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SPELEOTHEMS OF ÇATALHÖYÜK, TURKEY

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ABSTRACT

Speleothem samples such as flowstone, stalagmite and stalactites are one of the important finds at Çatalhöyük, which they have been carried hundreds of kilometers from its source. The "Çatalhöyük Speleothem Project" have been initiated with the aim of investigating Çatalhöyük's speleothems and identifying their provenance. In order to achieve this, speleothem samples at Çatalhöyük have been recognized and documented, and caves around Çatalhöyük have been investigated. Later, both selected Çatalhöyük speleothem and cave samples of flowstone, stalagmite and stalactites have been analysed by ICP-MS to recognize similar trace elements. In addition, the ages of samples have been obtained by U-Th method to find similarities between the Çatalhöyük samples and speleothem deposits from surrounding caves. The comparative results have been used to identify the sources of Çatalhöyük's speleothems.

KEYWORDS: Çatalhöyük, Cave, Speleothem, ICP-MS, U-Th

1. INTRODUCTION

Çatalhöyük consist of a pair of mounds in the Konya plain of Central Anatolia. Çatalhöyük East (ca. 7400 – 6000 BC) is one of the best known Neolithic sites in the Near East. It became well known because of its large size, the rich symbolism and dense concentration of 'art' in the form of wall paintings, reliefs, sculptures and installations. The site was first excavated by James Mellaart in the 1960s (1967), and after 1965 it was abandoned until a new project under the direction of Ian Hodder began in 1993 (Hodder 2006). Among the curious artefacts unearthed Speleothems (also known as cave formations) are one of the most important finds in Neolithic Çatalhöyük, which have been first mentioned by J. Mellaart (1967). He reported finding of broken stalactites in elaborately decorated buildings.

It is likely that the symbolic value of speleothems would have become more diverse in prehistoric lifeway, leading to its increased symbolic importance. A new research project was initiated by Trakya University and funded by TUBITAK Project no 108K436, with the principal aim of investigating Çatalhöyük's spelothems. The project also sought to identify the provenance of the Çatalhöyük's speleothems.

The Çatalhöyük Speleothem Project consists of 3 phases: 1) Re-examining some possible finds that could be cave origin and the detailed documentation of spelothems from new excavations. The first step was started out by just looking at rocks in the Çatalhöyük storage room with the help of geologists to identify speleothems. Later, each speleothem was recorded on a documentation form. Photographic images were also used for documentation. 2) An intensive cave survey: Areas within a 100 km radius around Çatalhöyük have been targeted for the cave survey. Information has been collected on known limestone caves, which were already found during the Turkish Institution of Mining and Technical Research (MTA) surveys. The speleothem samples were carefully collected in caves for chemical analysis 3) Analysis: Trace elements of speleothems from known caves have been measured by ICP-MS analysis. Ages of same samples have also been obtained by U-series (U-Th) dating method. Comparative results of the analyses by ICP-MS and dating works of the speleothem samples from Çatalhöyük and cave sites have been used for identifying the provenance of the Çatalhöyük's speleothems.

2. THE ÇATALHÖYÜK'S SPELEOTHEMS

The Çatalhöyük's speleothems consist of stalactites, stalagmites, flow stones and dogtooth spars. A total of 25 speleothem samples were identified. Dogtooth spars are large in number, which commonly form in caves, either in standing pools or as growths emanating from wall and roof fissures. All Çatalhöyük spelothem samples were found between levels I and VI. Speleothems are absent inthe post level VI assembleges.

The largest sample (Unit 11094) was found in a storage room of Building 52 at the 4040 area (Fig. 1). It is a stalactite, broken into three parts, and the largest part is 11x13 cm. in size. In this sample, the dog-tooth spars has grown as a stalactite. The larger calcite crystals with white -orange- brown banding forming on the outside of a finer-grained core. This heavy piece of stalactite was found in a storage bin together with a calcined bore skull (Bogdan 2005). At least two more spleothems were also found in storage rooms of buildings. A small 6,5x3 cm piece of banded dog-tooth spar (Unit 14019) was found in Building 65 at the SOUTH area. The sample shows non-parallel growth lines along it's length. Other sample (Unit 13952) is from a large cluster of calcite crystals showing orange-brown banding. It is a columnar banded dog-tooth spar that was found near a storage bin in

Figure 1. The largest speleothem sample in Building 52 at the 4040 area (Photo: N. Yücel)

Figure 3. The same dog-tooth spar in context together with a polished stone axe and a pigment (Photo: J. Quinlan)

Building 63 at the IST area (Özbaşaran & Duru 2006).

Some speleothems were found together with possibly exotic matarials in the buildings. For example, a small 5x3 cm piece of dogtooth spar (Unit 13342) was found together with a polished stone axe and a pigment in Building 56 at the SOUTH area (Fig. 2 & 3) (Nakamura 2011). A worked fragment of speleothem was found together with obsidian tools in Building 63 at the IST area. This fragment (Unit 12438) is a colourless band froming a dog-tooth calcite spar speleothem. It's rounded form suggests that this piece has been used. An elongated conical shape of a fine stalactite sample is noteworthy (Unit 17600). It was found in the debris of building 81 at the TP area (Fig. 4). Small pieces of dogtooth spars were also found in midden deposits at the SOUTH area.

Figure 2. A dog-tooth spar in Building 56 at the SOUTH area (Photo: N. Yücel).

Figure 4. A conical shaped fine stalactite sample in Building 81 at the TP area (Photo: N. Yücel).

Doubtfully, the most important and uniqe speleothem found at Çatalhöyük is a female figurine. It was made from a stalactite that can be identified with hollows at the core. Stalactites grow down from the roofs of caves and tend to be long with hollow cores (Fig. 5). The figurine has wide hips, thighs and folded arms. It was found close to a burial in midden context (Nakamura and Meskell 2004). The thin section examination of some pottery sherds suggests that the Çatalhöyük potters mix crashed dog tooth spars into the clay when making pottery (personal com. C. Doherty, 2010).

3. CAVE SURVEY

A total of 8 caves were investigated

Figure 5. A female figurine made from a stalactite (Photo: J. Quinlan).

within ca. 100 km radius of Çatalhöyük (Fig. 6). Data was collected from the original field surveys of the Turkish Institution of Mining and Technical Research (MTA) (Nazik *et al*. 2005). Due to the accessibility in the prehistoric times, only horizontally extending limestone caves were investigated and stalactites and stalagmites samples were collected. Collection was done from both *in situ* deposits, and from loose clasts on the cave floor.

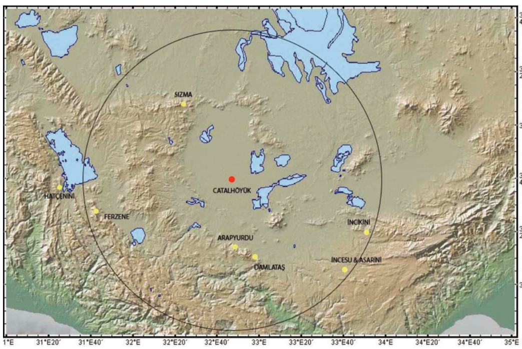


Figure 6. The map shows investigated caves within100 km radius of Çatalhöyük.

The *in situ* samples were carefully collected from areas in the caves where sample removal would not detract from the esthetics of the cave. Loose samples were taken from cave floors to further avoid damage to the caves' natural beauty. The majority of caves examined were developed in the middle Taurus region. Incesu (1356 m) and Asarini (793 m) caves are rich with stalactite and stalagmite formations. They are situated ca 9 km. south of Taşkale Town in the province of Karaman. The extensions and interrelations of Incesu and Asarini caves show that the system was previously consisting of one single cave. Two speleothem samples were collected only in Incesu cave. No prehistoric finds were found in and around caves. Incikini cave (173 m) is also located in the same region on the southern slope of the Güney Mountain. It consists of galleries with stalactite and stalagmite formations (Fig. 7). Morphologically similar dogtooth spars of Çatalhöyük and a stalactice sample were collected in this cave. Around the cave, obsidian implements and buff coloured course Neolithic pottery were found.

Figure 7. Incikini Cave (Photo: O. Özbek)

Arapyurdu and Damlataş caves are the closest caves to Çatalhöyük. A horizontally developed sinkhole type of fossil cave of Arapyurdu (91 m) lies ca. 45 km South of Çatalhöyük. A half-horizontal cave of Damlataş (130 m) is located ca. 50-55 km South of Çatalhöyük. Both caves are extremely rich in stalactites and stalagmites of many colours and shapes. A few hand made sherds were found in Arapyurdu cave, but they were small and worn. Stalagmite samples were collected at each caves. Sızma cave (508,5 m) is also close to Çatalhöyük, lies about 60 km. north of it. It is situated on a limestone hill. A single sample of stalagmite was collected in this cave.

Two major limestone caves are located on the eastern part of Çatalhöyük in the Beyşehir Lake region. Ferzene cave (346 m.) is located on the southwest of the Kuğu Lake, west of the Kalafat Tepe on the Kuyucak Mountain. It is interconnected with wide halls and narrow passages. In wide halls, there are stalactites and stalagmites as well as columns up to a diameter of 15-20 cm. Hatçenini Cave (83 m.) is located on the Sarpca Hill, east of the Beyşehir Lake. It is the farther investigated cave to Çatalhöyük. The cave consists of galleries with abundant stalactite and stalagmite formations (Fig. 8). Stalagmite samples were collected at each caves.

Figure 8. The entrence of Hatçenini Cave (Photo: O. Özbek).

SAMPLING AND ANALYTICAL METHODOLOGY

The number of 6 Çatalhöyük speleothem samples from different layers and contexts have been analysed together with 7 speleothem samples from caves. Thin sections were made from speleothems using standard techniques. Each speleothem samples with the exception of some small Çatalhöyük samples were cut in half vertically along its growth axis and thin sections were made from one of the halves of each sample. The thin sections were initially examined under the optical microscope in order to identify the character of the growth laminae. Each growth laminae has been analysed. The aim is to find out where exactly Çatalhöyük speleothem's were taken from. The Rare Earth Element (REE) patterns have been used to trace Çatalhöyük's speleothems. Trace elements of both Çatalhöyük and cave samples were analyzed by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). It is generally expected that spleothem samples from a single cave have generally similar REE concentrations normalised patterns. Unique REEs to each cave can be treated as a 'fingerprint', thereby allowing characterisation of that cave. REE are displayed by normalizing their concentrations to those of Post-Archean Australian Shales (PAAS) or chondrite (meteorite). In this study, we used PAAS – normalized REE pattern.

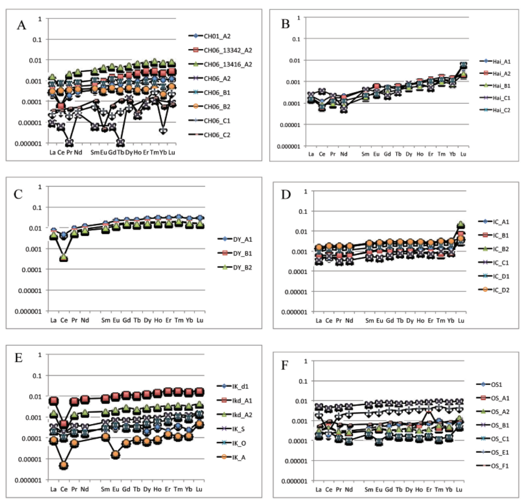
U-series (U-Th) dating was carried out on a VG sector-54 thermal ionization mass spectrometer (TIMS) in the Radiogenic Isotope Laboratory at the University of Queensland following the analytical procedures described in Zhao et al. (2001) and Yu et al. (2006). Unaltered calcite crystals free of any weathered surfaces were extracted from each of the samples, cleaned ultrasonically, and spiked with a ^{229}Th–^{233}U–^{236}U mixed tracer. The ^{233}U–^{236}U double spike with precisely known ^{233}U/^{236}U ratio was used to monitor and correct for U mass-fractionation to improve the analytical precision of U isotope ratio measurements. After total dissolution in nitric acid, concentrated hydrogen peroxide was added to decompose any organic matter and to ensure complete mixing between the spike and the sample. U and Th were co-precipitated with iron hydroxide, and then redissolved in nitric acid prior to purification using standard anion-exchange methods. The U and Th fractions were loaded onto individual pre-degassed, zone-refined rhenium filaments and sandwiched between two graphite layers. The ^{229}Th, ^{230}Th, ^{232}Th, ^{236}U, ^{234}U and ^{233}U signals were measured on a Daly ion counter of the TIMS as $^{232}Th/^{229}Th$, $^{229}Th/^{230}Th$, $^{233}U/^{235}U$, $^{234}U/^{235}U$ and $^{233}U/^{236}U$ ratios in peak jumping mode. U and Th concentrations, and $^{230}Th/^{238}U$ and $^{234}U/^{238}U$ ratios were calculated based on the measured isotope ratios, tracer and sample weights, as well as isotope concentrations and ratios of the mixed tracer. The $^{230}Th/^{238}U$ and $^{234}U/^{238}U$ activity ratios were then calculated using the decay constants of Cheng et al. (2000). The U/Th ages (Table 1) were calculated using Isoplot/Ex version 2 Program of Ludwig (1999), and included corrections for non-radiogenic ^{230}Th assuming average crustal $^{230}Th/^{232}Th$ atomic ratio of $4.4 \pm 2.2 \times 10^{-6}$ for the non-radiogenic component. Further details on analytical procedures and instrumentation are given in Zhao et al. (2001) with further modifications described in Yu et al. (2006).

RESULTS AND SIGNIFICANCE OF REE AND U/TH ISOTOPE INVESTIGATIONS

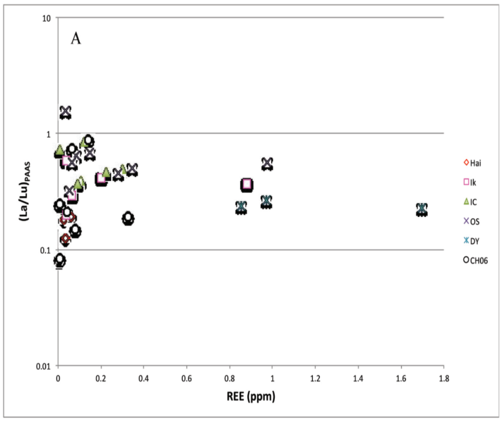
Rare Earth Elements (REE) are used commonly in addressing certain geological problems. All REE are chemically similar because they are all in the +3 valence state over a wide range of oxygen fugacities. In addition, REE are generally insoluble in aqueous fluids making them relatively immobile during weathering and alteration compared to major elements. Therefore, REE provide useful information to determine the origin of rocks and minerals.

Carbonate minerals (e.g., cave deposits or speleothems) collected from different locations are expected to have formed under different geological and physic-chemical conditions. For example, before the carbonate precipitating water has entered in the cave, it must have interacted with geological formations that would be different for different caves. Further, carbonate deposition in different caves would have occurred during different climate events affecting the REE compositions of the carbonate samples (e.g., Uysal et al., 2011). Due to such differences, REE pattern of samples from a cave will be different from samples from another cave that could be used in distinguishing and identifying the caves. Accordingly, we compared the REE compositions of the carbonate samples from Çatalhöyük with those taken from different caves in this area. Variations in PAAS – normalized La/Lu ratios and total REE concentrations can be used to asses if there are any similarities and hence a connection between the samples. In Graph. 1A, the REE pattern of samples from Çatalhöyük (except those with lowest REE contents) resembles mostly the REE pattern of samples from Hatçenini and İncikini caves. REE patterns of samples from other caves are significantly different. Likewise, Çatalhöyük samples show some similarities with Hatçenini samples in a plot of La/La ratios versus total REE concentrations (Graph. 2A).

In Graph 2B, La/Lu ratios are plotted versus Th isotope ratios. ^{230}Th is a radioactive decay product of ^{238}U, whereas

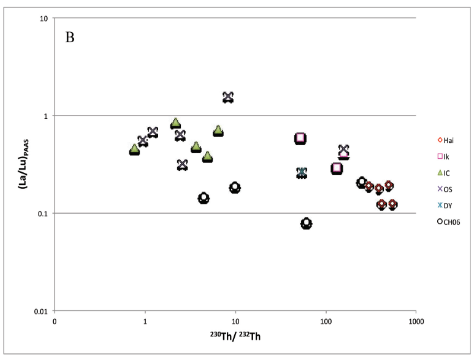


Graph. 1. PAAS – normalized REE patterns of the carbonate samples



Graph.2. PAAS – normalized La/Lu ratios vs. total REE contents (A) and $^{230}Th/^{232}Th$ isotope ratios (B).

^{232}Th is sourced from detriral (transported from outside of the system) components. Accordingly, Th in sample Hatçenini is largely pure and not a detrital contaminant. The opposite is true for samples Incesu ve Sızma caves whwrw contimination is present. Isotope values for a limited number of Çatalhöyük samples show that they are unlikely being originated from similar carbonates as the Incesu ve Sızma caves samples. However, a larger data set would allow us a more reliable interpretation.



Both Caves and Çatalhöyük speleothems were also dated using U-Th dating method. The aim is to find similarities between the dating results of Çatalhöyük and cave samples. ^{230}Th/U-dating requires precise and accurate measurement of the relevant U and Th isotope abundances to obtain the isotope activity ratios needed to calculate an age. The isotopes ^{238}U, ^{234}U, ^{230}Th have a different atomic mass and all decay by alpha emission. Mass spectrometry method is commonly used for U and Th isotope measurements. Summaries of the results obtained are presented in Table 1. Analytical results and ages are reported within 2 σ error. All Çatalhöyük samples dated are in excess of 450 / >500 ka. Similarities can be seen mostly between Çatalhöyük samples and Incikini and Hatçenini Cave samples.

DISCUSSIONS AND CONCLUDING REMARKS

One of the most intriguing question is why Çatalhöyük people brought speleothems from distant caves? In most places of the world, caves are delimiters of sacred places. Caves are not only physical geographic landmarks, but also part of the very structure of the spirit world. They are the dwelling of deities, a spot where one can pass from one cosmic zone to another. Cave may symbolize the dead and underworld. It may also symbolize the womb, childbearing and new life. Although usually portrayed as terrifying, dangerous or unpredictable places, caves appear as a source of growth, life and rebirth in many myths. Lewis-Williams (2004) suggests that Çatalhöyük houses may symbolize caves. Houses are small and dark, and the presence of broken-off stalactites in houses suggests "cosmological and religious beliefs about an underworld to which caves afforded one mode of access. In bringing the stalactites to the structures at Çatalhöyük, people may have taken parts of that topographic underworld to their own built underworld. The houses may therefore have paralleled limestone caves in certain ways and yet, at the same time, created conceptual distance between the structures and the natural caves" (Lewis-Williams 2004:34). Sacred caves may have

Table 1. U-Th dating Results

Sample	U (ppm)	^{232}Th (ppb)	(^{230}Th/^{232}Th)	(^{230}Th/^{238}U)	±2σ	(^{234}U/^{238}U)	±2σ	±2σ	corrected ^{230}Th Age (ka)
Çatalhöyük									
CH1 A1 #16	0,3882	4,70	250,17	0,9987	0,0015	1,0065	0,0007	19	499
CH2 #17	0,2594	3,55	222,28	1,0013	0,0011	1,0057	0,0005	22	547
CH06 A1 #18	0,0614	3,06	60,66	0,9976	0,0027	1,0091	0,0014	24	458
CH06-13342 A1 #19	0,0148	10,85	4,44	1,0706	0,0057	1,0233	0,0022		>500
CH06-13416 A1 #20	0,0286	9,36	9,95	1,0731	0,0044	1,0116	0,0021		>500
CH-b #21	0,0250	2,07	37,29	1,0166	0,0053	1,0240	0,0017	36	448
CH-K #22	0,0205	1,21	51,48	1,0012	0,0043	1,0109	0,0018	38	466
Caves									
DY/B-1	0,1098	6,38	54,56	1,0476	0,0051	1,0402	0,0022	66	521
Hal/A-1	0,2937	1,09	491,67	0,6044	0,0025	1,2600	0,0014	0,41	69,37
Hal/A-2	0,2707	0,90	541,72	0,5924	0,0024	1,2912	0,0014	0,37	65,18
Hal/B-1	0,3004	1,46	382,78	0,6144	0,0020	1,2918	0,0017	0,33	68,38
Hal/C-1	0,2779	1,75	301,04	0,6270	0,0018	1,3121	0,0015	0,30	68,69
Hal/C-2	0,3135	0,91	413,48	0,3985	0,0021	1,3167	0,0018	0,25	38,70
IC/A-1	0,1155	7,30	6,46	0,1349	0,0021	1,3068	0,0026	0,19	10,41
IC/B-1	0,1111	8,59	4,94	0,1261	0,0017	1,2755	0,0029	0,16	9,52
IC/B-2	0,0987	20,50	2,19	0,1504	0,0011	1,2591	0,0017	0,11	8,84
IC/C-1	0,0986	9,47	3,68	0,1168	0,0015	1,2787	0,0019	0,14	8,18
IC/D-2	0,0958	40,18	0,77	0,1070	0,0019	1,2133	0,0032	0,19	^{230}Th/ ^{232}Th
IK-d/A-1	0,1623	9,51	52,54	1,0174	0,0039	1,0690	0,0016	6	294
IK-o	0,1078	2,45	132,46	0,9962	0,0056	1,0261	0,0020	17	358
IK-s	0,1394	3,01	156,38	1,1154	0,0038	1,0468	0,0017		>500
OS/A-1	0,1591	8,03	2,62	0,0437	0,0004	1,1594	0,0016	0,04	2,89
OS/A-2	0,1344	8,54	2,43	0,0511	0,0011	1,1471	0,0019	0,11	3,31
OS/B-1	0,1737	83,73	0,94	0,1499	0,0025	1,1406	0,0035	0,28	2,01
OS/D-1	0,1416	54,90	8,28	1,0611	0,0037	1,0900	0,0020	7,6	312,7
OS/E-1	0,2477	5,08	158,75	1,0767	0,0056	1,0733	0,0019	24,9	417,5
OS/F-1	0,1625	22,49	1,21	0,0556	0,0012	1,1461	0,0023	0,12	1,77

been visited chiefly by men or shamans, seeking transcendence in order to achieve another level of jurisdiction over a domain more potent and supreme in its influence than that found in the everyday world.

Speleothems form at varying rates as calcite crystals build up, one upon the other. The most of Çatalhöyük speleotems have the crystal-like appearance. Crystals hold a special place in the shamanic tradition, and is possibly the most powerful object in a shaman's medicine bag. Shamans around the world have always utilized the special powers of crystals for healing purposes (Eliade 1964). Crystals are "living stones" that operate as Shaman's allies in the realm of spirit. When a shaman died, the crystal was removed and inserted between two ribs of a new shaman, granting him all the knowledge gained by his predecessor. The Çatalhöyük's speleothems might also have been used as healing objects.

Small pieces of Çatalhöyük's speleothem samples were found in refuse areas and others were found inside houses, especially in storage rooms. Various kinds of plant food have been stored in these storage rooms and speleothems were probably used for protective purposes. Besides speleothem pieces, figurines were often discarded in middens. Hodder (2006) suggests that they were used on a daily basis and discarded when their functions come to an end. Some small dog tooth spar speleothems might have also been used on a daily basis and discarded later.

Etnohistorical and ethnographical sources of Mesoamerica also show that newly married couples keep speleothems in their houses for health, fertility and good fortune (Brady et al. 1987). Similar applications may also have been accepted for some Çatalhöyük's speleothems. Nakamura (2011) suggests that cluster of objects found in houses might have had some kind of power or significance. The particular concentration of rare or exotic materials and deposits in some houses is intriguing. A speleothem was found together with a polished stone axe and a pigment in Building 56. All of the objects were rare and exotic materials that might have held particular power. A worked speleothem was also found together with obsidian tools in Building 63. Many scholars have also suggested that obsidian has both a symbolic and an economic vitality at Çatalhöyük (Carter 2007; Hodder 2006).

The Çatalhöyük Speleothem Project has recognised and documented a significant number of speleothem samples for the first time. Cave surveys and sample analysis have provided a firm ground for the investigation of the origin of the Çatalhöyük's speleothems. The results of the comparison analysis show that the Çatalhöyük's speleothems are derived from caves in Southern and Eastern parts of Çatalhöyük at a distance of about 100 km. Among these caves, İncikini is the most noteworthy. ICP-MS results show that most of the investigated speleothem samples from Çatalhöyük match with Hatçenini and İncikini caves in terms of the REE compositions. Neolithic artefacts have also been found around İncikini cave.

Speleothems probably played a role in relation to society, belief and meaning. They serve as vehicles for fertility, healing, protection or good fortune. They probably provided a durable symbolic medium for creating and maintaining social and religious ties.

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