Quaternary International 407 (2016) 140–149

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

A geochemical multi-proxy approach for anthropogenic processes in a Middle–Upper Pleistocene endokarstic deposit

Guadalupe Monge [a, *], Francisco J. Jimenez-Espejo [b], Manuel Pozo [c], María I. Carretero [a], Cecilio Barroso [d]

[a] *Dpto. Cristalografía, Mineralogía y Q. A. Facultad de Química, Universidad de Sevilla, Spain*
[b] *Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan*
[c] *Dpto. Geología y Geoquímica, Universidad Autónoma de Madrid. Spain*
[d] *Fundación Instituto de Investigación de Prehistoria y Evolución Humana. Lucena. Spain*

A R T I C L E I N F O

Article history:
Available online 26 February 2016

Keywords:
Geochemistry
Geoarchaeology
Middle–Upper Pleistocene
Cave sediments
Iberian Peninsula
Anthropogenic processes

A B S T R A C T

Deciphering human activities in archaeological sites is a priority issue in archaeological studies, nevertheless its geochemical fingerprints on sediments are poorly known. In sites belonging to the recent prehistory these geochemical signals have been taken into account, but in oldest sites this subject has not been studied sufficiently.

The aim of this paper consists on tracking geochemical proxies that can be attributed to anthropogenic processes in endokarstic Pleistocene deposits. Recognize these elements can be a key factor in order to explore the potential of non-excavated archeological levels and find out activities performed in those sediments more accurately. For that purpose a Middle–Upper Pleistocene endokarstic deposit (Cueva del Ángel) belonging to the Iberian Peninsula has been chosen. This site provides numerous evidences of human activities, as butchering and cooking of predated animals or the habitual use of fire throughout its main stratigraphic sequence.

This geochemical/archaeological approach highlights that the upper units consist of anthropogenic influenced sediments, while the lower unit shows a greater percentage of geogenic inputs. Based on P and Zn–Cu–Sr, several levels with higher anthropogenic inputs have been identified. These two attributes can be suggested as proxies of human activities for this site. High values of P appear to be linked with "butchering highly occupied" levels, and high levels of Zn–Cu–Sr seem to be related with fires. This geochemical information has been compared and tested with previous archeological information.

1. Introduction

Cave deposits are one of the most important archives in the geological record to infer past events, including anthropogenic ones, as they are unique environments preserving sediments derived from an assortment of geological and human processes (Goldberg and Sherwood, 2006). They can provide not only substancial information on the climatic and geomorphological history of the cave itself and its surroundings (Karkanas and Goldberg, 2013), but also a wealth of contextual information for interpreting the archaeological remains and the human role in the formation of the endokarstic deposit (Goldberg and Sherwood, 2006).

Although it has long been recognized that the study of artifacts without regard to their context is of limited value in archaeological interpretation (Schiffer, 1972, 1983), traditionally the attention has focused on archaeological remains like lithic tools or fossil bones, and only recently has systematic classification of cave sediments been proposed (Ford and Williams, 2007; White, 2007; Trappe, 2010).

The clue for a correct overall palaeoanthropological interpretation of a site will be a suitable characterization of cave sediments, as well as being able to differentiate geogenic sediments from anthropogenic ones. The geochemical characterization of sediments could be so helpful on deciphering the "anthropogenic degree" of a sedimentary level and deposit evolution, being commonly applied in lacustrine environments (García-Alix et al., 2013) and historical archaeological sites (Kawahata et al., 2014). In prehistoric sites, macroscopic physical features still represent the

---

* Corresponding author.
E-mail address: gmonge@us.es (G. Monge).

http://dx.doi.org/10.1016/j.quaint.2016.02.004
1040-6182/© 2016 Elsevier Ltd and INQUA. All rights reserved.

primary evidence of human occupation, although their distribution could be very patchy as many activities produce few (if any), while geochemical indicators which are directly related to occupation itself are more homogeneously deposited (Schlezinger and Howes, 2000; Monge et al., 2015) (e.g. ashes).

The overall relation between archaeology and geochemistry can be described as the enrichment or depletion of certain elements in sediments through the act of human occupation (Oonk et al., 2009). Traditionally, geochemical analysis of sediments have been used to confirm, deny, or expand the results achieved through other techniques (Popenoe, 1959; Cowgill, 1961; Cowgill and Hutchinson, 1963). Recently, the rise of high resolution non-destructive techniques (e.g. XRF-Scanners) combined with equipment portability (e.g. portable LIBS) and price reduction, offered the possibility to applicate these methods to climate and archaeological records (e.g. Marwick, 2005; Finlayson et al., 2006; Wilson et al., 2008; Skaberne et al., 2015). Geochemistry has become not only a characterization tool, but also an exploration one, as a possible primary step in the development of an excavation strategy (e.g. Parnell et al., 2001; Wilson et al., 2008).

These advances and the difficulty of the interpretation of geochemical data as proxies (Wilson et al., 2008), justify the re-evaluation of the relationship between geochemical and archaeological data, and between different elements as indicators.

The relatively low number of sites that have used geochemistry to address archaeological questions, include the Amerindian site Cape Cod (Schlezinger and Howes, 2000), where a comprehensive study of an anthrosol from the last glacial period reveals the utility of organic P and elemental ratios in delineating human occupations in sandy, acidic soils. Also, the prehistoric archaeological sites at Ban Non Wat and Nong Hua Raet in Thailand (Kanthilatha et al., 2014), from at least 4000 BP, revealed P, Ca an K as key anthropogenic elements which reflect the occupation intensity of ancient people in different floor surfaces.

In Guatemala, during Maya period, two sites has been geochemically studied. Piedras Negras site (Parnell et al., 2002), where elevated levels of Ba, P and Mn were found to be associated with areas of organic waste disposal whilst Hg and Pb concentrations were associated with craft production areas. At Las Pozas (Fernández et al., 2002), high levels of P, K, Mg and pH were related with food preparation areas, as well as high P concentrations and low pH with food consumption areas. During historical periods, geochemical studies mainly focused on Pb, Hg and other metal-related smelting activities (Kawahata et al., 2014), pigments (Emslie et al., 2015) or farming activities that can be recognized by Ca, Sr, P, Zn and Cu concentration patterns linked to charcoal and bone mediated for late 1800s farms (Wilson et al., 2008).

As geochemistry has not been used systematically at old prehistoric contexts (Oonk et al., 2009), this study focus on deciphering geochemical proxies which could be used to identify human activities. For that purpose Cueva del Ángel (Spain) has been chosen because it provides numerous macroscopic evidences of human activities (mainly fossil bones and lithic tools along the stratigraphic sequence). This paper also aims to review different elements and consider their validation as anthropogenic/geogenic proxies related to archeological sites located in caves.

2. Cueva del Ángel

Cueva del Ángel is located in the south of the Iberian Peninsula, near the town of Lucena in the province of Córdoba (Spain). The cave is situated at an altitude of 620 m above sea level (37°22′N, 4°28′W) on the foothills of the Sierra de Araceli (Fig. 1).

From a geological point of view, this cavity is hosted in a Mesozoic carbonate unit composed of limestone and dolostones (Lower and Middle Lias), belonging to the Betic Ranges (López-Chicano, 1990). Nowadays, the roof and walls are partially collapsed. Thus, the archaeological site is located on an open-air platform measuring around 300 m^2 with a strong slope southwards (Monge et al., 2014).

The most complete stratigraphic profile, named J/K, presents twenty stratigraphic levels organized in three stratigraphic units. They have been differentiated on the basis of lithology, colour, texture, structure, coarse fraction percentage, porosity and occurrences of archaeological material. Detailed stratigraphic descriptions and mineralogical results can be found in Botella et al. (2006), Barroso et al. (2011), Monge (2012) and Monge et al. (2014). The major traits are summarized in Table 1.

In a previous study, Barroso et al. (2011) state that the faunal assemblage dominated by *Equus ferus*, large bovids and cervids has been subjected to intense human actions reflecting selective predation (fragmentation of the bones for marrow extraction with an

Table 1
Mainly descriptive and mineralogical features from J/K stratigraphic levels and location of geochemical samples at sedimentary levels.

Stratigraphic Units	Stratigraphic levels	Depth (cm)	Geochemical Samples	Munsell Colour	Texture	Structure	Lithic Tools > 2 cm (%)	Fossil Bones > 2 cm (%)	Calcite (%)	Quartz (%)	Phyllosilicates (%)	Phosphates (%)
I	I	208-250	_	Pinkish gray (7`5 YR 7/2)	Loamy	Blocky	_	_	_	_	_	_
	II	214-258	S1 to S3	Very dark greyish brown (10 YR 3/2)	Loamy	Granular	2	7	52	9	28	11
	III	240-300	S5 to S-10	Dark reddish brown (7`5 YR 4/2; 5 YR 3/2)	Loamy	Granular	2	15	58	6	18	18
	IV	249-307	S12	Pinkish gray (5 YR 6/2)	Sandy loam	Blocky	0	0	65	7	22	6
	V	294-318	S13 to S15	Pinkish gray to dark brown (5 YR 6/2; 7`5 YR 4/2)	Loamy	Platy	0	0	62	5	22	12
	VI	253-355	S16 to S24	Dusky red (7`5 YR 3/2; 2`5 YR 3/2)	Loamy	Granular	3	10	41	7	36	17
II	VII	364-381	S28	Red (2`5 YR 5/7)	Sandy loam	Granular	0	0	32	7	53	8
	VIII	348-390	S25,S29	Dark brown to dark reddish gray (7`5 YR 3/2; 5 YR 4/2)	Sandy loam	Granular	7	15	30	10	30	31
	IX	363-422	S27,S30 to S32	Dark brown to dusky red (7`5 YR 3/2; 2´5 YR3/2)	Sandy loam	Granular	3	20	41	6	27	27
	X	374-434	S34-S35	Dark reddish brown (7`5 YR 4/2; 5 YR 3/2)	Clay loam	Granular	2	12	35	8	45	13
	XI	386-436	S36	Pale red (2`5 YR 6/2)	Sandy loam	Granular	0	3	51	8	30	11
	XII	398-438	_	Gray (2´5 Y 5/0)	Sandy loam	Granular	_	_	_	_	_	_
	XIII	400-449	S37	Pinkish gray (5 YR 6/2)	Sandy loam	Granular	2	10	24	8	45	23
	XIV	416-443	S38-S39	Pinkish gray (7`5 YR 7/2)	Sandy loam	Granular	2	8	44	6	29	22
	XV	405-470	S40-S41	Pale red to pink (2´5 YR 6/2; 2´5 YR 8/4)	Sandy loam	Granular	1	4	48	5	25	14
III	XVI	423-480	S43	Pale red (2´5 YR 6/2)	Loamy	Granular	1	4	62	5	22	11
	XVII	436-493	S44	Pinkish gray (7`5 YR 7/2)	Loamy	Granular	1	6	51	8	33	8
	XVIII	462-539	S46 to S50	Pinkish gray to pale red (5 YR 7/2; 2´5 YR 6/2)	Silt loam	Blocky	1	8	46	8	38	8
	XIX	494-550	S52	Reddish brown (5 YR 5/4)	Silt loam	Granular-Blocky	1	2	31	11	50	8
	XX	546-580	S53 to S55	Reddish brown to pink (5 YR 5/4; 5 YR 7/4)	Silt loam	Granular	1	5	36	11	46	7