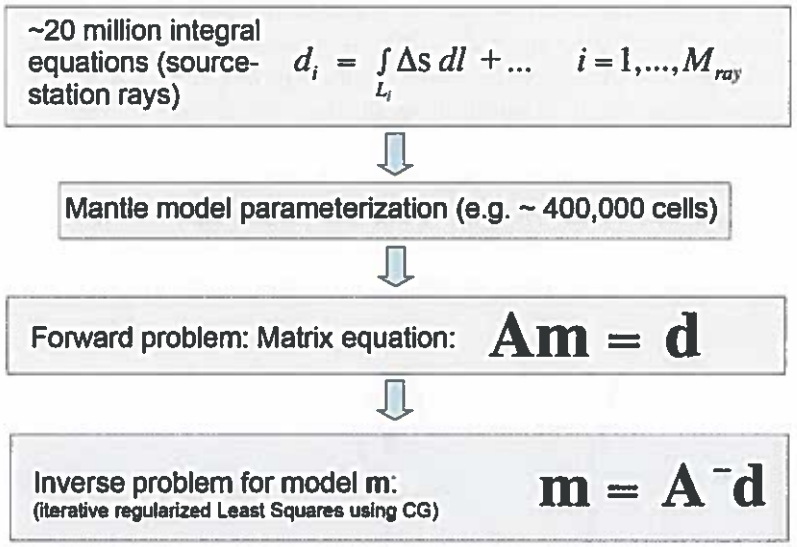
Exam *Geodynamics* course (Part II) ; 13-04-2016
Teachers: Spakman & van Hinsbergen.

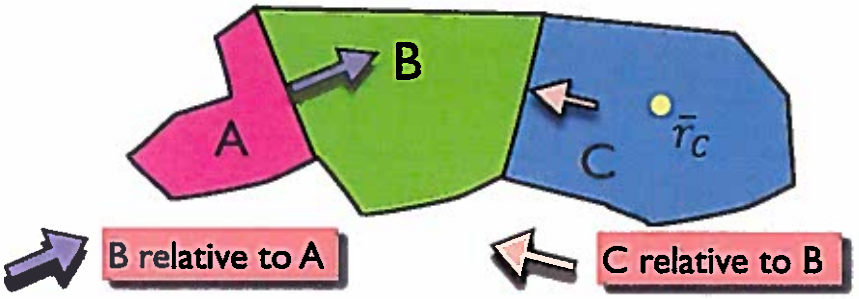
- *Write clearly. If we cannot read it, we cannot judge it!*
- *You may answer in Dutch or English.*
- ***Be extensive** in presenting your argumentation using scientific reasoning such that you demonstrate your understanding of the subjects.*
- *All 4 questions are of equal weight*
- *There is one **bonus 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).



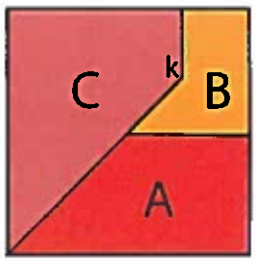
$$\overline{\Delta r_{CA}} = \overline{\Delta r_{BC}} + \overline{\Delta r_{AB}}$$

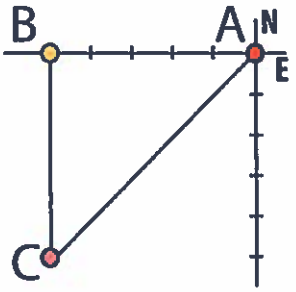
$$\overline{\Delta r_{CA}} = (\boldsymbol{R}_{BC}(\Omega_{BC}) + \boldsymbol{R}_{AB}(\Omega_{AB}) - 2\boldsymbol{I})\bar{r}_C$$

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 will that dataset show you if:
I) the rocks you sampled were deposited at that Euler pole;
II) the Euler pole lies 90° away from your section and coincides with the north pole;
III) the Euler pole lies 90° due west of your section and is located at the equator.

b)

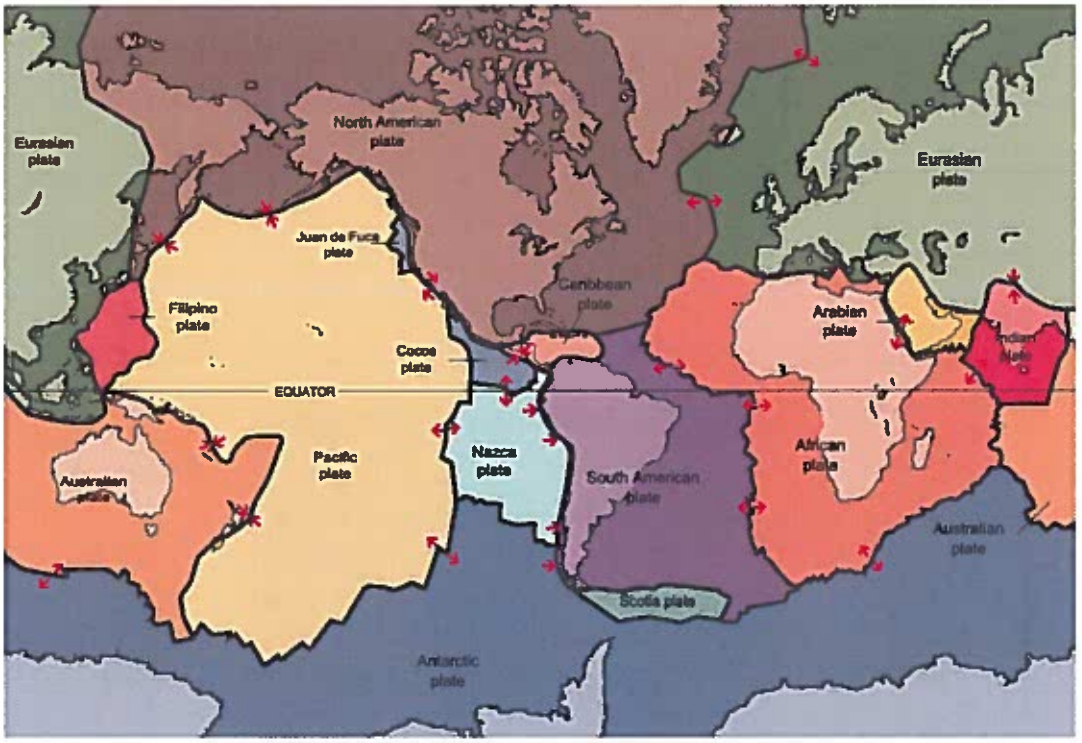




Consider the plates above, and the associated velocity diagram. Indicate the nature of the plate contacts. If subduction is involved, show for which subduction polarity triple junction ABC becomes stable. (1 point)

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

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



c)

A Canadian geologist wants to know the rate of subduction of the Juan de Fuca plate below Vancouver Island since, say, the Miocene. 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 he or she construct to assess the amount of plate convergence across the West-Canadian subduction zone? To answer this question, you can assume that the plate configuration shown in the above figure has not changed since the Miocene.

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, a TPW-corrected reference frame, and a moving hotspot reference frame. Which reference frame (or frames) is or are appropriate to study the following processes:

a) Dynamic topographic subsidence as a result of sinking of the Welford slab below NE Australia in the Miocene;
b) Paleoclimate change in the Oligocene
c) The influence of absolute plate motions on the Scotia Sea slab in the Pliocene;

d) Rates of plate motions between the Pilbara and Kaapvaal cratons in the Devonian, during which period diamond-bearing volcanic rocks were formed on both continents;
e) The rate of Arabia-Eurasia convergence between 80 and 53 Ma

Question 5 *(bonusquestion, 2 points)*:

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