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NON-DESTRUCTIVE XRF ANALYSIS OF *AEGYPTIACA* FROM SICILIAN ARCHAEOLOGICAL SITES

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ABSTRACT

This research is concerned with the investigation of Egyptian and Egyptianizing artifacts dating back to the period comprised between the 10th century BC and the first half of 6th century BC, which were found in some archaeological sites of eastern-central Sicily.
The examined *Aegyptiaca* include thirt-four items consisting of scarabs, funerary statuettes, figurines and unguentaria, which are mostly preserved at the regional archeology museum "Paolo Orsi" in Syracuse and, only in part, at the regional Aeolian museum "Luigi Bernabò Brea" in the Lipari island. Some of the investigated objects are made of faience (a glazed non-clay ceramic material, coated with an alkali-based glaze), while some others are in steatite or other stones.
Through the chemical investigation of the selected artifacts, the study aims to extend the compositional dataset available on *Aegyptiaca*, as well as to identify the colorants used for the preparation of the investigated glazes. For such a scope, non-destructive bulk chemical analyses through portable x-ray fluorescence spectrometry (pXRF) were carried out on both the bodies and the overlying coloured glazes.
A rather variable chemical composition was found in terms of both bodies and glazes, thus pointing to the use of different recipes and/or workshops for the investigated artifacts.
The results obtained demonstrate the validity of this analytical technique in revealing the elemental composition of artifacts belonging to museum collections.

KEYWORDS: Artifacts, Sicily, Egyptian style, steatite, faïence, chemical analysis, portable XRF, colorants.

1. INTRODUCTION

Aegyptiaca are prestigious objects coming from distant worlds and therefore indicative of a certain luxury associated to aristocratic elites, and in any case to religious beliefs, in particular the scarabs which are found mainly in infant and female graves. They were probably used as amulets and magical objects, and considered remedies for problems related to pregnancy, childbirth, and children's diseases. They can be defined as "historical documents" that help us understanding the contacts between Egypt and other Mediterranean civilizations and whose meaning outside the place of origin was subject to multiple interpretations on the basis of local culture. Indeed, in the lower flat part of scarabs, decorative motifs are often found engraved with hieroglyphic letters that sometimes allow reading, decoding and interpretation and therefore a precise chronology. Conversely, in other cases, the motifs are illegible or of difficult interpretation. Although most of *Aegyptiaca* have been found in tomb contexts, it is reasonable that they were used during life and later placed within the tombs as a grave goods.

Scarabs, the amulets that had more diffusion, were made of almost any kind of stone, often of glazed composition, or, more rarely of gold, silver, or bronze (Ward, 1994). The most common material used was steatite (also known as soapstone), a metamorphic rock mainly constituted by talc. In its natural state, this soft stone is easily carved and engraved, which accounts for its very common use in the manufacture of scarabs and other small objects. Once the scarab was fashioned, it was plunged into a hot liquid glaze which altered the chemical composition of the stone through dehydration so that it became very hard (Ward 1994). The glaze is actually an early form of glass that could be colored by the addition of coloring agents. Scarabs were most often given a deep blue or green glaze, imitating the color of the live insect (Ward, 1994).

The second most common material is faïence or paste, namely a glazed non-clay ceramic material, coated with an alkali-based glaze. The Egyptians used faïence to produce many objects, including bowls, tiles, amulets, beads, figurines, and scarabs (Kaczmarczyk and Hedges, 1983). It could be made in a wide variety of hues, such as white, yellow, violet, black, red, and brown (Tite et al., 2007) but was typically shades of blue or green, possibly in imitation of semiprecious stones such as lapis lazuli, turquoise, and green feldspar (Friedman et al., 1998; Okkelberg, 2011). The raw materials for the body consist of dominant quartz with additions of lime, one or more alkali salts, such as natron ($Na_2CO_3 \cdot 10\ H_2O$) or potassium carbonate (K_2CO_3) from the ash of burnt halophilic plants, and lesser amounts of other elements (Clerc et al., 1976; Lucas, 1962; Ward, 1994). The raw materials for the glaze consist of much the same components as the body as well as a metallic oxide for coloring. The metal in the oxide is typically copper, sometimes with added calcium (Kaczmarczyk and Hedges, 1983; Vandiver and Kingery, 1987). Copper oxide by itself can produce a range of colors between blue and green depending on the specific composition. The addition of calcium oxide produces the crystalline double salt "Egyptian Blue" ($CaO \cdot CuO \cdot 4SiO_2$), also known as cuprorivaite (Kaczmarczyk and Hedges, 1983). Other colors were produced using metal oxides such as iron oxide (brown to red), cobalt (dark blue), lead and antimony (yellow), and lead (white) (Andrews and van Dijk, 2006; Nicholson, 2009). Black manganese was commonly used to add hieroglyphs and decorative patterns (Nicholson, 2009; Okkelberg, 2011).

The artifacts studied here (Tab. 1) include mainly scarabs, unguentaria, one figurine, and one funerary statuette (or ushabti), currently preserved at the Regional Archeology Museum "Paolo Orsi" of Syracuse and, only in part, at the Regional Aeolian Museum "Luigi Bernabò Brea" in the Lipari island. The selected finds, dating from the 10th century to the first half of 6th century BC, were mostly found in some archaeological sites of eastern Sicily (Fig. 1). Here, *Aegyptiaca* appear a few decades later than in the Italian peninsula (Frasca, 2015) and their presence can be attributed to the intense trade exchanges which in that period interested the Mediterranean Sea, especially the Aegean area, Southern Italy and Pithekoussa. Other few samples among those here examined firstly belonged to private collections and successively were donated to the aforementioned museums. Some of the analyzed finds are of Egyptian production, while others are in Egyptian style but probably produced elsewhere. In this regard, the Greek island of Rhodes and the Greek-Egyptian trade harbor of Naukratis, founded by Greek merchants in 620 BC on the Nile Delta, are thought to be key centers of early Greek-style faïence production, exporting amulets and vessels across the Mediterranean region (Meek et al., 2016).

Many studies in the existing literature dealt with *Aegyptiaca*, with particular regard to those made in faïence. The first significant investigation on the production of Egyptian faïence was performed by Lucas (1962), who classified faïence into several variants, according to their appearance. Kaczmarczyk and Hedges (1983), with an extended appendix by Vandiver, provided the most comprehensive survey of the production technology of ancient Egyptian faïence. They also looked at the overall chemical composition of a large number of faïence glazes spanning the period from Predynastic through to the 1st century

AD to determine the raw materials. Tite et al. (1983, 2007), Tite and Bimson (1986), and Vandiver (1998) focused on the investigation of the glazing methods of faïence through the examination of the microstructures of both ancient and laboratory replicate faïence. Tite and Shortland (2003) investigated the production technology of the overall range of copper- and cobalt-blue vitreous materials (including faïence) from the New Kingdom site of Amarna. La Delfa et al. (2008) focused on the reproduction and characterization of ancient Egyptian faïences by efflorescence and cementation methods.

Among the analytical techniques employed in the examination of faïence, the most reliable instrument for determining the glazing method is the scanning electron microscope (SEM) (Griffiths, 2006; Kaczmarczyk and Hedges, 1983; Shortland and Tite, 2005; Tite et al., 1983), coupled with energy dispersive X-ray spectrometry (SEM-EDS) or wavelength dispersive spectrometry (SEM-WDS) to investigate the chemical composition of artifacts (Griffiths, 2006; Shortland and Tite, 2005; Tite et al., 2007). Some other authors used neutron activation analysis (NAA) for the elemental analysis of ancient Egyptian vitreous material (Aspinall et al., 1972) or the x-ray fluorescence (XRF) associated to the atomic absorption spectroscopy (AAS) (Foster and Kaczmarczyk, 1982). For artifacts belonging to museum collections, non-destructive techniques have increasingly been developed (Liritzis et al., 2018, 2020), such as portable X-ray Fluorescence (pXRF) (Calza et al., 2011; Castro et al., 2016; Frelih et al., 2015), synchrotron radiation X-ray fluorescence (SR-XRF) (Yamahana, 2000), Particle-Induced X-ray Emission (PIXE) (Meek et al., 2016), Raman Spectroscopy (Smith, 2004), Laser-induced Breakdown Spectroscopy (LIBS) (Okkelberg, 2011). Among these, XRF is the most widely used technique due to a number of favorable analytical characteristics, such as possibility of analyzing many elements, non-destructivity, high sensitivity and applicability to a wide range of samples (Afifi et al., 2020; Calza et al., 2011).

Although the numerous studies existing in the literature, published quantitative compositional data for Egyptian faïence still remain somewhat limited (Aspinall et al., 1972; Foster and Kaczmarczyk, 1982; Kaczmarczyk and Hedges, 1983; Meek et al., 2016; Shortland and Tite, 2005; Tite et al., 2007), especially those gathered through the use of the most recent non-destructive techniques. Additionally, to date, archaeometric analyses of *Aegyptiaca* found in Sicily and preserved in several museums are still missing. Of these, a minimum part is known from the catalog "*Magia d'Egitto*" 2015. The edition of the *Aegyptiaca* in Sicily is still in progress by Prof. Hölbl, whose analysis work has lasted for more than 20 years (Hölbl, 2001).

In such a context, this research aims at the archaeometric investigation, for the first time ever, of *Aegyptiaca* found in Sicilian archaeological contexts, so contributing to extend the available compositional dataset for faience and other Egyptian/Egyptianizing artifacts. In addition, the work aims at gathering information on the raw materials used for the examined items, with particular reference to the colorants of the glazes. For such purposes, the selected finds underwent bulk chemical analyses through portable X-ray fluorescence spectrometry (pXRF) that allows *in situ* investigation of museum collections which cannot be removed and/or sampled.

2. ARCHAEOLOGICAL SITES AND STUDIED MATERIALS

Aegyptiaca selected for this study were found in several archaeological contexts mainly located in the Syracuse area and subordinately in the inner part of Sicily (Monte S. Mauro, in the province of Catania, and Aidone, in the province of Enna) and the Lipari island (in the Aeolian archipelago) (Fig. 1). Specifically, from the city of Syracuse, the examined finds come from the archaic Fusco necropolis and from Ortygia, the historic city center. Here, objects were found in the sacred area of the *Athenaion* (on which the modern Cathedral of Syracuse was built), as well as in a context of habitation, namely the Prefecture houses (excavations in 1978 by Pelagatti), and in the *Agora*. Other finds come from the necropolis of the Marcellino Valley (in the Villasmundo territory), the necropolis of Megara Hyblaea (on the coast of the Augusta gulf) and the necropolis of Monte Finocchito (about ten kilometers west of Noto city), as well as from private collections, successively donated to the "Paolo Orsi" museum of Syracuse and the Regional Aeolian Museum "Luigi Bernabò Brea" of Lipari.

The complete list of *Aegyptiaca* selected for this study is reported in Tab. 1, while a table showing the relative photos is reported in Fig. 2.

Necropolis of the Marcellino Valley

It is located in the territory of Villasmundo and is composed of about a hundred tombs, mostly dating back to the 8th century BC (Voza, 1973, 1978). Among the grave goods, along with ceramic artifacts of both local production and Greek importation, the most ancient *Aegyptiaca* of Sicily were also found (Frasca, 2015). They include about forty scarabs, many of which are still inedited; among those edited, one in light blue-paste was found inside the tomb 44, while twelve (some of which set in gold or silver) come from the tomb 105. These objects are of certain Egyptian origin and have been dated to the Third Intermediate Period. Among these, six scarabs were selected for analysis (see table 1).

Necropolis of Megara Hyblaea

Megara Hyblaea is a Greek colony founded in 727 BC on the coast of the Augusta Gulf. In this site, several finds from tomb contexts have been brought to light, which suggest a predilection of the local population for Egyptizing objects. Among these, we can mention some scarabs nestled into rings, two circular scarabs, a steatite platelet, a fragmentary figurine in faïence, and three unguentaria in faïence. Four objects were selected for this study, i.e.: one scarab (coming from the tomb 510) in beige paste covered with greenish glaze, dating to the 7th century BC; a fragmentary figurine in faïence (from the tomb 709) of the 6th century BC, representing the Egyptian god Horus in the form of a falcon; and two faïence unguentaria in the form of a porcupine, one of which from the tomb 816 and the other of uncertain provenance, both dating to the 6th century BC (table 1).

Figure 1. Sketch map of central-eastern Sicily with location of the findspots of the selected artifacts (from Hölbl, 2001, modified). In capital letters: the Greek colonies; in lowercase: the indigenous centres.

Necropolis of Monte Finocchito

It consists of about 300 tombs, whose funerary objects testify to how much the Greek influence was changing the indigenous material culture. Inside a female tomb of the east necropolis, three very small blue-paste scarabs, here analyzed (Tab. 1), were found from P. Orsi, along with other personal ornaments and local pottery, whose chronology reports to 700-675 BC (Frasca, 1981, 2015). They were initially defined as imitations of Egyptian scarabs produced by a Phoenician workshop, while later studies have suggested an Aegean provenance.

City of Syracuse

In the archaic city of Syracuse, and in particular in the sacred area of Ortygia, near the *Athenaion*, together with various ivory objects of Egyptian inspiration but probably of Rhodian production, an unguentarium from the original iconography was found (see table 1): it represents a kneeling headless figure wearing an Egyptian type clothing and holding a vase between his knees and hands, with a frog on the lid. The type is called "God of the Nile". From the same area, comes a scarab in faïence, bearing engraved on the flat part the solar disk, a scarab and two uraei on the sides (Tab. 1). In Ortygia, other scarabs are documented from the *Agora*; one of these, in white paste covered with green glaze, bearing at the base the goddess Maat, was selected for analysis (Tab. 1). Interesting the discovery of other two blue scarabs (Tab. 1) inside the house 5 of the Prefecture area (Pelagatti, 1982); they are of probable Rhodian production and date back to the Third Intermediate Period, between the 10th and 8th centuries BC. In one of the two, a cow facing right with a feather is engraved, while in the other is a sphinx crouched to the right, with an inscription in hieroglyphics that reads "Perfect God, Lord of the lands". The discovery, though in a context of habitation, always refers to the magical-religious function of the amulets. Further five scarabs were selected from the *Fusco necropolis*, which comprises ca. 1500 tombs belonging to different centuries between the 8th and the 2nd century BC. Among the grave goods of the numerous archaic tombs, different objects have been found that testify to the Egyptian influence, including the five scarabs here examined (Tab. 1): two of these are made in steatite and date back to the 8th – 7th century BC (the one from tomb 412) and to the second half of the 10th to mid 8th century BC (the one from tomb 294), respectively (cfr. Orsi 1895); another scarab is made of a dark grey stone and dates to the 7th century BC; the last two are in light paste, one fragmentary with poorly readable decoration and the other with pseudo hieroglyphics, both purchased from the Regina property and therefore of uncertain chronology.

Monte S. Mauro

The archaeological site of *Monte San Mauro* is located in the territory of Caltagirone, in the province of Catania. The Greek site developed at the end of the

7th century BC on a pre-existing indigenous settlement. The tombs of the east and west necropolises, with the exception of a few ones that can be traced back to the indigenous substrate, are of Greek age and the relative grave goods consist of several Greek-oriental imported artifacts. From one of these Greek tombs comes a small blue scarab here analyzed (Tab. 1), that should have been manufactured in Naukratis around the 7th century BC. A small double-headed warrior unguentarium of Greek-oriental production, also selected for analysis (Tab. 1), was found inside the tomb 164, along with an aryballos in faïence (Frasca, 2001).

Aidone – Castelluccio collection – Caracciolo collection

Isolated discovery is a fragmentary green-blue paste scarab from Serra Orlando, *Aidone*, in the archaeological area of Morgantina. However, in the Museum several other scarabs are preserved, such as the one of the rich private collection of the Marquis Corrado del Castelluccio (Ciurcina, 2008), here analyzed (Tab. 1), which is considered to be a fake by the archaeologists. Other materials come from the private collection of Mr. Caracciolo, custodian of Palazzolo Acreide in 1919, which were successively donated to the "Paolo Orsi" Archaeological Museum of Syracuse. Four scarabs from this collection, thought to be of Egyptian origin and whose authenticity should therefore be verified, where selected for analysis (Tab. 1).

Lipari

Aegyptiaca found in Lipari include eight ushabti, two scarabs and an aryballos in faïence with cartouche. They are currently preserved partly at the regional Aeolian museum "L. Bernabò Brea" of Lipari and partly at the Ashmolean Museum of Oxford (four ushabti and the aryballos). The scarabs, recognized as of Egyptian production by G. Hölbl and attributed to the 7th century, were found one on the Acropolis and the other in the necropolis. The first, from the trench CA (excavation in 1958), derives from one of the layers of the Greek "foundation" and provides a precious *terminus ad quem*, directing, together with other materials, towards the highest of the foundation dates of the town provided by the sources (625/620 or 580/76 BC). The other scarab, found sporadic in trench XXXI (excavation in 1970), could be the only attestation of a small dissolved and unidentified child's grave. For this study, these two scarabs and one ushabti were selected for analysis (see table 1). The ushabti (XI-X cent. BC) is a gift by a private collector who found it in Lipari. It can be compared to the other specimens also discovered in Lipari and today in Ashmolean Oxford and at the Museo Fondazione Mandralisca in Cefalù, where they are currently being studied and edited by Professor Günther Hölbl and Dr. Elfriede Haslauer, who are thanked for providing the data in advance. We don't know if these ushabti come from grave contexts. It is known, in fact, that in the late republican and proto-imperial period (I cent. BC - I cent. AD) the fashion of collecting these objects also for funeral use was widespread. Therefore, it is very likely that this is the time span in which they were brought to Lipari, rather than in the archaic age, as documented in all other sites.

Table 1. List of the Aegyptiaca selected for the study.

SAMPLE	FINDSPOT	CHRONOLOGY	DESCRIPTION AND HYPOTHETICAL PROVENANCE	MATERIAL
NECROPOLIS OF THE MARCELLINO VALLEY (VILLASMUNDO)				
SC 1 Inv. 81470	Tomb 105	8th cent BC	Scarab On the back: distinct head, defined clypeus, a line divides the elytra and another divides the elytra from the chest. On the basis: animal facing right, *neb* and solar disk. Libyan age Egyptian production	White steatite
SC2 Inv. 81470	Tomb 105	8th cent BC	Scarab with silver setting On the basis: feather, animal facing right and solar disk. Libyan age Length 2,1 cm; width 1,47 cm Egyptian production	White steatite and silver
SC3 Inv. 81470	Tomb 105	8th cent BC	Scarab On the back: distinct head, well defined clypeus, a line divides the elytra and another one divides the elytra from the chest. Libyan age Egyptian production	White steatite

SC4 Inv. 81471	Tomb 105	8th cent BC	Scarab with silver setting On the basis, horizontal reading: *nfr*, feather, goose and solar disk. Reading: *nfr M3ʿt z3 Rʿ "The son of Ra is perfect of truth"*. Libyan age Length 1,89 cm; width 1,32 cm Egyptian production	White steatite and silver
SC5 Inv. 81471	Tomb 105	8th cent BC	Scarab set in a silver ring. Back partially covered by the setting, distinct head, a line separating the chest. Broken at the median level. Illegible at the base. Libyan age Diameter 3 cm Egyptian production	White steatite and silver
SC6 Inv. 81471	Tomb 105	8th cent BC	Scarab On the basis from right to left: *nfr*, feather, *Maat* goddess holding the ankh symbol and a solar disk with uraei turned at 90°. Similar to finds from Egypt and Pithecusa. Libyan age Length 1,33 cm; width 1,37 cm Egyptian production	White steatite and gold
NECROPOLIS OF MEGARA HYBLAEA				
SC17 Inv. 11752	Tomb 709	6th cent BC	Fragmentary figurine, now restored, representing the Egyptian god *Horus* in the form of a hawk. It belongs to a group of hawks dating to ca. 630-580 BC. Probable provenance from a workshop in the Egyptian Delta or Memphis.	Faïence covered with pale green and brown glaze
SC18 Inv. 10252	Tomb 510	7th cent BC	Scarab On the basis: two animals with long horns facing right On the back: solar disk Length 2,7 cm	Light brown paste covered with greenish glaze
SC19 Inv. 1841	No data on the findspot	6th cent BC	Porcupine-shaped unguentarium. On the top, over the head of the porcupine, is a bearded male head. Egyptian production	Faïence covered with pale green glaze; details painted in dark brown
SC20 Inv. 11964	Tomb 816	6th cent BC	Porcupine-shaped unguentarium. Egyptian production	Faïence covered with pale green glaze; details painted in dark brown
NECROPOLIS OF MONTE FINOCCHITO				
SC21 Inv. 13168	Tomb 15	7th cent BC	Scarab On the basis: recognizable only the sign *nb.* Dimensions 1,02 x 1,5 cm Aegean imitation	Blue faïence
SC22 Inv. 13168	Tomb 15	7th cent BC	Scarab On the basis: partially recognizable a crouched animal facing right. Dimensions 1,01 x 0,9 cm Aegean imitation	Blue faïence
SC23 Inv. 13168	Tomb 15	7th cent BC	Scarab Heavily damaged. Dimensions 0,8 x 0,6 cm Aegean imitation	Blue faïence
SYRACUSE				
SC24 Inv. 34061	*Athenaion* (votive deposit of the archaic altar)	7th – 6th cent BC	Scarab On the basis: the solar disk *Ra* and the scarab *Kheper*, flanked by two uraei. Petrie LI din XXIII Usarken III Length 2,3 cm; width 1,6 cm	Faïence (light brown)
SC25 Inv. 34056	*Athenaion* (votive deposit of the archaic altar)	7th – 6th cent BC	"God of the Nile" type unguentarium. Kneeling headless figure in Egyptian costume, holding a vase between his knees and hands that has a frog on the lid. The dress is decorated with concentric brown circles. Height 6,6 cm; length 5,2 cm Probable rhodian production	Faïence?

SC26 Inv. 102815	Ortygia, house 5 in the prefecture area (archaic housing structure)	10th - 8th cent BC	Scarab On the basis: a cow facing right with a feather. Length 1cm, width 0,5 cm Probable rhodian production	Blue faïence
SC27 Inv. 102814	Ortygia, house 5 in the prefecture area (archaic housing structure)	10th - 8th cent BC	Scarab On the basis: sphinx crouching to the right with uraeus and *nfr*, *ndjr*, "Perfect God, Lord of the lands." Length 1,4 cm; width 0,7 cm Probable rhodian production	Blue faïence
SC28 Inv. 105929	*Agora*	7th – 6th cent BC	Scarab At the base the goddess *Maat* holding the *ank* and the *men-kheper-ra* cartouche. Length 3,3 cm; width 2,3 cm Probable rhodian production	White paste with greenish glaze
SC12 Inv. 7257	Fusco necropolis (purchased from the Regina property)	?	Fragmentary scarab with poorly readable decoration	Whitish stone
SC13 Inv. 16542	Fusco necropolis (purchased from the Regina property)	?	Scarab with pseudo hieroglyphics in the flat face	Paste with greenish glaze
SC14 Inv. 9485	Fusco necropolis (purchased)	7th cent BC	Scarab Upper part with separation line between chest and elytra; in the flat part a seated griffin, wearing double crown, paw raised; over a low cupspiral plant. Length 1,7 cm; width 0,8 cm	Jasper or hematite?
SC15 Inv. 13674	Fusco necropolis Tomb 294	Second half of the 10th to mid 8th cent BC	Scarab On the basis: the *men-kheper-Ra* cartouche. Egyptian production (probably in the area comprised between the eastern Delta and the southern Palestine)	Steatite
SC16 Inv. 13783	Fusco necropolis Tomb 412	8th – 7th cent BC	Scarab On the basis: scroll decoration, perhaps a sacred knot. Egyptian production	Steatite
		MONTE SAN MAURO		
SC29 Inv. 22513	Greek tomb	7th cent BC	Scarab On the flat part, an animal facing right with feather and solar disk. Length 1,4 cm, width 1 cm Naukratic production	Blue faïence
SC31 Inv. 78132	Tomb 164	7th cent BC	Small double-headed warrior unguentarium Greek-oriental production (Rhodes or Naukratis)	Faïence
		AIDONE		
SC30 Inv. 17232	(Archaeological area of Morgantina) Purchased	?	Fragmentary scarab Upper part with separation line between chest and elytra, decorated with very thin grooves. Smooth flat part. Length 1,5 cm; width 1,2 cm Egyptian production? (due to the absence of inscriptions, its provenance is uncertain)	Green-blue paste
		LIPARI		
SC32 Inv. 18314	Acropolis (from the trench CA)	7th cent BC	Scarab	Whitish faïence with traces of greenish glaze

	Excavation in 1958		On the back: distinct head, defined clypeus, a line divides the elytra and another divides the elytra from the chest. On the basis: two caprae with long horns facing right Length 2,7 cm; width 1,8 cm Egyptian production?	
SC33 Inv. 18315	C.da Diana necropolis (found sporadic in trench XXXI) Excavation in 1970	7th cent BC	Scarab On the back: distinct head, defined clypeus, a line divides the elytra and another divides the elytra from the chest. Length 1,8 cm; width 1,3 cm Could be the only attestation of a small unidentified child's grave. Egyptian production?	Light brown faïence with traces of greenish glaze
SC34 Inv. 18481	Donation by a private collector	XI-X cent BC	Ushabti Statuette in the shape of a mummy, with crossed arms and in the hands a hoe and a sickle; face, with heavy features, framed by a wig. Height 9,7 cm; maximum width 4 cm Egyptian production?	Faïence? with light blue enamel
ADDITIONAL SAMPLES				
SC7 Inv. 36155	Donation by Caracciolo	?	Scarab Engraving with royal cartouche of Seti I above the nbw (gold) sign, flanked by two ostrich feathers and on the top a winged solar disk Egyptian origin?	Light brown paste
SC9 Inv. 36158	Donation by Caracciolo	?	Scarab Egyptian origin?	Light stone
SC10 Inv. 36156	Donation by Caracciolo	?	Scarab Egyptian origin?	White stone
SC11 Inv. 36159	Donation by Caracciolo	?	Scarab Egyptian origin?	Light stone
SC8 Inv. 25882	Castelluccio collection	?	Scarab In the flat part decorated with an open-winged scarab and other symbols False?	Steatite? (in the inventory of the early 1900s it is defined as "hard whitish matter without glaze")

3. METHODS

Portable X-ray fluorescence spectroscopy (pXRF) is a non-destructive analytical technique that allows to determine the chemical composition of an artefact.

The elemental analysis of selected finds was performed using a Bruker Tracer IV-SD system endowed with an x-ray tube with Rh target (and Pd slits) source and a 10 mm^2 Silicon Drift Detectors (SDD). The instrumental setup used for this study is as follows: i) 15 kV, 35 mA, no filter and vacuum condition for elements from Mg to Ca; ii) 40 kV, 17 mA, 304.8 μm aluminum + 25.4 μm titanium filter for the heavier elements.

The instrument head was placed in contact with the surface of objects or, at least, as closer as possible to it. Three analyses per spot were carried out, with an accumulation time of 60 s.

Identification of the elements peaks was gained directly on the laptop connected to the instrumentation by means of the software S1PXRF. Quantitative data were obtained by using PyMCA software based on fundamental parameter calculations. The configuration files were designed considering the Tracer IV-SD specification and the measurement setup. Both major elements, expressed as oxides (concentrations in wt.%), and minor/trace elements (concentrations in ppm) were determined. The major elements included: SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, K_2O, P_2O_5. Na_2O data were not used since they were considered affected by large measurement errors. The minor/trace elements included: Sc, V, Cr, Co, Ni, Cu, Zn, Ga, As, Rb, Sr, Y, Zr, Nb, Sn, Sb, Ba, La, Ce, W, Hg, Pb and Th.

Elemental data were corrected by using the best fit method calculated on 39 international minerals and rocks standards (AL1, ANG, BCR1, BEN, BIR1, BR, BXN, DNC1, DRN, DTN, DTS1, FE-MICA, FKN, G2, GA, GH, GSN, GSP1, KK, MAG1, MAN, MG-MICA, MGR1, NIMD, NIMG, NIML, NIMN, NIMP, NIMS, PCC1, SCO1, SDC1, SGR1, STM1, SY2, SY3, UBN, W2). Calculated best fit equations are available on request to the corresponding author. All best fits display R^2 values > 0.9 with the exception of Co (R^2=0.79) and V (R^2=0.79).

Figure 2. Table showing the examined Aegyptiaca. The photos of the finds were provided (and their publication authorized) by the "Archaeological and Landscaped Park of Syracuse, Eloro, Villa del Tellaro and Akrai" as well as (for the three items coming from Lipari) by the "Regional Pole of the Aeolian Islands".

4. RESULTS

The pXRF analysis of the selected archeological finds allowed to obtain their chemical composition in terms of major, minor and trace elements. In some cases, the measurements have been carried out on both the internal body and the outer colored glaze layer, while in other cases only on the body (where the glaze was missing) or on the glaze (where the underlying body was not exposed). The data obtained for scarabs are reported in tables 2 and 3, while those for unguentaria, ushabti and figurine are in tables 4 and 5.

4.1. Scarabs

4.1.1. Bodies

A first observation of the spectra obtained revealed some differences in the composition of the constituent materials of examined bodies. Some scarabs are made of MgO-rich stones, others of high silica stones, some others of $MgO-K_2O$-rich stones and one of high CaO stone (Fig. 3a,b).

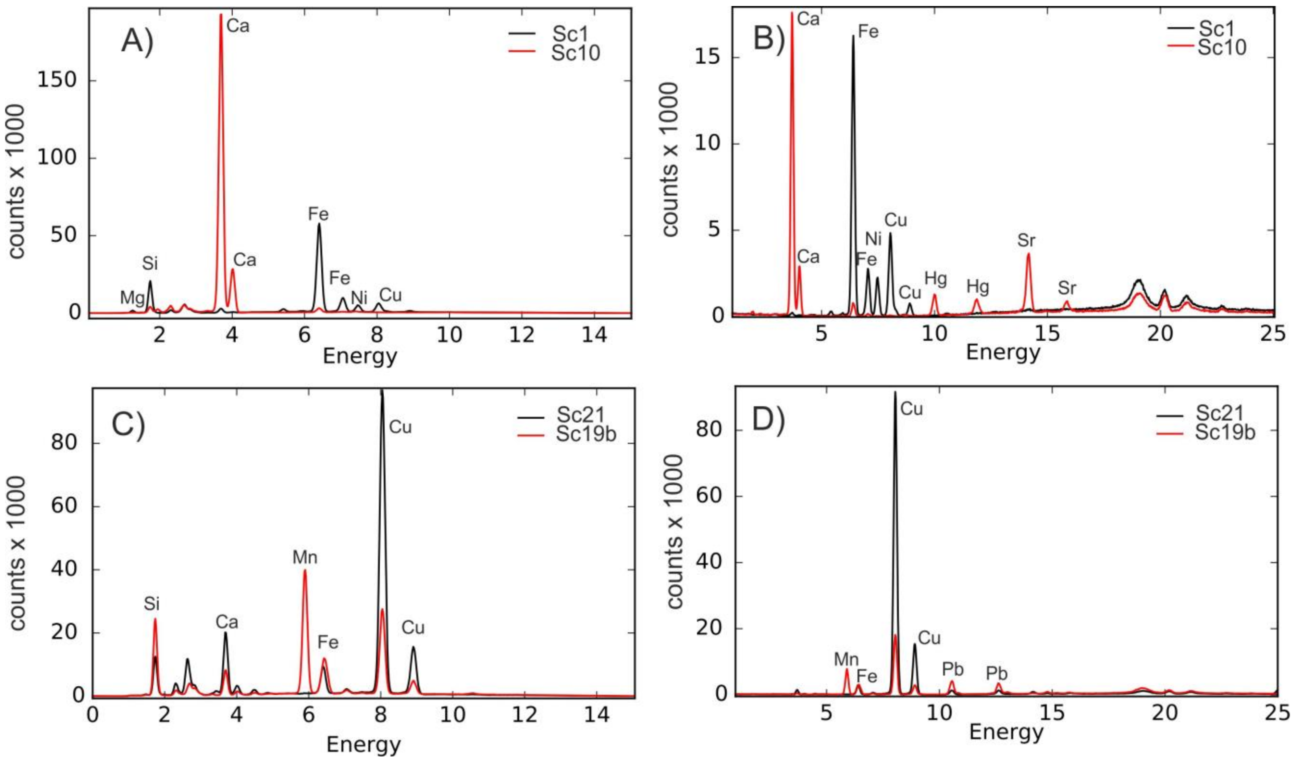


Figure 3. Spectra obtained by the pXRF analysis of some of the investigated samples by means of the light (A and C) and heavy (B and D) operational modes: samples SC1 (MgO-rich scarab body), SC10 (CaO-rich scarab body), SC21 (Cu-rich blue glaze), SC19b (Mn-rich dark brown glaze).

Regarding the quantitative analysis of the bodies, diagrams in Fig. 4 show a certain compositional variability either between artifacts from the same findspot or from different ones. Specifically, the six scarabs from the *Marcellino Valley* share low to moderate silica contents (<65%), high levels of magnesium (> 35%) and nickel (>290 ppm) and low potassium (<0.3%) (Tabs. 2 and 3; Figs. 3a,b and 4). Other elements show a wide variability within the group, e.g. the iron ranges from 1.2 to 4.5%, aluminum from 0.4 to 6.4%, tin from 94 to 2055 ppm and chromium from 16.5 to 490 ppm (Fig. 4).

Similarly, the scarabs SC12, SC15 and SC16 from the Fusco necropolis are characterized by low to moderate SiO_2 contents, high MgO and Ni and low K_2O, with concentrations falling into ranges similar to those of the scarabs from the Marcellino valley (Tabs. 2 and 3; Fig. 4). Some differences in the trace elements' contents are probably due to residues of the colored glaze on the bodies. Conversely, the black scarab SC14 from the same necropolis has completely different chemical features (see Fig. 4), namely low MgO (avg 5%), almost absent Ni (avg 0.2 ppm), very low Cu (avg 19 ppm) and high SiO_2 (avg 89%) (Tabs. 2 and 3).

The only one scarab coming from the Castelluccio collection (SC8) has a chemical composition very similar to that of artifacts from the Marcellino valley and Fusco necropolis, with concentrations of most major and trace elements falling in the same ranges (Tabs. 2 and 3; Fig. 4). Conversely, the scarab SC18 from Megara Hyblaea has its own distinct chemical features, such as high SiO_2 (92%), very low MgO (0.02%), Ni (0.9 ppm), Cr (3.5 ppm) and Co (1.4 ppm), along with much higher Pb (1217 ppm) than the other investigated bodies (Fig. 4).

Lastly, as regards the scarabs of the Caracciolo donation, it is worth to note that some chemical differences can be observed within this set of artifacts. Specifically, samples SC9 and SC11, similar to each other, display low SiO_2 (<50%) and high MgO (>40%), K_2O

(0.7-1.5%), Ni (>180 ppm) and Cr (up to 365 ppm) (Tabs. 2 and 3; Fig. 4). Therefore, their chemical composition is similar to that of the scarabs from the Marcellino valley and the Fusco necropolis, but with higher K_2O and lower Ni contents (Fig. 4a,e). Conversely, the SC10 sample is characterized by very high calcium levels (avg 62,5% CaO), together with high strontium (avg 625 ppm) and tin (avg 730 ppm), low potassium (0.2%) and very low magnesium (avg 2,5%), so confirming the limestone nature of the body, as supposed by its macroscopic appearance (Figs. 3a,b and 4).

Table 2. Concentrations (wt.%) of major elements obtained by portable XRF analysis of the investigated scarabs.

SAMPLE	ANALYSES	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	K_2O	P_2O_5
					MARCELLINO VALLEY					
SC1	SC1a_body	35.82	0.01	0.38	1.14	0.00	62.45	0.18	0.00	0.02
	SC1b_body	42.46	0.02	1.13	2.25	0.01	53.72	0.32	0.01	0.09
SC2	SC2a_body	45.32	0.04	2.50	1.74	0.01	48.58	1.03	0.11	0.67
	SC2b_body	46.37	0.05	2.66	2.75	0.01	46.66	0.87	0.04	0.58
SC3	SC3a_body	40.69	0.02	0.62	1.65	0.01	55.89	1.04	0.02	0.08
	SC3b_body	45.77	0.02	0.46	2.79	0.01	49.18	1.31	0.01	0.44
SC4	SC4a_body	39.66	0.01	0.61	1.66	0.00	55.64	0.70	0.04	1.68
	SC4b_body	50.68	0.07	2.88	3.91	0.01	36.38	3.16	0.03	2.88
SC5	SC5a_body	42.80	0.03	1.54	1.82	0.01	52.66	0.92	0.01	0.21
	SC5b_body	64.37	0.15	6.38	4.70	0.02	16.48	6.96	0.15	0.79
SC6	SC6a_body	49.65	0.06	2.88	2.12	0.01	44.24	0.94	0.09	0.01
	SC6b_body	56.01	0.08	4.03	3.66	0.02	33.96	1.82	0.27	0.16
					FUSCO NECROPOLIS					
SC12	SC12a_body	37.92	0.01	0.32	1.20	0.01	59.66	0.51	0.04	0.33
	SC12b_body	39.07	0.01	0.34	1.84	0.01	57.44	0.61	0.06	0.62
SC13	SC13a_green	85.12	0.16	3.81	0.55	0.02	3.16	3.81	0.09	3.28
	SC13b_green	63.33	0.05	1.64	0.25	0.01	1.25	14.35	0.04	19.07
SC14	SC14a_body	88.42	0.02	2.47	1.78	0.01	6.40	0.24	0.63	0.02
	SC14b_body	90.04	0.03	2.71	2.29	0.01	3.78	0.32	0.77	0.05
SC15	SC15a_body	49.58	0.09	6.37	2.08	0.01	33.61	7.80	0.43	0.03
	SC15b_body	47.06	0.10	5.00	2.13	0.01	40.60	4.16	0.45	0.48
SC16	SC16a_body	59.36	0.04	3.24	2.14	0.01	29.01	5.89	0.20	0.09
	SC16b_body	55.50	0.06	4.05	2.57	0.01	34.92	2.38	0.18	0.33
	SC16c_body	61.28	0.26	5.52	2.21	0.01	26.09	4.13	0.24	0.27
					MEGARA HYBLAEA					
SC18	SC18a_body	92.10	0.09	5.36	0.44	0.01	0.02	1.68	0.05	0.24
	SC18b_green	87.93	0.10	5.78	0.51	0.01	0.19	4.13	0.11	1.23
	SC18c_green	58.46	0.37	14.64	1.81	0.03	3.61	19.77	0.28	1.02
					MONTE FINOCCHITO					
SC21	SC21a_blue	81.48	0.37	6.95	0.81	0.01	3.26	6.67	0.23	0.22
	SC21b_blue	92.90	0.07	2.18	0.44	0.00	0.37	3.95	0.05	0.04
SC22	SC22a_blue	75.25	0.36	5.68	0.98	0.01	9.44	7.64	0.30	0.34
	SC22b_blue	89.62	0.09	3.55	0.53	0.01	0.75	5.20	0.10	0.15
SC23	SC23a_blue	82.65	0.29	5.14	0.92	0.01	3.67	6.83	0.26	0.24
	SC23b_blue	86.93	0.13	3.45	0.87	0.01	0.57	7.60	0.21	0.22

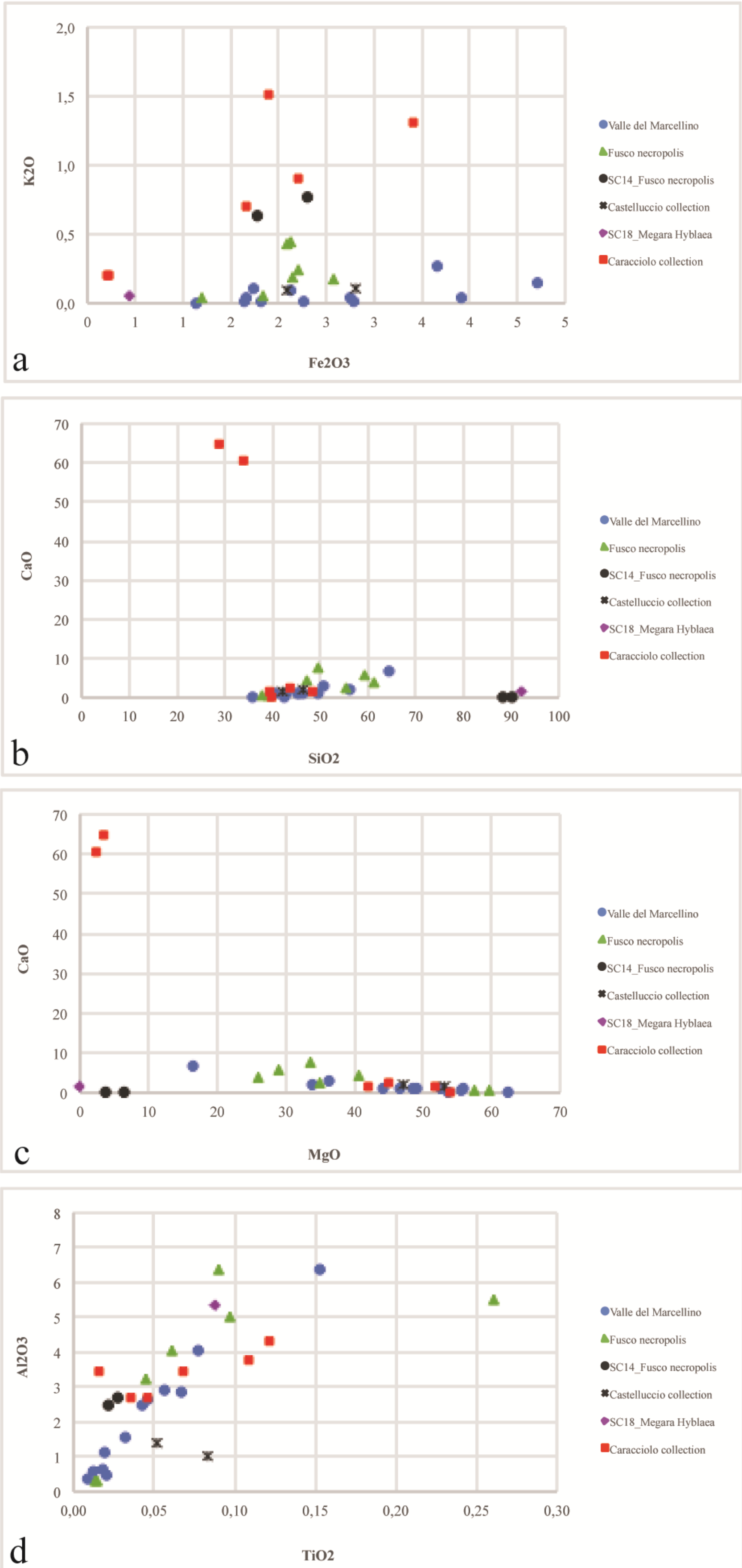
				SYRACUSE - ATHENAION						
SC24	SC24a_brown	93.19	0.12	3.51	0.40	0.01	0.04	1.96	0.25	0.52
	SC24b_brown	86.95	0.13	3.43	0.87	0.01	0.57	7.60	0.21	0.22
				SYRACUSE – PREFECTURE HOUSE						
SC26	SC26a_blue	82.29	0.58	5.22	1.20	0.01	0.47	8.70	0.35	1.18
	SC26b_blue	84.13	0.10	3.00	1.35	0.01	0.10	8.45	0.25	2.61
SC27	SC27a_blue	80.80	0.08	5.70	0.97	0.00	2.45	7.86	0.33	1.81
	SC27b_blue	76.14	0.10	8.46	1.18	0.01	2.09	9.56	0.48	1.98
				SYRACUSE - AGORA						
SC28	SC28a_green	82.92	0.15	6.38	0.83	0.01	1.19	6.43	0.48	1.62
	SC28b_green	83.77	0.12	5.68	0.77	0.02	1.26	6.81	0.33	1.24
				MONTE S. MAURO						
SC29	SC29a_blue	78.77	0.12	9.02	1.13	0.00	2.59	6.99	0.41	0.96
	SC29b_blue	76.98	0.12	9.81	1.24	0.01	3.39	7.10	0.33	1.03
				AIDONE						
SC30	SC30a_green	89.49	0.08	7.61	0.40	0.01	0.39	1.11	0.43	0.48
	SC30b_green	88.30	0.11	7.80	0.53	0.01	0.79	1.57	0.49	0.41
				LIPARI - C.DA DIANA						
SC32	SC32a_green	82.35	0.09	5.43	0.43	0.02	5.83	2.87	1.10	0.23
	SC32b_green	77.13	0.14	5.13	0.78	0.05	3.72	3.68	1.29	0.49
				LIPARI - ACROPOLIS						
SC33	SC33a_green	72.97	0.12	4.55	1.31	0.03	1.28	6.20	0.43	5.57
	SC33b_green	82.35	0.08	5.01	0.75	0.02	2.40	4.30	0.36	3.73
				CARACCIOLO COLLECTION						
SC7	SC7a_green	47.12	0.56	16.54	3.50	0.03	5.53	25.00	1.20	0.53
	SC7b_brown	52.70	0.51	18.21	3.48	0.04	0.38	22.40	1.91	0.38
	SC7c_brown	50.49	0.60	16.40	3.88	0.03	3.04	23.69	1.22	0.65
SC9	SC9a_body	39.77	0.02	3.43	1.66	0.02	54.06	0.24	0.70	0.10
	SC9b_body	48.32	0.12	4.33	2.21	0.02	42.12	1.78	0.90	0.20
SC10	SC10a_body	33.70	0.04	2.69	0.23	0.01	2.33	60.80	0.20	0.01
	SC10b_body	28.65	0.05	2.70	0.21	0.01	3.30	64.77	0.20	0.10
SC11	SC11a_body	39.53	0.07	3.43	1.90	0.02	51.73	1.58	1.52	0.23
	SC11b_body	43.83	0.11	3.76	3.42	0.05	44.90	2.35	1.32	0.27
				CASTELLUCCIO COLLECTION						
SC8	SC8a_body	42.17	0.08	0.99	2.09	0.01	53.05	1.42	0.09	0.09
	SC8b_body	46.24	0.05	1.38	2.81	0.02	47.19	2.03	0.10	0.17

Table 3. Concentrations (ppm) of minor and trace elements in the investigated scarabs obtained by portable XRF analysis.

SAMPLE	ANALYSES	Sc	V	Cr	Co	Ni	Cu	Zn	Ga	As	Rb	Sr	Y	Zr	Nb	Sn	Sb	Ba	La	Ce	W	Hg	Pb	Th
												MARCELLINO VALLEY												
SC1	SC1a_body	16	2	107	20	462	974	8	2	13	3	25	7	9	4	94	24	8	5	10	4	12	46	8
	SC1b_body	21	6	125	22	430	550	8	2	15	5	23	4	4	5	110	65	22	17	6	0	13	39	6
SC2	SC2a_body	3	0	51	21	390	1940	17	0	14	8	29	6	9	6	1070	3	1	10	19	0	22	31	5
	SC2b_body	0	0	198	16	383	1321	12	2	15	6	29	4	6	5	457	3	1	15	1	0	17	41	7
SC3	SC3a_body	11	6	29	21	445	2099	14	3	20	5	34	7	7	6	678	2	9	19	15	1	8	73	9
	SC3b_body	0	3	17	18	393	955	7	3	32	5	51	3	7	5	952	1	1	15	10	0	16	112	8
SC4	SC4a_body	1	0	121	14	329	2036	11	2	29	11	73	5	3	8	320	5	0	8	8	0	33	37	6
	SC4b_body	5	1	489	13	308	1742	14	1	22	9	68	4	6	3	269	1	4	1	0	1	30	29	11
SC5	SC5a_body	0	3	291	15	458	666	8	0	19	82	26	0	7	6	127	18	0	1	13	0	66	8	10
	SC5b_body	6	2	132	12	311	1038	5	0	38	240	51	1	7	8	2055	1	22	8	13	0	97	29	29
SC6	SC6a_body	3	8	18	19	354	5638	34	2	20	7	16	3	6	3	111	49	28	15	12	19	17	53	6
	SC6b_body	35	1	17	19	290	4866	41	2	24	27	21	3	12	8	140	11	13	18	16	33	26	18	9
												FUSCO NECROPOLIS												
SC12	SC12a_body	30	8	38	21	466	272	48	1	60	5	13	5	7	7	183	109	8	18	1	3	306	150	54
	SC12b_body	10	6	58	18	449	129	13	1	93	10	15	4	3	7	298	137	10	8	18	2	87	235	31
SC13	SC13a_green	1	11	5	4	20	9918	58	0	82	5	73	3	41	4	131	112	3	2	15	14	31	3021	16
	SC13b_green	4	0	6	2	8	4119	42	0	1	4	128	6	28	3	172	110	37	1	3	4	15	1953	8
SC14	SC14a_body	5	5	3	12	0	19	36	0	2	67	12	13	13	3	104	29	20	23	18	0	30	25	13
	SC14b_body	4	9	7	13	0	20	12	2	1	67	10	10	14	5	286	63	5	29	17	3	24	19	10
SC15	SC15a_body	2	1	42	18	431	4647	64	0	99	8	20	5	4	6	462	22	88	3	0	2	10	89	8
	SC15b_body	0	0	128	15	384	4994	59	0	104	8	18	6	5	6	1683	9	4	11	18	1	5	307	7
	SC16a_body	8	2	41	6	120	657	12	1	18	6	32	2	4	3	19	72	1	2	2	0	8	13	7
SC16	SC16b_body	3	1	349	17	313	1104	22	2	32	7	13	5	6	4	3	7	40	14	5	0	9	22	7
	SC16c_body	0	0	58	15	276	3568	41	1	45	9	40	6	2	4	80	195	538	1	0	4	9	35	15

MEGARA HYBLAEA																								
SC18	SC18a_body	13	2	4	1	1	457	9	0	3	5	17	9	57	5	201	15	1	27	7	1	8	1217	11
	SC18b_green	2	0	7	5	5	3150	18	4	0	3	32	8	54	7	26	18	28	14	3	2	14	1440	10
	SC18c_green	0	0	10	6	17	10430	42	0	1	4	31	9	47	5	222	12	26	2	3	15	23	1213	9
MONTE FINOCCHITO																								
SC21	SC21a_blue	1	0	6	8	33	20050	57	0	33	4	136	0	31	6	2417	182	310	6	22	35	5	842	12
	SC21b_blue	69	4	5	7	27	18250	50	7	2	2	132	6	33	3	2450	190	24	2	19	31	13	793	9
SC22	SC22a_blue	63	7	6	10	29	19710	58	9	3	2	126	4	28	4	2408	177	231	15	4	32	6	1003	17
	SC22b_blue	82	6	11	8	32	19740	54	3	10	3	136	7	32	4	2224	7	19	9	3	31	10	1097	10
SC23	SC23a_blue	1	0	5	5	26	17480	52	0	15	2	130	4	27	2	2258	1	133	0	8	29	6	786	8
	SC23b_blue	2	4	5	6	26	15750	47	0	14	3	129	3	26	3	1737	32	1	18	17	22	8	742	10
SYRACUSE - ATHENAION																								
SC24	SC24a_pale brown	31	1	6	5	2	517	20	0	21	6	43	9	121	2	260	104	95	5	4	1	5	268	3
	SC24b_pale brown	26	5	4	3	1	449	14	0	9	6	41	9	97	4	328	94	30	3	6	1	8	240	7
SYRACUSE – PREFETURE HOUSE																								
SC26	SC26a_blue	53	3	7	9	27	18400	54	12	57	4	228	5	14	2	828	346	219	24	11	27	12	2641	17
	SC26b_blue	77	8	9	10	28	19660	55	11	73	5	238	6	9	4	841	355	29	1	2	25	12	3323	17
SC27	SC27a_blue	1	8	10	11	35	22090	91	0	41	5	222	5	11	4	1072	309	1	27	11	38	4	1334	9
	SC27b_blue	2	6	6	9	27	20530	53	0	30	7	210	5	12	2	1240	134	46	6	0	32	9	1408	17
SYRACUSE - AGORA																								
SC28	SC28a_green	51	3	5	2	1	353	10	9	45	6	161	2	70	5	595	332	15	1	1	1	24	7028	18
	SC28b_green	52	2	6	5	2	522	6	1	79	5	137	2	64	5	903	375	11	10	35	1	22	6320	11
MONTE SAN MAURO																								
SC29	SC29a_blue	46	5	9	12	31	18180	59	24	233	17	183	1	23	1	381	563	34	9	5	22	47	3104	195
	SC29b_blue	1	0	3	11	34	19110	53	0	200	17	173	0	17	0	618	384	2	12	13	19	22	2870	194
AIDONE																								
SC30	SC30a_green	2	2	4	2	3	2417	45	0	0	9	213	5	63	6	7	85	1	11	16	1	72	1071	5
	SC30b_green	0	2	5	2	5	2668	40	0	11	14	337	8	54	3	264	1	18	8	0	3	126	1138	7

LIPARI – C.DA DIANA																								
SC32	SC32a_green	9	2	3	2	3	1575	15	6	1	27	397	7	45	5	83	86	28	17	1	2	36	34	8
	SC32b_green	1	0	2	3	5	2686	17	1	0	24	315	7	30	3	56	2	6	1	3	6	10	41	9
LIPARI - ACROPOLIS																								
SC33	SC33a_green	1	0	6	4	4	936	31	255	676	0	128	1	0	10	3	502	22	15	21	3	38	44600	1
	SC33b_green	30	4	6	3	1	550	21	192	603	16	114	168	14	17	88	283	28	28	6	1	39	39000	8
CARACCIOLO COLLECTION																								
SC7	SC7a_green	56	6	23	11	15	7613	29	2	4	31	528	15	54	10	124	280	13	16	28	8	67	29	13
	SC7b_pale brown	1	2	19	12	19	9861	34	4	2	27	490	15	46	7	5	213	3	18	13	13	61	25	8
	SC7c_pale brown	58	2	19	11	16	9354	33	3	8	27	436	10	39	10	37	193	29	9	0	17	60	21	11
SC9	SC9a_body	21	0	364	26	288	71	66	2	6	10	17	6	11	5	263	130	45	16	30	5	54	27	11
	SC9b_body	7	2	59	16	262	114	24	2	8	10	40	7	12	4	24	7	1	8	12	0	34	32	5
SC10	SC10a_body	16	1	4	1	2	9	0	4	0	9	660	12	10	4	634	26	3	12	1	2	814	16	11
	SC10b_body	239	1	1	1	1	7	0	3	2	6	594	13	10	5	827	46	1	8	7	1	191	16	7
SC11	SC11a_body	40	3	45	17	211	75	47	3	15	9	15	6	6	5	110	13	11	22	25	2	75	25	7
	SC11b_body	3	0	105	22	184	107	56	1	0	10	36	4	6	4	16	4	1	14	13	2	44	39	12
CASTELLUCCIO COLLECTION																								
SC8	SC8a_body	1	0	577	25	423	1029	60	0	35	8	12	1	5	5	0	3	3	5	1	0	69	109	7
	SC8b_body	95	1	292	21	329	620	61	2	26	2	9	4	6	5	23	9	25	12	12	13	20	82	14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K2O
Fe2O3
2,0
1,5
1,0
0,5
0,0
0 1 1 2 2 3 3 4 4 5 5
Valle del Marcellino
Fusco necropolis
SC14_Fusco necropolis
Castelluccio collection
SC18_Megara Hyblaea
Caracciolo collection
b
CaO
SiO2
70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70 80 90 100
Valle del Marcellino
Fusco necropolis
SC14_Fusco necropolis
Castelluccio collection
SC18_Megara Hyblaea
Caracciolo collection
c
CaO
MgO
70 60 50 40 30 20 10 0
0 10 20 30 40 50 60 70
Valle del Marcellino
Fusco necropolis
SC14_Fusco necropolis
Castelluccio collection
SC18_Megara Hyblaea
Caracciolo collection
d
Al2O3
TiO2
8 7 6 5 4 3 2 1 0
0,00 0,05 0,10 0,15 0,20 0,25 0,30
Valle del Marcellino
Fusco necropolis
SC14_Fusco necropolis
Castelluccio collection
SC18_Megara Hyblaea
Caracciolo collection

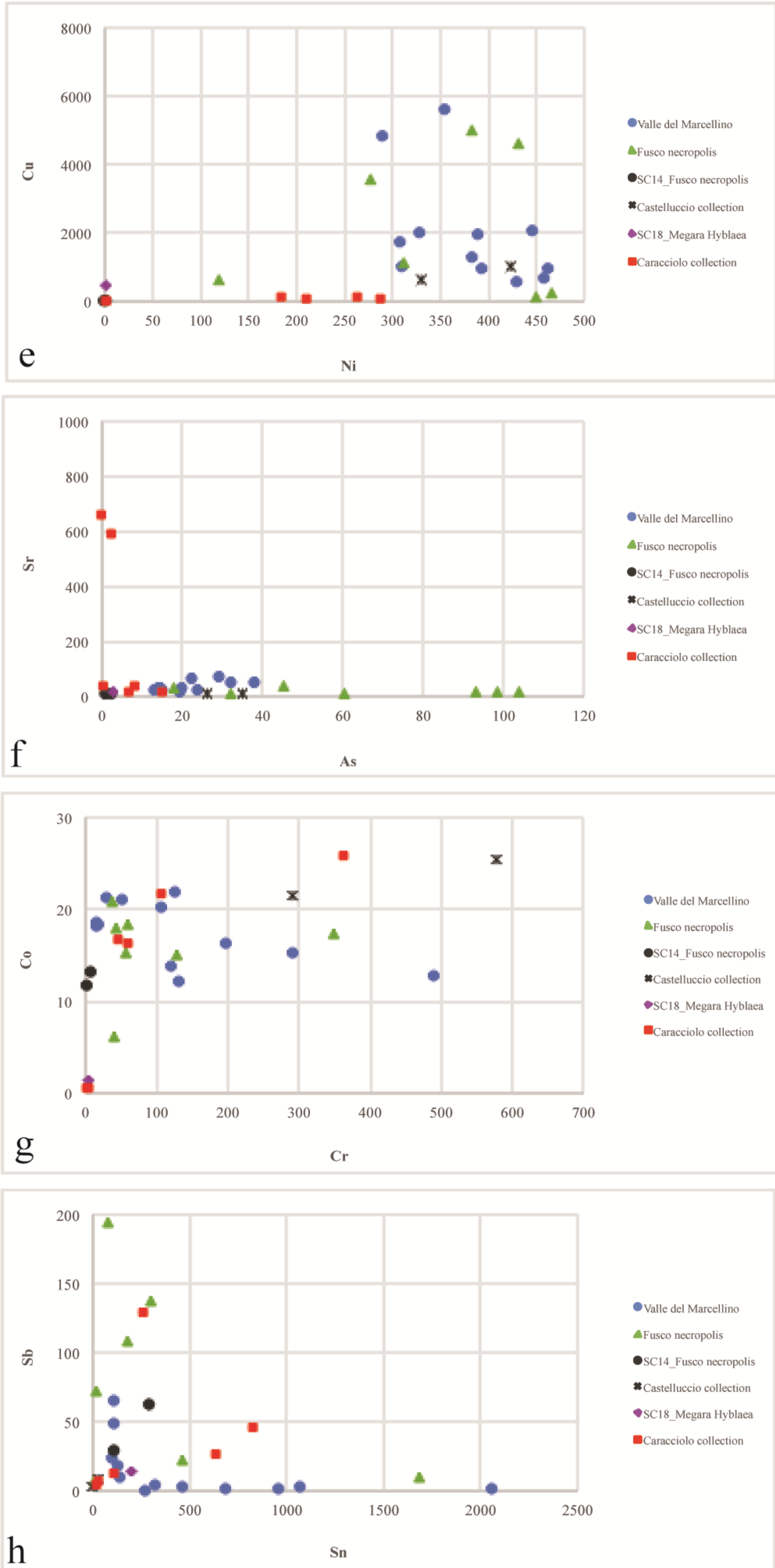


Figure 4. Binary diagrams of the most significant major, minor and trace elements determined through the pXRF analysis of the scarab bodies.

4.1.2. Coloured glazes

The fragments examined included mostly monochrome faïence, with outer glazes showing different hues of blue, green and pale brown. In the case of the figurine SC17 from Megara Hyblaea, the faïence is bichrome with both green and brown portions, while regarding the unguentaria and the ushabti, the monochrome green or blue or brown faïences have details painted in dark brown.

4.1.2.1. Blue

The blue-colored scarabs from Monte Finocchito, Prefecture house in Syracuse and M. San Mauro share a very similar chemical composition which is characterized by high SiO_2 (>75%) and Cu (>15000 ppm), low MgO (<10%), Fe_2O_3 (<1.5%), K_2O (<0.5%) and very low Co (<12 ppm) (Tabs. 2 and 3; Figs. 3c,d and 5). Nevertheless, some small differences can be observed between artifacts from different sites, particularly for arsenic, antimony, tin and lead (Fig. 5). Specifically, the scarab from M. San Mauro displays higher As (As_{avg} 210 ppm), Sb (>380 ppm) and Pb (Pb_{avg} 2987 ppm), and lower Sn (<620 ppm) contents than the others. Conversely, the scarabs from Monte Finocchito show the lowest contents of As (<35 ppm), Sb (<190 ppm) and Pb (Pb_{avg} 877 ppm) and the highest Sn (>1700 ppm) concentrations. The two amulets from the Prefecture house in Syracuse exhibit intermediate levels of these elements (averages: As=50 ppm; Sb=285 ppm; Sn=995 ppm; Pb=2176 ppm).

4.1.2.2. Green

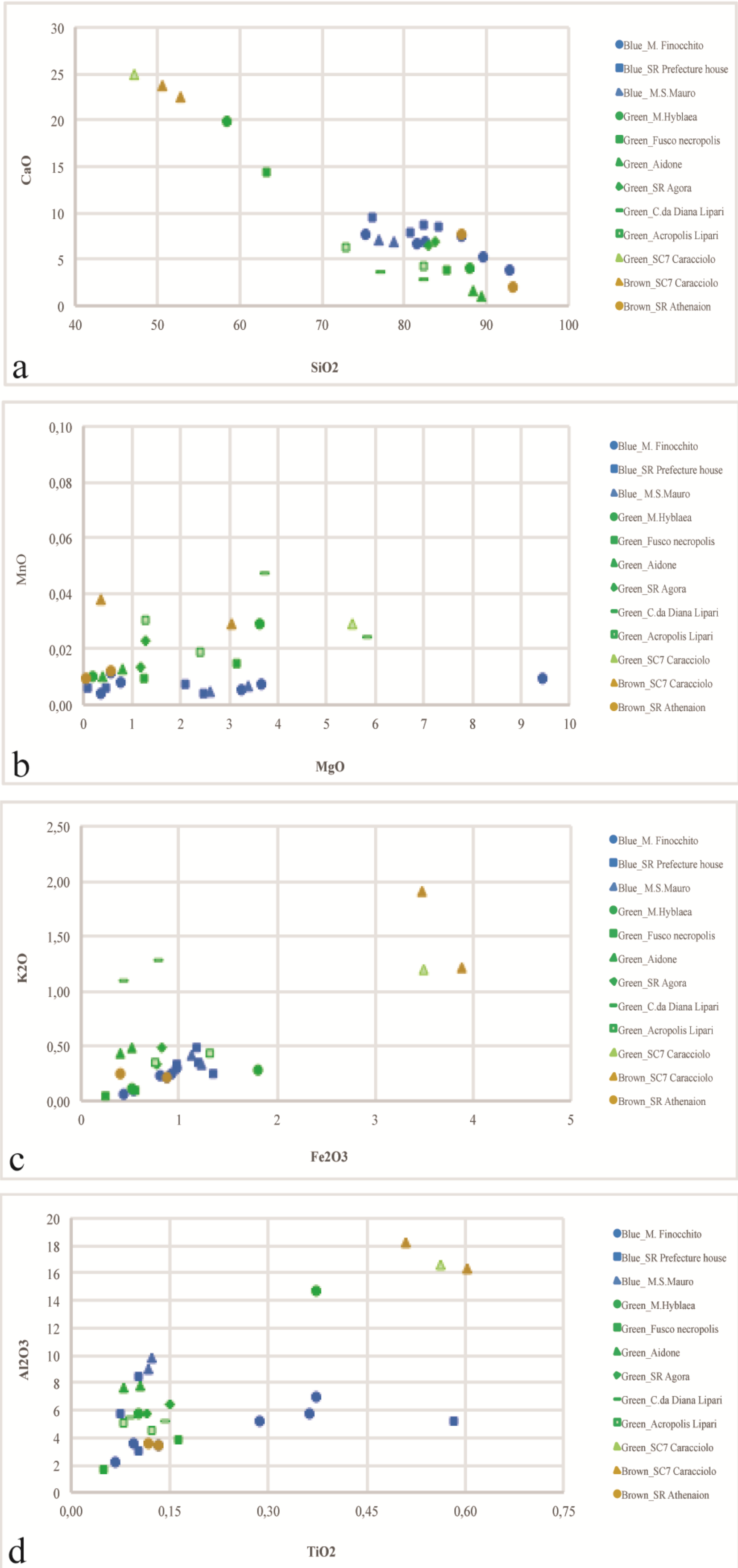
The seven green-glazed scarabs here investigated show some common features, such as high to moderate copper contents (but always lower than 10500 ppm), low tin (<300 ppm) and very low nickel (<20 ppm) and cobalt (generally <6 ppm) (see Tabs. 2 and 3 and Fig. 5). Despite these similar chemical characteristics, several compositional differences can be observed depending on the findspot (Fig. 5). In particular, the scarab SC7 of the Caracciolo collection clearly distinguishes from the others since it has lower SiO_2 contents (47%) and much higher CaO (25%), Fe_2O_3 (3.5%), TiO_2 (0.6%), Al_2O3 (16.5%) and Sr (530 ppm).

Even the amulets SC32 and SC33 from Lipari have some discriminant features with respect to the others; specifically, the former exhibits much higher Pb (>35000 ppm), As (>600 ppm), Sb (>280 ppm) and Ga (>190 ppm), while the latter has higher K_2O (>1%) concentrations. Lastly, the scarab from the Syracuse Agora (SC28) shows high levels of Sn (600-900 ppm) and Sb (>300 ppm) (Fig. 5).

4.1.2.3. Pale brown

The two scarabs with pale brown glaze, namely SC7 from the Caracciolo collection and SC24 from the Syracuse Athenaion, are characterized by completely different chemical composition (Tabs. 2 and 3 and Fig. 5). The former has lower concentrations of silica (avg 51.5% vs. 90%) and Zr (avg 42.5 ppm vs. 110 ppm) and higher contents of manganese (avg 0.04% vs. 0.01%), calcium (avg 23% vs. 5%), iron (avg 3.7% vs. 0.6%), potassium (avg 1.6% vs. 0.2%), aluminum (avg 17% vs. 3.5%), copper (avg 9500 ppm vs. 475 ppm), and strontium (avg 463 ppm vs. 42 ppm) than the latter.

As for the scarab SC7, it must be underlined that the chemical composition of its brown glaze is almost identical to that of the green portion occurring in the same sample and just discussed, except for small differences in some elements, such as copper, which is higher in the brown glaze (9600 ppm vs. 7600 ppm), while magnesium, antimony and tin are slightly higher in the green glaze (MgO=5.5%; Cu=7600 ppm; Sn=124 ppm; Sb=280 ppm) than in the brown one (MgO=<3%; Sn<40 ppm; Sb~200 ppm) (see Fig. 5).


a
CaO
SiO2
0
5
10
15
20
25
30
40
50
60
70
80
90
100
Blue_M. Finocchito
Blue_SR Prefecture house
Blue_ M.S.Mauro
Green_M.Hyblaea
Green_Fusco necropolis
Green_Aidone
Green_SR Agora
Green_C.da Diana Lipari
Green_Acropolis Lipari
Green_SC7 Caracciolo
Brown_SC7 Caracciolo
Brown_SR Athenaion
b
MnO
MgO
0,00
0,02
0,04
0,06
0,08
0,10
0
1
2
3
4
5
6
7
8
9
10
c
K2O
Fe2O3
0,00
0,50
1,00
1,50
2,00
2,50
0
1
2
3
4
5
d
Al2O3
TiO2
0
2
4
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8
10
12
14
16
18
20
0,00
0,15
0,30
0,45
0,60
0,75

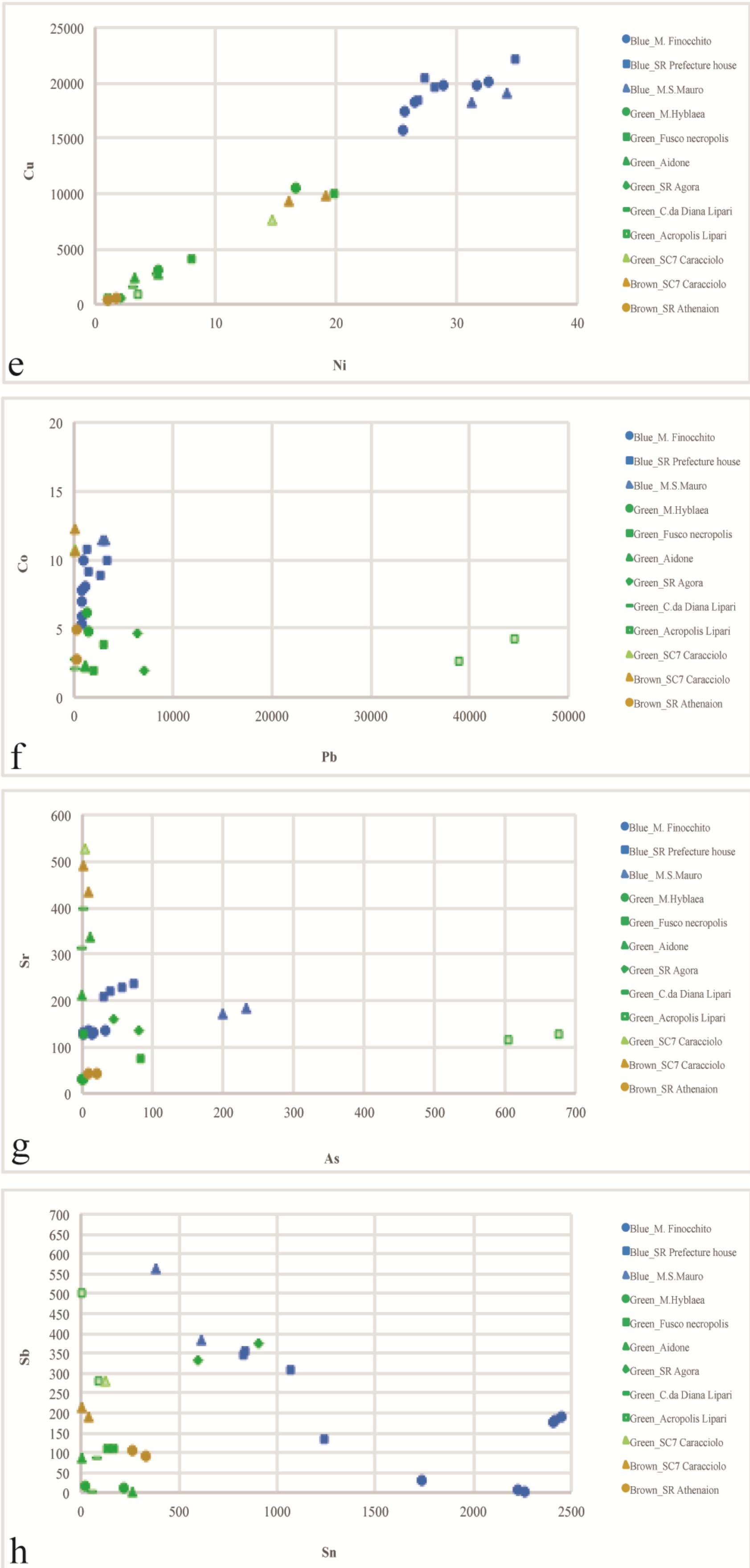


Figure 5. Binary diagrams of the most significant major, minor and trace elements determined through the pXRF analysis of the colored glazes occurring on the investigated scarabs.

4.2. *Unguentaria, ushabti and figurine*

Tabs. 4 and 5 and diagrams in Fig. 6 show a certain chemical variability among these objects for most of the investigated elements. All of them exhibit high silica contents (75-95%), and low iron (<1.5%), calcium (generally lower than 5%, except in samples SC25-white from the Athenaion with CaO=12% and SC31 from M.S. Mauro with CaO=15.5%), potassium (generally <0.8%, except in the ushabti SC34 from Lipari with an average K_2O of 1.2%) and magnesium (lower than 2%, except in the same sample SC34 whose average MgO is 4.8%). Manganese levels are higher in the brown glazes (0.9 - 2%; see Fig. 3c,d) than in the green ones (up to 0.1%) of the same object. However, this is not true for the ushabti from Lipari, where MnO occurs with the same concentrations in both the blue and the brown portions (0.06%) (Fig. 6).

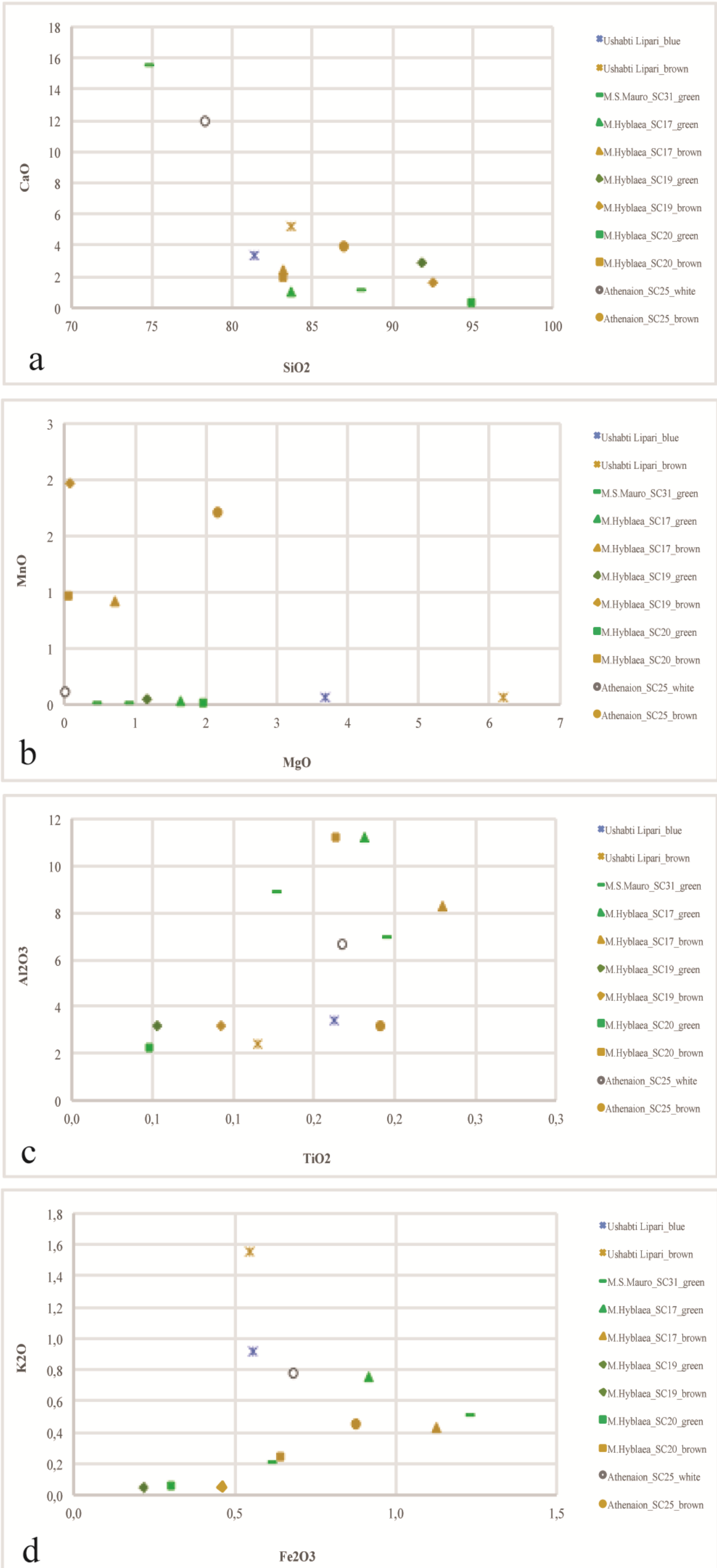
A careful analysis of the minor/trace elements reveals some other important compositional differences between the examined artifacts. Specifically, the figurine SC17 from M. Hyblaea has higher Sn (465 ppm in the brown portion and 1324 ppm in the green one) than the others (Sn <150 ppm) (Fig. 6). The unguentarium SC20 has much higher antimony (696 ppm in the green glaze and 871 ppm in the brown one), and lead (>21000 ppm), while the brown portion of the unguentarium SC19 shows much higher arsenic (250 ppm) compared to the other objects (Fig. 6).

Table 4. Concentrations (wt.%) of major elements in the investigated unguentaria, figurine and ushabti obtained by portable XRF analysis.

SAMPLE	ANALYSES	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	K_2O	P_2O_5
					MEGARA HYBLAEA					
SC17 Figurine	SC17a_green	83.70	0.18	11.25	0.92	0.03	1.64	0.98	0.76	0.55
	SC17b_dark brown	83.21	0.23	8.30	1.12	0.92	0.72	2.41	0.43	2.66
SC19 Unguentarium	SC19a_green	91.88	0.05	3.52	0.22	0.05	1.18	2.94	0.05	0.13
	SC19b_dark brown	92.49	0.09	3.17	0.46	1.96	0.09	1.61	0.05	0.07
SC20 Unguentarium	SC20a_green	94.92	0.05	2.23	0.30	0.01	1.96	0.38	0.07	0.07
	SC20b_dark brown	83.16	0.16	11.26	0.64	0.97	0.06	2.02	0.25	1.48
					SYRACUSE - ATHENAION					
SC25 Unguentarium	SC25a_white	78.32	0.17	6.70	0.68	0.11	0.01	11.91	0.78	1.32
	SC25b_dark brown	86.98	0.19	3.16	0.88	1.71	2.17	3.96	0.45	0.51
	SC25c_body	94.62	0.04	3.06	0.25	0.02	0.01	1.66	0.17	0.16
					MONTE SAN MAURO					
SC31 Unguentarium	SC31a_green	74.87	0.19	7.01	1.23	0.02	0.47	15.54	0.51	0.15
	SC31b_green	88.06	0.13	8.90	0.62	0.01	0.92	1.11	0.21	0.06
					LIPARI					
SC34 Ushabti	SC34a_blue	81.43	0.16	3.40	0.56	0.06	3.69	3.37	0.92	0.17
	SC34b_dark brown	83.70	0.12	2.39	0.55	0.06	6.19	5.18	1.56	0.07

Table 5. Concentrations (ppm) of minor and trace elements in the investigated unguentaria, figurine and ushabti obtained by portable XRF analysis.

SAMPLE	ANALYSES	Sc	V	Cr	Co	Ni	Cu	Zn	Ga	As	Rb	Sr	Y	Zr	Nb	Sn	Sb	Ba	La	Ce	W	Hg	Pb	Th
MEGARA HYBLAEA																								
SC17	SC17a_green	4	0	5	14	5	2556	17	13	140	24	90	6	76	7	1324	17	33	21	0	1	6	1055	4
Figurine	SC17b_dark brown	22	7	5	17	10	4363	60	1	80	7	52	2	55	5	465	106	34	11	2	4	2	1150	8
SC19	SC19a_green	1	0	1	3	3	1463	19	2	60	7	58	8	61	7	24	46	10	4	7	1	12	1245	13
Unguentarium	SC19b_dark brown	0	13	4	5	10	3811	19	1	251	9	37	0	42	4	31	3	1	0	21	3	23	2318	116
SC20	SC20a_green	0	0	6	3	4	1028	6	23	7	3	53	1	38	6	5	696	19	1	11	1	57	21030	38
Unguentarium	SC20b_dark brown	24	7	4	1	2	1274	17	13	14	4	40	44	36	8	82	871	18	1	18	2	60	21540	31
SYRACUSE ATHENAION																								
SC25	SC25a_white	75	1	3	3	2	197	23	1	9	14	78	7	41	7	44	76	64	6	2	1	5	87	12
Unguentarium	SC25b_dark brown	12	8	3	2	28	74	18	0	42	13	64	8	34	4	145	23	32	12	3	1	5	99	13
	SC25c_body	10	1	4	2	2	127	8	2	19	14	82	11	37	4	30	14	28	11	2	0	3	100	10
MONTE SAN MAURO																								
SC31	SC31a_green	2	0	4	6	10	6746	62	5	26	24	125	13	68	6	81	96	47	6	6	15	12	219	10
Unguentarium	SC31b_green	0	0	4	2	2	982	5	3	8	10	51	6	35	6	12	3	11	12	7	1	7	76	11
LIPARI																								
SC34	SC34a_blue	1	0	6	3	13	3173	37	3	14	11	34	9	23	8	6	1	16	9	6	7	12	83	11
Ushabti	SC34b_dark brown	0	1	4	3	12	2356	18	0	23	10	42	8	18	2	87	2	0	9	6	2	13	85	7


a
CaO
SiO2
18
16
14
12
10
8
6
4
2
0
70
75
80
85
90
95
100
Ushabti Lipari_blue
Ushabti Lipari_brown
M.S.Mauro_SC31_green
M.Hyblaea_SC17_green
M.Hyblaea_SC17_brown
M.Hyblaea_SC19_green
M.Hyblaea_SC19_brown
M.Hyblaea_SC20_green
M.Hyblaea_SC20_brown
Athenaion_SC25_white
Athenaion_SC25_brown
b
MnO
MgO
3
2
2
1
1
0
0
1
2
3
4
5
6
7
Ushabti Lipari_blue
Ushabti Lipari_brown
M.S.Mauro_SC31_green
M.Hyblaea_SC17_green
M.Hyblaea_SC17_brown
M.Hyblaea_SC19_green
M.Hyblaea_SC19_brown
M.Hyblaea_SC20_green
M.Hyblaea_SC20_brown
Athenaion_SC25_white
Athenaion_SC25_brown
c
Al2O3
TiO2
12
10
8
6
4
2
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0,3
Ushabti Lipari_blue
Ushabti Lipari_brown
M.S.Mauro_SC31_green
M.Hyblaea_SC17_green
M.Hyblaea_SC17_brown
M.Hyblaea_SC19_green
M.Hyblaea_SC19_brown
M.Hyblaea_SC20_green
M.Hyblaea_SC20_brown
Athenaion_SC25_white
Athenaion_SC25_brown
d
K2O
Fe2O3
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
0,2
0,0
0,0
0,5
1,0
1,5
Ushabti Lipari_blue
Ushabti Lipari_brown
M.S.Mauro_SC31_green
M.Hyblaea_SC17_green
M.Hyblaea_SC17_brown
M.Hyblaea_SC19_green
M.Hyblaea_SC19_brown
M.Hyblaea_SC20_green
M.Hyblaea_SC20_brown
Athenaion_SC25_white
Athenaion_SC25_brown

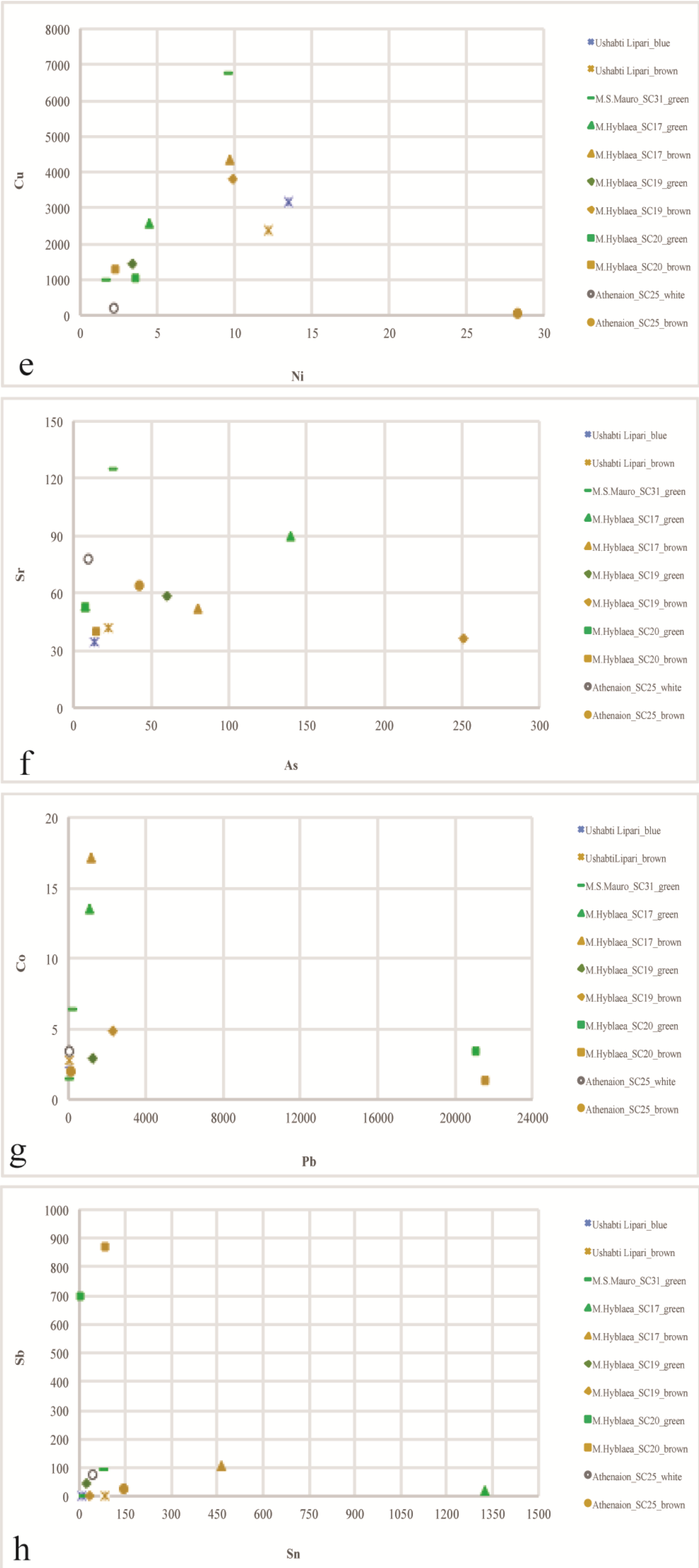

Figure 6. Binary diagrams of the most significant major, minor and trace elements determined through the pXRF analysis of the investigated unguentaria, ushabti and figurine.

5. DISCUSSION

In relation to the types and sites of discovery of the investigated finds, the detailed observation of the results obtained allowed us to draw the following considerations.

The scarabs of the Marcellino Valley have a chemical composition comparable to that of SC12, SC15, and SC16 samples from the Fusco necropolis and SC8 scarab from the Castelluccio collection, this latter being considered a fake by the archaeologists. This set of finds, characterized by high magnesium and nickel and low to moderate silica contents (see Fig. 4), can be considered as characteristic of the steatite. The scarabs SC9 and SC11 of the Caracciolo donation could be also assigned to this group, since they display some common chemical features which are typical of this type of material (such as high MgO and Ni contents; Fig. 4 c,e). However, their potassium concentrations are averagely higher (K2O from 0.7 to 1.5%) compared to the previous artifacts (K2O <0.4%) (Fig. 4a) thus possibly indicating two different types of steatite and hence a different provenance area for these two scarabs.

As for the other bodies analyzed, they are chemically different from each other, each showing its own specific compositional features. The black scarab SC14 from the Fusco necropolis, which the archaeologists hypothesized as made in dark grey jasper or hematite, is characterized by high SiO2 contents, along with low MgO and very low Ni and Cu (Fig. 4b,c,e). Such a chemical composition permits excluding hematite, while suggesting jasper as possible constituent material for this scarab. The amulet SC18 from Megara Hyblaea, in light brown paste, similarly to sample SC14, exhibits high SiO2 contents along with very low MgO, Ni and Cr (Fig. 4b,c,e,g); in addition, it has much higher Pb (1217 ppm) compared to all the other examined bodies (Tab. 3). However, it's worth noting that such high lead content registered for this sample could be due to traces (not visible to the naked eyes) of the overlying greenish glaze in the analyzed portion of the body, that could have affected the analysis. Lastly, the scarab SC10 of the Caracciolo donation, with its very high calcium (>60%) and strontium (>600 ppm) (Fig. 4b,f), suggests a calcareous stone as constituent material.

The blue-glazed *Aegyptiaca* analyzed include six scarabs (SC21-SC22-SC23 from Monte Finocchito; SC26-SC27 from prefecture house in Ortygia; SC29 from M. S. Mauro) and one ushabti from Lipari (SC34). The obtained data reveal that, despite some minor compositional differences between artifacts coming from different sites, all the scarabs of this group are characterized by a distinctive chemical feature, namely a very high copper concentration exceeding 15000 ppm (Fig. 5e). Conversely, the ushabti from Lipari exhibits a composition noticeably different from all the other objects in blue paste, since it has higher MnO and K2O and lower Cu, Ni, Sn, Sb and Sr contents (Fig. 5), so pointing to different recipes and/or provenance. Cobalt is absent to very low in all the examined blue items.

The green-glazed scarabs here investigated include one sample from Megara Hyblaea (SC18), one from the Fusco necropolis (SC13), one from Aidone (SC30), one from the Syracuse Agora (SC28), one from the Caracciolo collection (SC7), and two from Lipari (SC32 and SC33). The observation of binary diagrams in Fig. 5 points to some specific compositional features that allow to distinguish this group of artifacts from the blue-colored ones. Indeed, the green-glazed objects are generally characterized by lower Cu (<10500 ppm), Ni (<20 ppm) and Sn (<300 ppm, except for sample SC28) compared to the blue-glazed ones (Cu >15000 ppm; Ni >25 ppm; Sn >380 ppm) (Fig. 5e,h). Nevertheless, the comparison between the green-colored amulets investigated reveals a rather wide chemical variability for most of analyzed elements, hence pointing to the possible use of different recipes and/or provenance areas. This is also valid for the other green-glazed artifacts under study (unguentaria, ushabti and figurine), all made in faïence, whose data obtained, despite some common features (such as high silica and low iron, calcium, potassium and magnesium), reveal a large compositional variability, especially in terms of minor/trace elements (Fig. 6). Additionally, it's worth to note that the dark brown portions of the glaze of these faïence objects display high manganese levels (from 0.9 to 2%; Fig. 6b). This is not valid for the ushabti from Lipari whose manganese concentrations are identical in both the blue and the brown portions (MnO=0.06%; Fig. 6b). As concerns the "God of the Nile" unguentarium from the Athenaion (SC25), the white portion analyzed differs from the brown one particularly for some specific elements, such as calcium or phosphorous which are quite higher in the white glaze (see Fig. 6a and Tab. 4). For this reason, such white glaze could probably represent an altered portion of the original brown one. Indeed, as known, faïence, like most vitreous materials, deteriorates over time causing alterations in the color of the glaze (Meek et al., 2016; Helmi and Abdel-Rehim, 2016**).**

Lastly, as concerns the two scarabs with light brown glaze (SC7 from the Caracciolo collection and SC24 from the Syracuse Athenaion), their comparison reveals distinct compositional features so indicating the use of different recipes for these two amulets (see Fig. 5).

5.1. Multivariate statistical analysis

The picture arising from a first analysis of the chemical data is rather complex since a wide compositional variability is observed even within the same typology of findings. Therefore, in the attempt to gain additional information, a multivariate statistical analysis of the data, i.e. the principal component analysis, was also performed.

A first biplot (Fig. 7) was made taking into consideration both bodies and colored glazes. The elements used as variables were: SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, K_2O, P_2O_5, Cr, Co, Ni, Cu, Zn, As, Rb, Sr, Zr, Sn, Sb, and Pb. The biplot was obtained by considering the first two principal components, which, however, describe only about 50% of the total variance. For what concerns the bodies, the diagram seems to substantiate the considerations previously discussed (cfr. section 4.1.1). Indeed, the steatite-made scarabs (those of the Marcellino valley and the samples SC12, SC15, and SC16 from the Fusco necropolis), characterized by high levels of magnesium and nickel, are all grouped in the left part of the diagram, along with the scarab SC8 of the Castelluccio collection, which was considered to be a fake by the archaeologists. The scarabs SC9 and SC11 of the Caracciolo collection, fall into a separate area in the lower left part of the biplot but close to the aforementioned group, so possibly representing a subgroup of the steatite main one. The other scarab bodies analyzed are scattered in the right area of the diagram.

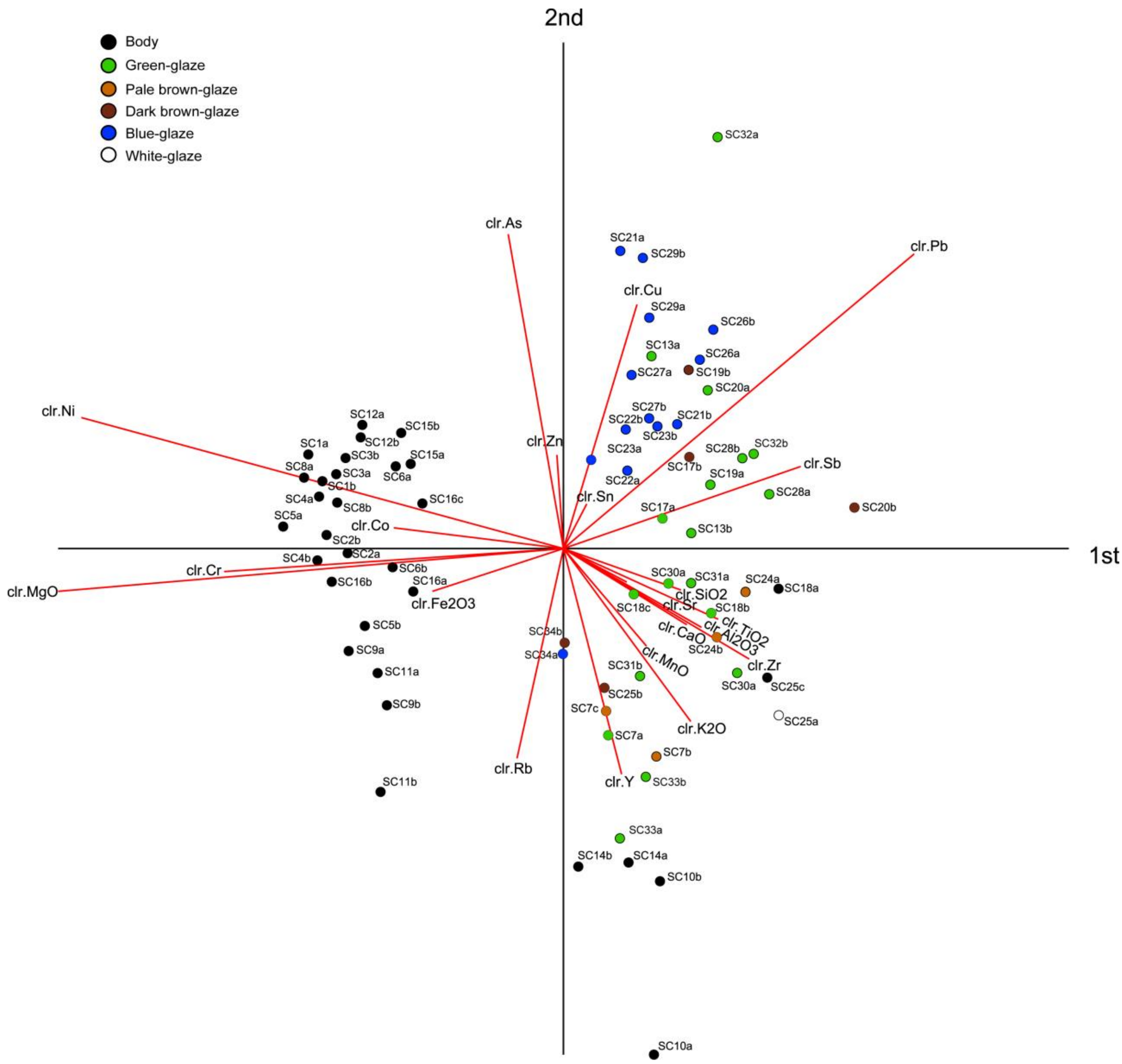

Figure 7. Biplot generated by the principal component analysis of both bodies and overlying colored glazes in the investigated Aegyptiaca.

As regards the glazes, the blue-colored artifacts fall into a restricted area of the upper part of the diagram, indicating that they share a common chemical composition, as already stated in sections 4.1.2.1 and 5. Only the ushabti from Lipari is located into a distinct area, in the lower part of the biplot so pointing to a different recipe. Conversely, as for the green-glazed and the brown-glazed objects, a major dispersion is observed which is indicative of a higher compositional variability among objects with the same glaze color and therefore the use of different materials and/or workshops.

A second PCA (Fig. 8) was made by considering only the scarab bodies and by using the first two principal components which, in this case, describe only about 70% of the total variance. The elements used as variables were the following: SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, K_2O, Cr, Ni, Rb, Sr, Y, and Zr.

On the whole, the obtained diagram shows for the examined bodies the same behavior observed in the previous biplot.

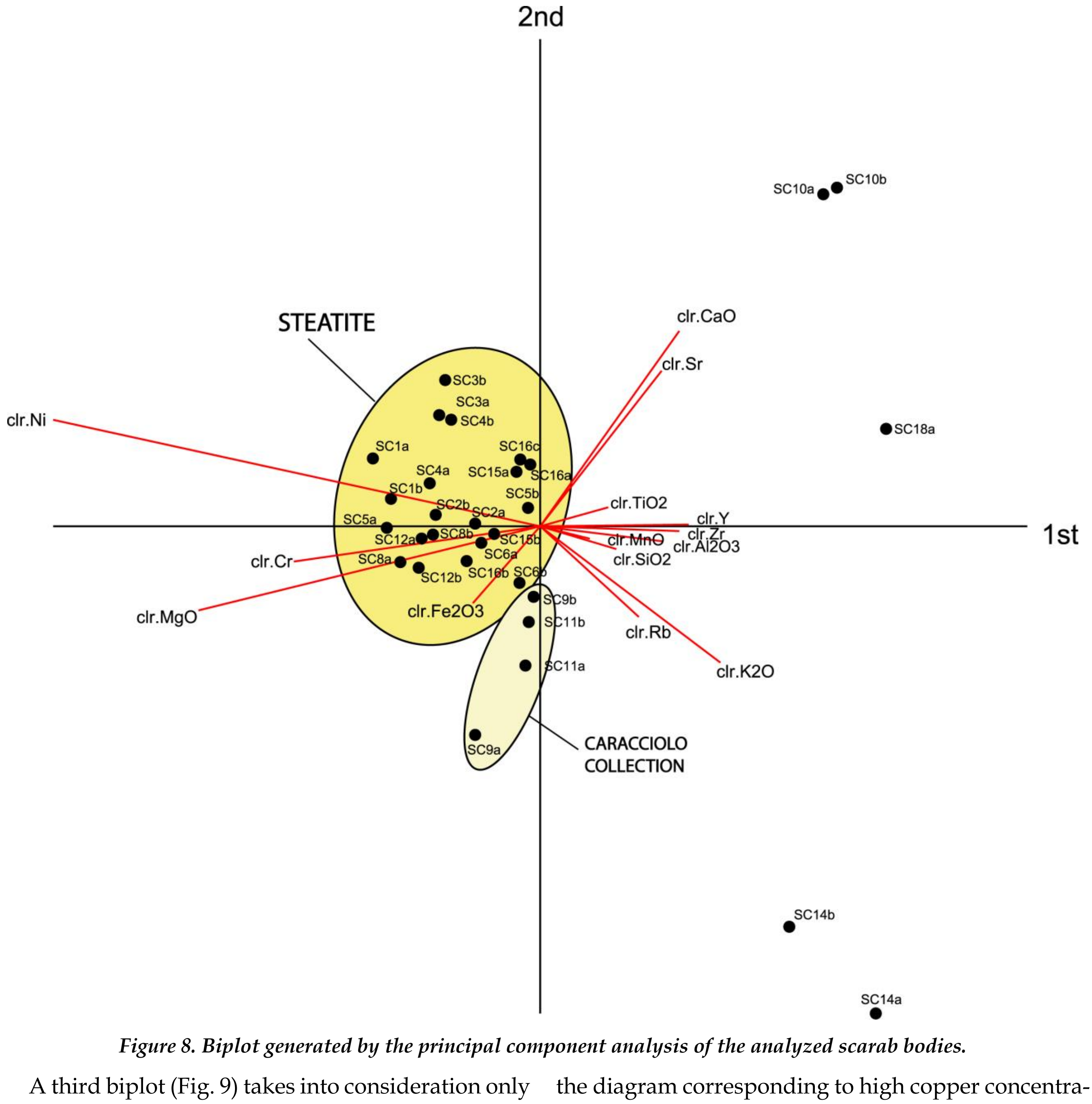

Figure 8. Biplot generated by the principal component analysis of the analyzed scarab bodies.

A third biplot (Fig. 9) takes into consideration only the colored glazes in order to better investigate their compositional differences. In this case, the variables used are: SiO2, Fe2O3, MnO, K2O, Cr, Co, Ni, Cu, Zn, As, Sn, Sb, and Pb. Again, the blue-glazed objects are clustered into a well definite area in the upper part of the diagram corresponding to high copper concentrations, with the only exception of the ushabti of Lipari (SC34) which is located in the opposite side of the biplot. Conversely, the green-glazed scarabs confirm a more complex behavior, falling into two distinct macro-areas: one on the left, corresponding to high lead and antimony concentrations, which includes the samples SC28 from the Syracuse Agora and SC32 from the Acropolis of Lipari (this latter also displaying high arsenic levels); and the other one on the right, corresponding to low lead and antimony levels, which instead includes the scarabs SC18 from Megara Hyblaea, SC30 from Aidone, SC33 from C.da Diana Lipari, and SC7 from the Caracciolo collection. The only one green-glazed scarab falling outside these two main macro-areas is SC13 from the Fusco necropolis, which is located in the upper part of the diagram, close to the area defined by the blue-colored artifacts, so pointing to chemical features intermediate between those of the green objects and those of the blue ones. Nevertheless, it should be noted that this sample displays elevated levels of calcium and phosphorus, which suggests that the object has probably undergone processes of post-depositional alteration and/or contamination by carbonates and phosphates (Meek et al., 2016). This will also cause modifications in the concentrations of all other components which will appear below their actual amounts. In this specific case, a change in color over time from blue to green cannot be excluded for this artifact, since similar modifications have been already demonstrated by other authors, such as Helmi and Abdel-Rehim (2016) in an experimental study on both ancient Egyptian faïence and properly manufactured replicas.

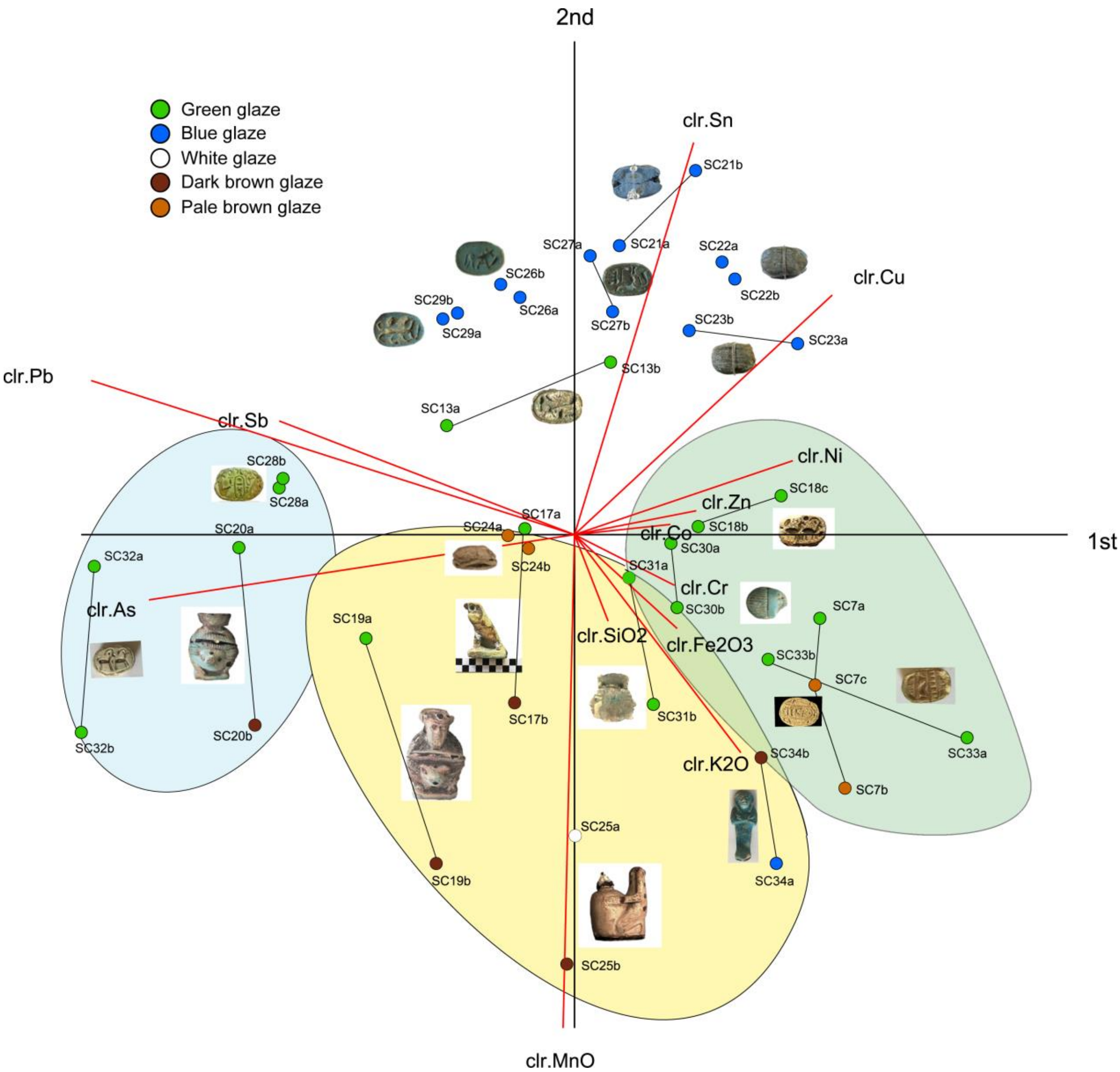

Figure 9. Biplot generated by the principal component analysis of the colored glazes in the examined Aegyptiaca.

As regards the two light-brown glazed scarabs, SC24 from the Athenaion and SC7 from the Caracciolo collection, the principal component analysis confirms their completely different compositional features, as already observed in section 5; indeed, the former falls in the left area while the latter in the right area of the diagram.

Lastly, concerning the other types of faïence -made *Aegyptiaca* here analyzed, namely unguentaria, figurine and ushabti, it's worth noting that the unguentarium SC20 from Megara Hyblaea falls into an area close to the high Pb-Sb green scarabs (SC20 and SC32). That is because it also displays high lead and antimony concentrations. As for the other items, though all of them fall into a macro-area distinct from those of the blue and green scarabs, their chemical features are quite different from each other, possibly indicating, even in this case, different recipes and/or workshops.

5.2. *Considerations on the colorants of the glazes*

Comparisons with literature data (Foster and Kaczmarczyk, 1982; Kaczmarczyk and Hedges, 1983; Meek et al., 2016; Shortland and Tite, 2005; Tite et al., 2007) on faïence artifacts dating back to different chronological periods, allow to make some considerations about the colorants used in the investigated glazes.

Green glazes. In most of the analyzed items, the green color was only caused by the presence of copper and/or iron oxides. No lead and antimony, or too low concentrations of these, have been found so indicating that no lead antimoniate opacifier has been added in their recipes. The presence of copper and lack of lead antimonate in such glazes was likely to have given them a turquoise appearance when produced. Only in a few items here examined the levels of lead and antimony were appreciably higher, suggesting that in these cases the green faïence glazes were colored by a combination of copper, iron oxides and lead antimonate that results in an opaque glaze. The hue obtained was a function of the relative quantities of each component. The artifacts belonging to this second group include the scarab SC32 from the Acropolis of Lipari (Pb_{avg}=41800 ppm and Sb_{avg}=390 ppm), the scarab SC28 from the Syracuse Agora (Pb_{avg}=6650 ppm and Sb_{avg}=350 ppm) and the unguentarium SC20 from Megara Hyblaea (Pb_{avg}=21000 ppm and Sb_{avg}=696 ppm); for this reason, these three items are clearly separated from all the other green-colored objects in the biplot of Fig. 9, where they fall into a restricted area in the left part of the diagram. These two identified types of green-colored glazes are consistent with those previously found by other authors in a significant number of faïence artifacts from Egypt, Rhodes, Mesopotamia, and Crete (Foster and Kaczmarczyk, 1982; Kaczmarczyk and Hedges, 1983; Meek et al., 2016; Shortland and Tite, 2005; Tite et al., 2007).

Blue glazes. Even in the case of the blue faïence, several authors pointed to two different types, namely cobalt-blue glazes and copper-blue glazes (Foster and Kaczmarczyk, 1982; Kaczmarczyk and Hedges, 1983; Meek et al., 2016; Shortland and Tite, 2005; Tite et al., 2007). Cobalt is known to produce a dark-blue color compared to copper that produces a lighter turquoise-blue one. In the case of artifacts here examined (SC21-SC22-SC23 from M. Finocchito; SC26-SC27 from the Prefecture house in Syracuse; and SC29 from M.S. Mauro), the use of copper-blue glazes was inferred, being cobalt too low, while copper dominates with an average concentration of 1.9 wt.%, associated with small amounts of tin (average 0.15 wt.%) and lead (average 0.17 wt.%). In the diagram of Fig. 10a, a good correlation is observed between the copper and tin contents of the examined blue glazes. In particular, two distinct trends can be observed, one being relative to the scarabs from M. Finocchito, which display higher Sn levels, and the other for the artifacts from Prefecture house in Syracuse and M.S. Mauro, whose tin concentrations are lower. Conversely, the lead contents found in these glazes, not properly correlated with copper, follow an opposite trend (Fig. 10b), being averagely lower in the amulets from M. Finocchito than in the others. Such data could indicate the use of different copper sources for the two distinct groups. In both cases, the presence of small levels of tin and lead associated with copper is consistent with the use of a leaded bronze containing a certain percentage of tin as the source of the copper colorant. In this respect, the extensive use of leaded bronze in faïence glazes was already observed by other authors for faïence items spanning the period from Predynastic through to the 1st century AD (Kaczmarczyk and Hedges, 1983) or from Ptolemaic to early Roman (Shortland and Tite, 2005). Alternatively, a relatively pure copper ore, such as malachite, with tin and lead occurring as impurities, could have been used, as already hypothesized by Foster and Kaczmarczyk (1982) and Tite et al. (2007).

As concerns the ushabti form Lipari (SC34), whose chemical composition, as above discussed, is completely different from that of all the other blue artifacts, the blue color is due to low levels of copper (0.3 wt.%), associated with magnesium (3.7 wt.%) and very low contents of manganese (0.06 wt.%) and iron (0.6 wt.%).

Dark brown glazes. Meek et al. (2016) found some small differences between the faïence objects from Rhodes and those from Naukratis. Indeed, the former contained some cobalt and nickel (though in low levels) associated with manganese and iron; conversely, the latter were colored with a mixture of only manganese and iron. Even other authors found similar different recipes for the dark colored glazes, often described as black or brown (Kaczmarczyk and Hedges, 1983; Shortland and Tite, 2005; Tite et al., 2007). In this study, the dark brown glazes occurring in four of the investigated items (two unguentaria SC19 and SC20 and one figurine SC17 from Megara Hyblaea and one unguentarium SC25 from the Syracuse Athenaion) do not contain any cobalt or nickel, while have significant levels of manganese (MnO from 0.9 to 2 wt.%). This result could allow to exclude a Rhodian provenance for the samples SC17, SC19, SC20 and SC25, this latter, in particular, hypothesized by archaeologists of probable Rhodian production. However, it's worth noting that the results obtained by those authors are only preliminary as the number of items they analyzed was not statistically significant to discriminate between the two workshops in Naukratis and Rhodes, and further analysis will be necessary to confirm such a potential provenance tool. As a last consideration, it must be underlined that since very little or no barium was detected in association with manganese and iron in the analyzed brown glazes, pyrolusite-rich deposits were probably used as source for manganese rather than psilomelane, as already observed by other authors (e.g. Kaczmarczyk and Hedges, 1983; Meek et al., 2016).

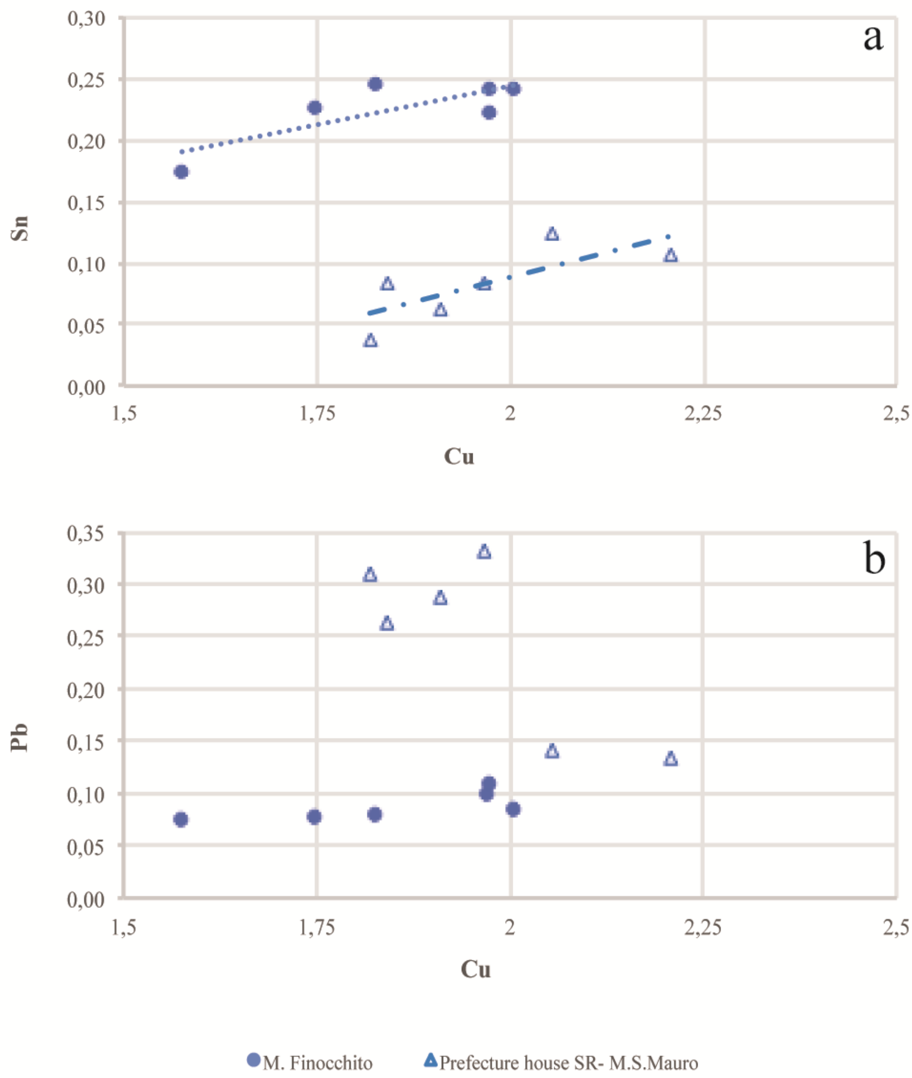

Figure 10. Binary diagrams illustrating the relationships between copper and tin (a) and copper and lead (b) levels in the blue glazes of the Aegyptiaca analyzed from Monte Finocchito, Prefecture house in Syracuse, and M. San Mauro.

6. CONCLUSIONS

In this work, *Aegyptiaca* coming from some Sicilian sites, spanning the period from the 10th to the 6th century BC, were characterized by means of non-destructive *in situ* investigations, using a XRF portable system. The results demonstrate the potentiality of this technique in revealing the elemental composition of artifacts belonging to museum collections which cannot be removed or sampled.

Rather variable chemical composition was found in terms of both bodies and glazes. Specifically, as regards the scarab bodies, the data pointed to a main steatite-made group of artifacts (including ten items) and a sub-group of this main one (including only two samples), with higher potassium contents, which indicates a different steatite source. Additionally, the results obtained allowed to identify the constituent materials of some of the examined items. For instance, in the case of the scarab SC14 from the Fusco necropolis, the chemical analysis revealed that it is made of dark grey jasper; the samples SC12 from the Fusco necropolis, SC9 and SC11 from the Caracciolo collection, generically defined by the archaeologists as made of "whitish stone", are constituted by steatite, as well as the scarab SC8 of the Castelluccio collection which in the inventory of the early 1900s was defined as "hard whitish matter without glaze". As for the sample SC10 of the Caracciolo donation, the pXRf analysis confirmed its calcareous nature.

Even regarding the colored glazes, varient compositions have been found, thus pointing to the use of different recipes and/or workshops for the investigated artifacts. Furthermore, information on the colorants used for the blue, green and brown glazes have been also gained. In this respect, as concerns the blue-colored items, almost all the investigated samples pointed to copper-blue glazes associated with small amounts of tin and lead. This result is indicative of the use of leaded bronze containing a certain percentage of tin as the source of the copper colorant, or, alternatively, a copper ore (such as malachite) with impurities of tin and lead. As for the green color, the exclusive presence of copper and/or iron oxides has been observed in most of the analyzed artifacts, with the exception of three samples whose levels of lead and antimony were appreciably higher, suggesting the addition in the recipe of lead antimoniate as opacifier. Lastly, the dark brown glazes occurring in some of the examined items showed high levels of manganese and the absence of barium indicating that pyrolusite was probably used as source for this colorant element.

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