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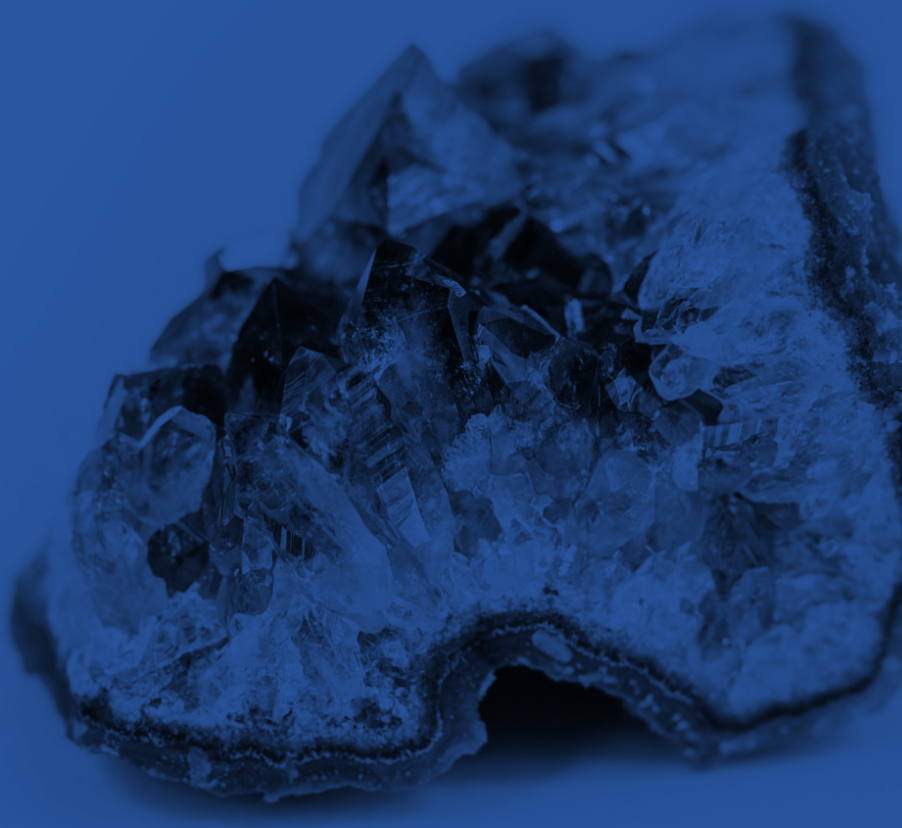
GEOLOGY

SP19: Investigation of the relationships between earthquake data (focal depth, magnitude and distance from plate boundaries) using data on Google Earth™



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Title SP19: Investigation of the relationships between earthquake data (focal depth, magnitude and distance from plate boundaries) using data on Google Earth™

Specification reference: F4.2b

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

Apparatus:
Google Earth Files on computer

Preparation:

1. Download and install **Google Earth** (https://www.google.com.earth/download).

2. Download and install the KML file "**Tectonic Plate Boundaries**" from:

- **Google Earth/KML Files – USGS Earthquake Hazard Program**. (https://earthquake.usgs.gov/learn/kml.php).

3. Download and install the KML earthquake data file from:

- **Google Earth/KML Files – USGS Earthquake Hazard Program**. (https://earthquake.usgs.gov/learn/kml.php)
- Select "**Real-Time Earthquakes**" option

or

- direct from (https://earthquake.usgs.gov/earthquakes/feed/v1.0/kml.php).

4. There are a number of choices (as of December 2016).

Recommended is:

- **Past 30 Days M2.5+ Earthquakes** (automatic feed – updates every 15 minutes)
- Within this there are options for earthquake epicentres to be coloured by **age** or **depth** (both recommended to be downloaded).

Method:

1. Select a suitable plate boundary to investigate subduction (e.g. Nazca – South American plate subduction) or not (e.g. Transform – San Andreas Fault).

2. Using a suitable sampling technique (if required – depending upon the number of earthquakes available), select individual epicentres and record two variables:

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

This can be measured (using the *ruler* from the menu bar) from the epicentre at right angles to the plate boundary or parallel to the direction of relative motion of the plate as indicated – this could lead to good evaluation on the merits of either.

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

(Note: 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, though discussing the options is a good educational experience.)

Analysis:

1. Data can be plotted onto a scatter graph to show correlation. Find the best fit line by eye (or by mathematics – slope of a straight line).

2. Apply a statistical test to confirm significance – e.g. Spearman's Rank Correlation Coefficient.

3. Conclusions; A comparison of contrasting plate boundaries is very profitable e.g. South America v San Francisco.

Evaluation:

A critical evaluation of the data collection and analysis could be undertaken, in particular the sampling method and the measurement from the epicentre to the plate boundary. (Where actually is the plate boundary on the surface? Is this significant at this scale? Should measurement be at 90^{o} to plate boundary or parallel to the direction of plate movement? Is this significant at this scale?)

Additional options:

Is there any correlation between other variables – e.g. magnitude and depth, magnitude and distance from plate margin?

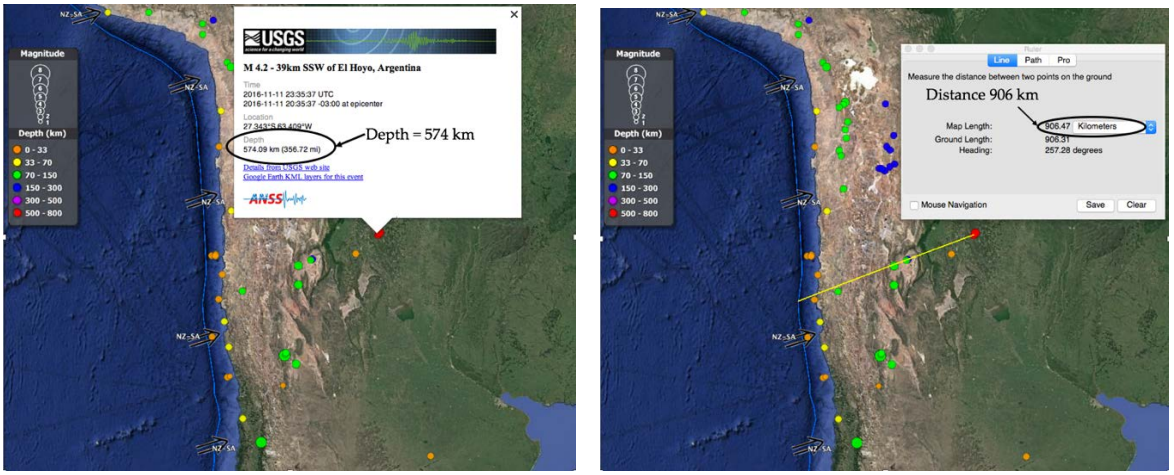
Teacher/Technician notes:

Practical techniques which may be assessed:
J. Use appropriate apparatus to record a range of quantitative measurements (to include mass, time, volume, temperature and length).
M. Use of ICT to:

- Compile and analyse geological data sets through to visualisation using geographic information system(GIS)
- Collect, process and model geological data.

Screen shots (5th December 2016)

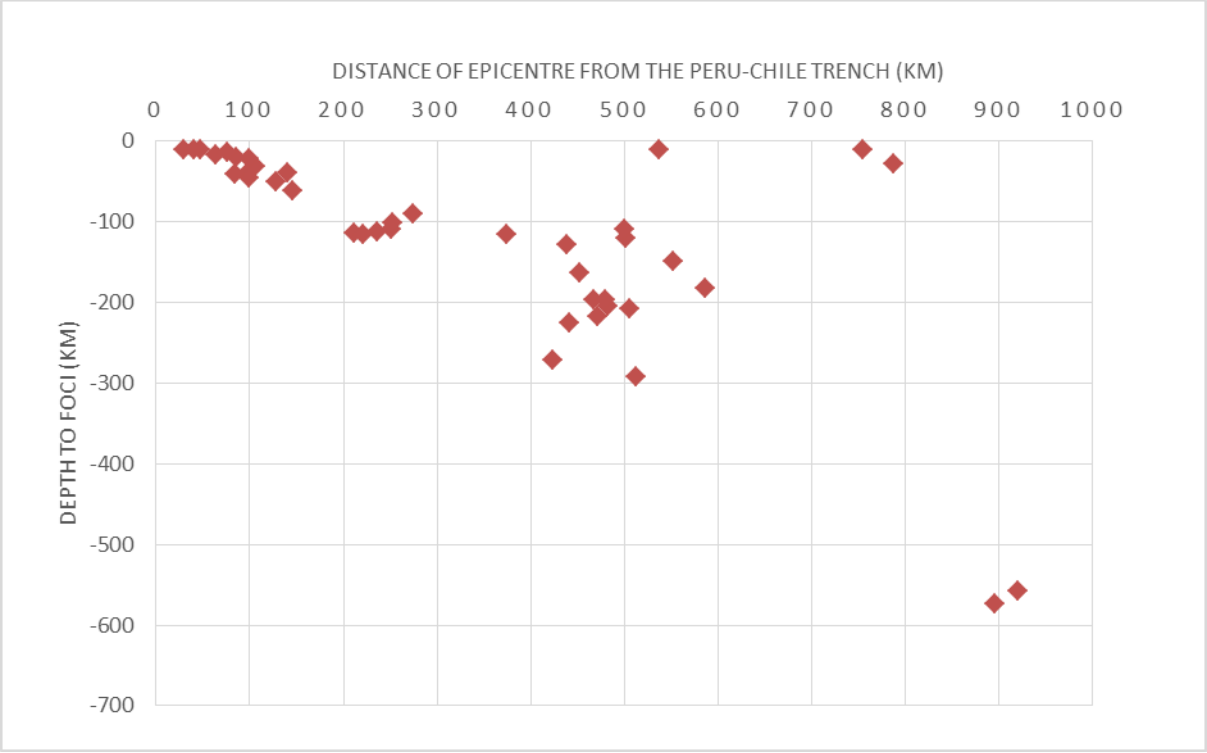
Nazca Plate/South American subduction earthquakes >2.5



www.google.com/earth

Scatter Graph of the relationship between depth of earthquake foci and the distance of epicentres from the Peru–Chile Trench indicating subduction at a convergent plate boundary.

(Data selected from Google Earth on 6th December 2016)



Spearman's Rank Correlation Coefficient

Depth to earthquake foci (km)	Rank	Distance to plate boundary (km)	Rank	Difference (d)	Difference squared (d^2)
-574	1	895	2	-1	1
-558	2	920	1	1	1
-10	38.5	755	4	34.5	1190.25
-28	31	788	3	28	784
-217	6	471	14	-8	64
-292	3	512	8	-5	25
-197	9.5	468	15	-5.5	30.25
-204	8	482	12	-4	16
-208	7	506	9	-2	4
-197	9.5	480	13	-3.5	12.25
-163	12	452	16	-4	16
-225	5	441	17	-12	144
-271	4	423	19	-15	225
-182	11	587	5	6	36
-149	13	552	6	7	49
-121	15	501	10	5	25
-110	20	500	11	9	81
-114	18	211	26	-8	64
-115	17	375	20	-3	9
-128	14	439	18	-4	16
-90	23	275	21	2	4
-109	21	251	23	-2	4
-113	19	236	24	-5	25
-102	22	252	22	0	0
-116	16	221	25	-9	81
-10	38.5	537	7	31.5	992.25
-31	30	106	30	0	0
-21	32	100	31.5	0.5	0.25
-20	33	86	34	-1	1
-10	38.5	29	40	-1.5	2.25
-17	34	64	37	-3	9
-39	29	141	28	1	1
-41	27.5	97	33	-5.5	30.25
-46	26	100	31.5	-5.5	30.25
-61	24	146	27	-3	9
-51	25	128	29	-4	16
-41	27.5	84	35	-7.5	56.25
-14	35	76	36	-1	1
-11	36	48	38	-2	4
-10	38.5	41	39	-0.5	0.25
					$\sum d^2 = 4059.5$

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

r_s = 1− 24357/63960
r_s = 1 − 0.38
r_s = 0.62

This shows a strong positive correlation that is significant at the 99.9% confidence level.

Therefore, the Null Hypothesis (H_0) that *"there is no significant correlation between the depth of earthquake foci and distance of the epicentres from the plate boundary"* can be rejected with a <0.1% probability that this correlation could have occurred by chance.