Aim: To Investigate the relationships between earthquake data (focal depth, magnitude, and distance from plate boundaries) using data on Google Earth™

For this exercise you will need to select a suitable plate boundary to investigate subduction (e.g. Nazca – South American plate subduction) to compare with a non-subduction boundary (e.g. Transform – San Andreas Fault).

You will need to use a suitable sampling technique (but this depends upon the number of earthquakes available) to select individual epicentres.

A random or systematic sample can be undertaken on data coloured by age (all the same colour) or a stratified sample on data coloured by depth. In reality, all data may have to be collected if data points are limited.

For each chosen epicentre you will need to record two variables:

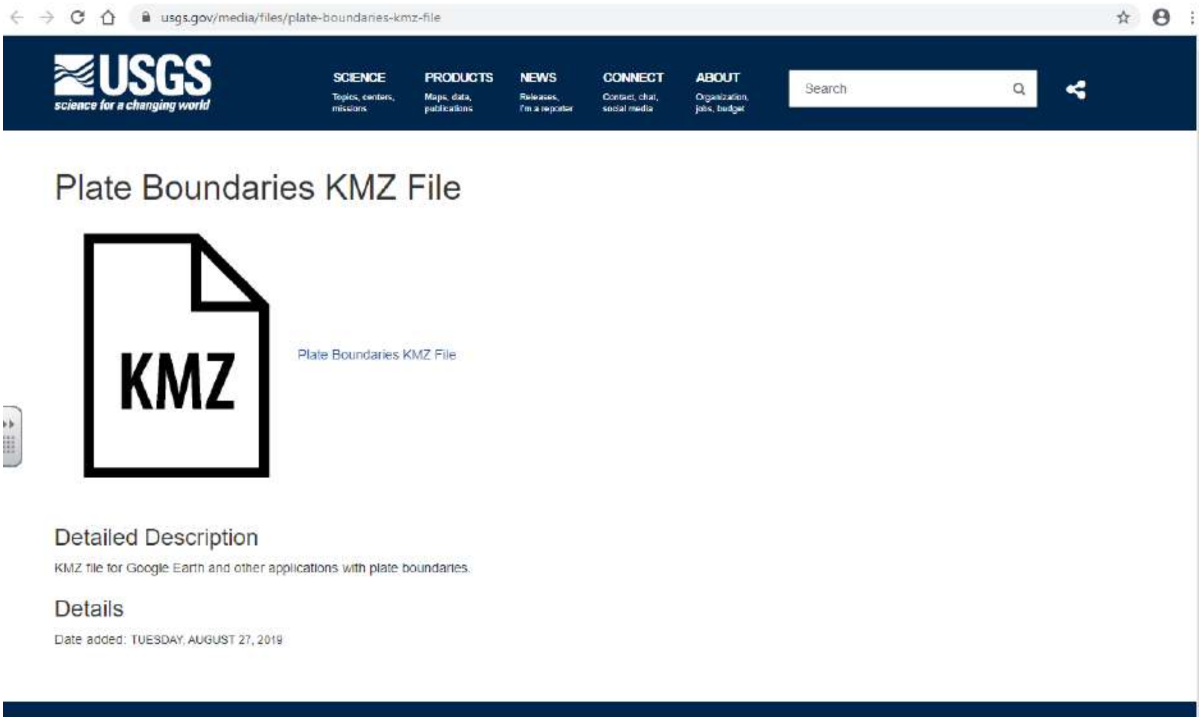
- **depth** (obtained by clicking on the epicentre)
- **distance** to plate boundary on surface (e.g. trench, mid ocean ridge, transform fault)

Ideally a minimum of **30** should be recorded for significant analysis.

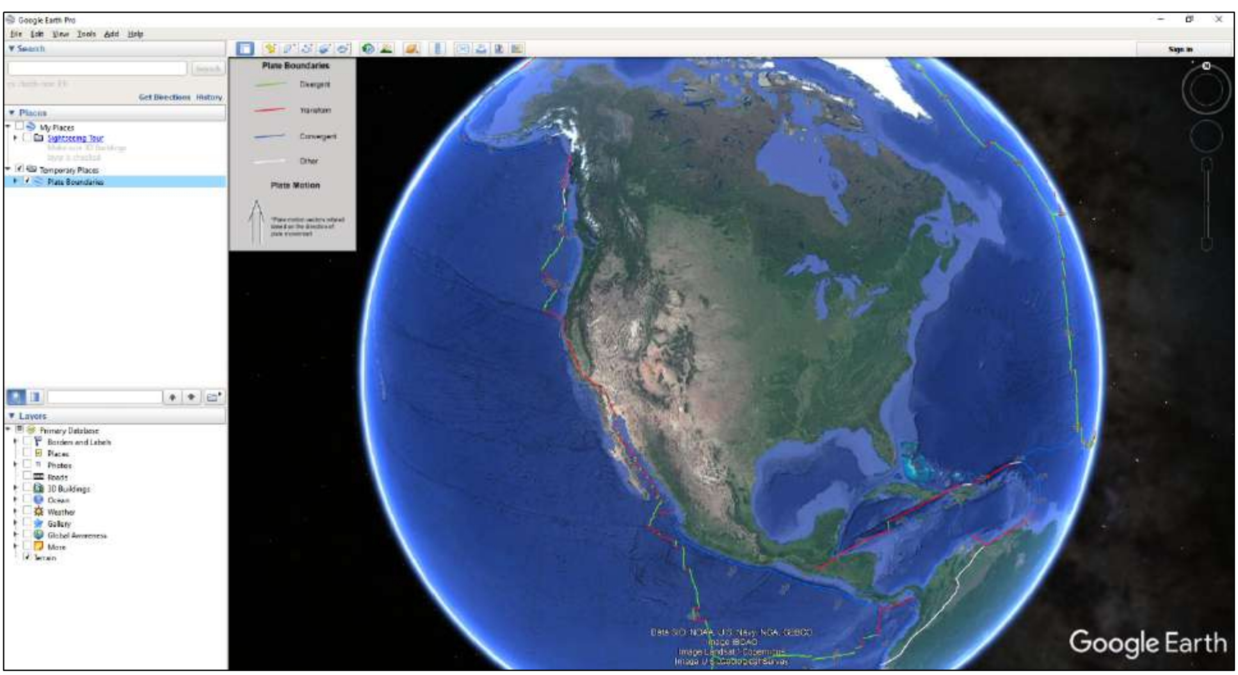
Instructions to get set up:

1. Open Google Earth by accessing the start menu, locate Google Earth from the programmes list and double click. If this isn't installed, the IT department will be able to install it for you.

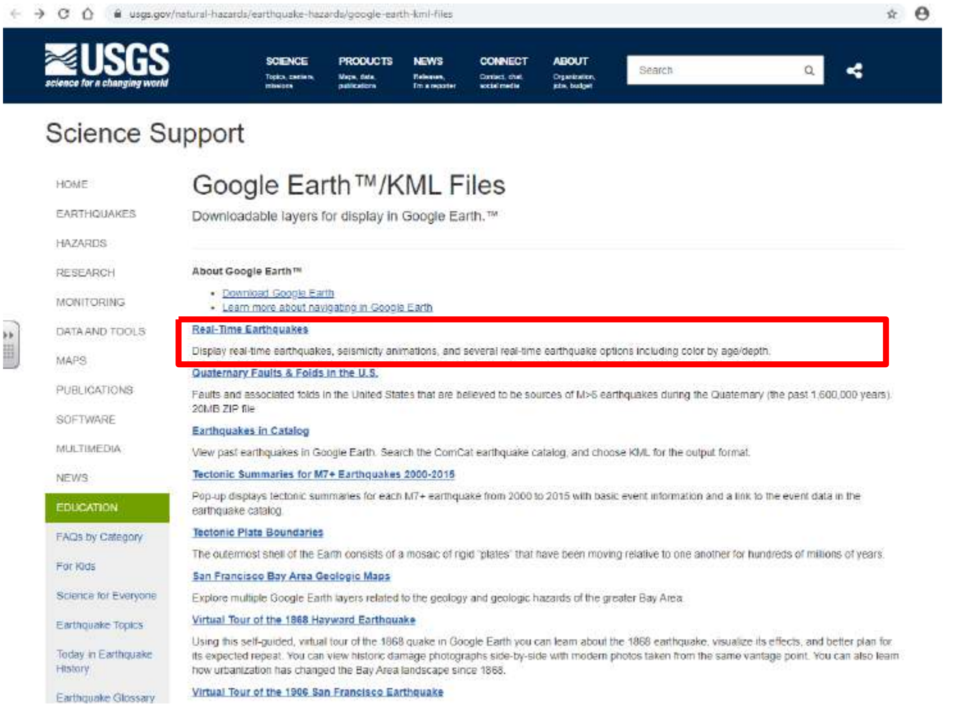
2. Download the "Tectonic Plate Boundaries" file by clicking the link on: https://www.usgs.gov/media/files/plate-boundaries-kmz-file (or just Google USGS Plate Boundary KMZ files)



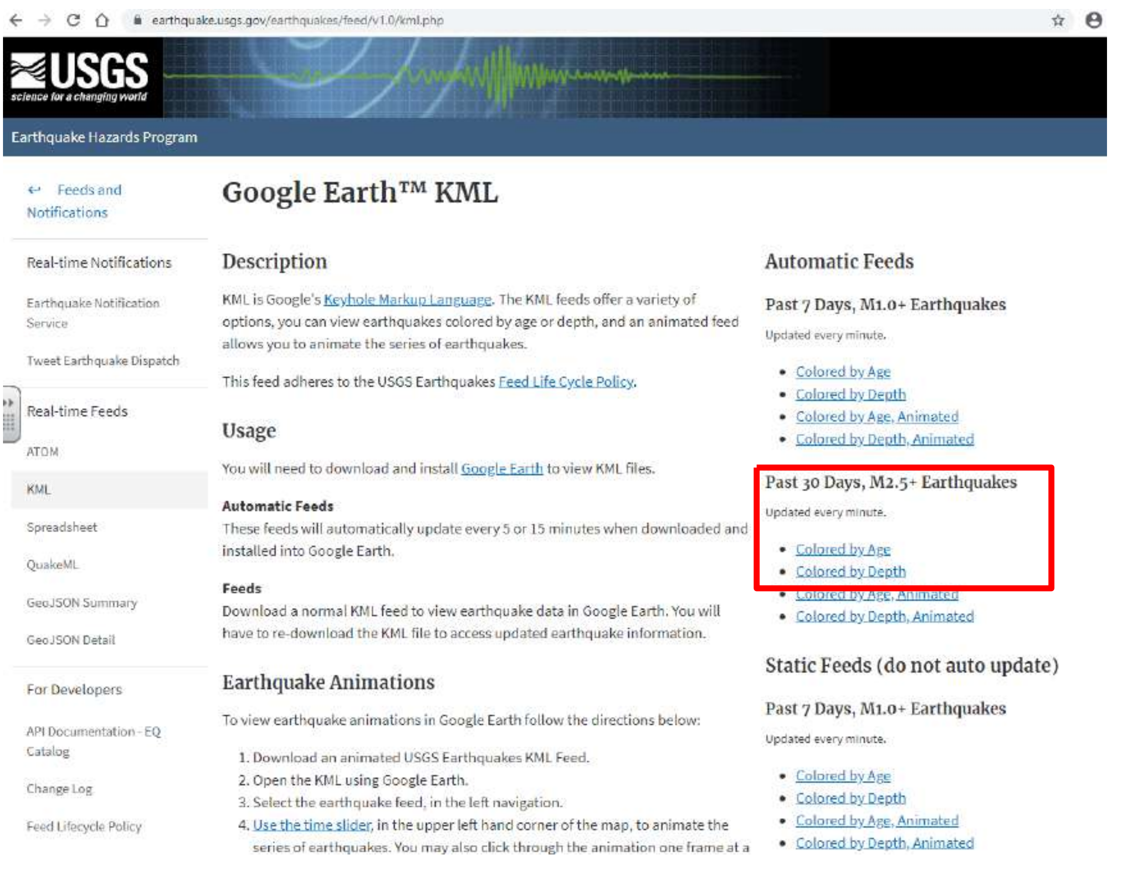
3. Once the "plate-boundaries.kmz" file has downloaded, double click it. This should open a "Temporary Places" layer called "Plate Boundaries" and the plate boundaries should be visible on the Earth image. **Note the different colours in the key!**



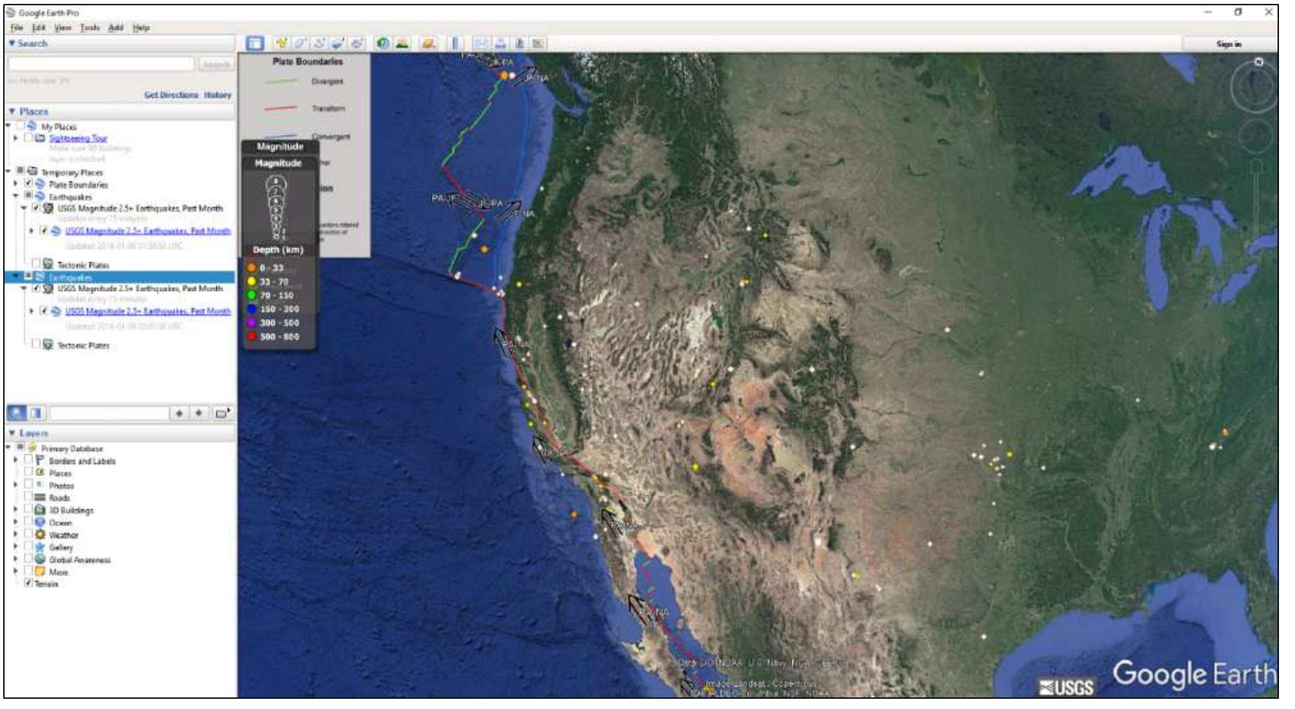
4. Go to https://www.usgs.gov/natural-hazards/earthquake-hazards/google-earth-kml-files and this time select the "Real-Time Earthquakes" link



5. On the right hand side of the screen are a number of automatic feeds which can be downloaded. It is recommended that under the "Past 30 Days M2.5+ Earthquakes" header, both the "Colored by Age" and "Colored by Depth" files are downloaded by clicking the relevant links.

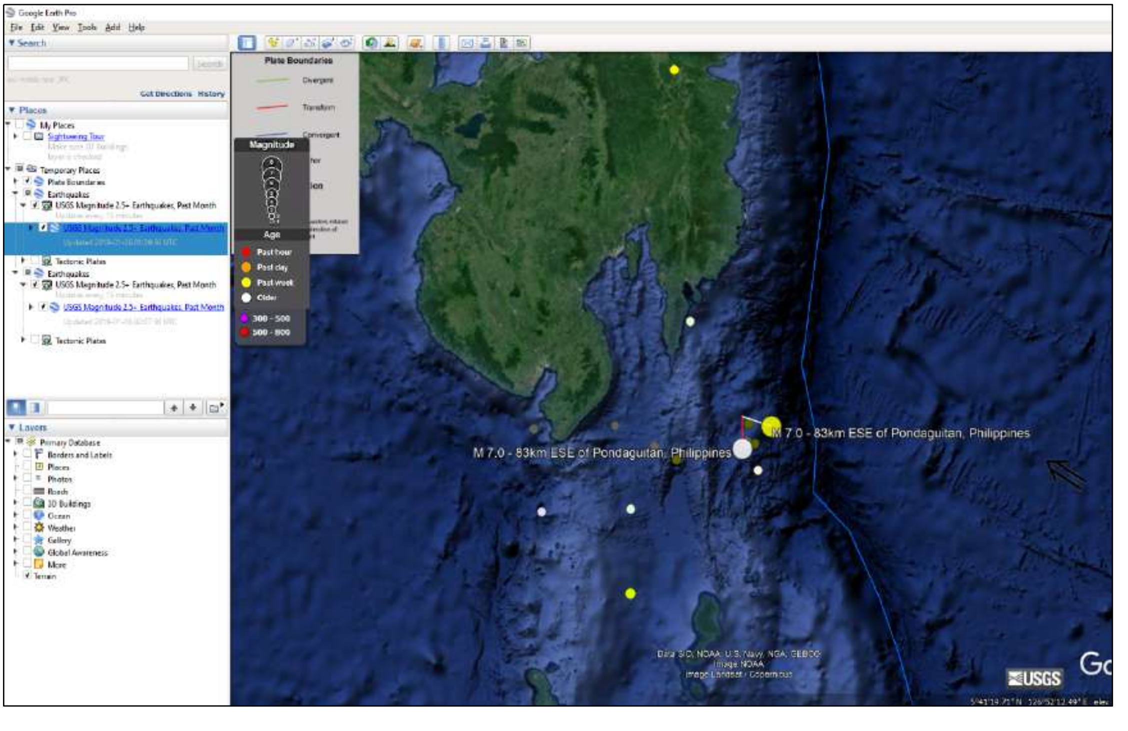


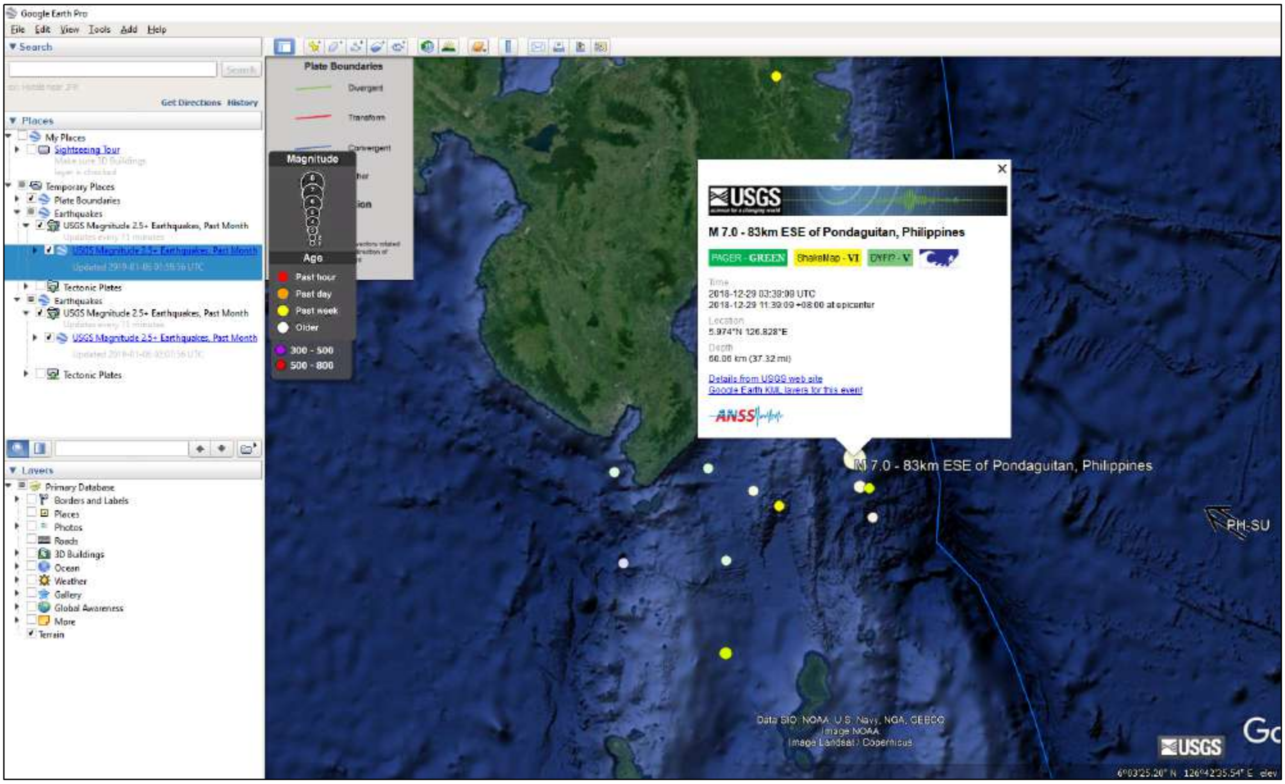
6. When both files (“2.5_month_age_link.kml” and “2.5_month_depth_link.kml) have downloaded, double click them. This should add two additional temporary layers to Google Earth as well as an additional two keys.



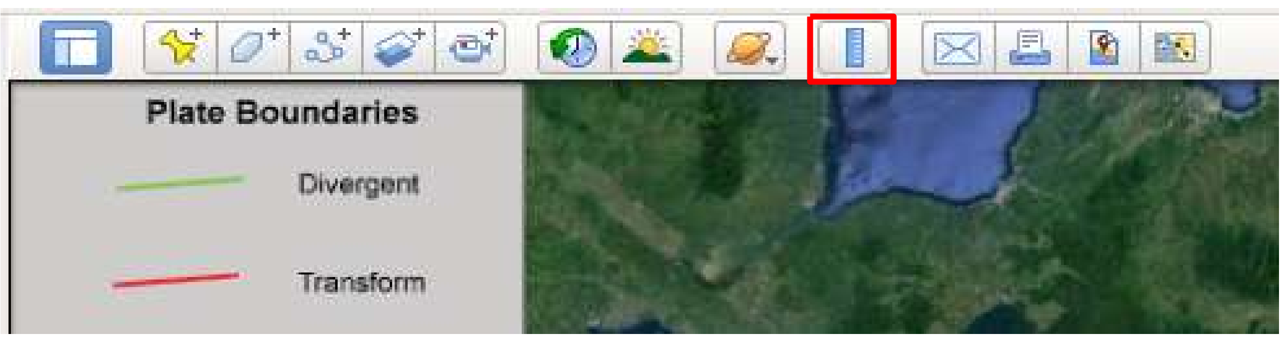
7. Unfortunately there is no way to drag or move the keys around the screen to prevent them from overlapping each other. To bring a particular key to the front, uncheck, then re-check the tick box next to that layer in the temporary places pane on the left of the screen.

8. To view the earthquake information, hover the cursor over the coloured dot, click on it, then click on the epicentre that you wish to view. You will then find the depth in the pop-up box.

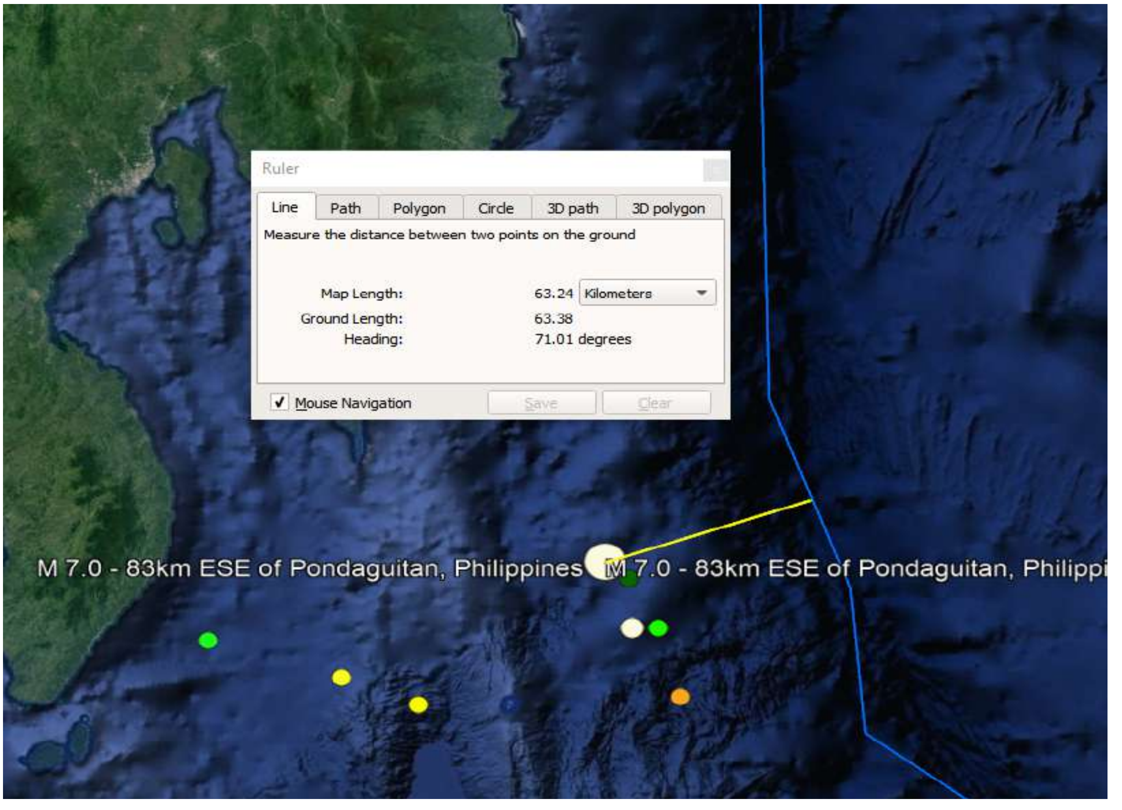




9. To measure the distance of the epicentre from the plate boundary, click the “Show Ruler” button from the top toolbar.



10. Using the target that appears, click on the middle of the epicentre circle. Releasing the mouse button, move the cursor to the nearest plate boundary and click the left mouse button again. To determine the most accurate distance, **the yellow line that is drawn should be at 90º (perpendicular)** to the plate boundary line.



11. Click on the path tab to see the distance covered by your line. You may wish to change the units using the drop down menu. When you have recorded the Ground Length distance, press the “Clear” button. You can now return to point 8 and repeat steps 8 to 11.

12. Record your data in the tables later on in this booklet. At the very least collect 30 data pairs for one boundary.

Analysis:

To analyse your results you must complete two tasks:

- Plot your data onto a **scatter graph** to show correlation with a line of best fit
- Apply a **statistical test** to confirm significance e.g. Spearman’s Rank Correlation Coefficient

Data table for the non-subduction zone plate boundary

Earthquake	Depth to focus (km)	Rank	Distance to plate boundary (km)	Rank	Difference (d)	Difference squared (d^2)
1	-11.71		102.84			
2	-8.36		48.96			
3	-3.13		170.87			
4	-4.80		145.11			
5	-7.10		136.90			
6	-8.17		126.69			
7	-8.14		60.61			
8	-10.39		3.00			
9	-26.35		24.57			
10	-23.47		18.80			
11	-8.60		4.85			
12	-10.41		4.85			
13	-24.36		29.09			
14	-22.14		55.74			
15	-11.97		139.42			
16	-10.98		99.60			
17	-6.09		94.90			
18	-16.00		16.40			
19	-24.01		14.63			
20	-4.38		0.15			
21	-16.00		4.27			
22	-3.10		4.18			
23	-3.10		4.06			
24	-14.21		2.21			
25	-13.30		2.21			
26	-13.69		59.05			
27	-5.73		55.81			
28	-9.13		0.78			
29	-10.58		0.88			
30	-3.98		2.58			

$\Sigma=$

Data table for the subduction zone plate boundary

Earthquake	Depth to focus (km)	Rank	Distance to plate boundary (km)	Rank	Difference (d)	Difference squared (d^2)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
						$\Sigma =$

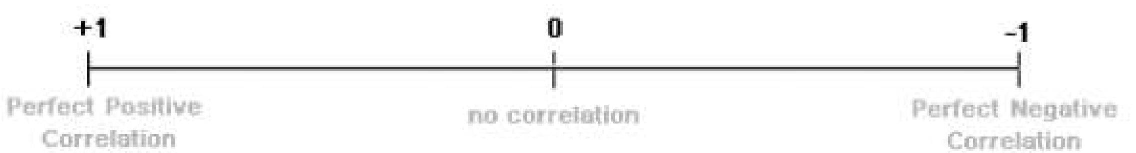
The Null Hypothesis (H0) is that "there is no significant correlation between the depth of earthquake foci and distance of the epicentres from the plate boundary".

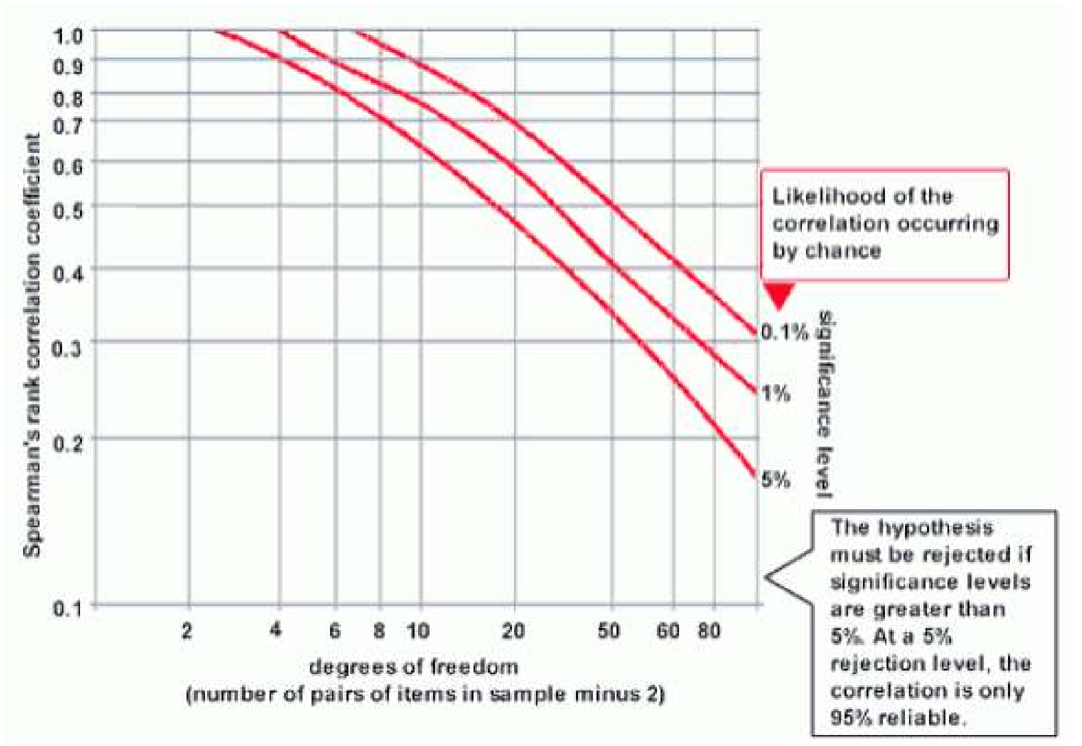
Can this be rejected? What is the probability that this correlation could have occurred by chance?

Use your data for <u>both</u> plate boundaries and the equation below to find out:

$$r_s = 1 - \frac{6\Sigma d^2}{n^3 - n}$$

Non-subduction zone:
Subduction zone:





Evaluation:

Finally you can now undertake a critical evaluation.

Think about the effectiveness of:

- Your sampling method

- Your data collection method
  (considering the scale you're working at)
  - e.g. measuring from epicentre to plate boundary
  - e.g. position of plate boundary on the surface

- How you have analysed the results