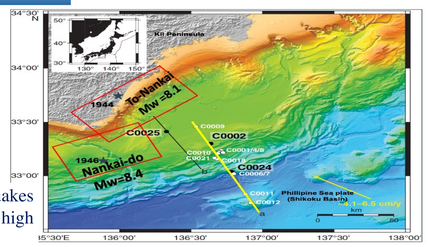
Hydrogeological properties at the toe of the Nankai accretionary prism, using drilling and petrophysical data from Hole C0024A - IODP NanTroSEIZE Project

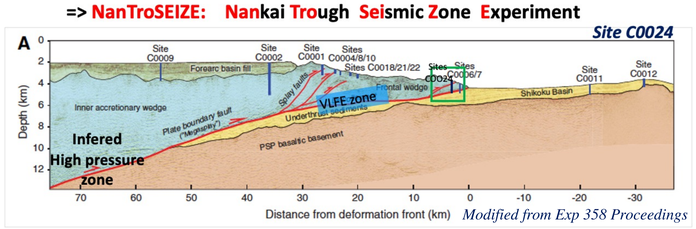
Pwavodi Joshua(*), Mai-Linh Doan,
ISTerre, Université Grenoble-Alpes, France
*Open for Postdoc and Job opportunities

1- Nankai Subduction Zone

- Nankai subduction is formed by the subduction of the phillipine sea plate under the Eurasian plate.
- Locus of high seismic hazard with M8+ earthquake with identified SSE and VLFE
- Tectonic deformations and earthquakes cycles are substantially influenced by high pore pressure and fluid flows.

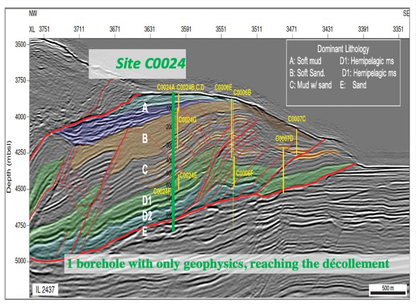


=> NanTroSEIZE: Nankai Trough Seismic Zone Experiment

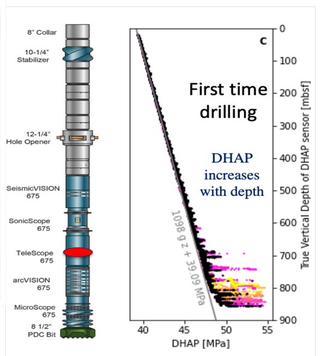


2- Objective

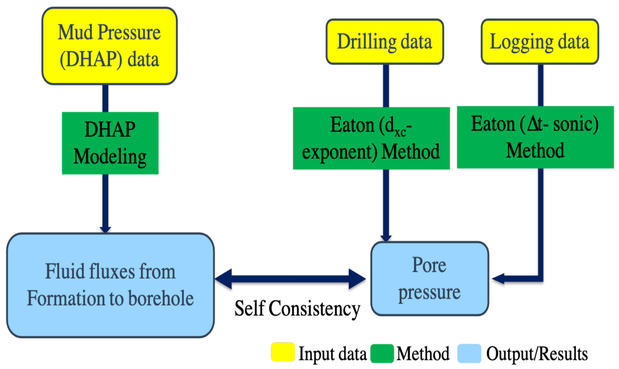
To provide continuous quantitative hydraulic information of the Toe of the Nankai accretionary prism at metric scale using a new technique by quantitatively interpreting Mud Pressure (DHAP) data.



Modified from H. Tobin et al 2020



3 - Methodology



4 – Results : Inflow from modeling of Mud Pressure

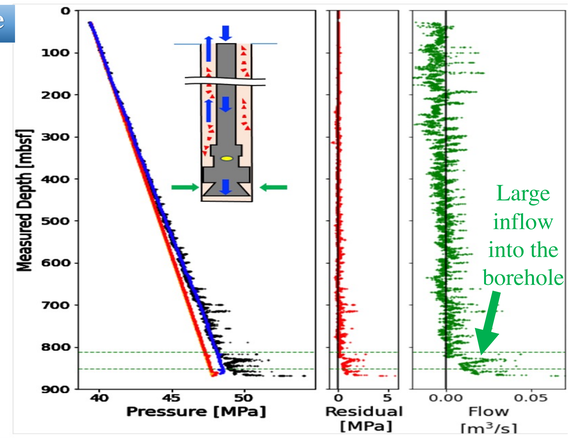
Hydraulic Model of Mud Pressure

Hydrostatic clean mud density
+ Weight of cuttings
+ Hydraulic (dynamic) losses due to mud circulation along the borehole
= Mud Pressure (DHAP) Model

Mud pressure anomaly not explained by the hydraulic model

⇨

large inflow into the borehole when crossing the décollement



5 – Results : Pore Pressure from Eaton's Model

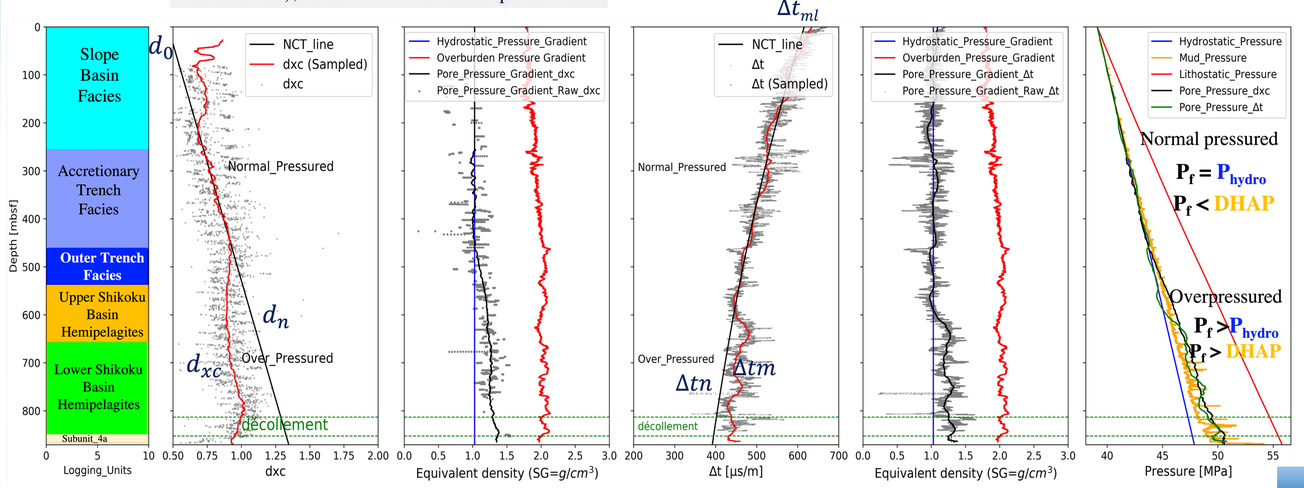
← D_{xc} – exponent method →

Proxy for "un-drillability", if lithology is the same, but *d*-exponent coefficient decreases (rocks get easier to drill), this is attributed to overpressure.

← Δt –sonic method →

Seismic slowness follows an exponential decay with depth. Same lithology but seismic slowness increases, this is attributed to overpressure.

Pore pressure



Hemipelagites in the Hanging wall are getting overpressurised.

There is further step in pore pressure when crossing each strand of the décollement into the footwall

$$P^* = P_f - P_{hyd}$$

$$\lambda^* = \frac{P_f - P_{hyd}}{\sigma_v - P_{hyd}}$$

Hemipelagites

P* ≈ 0.04 – 2.7 MPa

λ^* ≈0.27 – 0.34

Below the décollement

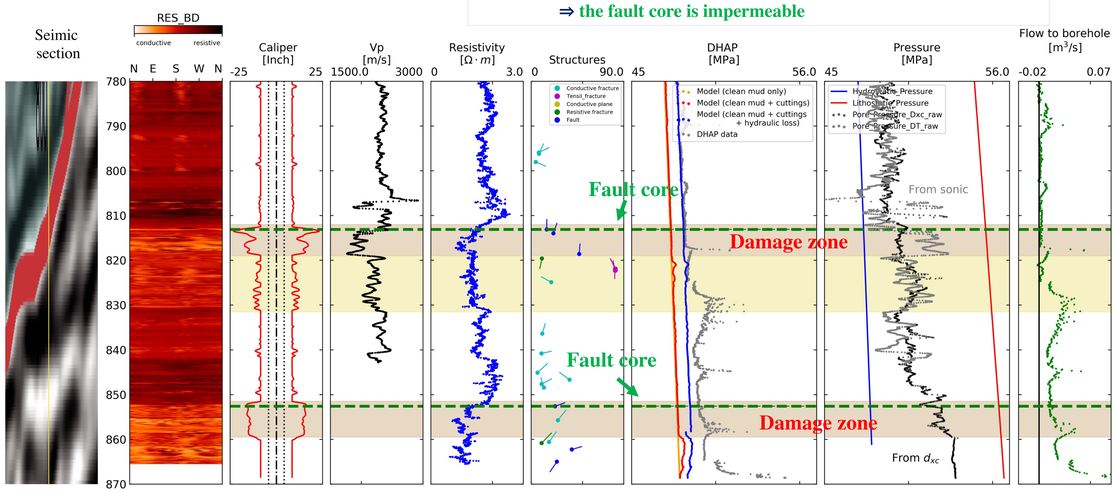
P* = 2.99MPa

λ^* = 38% of the overburden stress

6- Discussion

Hydraulic structure of the décollement

- **Décollement: 2 strands at 813 & 852 mbsf.**
- **Step in pore pressure when crossing the fault core**
  ⇒ no hydraulic connection between the hanging wall and the footwall
  ⇒ the fault core is impermeable

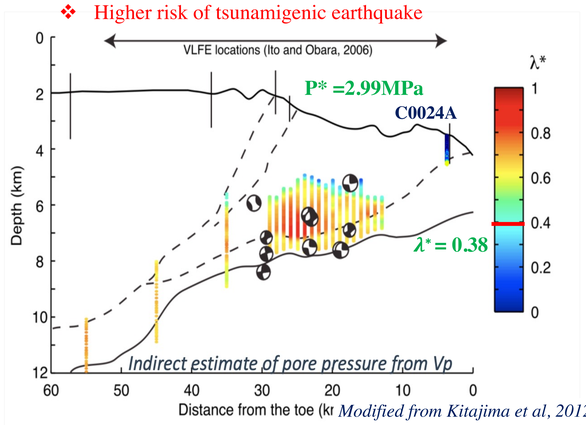


Damage zones: 2 asymmetric damage zones .

- There is a larger caliper (mechanically weak), low P-wave velocity, and low resistivity in the footwall rather than the hanging wall.
- **Also the footwall is the locus of fluid flow from the formation with higher pore pressure.**

Implication on Seismotectonics

- Extension of the high pressure zone to the toe
  - Higher risk of tsunamigenic earthquake



7- Conclusion

- We developed a methodology to characterize the hydraulic state along the C0024A borehole, by processing both drilling and geophysical data, in both time and space.
- Pore pressure increase is pervasive within the accretionary prism and not only at the fault zone.
- The décollement fault zone is associated to an hydraulic anomaly with large fluid flow (>0.04m³/s) and high pore pressure (**P* = 2.99MPa and λ^* = 38%**)
- High pressure happens up to the toe of the accretionary prism, favouring slow slip events and tsunamigenic earthquakes

8- References

- Kitajima, H., & Saffer, D. M. (2012). Elevated pore pressure and anomalously low stress in regions of low frequency earthquakes along the Nankai Trough subduction megathrust. Geophysical Research Letters, 39 (23), 1{5. doi: 10.1029/2012GL053793
- Saffer, D. M., & Tobin, H. J. (2011). Hydrogeology and Mechanics of Subduction Zone Forearcs: Fluid Flow and Pore Pressure. Annual Review of Earth and Planetary Sciences, 39 (1), 157{186. doi: 10.1146/annurev-earth-040610-133408