Introduction to Ancient Indian Technology.
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Lecture-34.

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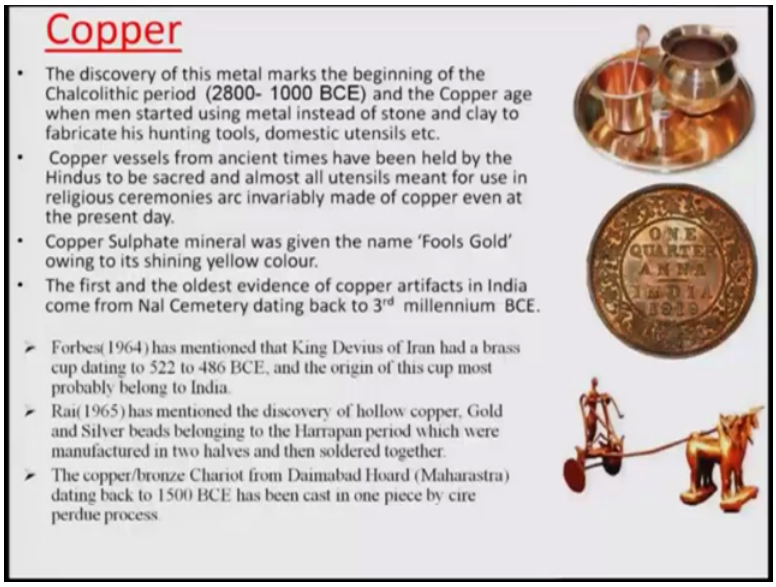

Let us start this lecture with a thought process that is smile begets smile. In the last lecture we basically started the discussion on the gold and later on we moved into the lead and silver because both the lead and silver are being discussed together and as it was being processed earlier days in the same way. Today we will be discussing about copper. Copper plays a very important role and it is a part of our civilisation and culture.

Even today also we are using copper utensils and other things for our rituals. You know for performing rituals we do use copper. The discovery of this metal marks the beginning of Chalcolithic period around 2800-1000 BCE. And this also is known as the copper age men started using metal instead of stone or the clay to fabricate the hunting tools, domestic utensils, etc.

And you will find that lot of euphorias are there among some people today that copper is having a lot of therapeutic values. Of course one has to check about that because copper vessels from ancient time were being held by Indians to be sacred and almost all utensil meant for use in religious ceremonies are invariably made of copper even at the present time as I had mentioned earlier.

Copper sulphate minerals was given the name 'Fool's Gold' and owing to its shining yellow colour. Of course it is not really the copper rather it will be the brass which can be considered as yellow. The first and oldest evidence of copper artifacts in India date backs to the Nal cemetery something 3rd millennium BCE. There is evidence also, the Forbes in 1964 had mentioned that King Devius of Iran had a brass cup dating back to 522 to 486 BCE. Its origin was probably belonged to India and Rai also has mentioned that discovery of hollow copper, gold and silver beads belong to the Harappan period which were manufactured in two halves and then soldered together.

And as I told earlier that people were also making some kind of a gold spheres by using the surface tension force and copper and bronze chariot from the Daimabad Hoard of Maharashtra dating back to 1500 BCE and it has been casted this figure I have shown you here. The copper or maybe bronze chariot is being casted in one piece by the investment casting, people call it cire perdue process.

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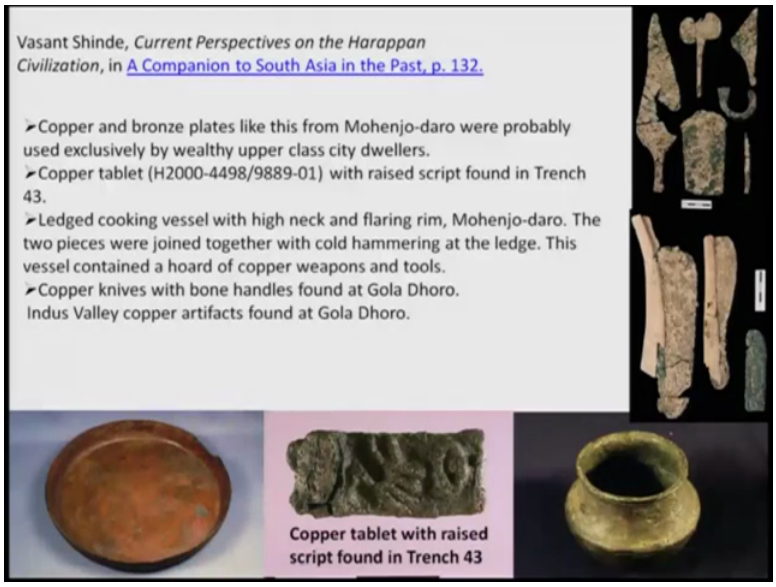

Maybe if you will time will permit we will be discussing about this investment costing. Maybe I will try to devote one lecture on that and of course during Harappan period. The several copper materials or copper artifacts being used and according to Vasant Shinde who is the vice chancellor of Deccan university and he has actually written an article. Current perspectives on Harappan civilization in a comparison to south asia in past. He has mentioned that copper and bronze plates like this whatever I have shown here from Mohenjo-daro were probably used exclusively be wealthy upper class city dwellers because it was it might be the costly.

Copper tablets with a you know raised scripts found in Trench of 43. If you look at these are scripts which is to be unravelled kind of things they found in Harappan region. Ledged cooking vessel with high neck and flaring rim, if you look at this having a neck and flaring rim, this one utensils are being used even today and he thinks that it must have made in two pieces and joined together by cold hammering at the ledge.

And this vessel contained a hoard of copper weapons and tools which I have shown here. These are the weapons, right, these are the kind of weapon people were using at that time. And copper knife with bone handle. If you look at this is basically bone and this is copper knife were found at Gola Dhoro regions. So it is the if you look at the copper were being used in by the Harappan people as being you know discussed in the article of Vasant Shinde.

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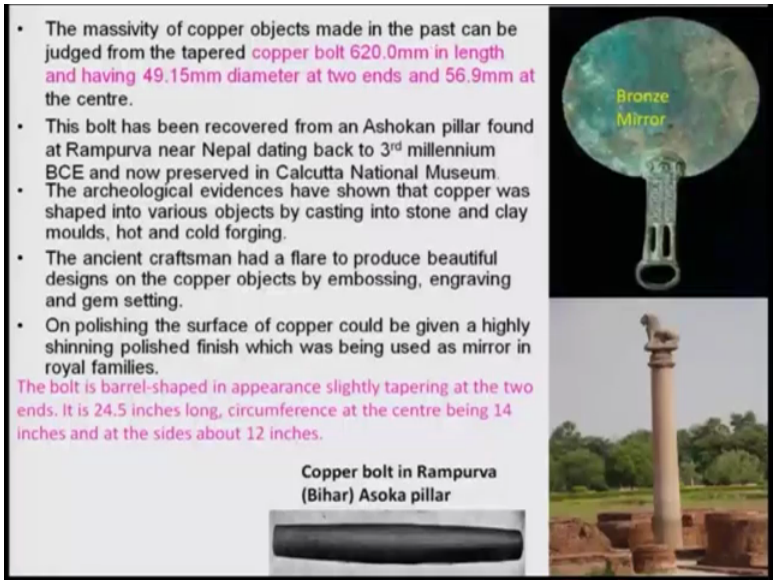

And massivity of the copper objects made in the past can be judged from the tapered copper bolt of 620 mm and this is the copper bolt which was huge in length and having 49.15 diameter, this diameter right. And the this is basically smaller diameter like 49.15 mm and this is a bigger one 56.9mm at the centre, right. And this bolt was used to join the two pieces. Particularly this emblem of the lion to this pillar and this is the Ashokan Pillar and which was found at Rampurva near Nepal which dates back to 300 BCE kind of thing. And now it is preserved in Calcutta National Museum.

There are several archeological evidence about the copper uses. And objects of various shapes are being made by casting and maybe claymoulds and sometimes people use hot and cold forging to make these objects of copper. Ancient craftsmen had a flare to produce

beautiful design in copper objects by embossing, engraving and gem setting. Also people were using this copper by polishing it properly you know as a mirror. This is the mirror which I have shown and this is the main portion of the mirror which is polished well. Polished mirror and when I was a kid I had seen similar mirror in one village earlier you know it was a piece which was being you know kept as a piece in one of the rich person home.

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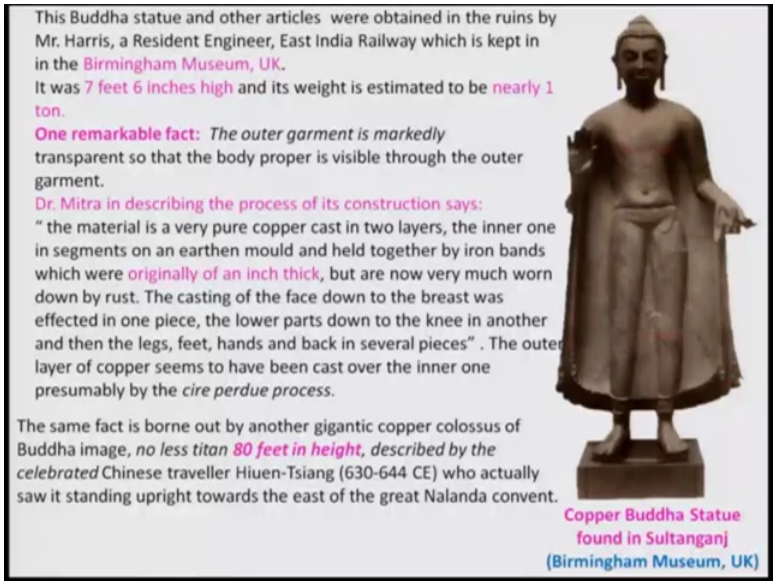

So if you look at this bolt which I discussed in the very beginning. It was having something 24.5 inch long, inches of long of the size. So here I have shown you a Buddha statue which is basically being unravelled in Sultan Ganj by a British officer who was Mr. Harris, a Resident Engineer in East India Railway company. Right and now this Buddha statue is being kept in Birmingham Museum in UK.

And it was 7 feet and 6 inch high and its weight was estimated to be around 1 ton, this figure you know. One very important part which was observed by Dr. Mitra about this statue that the outer garments, see if you look at this, there is the outer garments which is of course you can see from here, this portion was made in such a way that body you know is visible through the outer garment.

Dr. Mitra has described the process of construction of this statue as that material is a very pure copper cast in two layers, the inner one in segments on an earthen mould and held together by iron bands and these iron bands were originally of an inch of thick but unfortunately at that time it is might be rusted out.

The casting of the face down to the breast was effected in one piece that means till this you know this one piece it might have done. And the lower part down to knee in another piece, knee kind of things, right, tell knee. And then the leg and feet, hands and back in several other pieces outer layer of the copper seems to have been cast over the inner one.

Presumably by the invest I mean casting process. So if you look at how they are joining and so seamlessly. These are the question one need to ask but however more research is to be carried out. How it was fabricated in ancient time, such a colossal you know statue. Beside this statue there is a also mention of another very big statue which is 80 feet in height of the same Buddha image Lord Buddha, which was described by celebrated Chinese traveller Hiuen-Tsiang who came around 630-644 CE during the Harshwardhan period and he has written in his travel log that he saw it standing. It means the Buddha statue to be standing upright towards the east of the great Nalanda convent.

Because Nalanda was having university, so at that time. So in that university this status was there. But where is that statue today that nobody knows. So therefore this is the only from the travel log written by the Chinese traveller Hiuen-Tsiang that we could get. Copper ores and its extraction of copper in Ancient India.

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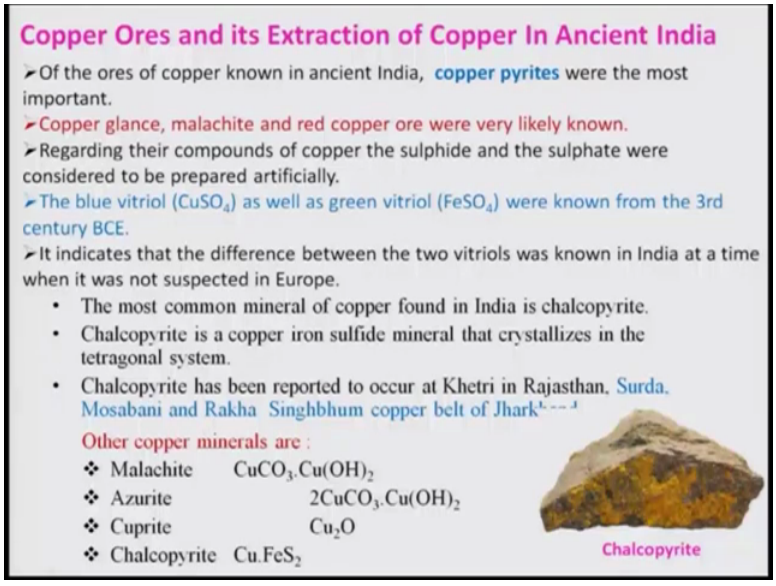

Let us look at how they were doing. Of the ores copper known as ancient, the copper pyrites were the most important ones. Beside this there are copper glance, malachites and red copper also present but they are not very much used or not known well known. Regarding compounds of copper. The sulphide and sulphates were considered to be prepared artificially

for example like the blue vitriol that is copper sulphate as well as the green vitriol iron sulphate were known from the 3rd century BCE, because in the Arthashastra it has been mentioned about this blue vitriol and green vitriol.

And it is very important that the difference between these two vitriols were there in the scriptures of Ancient India but unfortunately you know during that time 3rd century BCE it was not even suspected in Europe. That means Indians were knowing about this two blue vitriol and green vitriol much before the European could think of. The most common mineral copper found in India is basically chalcopyrite and chalcopyrite is a copper iron sulphide mineral that crystallizes in tetragonal system.

Chalcopyrite has been reported to occur at Khetri in Rajasthan, Surda and Mosabani and Rakha of Singhbhumi which is the copper belt of Jharkhand. Even today also we are having lot of copper ore mines. So other copper minerals one can think of Malachites which is the chemical formula is given here Azurite, Cuprite, of course the Chalcopyrite. We will be discussing about some process how it can be you know used for refining this Chalcopyrite and Chalcopyrite figure is shown here.

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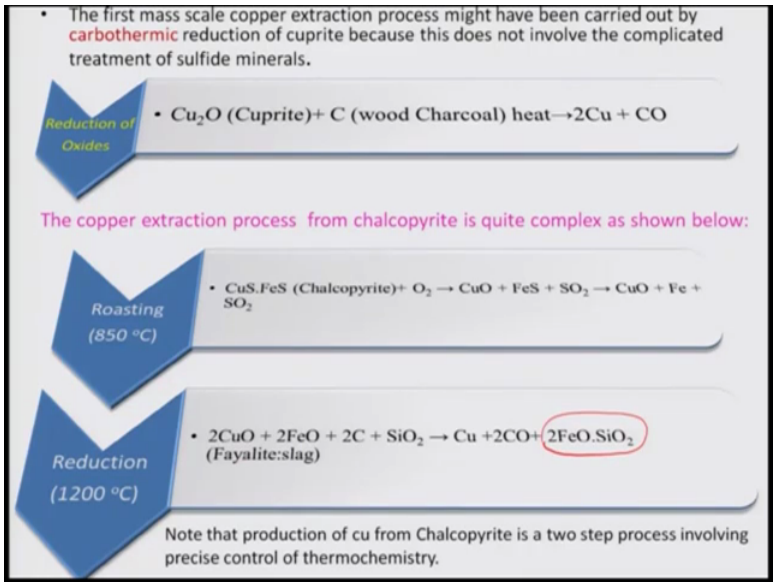

Reduction of cuprite can be done very easily by adding this you know carbon which is basically the wood charcoal were being used at that time and when you heat it, it will be getting into copper and then carbon monoxide. And this is of course a endothermic reaction. You will have to give some heat into that and once you have burned this charcoal you know like it will be used. And this really doesn't involve very complicated process like the when

we deal with the copper sulphide. The copper extraction process from the Chalcopyrite is quite complex as shown here and keep in mind there is two process which is being done. One is roasting which occurs at around 850 degree Celsius.

Chalcopyrite will be reacting with oxygen and it will give cuprous oxide, ferrous sulphide and sulphur dioxide. Then if you heat it further, you will get CuO, Iron and sulphur dioxide and reduction will be taking place around 1200 degree Celsius, and where the cuprous oxide will be reacting with ferrous oxide and carbon and of course the some silica will be present in that and you will be at 1200 degree Celsius of course that is a little difficult to get this temperature.

And you can get the copper and carbon dioxide and this is the fayalite or the slag. This portion is the basically the slag which will be removed out of this and then that is known as fayalite. And as I mentioned just now that the production of copper from the chalcopyrite is basically a two step process involving precise control of thermochemisty, because unless you control this temperature precisely you will not get really the right thing.

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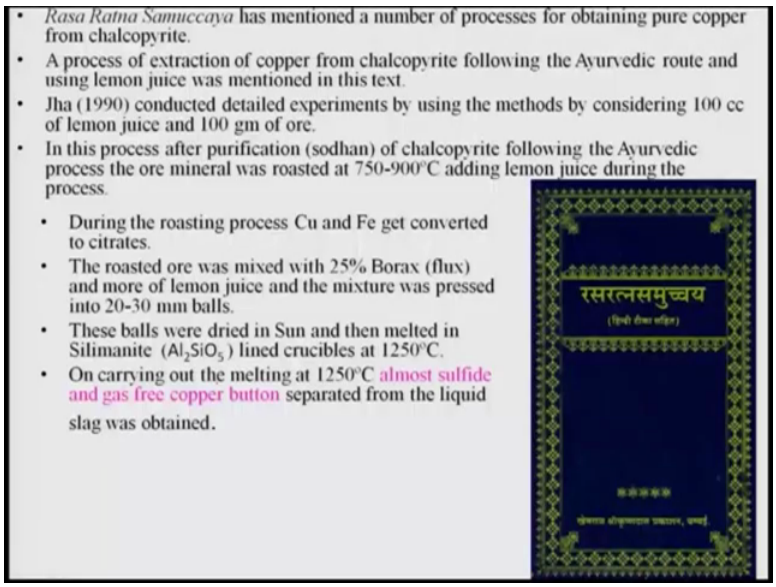

So therefore it is very important to have a control over that. And besides this there are several process of this preparing copper is being mentioned in the Rasa Ratna Samuccaya and these processes are basically meant to produce the copper in a small scale, the process of extraction of copper from chalcopyrite. You just say ayurvedic route using the lemon juice as a chemical.

In 1990 the Jha in IIT BHU conducted expreriments to find out whether this process given in Rasa Ratna Samuccaya is correct or not by using the method by considering 100 cc of lemon juice and 100 grams of ore and he conducted experiment very diligently and also reported in his PhD thesis.

In this process after purification sodhana what the you call in Hindi is chalcopyrite following the Ayurvedic process of ore mineral was roasted at 750-900 degree Celsius adding the lemon juice during this process. And during this roasting process copper and iron get converted into citrates. Roasted ore was mixed with the 25 percent of Borax which acts as a flux and more of the lemon juice and the mixture was pressed into 20 to 30 mm of balls.

Like they form these balls out of this mixing and these balls were dried in the sun. Then melted in the silimanite that is Al2SiO5 and lined crucibles. Again that you know this crucible is specially being line with this silimanite and which was heated at 1250 degree Celsius and on carrying out this melting almost sulphide and gas free copper button separated from the liquid slag was obtained.

That means they could prepare this copper bottoms out of this. That means it is very clear from this experiment that the process which is given in the Rasa Ratna Samuccaya is possible and one can use that method even today.

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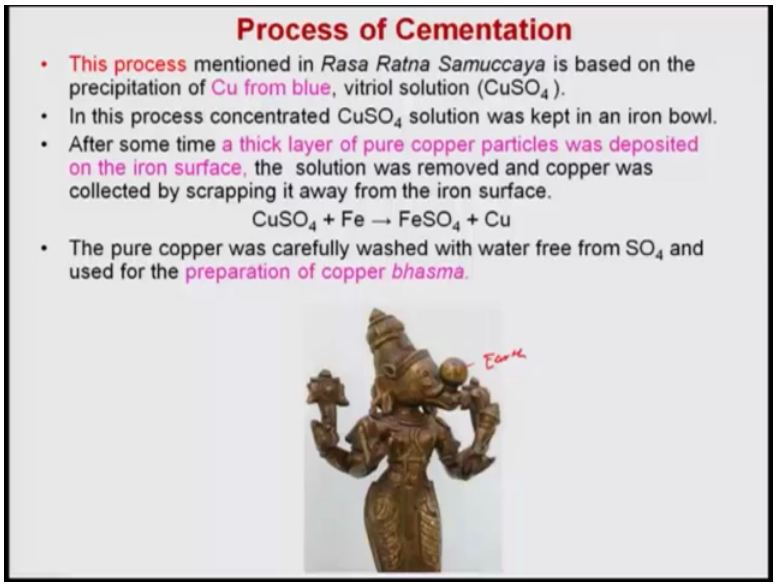

So we will be discussing about another process of forming copper in a small quantities that is the process of Cementation. This process has been mentioned in the Rasa Ratna Samuccaya which is based on the precipitation of copper from blue vitriol solution that is copper

sulphate. In this process the concentrated copper sulphate solution was kept in an iron bowl and after certain time a thick layer of copper, pure copper particles was deposited on the iron surface and the solution was removed and copper was collected by scraping it away from this iron surface.

This is a very simple process and if you look at the reaction. Copper sulphate reacting with iron became iron sulphate and then copper. And pure copper was carefully washed with water free from the sulphate and used for the preparation of copper bhasma. Because in earlier days, people were using the copper bhasma, gold bhasma and other metal bhasmas for the ayurvedic, so therefore this process being devised. So if you look at the processes what I have described till now.

Most of the things they mixed the natural products, natural ingredients and then make it. For example lemon juice is being used here. And that is the thing what need to be relook at it and also we can find out whether we can revive this processes. And beside this if you look at the copper also being used for making the brass items and also the there are several dhatus like navadhatu, asthadhatus and several alloys people have used using the copper and other alloys.

And I will just show a picture and which is about the statue of an Baraha which is made of this copper material and it has very intricate steps and how they fabricate a such a intricate statue and keep in mind that this Baraha is basically carrying a earth. And this earth, if you go to our mythology is basically round in nature so therefore lot of science and this thing are there in our sculptures and also the idols and then this thing we can learn about that how they were knowing.

And this process can be tested even today with the method mentioned in the scriptures the text like Rasa Ratan Samuccaya and several other scriptures are available even today. And we can revive this process and which are simple in nature. So with this we will stop over. Thank you very much and in the next lecture we will be discussing about how the iron was being made in this or iron making processes and how iron was being used in Ancient India. Thank you very much.