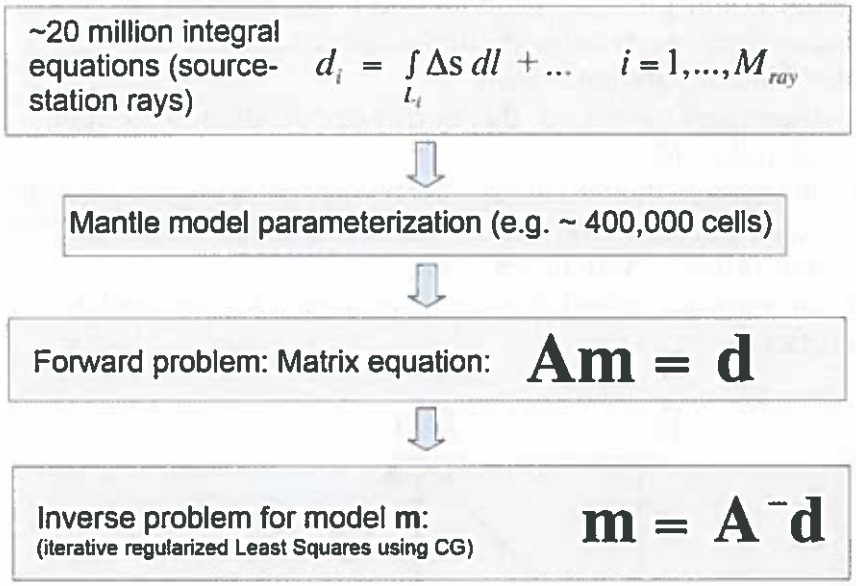
Exam *Geodynamics* course (Part II) ; 05-04-2017
Teachers: Spakman & van Hinsbergen.

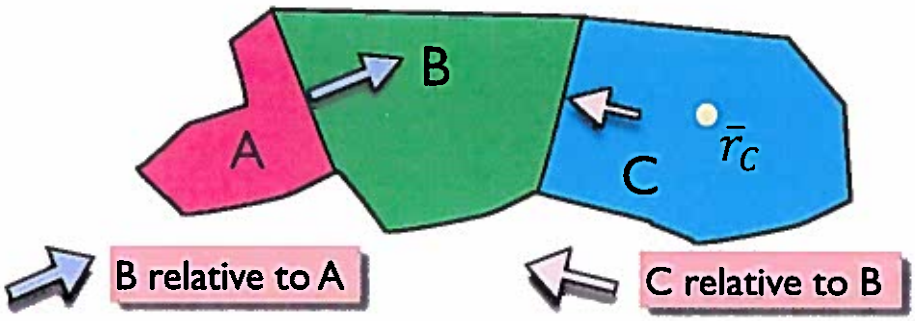
- *Write clearly. If we cannot read it, we cannot judge it!*
- *You may answer in Dutch or English.*
- ***Be extensive** in presenting your argumentation using scientific reasoning such that you demonstrate your understanding of the subjects.*
- *All 4 questions are of equal weight*
- *There is one **bonus question**. This may only help those that did not score sufficiently on the first 4 questions.*

Question 1 *(10 points)*:
This question concerns the general scientific reasoning underlying delay-time (or travel-time) tomography. Four basic tomography steps lead from observation to Earth model. This is schematically displayed in the figure below and was presented in detail during the course.
Discuss in a schematic way the assumptions and approximations involved in these steps. You can use formulas to illustrate your analysis.

Tomography steps (schematically)



Question 2 *(10 points)*:
Usually we only know the relative movement between adjacent plates. Consider 3 plates A, B, and C (see next Figure). Arrows indicate the relative displacement of a plate relative to the adjacent plate during a certain period Δt.
Derive these equations (all symbols are as used in course-materials).



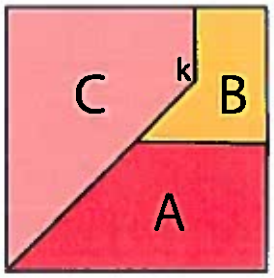
$$\overline{\Delta r_{CA}} = \overline{\Delta r_{BC}} + \overline{\Delta r_{AB}}$$

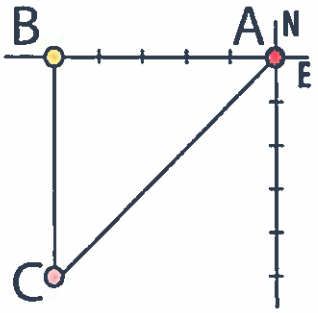
$$\overline{\Delta r_{CA}} = (\boldsymbol{R}_{BC}(\Omega_{BC}) + \boldsymbol{R}_{AB}(\Omega_{AB}) - 2\boldsymbol{I})\,\bar{r}_C$$

Question 3 *(3 + 5 + 2 points)*:

a) A plate rotated over 30 degrees clockwise along an Euler pole between 60 and 20 Ma. You found a sedimentary section, the lower part of which was deposited 60 Ma ago, and the upper part 20 Ma ago. You have obtained an excellent paleomagnetic direction for both times, corrected for all paleomagnetic artifacts, such as inclination shallowing. What the apparent polar wander path look like if:
I) the plate you sampled moved 30° due northward relative to the spin axis between 60 and 20 Ma;
II) the plate you sampled moved 60° due northward relative to the mantle between 60 and 20 Ma, but there was 30° motion to the south due to TPW (assume constant rates for both processes)
III) the plate you sampled moved due westward over 23.4° without a vertical axis rotation.

b)

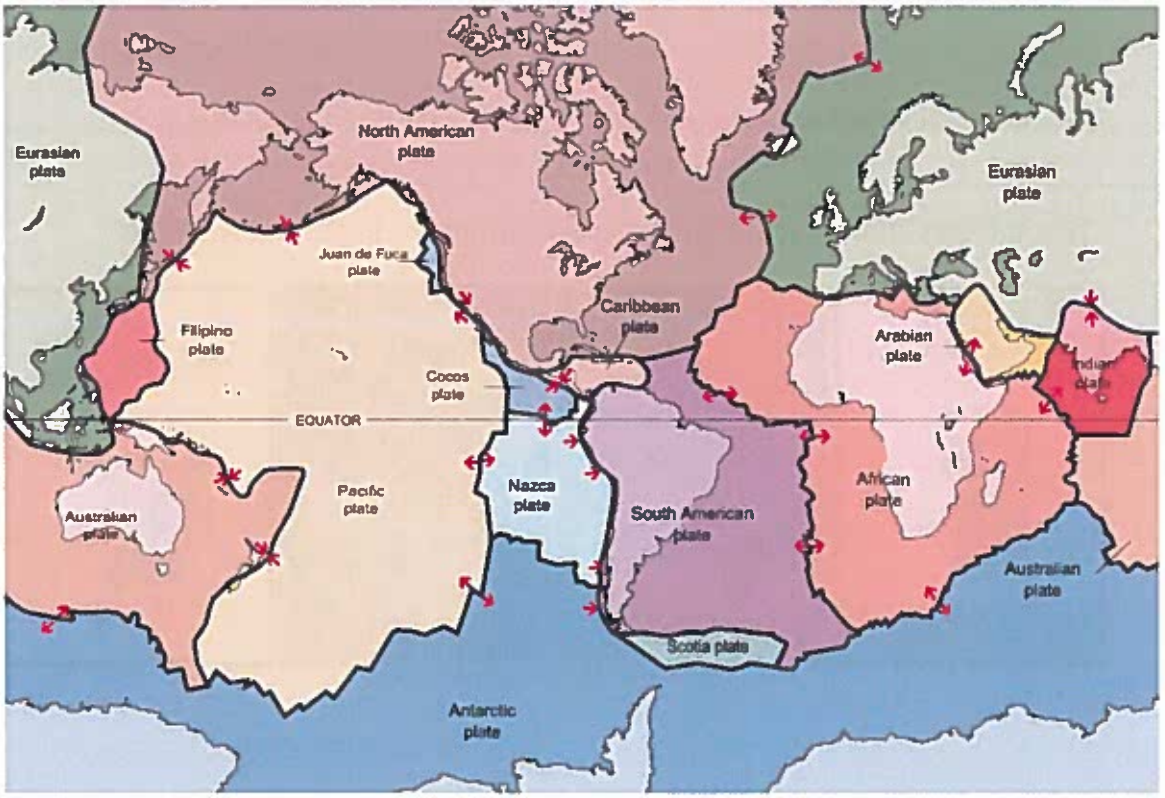




Consider the plates above, and the associated velocity diagram. Indicate the nature of the plate contacts. If subduction is involved, show for which subduction polarity triple junction ABC becomes stable. (1 point)

Show that when the triple junction ABC arrives in kink k an instable triple junction will form. (2 points)

Show **two** possible solutions how out of that instable triple junction a stable plate kinematic situation might arise. (2 points)



c)

An Indonesian geologist wants to know the rate of subduction of Australia below Eurasia, e.g. below the island of Java. He or she has access to all magnetic anomalies and fracture zone patterns of the world's oceans and is aware how to build a quantitative plate circuit. Which plate circuit should be constructed to assess the rate of plate convergence at Java? To answer this question, you can assume that the plate configuration shown in the above figure.

Question 4 *(10 points; 2 per sub-question)*:

You have a global plate circuit at your disposal, as well as a paleomagnetic reference frame, a slab-fitted reference frame, a LIP/kimerlite/LLSVP fitted reference frame, and a moving hotspot reference frame. Which reference frame (or frames) is or are appropriate to study,

a) Dynamic topographic subsidence as a result of sinking of the Bitterroot slab below western North America in the Miocene;
b) Paleogeographic boundary conditions for a paleoclimate model to study the Middle Eocene Climate Optimum;
c) The influence of absolute plate motions on the Lesser Antilles slab in the Miocene;
d) Absolute plate motion of the Colorado craton in South America relative to the Kaapvaal craton in South Africa in the Silurian.
e) Absolute motion of the Caribbean plate in the Early Cretaceous, around 130 Ma

Question 5 *(bonusquestion, 2 points)*:

What process is Earth undergoing here to annoy this poor field geologist?