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Provenance Study of Votive Figurines from the Sanctuary of Apollon in Emecik

Emecik Apollon Tapınağı'nda Bulunan Adak Heykelciklerin Hammadde Kaynağı Araştırması

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Abstract: Eighty-five limestone figurines found in the archaic sanctuary of Apollon within the territory of Knidos, near the modern Emecik village of Datça were investigated by means of ICP-OES and ICP-MS techniques. The aim of this study was to determine the provenance of the raw materials of the figurines from Emecik. Geological reference samples collected from the Datça peninsula and Cyprus were investigated as the possible origin. Micropaleontologic analysis by thin sections was applied to identify planktonic foraminiferal species in the samples. Based upon REEs and trace element contents, Emecik figurines are characterized into Group 1 and Group 2. The raw material of the Group 1 figurines has been identified as local. The geochemical composition of Group 2 showed high similarity with examples collected at outcrops from the Pakhna formation in Cyprus, although they exhibit minor variations. Our data suggest that in parallel with the predominance of the Cypriote source, simultaneous or asynchronous use of the local limestone type was evident in Emecik. This result can imply different connections and of itinerant sculptor routes from the Datça Peninsula to the other regions.

Keywords: Provenance • Limestone Figurines • Knidos • Cypriote Type • Aegean Class

Öz: Emecik-Datça'da bulunan Arkaik Dönem'e tarihlendirilen Apollon kutsal alanında yapılan çalışmalarda ele geçen 85 adet kireçtaşı heykelcik ICP-OES ve ICP-MS teknikleri ile analiz edilmiştir. Hammadde kaynağını bulmaya yönelik olarak yapılan çalışmada olası kaynak olarak Kıbrıs'tan ve Datça yarımadasındaki oluşumlardan jeolojik örnekler toplanmıştır. Örneklerin ince-kesitleri üzerinde yapılan mikro paleontolojik inceleme hammadde kaynağı olan kireçtaşının planktonik formiferal içeriğe sahip olduğunu göstermiştir. Nadir toprak elementleri ve diğer eser element analizlerine göre, 85 heykelcik Grup 1 ve Grup 2 olarak ikiye ayrılmıştır. Grup 1 olarak sınıflandırılan heykelciklerin yerel üretim olduğu anlaşılmaktadır. Grup 2'de yer alan heykelciklerin jeokimyasal özellikleri ise Kıbrıs'ta Pakhna formasyonundan alınan jeolojik örneklerle uyumludur. Böylelikle çalışmada elde edilen veriler, Kıbrıs kökenli hammadde ile yapılan heykelciklerin yanı sıra az sayıda da olsa eş-zamanlı olarak ya da ilk ithal örneklerden sonra Emecik'te yerel üretim olduğunu kanıtlamaktadır. Bu bulgu Arkaik Dönem içinde önemli bir yere sahip kireçtaşı heykelcikler için ilk kez Kıbrıs dışında bir yerel üretim olduğunu göstermesi açısından önemlidir.

Anahtar Kelimeler: Hammadde Kaynağı • Kireçtaşı Heykelcikler • Knidos • Kıbrıs Tipi • Ege Tipi

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This work is adapted from an unpublished PhD thesis (Muşkara, 2013).

Introduction

The type of limestone figurines known as Cypriote was popular during the Orientalizing and Archaic periods in the Mediterranean region. Figurines found at sanctuaries in Cyprus, the Aegean, Egypt, and the Syro-Palestinian coast, range in style from purely Cypriote to a mixed style including Aegean, Ionian and Egyptian elements. Previous studies have classified the figurines found outside Cyprus as Aegean Class[1] or mixed Cypro – Aegean Class[2].

Some scholars consider the mixed style figurines as products of Aegean craftsmen who responded to a demand already created through the success of Cypriote exports[3]. Alternatively, others attribute them to Cypriote craftsmen who were adapting the native style to meet the tastes of Aegean culture[4]. A Naucratic origin was also proposed by Kyrieleis for the figurines from Samos with major stylistic elements inconsistent with Cypriote type[5]. However, analytical studies have shown that the raw material of the Samos figurines displays characteristics similar to Cypriote limestones[6].

More recently, following Gjerstad, Sørensen, and Jenkins, Andrioti (2010; 2016) suggested a Cypriote origin for the mixed style figurines. Regarding the transmission of foreign elements into Cypriote art in general, she described, "The artists responsible for them show a remarkable ability of quickly and decisively incorporate these motifs into their repertoire with expressive purpose-to produce wares that would have appealed to a specific market. They could, on-demand and after short exposure, remove themes from original settings and recreate them in a new one[7]". She concluded that this understanding helps us realize the purpose of foreign elements in the mixed style figurines. She also mentioned that the studies by Fockenberg (2006), Muşkara (2007), Sneff (2009), and Tuna *et al.* (2009) failed to trace a local source.

The analytical studies included petrographic, physical, and chemical analysis using X-ray fluorescence spectrometry (XRF) and electron paramagnetic resonance spectrometry (EPR) attempted to identify the source of the raw material of the mixed style figurines[8]. Although the first scientific approach was made in 1989, the number of such studies is still limited, and only a few publications comprise a statistically significant sample size.

Provenance studies by Kourou *et al.* (2002) and Polikreti *et al.* (2004) involved analyses using EPR spectroscopy for investigation of the source of Aegean Class figurines from Samos and Rhodes (2004). Besides the thirty-five figurines from the Vathy Museum (Samos) and the National Archaeological Museum (Copenhagen), they included two figurines of Cypriote type from the Cyprus Museum (Nicosia) for comparison. They decided to concentrate on Cyprus, Samos, Rhodes, and Naucratis as possible sources. Microscopic examination of the figurine samples indicated the figurine's

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1 Kourou *et al.* 2002.

2 Sørensen 1978; Jenkins 2000.

3 Pryce 1928; Richter 1970; Hermary 1991; Sneff 1994; Berges & Tuna 2000; Tuna *et al.* 2009.

4 Gjerstad 1948; Schmidt 1968; Sørensen 1978; Riis *et al.* 1989; Jenkins 2000; Polikreti *et al.* 2004; Kourou *et al.* 2002; Jenkins 2001.

5 Kyrieleis 1988.

6 Kourou *et al.* 2002.

7 Andrioti 2016, 119.

8 Riis *et al.* 1989; Jenkins 2001; Kourou *et al.* 2002; Polikreti *et al.* 2004; Fockenberg 2006; Senff 2009.

raw material is a porous, chalky limestone, with a considerable quantity of nanofossils[9]. Visual analysis indicated the limestone samples from Rhodes and Naucratis are not physically suitable for carving; meantime, spectroscopic results excluded Samos and Egypt as possible candidates[10]. The spectral structure of the figurines was matched with a Cypriote limestone called Lympia-Kossi chalk from the Pakhna formation in Cyprus. They assumed that "Since Samos and Rhodes are excluded from the list of possible centers of production in the Aegean, it is Cnidos that remains as a possible candidate[11]".

The study by Fockenberg included XRF analysis of ten figurines and a column fragment from Emecik, and seven figurines from Milet (2006). Geological specimens from Cyprus and Datça were also collected to provide reference data (2006). According to the results, the element concentrations of the figurines including an architectural fragment were similar; consequently, the source of the figurines should be from Cyprus. However, the element contents of the geological specimens collected from Datça were entirely incompatible. The author concluded that the figurines might have been made from the Cypriot limestone; however, further research was needed.

In the study mentioned by Andrioti (2016, 110), a new analytical approach was applied to determine the origin of the Emecik figurines[12]. In geochemical characterization, since trace element contents, especially those of REEs, are the markers, establishing proper digestion and analysis methods were the primary aim. Therefore, the number of archaeological artefacts and geological specimens from possible sources was significantly limited in the study. The study's preliminary results showed that the REE fingerprinting was an effective tool for characterization and appointing the source material since figurines had a typical REE pattern; however, this pattern was different from that of the reference samples[13].

Here, we investigate the previous hypothesis about the Cypriot origin of the raw material. We have employed Inductively Coupled Mass Spectroscopy (ICP-MS) and Inductively Coupled Optical Emission Spectroscopy (ICP-OES) analysis techniques on a series of votive figurines recovered from Emecik and on reference samples from Datça and Cyprus to achieve this goal. The ICP-MS method is particularly advantageous for analyzing rare earth elements (REEs) with higher analytical precision. We presented the micropaleontologic and geochemical data and multivariate statistical analyses conducted on eighty-five figurines and reference sources collected from five different locations.

The Archaeological Context of Votive Figurines from the Apollon Sanctuary

The Apollon sanctuary is situated in the lower foothills of Emecik Dağ in the Datça Peninsula overlooking the cove of Sarıliman; however, it is not clear how the coastline was in antiquity (Fig. 2). Archaeological excavations at the site from 1998 to 2006, directed by Numan Tuna, showed the sanctuary was dedicated to Apollon since the Geometric period and appeared to be a component in the ritual network reflected in regional and overseas affairs, particularly during the Archaic period[14].

Turkish-German scholars collaborated on research at the sanctuary during 1998-2001, and the limestone figurines and other archaeological materials were published by Berges (2006). Later, Tuna

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9 Kourou *et al.* 2002, 37.

10 Polikreti *et al.* 2004, 1027.

11 Kourou *et al.* 2002, 75.

12 Muşkara 2007.

13 Muşkara 2007.

14 Berges & Tuna 2000; Tuna & Berges 2001; 2002; Tuna *et al.* 2004; 2008; 2009; Berges 2006.

et al. (2009, 229-243) reviewed the archaeological data from the 2002-2006 excavations and summarized the preliminary results of provenance studies.

Although they were used as filling material in the debris of the south terrace wall, they can be dated to before the wall was constructed, to not later than 560 BC. Some of the figurines have inscriptions, and some of them carry traces of paint[15]. The corpus of limestone votive figurines include falcons, Kouroi, priests, musicians, bull and ram figurines found with a more significant number of terracotta figurines, mostly in the form of bull figurines. Tuna *et al.* (2009, 229-243) mentioned stylistic and iconographical differences between the Emecik and Cypriote figurines, and he proposed a local production center.

Materials and Methods

Archaeological Samples

Eighty-five figurines recovered from the Apollon sanctuary were sampled (Fig. 1, see also plate). Various types of figurines were selected to ensure that the sampling was representative. For comparison, samples from an architectural fragment were also collected by a drill with a vanadium tip. Small flakes were obtained from eleven artefacts for micropaleontologic analysis.

Sample Name	Inv. No	Description
EF-01	ST.06.I12.d8.19	Male votary (priest?) body fragment
EF-02	ST.06.I12.d5.c12	Fragment
EF-03	ST.06.I12.d8.21	Miniature woman
EF-04	ST.06.H12.a3.16	Bird of prey (falcon)
EF-05	ST.06.I12.d6.B	Leg fragment
EF-06	ST.06.H12.d5.15	Fragment
EF-07	ST.06.I12.d7.43	Leg fragment
EF-08	ST.06.I12.d5.A11	Leg fragment
EF-09	ST.06.H12.a2A.23	Body fragment
EF-10	ST.06.I12.d6A.14	Leg fragment
EF-11	ST.06.H12.a5.22	Body fragment
EF-12	ST.06.I12d.6A.11	Male votary (priest?) body fragment
EF-14	ST.06.H12.a3.17	Leg fragment
EF-15	ST.06.I12.d7.45	Bird of prey (falcon)
EF-16	ST.06.I12.d5.B11	Lion fragment
EF-17	ST.06.I12.d3.9	Kouros body and legs fragment
EF-18	ST.06.I12.d5A.12	Lion paw fragment
EF-19	ST.06.I12.d5.17	Lion
EF-20	ST.06.I12.d7.44	Drapery fragment
EF-22	ST.02.I8b.18.3	Lion figurine
EF-23	ST.02.I8b.16A.11	Fragment
EF-24	ST.02.I8b.16A.11	Fragment
EF-26	ST.02.I8b.16A.11	Fragment
EF-27	ST.02.I8b.16A.11	Fragment
EF-28	ST.02.I8b.11.c26	Standing male votary figurine fragment carrying goat
EF-30	ST.02.K9c.28B1	Ornamented stone (base?)

[15] The limestone of the figurines is very white, although light grey or brownish varieties have also been observed. A sharp chisel was used in making, and cut marks can be seen (Berges 2006).

EF-31	ST.02.I8b.25.11	Kouros, feet and base
EF-32	ST.02.I8b.28A.11	Kouros, head and body
EF-33	ST.02.I8b.16A.16	Kouros, body and legs fragment
EF-34	ST.02.I8B.19.b6	Body fragment
EF-35	ST.02.I8b.11.b9	Body fragment
EF-36	ST.02.I8b.28.A2	Body fragment
EF-37	ST.02.I8B.16.A.15	Lion fragment
EF-38	ST.02.I8B.11c.29	Fragment
EF-39	ST.02.I8b.16.20	Leg fragment
EF-40	ST.02.8B.19A.13	Male votary (priest?) body fragment
EF-41	ST.02.I8B.19.6	Leg fragment
EF-42	ST.02.K9c.28.7.4	Kouros feet and base fragment
EF-43	ST.02.I8b.28.A3	Leg fragment
EF-44	ST.02.I8b.21.17	Lion
EF-45	ST.02.I8b.25.12	Lion
EF-46	ST.02.I8b.22.2	Fragment
EF-47	ST.02.I8b.28.6.3	Leg fragment
EF-48	ST.02.I8b.28.8	Kouros feet and base fragment
EF-49	ST.02.I8b.19.2	Leg fragments
EF-50	ST.02.I8b.19.2	Leg fragment
EF-52	ST.02.I8b.18.7	Kouros body fragment
EF-53	ST.02.I8b.14.17	Lion fragment
EF-54	ST.02.K9c.28.6	Leg fragment
EF-55	ST.02.K9c.27.4	Leg fragment
EF-56	ST.02.K9c.27A.13	Body fragment
EF-57	ST.02.I8b.11b.10	Kouros feet and base fragment
EF-58	ST.02.I8b.14.20	Male votary (priest?) body fragment
EF-59	ST.02.K9c.26.4	Bird pounces
EF-60	ST.02.I8b.20.2	Body fragment
EF-61	ST.02.I8b.23.11	Lion fragment
EF-62	ST.02.I8b.28A.2	Small fragments
EF-63	ST.01.G11.D1	Leg ? fragment
EF-64	ST.02.I8b.28A.2	Small fragments
EF-65	ST.02.K9c.27b.1	Leg fragment
EF-66	ST.02.I8b.21.20	Lion fragment
EF-67	ST.02.K9c.27A.3	Standing male votary figurine fragment carrying goat
EF-68	ST.02.K9.c28.14	Body fragment
EF-69	ST.02.K9.c27.A12	Bird
EF-70	ST.02.I8b.28.A9	Standing male votary figurine fragment carrying goat
EF-71	ST.02.I8b.14.30	Bird pounces
EF-72	ST.02.I8b.15.17	Fragment
EF-73	ST.02.I8b.16A.17	Bird of prey (falcon) tail fragment
EF-74	ST.02.I8b	Body fragment
EF-75	ST.02.I8b.28.3	Lion fragment
EF-77	ST.02.K9c.27a.11	Lion fragment
EF-80	ST.02.I8b.23.9	Leg fragment
EF-81	ST.02.I8b.23.9	Fragment
EF-84	ST.02.I8b.19.A12	Fragment

EF-85	ST.02.18b.19.A.12	Architectural fragment
EF-86	ST.00.K8C.16.148	Body fragment
EF-87	ST.99.I9b.4.65	Leg fragment
EF-88	ST.99.I9b.2.17	Leg fragment
EF-89	ST.01.I8.B.10.26	Body fragment
EF-90	ST.00.K8.C.16.151	Fragment
EF-91	ST.99.I9B.4	Fragment
EF-92	ST.02.I8b.28.B3	Fragment
EF-93	ST.00.D8.A.5.25	Body fragment
EF-94	ST.99.K8C.9.22	Leg fragment
EF-95	ST.00.K8C.16.152	Body fragment

Fig 1. *Description of Archaeological Samples Analyzed in this Study* (Muşkara 2013)

Geological Samples from the Datça Peninsula

For the investigation of a local source, systematic surveys were carried out around the Datça peninsula. Based upon the literature and the surveys in the area, the Kızlan region appeared to be the possible geological source[16]. Samples were taken from the facies exposed near Akyazı and Rüzgarlı representing the continental and marine sediment of Yıldırımlı formation (Pliocene) (Fig. 2, 4). The construction of wind farms around the region during the surveys made it possible to detect limestone outcrops.

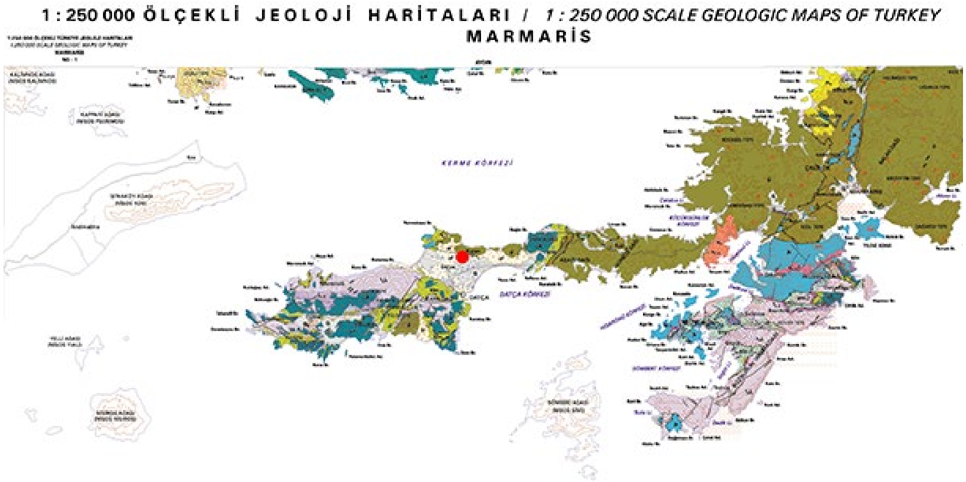

Fig. 2. *Geological Map of Datça Peninsula (after MTA 1997) with Sampling Locations* (Muşkara 2013).

Geological Samples from Cyprus

Following Kourou *et al.* (2002, 37-39) and Polikreti *et al.* (2004, 1017), reference samples were obtained from the quarries near Erdemli (Tremetousia) representing the Pakhna formation (Fig. 3-4). Samples from quarries at Değirmenlik (Kythrea) representing sedimentary rocks of the Değirmenlik (Kythrea) Group were also collected, as another possible source in Cyprus[17].

16 Muşkara 2013, 43-46.

17 Mccay *et al.* 2013, 354.

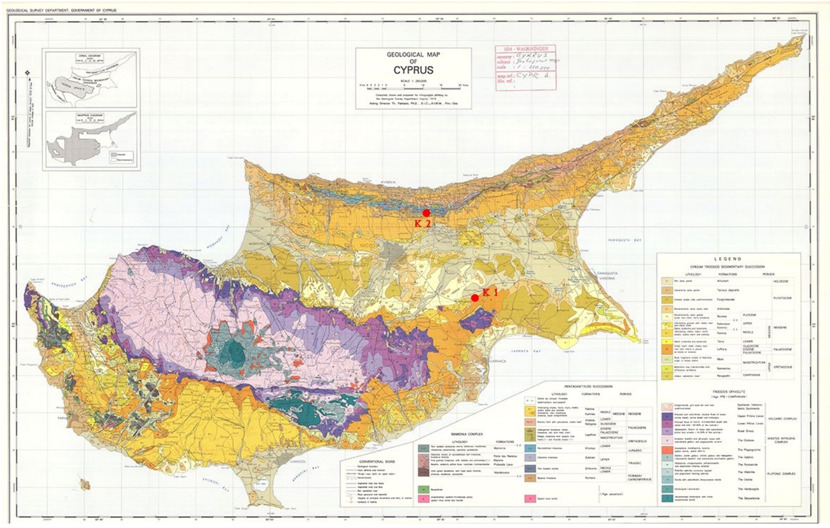

Fig. 3. *Geological Map of Cyprus (after Geological Survey of Cyprus 1979) with Sampling Locations K1 and K2* (Muşkara 2013)

Sample Name	Location	Latitude	Longitude
RZG1	Rüzgarlı, Datça	36°46.746'N	27°42.815'E
AKYA	Akyaka A, Datça	36°46.688'N	27°42.821'E
AKYB	Akyaka B, Datça	36°46.531'N	27°43.279'E
AKYC	Akyaka C, Datça	36°45.651'N	27°41.513'E
RZG2	Rüzgarlı, Datça	36°46.658'N	27°43.822'E
KRC	Kireçli, Datça	36°45.898'N	27°41.537'E
K1	Erdemli	35°04'15.8"N	33°37'01.7"E
K2	Değirmenlik	35°16'10.1"N	33°28'08.8"E

Fig. 4. *Coordinates of the Sampled Limestone Outcrops* (Muşkara 2013)

Analytical Methods

Geological samples and some of the archaeological samples were studied using an optical microscope in MTA (General Directorate of Mineral Research and Exploration) by Dr. Aynur Hakyemez to investigate the microfossil content and texture. In the preparation of samples' thin sections the Thin Section Laboratory at the Geological Engineering Department (Middle East Technical University) was used.

For ICP-OES and ICP-MS measurements, samples were powdered, of which 150 mg weight were dissolved by microwave digestion. Mg, Fe, Ba, Sr, and Mn were determined by a Leeman DRE ICP-OES instrument. Cr, Nb, Y, Hf and REEs, La, Eu, Ce, Gd, Nd, Ho, Sm, Er, Yb, and Lu were measured by Thermo X SERIES 2 ICP-MS instrument. Due to lower REEs concentrations and the Ca interference, standard addition method was applied for the Fe, Mg, and REEs. Meantime, Mn, Sr, and Ba were determined by external calibration[18]. Although ICP-MS can analyze all, we also employed ICP-OES for better calibration of analytes with different concentration ranges. NIST 1d Limestone and NCS DC 73306 Carbonate Rock as standard reference materials were applied to check the accuracy of the digestion and calibration methods.

18 For more details on the digestion procedure and instrument calibrations, see Muşkara 2013, 52-58.

Results and Discussion

Micropaleontologic analysis

Previous studies on the raw material properties of the figurines mentioned a particular type of limestone with foraminiferal inclusions were used in the production of figurines. Therefore we also applied micropaleontologic analysis when it was possible as well. According to the results, nine figurines are rich in planktonic foraminifera. On the other hand, EF-03, 30, and 85 were not produced using fossiliferous limestone. K1 and K2 representing Erdemli and Değirmenlik include almost the same foraminiferal contents[19] as the figurines studies (Fig. 5).

When considering the faunal composition, it is possible to say that K1 can represent the source material of nine figurines. On the other hand, although almost the same fauna is included in the K2 sample, a reliable correlation between examined artefacts and K2 is not possible due to insufficient micropaleontological data.

The Datça geological specimens containing only rare bivalve and ostracoda shells are not fossiliferous except for KRC.

Sample Name	Faunal compositions
EF-02	Globigerinid specimens
EF-03	Not fossiliferous
EF-04	*Globigerina praebulloides* s.l. Blow
	Globigerinoides sp., *Globigerina* sp.
EF-22	*Praeorbulina glomerosa curva* (Blow)
	Globigerinoides trilobus (Reuss)
	Dentoglobigerina altispira altispira (Cushman ve Jarvis)
	Globigerinoides cf. *subquadratus* Brönnimann
	Globoquadrina baroemoenensis (LeRoy)
	Praeorbulina cf. *glomerosa glomerosa* (Blow)
	Praeorbulina cf. *sicana* (de Stefani)
	Globigerina praebulloides s.l. Blow
EF-30	Not fossiliferous
EF-37	*Praeorbulina sicana* (de Stefani)
	Globoquadrina sp.
	Globoquadrina cf. *venezuelana* (Hedberg)
	Globigerinoides subquadratus Brönnimann
	Globoquadrina baroemoenensis (LeRoy)
	Globigerina praebulloides s.l. Blow
	Globigerina ciperoensis Bolli
EF-38	*Globigerinoides bisphericus* Todd
	Globoquadrina baroemoenensis (LeRoy)
	Globoquadrina dehiscens (Chapman, Parr ve Collins)
	Globigerina praebulloides s.l. Blow
	Globigerina ciperoensis Bolli
	Globigerina praebulloides occlusa Blow ve Banner
	Globigerina praebulloides praebulloides Blow
	Globigerinoides subquadratus Brönnimann
	Globigerinoides cf. *sacculifer* (Brady)
	Globigerinoides cf. *quadrilobatus* (d'Orbigny)
	Globigerinoides altiaperturus Bolli

[19] For thin-section photomicrographs of different foraminiferal species, see Muşkara 2013, 59-64.

EF-47	*Globigerinoides trilobus* (Reuss)
	Globigerinoides bisphericus Todd
	Globoquadrina dehiscens (Chapman, Parr ve Collins)
	Globigerina praebulloides s.l. Blow
	Globigerina ciperoensis Bolli
EF-56	*Globigerina praebulloides* s.l. Blow
	Globigerinoides sacculifer (Brady)
	Globigerinoides subquadratus Brönnimann
	Globigerinoides trilobus (Reuss)
	Globigerinoides bisphericus Todd
	Praeorbulina? sp.
EF-84	*Globigerina* sp., *Globigerinoides* sp
EF-93	*Globigerinoides trilobus* (Reuss)
	Globoquadrina baroemoenensis (LeRoy)
	Globigerinoides sp., *Globoquadrina* sp.

Fig. 5. *Samples examined by thin-section analysis and planktonic foraminiferal contents* (Muşkara 2013)

Provenance Discrimination of Figurines Using REE Geochemistry

Sc, La, Y and lanthanoids are known to be REEs with similar geochemical behavior. REEs are grouped into LREE (La-Eu) and HREE (Gd-Lu), based on their atomic weight. They are immobile elements; therefore, they can characterize a geological formation[20]. They are also more commonly used in provenance studies for various materials in archaeology. REE patterns are the diagrams where normalized REE compositional data have been plotted. Normalization of REE contents in sedimentary rocks to an average sedimentary standard are generally performed. Here, since the limestone is a sedimentary rock, REE patterns were constructed using the ratio of sample values to Post-Archaean average Australian sedimentary rock (PAAS)[21]. REE patterns of the representative figurines and geological samples are given in Figs. 6-7.

REE patterns of geological specimens and artefacts revealed some features that discriminate between the origins of these figurines:

REE pattern shapes: There is not a typical pattern. The shapes of the diagrams substantiate significant differences among the figurines. The patterns of geological sources from the Datça peninsula and Cyprus also likewise differ. In some situations, the analyte concentrations were reported to be too low to be detected, such as Eu, Yb, Ho that cause interruptions in the pattern.

Ce Anomaly: In seawater, conversion of soluble Ce(III) to highly insoluble Ce(IV) is known to be the reason for the depletion of Ce and negative Ce anomaly[22]. In this study, no Ce anomaly (Ce/Ce^* between 0.89 and 1.10), extreme to moderate Ce anomaly (Ce/Ce^* between= 0.30-0.70) and very extreme Ce anomaly ($Ce/Ce^* \leq 0.30$) were observed in the figurine samples analyzed. The geological samples obtained from Datça represented moderate to slight Ce anomalies (between $Ce/Ce^* = 0.56$ to 0.82) while the moderate Ce anomalies (between 0.50 and 0.66) were obtained from the samples taken from Cyprus (Fig. 8).

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20 Lipin & McKay 1989, 184-194; Krauskopf & Bird 1995, 546-550.

21 McLennan 1989.

22 Liu *et al.* 1988; Sholkovitz 1990 ; Bellanca *et al.* 1997.

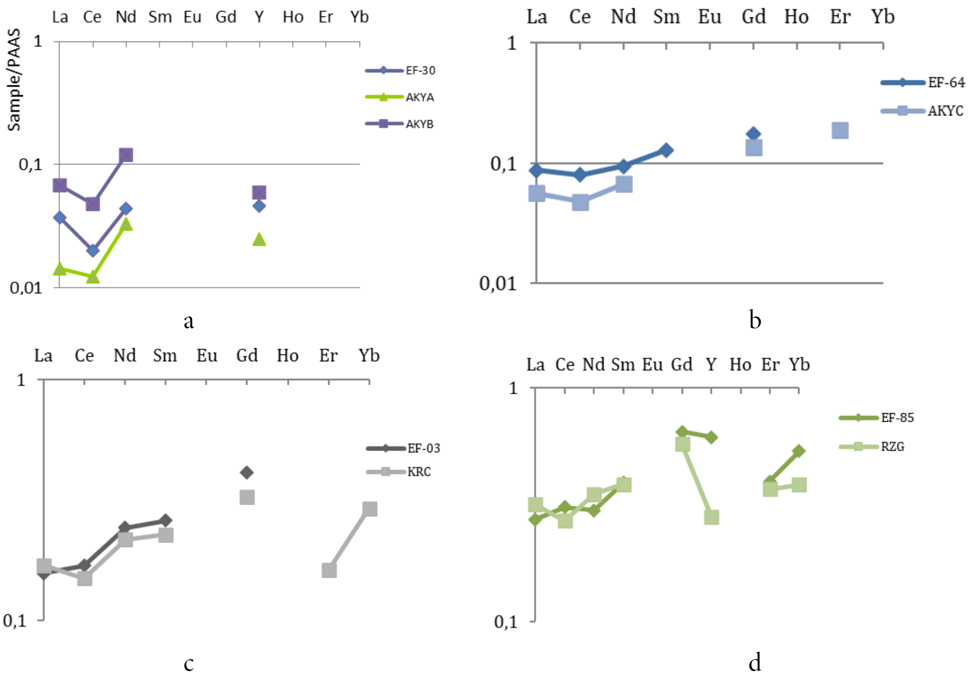

Fig. 6. *REE patterns in Group 1. Similar trends are shown*: a) *EF-30 and geological samples from AKYA and AKYB*; b) *EF-64 and geological samples from AKYC*; c) *EF-03 and geological samples from KRC*; d) *EF-85 and geological samples from RZG* (Muşkara 2013).

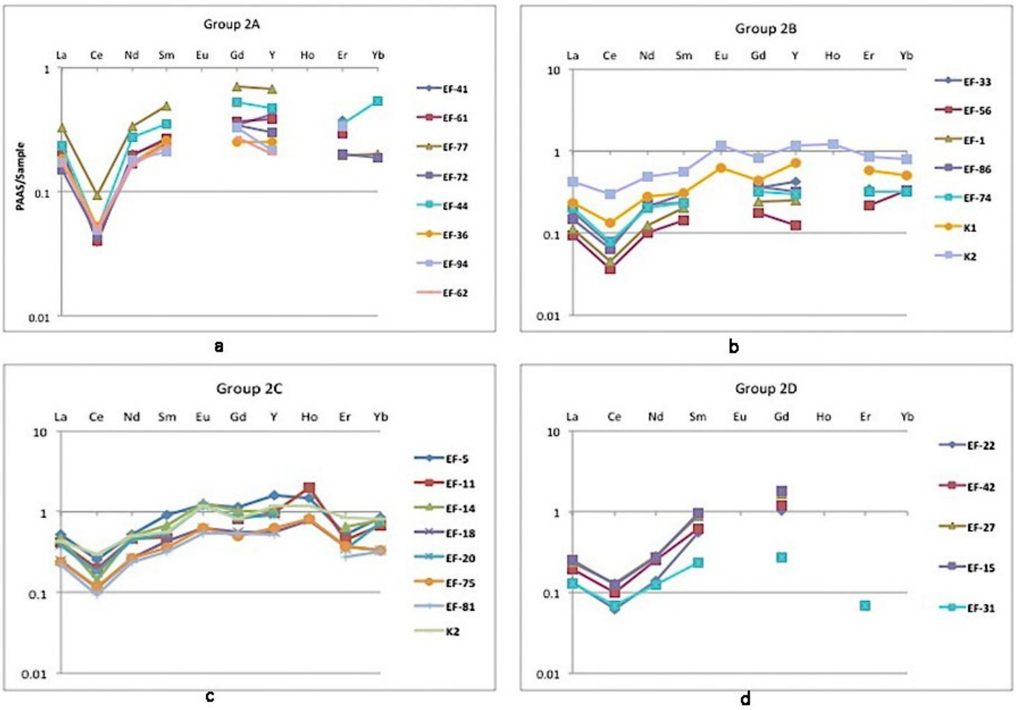

Fig. 7. *REE Patterns in Group 2. Representative Figurines for: a) Group 2A Defined with its Extremely Negative Ce Anomaly; b) Group 2B Formed with Slightly to Moderate Ce Anomaly; c) Group 2C Described by its REE Enrichment; d) Group 2D Characterized Regarding the Behavior of Nd-Sm in REE Pattern* (Muşkara 2013).

ΣREE: The total rare earth element (ΣREE) contents of EF-03, 40, 64, and 85 are significantly lower than the rest, similar to reference samples from Datça (Fig. 8).

LREE enrichment over HREE: $(La/Yb)_n$ ratios vary between 0.28 and 0.79 for the figurines, except for EF-77. The ratios between 0.9 and 1 are accepted as indicating a moderate depletion of LREE[23]. Therefore the majority of the figurines and samples from Cyprus show depletion of LREE. LREE enrichment could not be calculated due to low Yb concentration for some of the figurines and geological samples from Datça, AKYA, AKYB, AKYC, KRC, RZG (Fig. 8).

Meantime, LREE enrichment over MREE indicated as $(La/Sm)_n$ ratio is between 0.59-0.98 for the figurines in general. However, the lower ratios for EF-15, 22, 27, 31, and 42 could occur due to the density of foraminiferal tests[24]. While the Eu anomaly is another critical parameter for determining different limestone types, Eu concentration was generally below the detection limit in the study. For the figurines in which Eu could be determined, a slightly positive anomaly was observed just as is the case for K1 and K2[25].

Samples	Ce/Ce*	La_n/Yb_n	La_n/Sm_n	Gd_n/Yb_n	Nd_n/Sm_n	ΣREE (mg/kg)	Er/Nd
EF-01	0.39	na.*	0.55	na.	0.61	21.3	na.
EF-02	0.2	na.	na.	na.	na.	15.46	0.13
EF-03	0.91	na.	0.6	na.	0.93	35.54	na.
EF-04	0.31	0.53	0.7	1.19	0.95	52.48	0.06
EF-05	0.48	0.63	0.57	1.37	0.56	118.48	0.08
EF-06	0.51	0.55	0.47	1.54	0.58	85.76	0.09
EF-07	0.52	0.65	0.75	1.21	0.72	53.36	0.11
EF-08	0.5	0.53	0.6	1.3	0.66	63.19	0.06
EF-09	0.55	na.	0.98	na.	0.9	53.97	na.
EF-10	0.41	0.52	0.7	0.95	0.74	61.04	0.11
EF-11	0.45	0.62	0.85	1.21	0.96	85.77	0.08
EF-12	0.58	0.57	0.81	1.19	0.72	49.42	0.1
EF-14	0.3	0.59	0.7	1.26	0.74	87.98	0.11
EF-15	0.49	na.	0.26	na.	0.28	55.64	na.
EF-16	0.53	0.54	0.64	1.17	0.87	33.57	0.05
EF-17	0.34	na.	na.	na.	na.	11.31	na.
EF-18	0.44	0.75	0.58	1.67	0.61	51.01	0.12
EF-19	0.34	na.	0.69	na.	1.13	32.41	na.
EF-20	0.44	0.53	0.71	1.19	0.83	79.5	0.06
EF-22	0.46	na.	0.25	na.	0.25	27.03	na.
EF-23	0.47	0.38	0.57	0.81	0.76	47.86	0.08

23 Bellanca *et al.* 1997, 141-152.

24 Liu *et al.* 1988; Jarvis 1989.

25 For the processes effects PAAS normalized positive Eu anomaly, see McLennan 1989; Kurian *et al.* 2008; Madhavaraju *et al.* 2009.

EF-24	0.3	na.	0.43	na.	0.87	26.02	0.09
EF-26	0.51	0.36	0.66	0.91	0.9	63.25	0.07
EF-27	0.51	na.	0.27	na.	0.32	59.41	na.
EF-28	0.36	na.	na.	na.	na.	20.03	na.
EF-30	0.51	na.	na.	na.	na.	5.74	na.
EF-31	0.55	na.	0.56	na.	0.53	23.04	0.05
EF-32	0.45	na.	0.58	na.	0.76	39.81	na.
EF-33	0.38	na.	0.61	na.	0.7	35.79	0.14
EF-34	0.16	na.	0.67	na.	0.71	11.94	na.
EF-35	0.22	na.	0.59	na.	0.59	18.09	na.
EF-36	0.29	na.	0.72	na.	0.68	26.44	na.
EF-37	0.35	na.	0.58	na.	0.88	29.14	0.07
EF-38	0.33	na.	0.84	na.	1.23	11.54	na.
EF-39	0.4	0.51	0.6	1.21	0.73	21.97	0.14
EF-40	0.17	na.	0.62	na.	0.7	24.08	0.12
EF-41	0.18	na.	0.85	na.	0.78	33.95	0.16
EF-42	0.46	na.	0.32	na.	0.42	37.28	na.
EF-43	0.48	0.65	0.95	1.08	na.	41.99	0.16
EF-44	0.2	0.44	0.68	0.98	0.78	18.91	0.11
EF-45	0.18	na.	0.64	na.	0.56	27.7	na.
EF-46	0.41	0.84	0.78	1.61	0.85	25.05	0.12
EF-48	0.35	na.	0.62	na.	0.79	22.92	na.
EF-49	0.43	na.	na.	na.	na.	15.94	0.2
EF-50	0.46	0.51	0.77	1.06	0.91	46.34	na.
EF-52	0.47	0.5	0.76	1.1	0.93	44.1	0.06
EF-53	0.45	0.55	0.76	1.15	0.98	57.28	0.07
EF-54	0.62	na.	0.8	na.	0.82	31.32	0.06
EF-55	0.36	na.	0.66	na.	0.72	35.94	na.
EF-56	0.38	0.28	0.65	0.53	0.71	16.48	na.
EF-57	0.49	0.66	0.81	1.17	0.96	52.36	0.18
EF-58	0.52	0.78	0.78	1.48	0.75	30.9	0.06
EF-59	0.56	0.57	0.83	1.06	0.82	27.44	0.09
EF-60	0.58	0.58	0.77	1.15	0.75	51.26	0.17
EF-61	0.19	na.	0.78	na.	0.73	32.55	0.11
EF-62	0.29	na.	0.74	na.	0.7	24.2	0.13
EF-63	0.45	na.	0.68	na.	0.73	34.16	na.
EF-64	0.89	na.	0.68	na.	0.74	16.42	0.09
EF-65	0.16	na.	0.75	na.	0.86	24.7	na.
EF-66	0.47	na.	0.77	na.	0.91	49.68	0.21
EF-67	0.44	na.	0.56	na.	0.56	71.43	0.08
EF-68	0.42	0.56	0.71	1.27	0.94	46.81	na.

EF-69	0.51	0.53	0.74	1.07	0.9	43.19	0.06
EF-70	0.48	0.46	0.81	1.01	0.93	36.71	0.08
EF-71	0.53	0.57	0.9	0.99	0.76	27.26	0.07
EF-72	0.28	0.79	0.59	1.84	0.67	32.55	0.14
EF-73	0.45	na.	0.82	na.	0.94	33.58	0.1
EF-74	0.39	0.64	0.87	1.02	0.88	51.83	0.11
EF-75	0.47	0.72	0.65	1.52	0.73	57	0.13
EF-77	0.28	1.65	0.67	3.5	0.68	21.23	0.12
EF-80	0.16	na.	0.59	na.	0.79	44.56	0.05
EF-81	0.4	0.68	0.69	1.63	0.75	10.02	0.14
EF-84	0.15	na.	na.	na.	na.	69.75	0.1
EF-85	1.1	0.51	0.7	1.21	0.76	29.96	na.
EF-86	0.37	na.	0.65	na.	0.96	33.89	0.11
EF-87	0.43	na.	0.8	na.	0.82	8.38	na.
EF-88	0.19	na.	na.	na.	na.	11.82	0.05
EF-89	0.17	na.	na.	na.	na.	24.21	na.
EF-90	0.42	na.	0.67	na.	0.71	32.08	na.
EF-91	0.51	0.42	0.56	1.06	0.8	21.7	0.06
EF-92	0.18	na.	0.72	na.	0.79	13.68	na.
EF-93	0.35	na.	0.52	na.	0.59	26.01	0.1
EF-94	0.28	na.	0.82	na.	0.86	18.26	na.
EF-95	0.2	na.	na.	na.	na.	21.3	0.16
AKYA	0.6	na.	na.	na.	na.	12.04	na.
AKYB	0.56	na.	na.	na.	na.	3.34	na.
AKYC	0.8	na.	na.	na.	na.	10.53	na.
KRC	0.81	0.58	0.75	1.12	0.96	35.49	na.
RZG	0.82	0.82	0.82	1.49	0.91	60.03	na.
K1	0.54	0.47	0.77	0.88	0.91	55.55	0.17
K2	0.66	0.53	0.76	1.01	0.88	102.45	0.14

Fig. 8. *Ce Anomaly, REE Fractionations, ΣREE of Samples and Er/Nd Ratios of the Samples. na.* not Calculated due to Concentration below Detection Limits* (Muşkara 2013)

According to Features as Mentioned Earlier:

REE patterns of Group 1 (n=4) assign the figurines EF-03, 30, and 64 to local limestone from various locations in Datça (Fig. 6). The REE pattern of the architectural fragment EF-85 indicated it was made of local limestone, as expected.

The REE patterns show that the rest of the figurines, Group 2, have a Cypriote origin with minor variations (Fig. 7). Group 2A (n=20) could be defined with its extremely negative Ce anomaly and Group 2B (n=48) with its slight to moderate Ce anomaly. Group 2C (n=7) is described by its REE enrichment, and Group 2D is characterized regarding the behavior of Nd-Sm in the REE pattern.

Binary diagrams, used to find the correlation between two variables and how they are related, are also helpful in appointing the source. In this study, the diagram Ce anomaly vs. ΣREE allows the separation between Datça and Cyprus sources (Fig. 9). In the diagram, Group 1 figurines fall into the area of the Datça sources. The geochemical similarity between the Group 2B, Group 2D, and Group 2C and K1 and K2 indicate a Cypriote origin for these groups.

Statistical Analysis

Statistics Package for Social Science (SPSS 16.0 Statistical Package for the Social Sciences) was used in this study. Hierarchical cluster analysis (HCA) was applied to grouping the analyzed samples. In this study, the HCA classification method calculated the Euclidean distances between each sample. The algorithms used to perform the clustering procedure were the Complete Linkage or Furthest Neighbor analysis. Five variables were chosen for cluster analysis: Mg, La, ΣREE concentration, Mn/Cr and Ce/Ce* ratios.

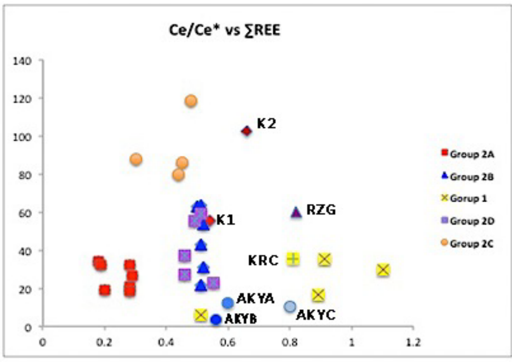

Fig. 9. *The Bivariate Plot of Ce Anomaly Versus ΣREE for the Figurines and the Limestone Sources. The Geological Samples from K1 and K2 are Represented in Red Diamonds; the Blue Circles are the Geological Samples from AKYA-AKYB-AKYC; the Yellow Square Representing KRC and the Purple Triangle Representing RZG.*

Cluster analysis confirms the existence of two major groups referred to as Group 1 and Group 2 (Fig. 10). Group 1 consists of local figurines. This group has higher concentrations of MgO, Mn, and Cr, while Ba, Sr, and REEs are relatively low. Group 2, consisting of several sub-groups, suggests that all are closer to Cypriote origin. Group 2 is divided into two main branches: one indicating the K1 source and one characterizing K2.

Conclusion

This provenance study of the votive figurines from Emecik was successfully completed using ICP-OES and ICP-MS techniques. It showed the ability of the REE pattern to distinguish between different types of limestone even when they have similar foraminiferal contents, and, therefore, to classify the resulting groups based on their element composition. Foraminiferal inclusion is an important feature for indicating a Cypriot origin, however insufficient to discriminate between different quarries. In the previous studies by the EPR technique, the figurines' origin was determined as the Lympia–Kossi chalk of the Pakhna formation. However, here we were able to specify not only local productions but also the Değirmenlik Group as another source in Cyprus. The division between quarries could be detected with the REE pattern, La, Mg, ΣREE concentrations, Ce/Ce*, and Mn/Cr ratio.

The results indicate that four archaeological samples (Group 1), including the architectural fragment, were made from the local limestone. Hence, we prove in parallel with the predominance of the Cypriote source, simultaneous or asynchronous use of the local limestone was evident at Emecik. This can imply different connections and routes of itinerant sculptors between the Datça Peninsula (the territory of the Knidians) and Cyprus and other regions. The artists in Emecik could have worked with Cypriote limestone to produce the mixed style figurines in the earlier phase. Furthermore, we believe the predominance of local sources increased in the later contexts, and therefore the later figurines should be stylistically different from the others. These figurines analyzed are representative samples for the larger groups found in the same contexts.

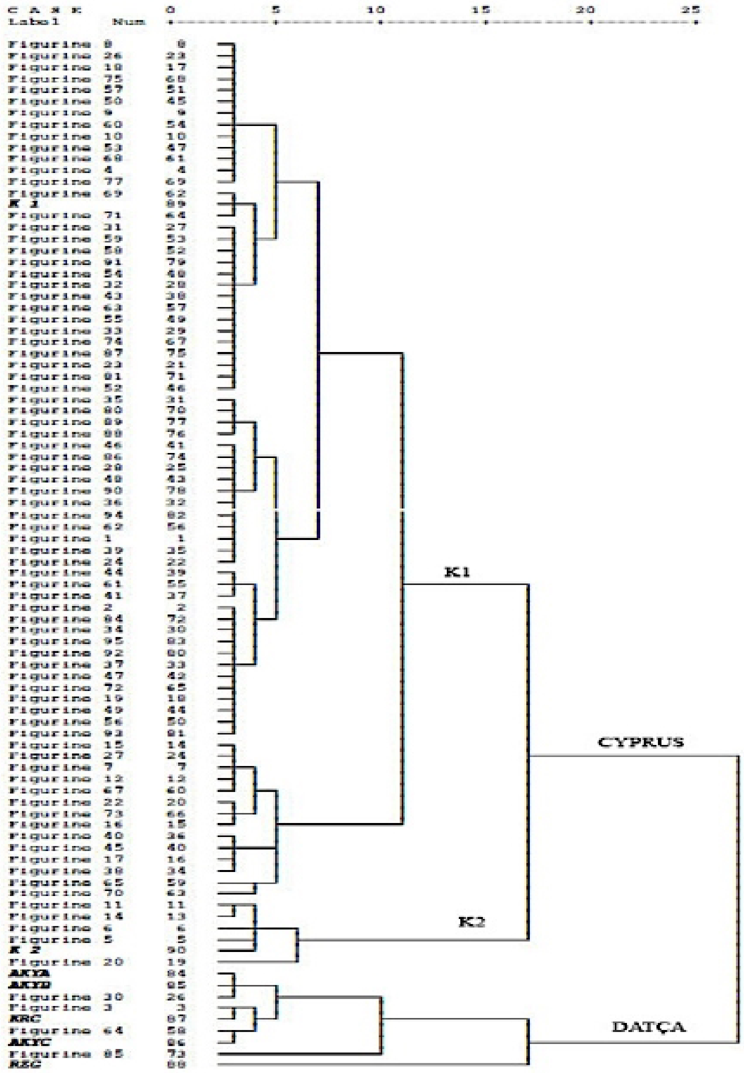

Fig. 10. *A Dendrogram Based on Hierarchical Cluster Analysis of the Data Set in Total. Two Main Groups were Clearly Identified with Respect to the Provenance* (Muşkara 2013).

The rest of the figurines were carved from Cypriote limestone, although they exhibit minor geochemical variations. The figurines of Group 2C seem to be produced from limestone obtained from around Değirmenlik, representing sedimentary rocks of the Değirmenlik Group. Limestone from Erdemli representing the Pakhna formation was used to produce other figurines. Further studies will include other figurines from Emecik to provide further interpretations.

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Plate

Illustrations of the various types of figurines sampled in this study (Muşkara 2013)

EF 01

EF 03

EF 04

EF 12

EF 14

EF 15

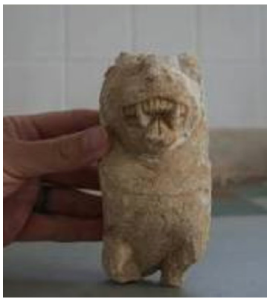
EF 16

EF 17

EF 18

EF 19

EF 20



EF 22


EF 28


EF 30


EF 31


EF 32


EF 33


EF 37


EF 40


EF 42


EF 44


EF 45


EF 48


EF 52


EF 53


EF 57


EF 58


EF 60


EF 61


EF 62


EF 66


EF 67


EF 75

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