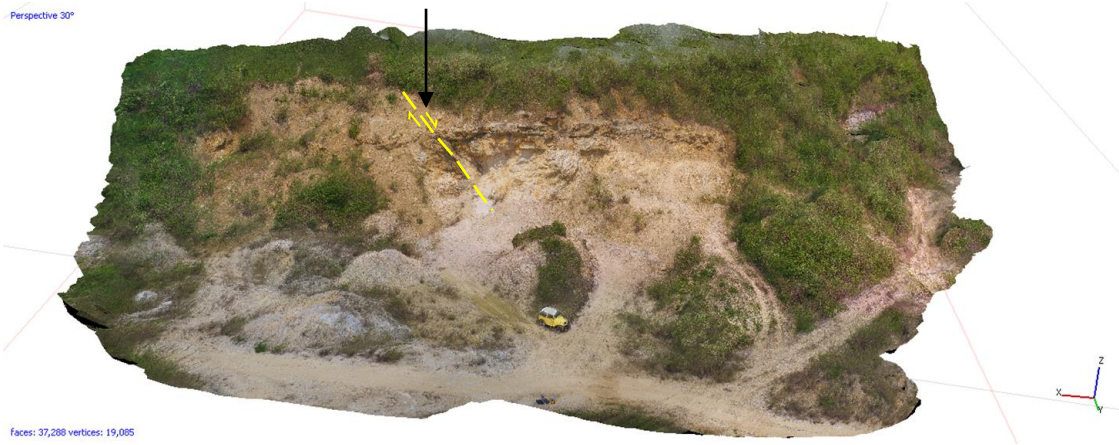
Jakarta - 18 Juli 2018

PERTAMINA LAPI ITB

OUTROPS LOCATION

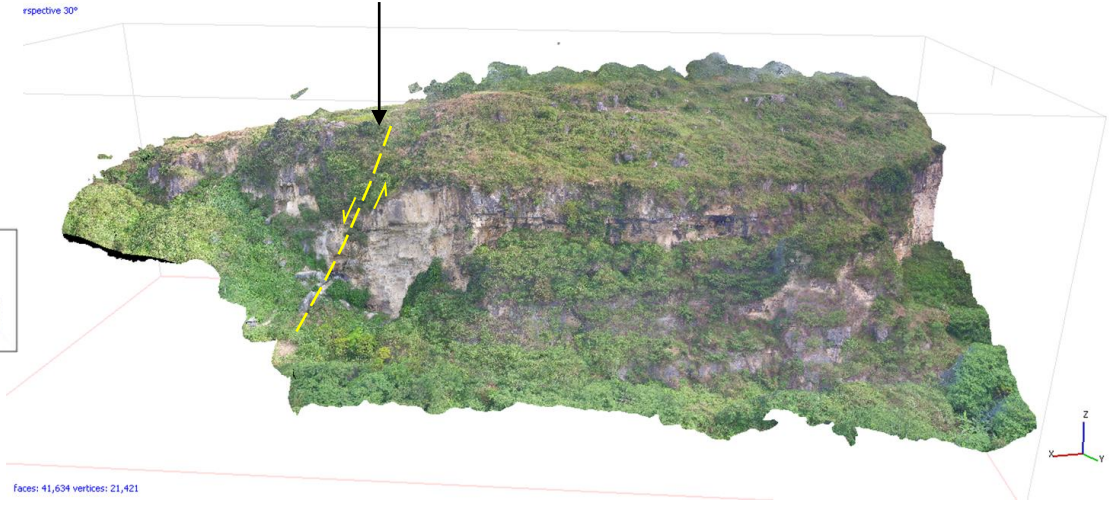
The outcrops are located in Padalarang, West Java

SESAR BATUNUNGGAL



SESAR GUHA

SESAR CIKAMUNING

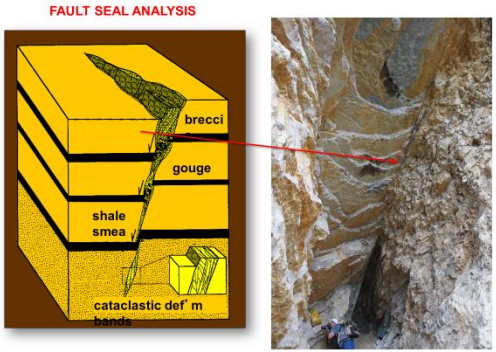


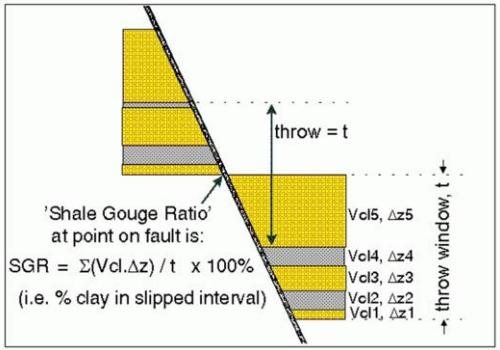
- FIELDWORK; DAMAGE ZONE, GOUGE
- SHALLOW DRILLING
- DEEP DRILLING
- XRD AND PETROGRAPHY

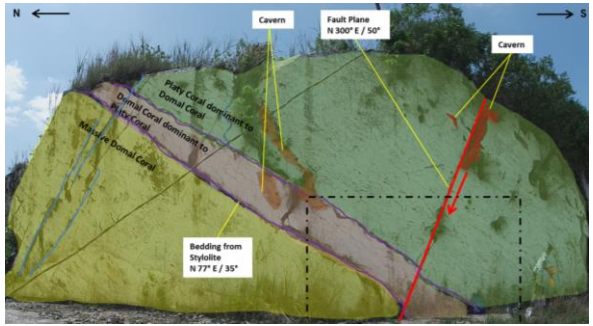
TUJUAN STUDI

- Kapasitas sekatan berdasarkan SGR?
- Penentuan nilai SGR di batugamping?
- Vcl (total lempung dalam batuan)
- Besaran Vcl di Batugamping ?
- Kontrol fasies vs. Throw?
- Efek diagenesa?

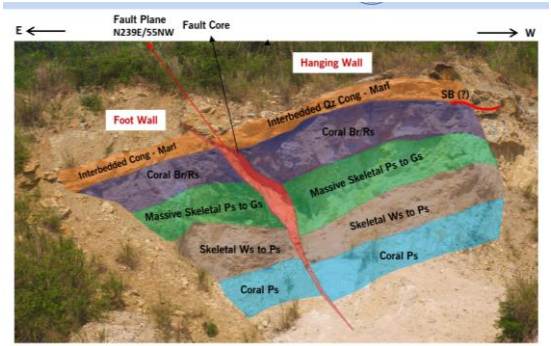
SGR = Shale Gouge Ratio (Yielding et al. 1999)



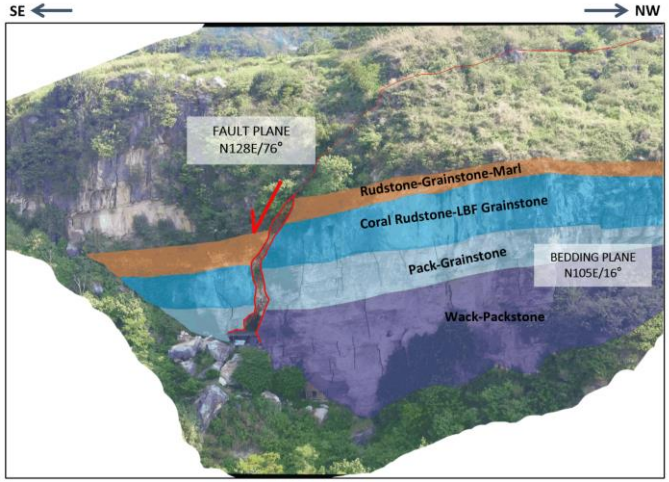




FAULT THROW: 10-15 CM



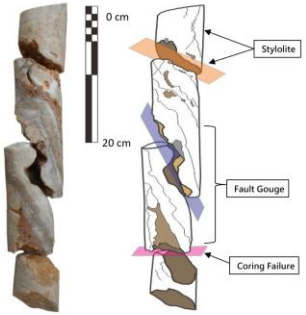
FAULT THROW: 80 -250 CM



FAULT THROW: ~ 6 M

CORE DAN LOG DATA

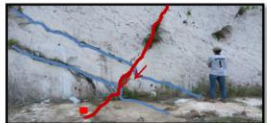
GUHA – CORE SAMPLE



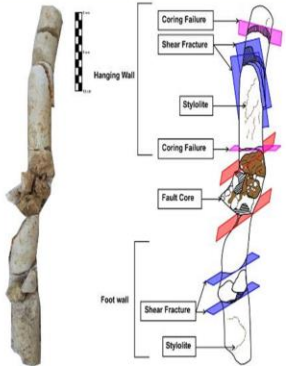
Coordinate : 764973 E / 9241757 S
Bearing and Azimuth : 61°, N 150° E
Sample Code Name : **GHG 1**
Length : 40cm
Lithology : Skeletal Packstone to Grainstone (SPG)
Facies : Massive Domal Coral
Description :

GHG 1
FAULT CORE

- SPG, beige to light brown, mainly consist of coral fragment, skeletal grain, red algae fragment. Matrix packstone consist of red algae and skeletal fragment.
- Found stylolite (ST1 dominant & ST2) filled mostly by iron oxide, much dissolved in vuggy structure in fault gouge .
- 9cm fault gouge, recrystallized with calcite and clay mineral.



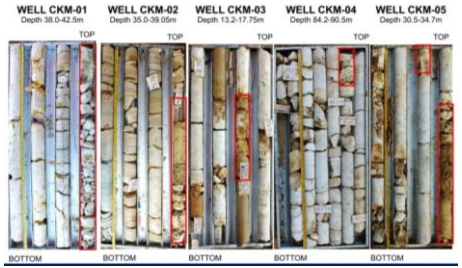
BATUNUNGGAL – CORE SAMPLE

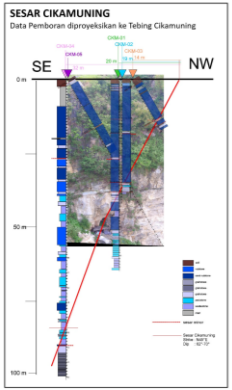


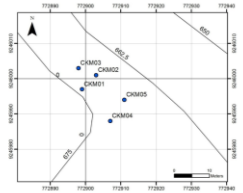
Coordinate : 766408 E ; 9242576 S
Bearing and Azimuth : 45°, N 175° E
Sample Code Name : **BTNGL CORE-2**
Length : 47 cm
Lithology : Limestone (Wacke-Packstone)
Facies : Skeletal Ws to Ps

BTNGL CORE-2
FAULT CORE

Description :
- [Hanging Wall] Packstone, light brown/bouge to white, fine-medium grain, grain suppoted, LBF (intensive), skeletal grain (intensive), spine echinoid, fingering coral clast, black mineral, solution seam.
Stylolite 1, parallel bedding, Stylolite 2 perpendicular bedding. Some of stylolites filled by non oxide
- [Foot Wall] Wackestone, light brown, fine grain, mud supported, skeletal, mud algae, spine echinoid replaced by algae, rhodolith (?).
Stylolite abundant, veinlet, striation

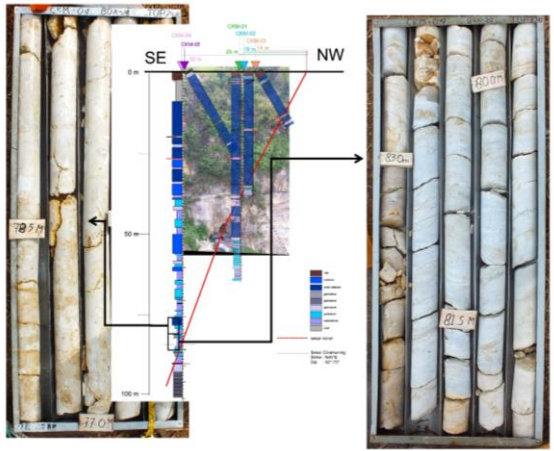




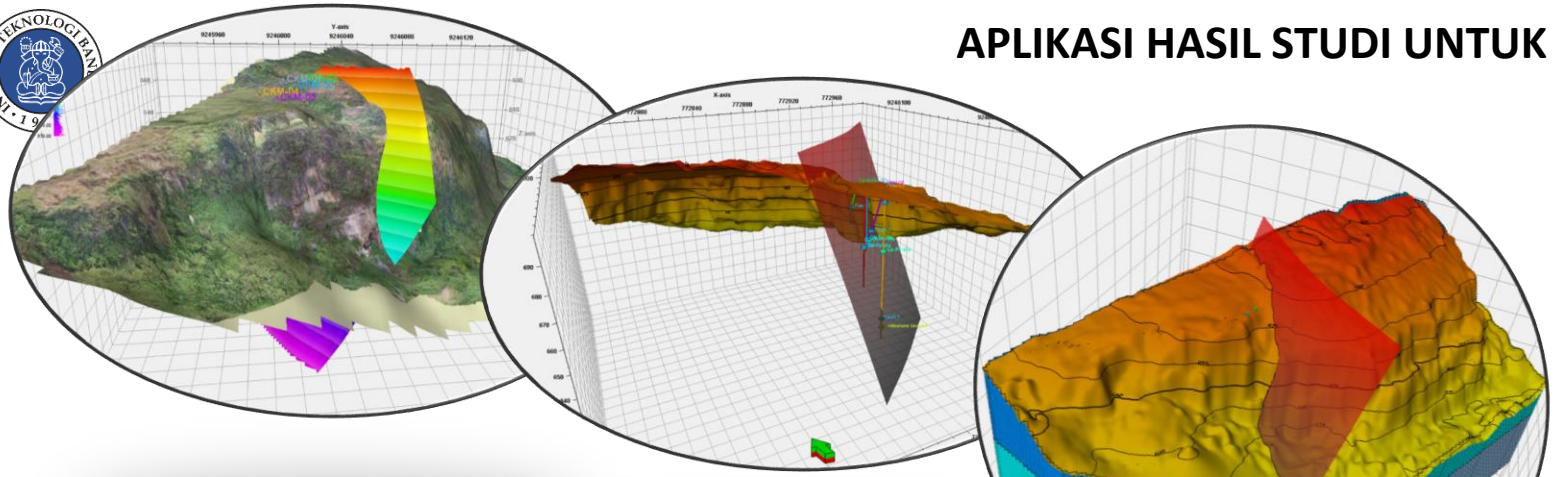


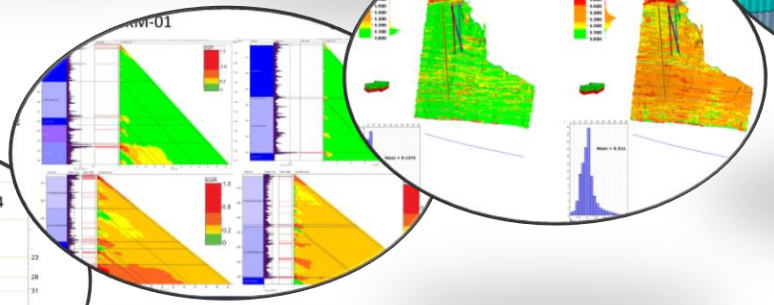
3 sumur vertikal dan 2 sumur miring

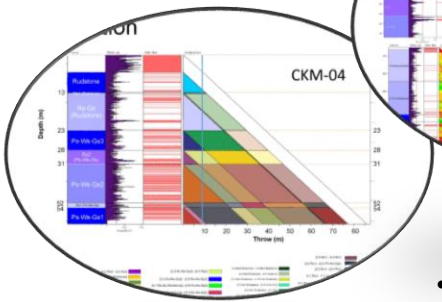
- CKM-01 Lokasi: 772899, 9245997
  Kedalaman: 65.0 m (12 hari)
- CKM-02 Lokasi: 772903, 9246001
  Kedalaman: 39.0 m (7 hari)
- CKM-03 Lokasi: 772898, 9246003,
  Deviasi: 60°, N320°E
  Kedalaman: 19.5 m, MD (3 hari)
- CKM-04 Lokasi: 772907, 9245988,
  Kedalaman: 99.5 m (13 hari)
- CKM-05 Lokasi: 772911, 9245994,
  Deviasi: 60°, N320°E
  Kedalaman: 45.2 m, MD (4 hari)

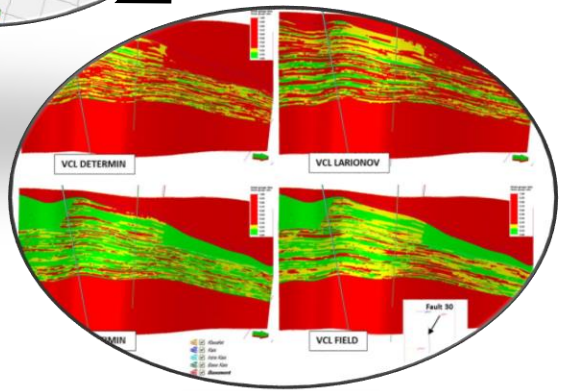


APLIKASI HASIL STUDI UNTUK STUDI KASUS





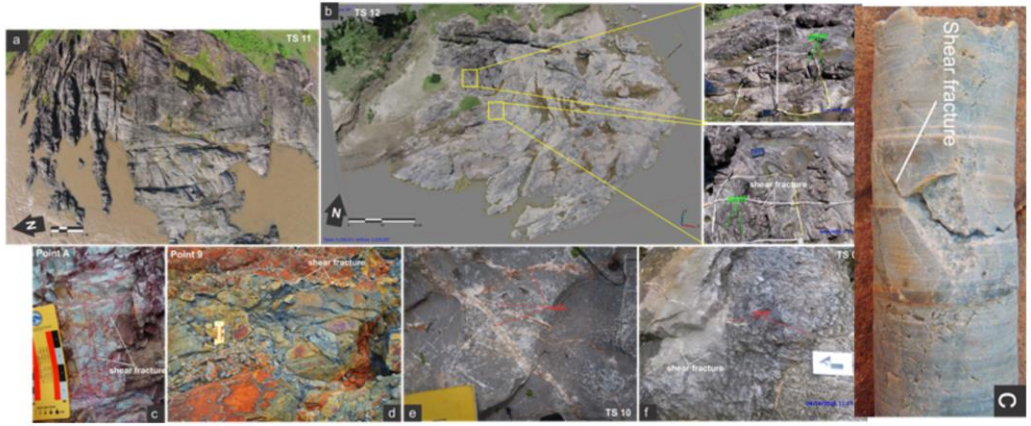




- **KOREKSI PARAMETER DAN METODA SGR DI BATU GAMPING**

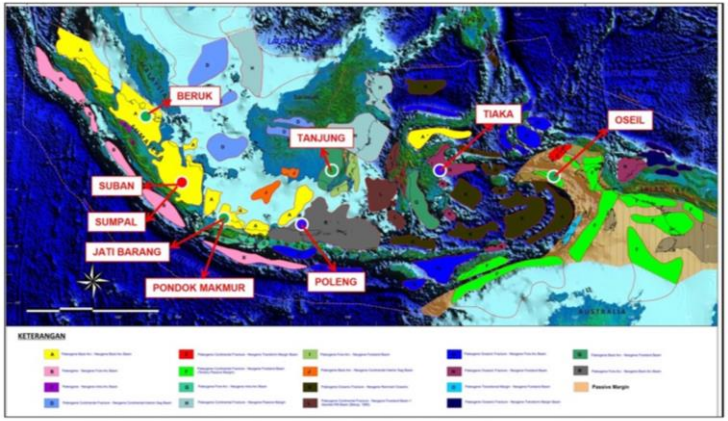
DEVELOPMENT METHOD OF UNDERSTANDING AND EXPLORING NATURALLY FRACTURED RESERVOIR

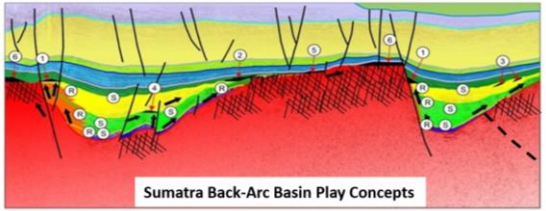
Benyamin Sapiie, Alfend Rudyawan, Indra Gunawan, Chalid I. Abdullah



HAGI-IAGI-IAFMI-IATMI

JOINT CONVENTION YOGYAKARTA
25-28 NOVEMBER 2019





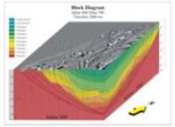
Sapiie et al. (2017)

- ✓ Uncertain Play
- ✓ Under Explore
- ✓ No clear concept

NFR

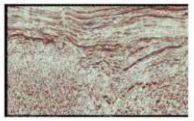
REGIONAL TECTONICS CONCEPT

- Fractures Attributes
- Fractures Behaviors
- Fractal/Scaling

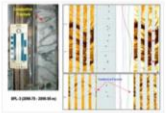


Modeling

Structural Geology Concepts



2D/3D Seismic



Well Bore Data

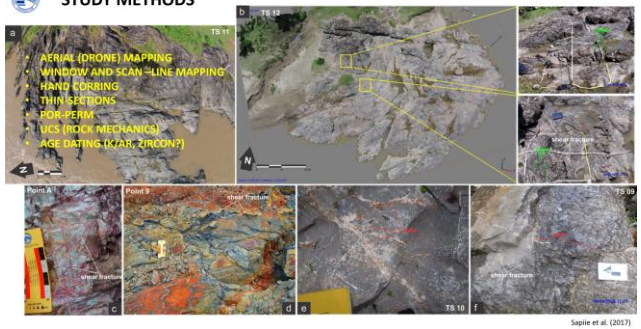
- Fractures Attitudes
- Fractures Intensity/Density
- Fractures Apertures
- DFN Approach
- Geomechanics (SV, SHMAX, SHMIN)

- Structural/Fractures History
- Palinspatic Reconstructions

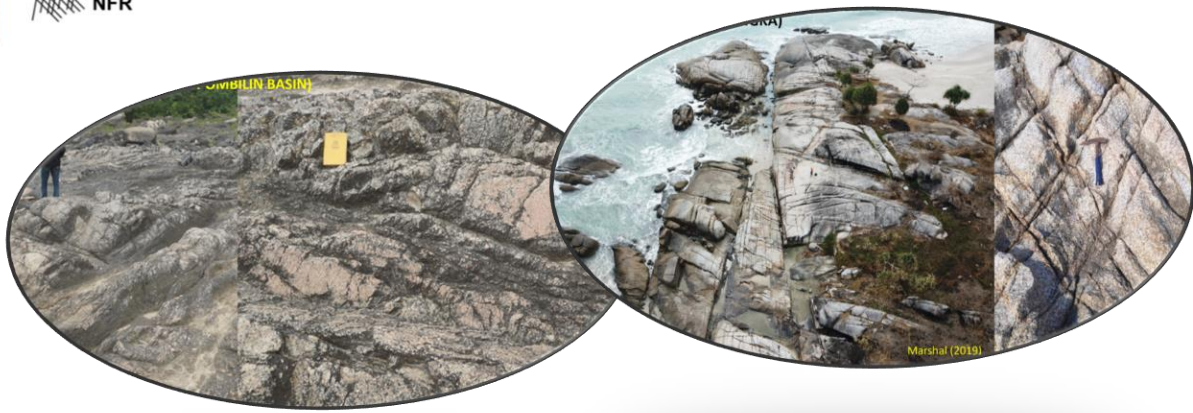
EXPLORATION CONCEPT OF NFR

Sapiie et al. (2006-2018)

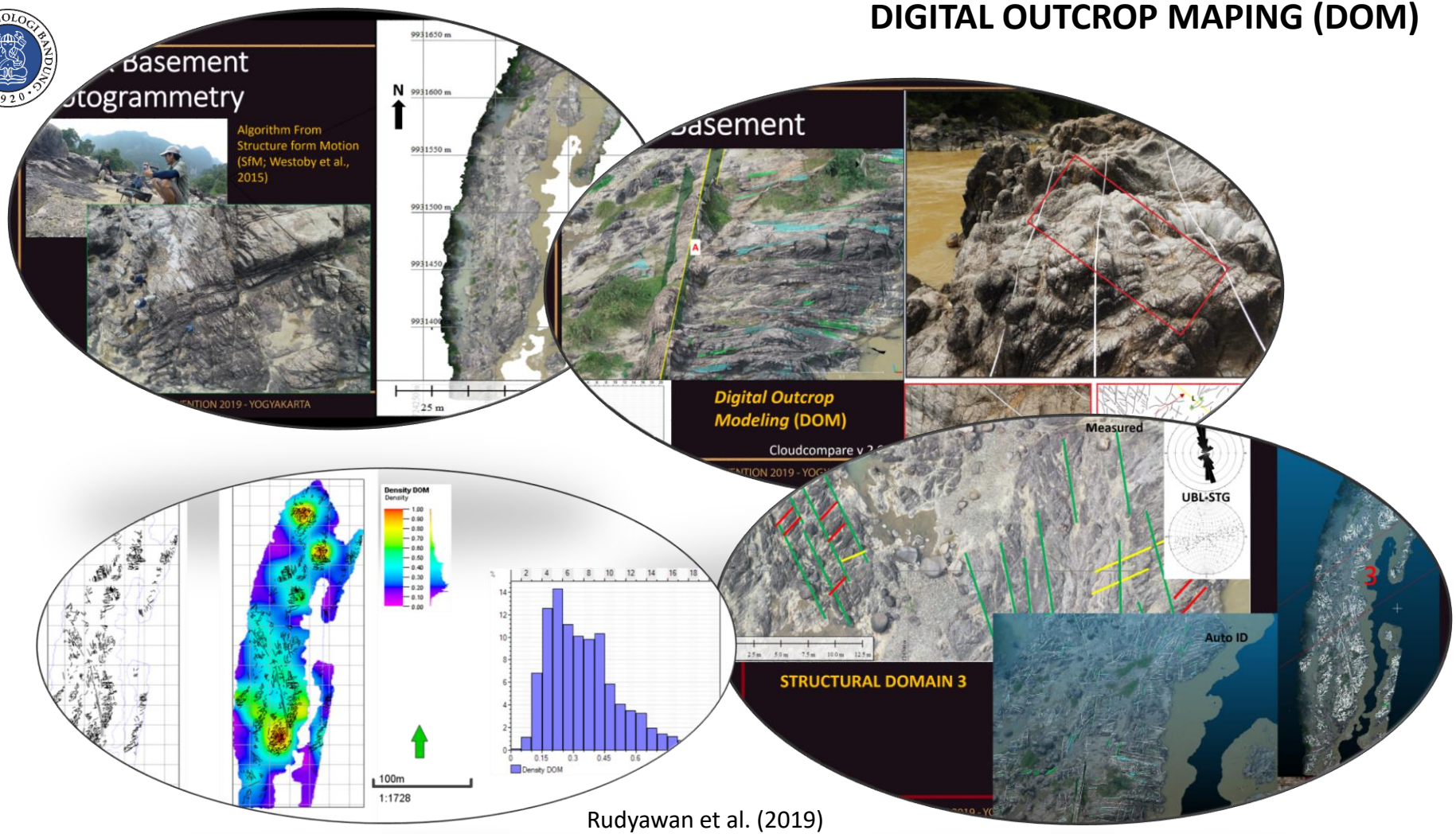
STUDY METHODS



Sapiie et al. (2017)

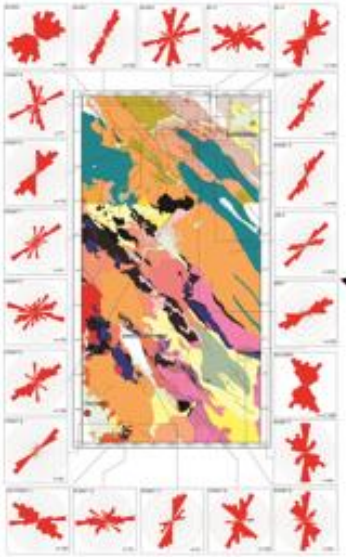


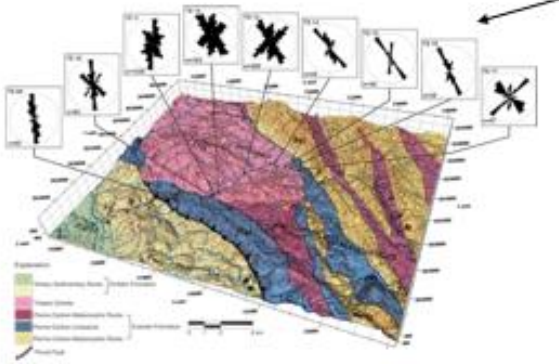
DIGITAL OUTCROP MAPING (DOM)

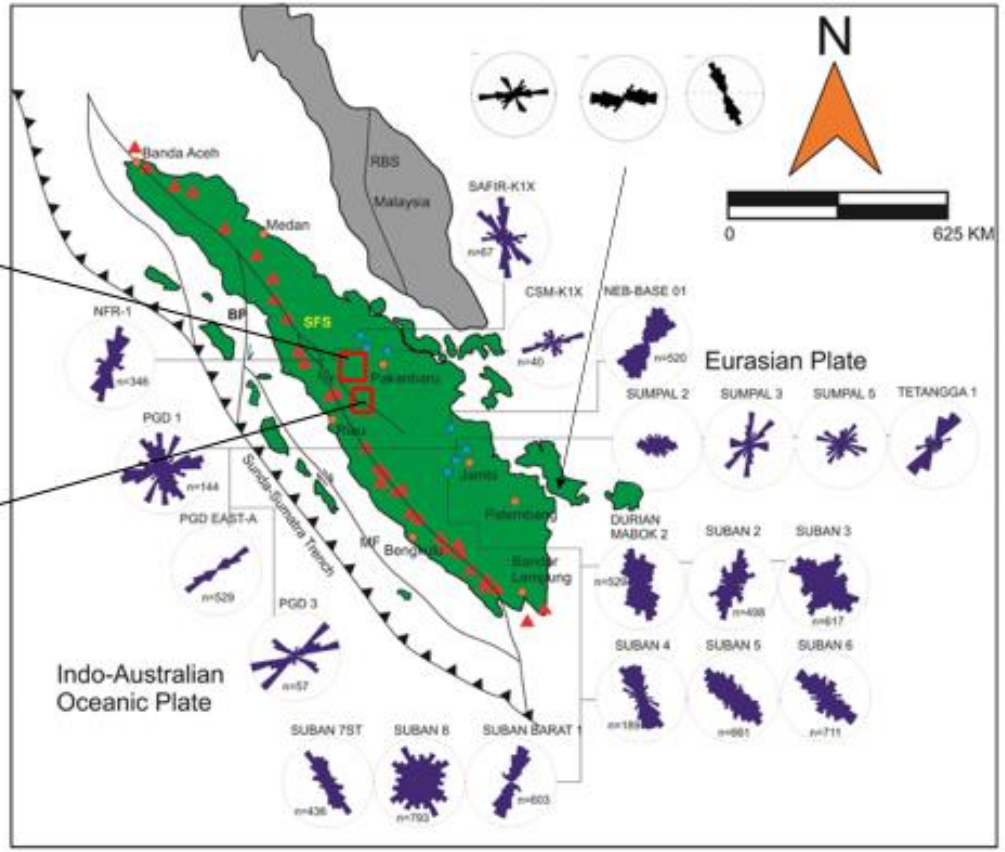


Rudyawan et al. (2019)

FRACTURES PATTERN OF BASEMENT ROCKS SUMATRA

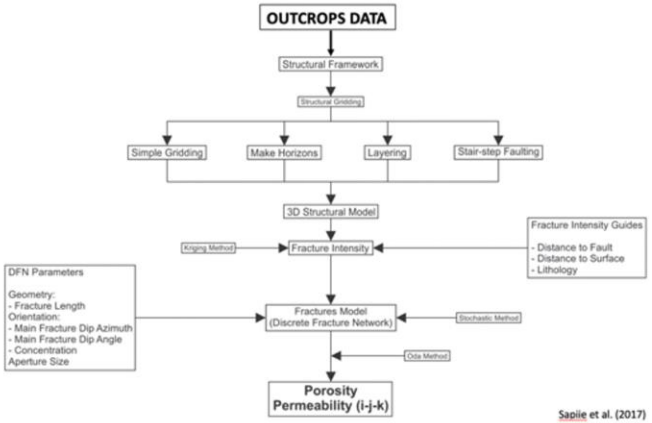




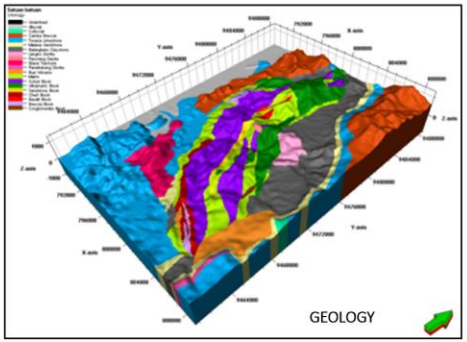


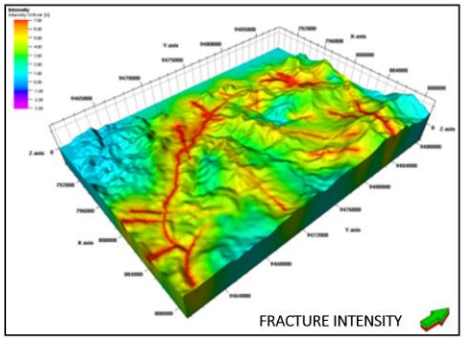
FROM OUTCROP TO SUBSURFACE

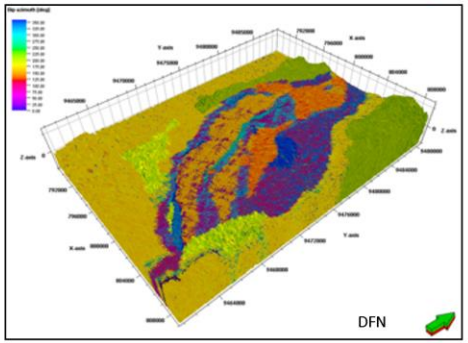
3D FRACTURES MODELING

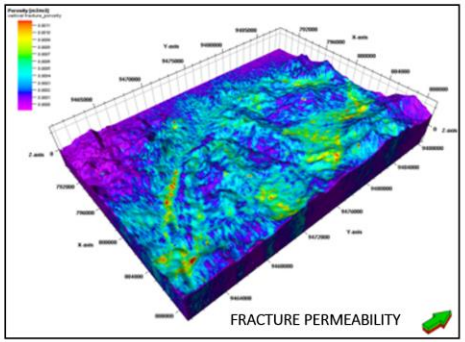


Sapiie et al. (2017)









Sapiie et al. (2017)

…….TO BE CONTINUE….. ON GOING RESEARCH …….

KESIMPULAN

- PERAN GEOLOGI STRUKTUR DI BERBAGAI BIDANG DAN APLIKASI (..*EVERYTHING ABOUT STRUCTURES*..)
- PENTING MEMISAHKAN PENGERTIAN ***STRESS*** DAN ***STRAIN***
- DEFORMASI BATUAN SEDIMEN MEMENUHI HUKUM COULOMB (*PORO-ELASTIC RHEOLOGY*)
- INTERPRETASI MEKANISME SESAR MEMERLUKAN PENGERTIAN BIDANG LEMAH (*DETACHMENT)*
- PENELITIAN MASADEPAN KONSETRASI PADA PENGERTIAN, MEKANISME DAN KONTROL PERKEMBANGAN REKAHAN TERUTAMA SESAR

Structural geologists realize that the true meaning of the scene is God giving man the gift of wisdom about fractures.

THE CREATION of MAN BY MICHELANGELO


TERIMA KASIH