CEG3707 – PRACTICAL 1

TECTONIC PLATE MOTIONS

The purposes of this practical are (i) to practice the computation of tectonic velocities using 'absolute' Euler vectors; and (ii) to compute and analyse velocities at plate boundaries using 'relative' Euler vectors. You will need to refer to your notes and handouts for some of the formulae.

You are given (via Canvas) a template spreadsheet to organise your working. *Green* cells should be used to input values of parameters, and *blue* cells should contain formulae that use those values. *Grey* cells are for for intermediate formulae (if you need to use them, e.g. for converting angles to radians). All other cells should stay blank.

To demonstrate your satisfactory completion of the practical, you should complete the online quizzes on Canvas, and as part of these upload a copy of your finished spreadsheet. Numbers in square brackets below refer to items in the quiz. Because Canvas only gives feedback after you submit a quiz, it is split into seven parts (A-G) so you can get rapid feedback on the earlier parts of the exercise to help you correct any errors in your working. You can resubmit each part of the quiz as many times as you like before the deadline; only your final version will count.

Motion within the Eurasian plate

The formulae in the lecture notes give the Cartesian geocentric velocity (*dX, dY, dZ*) of a point in terms of its position vector and the Euler vector of the plate. To express the movement in a topocentric system (local east, north, up movement: *dE, dN, dU*), you will need these additional relationships:

$$\begin{aligned} dE &= dY\cos\lambda - dX\sin\lambda \\ dN &= dZ\cos\phi - dXY\sin\phi \\ dU &= dXY\cos\phi + dZ\sin\phi \\ \text{where}\quad dXY &= dX\cos\lambda + dY\sin\lambda \end{aligned}$$

These relationships hold for any small change in coordinates (velocity is just a small change per year). Remember, latitude ϕ is defined as positive for N, negative for S; similarly longitude λ is defined as positive for E, negative for W.

(1) The ITRF2005 Euler pole for Eurasia is at 56.330°N, 95.979°W with a rotation rate ω of 0.261°/Myr. Use this to compute the topocentric velocities of the following points:

Greenwich	51.5°N, 0.0°E
Land's End	50.1°N, 5.6°W
John O'Groats	58.6°N, 3.0°W

After step (a) below, you should do steps (b)-(e) first for Greenwich, then copy the formulae in the relevant cells to other rows for the rest of the sites.

(a) In the upper main box, enter the Eurasia plate details, compute the unit vector e for the Euler pole location, and hence calculate the Euler vector Ω (remembering to convert ω to rad/Myr). **[A1,A2,A3]**

(b) In the lower main box, enter the site details in the appropriate row and copy (or cross-reference) the values of the Euler vector components in the relevant columns. Compute the position vector for each site (using its unit vector and the Earth radius R = 6371 km). **[A4,A5,A6]**

(c) Hence compute the site velocity in geocentric coordinates, using the vector product ("cross product") of the Euler and position vectors. Check your units! **[B1,B2,B3]**

(d) As a check, compute the total speed (magnitude of the velocity vector); also compute the quantity *dXY* as defined above. **[B4]**

(e) Use the above formulae to compute the velocity in local topocentric coordinates. **[C1,C2,C3]**

(f) Are you surprised by the vertical velocity? Why does it have this value? **[C4]**

(g) Check again by recomputing the total speed using the topocentric velocity vector. **[C5]**

(2) What do the differences in topocentric velocity (and speed) between the sites in Question 1 represent? Do these differences imply that Great Britain is deforming tectonically? **[D1]**

(3) Compute also the topocentric plate tectonic velocity for the individual location given to you in the Canvas quiz. Note that each time you attempt it, the location may change. This is the most important question, because it shows that you haven't just copied/fiddled the spreadsheet! **[D2]**

Relative Euler vectors and plate boundaries

The ITRF2005 Euler pole for the Nubia plate (western and central Africa) is at 49.955°N, 82.501°W with a rotation rate of 0.269°/Myr.

(4) (a) Compute the Euler vector for Nubia. Hence, using the Euler vector for Eurasia from Part A, compute the relative Euler vector for Nubia with respect to Eurasia. **[E1,E2,E3]**

(b) What is the relative rotation rate, and what are the latitude and longitude of the relative Euler pole? **[E4,E5,E6]**

(5) (a) What is the relative long-term plate velocity (topocentric, with respect to Eurasia) of Nubian lithosphere, in the vicinity of the plate boundary at Gibraltar (36.0°N, 5.5°W)? **[F1,F2]**

(b) If the plate boundary runs E-W, what style of deformation will occur there? **[F3]**

This practical forms part of the compulsory assessed coursework and is worth up to 4% of the total CEG3707 module mark (as part of the 15% practical report mark). For maximum credit, you must complete the online quizzes in Canvas including uploading your completed spreadsheet **[G1]** by the date and time below. The work is not formally graded, but a partial mark may be given for a very incomplete attempt, or zero for a woefully incomplete one.

PJC, Oct 2024

CANVAS QUIZ DUE: Mon 28 Oct 2024 (2pm)