| **OrientationCompass with solid fill** | **QR audio** |
| --- | --- |

Through the preceding activities, some questions arose regarding the Roman coin…

1. What is the Roman coin made of? What are the properties of this material?

2. From which region did the Roman coin denarius originate?

3. What information can we get by using archaeometric methods?

4. What information can we gather about the authenticity of the Roman coin?

5. Where else can we find similar coins?

*Discuss the above questions in the classroom as a whole*

**How can we answer these questions?**

**Record the results of the discussion**

| ***The students record the results of the discussion, concluding with the following***  **To answer the above questions we need to:**   * **Zoom in on the object to see details** * **Identify the ingredients from which it is made** |
| --- |

| *Record the views heard with a short video or audio recording  Name it “1.a Problems and Solutions”* | | *QR audio* |
| --- | --- | --- |
| **Conceptualization Questions outline** | **QR audio** | | |

*Discuss as a whole class.*

**How can we see item details?**

*Note or draw tools we can use  
to see details of an object*

| Instruments / Devices | Select |
| --- | --- |
| **Magnifying glass** |  |
| **Binoculars** |  |
| **Telescope** |  |
| **Optical microscope** |  |
| **Close up eye vision** |  |
|  |  |
|  |  |

| ***The students fill in their ideas above or draw the above instruments in this space.*** |
| --- |

*Discuss as a whole class about the instrument that can give us the best results and choose it from the table above.*

***Through the discussion we come to the optical microscope.***

| *Record the views heard  with a short video or audio recording.*  *Name it “1.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **Research Research with solid fill** | **QR audio** | |

Use your mobile devices (tablets, mobile phones, etc.) and scan the QR below.

Watch the video and download the results for your chosen device for Roman coin by clicking on the **"Results"** button.

****

***Discuss with the whole class the results of this particular device***

* In the first point of interest, we observe the Roman coin in terms of the material it is made of. Can you describe what the Optical Microscope shows? 

Picture 1 Picture 2 Picture 3

***The discussion with the students concludes that it is interesting to study the material from which the Roman coin is made. What information can we get with the optical microscope? We can identify a point of interest to study the material of the coin (Figure 1). Zooming in on the area of interest (material) we observe that it is not smooth (Figure 2). Using the Optical Microscope (Figure 3) we observe that the surface of the metal is rough and distressed.***

* In the second point of interest, we observe traces of colour on the other side of the coin. Can you describe how they appear in the optical microscope?



Picture 1 Picture 2 Picture 3

***Another point of interest is traces of colour on the other side of the coin (Figure 1). By zooming in on the area of interest (colour traces) we confirm their existence (Figure 2). The colour traces (Figure 3) as seen under the Optical Microscope.***

| *Discuss and record what the device does with a short video or audio recording.*  *Why do we use it and what results does it give us?  Name it “1.c Research”* | *QR audio* |
| --- | --- |
| **Conclusion Thought outline** | **QR audio** |

* **Why do we see three different images for the same point of interest? Can you sort them from lowest to highest magnification?**

**The three images give us an increasingly higher magnification of the same point.**

**The higher the magnification, the greater the detail we can observe.**

* **Do you observe anything different in the images of the different areas of the object we focused on?**
* *Write down your observations or draw the pictures below with arrows for the points of special interest.*

| **In the images taken by the Optical Microscope, the points of interest are any part of one side of the coin to study the material and the traces of colour observed on the other side of the coin. So, it would be interesting to get more information about these areas.** |
| --- |

| *Record your answers in three different short videos or audio recordings*  *Name them "1.d Conclusion A", "1.d Conclusion B"* | | *QR audio* |
| --- | --- | --- |
| **Conceptualization Questions outline** | **QR audio** | | |

*Discuss as a whole class.*

**What do we need to do to get more information  
about the points of interest?**

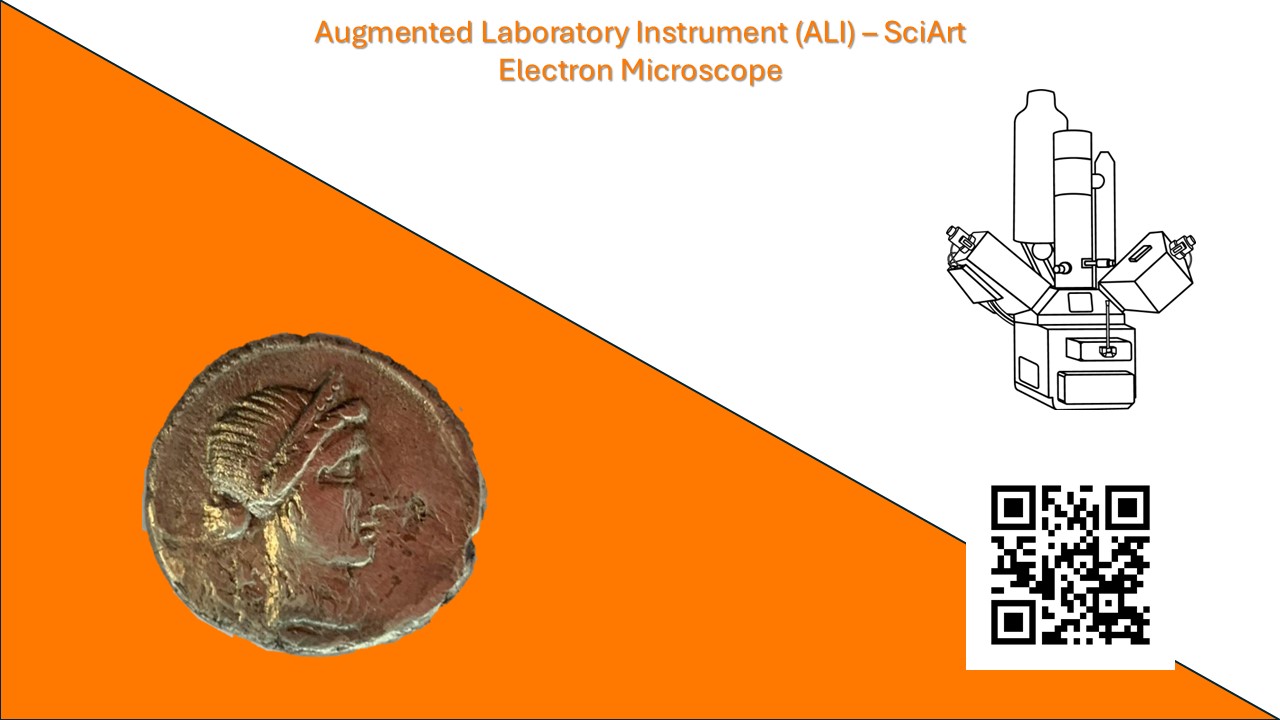
***A discussion is provoked in the class, in which we guide the students to focus on the need for further magnification.***

***The teacher introduces the Electronic Microscope as a solution for extra magnification.***

| *Record the views heard  with a short video or audio recording.*  *Name it “2.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **Research Research with solid fill** | **QR audio** | | |

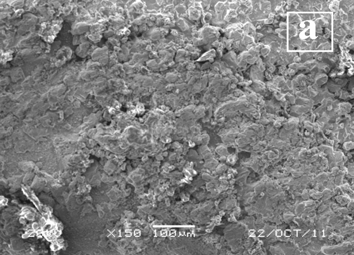
Use your mobile devices (tablets, mobile phones, etc.) and scan the QR below.

Watch the video and download the results for the Roman coin by clicking on the **"Results"** button.

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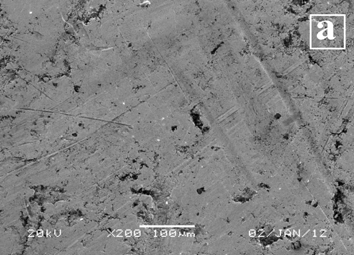
***Discuss the results of this device in the classroom***

* In the first point of interest, for the coin material, what do you observe in the SEM image? Can you describe its morphology?



***In the image we obtain from the SEM, we observe the surface morphology of the coin. The surface is rough, which is an indication of wear. We cannot obtain any additional information..***

* In the second area of interest, for the traces we spotted on the relief of the coin, what do you observe in the SEM image? Can you describe how the color traces are depicted?



***In the SEM image of the color traces we spotted on the relief of the coin we do not observe any information about the type of material, except for the fact that the traces look like tiny grains.***

| *Describe how the device works and what we use it for*  *with a short video or audio recording.*  *Name it “1.c Research”* | | *QR audio* |
| --- | --- | --- |
| **Conclusion Thought outline** | **QR audio** | | |

* **Which one of the two different points of interest, scanned with the SEM method, has the highest magnification? How can we find it?**

**Image 2 has the highest magnification of 200x. We can read the magnification directly from the information given at the image's bottom. We can also calculate the magnification from the given scale.**

***The two images have a magnification of 200x (Figure 1) and 150x (Figure 2). We can read the magnification from the information given at the image’s bottom. We can also calculate the magnification from the given scale.***

* **Why do we get black and white images?**

**We get black and white images because SEM does not use natural light but electrons.**

* **What do we observe in the images? What might they mean for our object? Can we conclude the components in the points of interest (coin material and traces of colour)?**
* **No matter how high the magnification of the artifact is, it cannot give us clear answers about the components of the coin's metal and the traces of colour found in one area of the coin.**
* **We assume from the points of different white-black gradation the existence of different materials. It would be interesting to use a new method to identify the components of materials.**
* **So, we select the points where the magnification of SEM shows us that there are different materials to find their components with a new method, EDS.**

| *Record your answers in three different short videos or audio recordings*  *Name them "2.d Conclusion A", "2.d Conclusion B", "2.d Conclusion C"* | | *QR audio* |
| --- | --- | --- |
| **Conceptualization Questions outline** | **QR audio** | |

*Discuss as a whole class.*

**What do we need to do to find the components   
of the points of interest of the artifact we are studying?**

**What should we recognize?**

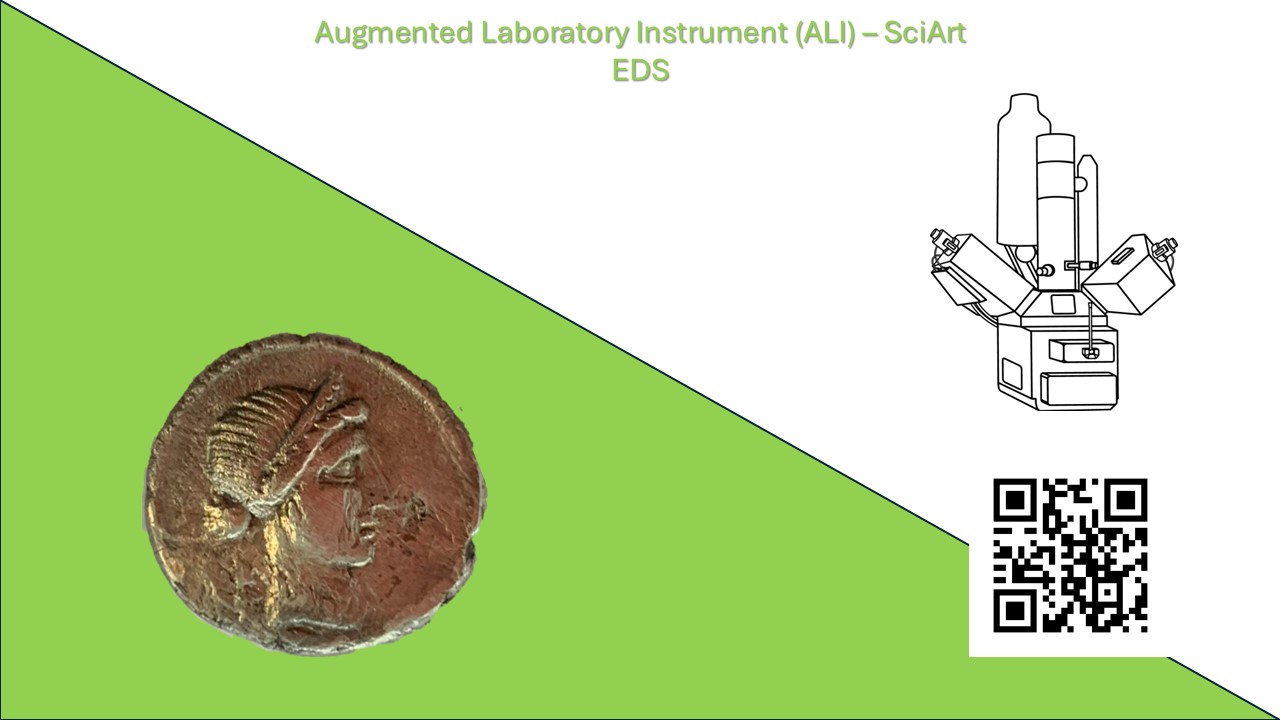
***A class discussion is provoked which leads to the need to identify the elements that the materials in the areas of interest (coin material and colour traces).***

***The teacher introduces the EDS method for the elemental analysis of the selected areas. "EDS, is an analytical method used to identify the elements found in a sample".***

| *Record the views heard  with a short video or audio recording.*  *Name it “1.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **Research Research with solid fill** | **QR audio** | | |

Use your mobile devices (tablets, mobile phones, etc.) and scan the QR below.

Watch the video and download the results of the Roman coin method by clicking on the **"Results"** button.

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***Study in your group and then discuss with the whole class   
the results of this particular method***

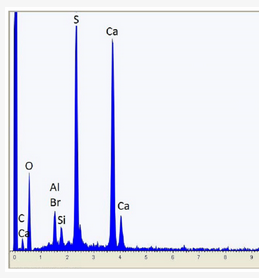
***Students observe the spectrum and identify the elements of the sample. The teacher explains to the students that an EDS spectrum is only obtained by selecting points of interest from the SEM images and asks the students to identify the elements found in the spectrum by the EDS method.***

* In the first point of interest, for the coin material, what do you observe in the EDS spectrum? What elements does it consist of and in what proportion?



***This is the spectrum we get from the EDS method for the coin material. The primary element of the coin's material is silver (Ag), with very small amounts of other elements such as copper (Cu), zinc (Zn), and even smaller amounts of sodium (Na), iron (Fe), lead (Pb), and gold (Au)***

* In the second point of interest, from the sample taken from the colour layer, what do you observe in the EDS spectrum? What elements does it consist of?



***This is the spectrum and elemental analysis taken from the EDS method regarding the red traces found on the coin's relief.***

***The analysis shows elements such as aluminum, silicon, and calcium, which are associated with aluminosilicates and limestones typically found in soil. This soil might be related to a burial site. The detection of bromine is an unusual finding because it is not a common component of soil.***

| *Discuss and record how the method works*  *with a short video or audio recording.*  *What results did it give us? What else did we have to do?*  *Name it “3.c Research”* | | *QR audio* |
| --- | --- | --- |
| **Conclusion Thought outline** | **QR audio** | | |

Write down your conclusions about the elements identified in the two points of interest in the table below.

| **Points of interest** | **Compounds** |
| --- | --- |
| Coin material | **It consists mainly of Silver (Ag) with 95%, while there are other elements in very small percentages, such as 2.7% Copper (Cu), 1% Zinc (Zn) and <1% Sodium (Na), Iron (Fe), Lead (Pb) and Gold (Au).** |
| Traces of colour found on the coin | **Our analysis shows elements such as aluminium, silica and calcium associated with clay silicates and calcretes commonly found in soil. The soil may be associated with a burial site. The bromine detected is curious because it is not a component of the soil.** |

| *Record your answers in a short video or audio recording*  *Explain how you got there.*  *Name them "3.d Conclusion"* | | *QR audio* |
| --- | --- | --- |
| **Conceptualization Questions outline** | **QR audio** | | |

*Discuss as a whole class.*

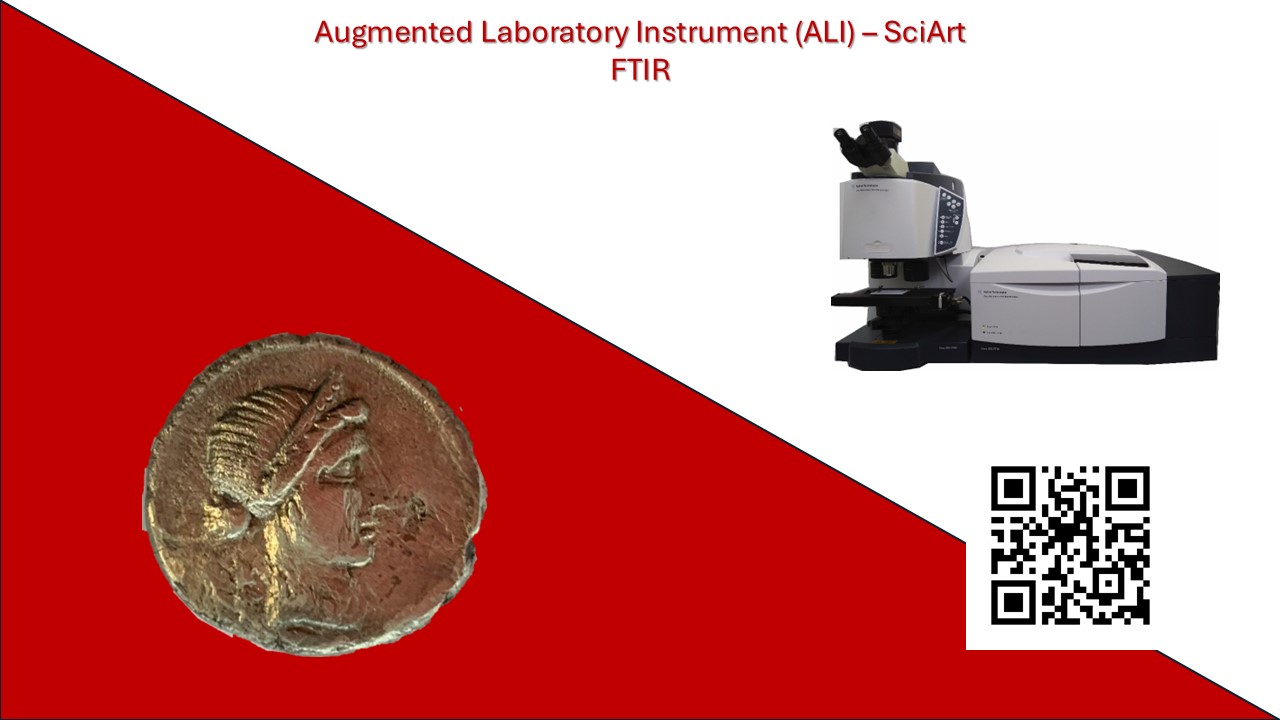
**What information will we get if we use the FTIR method to the two points of interest?**

***Students will use the FTIR method and they will find that this technique does not give results for the coin material, but it does give results for the colour traces in the second point of interest!***

| *Record the views heard  with a short video or audio recording.*  *Name it “4.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **Research Research with solid fill** | **QR audio** | | |

Use your mobile devices (tablets, mobile phones, etc.) and scan the QR below.

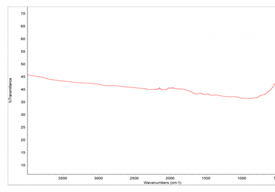
Watch the video and download the results of the Roman coin method by clicking on the **"Results"** button.

****

***Discuss the results of this method with the whole class***

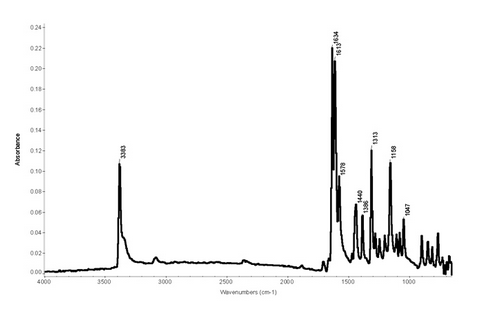
***The teacher explains to the students that the FTIR method does not give results for all materials. As seen from the results, we do not have a spectrum for the coin material, but we do have results for traces of colour.***

* In the first point of interest, for the coin material, what do you observe in the FTIR spectrum? Does it give results?



***The FTIR method does not provide results for the metal used. This method is not suitable to study this kind of material.***

* In the second point of interest, the sample taken from the colour traces, what do you observe in the FTIR spectrum? What is the material identified?



***This is the FTIR spectrum of the red trace found on the coin's relief.***

***The FTIR method fully identifies the unknown substance as the pigment called Tyrian purple. The chemical formula of Tyrian purple is C16H8Br2N2O2, which explains the bromine detected through elemental analysis.***

| *Discuss and record how the method works  with a short video or audio recording. What results did it give us?*  *Name it “4.c Research”* | | *QR audio* |
| --- | --- | --- |
| **Conclusion Thought outline** | **QR audio** | | |

* **Does the FTIR method give results for all materials? If not, list in the table for which materials it did not give results.**

| **Silver which is the main material of the coin** |
| --- |

* **Does the FTIR method give results for colour traces? If so, write down in the table which material was identified.**

| **Tyrian purple. The chemical formula of Tyrian purple is C16H8Br2N2O2** |
| --- |

| *Record your answers  in a short video or audio recording.*  *Explain how you got there.*  *Name them "4.d Conclusion"* | | *QR audio* |
| --- | --- | --- |
| **Conceptualization Questions outline** | **QR audio** | | |

*Discuss as a whole class.*

**What might the inability to identify a chemical compound by FTIR method mean for some materials?**

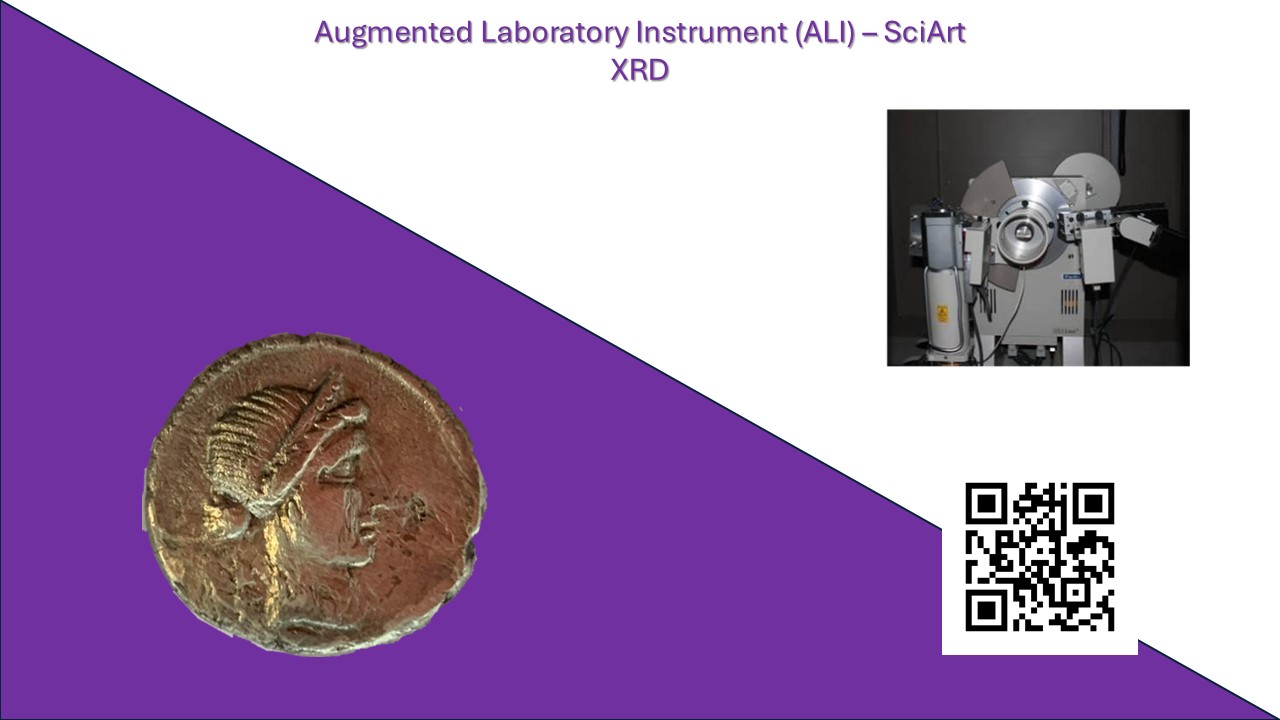
***A class discussion is provoked to show that each method has its limitations.***

***This is why we use more than one method when studying a sample. There are chemical compounds for which the FTIR method is unable to give results and that is why some of the elements we originally found using EDS did not appear in our results. Thus, the teacher introduces the need to use another method to accurately identify the composition of materials, the XRD method.***

| *Record the views heard  with a short video or audio recording.*  *Name it “5.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **Research Research with solid fill** | **QR audio** | | |

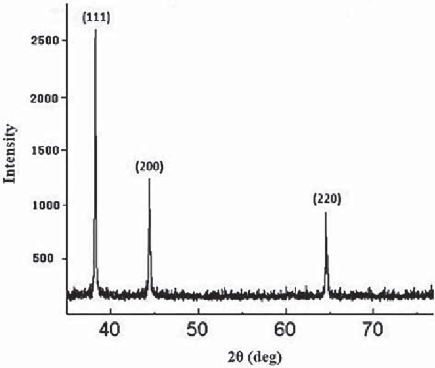
Use your mobile devices (tablets, mobile phones, etc.) and scan the QR below.

Watch the video and download the results of the Roman coin method by clicking on the **"Results"** button.

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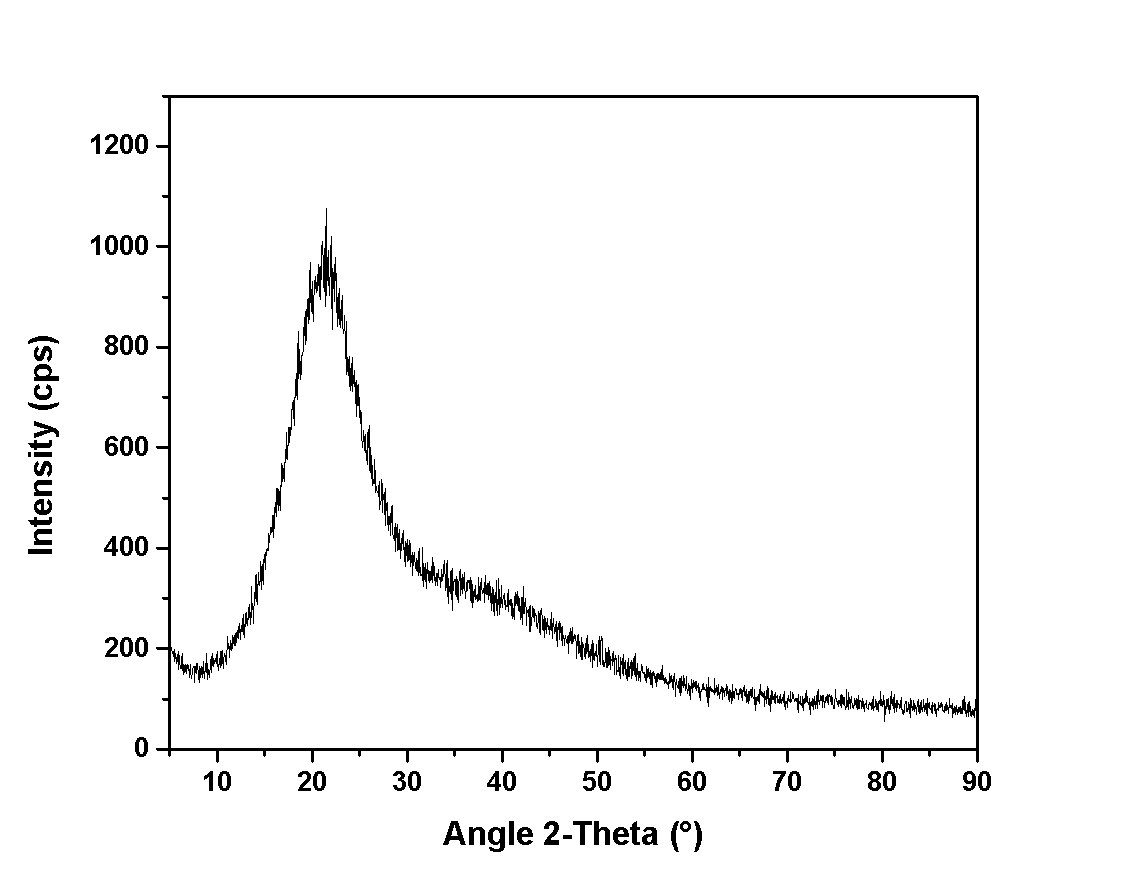
***Discuss the results of this method in the whole class***

***The students observe the graph (diffractogram graph) for each area of interest.***



***This is the XRD pattern of the main body of the coin.***

***The analysis of the diffractogram confirms that the coin is mainly made of silver.***



***This*** ***is the XRD pattern of the red traces collected from the coin's relief.***

***The analysis of the pattern does not lead to any conclusions, other than suggesting it is likely an organic material.***

| *Discuss and record how the method works  with a short video or audio recording.*  *What results did it give us?*  *Name it “4.c Research”* | | *QR audio* |
| --- | --- | --- |
| **Conclusion Thought outline** | **QR audio** | | |

* **Write down the material/chemical compound you have identified using the XRD method.**

| **Points of interest** | **Chemical Compounds** |
| --- | --- |
| Material of the coin | **The coin is silver, i.e. it consists mainly of silver (Ag).** |
| Traces of colour on the coin | **The analysis of the pattern does not lead to any conclusions, other than suggesting it is likely an organic material.** |

| *Record your answers  in a short video or audio recording.*  *Explain how you got there.*  *Name them "4.d Conclusion"Name them "4.d Conclusion"* | *QR audio* |
| --- | --- |

**Back to the initial questions...**

1. What is the Roman coin made of? What are the properties of this material?

2. From which region did the Roman coin denarius originate?

3. What information can we get by using archaeometric methods?

4. What information can we gather about the authenticity of the Roman coin?

5. Where else can we find similar coins?

| **Conceptualization Questions outline** | **QR audio** |
| --- | --- |

*Discuss as a whole class.*

**How can we use the conclusions drawn from archaeometric methods to answer the initial questions?**

*Please provide questions that you can ask an AI machine. The answers it gives you, combined with the results you already have, will help address the initial questions*

| ***The teacher facilitates a class discussion to formulate the questions the students need to answer. Such questions may be:***   * **What is Tyrian purple? What are its properties? Where is Tyrian purple used today?** * **What are the properties of silver? Where is it used?** * **In Roman times were silver coins common?** |
| --- |

| *Record the questions you will ask on ChatGPT with a short video or audio recording.*  *Name it “6.b Conceptualization”* | *QR audio* |
| --- | --- |
| **Research Research with solid fill** | **QR audio** |

Use ChatGPT to get information on the above questions. Write down the information you need to answer the questions.

| **Question** | **ChatGpt answer key points** |
| --- | --- |
| What is Tyrian purple? | **Tyrian purple is a type of extremely expensive and luxurious natural stone used mainly for decorative and architectural purposes. It has been used since archaeological times to create monuments, statues and other works of art. Porphyry is characterised by its colour, which is usually purple, violet or red, due to the presence of endogenous pigments. The best known sources of purple are found in ancient Greece and the Byzantine Empire, and it was often used to decorate imperial and royal palaces, as well as to create iconic objects such as purple robes. Because of its rare and precious nature, purple was a symbol of wealth and power in the ancient and medieval worlds.** |
| What are the properties of Silver? Where is it used? | **Silver is one of the best conductors of electricity and heat. It is resistant to corrosion, which makes it suitable for use in jewellery and objects subject to high humidity conditions. It has a characteristic shine that makes it suitable for jewellery making. It also has strong antimicrobial properties, which makes it suitable for use in medical applications and everyday objects such as cutlery and coin holders.** |
| In Roman times were silver coins common? | **At the beginning of the Roman Empire, the silver coins used were mainly silver denarius coins. The silver dinar was the main currency of the Roman Empire for many centuries.** |
| From which region did the Roman denarius coin originate? | **The denarius was widely used in all provinces and territories conquered by the Roman Empire, including present-day Italy, France, Spain, Britain, Greece, Turkey, Egypt and other areas. Thus, silver dinars circulated widely throughout the Roman Imperial territory and beyond!** |

*Discuss in class the answers  
to the specific questions you posed in ChatGPT*

| *Note the main points of the answers for each question.  Did it help you find the answer?  How?*  *Name it “4.c Research”* | | *QR audio* |
| --- | --- | --- |
| **Conclusion Thought outline** | **QR audio** | | |

*Record the answers to the initial questions of the investigation.*

| **1. What is the Roman coin made of? What are the properties of this material?** |
| --- |
| ***The Roman coin is silver! The properties of silver are that it is a good conductor of electricity and heat, is resistant to corrosion, has a characteristic shine and has antimicrobial properties.*** |
| **2. From which region did the Roman coin denarius originate?** |
| ***The denarius was widely used in all provinces and territories conquered by the Roman Empire, including present-day Italy, France, Spain, Britain, Greece, Turkey, Egypt and other areas. Thus, silver dinars circulated widely throughout the Roman Imperial territory and beyond!*** |
| **3. What information can we get by using archaeometric methods?** |
| ***....................................................*** |
| **4. What information can we gather about the authenticity of the Roman coin?** |
| ***..................................................*** |
| **5. Where else can we find similar coins?** |
| ***..................................................*** |

|  | *QR audio* |
| --- | --- |

**Create a video of your answer to each   
interview question.**

**One of you will ask the question**

**and the other person will answer!!!!**

*Name the videos "Final Answer 1", "Final Answer 2", etc.*