Geodynamics

Kinematics of plate tectonics
Lecture 2.5 - Triple junctions

Lecturer: David Whipp
david.whipp@helsinki.fi
Goal of this lecture

- Introduce triple junctions and how to determine whether they can exist
Plate boundaries can only end in a **triple junction**, where they intersect another boundary.

A ridge-ridge-ridge (RRR) triple junction

![Diagram of a triple junction with labels A, B, and C, and angles 360° - α, 110°, and triple junction angle.](Fig. 1.36, Turcotte and Schubert, 2014)
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Triple junctions are typically listed in shorthand based on the types of plate boundaries involved in the triple junction:

- **R** = ridge, **T** = trench (subduction), **F** = transform fault
- **RRR** = ridge-ridge-ridge triple junction
Triple junctions

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- For plates A and B, this means spreading at an azimuth of 90°
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For a triple junction to exist, the vectors of relative motion must form a closed triangle.

In other words, \[ \nu_{BA} + \nu_{CB} + \nu_{AC} = 0 \]
Let’s consider an example based on the RRR triple junction.

Assume we know $v_{BA} = 100 \text{ mm a}^{-1}$ and $v_{CB} = 80 \text{ mm a}^{-1}$.
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Using the geometry and spreading rates of two of the ridges, we can find the orientation and spreading rate of the third since $v_{BA} + v_{CB} + v_{AC} = 0$. 

Fig. 1.36, Turcotte and Schubert, 2014
Triple junctions

- We can find $v_{AC}$ using the law of cosines:
  
  \[ c^2 = a^2 + b^2 - 2ab \cos \alpha \]

- Thus, $v_{AC} = (v_{BA}^2 + v_{CB}^2 - 2v_{BA}v_{CB} \cos 70^\circ)^{1/2}$

- $v_{AC} \approx 105 \text{ mm yr}^{-1}$
Triple junctions

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  \[ c^2 = a^2 + b^2 - 2ab \cos \alpha \]
- Thus, $v_{AC} = (v_{BA}^2 + v_{CB}^2 - 2 v_{BA} v_{CB} \cos 70^\circ)^{1/2}$
- $v_{AC} = \sim 105 \text{ mm yr}^{-1}$
- We can find the orientation of $v_{AC}$ using the law of sines:
  \[ \frac{\sin \alpha}{a} = \frac{\sin \beta}{b} = \frac{\sin \gamma}{c} \]
  or more simply, \[ \frac{a}{b} = \frac{\sin \alpha}{\sin \beta} \]
- Thus, \[ \frac{v_{CB}}{v_{AC}} = \frac{\sin(\alpha - 180^\circ)}{\sin 70^\circ} \]
- $\alpha = \sim 230^\circ$
Stability of triple junctions

- A triple junction can either be **stable** with a geometry that does not change with time, or **unstable** with a geometry that will only exist momentarily before changing.

- A stable geometry can be moving with time, as long as the relative motion of the plates, and the azimuths and types of plate boundaries do not change.

- Four or more plates intersecting is always **unstable**.

Fig. 1.36, Turcotte and Schubert, 2014
Test your might

- You can find a short quiz about this lecture at https://elomake.helsinki.fi/lomakkeet/63056/lomake.html
- Please take the quiz to help me know what you have learned
- Your answers are anonymous and will not count in your course grade