Evolution of the Earth and Life
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Discussion on Posted Questions

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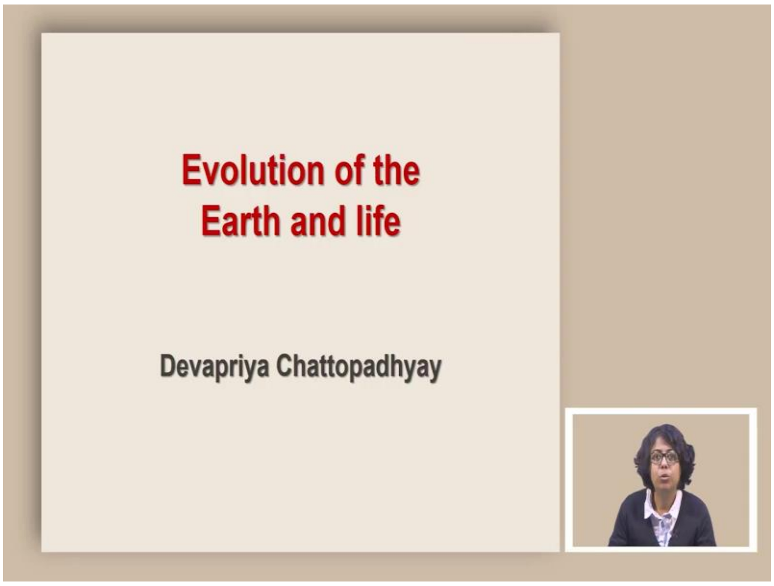

Welcome to the course Evolution of the Earth and Life. Today we are going to discuss a few questions that I posted along with the slides.

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This was a question that I posted when we talked about metamorphic rocks, you were requested to identify the metamorphic textures. Here, the important point to notice are all of these sculptures and buildings, they actually have some metamorphic rocks ingrained to them. So, let us start with the first one, which is A. A has a texture which do not show any colour variation, it is white in colour, and what we see is there is no foliation to it. So, there is no preferred direction, which tells us anything about the compression or any kind of preferential stress. This is an example of a marble. This is calcium carbonate.

So, when limestone gets metamorphosed, it basically produces a pattern, which does not show any foliation. It is primarily created by heat. And this kind of metamorphism will create a marble which is unknown foliated metamorphic rock.

Now, let us take a look at B. So, what I indicate by this are these rocks, these are metamorphic rocks. So, just by looking at their use, it is quite clear that they are plateau in nature. And the reason they are plateau, because they have a tendency to break along these lines and along these planes, and these planes are the planes of weakness and these are the record of slaty cleavage and this rock is slate.

Now, if we are talking about the texture, this one has foliation basically this is a rock foliation that we are talking about, because in slate, if you break it, it basically tends to break as sheets and this is again showing that they have a weak plane around them along with the tend to break and this is a remnant of low grade metamorphism of original rock which are shale or other siltstones. These generally convert to slate through a low grade metamorphism.

Now we come to the sculpture C, where we find slightly interesting pattern that is that there is a slight variation in the shade. And the shade variation actually indicates something about the arrangement of dark coloured minerals versus light coloured minerals. And especially the development of mica. These mica can develop because of these mica can develop and orient themselves because of these foliation patterns because of compression and this is an example of a schist. So, compared to slate, schist is going to be slightly more higher grade. And this will involve an increase in the proportion of mica and because of mica, this has a shiny appearance.

Then we come to this sculpture. It is an Egyptian sculpture, where we see that this metamorphic rock has dark coloured bands and also light coloured bands. This separation complete separation of dark and light coloured bands indicate that they are towards the higher grade metamorphism not only that, there has been complete separation of felsic and mafic minerals. These kinds of things are a character of metamorphic texture which is called gneiss.

This gneissic texture indicates that because of high temperature and pressure condition, there is a development of arrangement where the mafic minerals are basically orienting themselves. If this is the point where things are getting stressed, it is a compression, then they are going to orient themselves along these lines. And the felsic minerals are going to be in between. And that is what creates these kind of banding. And this is clearly visible in this particular sculpture.

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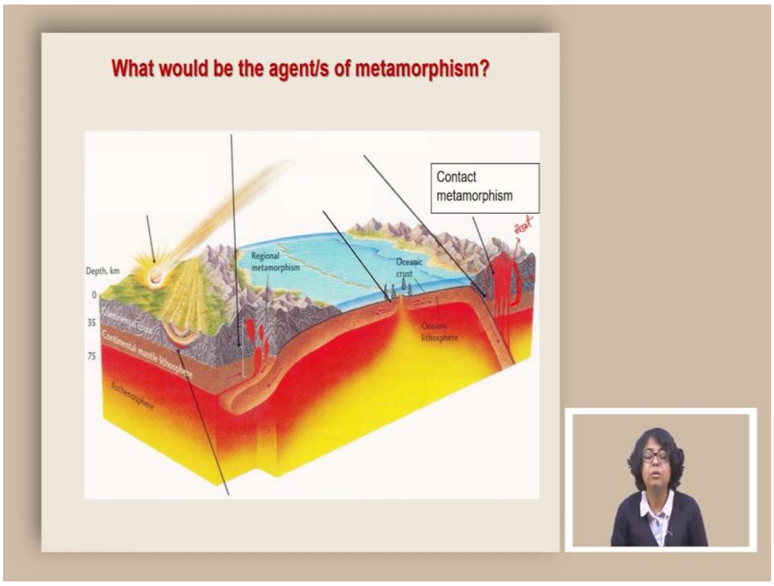

Moving on to the next question. This question asks for this particular type of metamorphism. And what might be the agent of this metamorphism? So, we are talking about contact metamorphism, where a magma is coming up, and because the magma is hot, it is also changing the composition of the rocks which are next to it. And this is a classical case of contact metamorphism. And this kind of metamorphism involves primarily heat, and therefore, the answer to this question is going to be heat.

There would be a change in the metamorphic rate because the ones which are right next to this magma will be affected the most so they will have a really strong metamorphic pattern. But as we are going away from it, we will eventually get unmetamorphosed sedimentary rock if the rock original rock was a sedimentary one.

And some of these things can create metamorphic texture, which is known foliated because there is very low involvement of pressure in this entire system. And therefore, the agent of metamorphism is going to be only heat.

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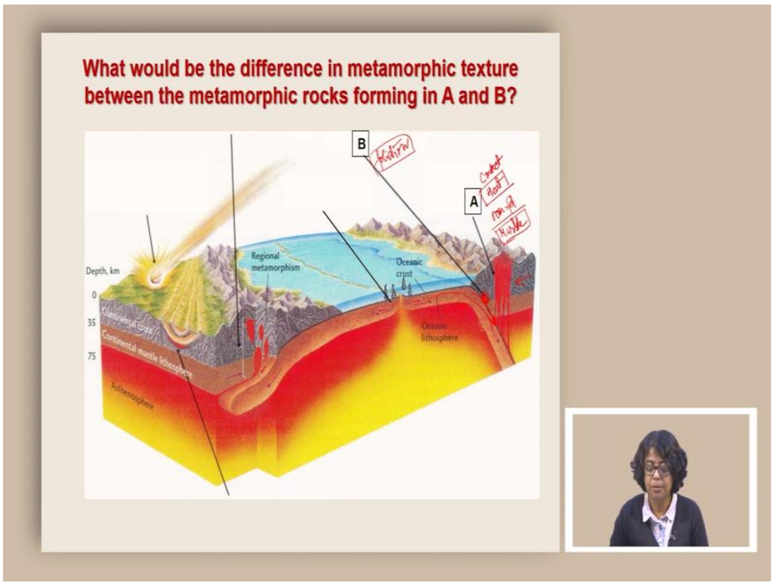

Moving on to the next question. This question asks you what would be the difference in metamorphic texture between the metamorphic rocks formed in A and B? So, again, A indicates place, which is at the contact of this magma which is coming up. On the other hand, B indicates a place which is going as part of the subduction zone. So, there is going to be a difference and the primary difference is going to be that in A because it is a contact metamorphism the primary agent of metamorphism is heat. But if you look at B, it is happening because this oceanic lithosphere is going down and it is impacting the materials which are on top of it and therefore, there is a sense of stress, the stress will generate foliation.

So, here we are going to expect non foliated rocks. And here we are going to expect foliated rocks. Now non foliated rocks will be depending on what kind of composition is there already, it can be something like marble, it can be something of some other kind, but it will not have any foliation to it.

On the other hand, in B because things are going down. So, there is either movement in terms of a compression or there can be a bit of shearing too. Because of these, these will create foliation depending on which depth the particular rock is in, it can create either a gneiss or a schist depending on the original composition and also the grade of metamorphism and the pressure, temperature condition. So, all of these things are going to create a foliated rock depending on the parent rock, depending on the pressure, temperature which are going to be controlled by depth, the final grade of the metamorphism will be decided.

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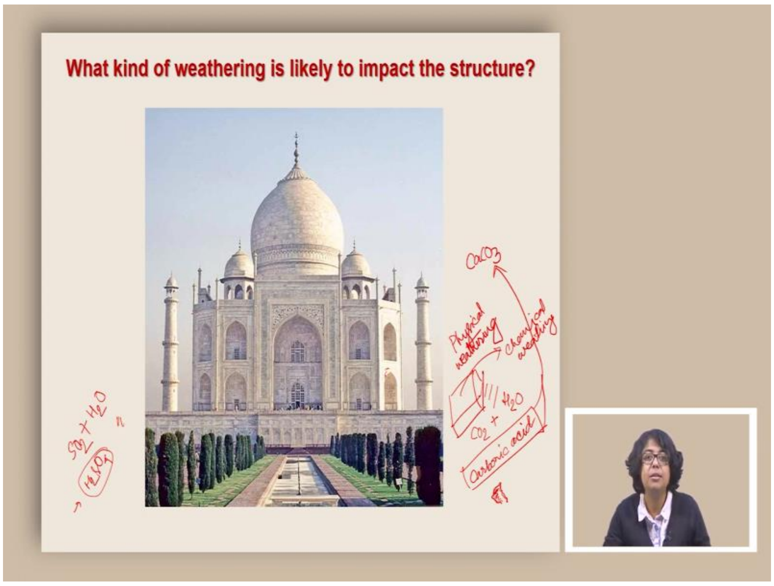

This is a question which asks what kind of weathering is likely to impact this structure? Now this is Taj Mahal as we all know, and it is made up of calcium carbonate. Now calcium carbonate is one of the most reactive materials that we find in nature, and it reacts to acid. Now what is the most common acid that we find in nature? One of the most common acid is this weak acid called carbonic acid. So, when it rains, it brings water and then there is enough carbon dioxide already. So, this produces an acid which is basically weak in nature and it is called a carbonic acid.

And this carbonic acid, once it starts to react with calcium carbonate, it is going to produce bicarbonate and it is going to literally break it. Now, the thing is around Taj Mahal, this has been this would be one process which will be operating for quite some time and this will slowly corrode areas which already has some cracks to it or some unevenness to it, because we know that physical weathering actually helps chemical weathering. Physical weathering increases the surface area exposed surface area and exposed surface area accentuates the chemical weathering. So, with increasing breakage, it is going to increase the chemical weathering.

On top of that there are factories near Taj Mahal. And many of these factories because of the nature of the product, they also emit Sulphur dioxide. Sulphur dioxide when mixed with water creates the sulfuric acid which is a much stronger acid. And this sulfuric acid can corrode things much faster. So, when eventually it rains, it is basically bring down something which is more dilute sulfuric acid, because of which it is also called an acid rain, this is going to impact the structure in a very strong way unlike this carbonic acid, and therefore the smaller places where etchings are done, where it is already corroded to accommodate other rocks to create these designs, the surfaces of those things are going to get are going to start corroding.

So, basically, we are looking at some sort of an acid induced dissolution. And that is what we are going to expect to see in a structure like this.

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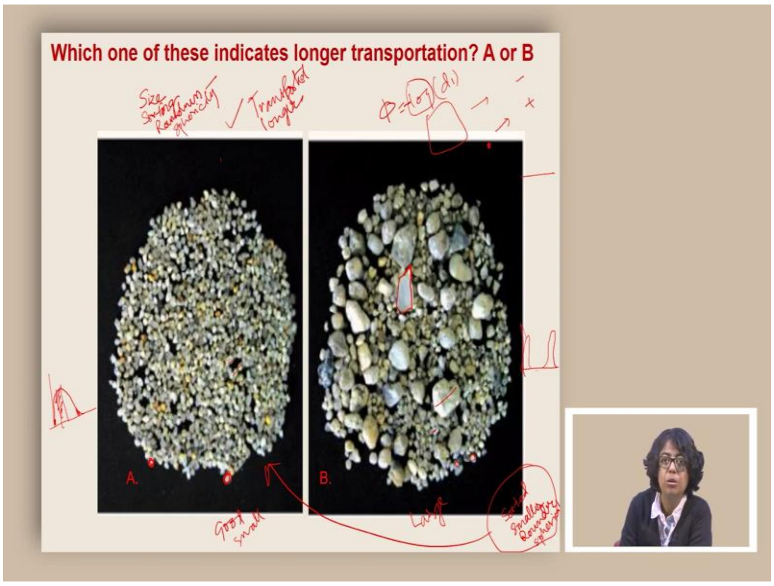

This question is related to the sediment transport. The question asks, which one of these indicate longer transportation A or B? Now, let us take a look at how A looks like? We can see that they are smaller grains and they are also more circular grains. Now, when we look at B, we are seeing that there are some smaller grains which are circular, but then there are larger grains and some of them are not circular at all. They are angular and they are not even round.

So, there are a couple of points that we can understand one is the size. The second one is sorting. The third one is roundness. The fourth one is sphericity. All of these are indicators about how long something has been transported. If something gets transported for very long, they tend to get eroded, they tend to get weathered, and because of this process, the nature works like a filter, you will end up finding things which are smaller, more rounder, more spherical and also all of them are going to be similar looking and therefore the term for this is called sorted. So, the sorting is going to be good.

And this we find in this particular case where all of them are round, they are the angles are not unlike this one where we see sharp angles, this is not the case here, we also find things which are more not angular and more spherical more close to a sphere. Then all of them look the same, and that means the sorting is good. Whereas here, some of them are larger, and some of them are very small, and therefore, the sorting is poor. We also found that the overall size, if I have to calculate, this one would be small, and this one is going to be large. So, all of these indicate that this one has transported longer.

The way to quantify this is to measure every grain. And once we measure every grain, we can plot that, but we convert it to a phi scale. A phi scale basically means it is the diameter, but we convert the diameter to a log scale. But once we convert it to a log scale, we tend to get a large number for a large diameter, and smaller number for small diameter, sometimes negative number for a small diameter, but because in nature, mostly smaller things are available. And we like to see numbers in a positive version, not the negative version, we added as minus to this formula.

So, what it does? It makes large boulders to a negative number, but very small grains to a positive number. And by this, we can accommodate very large grains and very small grains in the same scale because it is a logarithmic scale.

Now, if we try to now plot it in a plot, what we will find is, here, we are going to see a distribution which looks more like this, because there are some very small grains there are some very large grains, but most of it basically is in the same place. And it shows that all of them are of the same size. If I have to plot this one, this will probably look something like this. And then like this, because there are some very large ones. And then there are very small ones. So, visually also it is possible just by looking at the information looking at the numbers to identify which has been transported longer versus shorter.

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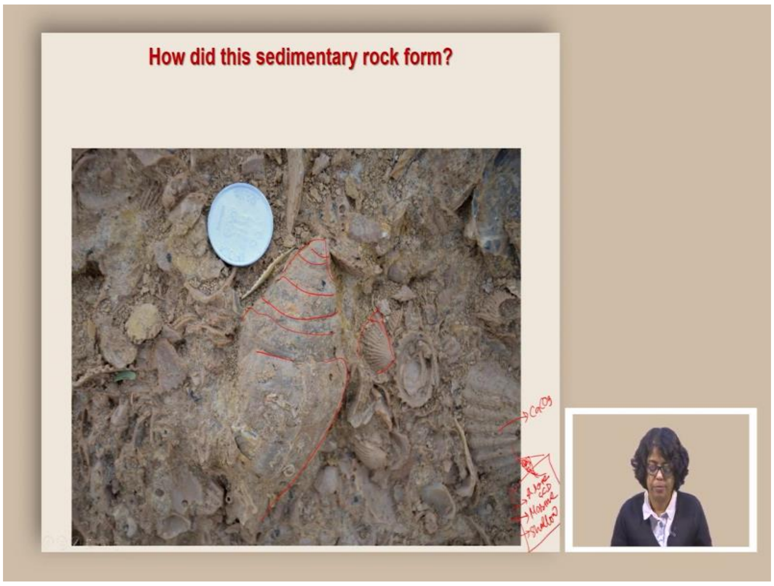

This question asks you how did this sedimentary rock form? So, this sedimentary rock has some fossils, you can see a large snail and other clams. So, this is a fossiliferous rock. It also has this entire rock is composed of mostly these materials which are made up of calcium carbonate. So, this is a carbonate rock. The way these carbonate rocks formed is when these animals die. They basically deposit in the sea floor. And these are made in rocks. So, this is a seafloor where all these sediments or all these organisms deposit and they mix with the sediments. And because it is carbonate, the sediments can also have a bit of carbonate, they attach to each other, creating something like a glue or cement. And that is how these rocks are created.

It indicates that it is marine, because you do not see these organisms anywhere other than marine rocks. It is not too deep. It is a shallow marine region, because these organisms are also living in shallow paths. They only survive in places where the calcium carbonate is not dissolving, and therefore it is above CCD. So, all of these information one can extract by looking at this rock.

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This is a question which asks which agent river, wind, glacier is responsible for forming this rock? So, one important thing about this rock is we see some of the large boulders, which are part of the rock. Some of these boulders are quite angular in nature, some of them are not so angular. And if we look at the groundmass, so the ones which are not bolder, they are quite fine, because you cannot really see individual grains in there. So, it is a fine thing. And on top of it, there are some large boulders. So, the way the logic goes, is if you think about a wind, the wind cannot carry material, which is as big as this. So, this hammer is for scale.

So, we are easily talking about, let us say 15 to 20 centimeters diameter, and this direction is going to be even bigger than that. It could even be a larger version depending on what kind of hammer we are looking at. So, these kinds of really large boulders are impossible for wind to carry, wind velocity never goes to that level. And also the density of the medium plays a role, the wind density is very low.

Now comes to river. The rivers during the flash flood, or when it is it has a lot of water and high velocity can carry some boulders like this, but still, this one is really larger even for a river to carry, not only that, river pebbles that generally they carry, they tend to be rounder in nature, they do not have these angular pots, because they are constantly tumbling in the ground and that makes them that gives them a smoother surface. And that leaves us with glacier.

Glacier is a high density material, it also has velocity and it can actually carry these large materials. And when they are depositing they also deposit fine materials which they have been getting along with these very large materials. So, this is definitely a glacial deposit which is indicated by the difference in sorting. This is very different in terms of size comparison to this. So, if you are looking at if you have to comment on the sorting of this entire rock, it is going to have a very poor sorting. It will also have very angular fragment. These are typical signatures of glacial deposit. So, glacier is the responsible agent for creating this rock. Thank you for your attention. I hope that cleared most of the questions.