Applying the principles of sustainability in cultural heritage objects care: the case study of cuneiform tablets

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Abstract

This paper discusses application of sustainability principles in the care of museum's collections and more specifically, in the case of cuneiform tablet collection. The principles of sustainability are inherently present in the idea of memory institutions and their rules of collection preservation. This paper shows how digitalization of collections and the new ways of data storage are well suited for reaching goals of preservation of the collection for future and simultaneously widening access to the collection for those interested. Various methods and approaches employed to achieve protection and opening the collection are presented.

Keywords

cultural-goods, preventive care, cuneiform tablets, sustainability, digitalization.

Introduction

The basic tasks of museums, libraries, archives and other institutions of similar type include, among other things, the preservation of cultural heritage objects in the best condition possible for future generations, despite the fact that all materials inevitably age and deteriorate. The rate of deterioration is strongly influenced by surrounding environments.

The most effective tool for applying the concept of sustainability for artefacts/objects of cultural heritage is consistent, responsible and comprehensive preventive care, which not only includes minimizing all the known risk factors in storing, displaying or transporting these objects (temperature and humidity - extreme values, sharp changes, lighting, atmospheric pollution and dust, vibration etc.), but also minimizing interventions into the authenticity of the artefacts (interventions involving repairing, restoring and conserving it – restricting the use of substances with ill-suited ingredients), consistently protecting the objects from biological pests (Integrated Pest Management using modern methods, i.e. limiting or eliminating the use of chemicals), or by using non-destructive methods in researching the material of the artefacts, including detecting hidden structural defects and damage (e.g. cavities and pores).

A comprehensive approach to providing preventive care for movable objects of cultural heritage has therefore been chosen for the research project "Analysis, description and archiving of aggregate information on the properties of cultural heritage objects and usage of such data in restoration, conservation, and research". Three research institutions from the technical sciences and humanities, the Institute of Theoretical and Applied Mechanics of the Academy of Sciences of the Czech Republic v.v.i., the National Museum and the Charles University, Faculty of Arts are taking part in this research.

Some results of this approach will be demonstrated on a representative sample, the case study of cuneiform tablets, using equipment and systems for documenting and analysing cultural heritage artefacts from a collection of cuneiform tablets of Czech researcher Prof. B. Hrozný from finds at Kültepe, Turkey.

The data obtained from using advanced imaging and documentation methods (the Structure from Motion, computer tomography method, etc.) has been supplemented by findings obtained by non-destructive methods of analysis (microscopic analysis, analysing the elemental composition of the surface, color measurement), and the conclusions of the work will be annotated with meta-information describing other properties of these cultural heritage objects, that were obtained by methods used in the humanities (historical, linguistic, paleographic, ethnographic analyses and others). Digital technology also makes it possible to reconstruct the social life of the distant past (reconstruction of recorded text), which could provide a significant contribution into looking at the society and culture embedded in the object/collection.

The aim of this comprehensive approach is to obtain the maximum information to be used not only for storing the objects themselves, but also for preserving their testimony in full compliance with the principles of the concept of sustainability, with special emphasis on the environmental and social aspects of the concept.

Caring for cultural heritage: history, present and future

Cultural heritage is along with other components of artistic work like the fine arts – music, theatre, dance, etc., an integral part of the cultural heritage of every nation/society. In a broader sense, it consists of a set of specific elements understood as co-owned by all of society, and so it is the responsibility of society to take care of them so that they can be passed on to succeeding generations in the best possible condition.

Intangible cultural heritage with various social practices, generally applicable experience or skills, adages, sayings, etc., is passed down from generation to generation; this can (but need not) change over time.

Material cultural heritage (e.g. architectural and sculptural works, paintings and graphic works, various objects of applied art, as well as different works of landscape architecture) deteriorate over time by comparison.

Therefore, caring for movable cultural heritage is an integral part of preventive care, which provides the best and most effective protection.

This is not something that has come to fore in the past few decades; in certain, if often, unconscious forms (such as tributes to established values or to those who created these values), it has existed since practically time immemorial.

From past to present

In Europe, caring for objects of cultural heritage has evolved more or less equally over a relatively long period of time. In the early 19th century, however, regional differences began to show up in the systems created for caring for objects of cultural heritage.

The beginnings of the new concept of caring for objects/artefacts of cultural heritage, provided by the state, can be found in France at the very beginning of the 19th century (creating the position of "Inspector General for the Protection of Architectural Heritage" in 1830, the establishment of a commission for historical monuments in 1837 or the Commission for Religious Monuments in 1848) (Jokilehto, 1999, p. 128), while in Bavaria the "General Inspection of Sculptural Monuments of the Middle Ages" was created in 1835 (Kiesow, 2012, p. 24); and in England the Society for Antiquaries was formed in 1751, etc. (Voděrová, 1992).

At the turn of the 19th and 20th century, cultural heritage, or just plain culture, began to be seen through a somewhat different lens. In connection with the development of various technologies that enabled certain works of art to be reproduced at low cost, these works were now available to a wider audience, and later (with the development of radio, film, television and video) a boom in the spread of this type of culture took place.

The system of caring for objects/artefacts of cultural heritage continued to undergo development and evolution up until today's multicultural and global epoch, where a need inevitably arose to create rules for coordinating this care at the international level, namely through the establishment of several organizations, especially UNESCO (United Nations Educational, Scientific and Cultural Organization) (UNESCO, 2004), ICOMOS (International Council of Monuments and Sites, Madole, 2014) and ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property, Jokilehto, 2011).

Thanks to all these works and activities, the measurements of climatic parameters (temperature, relative humidity) in storage facilities and expositions, and the measuring of light levels, is today relatively widespread in museums, archives, galleries and other similar institutions. Objects/artefacts of cultural heritage nevertheless remain threatened by other factors, such as indoor vibrations (buildings located near roads can transmit vibratory effects to objects in storage facilities; over the long term, vibrations can inflict damage on objects of cultural heritage), construction work during the renovation of the building (Watts, 2002; Johnson, 2013), or vibrations caused by the movement of people indoors, especially in historic buildings with wooden floor structures (Thickett, 2002), the presence of biological pest control, gaseous pollutants or dust (Štefcová, 2001), (Figure 1).

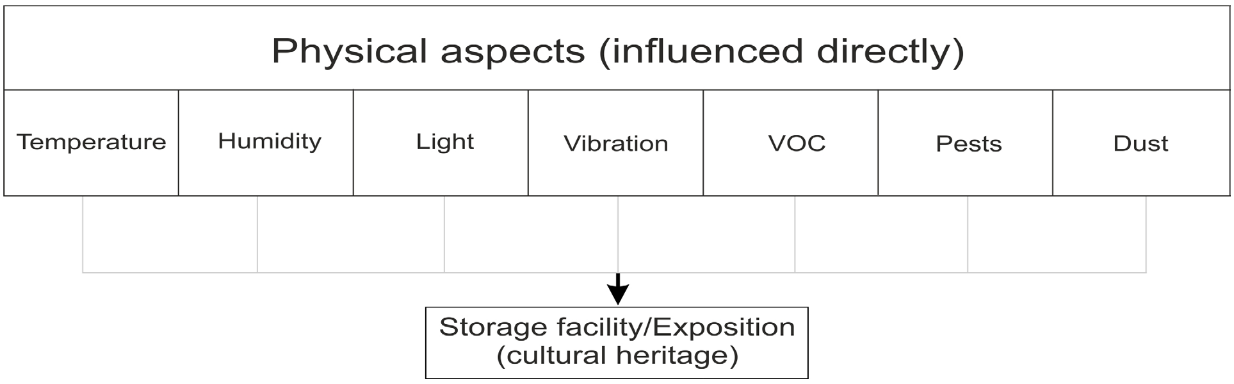

Figure 1 – Indicators of the indoor quality in storage facilities/expositions (diagram).

From present to future

The dynamic development of society and the changes that have occurred in the last few decades are reflected in various sectors and regions and they lead to the creation of new, unfamiliar socio-economic values.

In the 1990s, a normative concept of sustainable development was therefore formulated (and more or less universally accepted) through the UN (United Nations), based on the idea of the uniform behavior of individuals in society, focusing on socio-economic prosperity and environmental integrity, which takes into account the need for some form of cohesion both within one and the same generation and between several generations coexisting at the same time, pursuing a better life and protecting natural resources and ecosystems (United Nations, 1992). More detailed specification of these objectives has been elaborated in the loosely related documents of the Millennium Declaration and Millennium Development Goals, among others.

With the very rapid development of new technologies (the Internet, digitalization....) comes the emergence of new, unfamiliar positive and negative effects in the field of cultural heritage.

The extensive digitalization of objects of cultural heritage is currently underway in many archives, museums and other similar institutions, without mandatory standards being succinctly formulated for this activity; in terms of the future usability of data or the sustainability of its values, a good description of the data is an important aspect, namely by using metadata and recording accurate information regarding the methods and devices used. At present, moreover, little is known about the method for properly processing and storing data. The emergence of many modern educational and training applications or a change in the approach to exhibiting objects of cultural heritage (the transformation of traditional forms of exhibitions/expositions into interactive expositions) is therefore seen as positive.

In May 2018, the European Commission adopted a document entitled "A New European Agenda for Culture"; it is a set of measures that declare the need to strengthen cooperation in the fields of culture and education, as well as cooperation with other sectors and industries, because cultural heritage, or simply culture as it is, is influenced by many multi-level trends (so-called megatrends) that shape the present (see the diagram in Figure 2) (Horx, 2018).

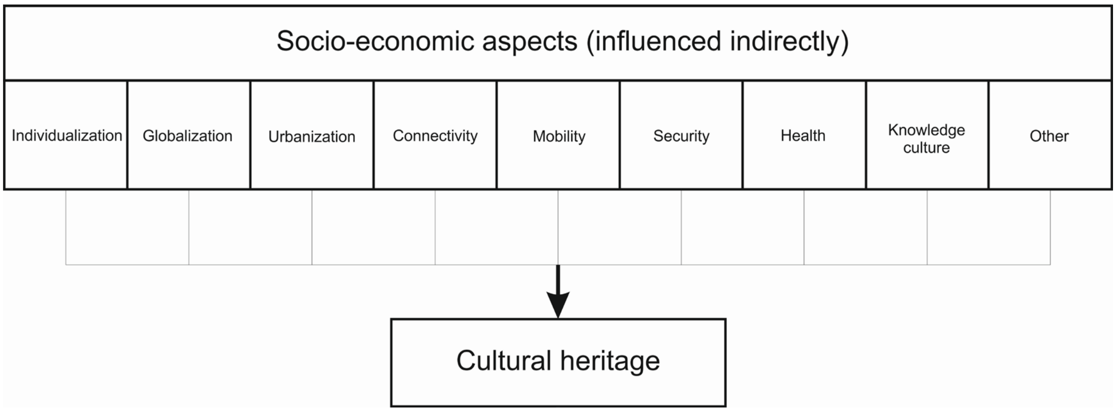

Figure 2 – Socio-economic aspects affecting cultural heritage (simplified diagram).

It is clear that in today's society there is an increasing degree of globalization (population growth, global cities, global migration…) and urbanization (global cities, co-living, megacities, progressive province, rural cities…).

New ways of work undoubtedly have an important role (start-up culture, creative economy, collaboration, coworking, open innovation….), connectivity (artificial intelligence, augmented reality, digital literacy, predictive analytics, internet of things, digital creatives, smart devices, real digital, online, social networks…), mobility (turistification, bike boom, seamless mobility, micromobility), knowledge culture (augmented learning, open knowledge, digital creativities, open innovation…) and other aspects (so-called silver society /slow culture, forever youngsters, lifelong learning etc./, gender shift (new feminism, womanomics, progressive parents, post-gender marketing../ etc.) (Horx, 2018).

A reliable way to improve the protection of cultural heritage is to make it available to the public using every safe method of presentation and to the maximum extent possible so that all of society can share in the ownership of cultural heritage.

Despite the minor negative aspects described above, the digitalization of objects of cultural heritage is one of the promising ways on how to achieve the stated objectives of the sustainability of cultural heritage (working with collections can be done via remote access, digital replicas of objects made with 3D printers make interaction between the object and visually handicapped people possible, etc.).

The present case study, conducted on a set of cuneiform tablets, is an example of how this goal can be reached to the maximum extent possible.

Experimental part

The goal is to build a workplace with a range of highly specialized equipment for the comprehensive research and documentation of cuneiform tablets and other objects of cultural value with high demands on the precision of visualization.

The equipment built and techniques used are useful for acquiring various types of records on the properties of the examined objects; the resulting database will combine information on the surface of the objects, their internal structure and elemental composition together with other information relating to that collection of objects (e.g. with information about the cultural and historical context). The workplace has been conceived as mobile (eliminating the risks accompanying the transport of objects) and will serve not only for the preventive protection of the objects (possibility of detecting hidden damage and defects early on), but also, after all the data has been added to the database, make these objects available to the general public and it will be a valuable source of information for different educational and teaching activities (sharing digital models in computer networks).

Examined objects (cuneiform tablets)

Generally, the cuneiform tablets represent one of the oldest means of textual records. The cuneiform script, originating from pictograms, can be traced to Mesopotamia in the third millennium BCE, and its subsequent spread reached several neighbouring areas, including Anatolia.

The script as such evolves from a system of pictograms invented by Sumerians (cf., e.g., Monaco, 2014), and is characterized by wedge-shaped marks. In the third millennium BCE, the system lost the pictographic character and changed into a script that combined several principles and is usually labelled as alphabetic script, although the correlation of a syllable in a word and in the script is sometimes loose.

The most common medium of the cuneiform script are clay tablets, although other types of material were used (stone, wood, ivory, precious metals, wax tablets, etc.). It can be noted that it was the clay that played major role in the transition of a system of pictograms into the cuneiform script.

Various types of moisturizing techniques were used to enhance the possibilities to use the wet surface for writing (tablets may contain imprints of textiles supposed to slow down the drying). A special instrument called stylus (usually made of reed, cf. Cammarosano, 2014) was used for writing. Other techniques were used for the verification of the originality of the texts, such as usage of clay envelopes for legal contracts, etc. Generally, this type of writing medium was used for several millennia, starting from the mid 3rd millennium BCE until the first centuries CE (Taylor, 2011; Taylor & Cartwright, 2011).

While it may seem that all (communicated) information is contained only in the record itself, it is necessary to take into account the present material of the record (stone, pottery, papyrus, parchment, leather, etc.), which at first glance may contain little apparent additional information. This is the case of the cuneiform tablets that are the subject of this study, which can provide valuable information through an analysis of the record itself and also an analysis of the material of the record, i.e. of the tablets. The examined sample includes about 450 cuneiform tablets of a collection belonging to Czech researcher Prof. B. Hrozný stored at Charles University in Prague.

Archaeological site

The archaeological site of the tablets, *Kültepe,* where a number of archaeological finds have already been made, is among the most important sites (the largest collection of cuneiform tablets have been found at Nineveh, Nippur, Mari, Ugarit and Alalakh, Lagash, Kültepe, Babylon, Uruk and Ur, Assyria and other places in the ancient Near East); from the end of the third millennium until about half of the second millennium BCE (circa 1950-1718 BCE), this location was an important center of the important trade network between Anatolia, Syria and Mesopotamia (Figure 3).

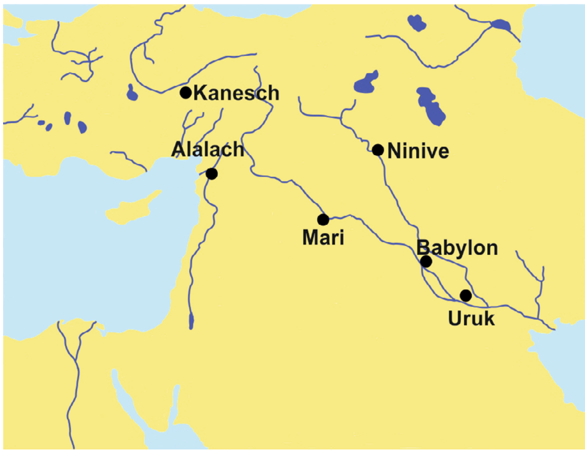

Figure 3 – Spatial integration of some of the aforementioned excavation sites (taken from www.wibilex.de, 2011, repainted Polak, 2018).

Unlike royal or temple archives found at other ancient sites, the cuneiform tablets of Kültepe include many private texts that can be considered private libraries for the political, commercial and legal documents of ancient Anatolia. It is reported that more than 23,000 cuneiform tablets have been discovered up until now, most of which have been deposited in Turkey (Istanbul, Ankara).

Issues involving cuneiform tablets have occupied a limited number of specialists at several workplaces throughout the world. Of the work done on this subject, the Cuneiform Digital Library Initiative (CDLI, http://cdli.ucla.edu/) is the best-known project, where several institutes have been involved (Oxford University, UCLA, Max Planck Institute and the Freie

Universität Berlin, and where the Institute of Comparative Linguistics of the Faculty of Arts at Charles University has also published its own collection, cf. https://cdli.ucla.edu/collections/.

Tools and Methods Used

Textual analysis

Given the method involved in making and recording the information, each tablet represents an individual and unique object. The textual information on the surface of the tablets is certainly the most important part and its analysis is crucial for understanding the life of ancient societies. The analysis is based on common techniques used in cuneiform studies and it is supplemented by the techniques of the contemporary corpus linguistics. As the textual information is contained in the most vulnerable part of the tablet, it is often necessary to reconstruct the signs and the text itself, which includes a correlation of data from linguistics, philology, palaeography, history, etc. The reconstruction of a word is schematically represented in Figure 4 (sign to word analysis). Once a word is identified, standard corpus linguistics techniques are applied, and the text is opened to research methods standard in the humanities.

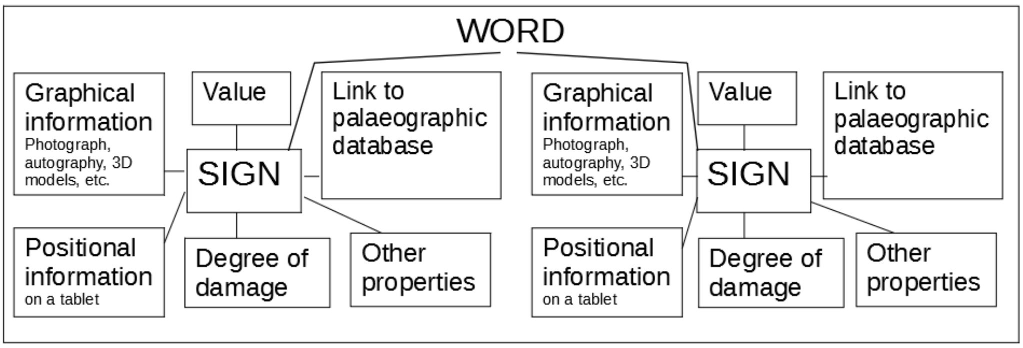

Figure 4 – Schematic representation of a sign to word analysis.

Material analysis

An analysis of the material composition of the tablets, especially the elemental composition of the surface of the tablets (XRF analysis) has been given quite a lot of attention, as evidenced by several large-scale works. This method is also used by the authors of this study (Štefcová, Valach, & Zemánek, 2016), who have supplemented these measurements with other nondestructive methods of research (optical mineralogy / petrology /, spectrophotometry).

During the physical-chemical analyses conducted exclusively with nondestructive methods of research, the elemental composition of the surface material of each tablet (or their envelopes) was measured (using the Artax 400 µXRF spectrometer made by Bruker; a mobile spectrometer for in situ measurements without limitations on the size of the object, calibration using 4 standards) (Imai, 1995). An objective color measurement (using the X-Rite RM200QC hand-held spectrophotometer – RAL K7 Classic color card was used as the standard) and detailed microscopic surface survey (UV/VIS optical microscopy on the Leica MZ16FA stereomicroscope) were also performed.

Other non-destructive methods used include digitizing the tablets (with a device combining the method of photometric stereo /FS/ and the Structure from Motion /SFM/ method) and the creation of 3D models (computerized tomography; showing the geometry and internal structure).

Combining the data from physical measurements with other available information (analysis of content) successively creates an extensive multidisciplinary data structure that is associated with that particular object and forms the basis of the database record, which will be gradually supplemented with contextual information from the described objects.

Database of the project

The architecture of the specialized database reflects the diversity of measured and evaluated quantities (physical, chemical, text, image ...). The structure and format of the output data (web server) is chosen to be user-friendly for the professional and lay public.

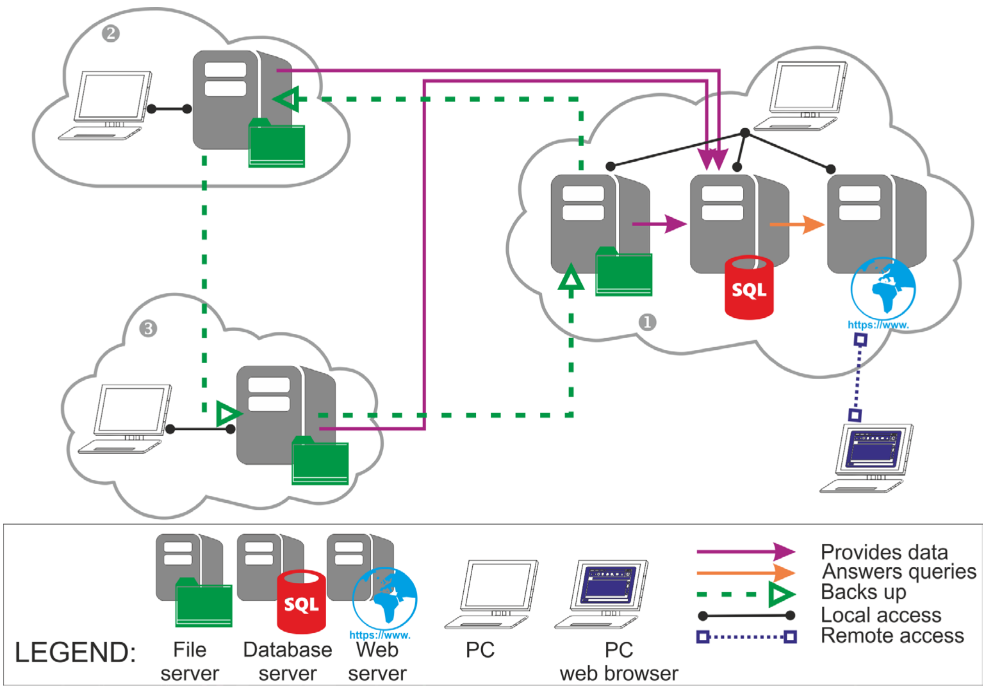

Figure 5 – Schematic illustration of the workflow of the data measured and processed.

The successive placement of data from CT and digitalization into a single record will make it possible to compare these records and their combinations in the future.

The Methodology of Processing Measurement Results

Simultaneous data processing is performed by an automatic computational method of the average value and standard deviation for each specified element in the sample, excluding the minimum and maximum values. This is carried out by means of a proprietary software written for Windows OS in the AutoIT language.

To process the data from the color measurement of the samples (generating a graph representing the measured color in RGB space and its location in the CIE 1976 chromaticity diagram) was used other proprietary software. Tried and tested commercial software (e.g. Matlab) is expected to be used for the final processing of all results.

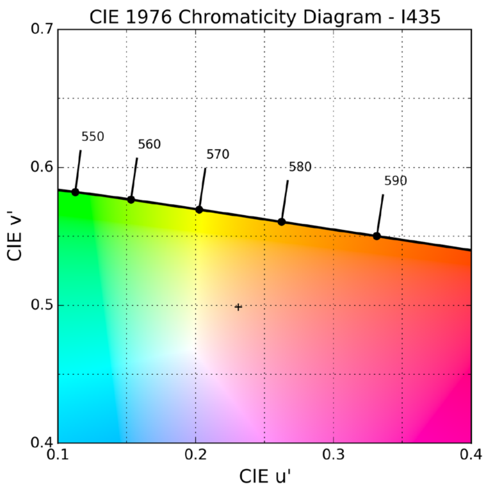

Figure 6 – Chromacity diagram (CIE 1976) in RGB (red-green-blue, cuneiform table I 435).

Results

Ceramic materials (natural raw material) are among the oldest materials used in history. Their relatively wide range gives them considerable importance among clay-based materials. Objects of cultural heritage made of pottery make up an important part of museum collections as well as provide a valuable source of information. This unreservedly applies for the examined set of cuneiform tablets.

The fact is that all natural raw materials are highly variable. This is also the case of the ceramic materials, where the content of some elements also affects their color. Clay, claystone, marl and marlstone are usually light gray to dark gray in unweathered condition, but may be greenish, yellowish, brown or red (Weis, 2005).

The physical-chemical measurements, i. e. material properties, undertaken to date on approximately 60 % of the investigated group of cuneiform tablets and envelopes suggest some previously unforeseen trends; in other respects they confirm the expected context.

The high variability of used/starting materials found in the quantitative analysis of the elements and characteristic of clay minerals (see Figure 7, a ternary diagram for Fe, Ca, K) is – despite all the known reasons and causes – rather surprising. See, for example, the distribution of Ca detected in the range of about 10 to 95 wt. %, with a higher frequency in the range of 40 to 70 wt. %.

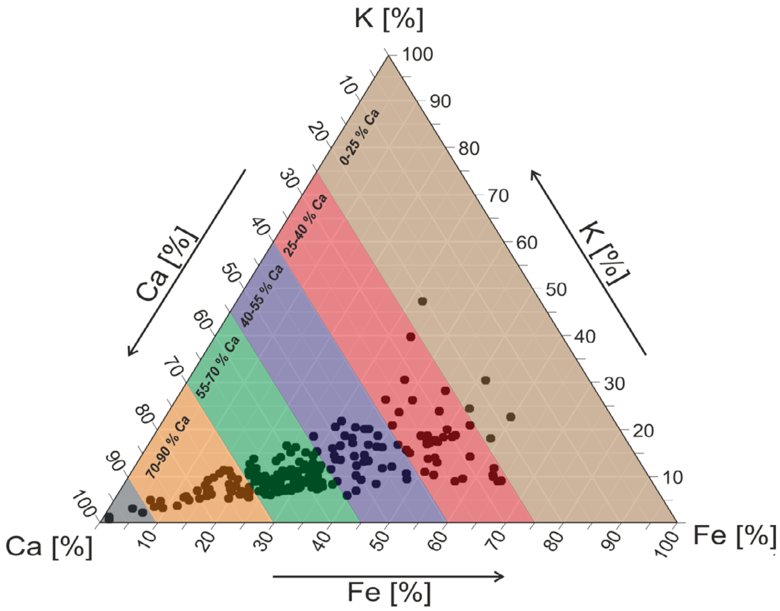

Figure 7 – Ternary diagram of Ca-Fe-K, relative to 100 wt. %.

On the contrary, the trends indicated of the relationship between the color of the tablet/ envelope and contents of some elements confirm the expected context. The seven total identified tablets of different color groups (of which the most numerous were represented by the group evaluated as "gray beige", more than half of all previously measured samples, while the least was the group labeled "brown beige", about 2% of all measured samples) must then be subjected to more detailed analysis, especially in relation to the content of the other components identified.

Although a considerable amount of the results are already currently available, there is a high degree of caution going on in the evaluation and interpretation of them on site, whether due to various inaccuracies arising from the measurement (the complexity of the shape and dimensions of the tablet), or because, for example, the identified range of colors has been determined not only by the elemental composition of the material, but also by the interaction of other factors (e.g. the presence of foreign materials in the vicinity of the discovered site – corroding iron, decaying plants, etc.).

Conclusions

Given the high variability of the materials used for producing the tablets, the diversity of their shapes, sizes and the subsequent processing of the tablets (firing, drying, applying a protective surface layer, climatic/soil conditions in the archaeological location, etc.), each of the evaluated tablets represents a completely singular and unique object.

The objective evaluation and interpretation of the results is therefore a complex multidisciplinary issue. Despite the undeniable importance of all physical-chemical analysis carried out, the analysis of the textual information (both in relation to interested individuals and to places and activities performed) has the greatest importance and weight in this complex process. Definitive conclusions from these findings, however, can only be made after the database has been filled with all the measured data and after all the planned analyses have been completed, linking the results of the physical-chemical analyses to the analysis of the textual content.

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