Modelling Thermal Maturity in an accretionary wedge

Authors:

Utsav Mannu¹, David Fernández-Blanco²,³, Ayumu Miyakawa⁴, Taras V. Gerya⁵, Masataka Kinoshita⁶

¹Department of Earth & Climate Science, Indian Institute of Science Education and Research
²Université de Paris, Institut de physique du globe de Paris, CNRS, F-75005 Paris
³Basins Research Group (BRG), Department of Earth Science & Engineering, Imperial College London
⁴Geological Survey of Japan, AIST
⁵Institute of Geophysics, ETHZ Zurich
⁶Earthquake and Volcano Information, Earthquake Research Institute, Tokyo-U

Email: utsav@iiserpune.ac.in
Initial Model Setup
Models

TD1: Models with weaker décollement strength ($\mu=0.03$)

- TD1_S1: Only hinterland sedimentation
- TD1_S2: Both hinterland and trench sedimentation
- TD1_S3: Only trench sedimentation

TD2: Models with stronger décollement strength ($\mu=0.07$)

- TD2_S1: Only hinterland sedimentation
- TD2_S2: Both hinterland and trench sedimentation
- TD2_S3: Only trench sedimentation

Reference model with no sedimentation

Experimental Strategy: Model runs
<table>
<thead>
<tr>
<th>Models</th>
<th>Incorporated Thermal Conductivity</th>
<th>Décollement Strength (Coefficient of friction)</th>
<th>Sedimentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD1_S0</td>
<td>×</td>
<td>0.03</td>
<td>None</td>
</tr>
<tr>
<td>TD1_S0</td>
<td>✓</td>
<td>0.03</td>
<td>None</td>
</tr>
<tr>
<td>TD1_S1</td>
<td>✓</td>
<td>0.03</td>
<td>Hinterland(15km³/Myr)</td>
</tr>
<tr>
<td>TD1_S2</td>
<td>✓</td>
<td>0.03</td>
<td>Hinterland(7.5km³/Myr); Trench(7.5km³/Myr)</td>
</tr>
<tr>
<td>TD1_S2</td>
<td>✓</td>
<td>0.03</td>
<td>Trench(15km³/Myr)</td>
</tr>
<tr>
<td>TD2_S0</td>
<td>✓</td>
<td>0.07</td>
<td>None</td>
</tr>
<tr>
<td>TD2_S1</td>
<td>✓</td>
<td>0.07</td>
<td>Hinterland(15km³/Myr)</td>
</tr>
<tr>
<td>TD2_S2</td>
<td>✓</td>
<td>0.07</td>
<td>Hinterland(7.5km³/Myr); Trench(7.5km³/Myr)</td>
</tr>
<tr>
<td>TD2_S2</td>
<td>✓</td>
<td>0.07</td>
<td>Trench(15km³/Myr)</td>
</tr>
</tbody>
</table>

**Experimental Strategy: All Model runs**
Thermal Conductivity in Nankai Accretionary Wedge

Figure modified from Sugihara et al [2014]
Shallow thermal conductivity regime in Nankai accretionary wedge is 
\[ TC = 6.17 \times 10^{-4} \cdot Z + 0.96 \]
Where, Z is depth from the seabed.

To incorporate thermal conductivity we use a modified thal conductivity for sediments in our models as 
\[ TC = 0.96 + (0.64 + 807(T + 77.0)) \cdot \exp(KP \cdot P) \cdot (1 - \exp(-Z^2/1e7)) \]
Where, T is Temperature; KP is specific heat; P is pressure and Z is depth from the seabed.

For Décollement (to incorporate heat transfer by fluid advection) 
\[ TC = 0.96 + (0.64 + 807(T + 77.0)) \cdot \exp(KP \cdot P) \cdot (1 - \exp(-Z^2/1e4)) \]
Where, T is Temperature; KP is specific heat; P is pressure and Z is depth from the seabed.

Incorporating Empirical Thermal Conductivity Values from Nankai

Figure modified from Sugihara et. al [2014]
Incorporating Empirical Thermal Conductivity Values from Nankai
Incorporating Empirical Thermal Conductivity Values from Nankai

Figure modified from Sugihara et. al [2014]
Partitioning Depth:
Depth above which most sediment either get eroded or follow a Low-thermal Maturity and below which most sediment follow a High-thermal Maturity.
The Partitioning depth between high and low maturity path fluctuates, and correlates with the frequency and spacing of frontal thrust nucleation.

Periodic perturbation of Partitioning depth
Increase in trench sedimentation leads to wider zones of HIGH MATURITY, so does the width of thrust sheets.

Comparing Perturbation of Partitioning depth with increase in trench sedimentation

$L = \text{Length of the oceanic plate under consideration}$

$A = \text{Area of the sediments transitioning to high thermal maturity}$

$N = \text{Number of faults} = \text{Number of crest in high thermal maturity region}$

$\bar{W} = \text{Average width of high-maturity zone defined as } \bar{W} = \frac{A}{L+N}$
The syn-accretion location of sediment in the wedge sets its trajectory, and therefore its thermal maturity.

- Sediment underlying the active frontal thrust translates inland closer to the decollement along a high maturity path.
- Sediment overlying the active frontal thrust translates inland closer to the surface along a low maturity path.

**Thermal maturity is thus controlled by the spacing and timing of thrust growth.**

**Conclusion**
Thanks You

References: