GEOLOGY 220: TECTONICS
Homework: Euler poles

INTRODUCTION

Euler poles are very useful ways to understand the relative motions between plates. In this exercise, you'll be investigating the relative motion between the Pacific and Australian plates and how it has affected tectonics in New Zealand over the past 4 m.y. You'll also have the chance to predict the locations of Euler poles for two other pairs of plates.

PACIFIC -AUSTRALIAN PLATE MOTION

Note that the boundary between the Pacific and Australian plates is marked on the attached map between 30˚S and 53˚S. This boundary runs through the North and South Islands of New Zealand. Points east of the line lie on the Pacific plate; points west of the line lie on the Australian plate. The location of the current Euler Pole for the movement of the Pacific plate relative to the Australian plate according to DeMets (1994): *60.1˚S; 178.3˚W* with a rotation rate of 1.07˚ counterclockwise per million years.

To figure out the relative motion plate motions over the past 4 m.y.:

a. Plot the location of the Euler pole on the map provided.
b. Mark points lightly in pencil on the boundary at every degree of latitude between 36˚S and 53˚S.
c. For each point you plotted, draw a light pencil line from the Euler pole to the point, measure the distance (in mm) from the point to the Euler Pole and enter it in column 2 of the attached table.
d. Fill out column 3 of the table. When converting your measured mm to degrees of latitude. Measure 20 degrees of latitude along a meridian (e.g. 180˚E) in mm and determine your scale factor. (You may want to enter your answers into an Excel spreadsheet instead of the attached table.)
e. Fill out column 4. This calculation can be done by taking:

   sin (D) * radius of Earth * rotation rate,

   where D is the value from column 3 and the rotation rate is in radians/m.y. This value is the displacement of the plate boundary point in km/m.y.
f. Fill out column 5. Find the magnitude of displacement for 4 m.y. and convert this distance (km/4 m.y.) into mm for the map.
g. Now, at each of your points on the plate boundary, draw a line perpendicular to the line from the Euler pole to that point, of a length equal to the length (in mm) from column 5 in your table. (It should be ~ 5 mm.) We are winding the Pacific plate back 4 My, so it runs east from the current boundary.
h. Draw a line connecting the ends of the lines at each point. This shows where the rocks now at the plate boundary were 4 m.y. ago.

QUESTIONS: Answer the following questions on a separate piece of paper (typed answers are preferred). Include some brief text explaining your answers.

1. How much Pacific plate has been subducted at latitude 39˚S? In this case, subducted means material consumed perpendicular to the boundary.

2. Where along the boundary is the motion approximately transcurrent? What sort of faulting would you expect here?

3. The Alpine fault is the plate boundary for much of the South Island of New Zealand. How much movement has there been on the Alpine Fault in the last 4 Ma? What is the equivalent slip rate in mm/yr?

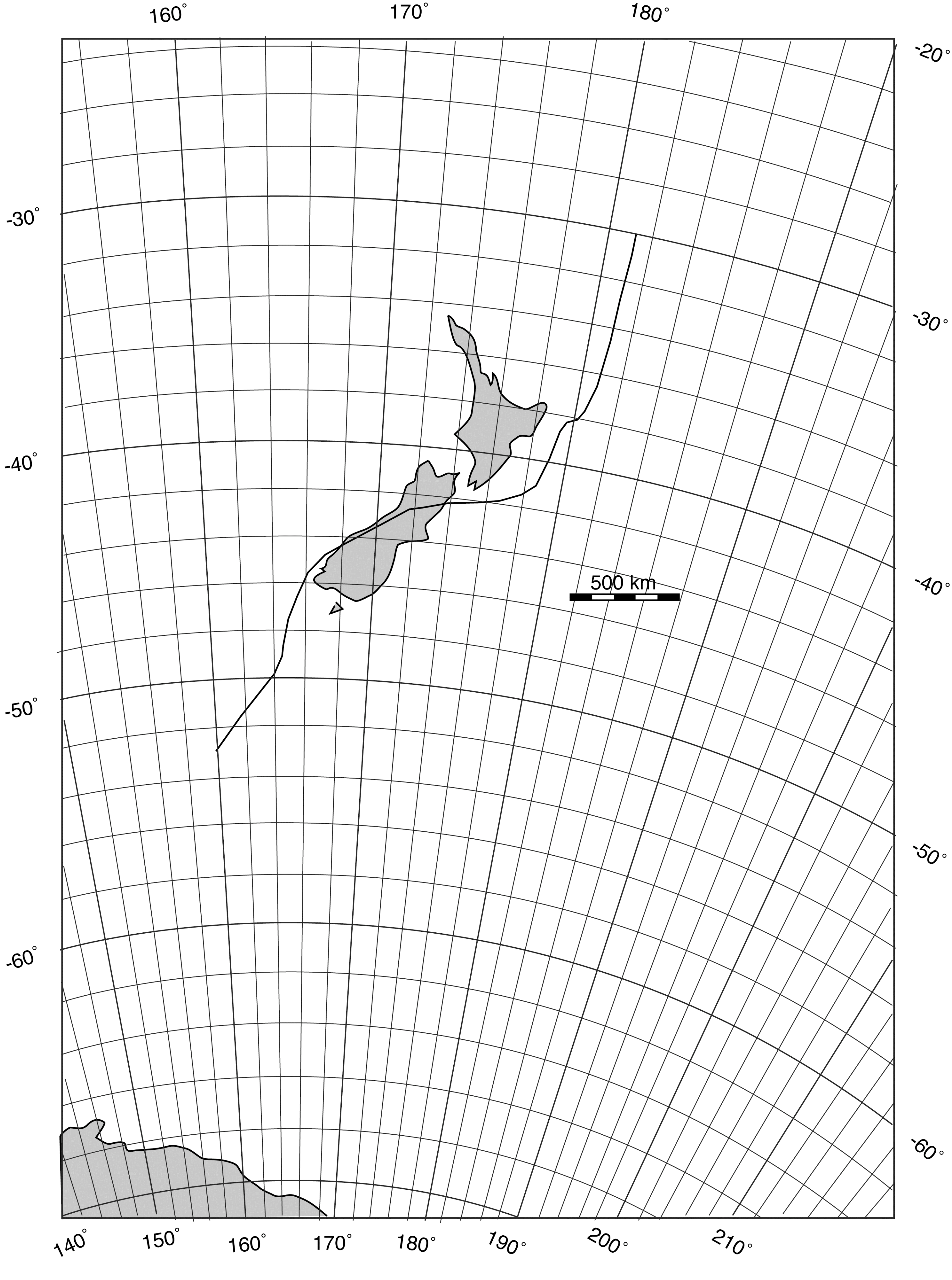
4. How much Australian plate has subducted under Fiordland (45˚S). For this, you'll need to plot the negative of your displacement vector at 45˚ S.

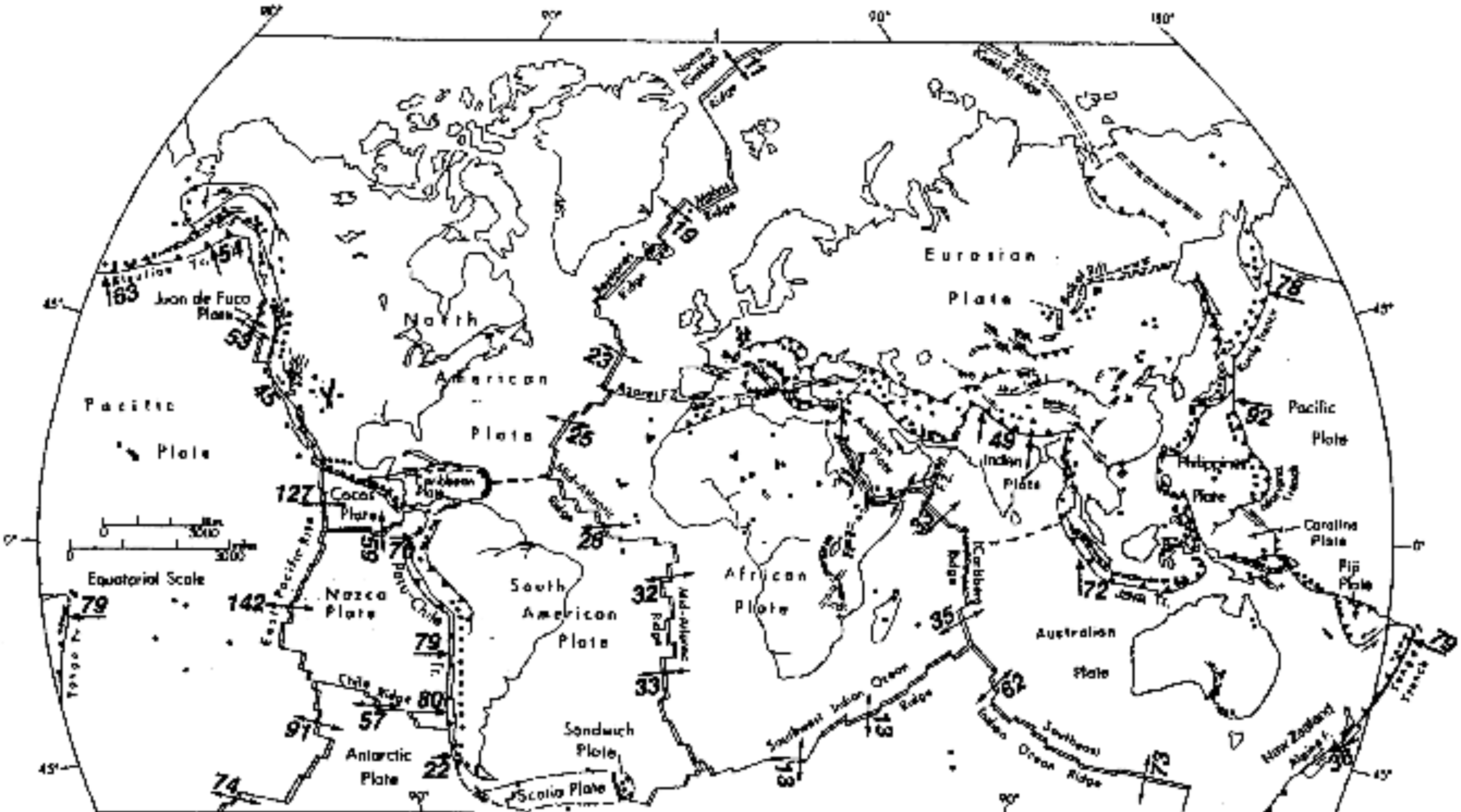
5. Now that you've had a chance to think about the New Zealand example of Euler pole and plate motion, use the world plate boundary map on the last page to predict the location of the Euler Pole and approximate rotation rate around this pole for:

    a. Nazca –South America
    b. North America – Pacific plate

    This will probably need to be an approximate answer – a sort of back-of-the-envelope calculation, so don't stress about it too much. Plot your approximate Euler pole locations on the plate boundary map and explain your reasoning in words. You may need to draw cartoons to help illustrate your answers.

1 point	2 distance	3 converted distance	4 motion/year	5 4 m.y. motion
latitude (˚)	distance from E.P. (mm)	distance from E.P. (˚)	(km/my)	=4*column 4 (mm)


160°
170°
180°
-20°
-30°
-30°
-40°
-40°
-50°
-50°
-60°
-60°
500 km
140°
150°
160°
170°
180°
190°
200°
210°



GLOBAL TECTONIC AND VOLCANIC ACTIVITY OF THE LAST ONE MILLION YEARS

Paul D. Lowman Jr.
Goddard Space Flight Center Sept 1980

Van der Grinten Projection
Physiography from "The Physical World," © 1975 by the National Geographic Society.

Revised 1996 by T. Atwater

Plate Boundary Map

Rates are in mm/yr or km/my

LEGEND

- Active ridges and continental extensions; minor transform faults generalized
- Spreading whole rates and subduction rates from De Mets, et al., 1994, NUVEL-1A Model
- Major active fault or fault zone, dashed where nature or activity uncertain
- Normal fault or rift; hachures on downthrown side
- Reverse fault (subduction or overthrust zone), barbs on upthrown side
- Volcanoes active within the last 1 million years; generalized (some isolated basaltic centers omitted)