Using latest Miocene changes in Pacific plate motion to analyze plate boundary forces

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Overview

Rapid changes in plate motion pose a **challenge** and an **opportunity** for understanding plate motion:

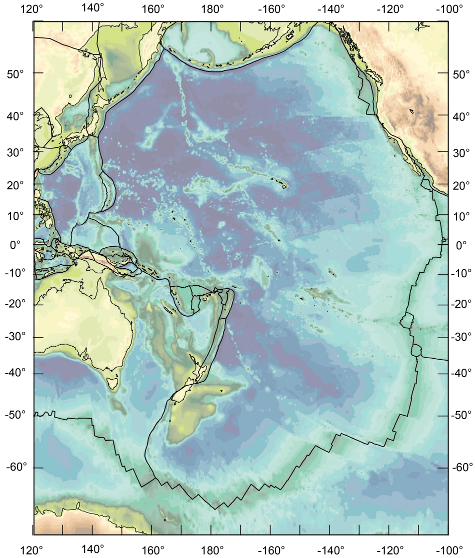
- Challenge: They cannot be explained by changes in mantle flow
- Opportunity: Basal shear stresses can be filtered out

⇒ Rapid changes can be used to gain knowledge about plate boundary forces.

Geologic record

Make use of the geologic record:

Identify a **recent** and **rapid** change in plate motion



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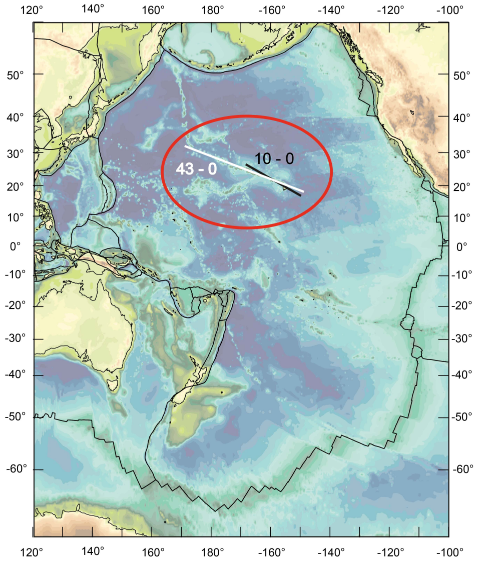
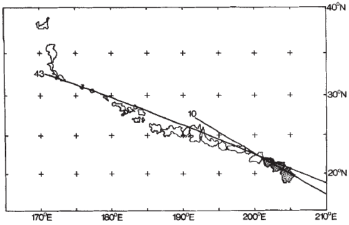
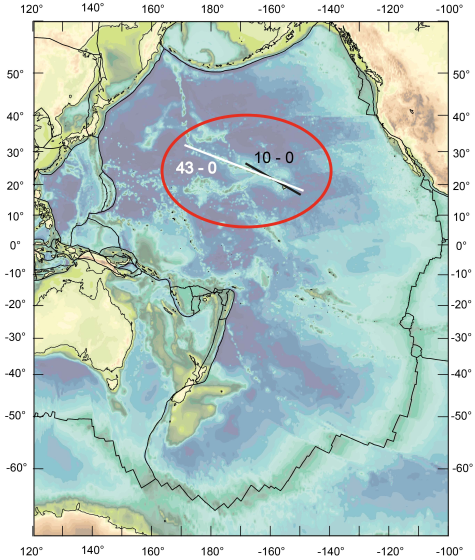


Changes at 6 Ma



Hawaiian seamount chain.

Trend of chain for Pacific plate hotsports with ages 43-0 Ma and 10-0 Ma. Stippled areas: volcanic edifices < 5 Ma.
[Cox and Engebretson, 1985]



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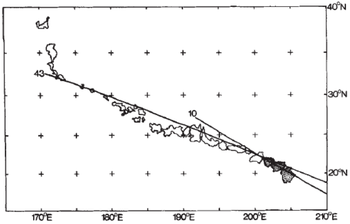

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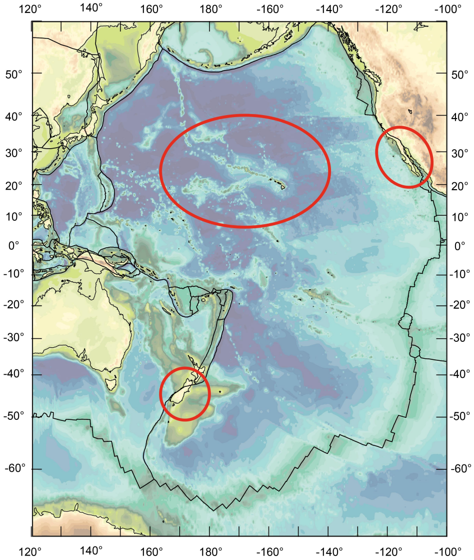
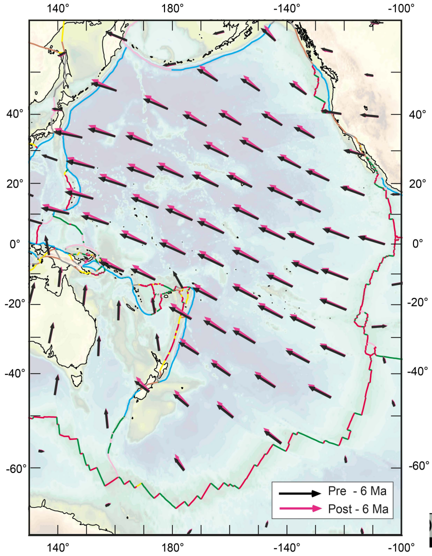


Clockwise rotation of Pacific plate motion at 6 Ma



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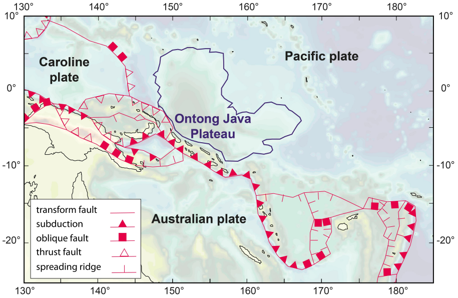

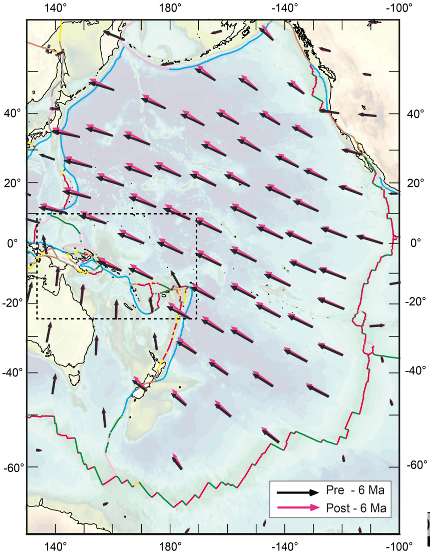

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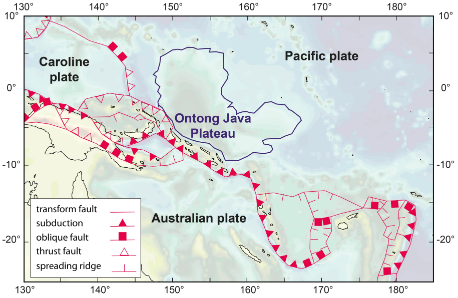

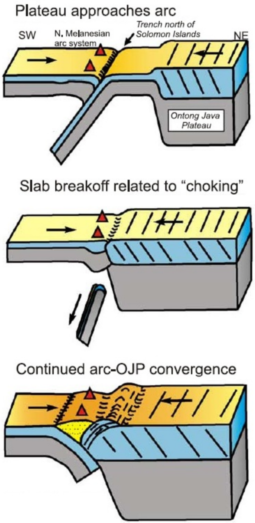

Mann and Taira, 2004

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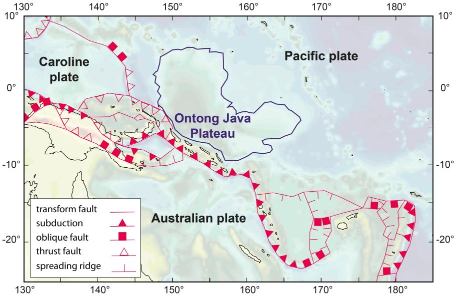
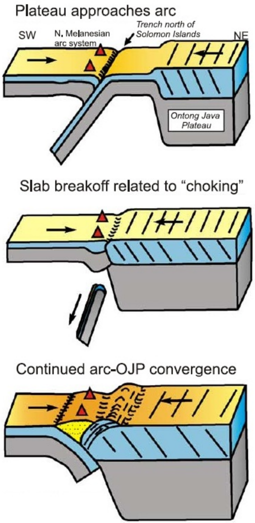


Can cessation of subduction trigger rapid changes in plate motion?



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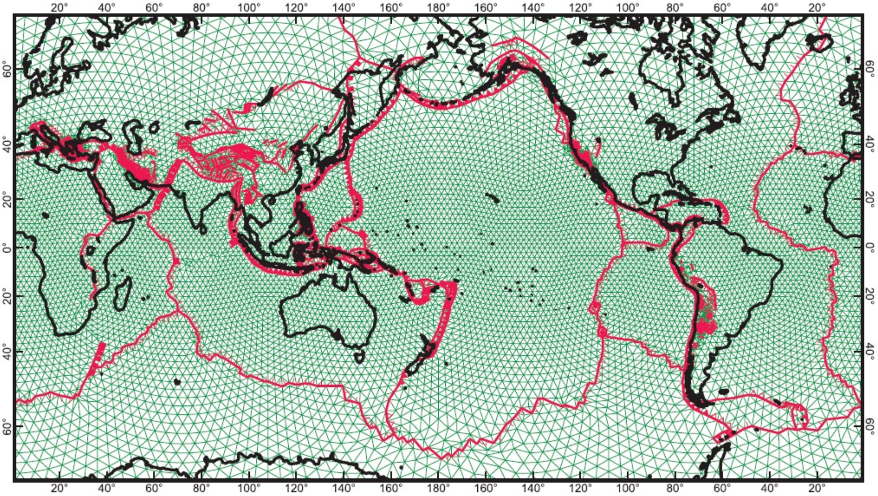
Tectonic inverse problem

Simulation of a pre- and post-6 Ma model

→ **Input**: Plate velocities via Euler poles for each plate
→ **Output**: Plate driving forces for each plate

Relate change in forces to cessation of subduction

Grid



Bird et al., 2008

Torque balance I

Assumption: angular acceleration is vanishingly small and hence torques on each plate must integrate to zero.

$$\iint_S \vec{r} \times (\tilde{\sigma} \cdot \hat{n}) \, dS = \vec{0} = \vec{Q}_{LP} + \vec{Q}_{SS} + \vec{Q}_{BS}$$

Split up the equation to obtain different driving torques:

$$\tilde{\sigma} = \tilde{\tau} - P_{lith}\tilde{I}$$

$$\vec{Q}_{LP} = \iint_{S_{side}+S_{base}} \vec{r} \times (-P_{lith} \cdot \hat{n}) dS$$

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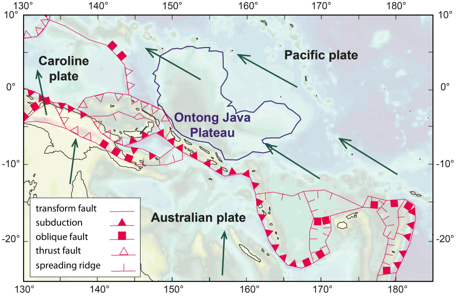
\end{aligned}$$

Input

Post 6 Ma Input



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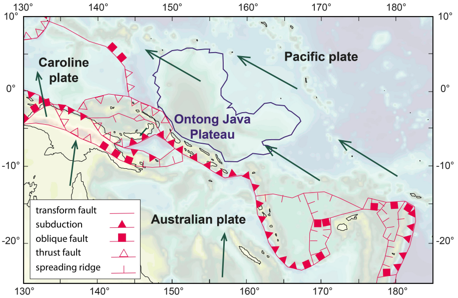

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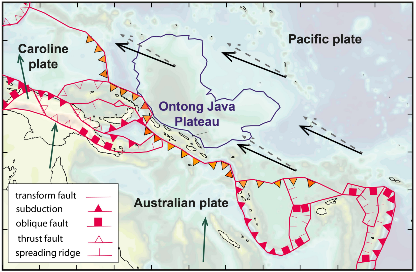
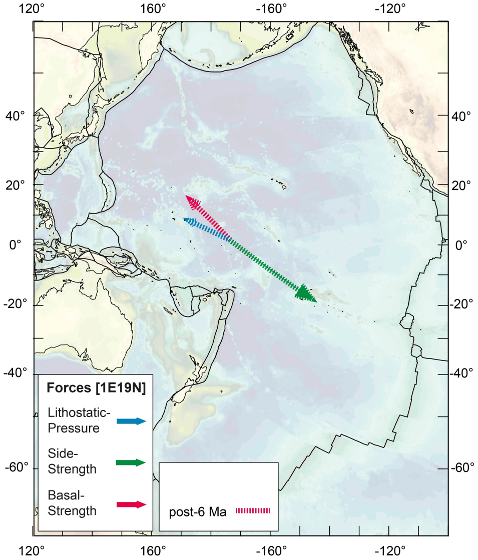
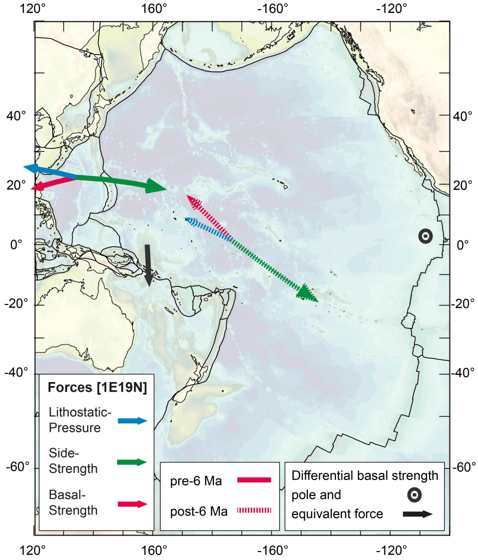


Torque balance II



Change in boundary forces



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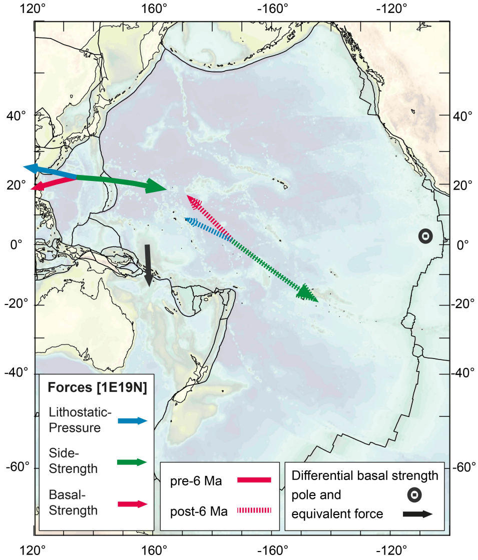

Magnitude of differential basal strength force: 4 TN/m

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- We set up a geomechanical model to analyze short timescale changes in plate motion
- Slab detachment and subsequent subduction polarity reversal can explain the change of Pacific plate motion at 6 Ma
- Major geologic event had only relatively small influence on the Pacific plate motion

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