Sediment Accretion during Horst and Graben Subduction associated with the Tohoku Earthquake, Northern Japan

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Who Forgot the Paleontologists Anyway?

A story of oddball stratigraphy
Japan: A Nexus of Plate Boundaries

Tohoku Earthquake (March 11, 2011)
Incoming Horst and Graben Terrane off Northern Japan (GeoMapApp data)

Horst width of several km
Vertical offsets into grabens ca. 400m
V.E. = 8 x
**Tohoku-oki Earthquake-related Deformation** (Kodiara et al., 2012, Nakamura et al., 2013, Chester et al., 2013)

- Defromation of graben fill
- Plate Boundary Fault dives beneath graben fill, and tends to emerge near trench axis
- Overall ~ 50 m of displacement
Plate Boundary Fault:
Very Fine Grained, Rich in Smectite

1 m Core of Scaly Claystone
Detail of 49-58 cm
Fault Zone
Chert
Fault Zone
High Resistivity Zone
Brown Clay
Chert
Steep Dips (< 817 mbsf)
Sweet Spot
Shallow Dips (> 824 mbsf)
Capturing the Graben-filling Sediment Plate Boundary Fault is very weak Due to enrichment in smectite and fine grain size

Ikari et al., 2015 Sliding Friction = 0.2-0.26 verses 0.5 in wall rock

Ujiie et al., 2013. Coefficient of friction: 0.15 to 0.05

Fulton et al., 2013. Apparent coefficient of friction: 0.08

Kameda, et al. 2015. Smectite enrichment Sawai et al, 2014 Coefficient of friction in Pelagic Clay Site 436: < 0.2
Pleagic Clay Unit thickness about 47.5 m but boundaries transitional).
Sediments on modern Pacific Plate in deep water, excluding seamounts, islands or oceanic plateaus

(Absolute plate motion in moving hotspot reference frame Doubrovine, 2012; sediment distribution from Moore et al., 2015)
Thick (120m) Quaternary section lies just above plate boundary fault Where from?

Conceptual Cross Section Showing Evolution of Horst
1) Plate boundary Fault
Correlates with basal low dip zone
2) Shallow dips about 120 m shallower than Plate Boundary Fault may represent shear zone at upper boundary of Quaternary deposits

Shear Zone: Dips steeper in core and shallower on the flanks.
A. Equal angle lower hemisphere

Hole C0019B poles to bedding from resistivity image

- Predicted Fold Axis Trend
- Convergence Direction 292 deg.

- Best fit plane:
  - strike = 300.1, dip = 88.5° NE

N = 58
Observations and Conclusions

• At the Tohoku Location, Accretion wins over subduction or subduction erosion because of extremely wide-spread, weak basal shear zone in smectitic pelagic clay overlying strong basal horst and graben terrane
• Quaternary “slab” reflects early development of complex structural geology in a rapidly converging or high strain system
• Structural Processes operating in absence of lots of fluids fluids, based on interpretation of Annular Pressure While Drilling.