[ePS]Yinggehai (Red River) Strike-Slip Fault Zone Displacements and the Tectonic Evolution of the Yinggehai Basin, South China Sea - Insights from Numerical Simulations*

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Abstract

The Yinggehai-Red River (Song Hong) Basin extends from the northern territory of Vietnam southeastward to the South China Sea and is the largest Tertiary sedimentary basin in Southeast Asia. Its formation was mainly influenced by Tibet crust extrusion to the southeast as a consequence of the India-Eurasian collision about 32 Ma ago. The Red River Basin is considered as having high potential as an oil and gas basin, however the tectonic evolution of the basin with regards to hydrocarbon generation, migration and accumulation remains controversial.

In this research, which was based on the interpretation results of 10,000-km of 2D regional seismic profiles tied with well data to study the geological history of the basin, we have set up a numerical model to reconstruct the formation of the basin during regional tectonic evolution. The simulated results showed very clearly two tectonic phases of basin formation that are consistent with two phases of strike-slip displacements along the Red River fault zone. They are: 1) compressional and left-lateral strike-slip faulting; 2) extensional prior right-lateral strike-slip faulting. The simulation results also showed stressed field distributions along the Red River fault that are in accordance with observations. These results are very important in understanding the hydrocarbon accumulation and migration/secondary migration in the Yinggehai (Red River) Basin for recent discoveries.

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Matsuoka, T., and T. Miyoshi, 2004, Parallel computing of fluid flow in porous rock by 3D lattice Boltzmann method: Butsuri-Tansa, v. 57/6, p. 697-708.

Métivier, F., 1996, Sedimentary volumes and balances Masasi in Asia during the Cenozoic (*Volumes sédimentaires et bilans de masas en Asie pendant le Cénozoïque*): Paris VII, Paris. 255 p.

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Yinggehai (Red River) Strike-slip Fault Zone Displacements and the Tectonic Evolution of the Yinggehai Basin, South China Sea, Insights from Numerical Simulation

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Distinct Element Method (DEM)

- It's a member of Discrete Element Method by Cundall & Strack (1971). Developed since 1979
- Using circular particles to study the rock mass behaviour: velocities, stress fields, displacement in the fields of civil engineering, soil mechanics, water flow engineering (PFC^{2D} & PFC^{3D})
- It can be applied in modelling fractured and fault zones more potentially than other continuum assumption
- It was applied also in studying of tectonic evolution (Matsuoka et al, 2004; Huyen et al, 2005)

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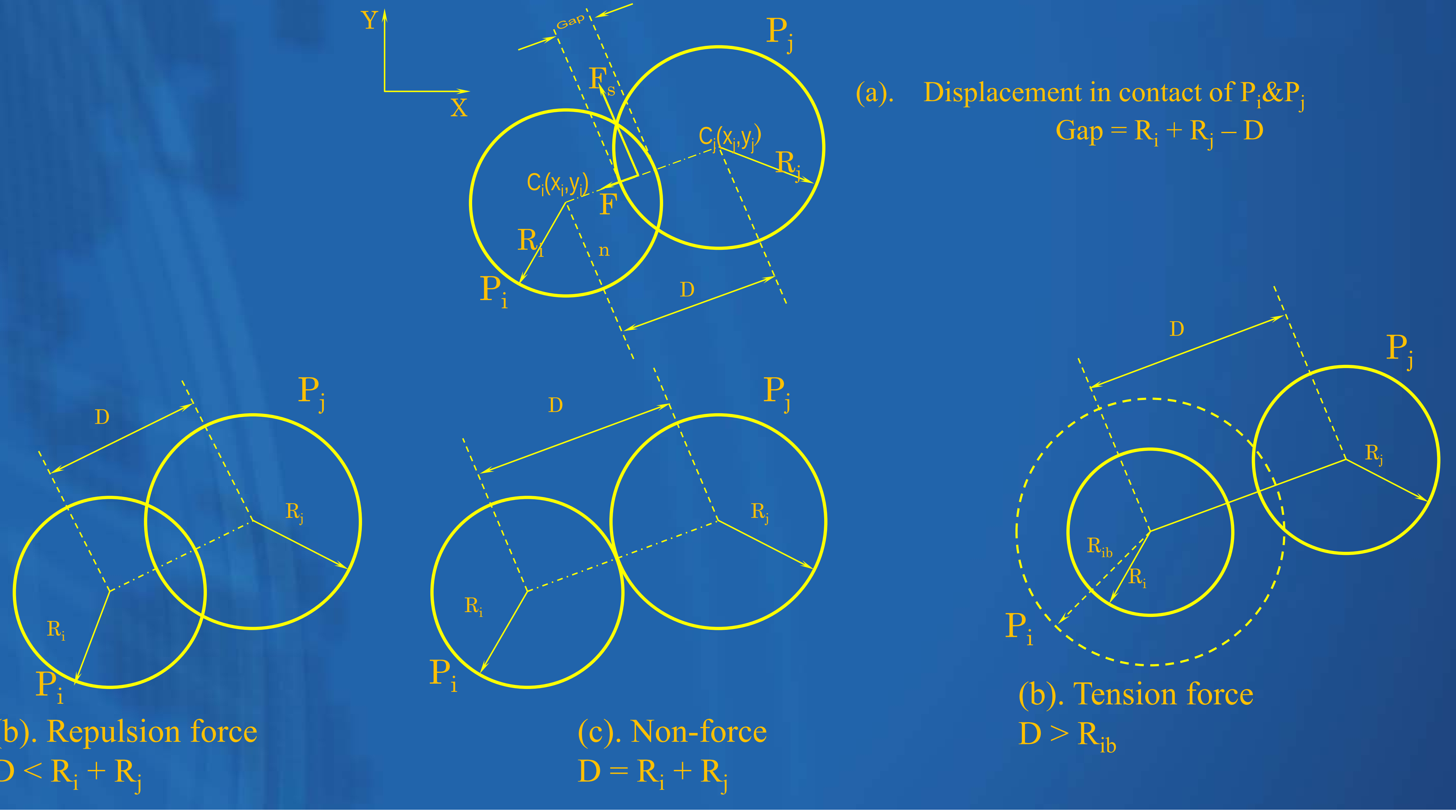
Particle Interactions



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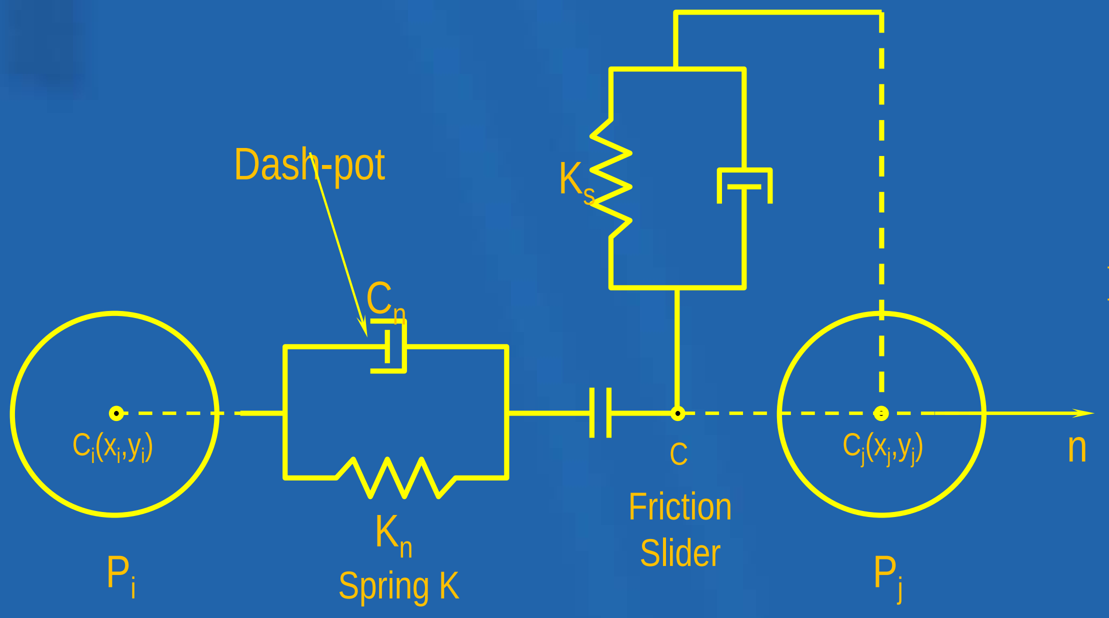
Force Displacements at the Contacts



Spring dash-pot model of a contact point C

- Displacement Force:
- Interactive Forces:
- The normal & tangential forces
- Condition:
- ✓ Motions of particles correspond to the 2nd Newtonian law

$$F_{ij} = k.gap.e_{ij}$$

$$F_{ji} = -F_{ij}$$

$$F_n(t+\Delta t) = F_n(t) + \Delta F_n(t)$$

$$F_s(t+\Delta t) = F_s(t) + \Delta F_s(t)$$

$$F_s < \mu.F_n$$

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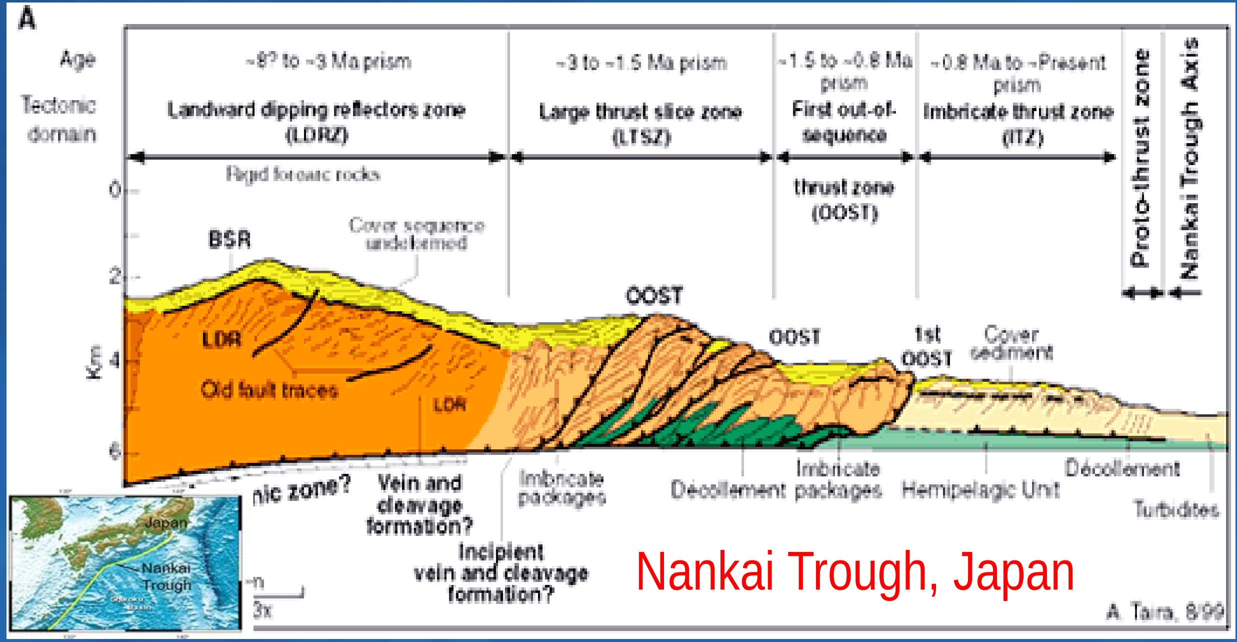
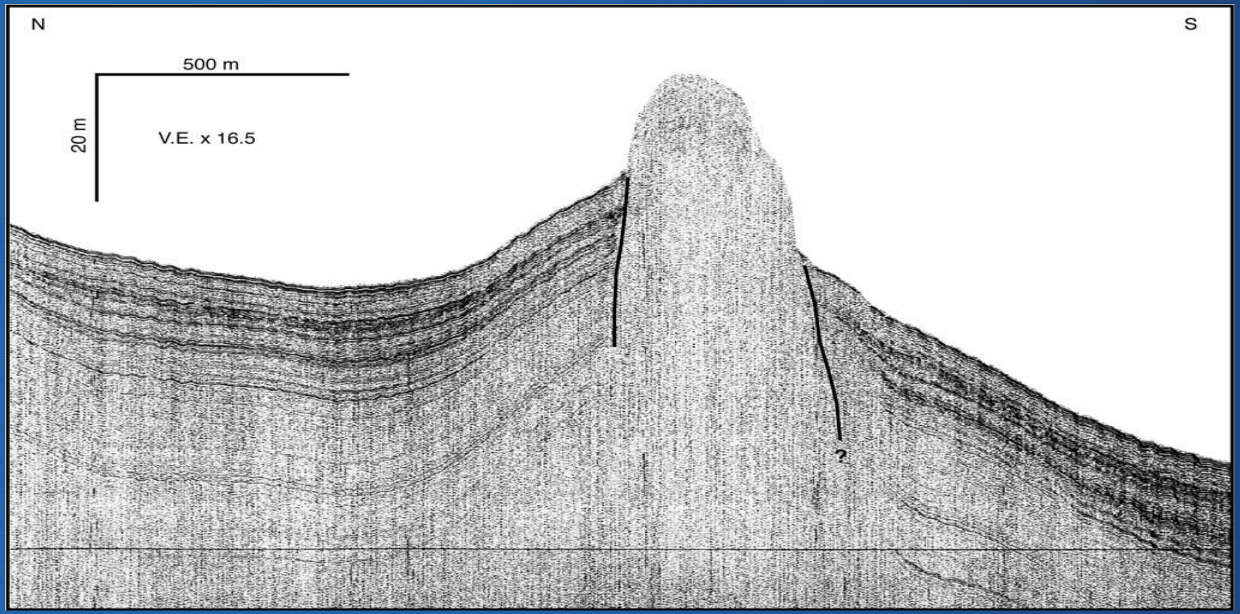
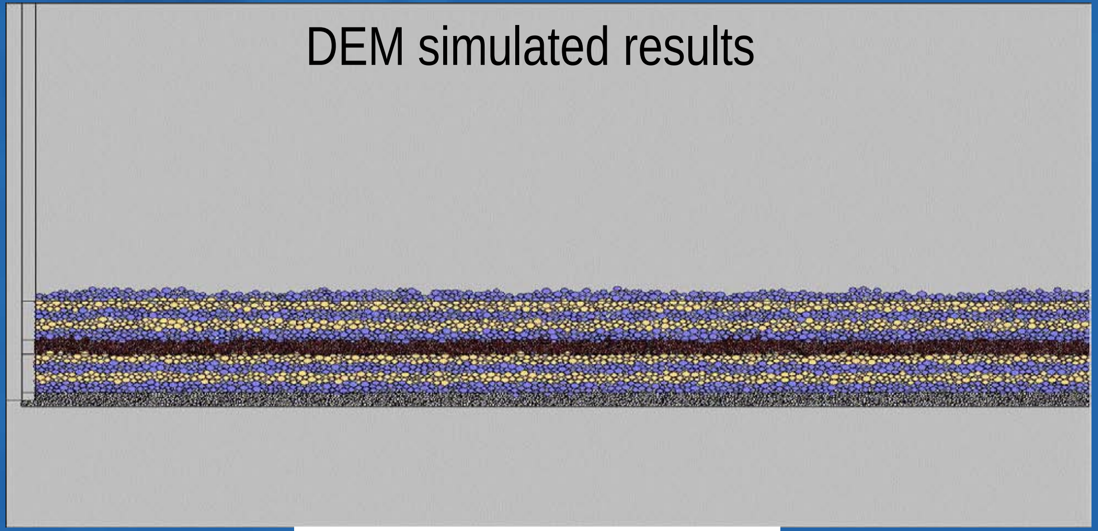
Applications of DEM in Geology



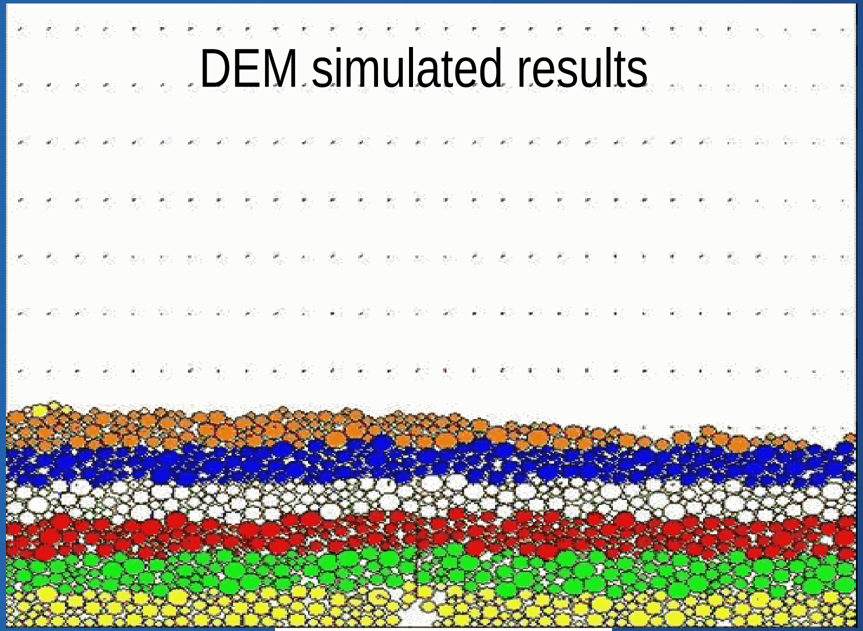
Nankai Trough, Japan



Mud volcanoes in Santa Monica Basin, offshore Southern California
(Normark & Piper, 1998)



(Matsuoka et al, 2004)



Bui et al., 2007

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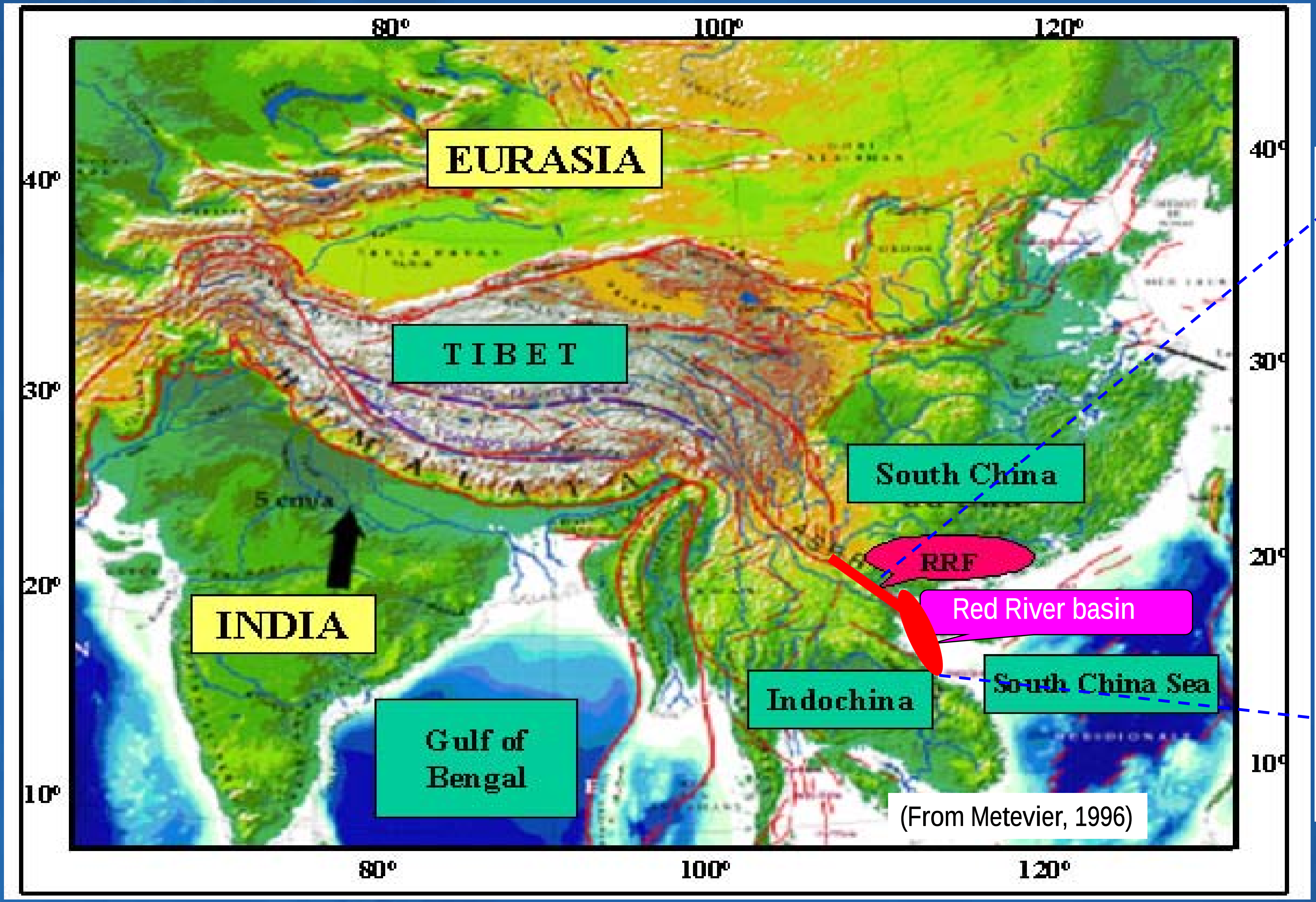
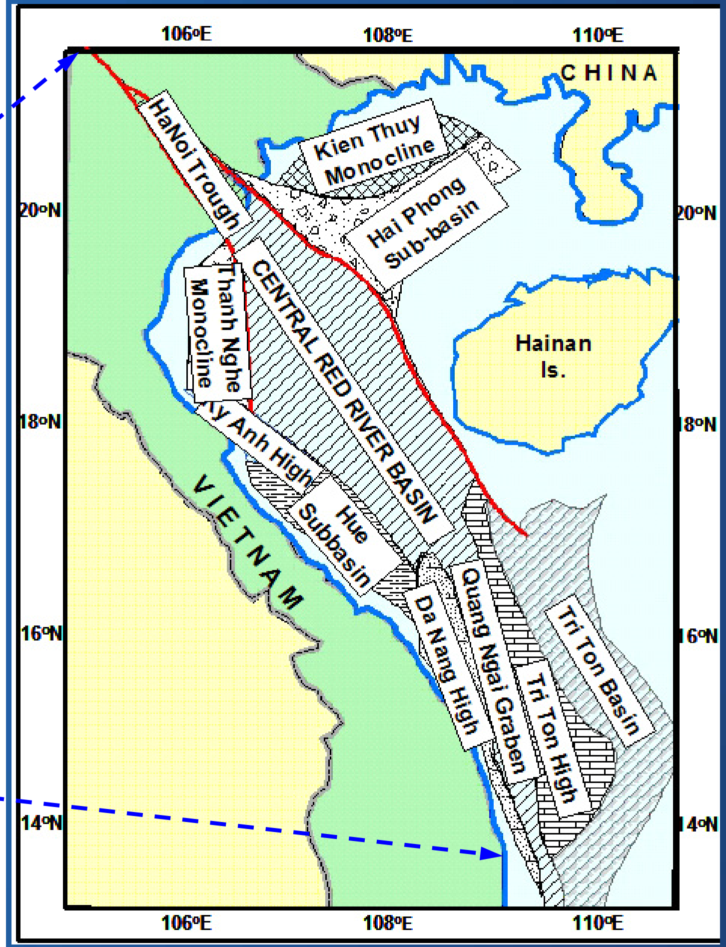
Present deformation zone of India-Eurasia Collision



(From Metevier, 1996)

Structure framework of the Red River basin



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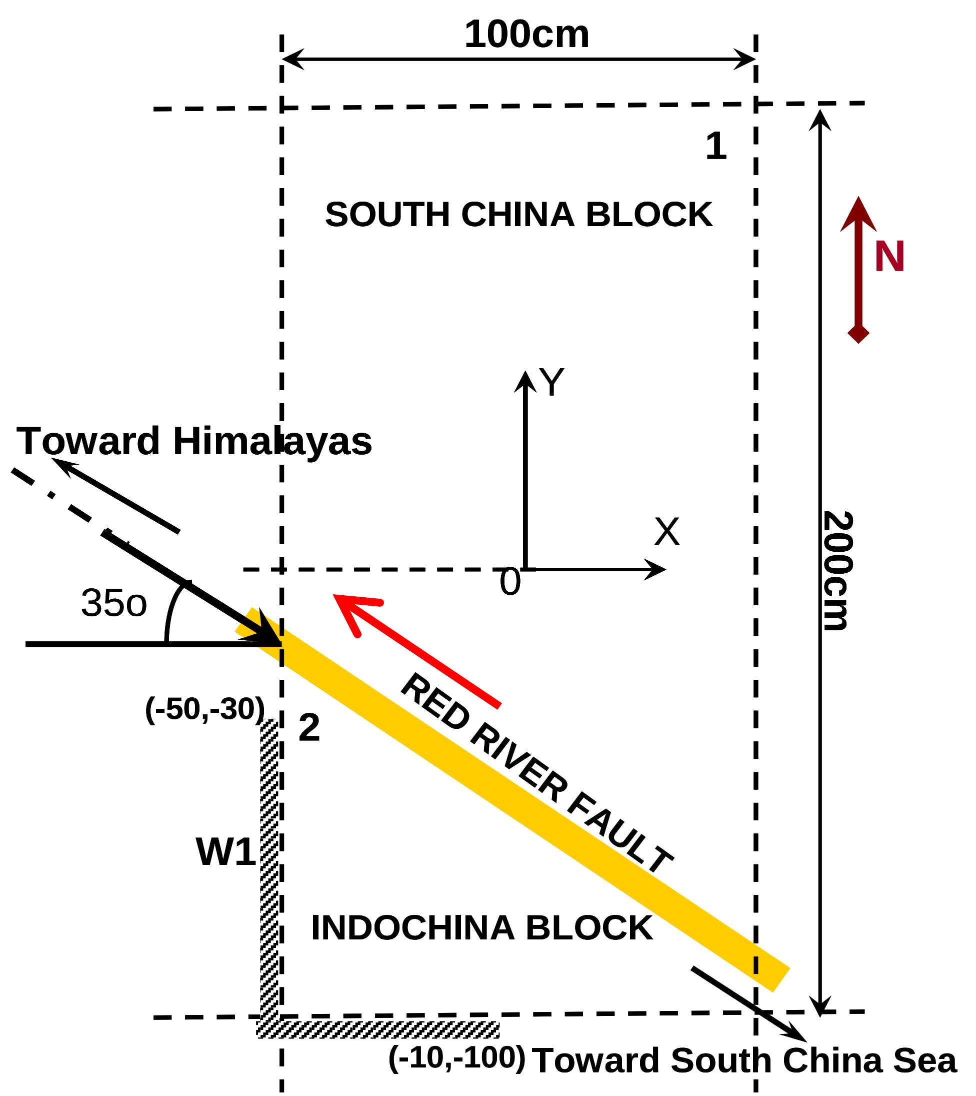
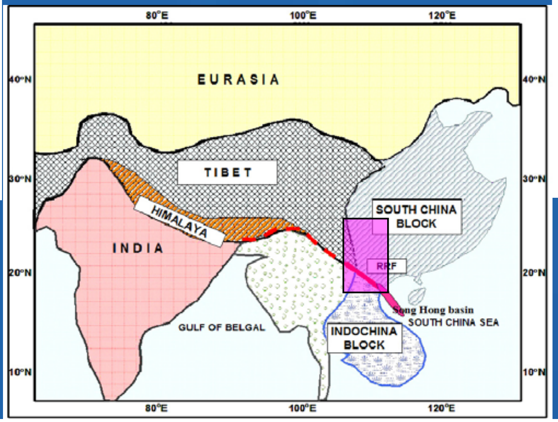
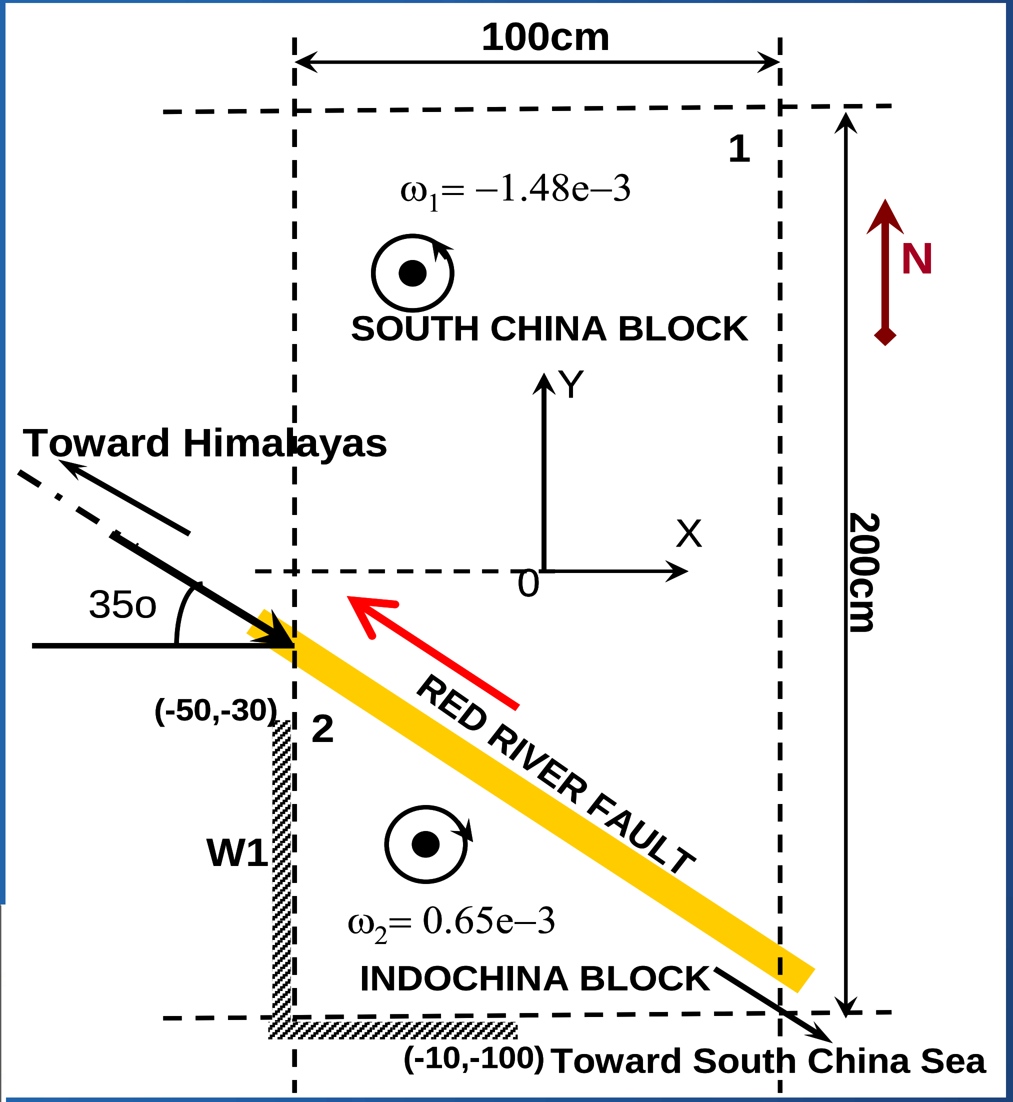
DEM Simulation for Strike-slip Fault Displacements (1)



Model 1: Without Block Rotation





Model 2: With Block Rotations

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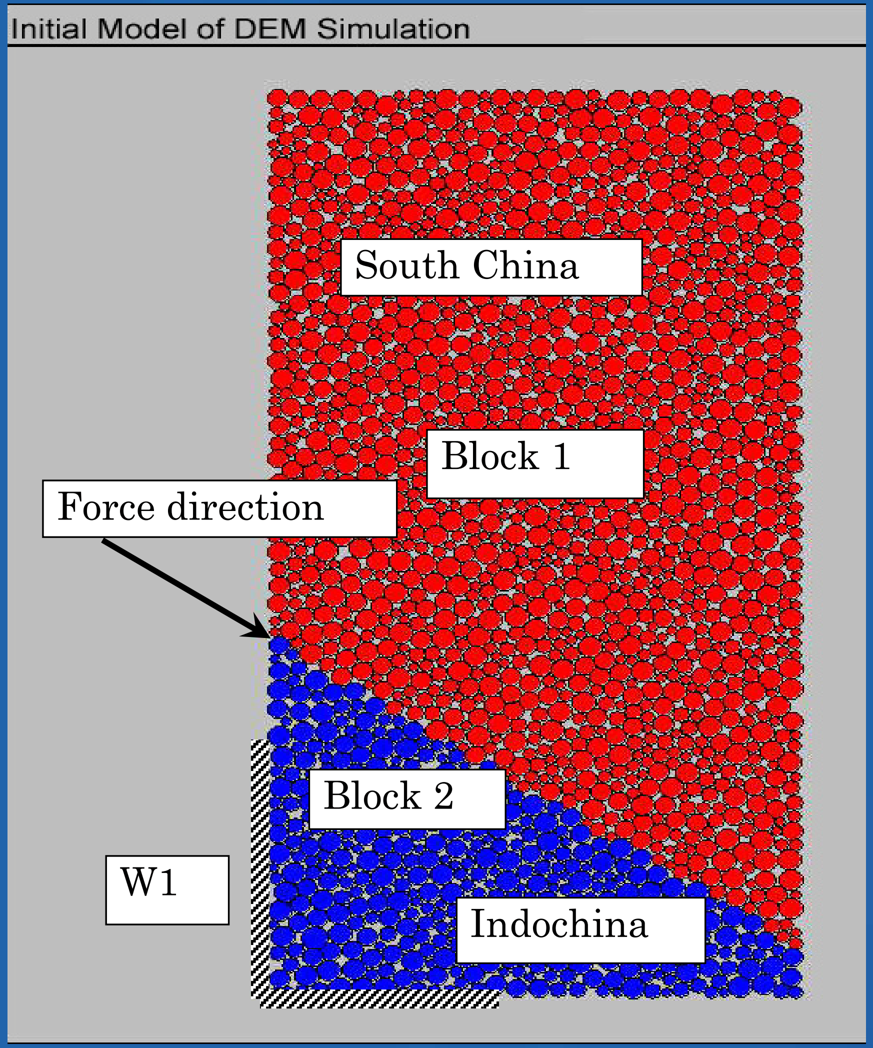
DEM Simulation for Strike-slip Fault Displacements (2)



The initial model of particle assembly used in DEM simulation

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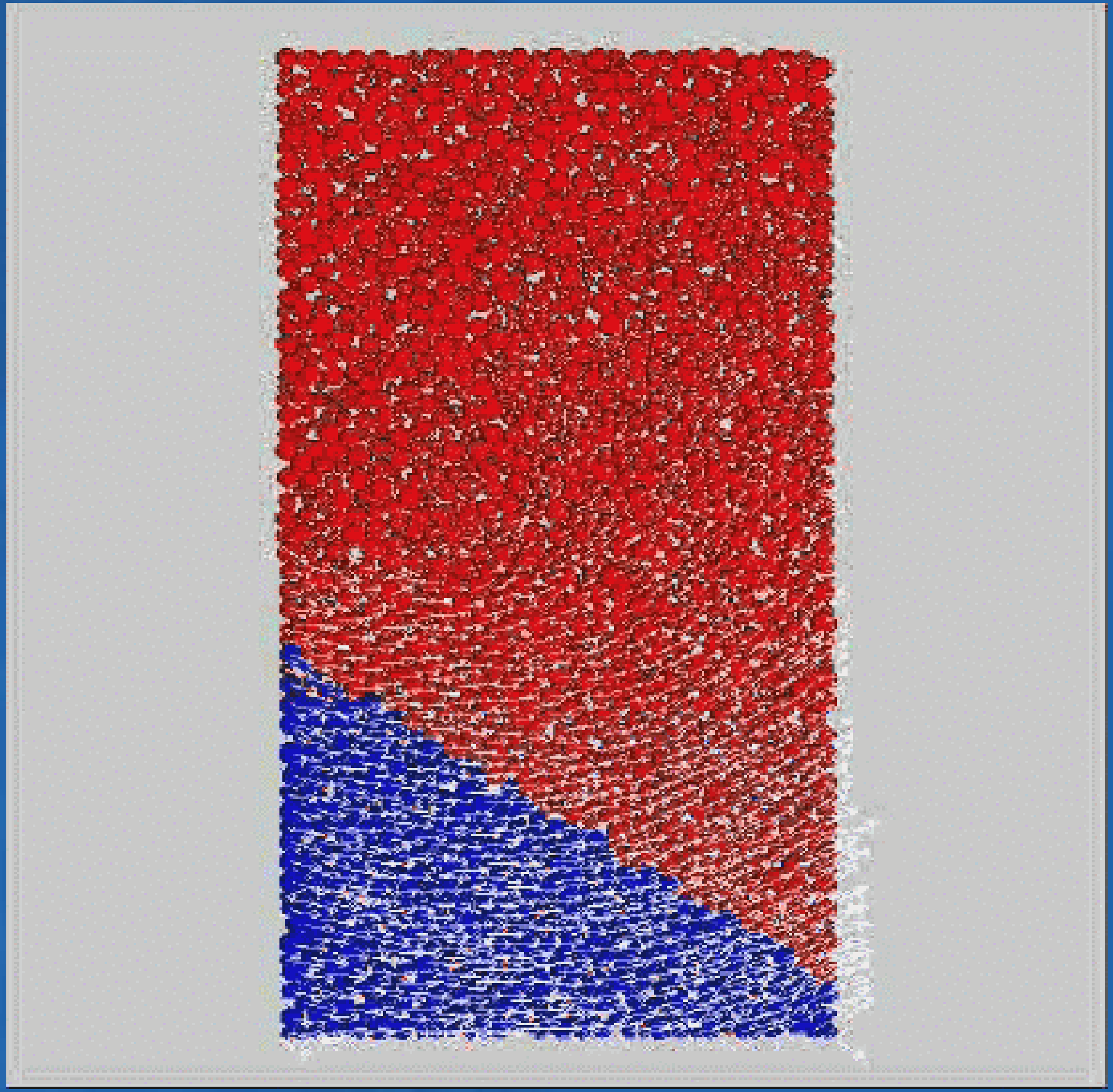
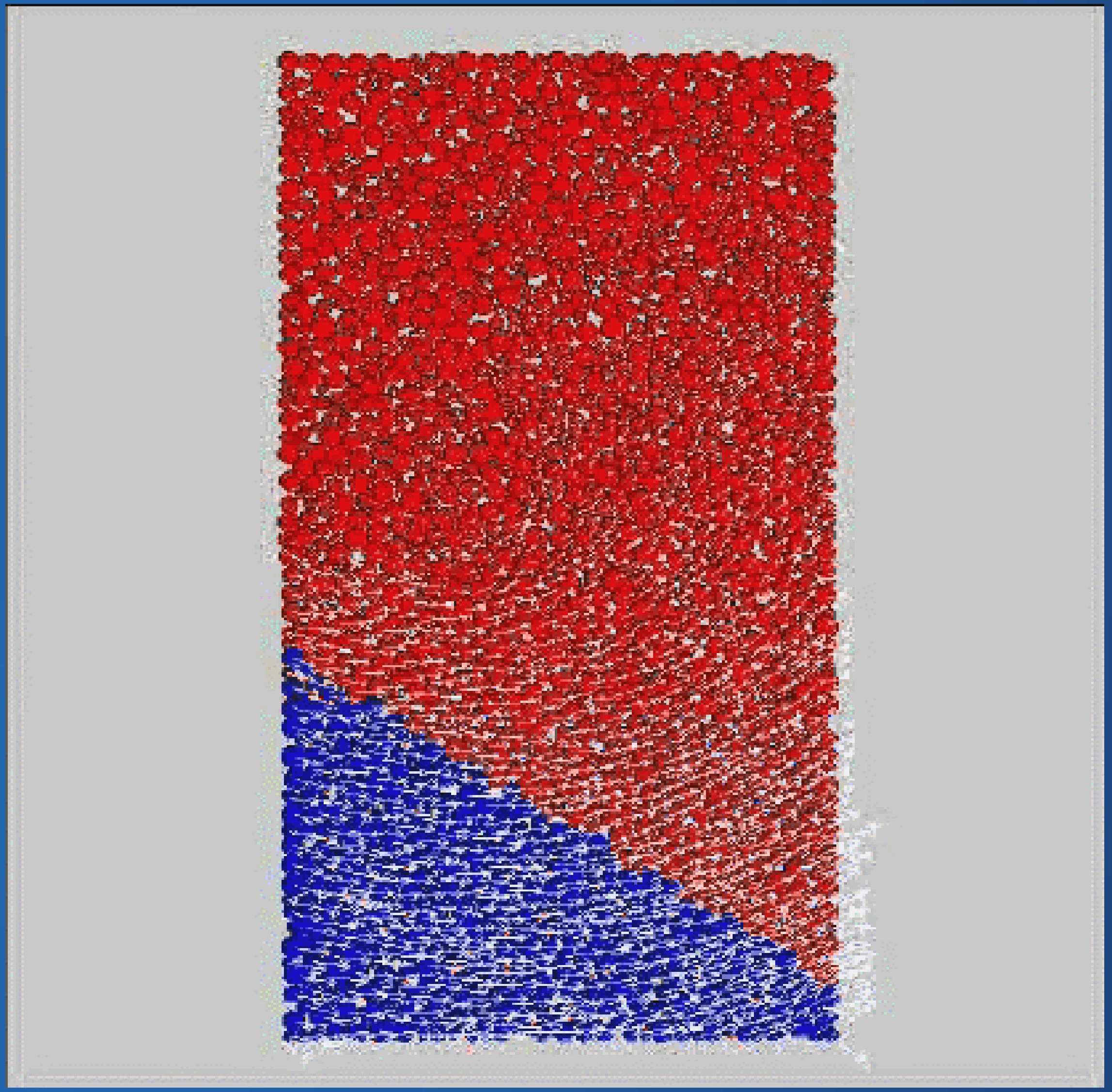
DEM Simulation for Strike-slip Fault Displacements (3)

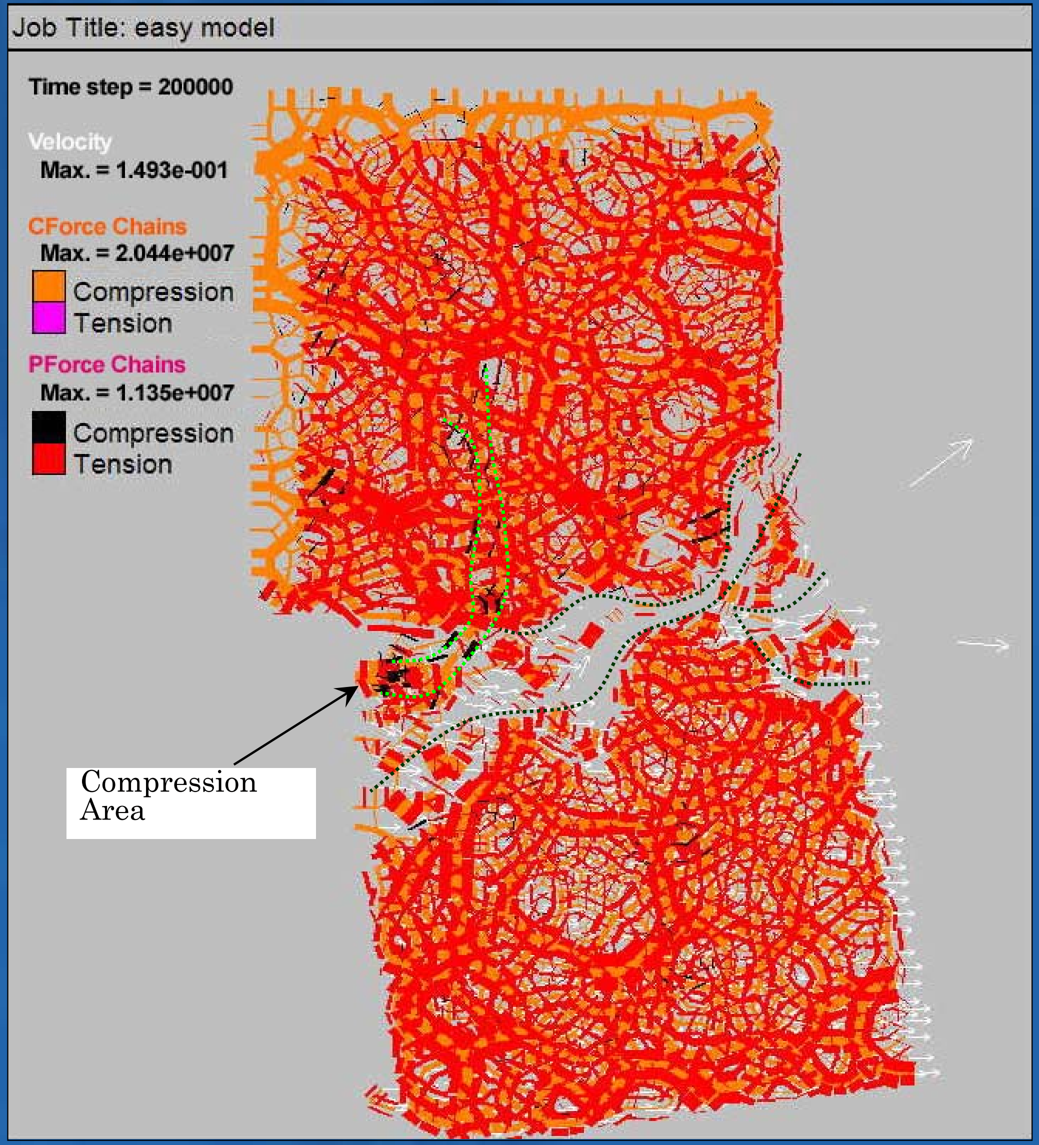


Without Block Rotation

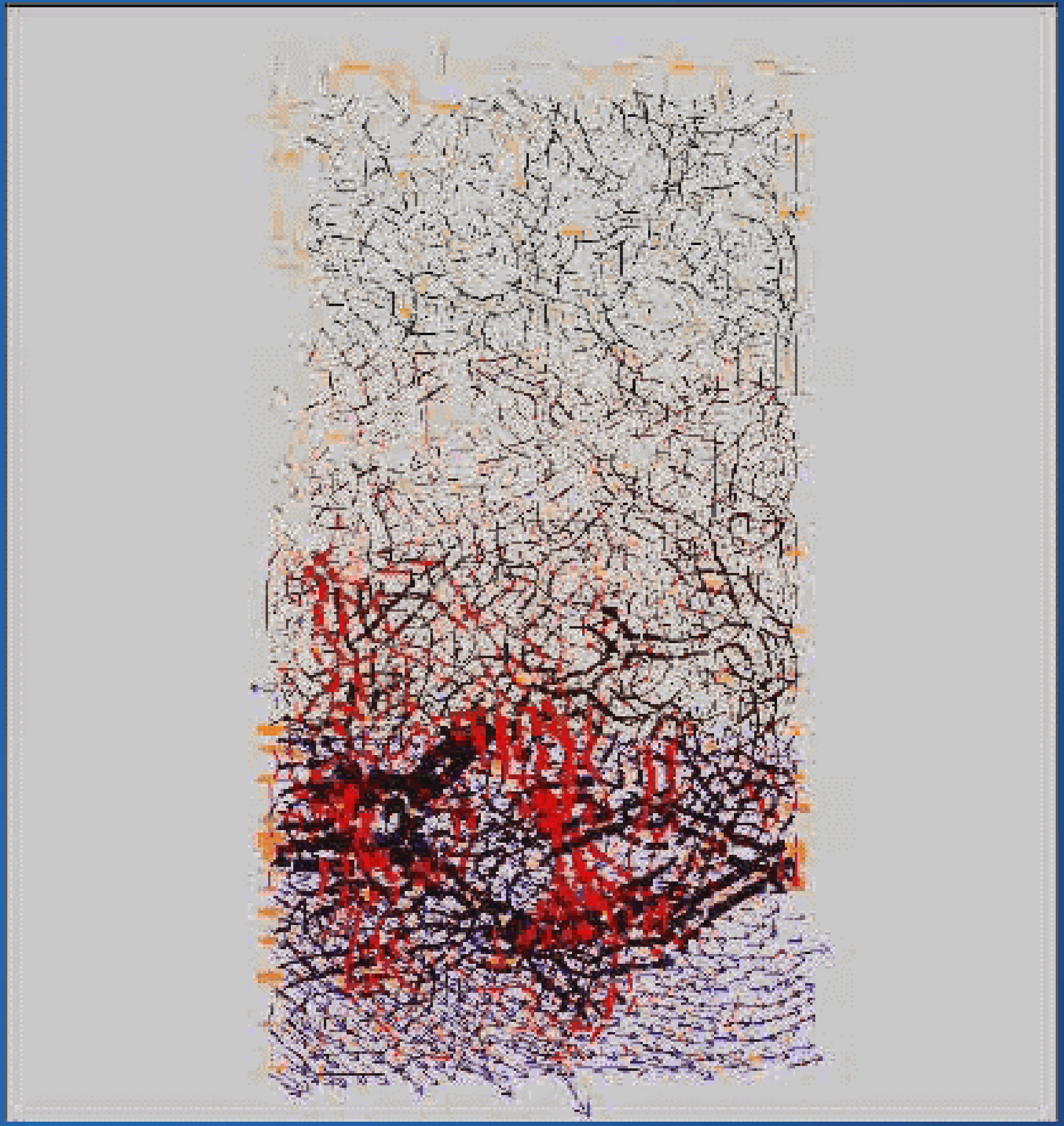


With Block Rotation

Stress Field Distribution along the Fault

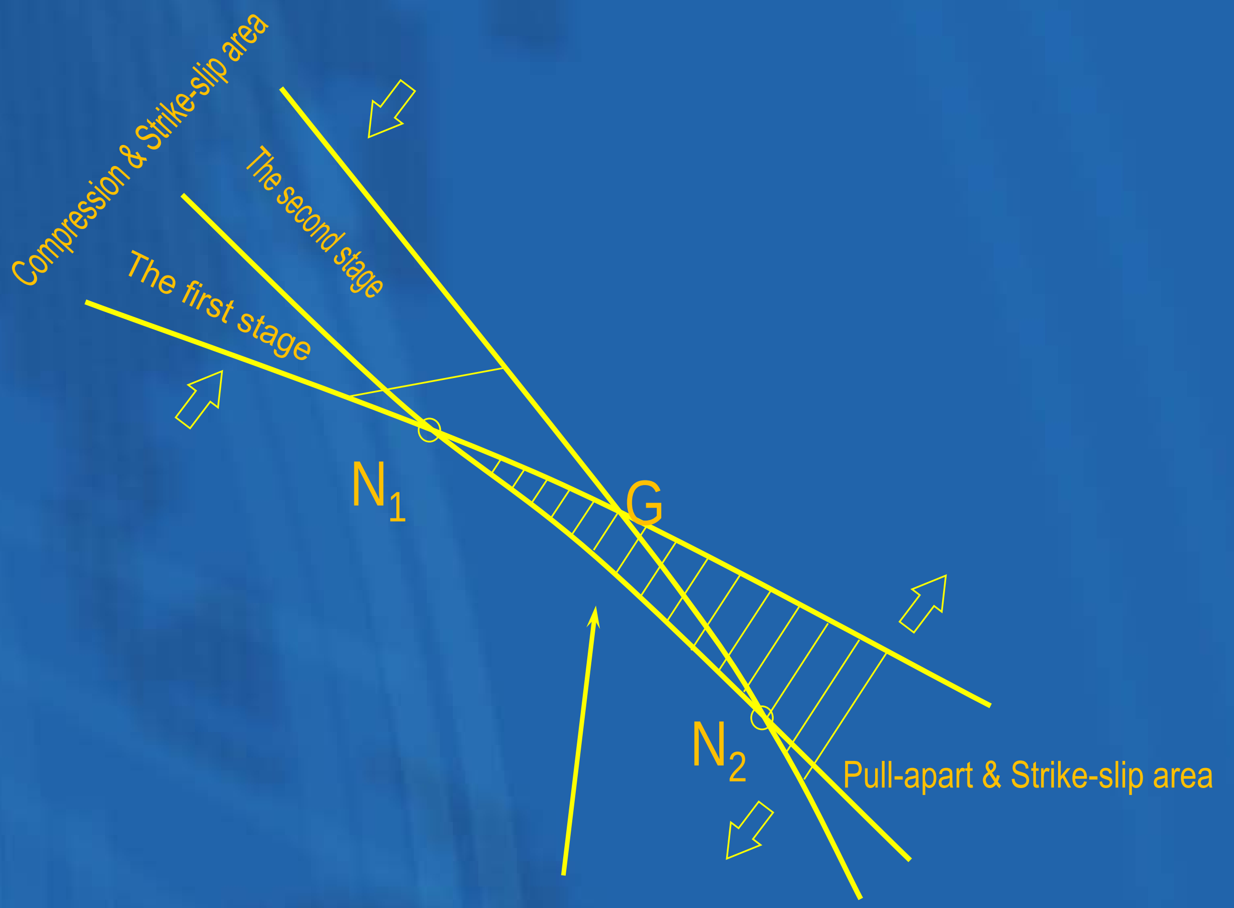


Without Block Rotation



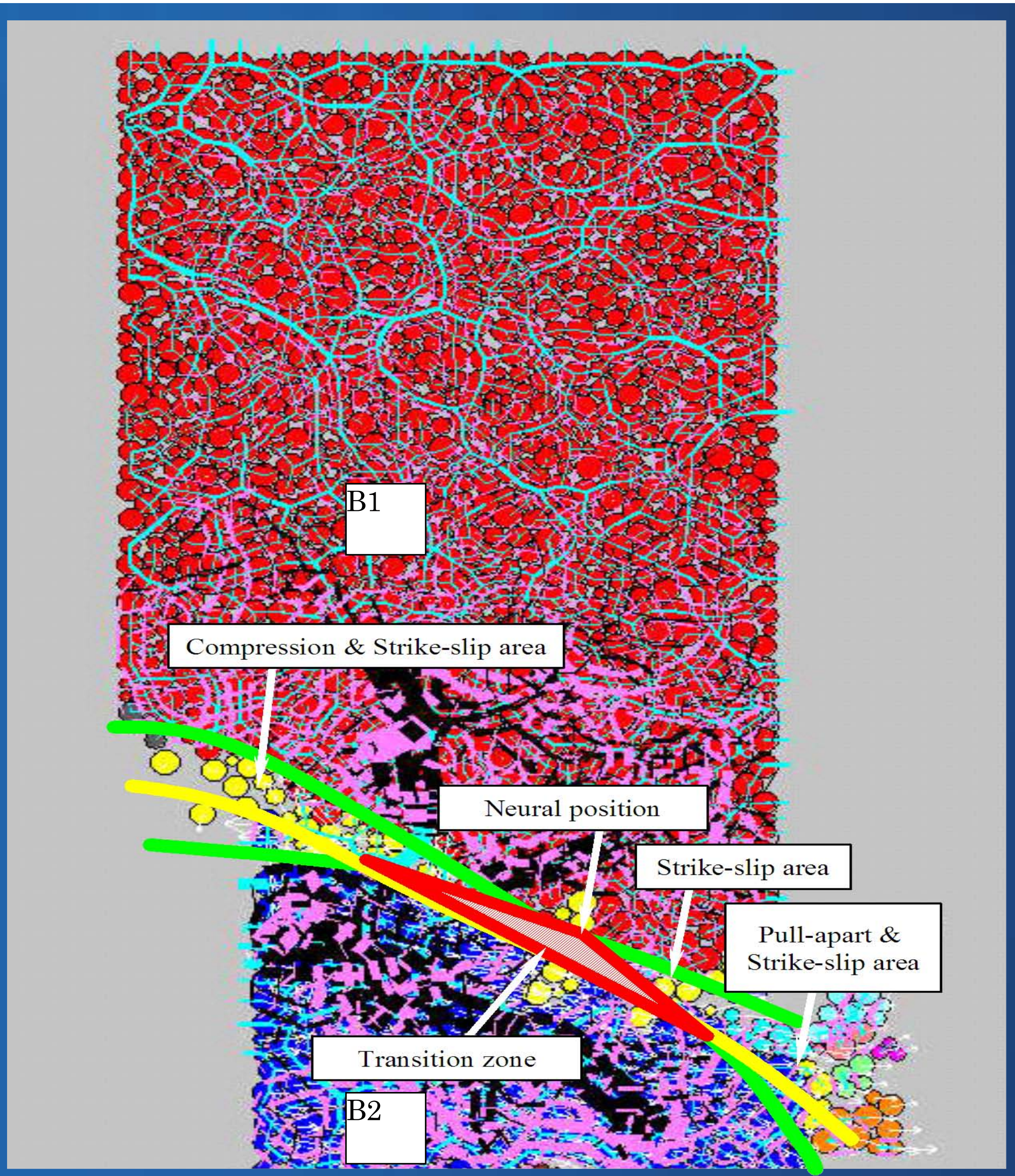
With Block Rotation

Comparison with Geological Model



Triangle area N1GN2 is the transition zone from compression to pull-apart

(Thang et al, 2004)



Model II after 200,000 time steps ~17 Ma ago

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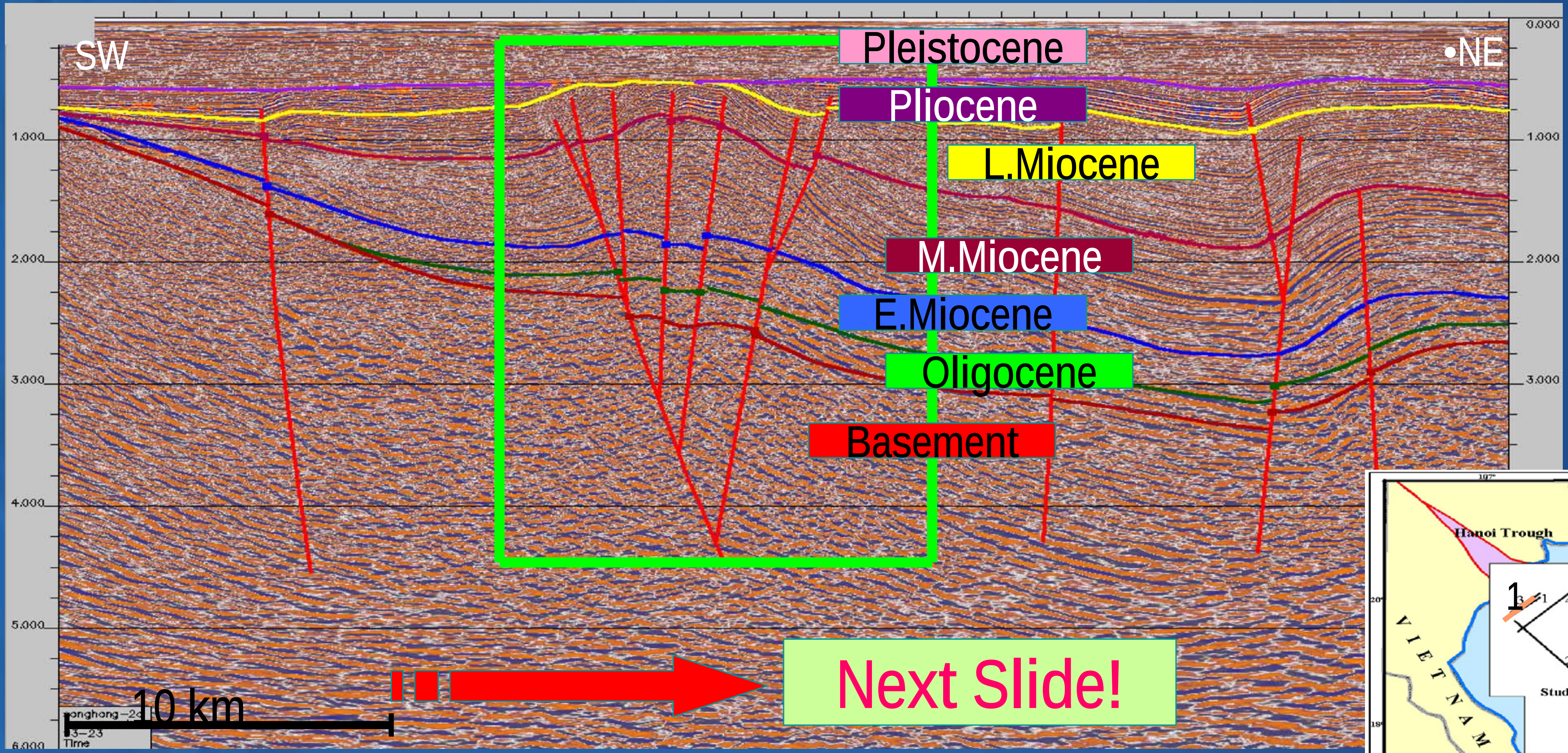
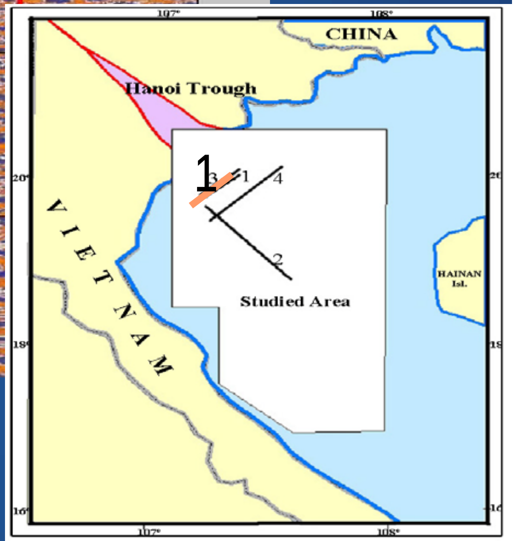
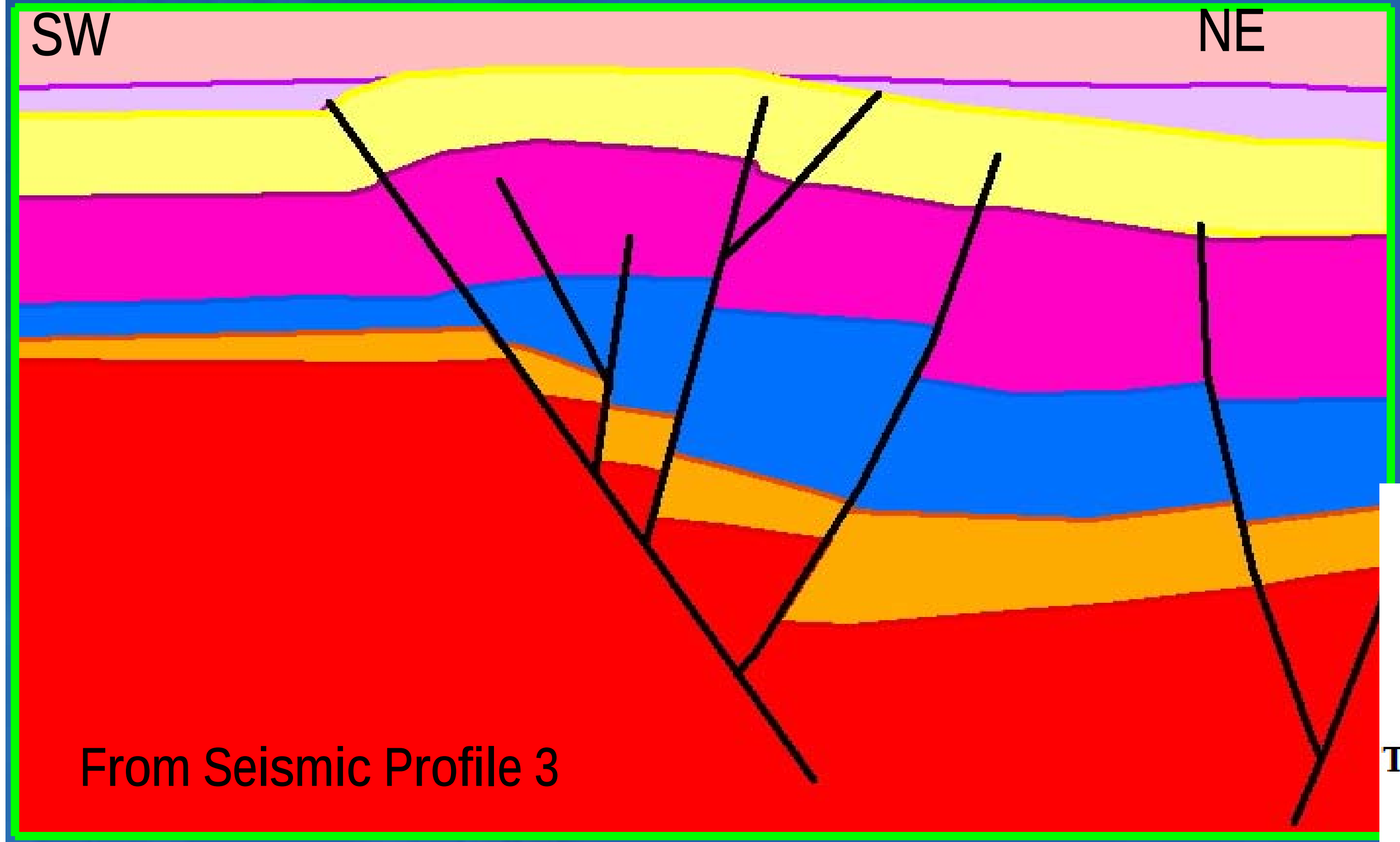
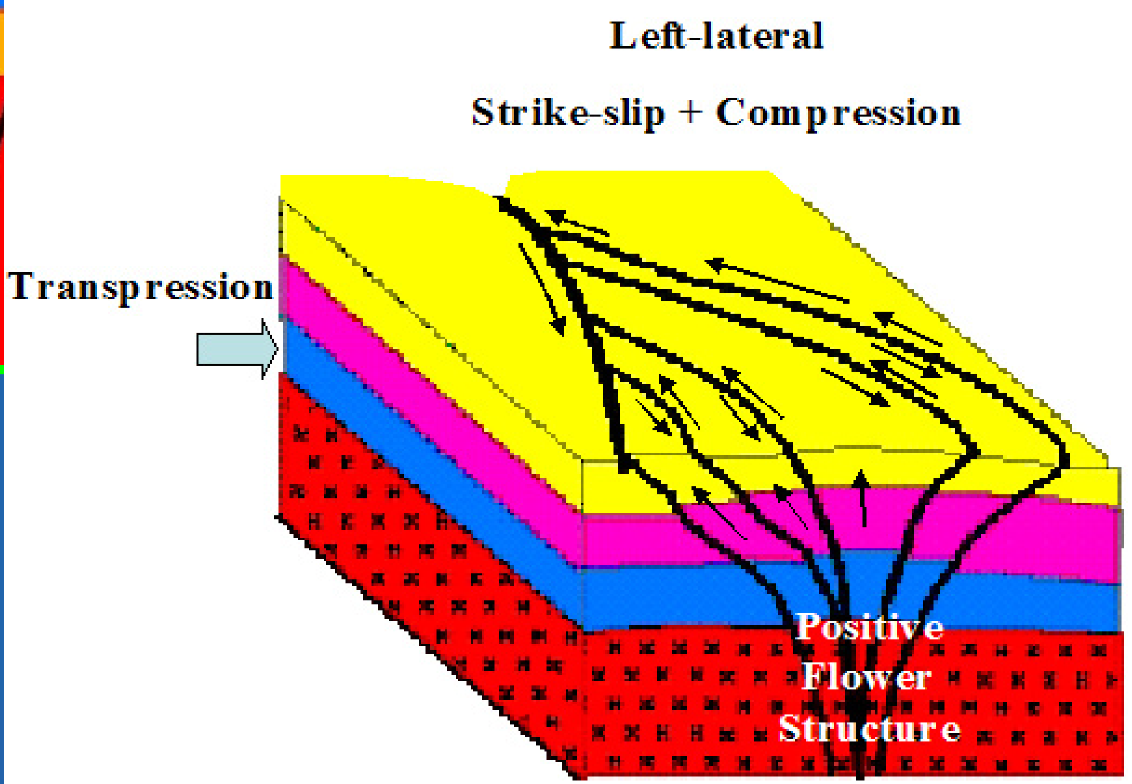
Seismic profile 1: Flower structures in Miocene sediments by strike-slip displacement of major faults





Flower structure on profile 3





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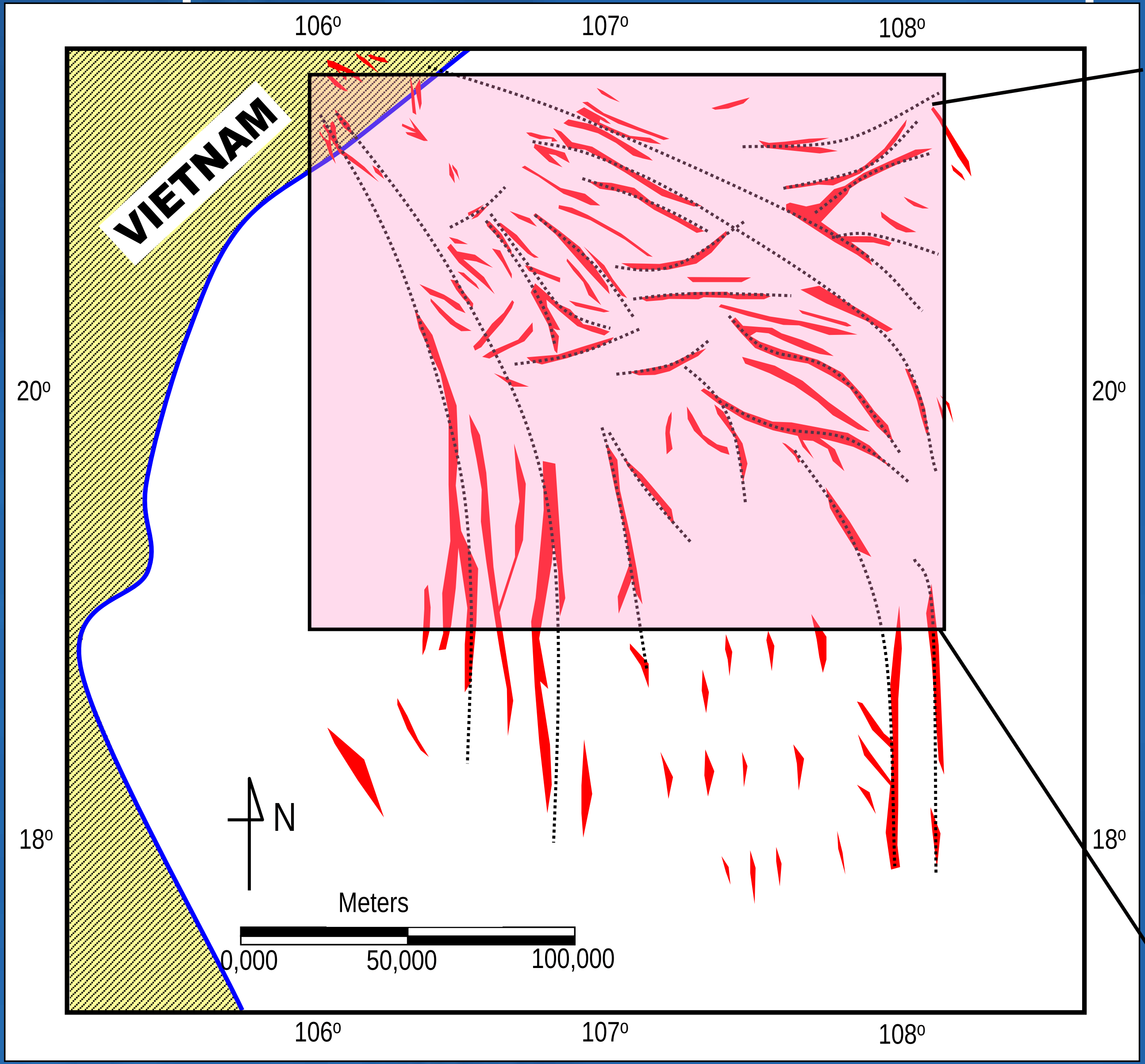
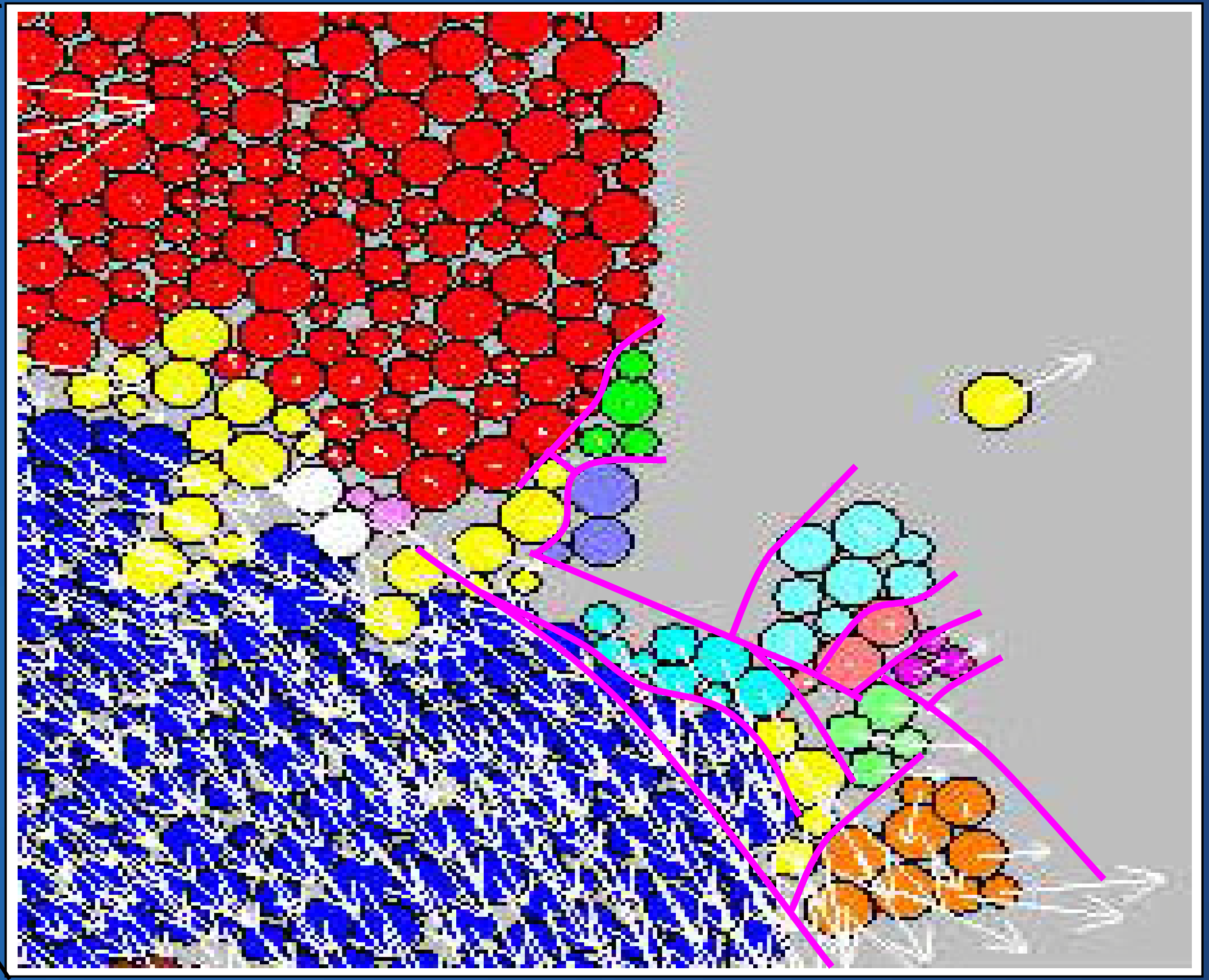
Comparison with Seismic Interpretation





DEM simulated results

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Summary

1. Simulation results reconstructed the characteristic lateral variations in the Red River fault displacement with internal block rotation of the South China & Indo-China
2. Simulation also revealed the stress pattern along the fault
3. Simulation suggested extensional environment & development of sedimentary basin in offshore area, that corresponds to the Song Hong basin formation and development
4. This study showed a new approach for studying the Red River fault development and basin evolution by using DEM
5. The results also play important roles for H.C exploration in this area.
6. DEM should be widely applied in modelling of geological and tectonic processes.

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Thanks for Your Kind Attention!

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