Lamont-Doherty Earth Observatory
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Lithospheric Thickness of Volcanic Rifting Margins: Constraints from Seaward Dipping Reflectors

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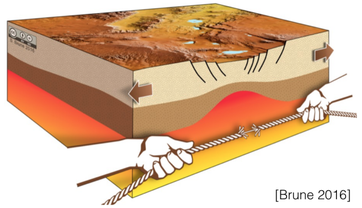
GeoPRISMS TEI Synthesis & Integration 2019
February 27 to March 1, 2019 | Menger Hotel, San Antonio, TX

0 Question

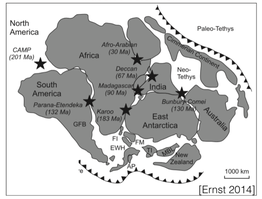
Plate Strength at time of rifting?



[Brune 2016]

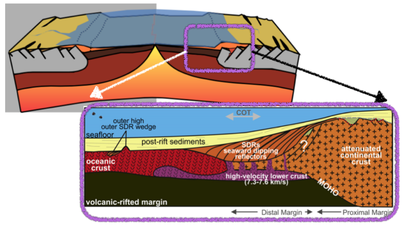
1 Background

Continental Breakups correlate with Massive Volcanism



[Ernst 2014]

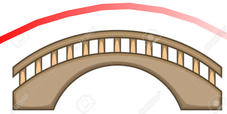
Seaward Dipping Reflectors (SDRs) at continent-ocean transition zone provides unprecedented information for plate strength at rifted margins during rifting



[Baets et al., 2016] [Franke et al., 2014]

2 Goal:

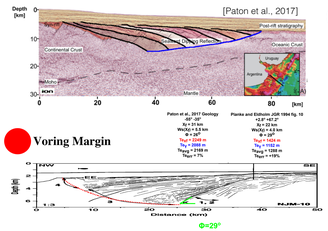
SDR geometry

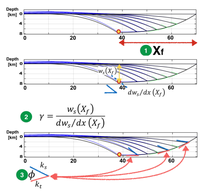


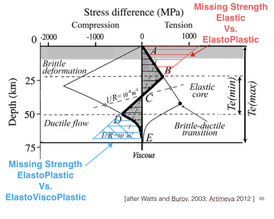
observables

Plate strength

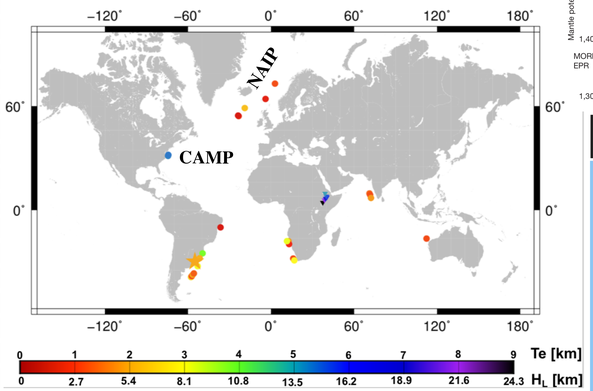
Argentinian Margin

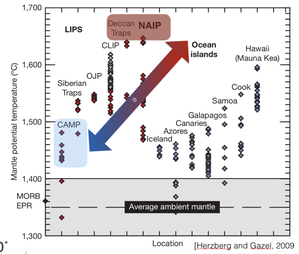






5 Summary





Take home:

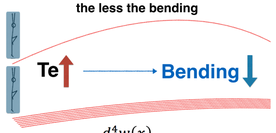
#1#
Three observables: horizontal distance Xf, ratio γ and angle ϕ to link observed SDRs shape to effective elastic thickness (Te) to be 1 ~ 6 km.

#2#
Develop a series of models including 2D thermal-mechanical models for SDRs formation. Models provide a mapping from elastic thin plate (Te) to lithospheric thickness (H_L) of thick elasto-visco-plastic (EVP) plate.

#3#
Mapping gives H_L at rifted margins during rifting of 4 ~ 18 km. Mantle temperatures correlate inversely with H_L.

3 Hypothesis

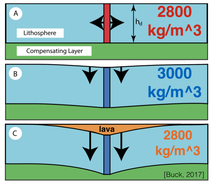
3.1 Basic idea



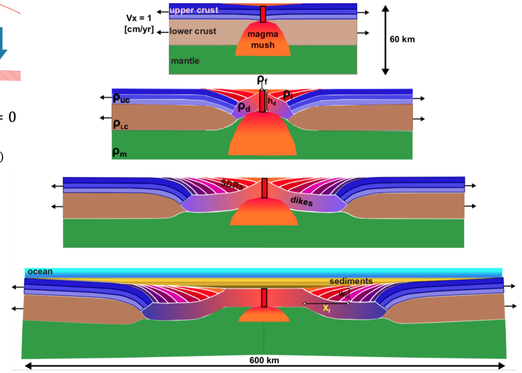
$$D\frac{d^4w(x)}{dx^4} + g\Delta\rho_s w(x) = 0$$

$$D = ETe^3/12(1-\mu^2)$$

3.2 Magma as loads



3.3 Rift to drift with SDRs formation:



4 Model

4.1 Analytic thin plate model:

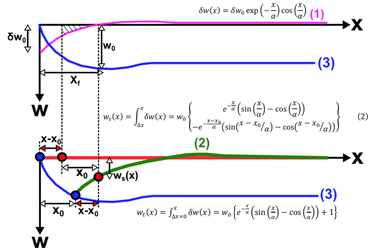
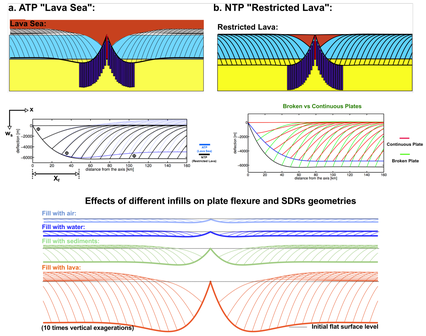
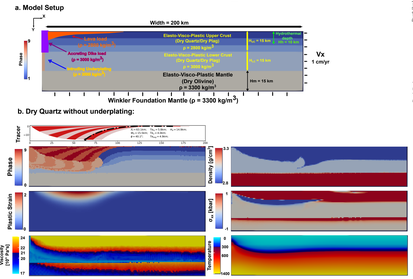
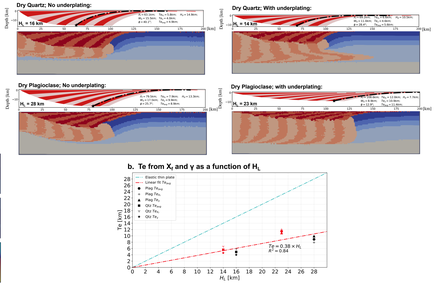
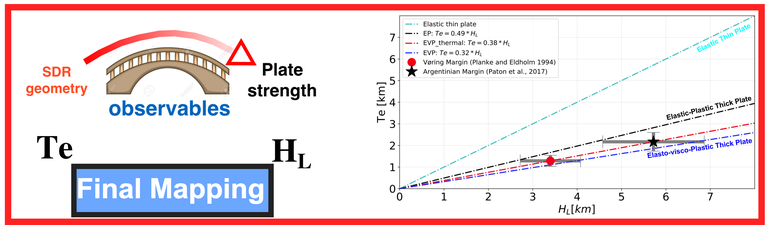


Figure S1. Cartoon illustration of the analytical equations for SDRs geometry. Magenta line is the plate deflection due to one dike load, quantified by equation (1). Green line evolves from the red line and is the deflected SDR that has experienced x_0 amount of plate extension and dike widening, quantified by equation (2). Following the motion of an arbitrary particle (red dot), integrating equation (1) (magenta line) from $\Delta x = x - x_0$ to x gives its current location at $(x, w_s(x))$. The value of $w_s(x)$ is also represented by the shaded area indicated between the magenta line and the X axis. Integrating equation (1) with $\Delta x = x - x_0 = 0$ gives the motion of the blue dot that moves on the dike lava interface (blue line), quantified by equation (3). Here, the distance between the blue and red dots are assumed to be invariant.

4.2 Numerical thin plate model:

The thin-plate flexure model assumes that the lava is filled everywhere instantaneously. However, in reality, it is more likely to be restricted in a certain distance away from the rift center. Here, we use finite difference method to solve the general 4th-order flexure equation with distributed load q(x) =Δρ·gw only at where w < 0.



4.3 Numerical thick plate models: