Evolution of the Earth and Life
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Discussion on Posted Questions

Welcome to the course Evolution of the Earth and Life. Today we are going to discuss some of the questions that I posted in the slides.

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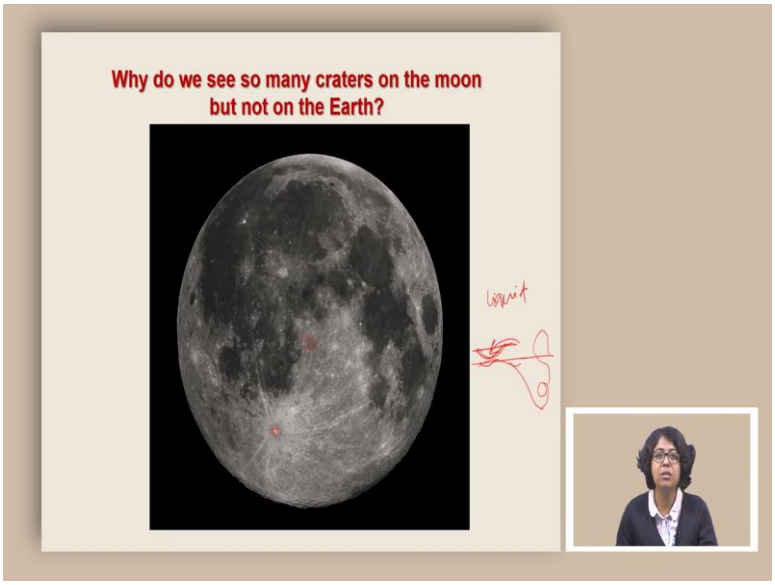

This question asks, why do you see so many craters on the moon, but not on the earth? It is true that when you look at into the moon, you actually do see a lot of craters. And careful look, gives you distribution of the craters of different size. Because Earth and the Moon had similar histories, it is also understood that the earth must have had similar impacts during its time. But the reason Earth does not retain those craters is because Earth has a very strong plate tectonics. And whatever craters were formed, especially in the ocean floor, they have already been abducted and consumed.

And eventually when it again comes back up as part of the mountains or things like that, they do not retain the characters in terms of those craters. So, therefore, we do not have those craters preserved in the earth surface. Now, when we look at the moon surface, Moon does not have plate tectonics, at least right now. And even if they are because moon score has frozen, and there is no plate tectonic motion in the moon, and therefore, it does not really get consumed and subducted and it retains that early characters of the surface.

The second important point is the Earth has liquid water. And what liquid water does, it also contributes significantly in terms of weathering. And because of the weathering, many of these changes in the flat land. If it is in the form of crater, it gets the sediments get deposited gets filled it up. These are all part of the weathering process. On the other hand, on moon, because there is no liquid water. That weathering cycle is not as active as we see in the earth. So, because of these two reasons, we can see so many craters on the moon, but not on the earth.

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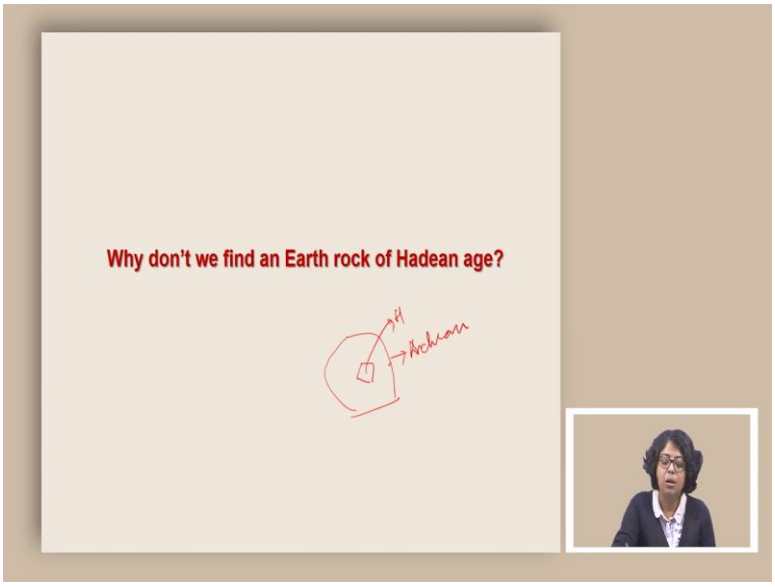

The second question is, why do not we find Earth rock of Hadean age? As we mentioned that we do find minerals of Hadean age as part of rocks, which are of Archaean age. So, the mineral grains represent a Hadean age, but the overall rock represents an Archaean age. This is because during Hadean time, there were large impacts and because of these impacts, Earth went through multiple cycles of melting and re melting. And that stopped many of these rocks to get preserved. Majority of the rocks probably went through cycles of multiple melting and did not survive. And every time something melts, the radioactive clock resets and therefore it does not really record the initial phases of crystallization, it will only record the last time it crystallized. And those times are correspond to Archaean.

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Compare the concentration of oxygen in the Earth during Archaean with the present day? So, if we look at the concentration of oxygen, what we will find that the present day has a much higher oxygen concentration compared to Archaean. Because during Archaean there was no mechanism to produce oxygen. The majority of the oxygen is produced by photosynthesis. And if we look at the organisms which appeared during early Archaean, we are not really talking about eukaryotes it is primarily prokaryotic organisms. And these prokaryotic organisms were not very efficient photo synthesizers.

Probably there was some development of oxygen at some point of time towards the late Archaean. But then there was enough materials in the Archaean, which were formed during the reduced phase. As a result, they acted as a sink of this oxygen early produced oxygen. So, immediately things will oxidize and take up the oxygen. So, overall level of oxygen in the Archaean atmosphere was fairly low and definitely lower than the present day.

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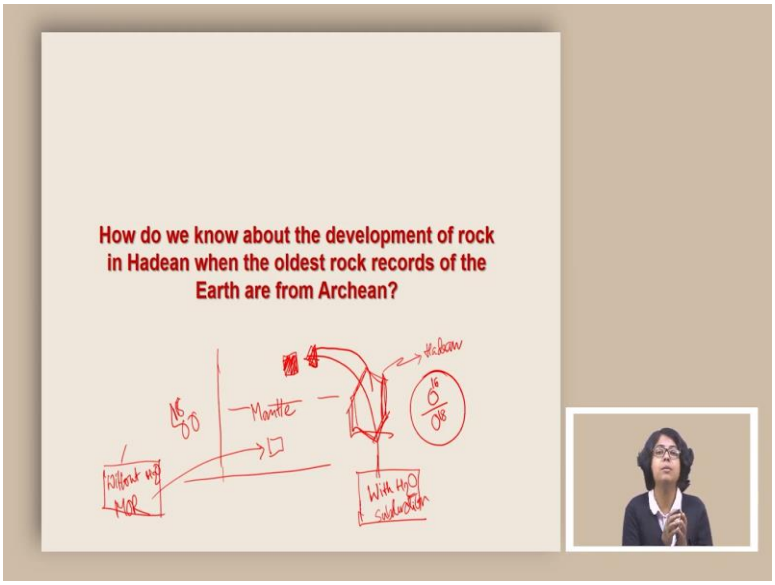

How do we know about the development of rock in Hadean when the oldest rock records of the art are from Archaean? This is related to some of the questions that we discussed just now that we look at these zircon grains, which represents the age of Hadean. These zircon grains tells us a lot. First of all, these zircons are generally associated with a specific type of rock such as granite. And these granitoids or granite are rocks which are formed as part of the continental crust formation. So, people believe that these Hadean zircons were probably associated with such formation of crust.

Second point that one can do is to look at their geochemistry and as we mentioned that in geochemistry there can be something called stable isotope. So, Oxygen 16 and Oxygen 18 ratio. And people looked at the Oxygen 16, Oxygen 18 ratio of zircons of Hadean age and then they also looked at of the modern time. So, in modern time, you can create some of the rocks which are coming directly from the mantle. So, without water without liquid water. Things like which are forming in the as part of the mid oceanic ridge.

And then there can be rocks which are forming with substantial amount of liquid water. Such as things which are forming in the subduction zone because subduction zone actually takes quite a bit of water in the process of melting and creates different metamorphic rocks and igneous rocks. Now, if you look at the zircons which are produced by this and which are produced by this, we will see that if we somehow look at this O 16, O 18 ratio, then there is a part which separates the mantle derived oxygen ratio.

So, all the things without liquid H2O will plot below it. And the things which are with H2O will plot above it. Now, if we want to plot Hadean zircons in terms of O 16, O 18 ratio. What we find that this one basically plots over here, this one show are relatively heavy ratio, which indicates looking at the present day configuration that they must have been formed during a time when liquid water was present as part of the rock, which is similar to a granitoid.

And this is how we know about the development of rock in Hadean. When we do not really have rocks from Hadean, we only have minerals. And the minerals can tell us something about the rocks. So, that is how we know about the rocks of Hadean although we do not have the physical presence of the rocks of Hadean.

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How will you challenge Aristotle's idea of spontaneous generation of life? One way of challenging this idea which argues that if you leave certain things, they will spontaneously generate more life. And he gave an example, that if you keep a piece of meat, after some time, you will see flies appearing out of nowhere. And that was the whole idea of spontaneous generation of life. You can test it along the same line of paths to where you can keep this meat in a closed space and you can take out all the air out of it.

So, that you are ensuring that there is no existing life into it. If you do that, well up, you will find that there is no development of flies. In fact, the fly larvae there were so small that people did not recognize them when Aristotle was making this observation, and that is why he erroneously thought that from the meat, the flies are originating apparently without any seed.

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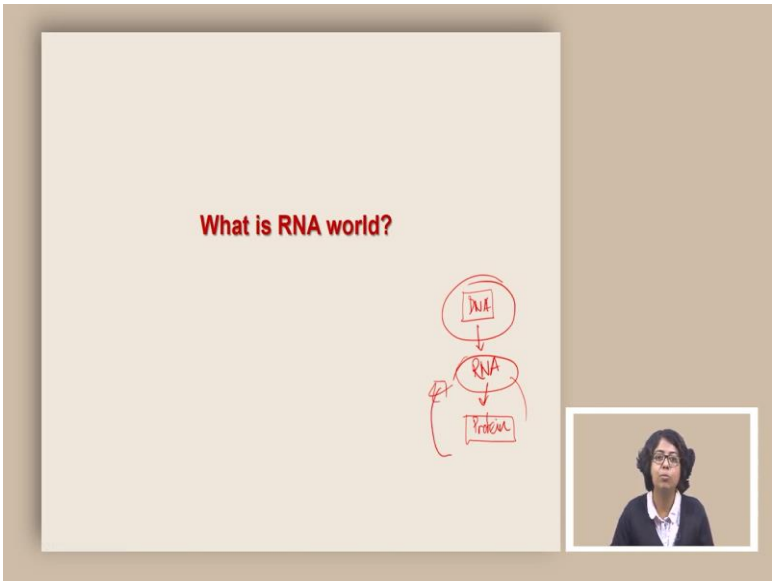

What is RNA world? So, this goes back to the discussion of what was the first biomolecule? So, we understood that there is a central dogma of biology, which argues that there is DNA, which is the source of information, then it goes to RNA, and then RNA can passes this information in terms of forming protein. And the question was that, if what is going to be the first molecule? Because the first molecule need to have this blueprint or the information to make the protein and who creates this information if proteins are not there?

So, as it turns out, that it is neither DNA nor protein, it is actually the RNA, which can operate as a good intermediate material, but it could also operate as a bio catalyst, which can perform like an enzyme. So, basically it can carry information, but it can also operate like a protein and enzyme. And therefore, then the idea came that initial biomolecule could have been an RNA, which operated in both ways and created the development of protein eventually, and over time, because DNA is more stable, this took over and now we have this kind of a pattern from DNA to RNA to protein. So, the world where the RNA appeared as the first biomolecule and things went from there is the idea of origin of life through an RNA world.

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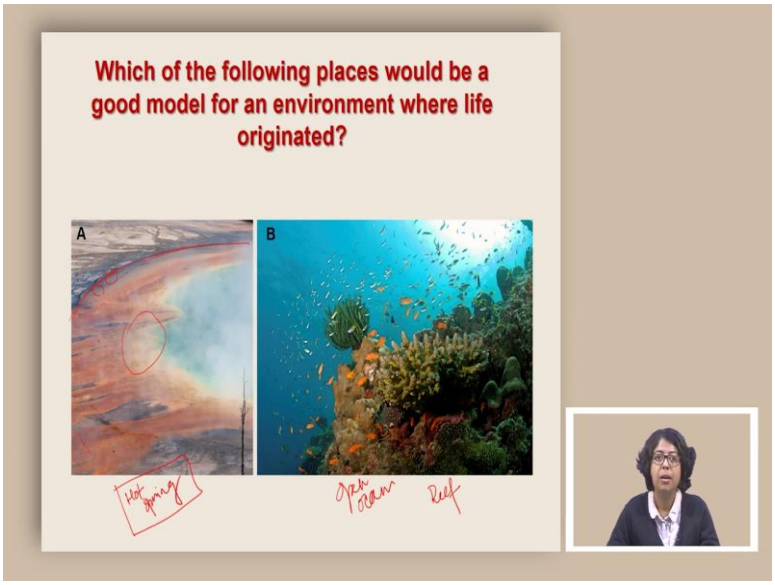

Which of the following places would be a good model for an environment where life originated. So, here are two pictures. In one picture, we see a reef a modern-day reef, where there are plenty of biodiversity and then another one, which is a hot spring. Now, as we know that reefs are very well oxygenated, so, if well oxygenated environment is there, the initial biomolecules, the long chain molecules will not survive, they are going to be oxidized very quickly. And therefore, this will not be a place where the life could originate.

More importantly, the some of the reactions especially for forming peptide bonds, it also requires some desiccation reaction, and waves because they are completely underwater. They cannot give you this desiccation reactions, which happens in these hot springs, where the sides of it are often a desiccated during different cycles of the day. And therefore, if some of these molecules basically are concentrated around the sides, they can go through these cycles.

The final point is in reef, it is connected to the open ocean, and in open ocean, any concentration of biomolecule will not be enough, because there would not be enough concentration. But here because of lack of circulation, and also a relatively smaller area, there can be a critical concentration formed and from this concentration, you can also create the subsequent steps of life. So, considering all of these points hot spring appears to be a more viable place for a good model of an environment where life originated. I hope you found all the answers of the questions and you will also understood the reason behind it. Thank you.