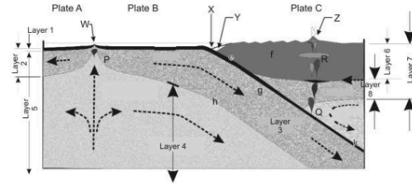


2.

Same sketch as in the previous question, a cross-section through the ridge offshore and our subduction zone here in Cascadia. Choose the best answer to the following layers.

[Note: be careful - There isn't anything tricky, but you have to look carefully to see some of the arrows that define where the layer in question extends to/from. It's easy to go too quickly and make a mistake...]

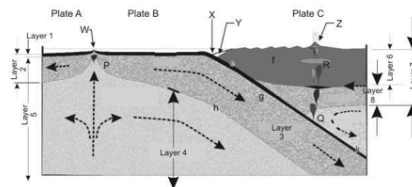


Statement	Response	Value	Correct Match
Name of Layer 1 (thin black layer)	oceanic crust	14.28%	oceanic crust
Name of Layer 2	oceanic lithosphere	14.28%	oceanic lithosphere
Name of Layer 4	asthenosphere	14.28%	asthenosphere
Name of Layer 5	mantle	14.28%	mantle
Name of Layer 6	continental crust	14.28%	continental crust
Name of Layer 7	continental lithosphere	14.28%	continental lithosphere
Name of Layer 8	lithospheric mantle	14.32%	lithospheric mantle
Score:	3.5/3.5		

3.

This is a cross-sectional sketch of the Cascadia area. Compare this with the many different similar figures in the pdf notes to make sure you are oriented as to what the layers are. The dashed arrows indicate the motion of the plates and of the asthenosphere. The sketch isn't exactly to scale but is reasonable.

Match them up:



Statement	Response	Value	Correct Match
Name of location X	trench	14.28%	trench
Name of feature shown by Y	accretionary wedge	14.28%	accretionary wedge
Thickness of Layer 1 (black layer)	~7 km	14.28%	~7 km
Fault type most likely to occur at e (see below Y, on the interface between the black/grey)	50-75 km	0.0%	30-35 km
Fault type most likely to occur at f	thrust	14.28%	thrust
Fault type most likely to occur near W	strike-slip	0.0%	thrust
Fault type most likely to occur near Z	normal	14.32%	normal

General feedback: Layer 5: You would only get super thick continental crust (close to 70-75 km thick) in a continental-continental collision like you see in the Himalaya. So, when you see the numbers of 20-70 km given for continental crust, that spans the range, but it isn't correct for every location. You need to think about where you are. Typical thickness is 35 km. That would be a decent standard answer unless you KNEW you were looking at a continent-continent collision. Here under Vancouver the crust is about 30 km thick. The continental crust thins close to the edge of the plate (to even less than 20 km)

e: megathrust interface  
 f: convergent boundary - compression - thrust faults dominate.  
 W: ridgecrest - tension - normal faults.

Score: 2.5004/3.5

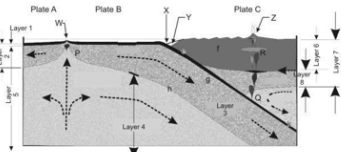
1.

We'll be talking a lot about 'Cascadia' (the Pacific Northwest including southwest BC) through the earthquakes/volcanoes sections. Here is a sketch of a cross-section of the Cascadia area that we are part of here in Vancouver (I'd expect you to be able to roughly sketch and label the basic types of plate boundaries like this).

Note that this could be a cross-section through just about any oceanic-continental subduction zone. Cascadia is a little unusual (but not too unusual) in that there is a ridgecrest within a few hundred kilometres of the trench.

The sketch isn't exactly to scale but is reasonable. The bottom of the sketch is at roughly 150-250km. The different shades/textures represent major differences in either composition or rheology of the rock.

Rather than label it by hand, your job is to match the labels on the drawing with a list I've provided. It's fine to use labels more than once if you need to.



Statement	Response	Value	Correct Match
Plate A	Pacific Plate	33.33%	Pacific Plate
Plate B	Juan de Fuca Plate	33.33%	Juan de Fuca Plate
Plate C	North American Plate	33.34%	North American Plate

General feedback: Make sure you understand this question - as well as adapt to similar ones for other plate boundaries. Sketch out the different plate boundaries (this one gives you two). Add all the other info.: composition, rheology, thicknesses, earthquakes, volcanism, motion, heat flow... This is a good way to consolidate all the information you have.

If you put Farallon plate instead of Juan de Fuca plate... well, you were partially correct I suppose. The Juan de Fuca is a last remaining fragment of the once giant Farallon plate. Check out the animations of plate motion in the Plate Tectonic Resources section. You'll see how the Juan de Fuca plate as well as the Nazca and other small plates down the west side of Central/South America used to be part of the Farallon Plate. Pretty neat animations...

Score: 1.5/1.5

4. Which of the following events has a similar physical mechanism to the rupture that causes an 'earthquake'?

Student Response	Value	Correct Answer	Feedback
1. Tearing a sheet of paper.			
<input type="checkbox"/> 2. A broken elastic snapping back.	100%	is	Yes, the crust deforms elastically, and then breaks (brittle deformation). But the earthquake is associated with the vibrations from the release of the stored elastic energy.
<input type="checkbox"/> 3. A glass breaking when you drop it.		is	

Score: 1/1

5. The most complete and meaningful way of characterising the size of an earthquake is the moment magnitude. It requires more time to calculate than the simpler methods (e.g. Local (or Richter) magnitudes) as several parameters must be determined. Which of the following are necessary to calculate the moment magnitude? [There are several correct answers]

Student Response	Value	Correct Answer	Feedback
<input type="checkbox"/> A. the area of the rupture zone along the fault	34%	is	
<input type="checkbox"/> B. the distance the fault plane slipped along the rupture	33%	is	
C. maximum ground motion measured at the surface			
<input type="checkbox"/> D. the physical properties of the fault zone rocks (e.g. rigidity, compressibility)	33%	is	
E. the gradient of damage moving away from the epicentre			
F. the focal mechanism of the earthquake			

General Feedback: Moment magnitudes depend on: the area of the fault that ruptured (length/depth), the distance it slid, and the strength of the rocks that broke. (1, 2, 4)  
The maximum surface motion or vibration is what is used to determine local magnitudes (or Richter magnitudes in California).  
The amount of damage is used to calculate the Mercalli intensity index.  
The focal mechanism simply relates to whether it is a normal fault, thrust fault or strike-slip fault.

Score: 1.5/1.5

6. On September 19th 2011, there was a M5.6 quake beneath the Aleutian Islands. For more information, see: [Fox Islands, Aleutian Islands, Alaska](#)  
There are maps and other information (like depth) on those pages, including historical seismicity maps. From the location of the earthquake and its depth (see the map, you could plug the coordinates into Google Earth if you like), it was most likely related to:

Student Response	Value	Correct Answer	Feedback
A. Transform motion (strike-slip faulting)			
<input type="checkbox"/> B. Subduction thrusting in the overriding plate.		is	
C. Ridgecrest spreading (normal faulting)			
D. Subduction thrusting on the plate interface		is	
<input type="checkbox"/> E. Subduction-related faulting within the downgoing plate	100%	is	Yes, also possible at this depth. The earthquake occurred at a depth of 35km so it could well be within the downgoing plate.

Score: 2/2

7. On Sept. 25th 2011, there was a M4.9 quake in the Northern Atlantic Ocean basin. For more information, see: [Northern Mid-Atlantic Ridge](#)  
There are maps and other information (like depth) on those pages, including historical seismicity maps. From the location of the earthquake and its depth (see the map, you could plug the coordinates into Google Earth if you like), it was most likely related to:

Student Response	Value	Correct Answer	Feedback
A. Transform motion (strike-slip faulting)		is	
<input type="checkbox"/> B. Ridgecrest spreading (normal faulting)	100%	is	Yes, the focus was pretty much on the ridge so most probably related to tension - a normal fault.
C. Subduction thrusting on the plate interface			
D. Subduction thrusting in the overriding plate.			
E. Subduction-related faulting within the downgoing plate			

Score: 2/2

8. On November 17th 2009, there was a M6.6 quake near the southern Haida Gwaii (Queen Charlotte) Islands. For more information, see: [Queen Charlotte Islands Region](#)  
There are maps and other information (like depth) on those pages, including historical seismicity maps. I recommend also referring to the pdf notes for this one to double check the nature of the plate boundaries. From the location of the earthquake and its depth (see the map, you could plug the coordinates into Google Earth if you like), it was most likely related to:

Student Response	Value	Correct Answer	Feedback
A. Subduction thrusting on the plate interface			
B. Subduction thrusting in the overriding plate.			
<input type="checkbox"/> C. Transform motion (strike-slip faulting)	100%	is	Yes, on the Queen Charlotte fault. Strike-slip motion between the Pacific Plate and the North American Plate.
D. Subduction-related faulting within the downgoing plate			
E. Ridgecrest spreading (normal faulting)			

General Feedback: Note that the USGS website has a very simple plate boundary labelling system that is generally correct, but it is completely wrong in some area. Wherever there is a ridgecrest with offsetting transform faults - the transforms don't show up at all (like on the Juan de Fuca ridge offshore of southern BC). And, in some cases, very large transform faults like the Queen Charlotte fault do not show up properly. However, the correct plate boundaries are noted in the text and pdfs.

Score: 2/2

9. Which of the following points are TRUE?  
 [There may be more than one correct answer, penalty for wrong answers]

When oceanic lithosphere is subducted into the asthenosphere and lower mantle, \_\_\_\_\_.

Student Response	Value	Correct Answer	Feedback
A. the entire lithospheric plate eventually melts and is reincorporated back into the convecting mantle	-25%		This point is FALSE. If the entire plate melted, then that would mean that the mantle is also molten since most of the downgoing plate is mantle rock. Only a small portion of the downgoing plate melts - the upper portion of the crust that has a lot of water incorporated into it.
B. the seawater-saturated oceanic crust melts a little and releases water into the mantle above, which can in turn melt, generating a volcanic arc on the surface above.	33%	Yes	Yes.
C. the subducting lithosphere gradually heats up to the temperature of the surrounding mantle and is reincorporated back into the lower mantle.	34%	Yes	True.
D. earthquakes can occur within the subducting lithospheric plate down to the base of the transition zone (~660-670 km depth)	33%	Yes	This is true.
E. Earthquakes commonly occur on the interface between the upper surface of the downgoing plate and the asthenosphere and lower mantle. These earthquakes define the Wadati-Benioff zone.			

General Feedback: One of the main points here is that the downgoing plate doesn't really melt when it is 'recycled' back into the mantle. Remember, the mantle isn't liquid - it is solid. And almost all of the subducting lithosphere is mantle rock. So... for the most part it simply just heats up. Only a small portion of the downgoing plate melts - the upper portion of the crust that has a lot of water incorporated into it. A little of it melts - and it also releases a lot of water into the mantle above the subducting plate. That water decreases the melting temperature there and causes melting in the mantle itself. That is going on where the subducting plate is roughly 100 km beneath the surface - the line of volcanoes (like Mt. Baker and Mt. Garibaldi) mark that position nicely.

Score: 1.5/2

10. Continental and island arc volcanism are quite similar, but have a few important differences. Which of the following points are true (more than one may be correct, points deducted for wrong answers).

Student Response	Value	Correct Answer	Feedback
1. Continental arc volcanoes are subduction related, island arc volcanoes are caused by plumes (or hotspots).			
2. One main difference is that island arc volcanoes tend to be more mafic in composition than continental arc volcanoes. Island arcs are more mafic->intermediate while continental volcanoes would be more intermediate->felsic.	34%	Yes	Yes
3. Island arc and continental arc volcanoes are both related to subduction.	33%	Yes	Yes.
4. Many islands in the Caribbean are island arc volcanoes (look at a map of plate boundaries to decide)	33%	Yes	Yes
5. Hawaii is an island arc volcano.			

General Feedback: Many people get hotspot volcanoes confused with island arcs. There are two types of volcanism: 1) Arc volcanism caused by subduction. This includes continental arcs (oceanic plate subducting under continental plate) and island arcs (oceanic plate subducting under oceanic plate). In both cases you have a subduction zone with active volcanoes scattered all the way along the chain. For example, here in Cascadia. In the Andes in South America, The Aleutians in Alaska, the Philippines, etc. etc.. 2) Hotspot or plume volcanism. This doesn't require plate tectonics (e.g. Mars, Venus). However, if the plate above is moving, you end up with a chain of volcanoes. Only one volcano is active - the one right at the tip - the others in the chain are extinct. Of course, the classic example is Hawaii. But there are many others (e.g. Yellowstone, the Canary Islands, Iceland...).

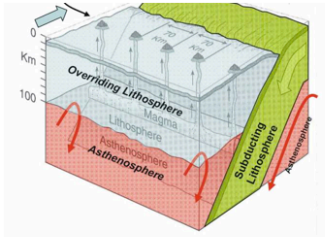
Score: 2/2

11. Subducting plates produce a chain of volcanoes called a volcanic arc. Approximately how deep is the upper surface of a subducting plate beneath the volcanoes?

Student Response	Value	Correct Answer	Feedback
A. 10 km			
B. 50 km	0%		
C. 100 km		Yes	
D. 200 km			
E. 660 km			
F. Anywhere from 0 to ~660 km			

General Feedback: About 100 km. It depends a bit on the age of the plate subducting (i.e., how cool it is - the older, the cooler) and the dip that it subducts at (which also depends on its age/temperature). But 100 km is a pretty good average.

Score: 0/1



Student Response	Value	Correct Answer	Feedback
A. lavas are intermediate to mafic in composition	20%	✘	Island arc, so intermediate (and this is a young one, so mafic-intermediate)
B. lavas mostly felsic			
C. lavas very high in silica (SiO <sub>2</sub> ) content: around 75%			
D. lavas mid-low silica (SiO <sub>2</sub> ) content: around 60%	20%	✔	Yes, typical island arc compositions. Perhaps a bit lower for a very young island arc.
E. lavas very low silica content: < 50%			
F. Moderately viscous magma and 20% gas in the magma, possibility for water to get into the magma, potential to be quite explosive.		✔	
G. Very fluid magma, little gas, not explosive			
H. Volcano age (the age of the youngest lava erupted) gets progressively older from left to right down the chain			
I. Very gently sloped, shield volcanoes			
J. Composite volcanoes - steeper and built from layers of lava and ash on the exposed parts of the volcanoes (above water).	20%	✔	
K. Melt feeding the volcanoes was sourced from material in the lower mantle (hot spot plume)			
L. Melt feeding the volcanoes formed by melting in the mantle just above the subducting plate.	20%	✔	Yes, water released from the subducting plate decreases the melting temperature of the asthenosphere above it - it melts and away we go...

Score: 2.5/2.5

13. Which of the following statements about magma are FALSE? (Note: several answers may be possible)

Student Response	Value	Correct Answer	Feedback
A. The viscosity of a magma increases as the silica content decreases. Note: high viscosity = thick, low viscosity = fluid	34%	✔	More silica = more felsic rock = stickier magma = higher viscosity
B. High temperature magmas are more fluid (less viscous) than low temperature magmas.			
C. The more gas a magma contains, the less violent the eruption	33%	✔	Gas is what makes an eruption explosive - combined with a magma that is viscous enough to allow pressure to build
D. Mafic magmas are very explosive	33%	✔	No, mafic magmas are so fluid that any gas can easily escape. So pressure doesn't build up.
E. A magma can contain solids (unmelted minerals) and gas.			

Score: 2/2

14. Mount Baker (just southeast of Vancouver) and Mount Garibaldi (just south of Whistler and close to Squamish) are examples of: (more than one choice is possible)

Student Response	Value	Correct Answer	Feedback
A. a cinder cone			
B. a stratovolcano (composite volcano)	50%	✔	
C. a shield volcano			
D. plume (or hotspot) volcanism			
E. continental arc	50%	✔	
F. island arc			

Score: 2/2

15. You live 15 km away from the base of a glacier-covered stratovolcano (perhaps Mt. Baker, or Mt. Rainier, or Mt. Fuji in Japan). Your house is in a lovely, scenic river valley (the river formed by drainage from the runoff and snow/ice melt from the volcano). And, just because of the prevailing wind patterns, your house is generally downwind from the volcano. Which order of hazards (from extremely hazardous to not very) correctly describes the situation?

Statement	Response	Value	Correct Match
most hazardous:	Lahar	25.0%	Lahar
a likely problem, but not extremely hazardous:	Pyroclastic flow	0.0%	Tephra (ash) fall
hazardous but not that likely:	Tephra (ash) fall	0.0%	Pyroclastic flow
not a problem:	Lava flow	25.0%	Lava flow