Multidisciplinary symposium

Non-destructive and Destructive Methods to Identify Archaeological Finds and their Host Deposits in Arid and Semi-arid Areas

@ Royal Belgian Institute of Natural Sciences
15-16 March 2016
Grand Auditorium - 29 Rue Vautier -1000 Brussels

www.greatermesopotamia.be/home/symposium.html

Hosted by the Royal Museums of Art and History and the Royal Belgian Institute of Natural Sciences, Brussels (Interuniversity Attraction Poles project ‘Greater Mesopotamia’)
Multidisciplinary Symposium

Non-destructive and Destructive Methods to Identify Archaeological Finds and their Host Deposits

Brussels: 15 & 16 March 2016
Royal Belgian Institute of Natural Sciences
Vautierstraat 29, 1000 Brussels

Organizing Institutes
Royal Belgian Institute of Natural Sciences, Brussels (RBINS)
Royal Museums of Art and History, Brussels (RMAH)
an initiative of the Interuniversity Attraction Poles research network ‘Greater Mesopotamia—Reconstruction of its Environment and History’ (www.greatermesopotamia.be)

Organising Committee
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Anne Devillers (RMAH—ULB)
Eric Gubel (RMAH—VUB)
Hendrik Hameeuw (RMAH—KU Leuven)
Rindert Janssens (RBINS)
Programme

Tuesday 15 March
Afternoon  Room: VIP

13:00-13:30  Registration & Coffee

13:30-13:45  Welcome & Introduction

13:45-14:20  Key Note 1: Georges Stoops - “The use of micromorphology in archaeology of the Near East”

14:20-14:45  Frank Carpentier - “Zooming in: The added value of soil micromorphology at Sissi, Crete”

14:45-15:10  Thomas Van de Velde - “From site to seepage: determining the origin of archaeological bitumen”

15:10-15:40  Coffee break and Poster Session

15:40-16:05  Astrid Nunn & Heinrich Piening - From the identification of pigments to the reconstruction of the polychromy on Mesopotamian stone statues

16:05-16:30  Cornelis Stal, Philippe De Maeyer, Berdien De Roo, Bart De Wit, Amaury Frankl, Britt Lonneville, Annelies Vandenbulcke & Alain De Wulf - “Optimized airborne 3D mapping using flexible and cost-efficient UAV-based photogrammetry”

16:30-16:55  Eslam Shaheen & Omyma Samieh Ali - “Integrated documentation and archaeometric study of Tutankhamun’s shields”

18:30  Conference Dinner at L’Oriento Jourdan (Chaussée de Wavre, 341) [on invitation]
Wednesday 16 March

Morning

09:00-09:45  **Key Note 2**: Patrick Degryse - “The origin and spread of glass making: The isotopic evidence”

09:45-10:10  Anna Hodgkinson & Frank Kutz - “The usability of portable XRF for the study of Egyptian plant ash glasses from the Late Bronze Age: A pilot study”

10:10-10:30  Coffee break and Poster Session

10:30-10:55  Nagmeldeen Hamza - “Beyond the visible, Combining scientific analysis and conventional methods for documenting the collection of Tutankhamen's loincloths: Integrated approach”

10:55-11:20  Thomas Goovaerts - “Precious and semi-precious stones: an introduction and a brief overview on identification methods”

11:20-11:45  Athena Van der Perre & Hendrik Hameeuw - “The use of multispectral visualizations for the identification of pigment patterns”

11:45-12:10  **Demo**: Using a portable XRF

12:10-13:20  Lunch break with sandwiches

Afternoon

13:20-13:45  AbdelRahman Medaht, Hussien Kamal, Omyma Ali, Islam Abd el Maksoud, Mohamed Ragab, Mona Akmal & Dina Atwa - “Non-Invasive study of pigments used in ancient Egyptian wooden models dating back to the Middle Kingdom”

13:45-14:10  Shlomo Shoval, Yitzhak Paz, Golan Shalvi & Dana Harari - XRF and LA-ICP-MS methods in the study of Canaanite ceramic technologies

14:10-14:20  **Demo**: The multi-spectral Portable Light Dome

14:20-14:40  Coffee break and Poster Session

14:40-15:25  **Key Note 3**: Dennis Braekmans - Integrating technological and archaeometric approaches to 1st Millennium BC ceramics from the Southern Levant and North Africa

15:25-15:50  Possum Pincé - The combination of chemical and petrographic analyses on pre-Islamic ceramics from the Kur River Basin (Fars, Iran)

15:50-16:10  Closing remarks
Book of Abstracts
(in alphabetical order)

ORAL PRESENTATIONS

1 — Integrating technological and archaeometric approaches to 1st Millennium BC ceramics from the Southern Le- vant and North Africa (Dennis Braekmans)

2 — Zooming in: The added value of soil micromorphology at Sissi, Crete (Frank Carpentier)

3 — The origin and spread of glass making: The isotopic evidence (Patrick Degryse)

4 — Precious and semi-precious stones: an introduction and a brief overview on identification methods (Thomas Goovaerts)

5 — Beyond the visible, Combining scientific analysis and conventional methods for documenting the collection of Tutankhamen's loincloths: Integrated approach (Nagmeldeen Hamza)

6 — The usability of portable XRF for the study of Egyptian plant ash glasses from the Late Bronze Age: A pilot study (Anna Hodgkinson & Frank Kutz)

7 — Non-Invasive study of pigments used in ancient Egyptian wooden models dating back to the Middle Kingdom (AbdelRahman Medaht, Hussien Kamal, Omyma Ali, Islam Abd el Maksoud, Mohamed Ragab, Mona Akmal & Dina Atwa)

8 — From the identification of pigments to the reconstruction of the polychromy on Mesopotamian stone statues (Astrid Nunn & Heinrich Piening)

9 — The combination of chemical and petrographic analyses on pre-Islamic ceramics from the Kur River Basin (Fars, Iran) (Possum Pincé)

10 — XRF and LA-ICP-MS methods in the study of Canaanite ceramic technologies (Shlomo Shoval, Yitzhak Paz, Golan Shalvi & Dana Harari)

11 — Integrated documentation and archaeometric study of Tutankhamun's shields (Eslam Shaheen & Omyma Samieh Ali)

12 — Optimized airborne 3D mapping using flexible and cost-efficient UAV-based photogrammetry (Cornelis Stal, Philippe De Maeyer, Berdien De Roo, Bart De Wit, Amaury Frankl, Britt Lonneville, Annelies Vandenbulcke & Alain De Wulf)

13 — The use of micromorphology in archaeology of the Near East (Georges Stoops)

14 — The use of multispectral visualizations for the identification of pigment patterns (Athena Van der Perre & Hendrik Hameeuw)

15 — From site to seepage: determining the origin of archaeological bitumen (Thomas Van de Velde)
1 — Recurrent methodological issues on the identification and technical analysis of Egyptian faience (*France Ossieur & Vanessa Boschloos*)

2 — Application of handheld X-ray fluorescence analysis in the arrow collection of King Tutankhamun (*Nagmeldeen Hamza, Ahmed Abd Elrady Ibrahim Hassan*)

3 — Preliminary results of pXRF analyses on Roman lead curse tablets (*Rebecca Scott, Vanessa Boschloos, Eric Gubel*)

4 — Understanding rocks, sediments and soils: introducing MINPET’s (geo)archaeological toolkit (*Dimitri Vandenberghe, Johan De Grave, Morgan De Dapper, Jean Bourgeois*)
Ceramics are one of the key commodities to understand production and movement of goods in the past. Critical questions in studying the significance of ancient ceramics are their production, technological tradition and origin. The main difficulty in provenance studies is to identify features which are transferred unchanged during the production process from the raw material to the object itself. Through its sheer abundance in the archaeological record this material category is excellent as a proxy for discovering cultural contacts, production choices and trade, and thus fulfils a key role in the study of ancient economies.

Connecting raw materials, production technology and socio-cultural choices is a long-term problem in the field of Mediterranean archaeology. Uniform geologies of various regions, especially regarding arid and semi-arid regions, hamper the possibility to trace material objects to their exact source of origin by means of conventional methods. A multidisciplinary analytical approach including methodologies from archaeology, geology, chemistry and materials science generates much needed information regarding a comprehensive identification of ubiquitous local and regional ceramic productions and workshops.

This paper wishes to concentrate on the identification, selection and use of raw materials for ceramic production and contribute to the localization of ancient production sites in modern day Tunisia, Israel and Jordan. The application of destructive and non-destructive state-of-the-art analytical methods could produce a link of raw material outcrops with various pottery workshops and ceramic products. With this detailed information a longue durée perspective of changes in local and regional ceramic production and resource use can be constructed.
Traditionally, the Cretan Bronze Age archaeological community is often reluctant in adopting new approaches within the discipline. An example of this is its use of soil micromorphology, the study of (archaeologically relevant) soil at the microscopic level. Despite a decades-long presence in archaeology and its tried and proven merit as a unique source of information for stratigraphical and geomorphological analysis, the use of soil micromorphology remains undervalued as an analysis technique in Cretan Bronze Age Archaeology, with approximately only one in ten excavations in the last ten years including soil micromorphological analysis. One such exception has been the joint Université catholique de Louvain - KU Leuven excavations at Sissi carried out between 2007 and 2011, where extensive micromorphological sampling and analysis of intra-building contexts took place. Using the results of this research as an example, this paper aims to highlight the added value of soil micromorphology for the understanding of these contexts, even in cases where significant bioturbation has occurred. Specifically, the emphasis will be on the insights regarding materiality and formation processes of archaeologically relevant soil constituents gained through the adoption of soil micromorphology as an integrated field work technique.
The origin and spread of glass making: the isotopic evidence

Patrick Degryse

Oral Presentation

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The history and technology of ancient glass has received much academic attention in the past two decades. Glass in archaeology has evolved from a small find in excavations, to objects which can help us understand the evolution of pyrotechnology, the development of man-made materials and the history of exchange, trade and economy in ancient society. The origins of glass as a material, and the provenance of the raw materials used in its making, are crucial aspects in this archaeological-anthropological research. By their very nature, vitreous materials are challenging in terms of characterization and provenance determination. The use of geochemical techniques in archaeological science has enabled a new view on glass. This paper discusses elemental and isotope geochemistry, and in particular their combined use, to reconstruct exchange and trade patterns of raw glass, and to probe the origins and spread of glass as a material.
Gemstones have always fascinated and captivated humans with their natural beauty and have been used by humans since the dawn of civilization. Previously their scarcity restricted them mainly to the rich and powerful but nowadays they are affordable to everyone.

The term gem can be applied to any mineral that, after polishing and/or cutting, attains such beauty that it can be used in ornamentation and jewelry. Each gemstone has a unique set of attributes (hardness, color, luster, transparency...) that lend certain properties and value to the stone and distinguish it from others. Aside from these intrinsic properties, rarity and fashion also play an important role in the popularity of a gem.

The presentation entails a brief overview of ancient and modern materials used as gemstones and the procedures and techniques used for identifying and appraising gemstones.
An impressive number of textiles was found in the tomb of king Tutankhamun. Howard Carter recognized that: “The material from this tomb will be of extreme importance to the history of textile art and it needs very careful study.”

The collection of the textiles of king Tutankhamen is divided into 740 garments, shrouds, covers of statues, loincloths and textile objects such as quivers and sails of boat models. The textiles were found distributed inside the rooms of the tomb, stored in several chests and boxes, some of them used for wrapping funerary equipment, in other cases, they formed part of elaborate, ceremonial robes covered with gold sequins and embroideries.

This study focuses on one of the garment pieces from the wardrobe of king Tutankhamun, the loincloths which are in striking number, an estimated 145 bundle rolls which still remain unfolded because of their delicate condition. A loincloth is a simple garment that has a triangular form and was one of the few types of garments worn by both men and women. It wrapped around the waist while the rest is drawn between the legs. Some examples from this collection are on display at the Egyptian Museum in Tahrir.

The goal of this study is to identify the folding system of loincloths made by the priests of the king. Indeed, this study gives us great semantic confirmation that the king wore these pieces. It also gives an insight into the fashion styles of loincloths and even into the physical details of the king’s body.

On the other hand, this study investigates the feasibility, effectiveness, and overall value of Reflectance Transformation Imaging (RTI) in documenting the texture of Tutankhamen’s loincloth. From where, the ability to manipulate the light source and enhance the surface attributed with RTI facilitates the identification of important textile features. Also, this paper compares RTI, digital photography, Multispectral Imaging (UV and IR) for the documentation of varied textiles of king Tutankhamen.

Finally, the loincloths of Tutankhamen were investigated by optical microscope, polarizing microscope and Scanning Electron Microscope (SEM) to obtain a more detailed observation of the condition and physical characteristics of the fabric.
This paper presents the results of a pilot study researching the usefulness of chemical analysis using portable XRF technology (pXRF) on Late Bronze Age (LBA) plant ash glasses from Tell el-Amarna in Middle Egypt. 68 objects from the collection of the Egyptian Museum, Berlin have been analysed and the data evaluated in preparation for a season of chemical analysis of glasses at Amarna in late 2016:

Since the beginning of the 20th century, excavations at Amarna have yielded numerous glass artefacts, in addition to a large amount of evidence of glass-working, including glass rods, ingots and cylindrical vessels (i.e. ingot moulds). Many of the objects from old excavations are only loosely provenanced and are kept in museums worldwide, although finds from modern excavations, stored on site, can be referenced to specific findspots. For instance, recent excavations at houses M50.14-16 have produced over 300 glass objects, including two ingots.

Amarna is one of the first sites in Egypt to have produced glass from raw materials, and it is, therefore, of particular importance to gather as much information as possible on the chemical composition of the objects kept at Amarna. Colourants and trace-, major- and minor elements can help determine the origins of these glasses and to chemically relate these items to other LBA glasses. For example, some of the glass ingots from the Uluburun shipwreck may have been made in Egypt based on their trace elements. Furthermore, blue is the most prevalent colour of Amarna glasses, being derived from cobalt or copper, but it is not always possible to tell the difference with the naked eye.

Since it is impossible to export the objects from Egypt for analysis, or to sample and analyse such a large quantity of objects using laboratory methods, and despite the known issues involved in detecting natron, magnesia and the weathering crust of the objects, pXRF technology is the only feasible solution. Although its usefulness is limited, this paper concludes that pXRF can be applied for the chemical analysis of LBA plant ash glasses from Egypt at least to determine an object’s origin and colourants used.
Driven by the need to study precious and irreplaceable objects without compromising their integrity, researchers have undertaken numerous efforts to develop non-invasive examinations, analytical tools and methodologies that can provide a chemical description of cultural heritage material without any contact with the object.

The challenge is that the objects are made of a complex mixture of materials, often with heterogonous and unknown layers. The pigments analysed in this research originate from a well dated ancient farm model dating back to the Middle Kingdom found in Dayr al-Barsha. The pigment identification depends on a non-invasive approach to gather an insight into the chemical composition of the colored compounds. This study was conducted by means of archaeometric methods, with XRF and digital spectral imaging (UV, IR).

This multi-technique approach has led to the identification of the pallet of pigments and all the previous conservation acts on the object.
Although only a few traces of paints are visible to the unaided eye on Mesopotamian stone statues, but assuming that many (or all?) Mesopotamian statues were painted, a team has been striving to reconstruct the colours of the Mesopotamian stone statues, dating from the 4th to the 1st millennium BC.

This team consists amongst other of the archaeologist Astrid Nunn and the physicist and restorer Heinrich Piening. Scientific examination was carried out using Raman spectroscopy, but the best technique to determine pigments as well as the colour hues has proven to be the UV/VIS spectroscopy, which measures the wavelength of a sample using a Xenon lamp as excitation source.

Black and red are the best preserved colours. The pigments are identical to those used in the other techniques (painting, glazing) and on other supports (clay, plaster). An iron oxide ($\text{Fe}_2\text{O}_3$), mostly ochre and haematite, is used for colouring in red and in shades from yellow to brown. The pigment black has proven to be more diverse than previously thought. So far, only carbon and bitumen have been recognized, but in fact bitumen did not served as a pigment, but only as an adhesive. Biochar has emerged as a major pigment. Also known as "Ethiopian ink" this was carbonized at low temperature and consisted of wood, such as date seeds and poplar bark in the Near East. It is carbonized in a vacuum and produces a greasy tar-like mass.

In seeking to reconstruct the Mesopotamian colouring we have addressed technical, historical and iconological issues. We will try to find out whether all statues, be they made of white or dark stone, were painted and whether they were completely coated. We would like to know more about the painting techniques. How was the stone first prepared? Was the paint directly applied to the unprocessed stone or to a ground layer? Are the layers of paint thick or thin, fine or coarse? A historical approach would be to follow up the development in the use of colours. We are particularly interested in the symbolic meaning of the colours, especially on the skin and on garments. This brings us to the interrelationship between colours as archaeologically recorded and that what the relevant texts may say. What do texts record about the feeling of colouring in Mesopotamia in general and about the colouration of statues, of faces or of garments in particular. Our final aim is a cultural history of ancient oriental colours on human representations. By combining the scientific results with the philological we will address realism and symbolism, naturalism and color codes on statues.

H. Piening will present our technical approach by the UV-Vis spectroscopy and A. Nunn will address the results and their meaning for the cultural history of Ancient Mesopotamia.
In this contribution, the results of three archaeometric techniques, implemented on pre-Islamic ceramics from the Kur River Basin (Fars, Iran), will be presented. The first applied analytical technique is the handheld X-ray Fluorescence (hXRF) spectroscopy, which is a non-destructive method to study the elemental composition of the ceramics and the pigments used for decoration. In addition, Micro X-ray Fluorescence (μXRF) spectroscopy is performed. This technique also detects the elemental fingerprint of the ceramics, allowing a methodological comparison of these two analytical methods. Moreover, the imaging capacities of μXRF elucidate the differences in the composition of the clay fabric and the inclusions, which is almost impossible with hXRF. The third technique, namely thin section petrography, enables the determination of manufacturing processes and the origin of the primary materials by identifying the rocks and minerals present in the thin sections.

Micro X-ray Fluorescence and thin section petrography could only be implemented on a selection of the dataset since no sampling was allowed on the major part of the ceramics. However, the combination of hXRF with these techniques is crucial for the interpretation of the different compositional groups deriving from the hXRF-analysis. Hence, more insight in the provenance of the raw materials and in the technological differences and changes in the ceramics can be obtained.

This study is part of a larger investigation on the chemical and petrographic characterization of the ceramics from the Vanden Berghe collection present at the Royal Museums of Arts and History (Brussels, Belgium) funded by the Belgian Federal Science Policy Office (BELSPO) BRAIN-be project: Belgian Archaeological Expeditions to the Orient (BAREO).
The ceramic technologies in the manufacture of two groups of Canaanite pottery were studied by using XRF and LA-ICP-MS methods. These ceramic groups are 'Brown Ware' from Early Bronze Age II (EBII) at Northern Canaanite sites and paint decorated Canaanite ceramics from the Late Bronze Age at Tel Esur (Assawir). We have shown that the XRF and LA-ICP-MS methods enable direct analyses of the ceramic material as well as of the thin painted decoration on the surface of the vessels.

In the study of the 'Brown Ware' from Northern Canaanite sites, we reveal that the ceramics of this family were produced in Canaanite workshops at a basaltic provenance. This provenance is confirmed by petrographic analysis by the presence of basalt particles in the ceramic material. The analysis of the ceramic body shows high concentrations of SiO$_2$ and Al$_2$O$_3$, lesser concentrations of Fe$_2$O$_3$ and small concentrations of CaO. The high concentration of iron oxides in the ceramics manufacture from basaltic soil raw material and an oxidation on their surface gives the 'Brown Ware' family their brown color. The specialization in production of the 'Brown Ware', mainly for cooking, seems to be in conjugation with the Northern Canaanite urbanization during the EBII. Their importance lies on the way they were manufactured from a specific type of noncalcareous clay, basaltic soil raw material, which was specifically designed for cooking and on the fact that they were exported to other southern Levantine regions as part of a flourishing trading network.

In the study of the paint decorated Canaanite Ceramics from Tel Esur, we found that most of the examined paint decorated ceramics were produced in Canaanite workshops at the Mediterranean coastal plain region of Israel. This provenance is confirmed by petrographic analysis by the presence of quartz grains in the ceramic material. The analysis of the ceramic body of these vessels shows high concentrations of SiO$_2$, Al$_2$O$_3$ and CaO and small concentrations of Fe$_2$O$_3$. This composition is in accordance with the utilization of such clay raw material for the production of the vessels themselves. In contrast, the black paint decoration consists of ferromanganese-based pigment comprising manganese and iron. However, a source for such ferromanganese-based pigment ore is practically not found in the vicinity of the coastal plain of Israel. Thus, for the black painting at the Canaanite workshops the pigment ores were brought from external ore source. Ferromanganese ores are not common. The XRF and LA-ICP-MS patterns aimed to determine whether the source of the manganese ore was from Timna and Feinan region in South Israel and Jordan, or import from the region of Cyprus (Cyprus umber ore) or utilized from unknown ore source.
Among the military equipment found in the tomb of Tutankhamun were eight shields, four of which are ceremonial and are of openwork wood, incised and gilded. At the same time it provides us with a lot of information related to the usage of shields by the king as a symbol of power and strength of the royal authority at that time. Shields are made of wood in several pieces pegged and glued together, the border and central panel covered with gesso and gilt, the remaining field covered with the hide of a cheetah (see spots), the hair well preserved.

The goal of this study is to identify the structure of shields, looking inside their layers, made by the priests of the king. Indeed, this study gives us great semantic confirmation whether the king used these pieces or not. It also gives an image for the development of weapons in the New Kingdom.

On the other hand, this study investigates the feasibility, effectiveness, and overall value of Reflectance Transformation Imaging (RTI) in documenting the impressions on Tutankhamen’s shields. The ability to manipulate the light source and enhance surface attributes with RTI facilitates identification of important shield features for documentation of shield impressions. Also, this paper compares RTI, digital photography and Multispectral images (Ultra Violet and Infrared ) for the documentation of shields of king Tutankhamen.

One important and widely used archaeometric study is handheld XRF (x-ray fluorescence), an elemental analysis technique that quickly and easily provides data regarding the elemental composition of samples. It is a nondestructive trace element analysis that doesn’t alter or deface samples. The analysis by handheld X-ray fluorescence of the shields belonging to king Tutankhamun identified pigment and composition of the gilded layer on it. From the discussion of the result we can probably identify the region of provenance of the materials which were used in the composition of gold alloys in this period.
The department of Geography of Ghent University has participated in the field of Unmanned Aerial Vehicles (UAV)-based 3D modelling in 2013, when it purchased a rotary wing platform. This decision was motivated by the ambition to develop a flexible and cost-efficient airborne data acquisition platform, capable of being deployed in remote study areas. This would inherently result in highly accurate orthoimagery, digital elevation models and full 3D models, which will be used in high-level research on the monitoring and mapping of geomorphological systems, environmental phenomena or the modelling and study of cultural heritage.

The availability of the airborne system has allowed the department to participate in some interesting international and interdisciplinary research projects. In order to organize airborne data acquisition, compactness and flexibility in terms of transportation and deployment, as well as cost-efficiency are crucial parameters.

The objective of the first international campaign was the photorealistic 3D modelling of Mayan ruins in Campeche (Mexico). The experience from this campaign allowed the development of a systematic acquisition methodology of the archaeological site of Thorikos (Greece). During the 50 years of scientific research at this site, no high-resolution ortho-images nor elevation models were available of the site. With the deployment of the UAV, such deliverables were generated within a limited period, covering a reasonable area of the site with a resolution of a few centimetres.

Notwithstanding the success of the above-mentioned projects, it became obvious that a thorough knowledge of the UAV is indispensable and a higher degree of acquisition automation is desirable. This was an important motivation for the development and construction of our own series of UAVs. Among others, the capacity of the batteries and the motors, the configuration of the platform and the selection of the system controller and Positioning and Orientation System (POS) are chosen so that the resulting platform fulfils the requirements of an international campaign. Furthermore, the latest version of the platform is equipped with an autopilot system, allowing the autonomous traversing of a series of waypoints. This system was successfully deployed at the archaeological site of Turpan (China) and Copán (Honduras).
Soil micromorphology deals with the study of undisturbed, oriented samples with the aid of microscopic and/or ultramicroscopic techniques, in order to determine the composition of the constituents and their spatial relationship, with the aim to deduce their genetic and chronological relation.

The study comprises five steps:

- **Sampling in the field**: strategy; techniques for obtaining undisturbed samples;
- **Sample preparation in the laboratory**: stabilisation with resin, thin sectioning;
- **Observation**: The most used technique is the study of thin sections (20-30 µm thick) with a petrographic microscope allowing to observe the materials in transmitted polarized light (PPL) and under crossed polarisers (XPL). Additionally microscopic studies in oblique incident light (OIL) and of autofluorescence in blue or UV light (e.g., for identification of bone splinters) are possible. Apart from observations with the optical microscope, studies of thin sections or undisturbed samples by ultramicroscopic techniques, such as scanning electron microscopy (SEM), microprobe, micro X-ray diffraction, etc. are possible.
- **Recording of observation**: In the past several morpho-analytical systems were developed. Worldwide the system developed by Bullock et al. (1985) and Stoops (2003) is nowadays the most commonly used. It comprises both well-defined concepts and a systematic terminology, translated in more than 15 languages. A consistent standard terminology is necessary for correct communication and input of information to databases.
- **Interpretation**: based on similar observations described in literature, on comparison of different materials and situations, and on experimental work (e.g., heating substances at increasing temperatures).

Roughly one can distinguish the following **fields of application** of micromorphology in archaeology:

- **material studies**: identification of the nature of sample (e.g., bone fragments, phytoliths) or complex constituents (e.g. carnivore excrements, ash deposits, morzars);
- **reconstruction of ancient technology** (e.g., preparation of mortar, application of plaster, daub preparation, feeding of domestic animals);
- **reconstruction of the archaeological context** (e.g., animal gathering enclosures), microstratigraphy (floor deposits, fire places, cave sediments) and post-burial changes;
- **impact of man on his environment** (e.g., forest clearing, ploughing);
- **reconstruction of the palaeoenvironment** by study of sediments and palaeosoils (e.g., position in the palaeolandscape, drainage erosion features).
The visualization and analysis of artefacts, their materials and pigments, today, has a wide range of methods and techniques at its disposal. In most circumstances however, complete & high-quality photorealistic visualizations of an object and scientific analyzations of the physical elements are two different actions, resulting in separate data-sets. Registration and documentation methods that can combine and integrate both such actions into one application have the benefit that the physical characteristics of an artefact (e.g. the relief) can be examined in relation to analyses of the materials (e.g. pigments).

Interactive HQ visualization methods, whether for 2D or 3D applications, have become standard approaches for the registration and documentation of art, historical and archaeological objects. In collaboration with the University of Leuven (Belgium), the Royal Museums of Art and History (RMAH, Brussels) have grafted and tested a multispectral component on a multi-light/directional imaging acquisition and visualization system, called the Portable Light Dome. The implementation of various well-defined spectra allows a multi-layered analysis of the different components in the examined surface. The registration process results in a data-set that can visualize the color, texture, relief and reflection mapping of one and the same surface, pixel per pixel.

As case-studies — part of the BRAIN-Pioneer project EES — inscribed execration figurines, a groups of Roman Fayum portraits and ceramics from ancient Egypt, were processed by the multispectral Portable Light Dome system. It enables comparative research within these ad hoc selected group of objects. On the different types of objects patterns of pigments can be differentiated from each other, mapped and visualized by applying BRDF and false color PCA analyses.
It is practically impossible to mention the Near East without having to think about the oil or petroleum industry. But contrary to common knowledge — that petroleum is only a product of the last two centuries —, oil has always shaped the East; there is evidence of the (exemplary) usage of bitumen as early as the Palaeolithic Period and the material became increasingly popular in the 7th and 6th millennium B.C. in the Near East, eventually becoming a specific product of trade which travelled distances of over 2000 kilometres.

Generally bitumen has little to no decorative value, hence little attention was paid to this material by the early explorers of the area. The first real comprehensive study on bitumen was by the hand of R.J. Forbes (1958) which focused not only on the different types of bitumen usage, but also on bitumen in the cuneiform texts, the composition of bitumen mixtures and the possible origins of the material. Later on, a geochemical toolset — largely based upon that from the petroleum industry — was developed to determine the geologic origin of archaeological bitumen. Once it was possible to relate individual archaeological bitumen to their exact place of extraction, changes in bitumen source were noted for single settlements throughout time and exchange networks have been identified. Consequently, this material is extremely suitable to form hypotheses on the dynamics of multi-regional interaction and trade contacts in archaeology, especially considering the limited number of extraction areas of this resource.

This paper will highlight the main advances in the specific practice of fingerprinting archaeological bitumen and outline the different techniques and analytical protocols which are used to successfully relate an archaeological sample to a source area. We will use several case-studies from various archaeological sites in Iran and the Persian Gulf to illustrate the various chemical preparations and analyses whilst stressing out the possibilities and possible pitfalls of this type of research. Consequently, we will show how these studies relate to bigger archaeological issues such as long-distance trade, the Ubaid expansion, and state-controlled labour.
In the study of Egyptian faience (“Quarzkeramik”, “earthenware”) and related materials, a fundamental problem persists: the precise identification of production techniques and materials still poses a problem for the untrained eye.

Scholars can call upon a range of scientific techniques to gain insights into the composition of archaeological materials, though often not when conducting research in the field. Secondly, researchers, scholars, museum curators and conservators generally focus on different aspects; they may look at the same objects, but ask different questions and each field uses its own terminology and conventions. Subsequently, terminological confusion and incorrect definitions impede the proper study of ancient faience objects.

This poster presents the results of an initiative launched at the ceramics conservation laboratory of the Royal Museums of Art and History in Brussels, seeking to facilitate the valorisation of technical studies on faience objects in its collections. A user-friendly protocol was developed, consisting of a methodological approach that encompasses descriptions based on experimental technical studies, microscopic examination and non-destructive analyses. It aims at bridging archaeometric approaches and the reality of daily use by non-specialised stakeholders.
The collection of arrows which belongs to king Tutankhamun (18th Dynasty) comprises the most complete collection of arrows discovered in Egypt up till now. At the same time it provides us with a lot of information related to the usage of arrows by the king as a symbol of power and strength of the royal authority at that time. A considerable number of over 430 arrows were found in Tutankhamun’s tomb. Howard Carter makes reference to sixteen different classes of arrows, varying in detail and size. A proposition is to discuss the results of an analysis on these arrow heads by XRF to identify the composition of the bronze alloys in this period based on the concentration of the elements in the bronze heads. Analysis on glass heads has given information on the elemental composition of the glass and other lithic materials as evidence of human trade and migration.

One important and widely used archaeometric method is the handheld XRF (x-ray fluorescence), an elemental analysis technique that quickly and easily provides data regarding the elemental composition of samples from magnesium (Mg) to uranium (U). It is also a non-destructive trace element analysis and it doesn’t alter or deface the samples. The analysis by handheld X-ray fluorescence on the arrows belonging to Tutankhamun’s tomb concentrated on the heads of the arrows, which include glass, bronze and pigments on the main shaft of the arrows. From the discussion of the result we can probably identify the provenance of the materials which were used in the composition of the glass. Also we can interpret the usage of some materials during the manufacturing. From the analysis of the bronze head we can compare between different shapes of bronze heads and their composition, and unmistakably identify the composition of the bronze alloys with additive materials in this period.
During the 2013 excavation campaign at Tyre (Lebanon) directed by the Archaeological Museum of the American University of Beirut, archaeologists from the Royal Museums of Art and History brought a considerable lot of fairly well preserved folded lead plaques to light while emptying the contents of a Late Roman cistern of a private house. After unfolding and restauration, they revealed to represent *defixio tabellae* or “curse tablets”, magical phylacteries in the form of thin plaques, found all over the Roman world. The plaques from Tyre represent the largest provenanced group thus far discovered in the Levant in a single closed context. In additional to the epigraphic study of their contents, a chronological assessment of the cistern’s other finds, and pioneering 3D imaging of the tablets, the research focusses on the archaeometric analysis of the lead. This poster presents the results of portable X-ray fluorescence analysis conducted on these defixiones.
Rocks, sediments and soils - whether natural or anthropogenic - are ubiquitous at archaeological sites. They represent the contextual archive for archaeological sites and their associated remains, are the silent witness of our predecessors’ natural environment and their mutual interaction, and/or are the main constituents of a range of anthropogenic structures and objects. Over the past two decades, an increasingly complex, sophisticated and broad spectrum of analytical techniques has become available that allows characterising and understanding rocks, sediments and soils in order to interpret the archaeological record more accurately and completely.

This poster presents an overview of the analytical techniques that are currently employed by the UGent Laboratory of Mineralogy and Petrology (MINPET) in support of (geo)archaeological research. MINPET’s toolkit includes optical microscopy using thin sections, scanning electron microscopy, X-ray diffraction and fluorescence spectrometry, physical and chemical analyses of rocks, sediments and soils, and luminescence chronometry of consolidated and unconsolidated rocks. In terms of new methodological developments, we highlight the potential of innovative luminescence techniques to unravel the Young Quaternary light-exposure histories of consolidated rocks.

The integrated use of these techniques to underpin (geo)archaeological investigations in arid and semi-arid areas is illustrated through examples drawn from MINPET’s most recent activities in this field of research. Examples concern (i) human occupation and migration in the Fertile Crescent, and understanding the development, functioning and correlation of archaeological sites in relation to the forcing environmental context, (ii) the interpretation of Old Stone Age sites in Central Asia and (iii) understanding the technology and chronology of various man-made features (such as quanats, stone alignments, petroglyphs, bricks and ceramics).

The main aim of this contribution is to make Belgian researchers aware of the fundamental scientific and analytical expertise that is available at MINPET. The configuration of the laboratory is unique. It seeks to combine methods, materials and research questions that are of common interest to members of various disciplines. MINPET is keen to support and undertake collaborative research and provides its scientific services at request.