The evolution of the Earth and life

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Discussion on Posted Questions

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Welcome to the course evolution of the earth and life. Today, we are going to discuss some of the questions that I showed in the previous slides. The first question was about mineralogy, you have to identify the shapes and the luster. So, this one A has a shape, which is called a botryoidal shape, B has a shape which is called a layered shape. On the other hand, luster A has a luster which is called a metallic luster. And this one has a luster which is called the glassy luster. Using a combination of shape, as well as luster, it is possible to identify and distinguish between a variety of minerals.

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Moving on the other question was, which tetrahedral arrangement does this mineral represent. So, this is a mineral, which is clear that it can be peeled off. So, if you look at the boundary of this mineral, this piece actually came off from this part. So you can peel it off from the mineral, and it will look something like this. So, now, if I take a look at this side and look in this direction, it is going to look something like this where there would be multiple layers. And what I am saying is, these layers can be peeled off, these layers comes off very easily. So, this is a classical example of a biotite and Muscovite.

So, this one is a biotite and this one is a Muscovite these are all Mica. Now, if you recall that in the arrangement of silica tetrahedral, we first learned an independent silica tetrahedra where there is a single to silica tetrahedra and the unbalanced charges can be balanced by other metal ions and connecting those by balancing those unbalanced charges at the corner.

Then you can also have an arrangement where the silica tetrahedra is balanced by other silica tetrahedra and therefore creating a chain like structure. And this kind of chain like structures are also found in certain minerals. But you can also have something like a double chain structure where you are going to see 2 series of chains creating the structure. If you think about the extreme version of it, you can create these chains and create a complete plane out of it. And these are called sheets silicate and the one that we are looking at these are examples of sheets silicate where the silica tetrahedra are joined in such a manner that it creates a plane.

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The question is how does the observation of glacial rocks connect to drifting continents? If you recall, during Alfred Wegener's time when he was proposing continental drift, he also observed that glacial rocks show up in different parts of the world. If you look at the world, today, glaciers are of two types. One is a continental glacier, those glaciers are formed because of the extreme temperature of the poles and therefore you are going to see those glaciers close to the polar regions.

So if this is the earth, you are going to see the glaciers in the polar region. But then there can also be things which are called altitudinal glacier things that we find even in Himalayas today because of the height where these mountains are and because of the drop in the temperature with height, it can form into glaciers, which will only be found in the mountains. What we find in the rock record are thus striation marks that generally these glaciers leave. So if there is a background rock or ground rock, and on top of which the glacier is moving in this direction, they basically scratch the surface of this bedrock, and you are going to find striation like these, these striation are going to tell you the general direction, which way the glacier is going.

In the glacial rock distribution, what we find that there are glacial rocks in India, near the southern part, parts of Africa, again, in the southern part, some parts of South America as well. Now, the question is, these glacial rocks, how did they form one possibility is that they were already altitudinal glacier, they were very high. But again, they were not related to a mountain change.

And therefore, altitudinal glacier are not the best idea to explain these features. Rather, it looks like continental glaciers and again, if we look at the striation patterns, it basically shows the direction of an outward direction. And therefore, Wagner concluded that there was a point where all of these continents were closer probably towards the pole, and where you have this development of continental glaciers, which move away from the central point. So that is how these glacial rocks and their striations are fit in to the idea of continental drift.

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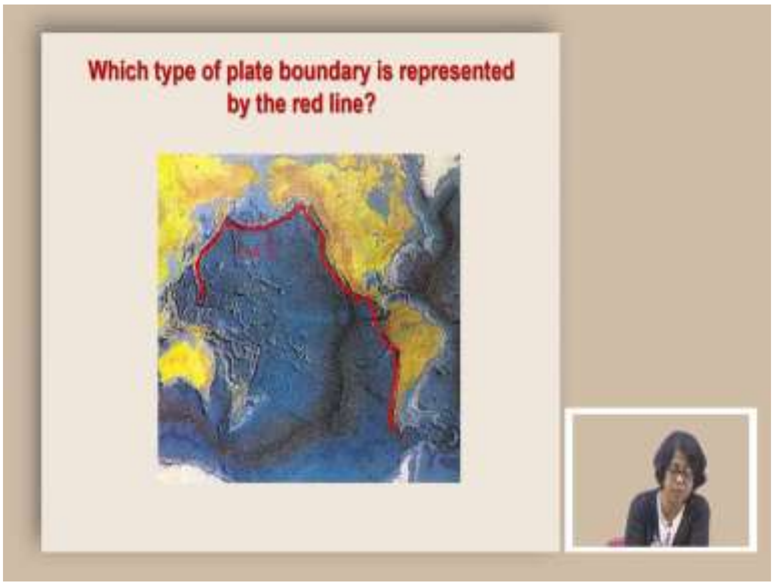

Which type of plate boundary is represented by the red line, if you look at the red line, it starts somewhere from the southern part of South America, and extends all the way to North America crosses over and comes towards the eastern part of Asia and Europe. And this is the boundary of the Pacific Plate, Pacific Plate is an oceanic plate and if you look at the continents around it, they also have a margin with this plate.

So this plate, it is an old oceanic plate, which is converging and which is basically submerging under the light continental plates around these positions. And here, it is actually subducting under another oceanic plate. And this creates convergent boundary, it is a convergent plate boundary. And these are also places where we have high degree of magnetism, and therefore it is also called Ring of Fire.

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Which of the following rock cool down faster? Now if we look at these two rocks, we will see that this rock in B, we see some of the crystals that have formed, some of them are black, some of them are gray, some of them are pink in color. But if we look closely, we can actually see formation of the crystals. And if we take a section and look at it under microscope, we are going to see it even more clearly.

On the other hand, this rock does not show any difference in terms of formation of crystals. In fact, when it breaks, it does not have a preferred orientation. And that is why it breaks in this very interesting pattern, which is called a conchoidal fracture. This one is a volcanic glass. And this volcanic glass can only form if things are cooling down really really fast, where they do not get a chance to develop large crystals, any crystals for that matter.

On the other hand, in B we see formation of large crystals. So in comparison, this rock is represented by A which is volcanic glass cool down much, much faster compared to B.

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Between the following minerals which one will crystallize first from a cooling magma. Now, again, there are some indicators how you can figure it out. First of all, you need to know what Bowen's reaction series is because Bowens reaction series tells us with decreasing temperature, which minerals are going to form first, we will start with olivine and then we are going to go down and finally, form things like quartz and feldspar. In between it follows the same pattern as the increasing chain of silica tetrahedra.

So, in olivine, the silica tetrahedra is basically an independent one, and as we are going down at least in the discontinuous series, we find that it forms a chain, then it forms a double chain, then it forms a sheet and then it forms a complicated 3-dimensional structure, these 3-dimensional structure corresponds to quartz and feldspar. Now, this one again it cleaves off easily and therefore, we are finding sheets. So, these are examples of sheets silicate. On the other hand, this one forms a nice crystal, it also has a very interesting color, which corresponds to olivine.

So, between olivine and mica olivine will crystallize first from the magma, whereas, mica will crystallize later. In fact, these are some of the first crystallized minerals and this picture has been taken from some minerals, which crystallized very, very deep in the earth, they are often called mantle xenoliths. That means, they represent a crystallization in the mantle, or development of crystallization in the mantle.

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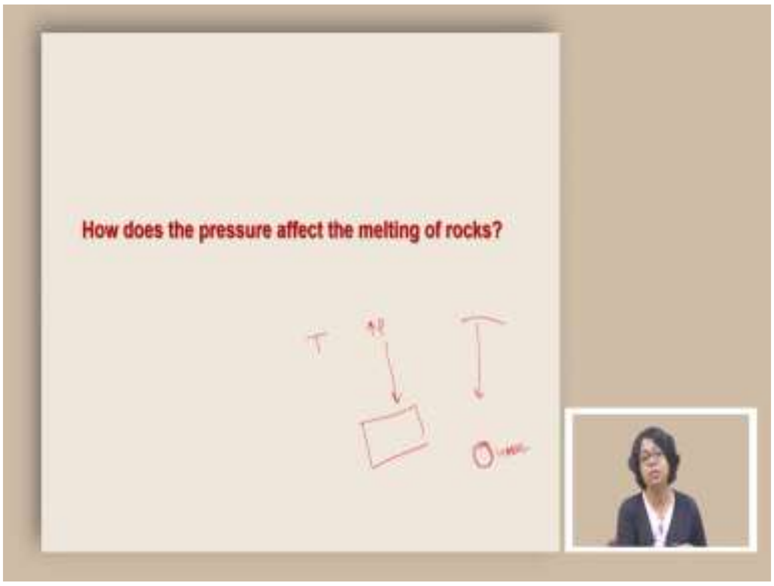

How does pressure affect the melting of rocks. So, melting point or phase change from solid to liquid, these are always dependent on pressure. So, temperature and pressure sort of acts against each other with increasing temperature, it favors those minerals which has a larger volume. Whereas, for increasing pressure, it favors those minerals or those phases, where the structure is much more compact. So, therefore, with increasing pressure, it is going to be more difficult to melt the rock. And that is why what we find is if you keep the same temperature, but increase the pressure in the same temperature, you can find a point where the rocks are not going to melt.

But if you drop the pressure down, there can be a point where with the same temperature, it will start melting. It is something similar to when you are trying to boil the water, it becomes more difficult to boil the water if the pressure is high. If the pressure is high, it does not go from liquid to vapor, it does not boil, and therefore the temperature can go up significantly, but still, it will not boil. This is the principle of what we use for pressure cooker. And this is also the reason when you go up high up in the mountain, it is so difficult to boil the water.

Similarly, for the rocks also, if we go down deep in the Earth's structure, the pressure increases to the point where the pressure is so high that it cannot, the rocks or the materials cannot be melted at that temperature even if the temperature is high enough. That is partially the reason why we have something called a solid inner core. Apart from the difference in composition, the pressure there is so high that this cannot be converted to a molten phase with the available temperature.

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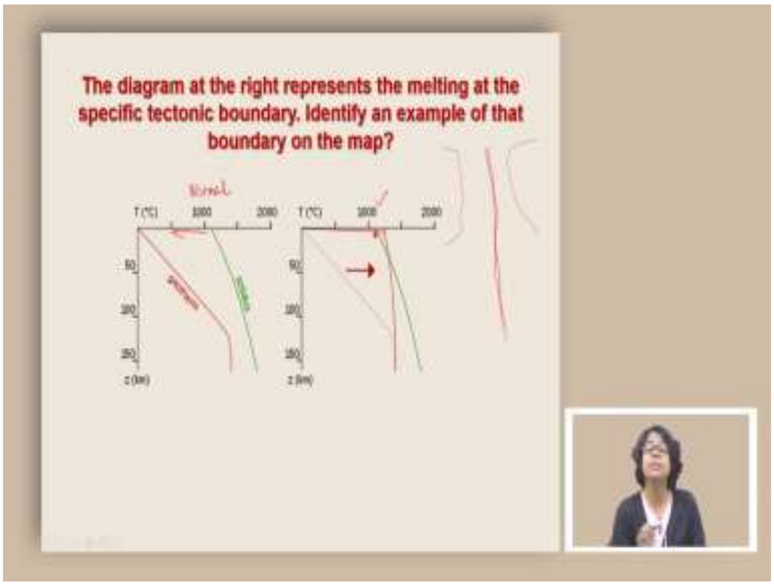

The diagram at the right represents the melting at a specific tectonic boundary, identify an example of that boundary on the map. Now we know how the geotherm interact with solidus. Solidus means that in this side of this green line, everything is going to be completely solid. Geotherm means it is showing you how the temperature is changing with depth. Now this is a normal situation where we are not really looking at a specific plate boundary.

Now, in this picture, what we see is the temperature increase is very high. In fact, the depth involved for this temperature increases very low, you do not even go to a greater depth to see this temperature change, and therefore, it intersects the solidus, which means that things which were solid at this point before, will start to melt at that temperature, and at that depth. So this is what happens because of decompression melting.

In decompression melting in the mid oceanic ridge, even at relatively lower temperature, it can melt simply because the pressure is also low. So if you increase the pressure, the melting point increases, if you reduce the pressure, it can start to melt at relatively lower temperature. And that is what is happening here, because of which we are getting the melting even closer to the surface. So if we have to identify such a place in the map, you should look at the mid-Atlantic Ridge, which separates the American continent from the Eurasian continent. And you will find at the middle of Atlantic there is a ridge, which supports these kinds of melting.

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Why is this rock floating in water? So the rock can only float in the water if the overall rock density is lighter than water. Now if we know something about the composition of the rock, we know that silica, if you look at the silica and its density, compared to water, it cannot really float if it is completely made up of silica. However, if you create a rock where there are a lot of pore spaces, that means it is also trapping water, that effectively increases the volume without increasing the mass. And that is what happening for these rocks.

How can you trap such large gaps in the rock. And that happens when the magma has a lot of gas inside and these gases get trapped and eventually, when the rock forms, it is full of these vesicles or holes. And that creates a type of igneous rock, which is going to be really light because of these pore spaces. And these are called pumice. Because of this lighter color, we know that it is not scoria it is actually pumice. And because of the vesicles, it is very light, it can float in the water.

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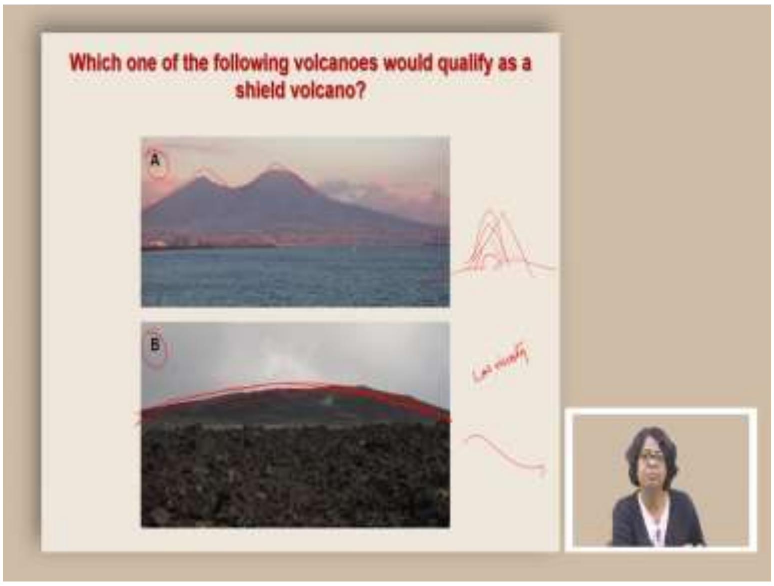

Which one of the following volcanos would qualify as a shield volcano with the same scale, we can see that these volcanoes are steeper than the volcanoes here, which has a very, very gentle slope. Now the gentle slope is a result of the fact that it is primarily a low viscosity magma. If a magma has low viscosity, then it can flow very easily and create these gentle structures.

On the other hand, these kinds of sharp conical features can only be produced by magma, which has high viscosity and therefore it cannot really flow very easily covering the existing topography, it will have a mound like structure it will build up and eventually with multiple such structures, it can create a volcano, which has a very steep angle to it. So by definition, a low gently developing volcano is called a shield volcano, because it actually looks like the warrior shield. And that is why example B is going to be an example of the shield volcano and not volcano A.

So that is where we are going to stop discussing the questions. We are again going to have another discussion answering the questions that I show in the slides. Thank you.