What drives the plates? The evidence

Examine the evidence for the different plate tectonic driving mechanisms

There are three main theories for the mechanisms which move tectonic plates. These are:

- **Mantle drag** – the convection current theory – a convection current of flowing mantle material drags the plate above along;
- **Slab pull** – the subducting plate material is more dense than the mantle beneath, and so sinks and subducts, pulling the plate along;
- **Ridge push** – plates form at oceanic ridges, which are higher than the surrounding area – the plate slides off, pushing the plate along.

These theories can be tested, because if:

- **Mantle drag** were the main force – plates should all be moving at the same speed; also plates on either side of a divergent margin should be moving at the same speed;
- **Slab pull** were the main force – plates with boundaries that have greatest percentage of subducting margin should be moving fastest;
- **Ridge push** were the main force – plates with boundaries that have greatest percentage of divergent margin should be moving fastest.

Evidence to test these theories was compiled by Colin Price (Price, C. 2019, p32 – see below) in this table.

TECTONIC PLATE	AREA (km²)*	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
Correlation coefficient with plate speed:				0.89		0.06		

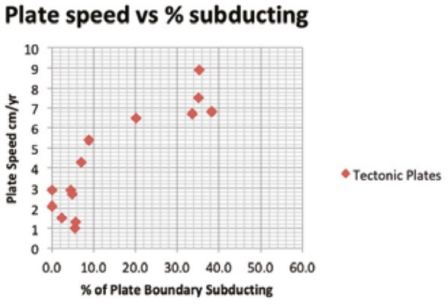
To assess whether **mantle drag** is the main plate-driving mechanism, pupils could be asked to study the plate speed data in the table to see whether a) all plates are moving at the same speed, b) plates on either side of a particular plate margin are moving at the same speed – and draw their own conclusions.

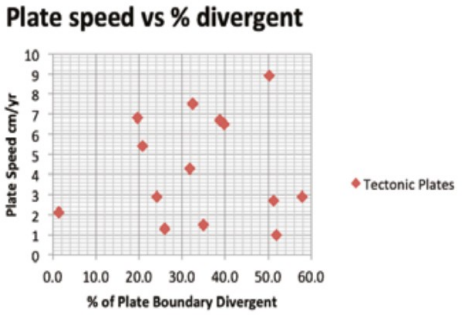
To assess whether **slab pull** or **ridge push** is the main plate-driving mechanism, pupils could use the information in the table in three different ways:

- they could measure the lengths of plate boundaries of several significant plates and then the lengths of their subducting boundaries and their divergent boundaries and calculate these as percentages; they could then use their data, and the plate speed data from the table, to plot their own scattergraphs manually or using a computer spreadsheet program;
- they could use the data in the table to calculate the percentages of subducting and divergent plate margins of several significant plates, and plot the results on a scattergraph;
- they could be asked to view the scattergraph plots using the data from the table, given below.

Following one of these exercises, they could be asked to look for correlations and to draw their own conclusions.

The scattergraphs were taken from page 33 of the article by Colin Price.





The conclusions that the pupils might draw are as follows.

- **Mantle drag** – the plates are not moving at similar speeds; they move at different speeds on either side of a divergent boundary; therefore mantle drag (the 'convection current theory') is not the main plate-driving mechanism.
- **Slab pull** – as the first scattergraph shows, there is a good correlation between plate speed and the percentage of subducting boundary; therefore slab pull is likely to be the main driving mechanism.
- **Ridge push** – the second scattergraph shows that there appears to be no correlation between plate speed and the percentage of divergent plate boundary, so ridge push is likely not to be the main plate-driving mechanism. However, as Colin Price points out (page 33) where plates are slow-moving, ridge push may be important; also it may provide some of the driving mechanism for the faster-moving plates.

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The back up

Title: What drives the plates? The evidence.

Subtitle: Examine the evidence for the different plate tectonic driving mechanisms.

Topic: Using plate data to judge the different theories about plate-driving mechanisms.

Age range of pupils: 14 years upwards

Time needed to complete activity: This depends of the approach taken, from 5 minutes to 45 minutes or longer.

Pupil learning outcomes: Pupils can:

- explain three plate-driving mechanisms;
- explain the evidence on which of these is likely to be the most important;
- interpret data given in tables and graphs.

Context:
This is the first of four Earthlearningidea activities focussed on the mechanisms driving plates. The others are shown in the table on page 3.

Following up the activity:
Try the other three activities.

Underlying principles:

- Three of the theories for driving plates are as described above.
- Potential evidence for three different plate-driving mechanisms is also described above.
- This evidence indicates that slab-pull is the main plate-driving mechanism but ridge push might be important for slow-moving plates or may increase the movement of faster-moving plates. There is no evidence that mantle drag (the convection current model) is an important plate-driver.

Thinking skill development:
Using numerical data to spot patterns is a construction activity. Moving from an understanding of the pattern to the real world of plate-driving mechanisms involves bridging.

Resource list:

- if pupils plot their own scattergraphs they will need either a computer with a suitable program, or materials to make manual plots

Useful links:
The article by Colin Price is: Price, C. (2019) An evidence-based approach to teaching plate tectonics in high school. *Teaching science*, 65.2. 30-37. This uses information on plate areas taken from Alden, A. (2017) *Here are the sizes of tectonic or lithospheric plates*, at.: https://www.thoughtco.com/sizes-of-tectonic-or-lithospheric-plates-4090143
Access the other Earthlearningideas on plate tectonics at: https://www.earthlearningidea.com/home/Teaching_strategies.html#platetectonics

Source: Chris King of the Earthlearningidea Team based on the work of Colin Price, described above.

The Earthlearningidea "What drives the plates" activities	
What drives the plates? The evidence. Examine the evidence for the different plate tectonic driving mechanisms.	https:www.earthlearningidea.com/PDF/347_What_drives_plates1.pdf
What drives the plates? In slab pull, what is it that pulls? Understanding how slab pull works through examining the data.	https:www.earthlearningidea.com/PDF/348_What_drives_plates2.pdf
What drives the plates? Modelling slab pull. Modelling and discussing the slab pull plate-driving mechanism in the classroom.	https:www.earthlearningidea.com/PDF/349_What_drives_plates3.pdf
What drives the plates? Using a pupil model to demonstrate that slab pull is the main plate-driving force.	https://www.earthlearningidea.com/PDF/217_Slab_pull.pdf