Student Worksheet: What drives plate tectonics?

POSSIBLE DRIVING MECHANISMS FOR PLATE MOTION

Mantle convection: Convection is driven by heat from the core and involves either the whole mantle or convections cells within the plastic asthenosphere. The upwelling in the convection cells occurs under the Earth's divergent plate boundaries, and cooler material sinks at the convergent boundaries. The lithosphere plates are dragged along by the horizontal flow of the asthenosphere like a conveyor belt.

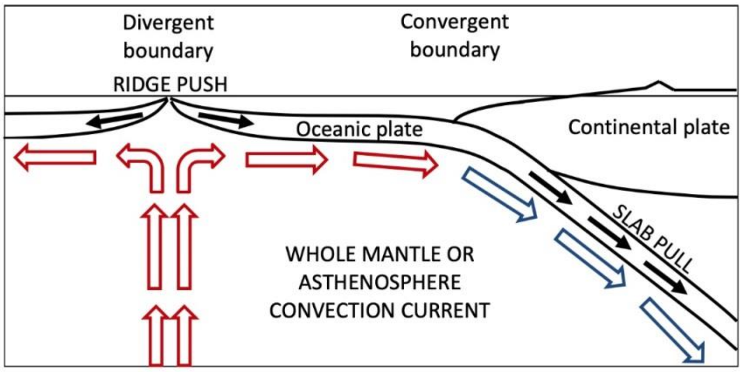


Diagram showing mantle convection, ridge push and slab pull mechanisms

Ridge push: Hot buoyant mantle lifts and pushes the plates apart at mid-ocean ridges where magma solidifies to form new oceanic lithosphere. Gravity pulls the oceanic plates downhill from the ridges towards the deep ocean trenches (or downhill from uplifted continental rift zones like the East African Rift).

Slab pull: Relatively cool and dense oceanic plates (slabs) have negative buoyancy after subducting at ocean trenches and sink into the ductile, less dense asthenosphere, pulling the rest of the tectonic plate along behind it.

Empirical tests (based on observations only) to determine the dominant driving mechanism:

Mantle convection: plate speed should not be related to plate boundary types, and plate speeds should be similar either side of divergent boundaries if convection is symmetric (as presented in Figure 1).

Ridge push: plate speed should be related to the percentage of its boundary that is divergent.

Slab pull: plate speed should be related to the percentage of its boundary subducting under another plate.

Table 1: The relationship between % of a plate boundary subducting or divergent and its speed.

TECTONIC PLATE	AREA (km^2)*	Boundary (km)	Boundary subducting (km)	**% subducting**	Boundary divergent (km)	**% divergent**	**Average speed cm/yr**	Direction
Pacific	103,300,000	46,456	16,311	**35.1**	15,110	**32.5**	**7.5**	WNW
North American	75,900,000	33,670	810	**2.4**	11,740	**34.9**	**1.5**	NW–-SW
Eurasian	67,800,000	44,150	1,990	**4.5**	10,630	**24.1**	**2.9**	NE–SW
African	61,300,000	40,560	1,960	**4.8**	20,790	**51.3**	**2.7**	NE
Antarctic	60,900,000	39,600	2,170	**5.5**	20,540	**51.9**	**1.0**	S–N
Australian	47,000,000	36,365	7,310	**20.1**	14,490	**39.8**	**6.5**	NNE
South American	43,600,000	33,380	1,890	**5.7**	8,660	**25.9**	**1.3**	N
Somali	16,700,000	20,410	0	**0.0**	11,820	**57.9**	**2.9**	NE
Nazca	15,600,000	19,300	6,500	**33.7**	7,480	**38.8**	**6.7**	E
Indian	11,900,000	17,010	1,490	**8.8**	3,530	**20.8**	**5.4**	NE
Philippine	5,500,000	11,260	4,300	**38.2**	2,223	**19.7**	**6.8**	WNW
Arabian	5,000,000	10,530	730	**6.9**	3,350	**31.8**	**4.3**	NE
Caribbean	3,300,000	9,070	0	**0.0**	130	**1.4**	**2.1**	NE
Cocos	2,900,000	7,920	2,790	**35.2**	3,980	**50.3**	**8.9**	NNE

Data Sources:

Plate names and areas from https://www.thoughtco.com/sizes-of-tectonic-or-lithospheric-plates-4090143 Accessed 12/07/17

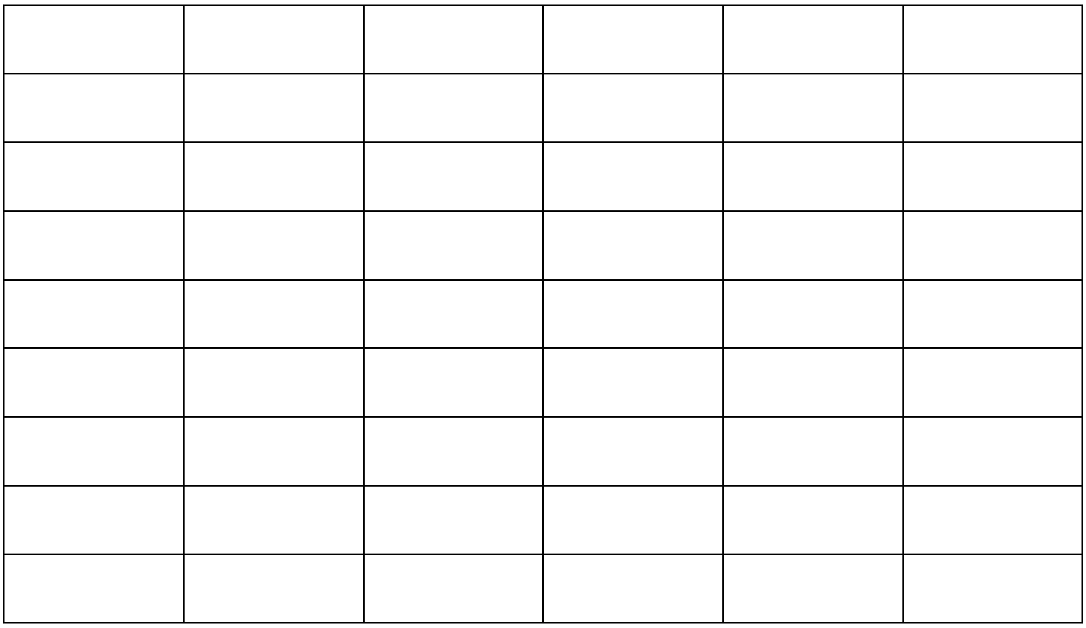
*Plate boundaries, % subducting and % divergent were measured on **Google Earth** using plate boundaries defined by the USGS*

Plate speeds and directions based on average movement of GPS stations within each plate from http://sideshow.jpl.nasa.gov/post/series.html Accessed 26/04/13

Plot the data on the graphs below.

Tectonic plate speed and percentage of boundary subducting

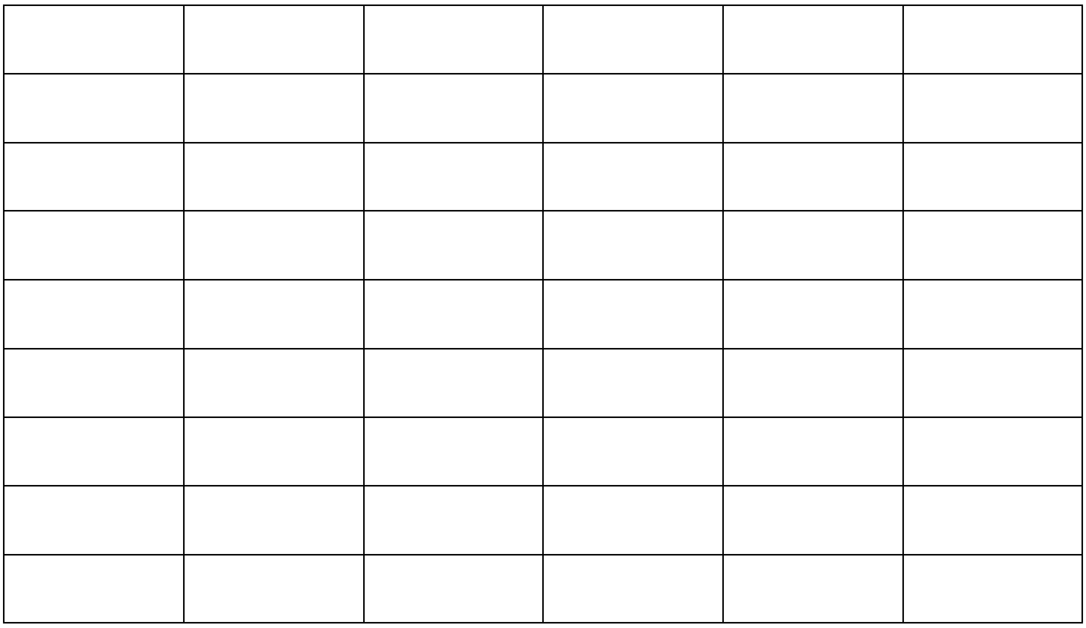
Tectonic plate speed (cm/yr)



% of plate boundary subducting

Tectonic plate speed and percentage of boundary diverging

Tectonic plate speed (cm/yr)



% of plate boundary diverging

Questions:

1. Based on this data and the empirical tests, what is the dominant driving mechanism for plate motion? Explain your answer by referring to the graphs.

2. Copy the data from Table 1 into an Excel or similar spreadsheet, and determine the correlation coefficients between: **% subducting** and **average plate speed** _______

   % divergent and **average plate speed** _______