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# TESTING A NEW METHODOLOGICAL APPROACH TO DEFINE THE USE OF DOLERITE OUTCROPS FOR PREHISTORIC TOOLS PRODUCTION IN MEDITERRANEAN IBERIA

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## Abstract:

A methodology based on the mineral analysis determination has been developed to identify the origin of dolerite stone outcrops collected to fabricate lithic objects during the Late Prehistory. Rare earth elements (REE) and trace elements were measured by Inductively Coupled Plasma Spectrometry (ICP-MS) and also X-ray fluorescence (XRF) was employed for major elements analysis. Samples from different natural outcrops and archaeological sites located in the Mediterranean area of Spain were studied to test the proposed methodological approach.

The employed REE/PAAS ratios allow us to establish geochemical differences between dolerites collected from different areas in this geographical framework.

## Key words:

Dolerites, Rare earth elements (REE), ICP-MS, Late Prehistory, Valencian region

## Introduction

It is during the Neolithic, in the middle of the sixth millennium cal BC, that polished tools start to be produced and become an important part of the archaeological record related to this period. In the Mediterranean Iberia dolerites are the raw material commonly used as support. The petrographic characterization of rocks and determination of their geological source area is an extended practice in archaeological research. Many researchers have tested the application of diverse characterization techniques, according to the characteristics of the various lithic materials, aiming an approximation to the technology, exploitation, supply and circulation of these materials.

In the Valencian region numerous dolerite outcrops are known and have been studied petrologically and characterized in detail (Alonso, 1982). There are holocrystalline rocks, with fine and medium grain, and a clearly inequigranular texture that oscillates between the ophytic, subophytic and doleritic. In terms of their mineralogical composition, they present as main components: feldspars plagioclase type and augitic pyroxenes. The rocky outcrops present a great textural variability, detailed in the specific bibliography (Alonso, 1982).

In this geographical and geological context a previous work has been developed, obtaining interesting results (Orozco, 2000). Polished stone axes and adzes are known from the earliest Neolithic phases, but are more abundant in absolute and relative terms in the Later Neolithic and Copper Age periods. However it is in the late fifth to mid third millennia BC, when a lot of polished tools brought from long distances are found. During these periods there is a major increasing in artefact types and lithotypes used. Throughout the late prehistory local rocks were chosen, showing a continuous demand met with local supply (Harrison & Orozco, 2001).

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Petrographic determination of rocks, employing thin sections analysis, has been carried out in previous works. During these studies it was in some case difficult to discern between various source areas (Orozco, 2000), this because, based on their composition and texture, the dolerite outcrops located in the central and southern parts of the Valencian region can be grouped into many different source areas. On the other hand, the heavily weathered outcrops of dolerite in the northern part do not seem to have been exploited for implement manufacture (Harrison & Orozco, 2001).

The purpose of this work is to test the capability of geochemical characterization of dolerites by rare earth elements, trace elements and major element analysis, in order to distinguish different outcrops and to determine the possible variability in the same outcrop. To do so, we have selected some outcrops where for some of those several samples have been analyzed. Since our purpose is primarily methodological, we have included only a few samples of archaeological materials. Finally, we have only used dolerites, avoiding other lithologies such as amphibolites or sillimanites, as well employed for polished implements manufacturing in the prehistoric sites of the Valencian region.

## Materials and Methods

As mentioned, this work was focused on dolerite rocks geochemical analysis. To test the proposed methodology, a set of 16 samples has been selected, 3 of them come from prehistoric tools and 13 come from natural outcrops, some of which were exploited in Neolithic and Chalcolithic phases. The numbers of samples and their origin are presented in Table 1. The field samples come from outcrops mostly located in the central and southern areas of the Valencian region (Fig. 1). In this area the large macrostructural units that arrange the relief are the Iberian mountain range (NW-SE orientation) and the Betic chains (ENE-WSW orientation). We are in an area where lithologies are mostly of sedimentary origin, with few outcrops of metamorphic, volcanic and subvolcanic materials. Among the latter, the studied rock stands out. In previous works (Orozco, 2000) it was verified that the dolerite outcrops located in the Betic domain show less alteration and a fresher rock than those located in northern areas (corresponding to the Iberian mountain range), and was a preferred area of lithic raw material sources during the Late Prehistory. Samples S1, S2 and S3 were collected in Finestrat-Orxeta, a quarry of aggregates exploited until recent times, where a relatively fresh igneous rock emerges. Samples S4, S5, S6, S7 and S8 come from several places located in a wide area that corresponds to the course of the river Vinalopó and nearby areas. Here rocky outcrops of small dimensions are numerous. Two places stand out for their greater dimensions: Cabezo de la Sal (Pinoso-Xinorlet) and the quarry of Santa Eulalia, in the depression of the Vinalopo river, today completely exploited.

Sample	Proceeding	Origin	Rock type
S 1	Finestrat (Cantera)	outcrop M7, LD	Dolerite
S 2	Finestrat	outcrop M4, LD	Dolerite
S 3	Finestrat	outcrop M5, LD	Dolerite
S 4	Pinoso-Xinorlet	outcrop	Dolerite
S 5	Vinalopó-Sta Eulalia	outcrop M1, LD	Dolerite
S 6	Vinalopó-Sta Eulalia	outcrop M3, LD	Dolerite
S 7	Vinalopó-Sta Eulalia CG	outcrop	Dolerite
S 8	Vinalopó-Sta Eulalia CG	outcrop	Dolerite
S 9	S. Orihuela (Tunel)	outcrop	Dolerite
S 10	Altura	outcrop	Dolerite
S 11	Almansa –C. Cuchillos	outcrop	Dolerite
S 12	Almansa –C. Cuchillos	outcrop LD Lc 1	Dolerite
S 13	Almansa –C. Cuchillos	outcrop LD Lc 3	Dolerite
S 14	Arenal de la Costa	Arch. 88.28.01	Dolerite
S 15	Banca de Satorre	Arch. AC-76-24	Dolerite
S 16	Ereta del Pedregal	Arch. EP-21348 SIP	Dolerite

Table 1: Description of the analyzed samples.

From the southern part of the studied area (Sierra of Orihuela), a sample from 'El Tunel' quarry has been analyzed. The dolerites that appear in this southern zone correspond to fresher rocks, with a fairly homogeneous grain and a greater presence of quartz.

We have also included a field sample, S10 (Altura), from a dolerite outcrop that corresponds to the Iberian geological domain and shows greater alteration of the mineral components. Samples S11, S12 and S13 are dolerites coming from Cerro de los Cuchillos (Almansa), an outcrop situated outside the present

Valencian lands, but which connects geologically and structurally with the already referred area of Vinalopó.

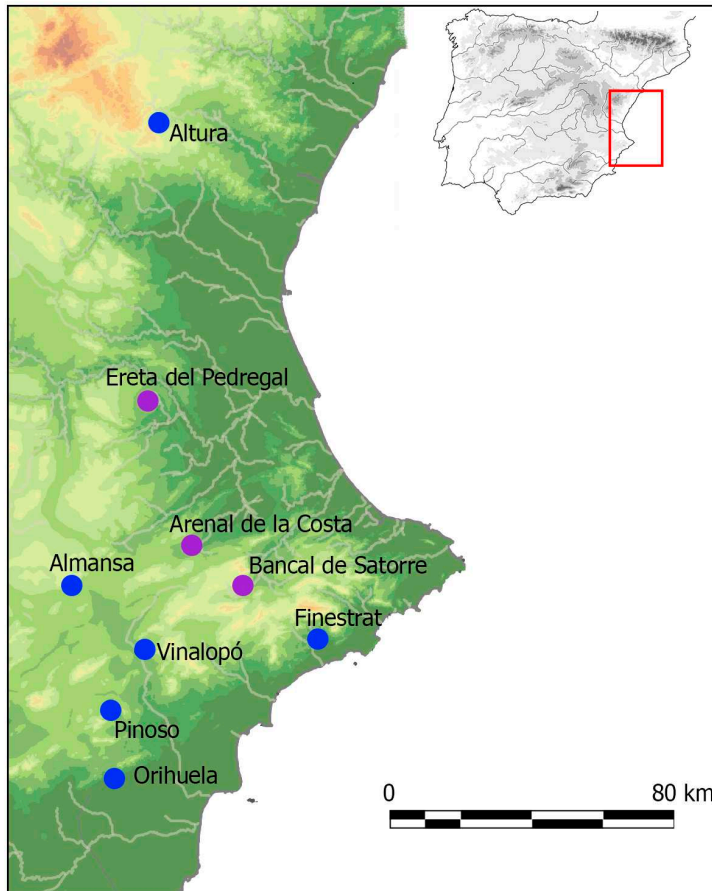


Figure 1: Map of the studied area. Blue dots represent dolerite outcrops, while the pink dots show the location of the archaeological sites taken into consideration. For this work, the only rocky outcrop analyzed belong to the Iberian domain is Altura. The remaining sills of dolerites taking into account emerge in diverse units of the Betic Mountain ranges.

In this region, the representation of dolerites in polished axes and adzes can vary in the archaeological contexts, as it has been shown in previous works, appearing both types of tools in settlements and as well in burial contexts. We also noted the high fragmentation of these pieces in open-air settlements, in front of the greater integrity of the objects deposited as funerary remains (Harrison & Orozco, 2001; Orozco, 2000).

For this work, we have selected three archaeological samples from fragmented objects, coming from different prehistoric open-air settlements. We have employed in this study the remaining samples from the previous petrological analysis (thin section). S14 came from the excavation of Arenal de la Costa (Ontinyent, Valencia). It is an open-air site of a single phase of occupation, dated in the early second millennium BC (Bell-Beaker Horizon). The axe fragment analyzed is not related to the various structures documented in the settlement (pits, trenches, post holes). Sample S15 came from Bancal de Satorre (Benifallim, Alicante), an unexcavated archaeological site with an estimated chronology -according to the ceramic materials documented in surface- belonging to the beginning of the Neolithic. S16 corresponds to a piece recovered in Ereta del Pedregal (Navarrés, Valencia), a large Chalcolithic settlement that has a nearby dolerite outcrop close by, which was used extensively for a large collection of polished tools production (Gallart & Lago, 1988). The assemblage of Ereta is interesting by its numerical importance (300 pieces). But many of these artifacts were recovered in ancient excavations, which makes difficult to know a diacronic evolution. However, they can be broadly framed chronologically between the Chalcolithic and the Bell-Beaker Horizon (Orozco, 2000).

## Chemical analysis of the samples: ICP-MS and XRF

Archaeological and geological samples were analysed exactly the same by Inductively Coupled Plasma Spectrometry and portable X-ray fluorescence.

Sample preparation and digestion were carried out pre-crushing the stone samples employing a jaw crusher, homogenized and pestle by using an agate mortar. The digestion method was developed for ICP-MS analysis sample preparation as described by Gallelo et al. (2015). The prepared dilutions were analysed by ICP-MS with Perkin Elmer Elan DRCII (Concord, Ontario, Canada).

Rare earth elements ratios La/Yb\*, La/Gd\*, La/Sm\* and Sm/Yb\* (REE/PAAS) were employed to observe the rate of chemical weathering between the studied samples. Post Archaean Australian Shales (PAAS) values of Ytterbium (Yb\*), Gadolinium (Gd\*) and Samarium (Sm\*) were employed to calculate the ratios (Taylor & McLennan, 1985).

To measure major elements spectra a portable model S1 Titan energy dispersive X-ray fluorescence spectrometer from Bruker (Kennewick, Washington, USA) was used. GBW07408 was the standard reference material for evaluating the quality of the employed methods.

## Results and discussion

### The elemental composition of dolerite rocks analysed by ICP-MS

Trace elements and total rare earth elements, Sc and Y obtained results are reported in Tables 2a–2b and 3, being expressed the concentration in  $\mu\text{g/g}$ . The obtained mean concentrations with their standard deviations pointed differences in geochemical composition between samples.

ID	Ba	Bi	Cd	Cr	Co	Cu	Pb
S4	44 ± 8	0.0408 ± 0.0007	0.076 ± 0.004	200 ± 50	19 ± 5	9 ± 2	3.0 ± 0.5
S10	33 ± 8	0.08 ± 0.02	0.068 ± 0.010	89 ± 16	17 ± 5	19 ± 5	2.4 ± 0.7
S9	35.52 ± 1.04	0.018 ± 0.002	0.0223 ± 0.0008	108 ± 7	29.43 ± 0.12	132 ± 4	2.93 ± 0.15
S1	54 ± 8	0.061 ± 0.005	0.102 ± 0.006	8.9 ± 0.6	25 ± 2	131 ± 14	3.5 ± 0.5
S11	133 ± 22	0.0329 ± 0.0014	0.0142 ± 0.011	29 ± 2	20.8 ± 0.4	92 ± 2	5.3 ± 0.8
S12	124 ± 2	0.0115 ± 0.0012	0.122 ± 0.002	24.5 ± 0.9	17.6 ± 0.4	90 ± 4	7.56 ± 0.15
S5	783 ± 11	0.030 ± 0.003	0.0570 ± 0.0004	61 ± 10	17.3 ± 0.7	56 ± 2	10.0 ± 0.6
S6	383 ± 85	0.005 ± 0.003	0.108 ± 0.012	62 ± 16	32 ± 9	78 ± 22	7.4 ± 1.4
S7	118 ± 18	0.018 ± 0.003	0.089 ± 0.005	42 ± 12	54 ± 11	118 ± 25	13 ± 2
S8	88 ± 4	0.02 ± 0.005	0.113 ± 0.006	61 ± 3	21.1 ± 0.8	104 ± 2	4.1 ± 0.6
S2	59 ± 5	0.029 ± 0.003	0.045 ± 0.004	97.34 ± 0.03	21.1 ± 0.7	68 ± 4	2.04 ± 0.07
S3	71 ± 4	0.029 ± 0.003	0.027 ± 0.002	148 ± 9	25.7 ± 0.7	90 ± 2	3.1 ± 0.2
S13	116 ± 7	0.025 ± 0.006	0.055 ± 0.006	110 ± 10	22.33 ± 0.96	80 ± 3	8 ± 2
S14	67 ± 4	0.07 ± 0.02	0.111 ± 0.002	180 ± 40	23 ± 3	116 ± 12	43 ± 9
S15	125 ± 7	0.022 ± 0.008	0.0902 ± 0.0011	50 ± 10	24 ± 4	62 ± 7	9 ± 2
S16	590 ± 30	0.014 ± 0.005	0.0895 ± 0.0008	100 ± 20	18 ± 3	16 ± 2	4.0 ± 0.9

Table 2a: Trace element values and standard deviations expressed as  $\mu\text{g/g}$ .

ID	Li	Mn	Mo	Ni	Sr	V	Zn
S4	63 ± 8	420 ± 80	0.12 ± 0.02	56 ± 17	88 ± 6	200 ± 50	130 ± 30
S10	115 ± 8	1690 ± 340	0.238 ± 0.003	34 ± 10	29.61 ± 0.10	130 ± 30	250 ± 10
S9	23 ± 5	390 ± 30	0.120 ± 0.007	43.4 ± 0.2	53 ± 3	58 ± 3	61 ± 2
S1	15 ± 3	830 ± 10	0.286 ± 0.012	28.8 ± 1.5	49 ± 3	219 ± 5	189 ± 5
S11	37 ± 9	650 ± 20	0.169 ± 0.004	90 ± 3	155 ± 13	157.1 ± 1.2	159 ± 8
S12	34 ± 6	710 ± 30	0.070 ± 0.004	25.5 ± 0.7	164 ± 3	135 ± 2	144 ± 4
S5	42 ± 7	530 ± 50	0.290 ± 0.007	35.90 ± 1.03	254 ± 14	140 ± 10	130 ± 10
S6	24 ± 3	1190 ± 320	0.034 ± 0.007	57 ± 17	310 ± 3	100 ± 30	140 ± 30
S7	28 ± 2	770 ± 160	0.28 ± 0.03	51 ± 11	202 ± 4	200 ± 50	130 ± 30
S8	26 ± 2	580 ± 60	0.102 ± 0.003	25.63 ± 1.12	56 ± 2	130 ± 10	164 ± 8
S2	19.6 ± 0.8	600 ± 10	0.2640 ± 0.0006	31.9 ± 1.2	58 ± 4	140 ± 2	105 ± 2
S3	23.0 ± 0.3	610 ± 40	0.5 ± 0.007	40.31 ± 1.10	98 ± 8	200 ± 10	99 ± 6
S13	25.8 ± 0.4	750 ± 80	0.6 ± 0.013	45 ± 2	51.1 ± 0.9	140 ± 10	130 ± 10
S14	66 ± 8	900 ± 180	0.359 ± 0.010	35 ± 5	32.7 ± 1.0	160 ± 30	190 ± 30
S15	23 ± 5	690 ± 160	0.205 ± 0.011	41 ± 7	39 ± 2	220 ± 50	180 ± 40
S16	101 ± 12	990 ± 200	0.6 ± 0.03	13 ± 3	150 ± 14	190 ± 40	110 ± 20

Table 2b: Trace element values and standard deviations expressed as  $\mu\text{g/g}$ .

ID	REE	Sc	Y
S4	61.34	9.6 ± 3.2	8.2 ± 0.4
S10	132.54	10.6 ± 3.5	12.2 ± 0.5
S9	23.00	4.837 ± 0.103	5.01 ± 0.10
S1	61.21	6.7 ± 0.6	10.37 ± 0.09
S11	83.13	4.8 ± 0.3	16.0 ± 0.2
S12	72.69	3.52 ± 0.13	13.4 ± 0.5
S5	59.88	5.6 ± 0.2	10.09 ± 0.02
S6	94.61	23.3 ± 8.4	17.91 ± 1.13
S7	107.04	23.1 ± 7.2	19.7 ± 1.7
S8	64.34	3.3 ± 0.2	11.9 ± 0.2
S2	48.52	3.39 ± 0.09	7.07 ± 0.05
S3	48.51	5.75 ± 0.07	7.7 ± 0.2
S13	69.97	3.29 ± 0.11	11.26 ± 0.13
S14	80.24	2.7 ± 0.5	13.3 ± 0.4
S15	77.72	2.8 ± 0.6	11.9 ± 0.6
S16	195.63	18.5 ± 3.3	18.7 ± 0.9

Table 3: Total Rare earth elements values (REE) and Sc and Y values standard deviations expressed as µg/g.

While trace elements values didn't allow to see clear differences between samples, interesting results could be observed looking at the total total REE, Sc and Y concentrations (Table 3). Finestrat samples (S1, S2, and S3) REE and Y values are similar, especially this could be observed among samples S2 and S3. Samples S11, S12, and S13 (Almansa) also have similarities in REE, Sc values and Y values. Vinalopó samples S5, S6, S7, and S8 presented similar concentrations of REE, Sc and Y between S5 and S8 on one side and S6–S7 on the other side. Important differences in their geochemical profiles (REE, Sc and Y) between the two pairs of samples can be appreciated despite all comes from the same locality. Furthermore REE, Sc and Y values show marked variations between the samples S9 (Orihuela) and S10 (Altura) collected in the opposite sides of the studied region (Fig. 1).

Archaeological samples S14 (Arenal de la Costa) and S15 (Bancal de Satorre) are very similar in their REE, Sc and Y values. The other archaeological sample (S16, Ereta del Pedregal) has higher values in those elements and so it is clearly different from the other two archaeological samples. Therefore REE, Sc and Y clearly put in evidence geochemical differences between dolerites collected from different areas of the same region.

Major elements results are reported in Table 4.

ID	Al <sub>2</sub> O <sub>3</sub> %	SiO <sub>2</sub> %	K <sub>2</sub> O%	CaO%	Ti%	Fe%
S4	10.6 ± 0.3	51.2 ± 0.2	0.277 ± 0.010	4.8 ± 0.07	0.652 ± 0.007	6.87 ± 0.11
S10	13.6 ± 0.7	44.7 ± 1.2	3.54 ± 0.12	1.8 ± 0.04	0.98 ± 0.03	8.16 ± 0.11
S9	10.0 ± 0.4	49.3 ± 1.2	0.373 ± 0.008	8.4 ± 0.18	0.487 ± 0.009	8.485 ± 0.012
S1	11.38 ± 0.79	47.3 ± 0.8	0.871 ± 0.016	7.8 ± 0.11	0.64 ± 0.04	9.22 ± 0.08
S11	11.5 ± 0.3	44.2 ± 2.8	2.61 ± 0.11	6.1 ± 0.39	0.67 ± 0.04	8.95 ± 0.14
S12	12.0 ± 1.6	52.7 ± 0.4	5.48 ± 0.03	5.4 ± 0.07	0.586 ± 0.009	8.62 ± 0.14
S5	14.11 ± 0.014	53.0 ± 0.2	2.16 ± 0.02	5.5 ± 0.12	0.648 ± 0.006	7.95 ± 0.06
S6	11.23 ± 0.14	52.70 ± 0.02	0.951 ± 0.006	8.268 ± 0.003	0.755 ± 0.003	9.892 ± 0.004
S7	10.67 ± 0.10	45.60 ± 1.04	1.54 ± 0.04	6.5 ± 0.09	0.836 ± 0.008	9.67 ± 0.25
S8	13.84 ± 0.06	50.95 ± 0.07	2.09 ± 0.04	7.2 ± 0.08	0.729 ± 0.012	9.63 ± 0.11
S2	11.957 ± 0.008	47.2 ± 0.2	0.80 ± 0.002	8.6 ± 0.06	0.631 ± 0.009	9.12 ± 0.05
S3	13.1 ± 0.5	49.3 ± 0.4	0.677 ± 0.021	9.3 ± 0.10	0.565 ± 0.009	9.31 ± 0.02
S13	13.73 ± 0.15	51.9 ± 0.5	1.06 ± 0.02	7.8 ± 0.15	0.6271 ± 0.0014	9.89 ± 0.19
S14	13.04 ± 0.09	48.26 ± 0.06	2.94 ± 0.03	6.2 ± 0.06	0.632 ± 0.004	9.13 ± 0.06
S15	14.3 ± 0.3	52.6 ± 1.7	1.57 ± 0.05	6.7 ± 0.25	0.65 ± 0.03	8.56 ± 0.14
S16	14.03 ± 0.11	51.3 ± 0.4	1.84 ± 0.03	4.2 ± 0.09	0.571 ± 0.003	6.60 ± 0.16

Table 4: Oxides and major element values and standard deviation expressed as percentage (%)

Ti/Fe relationship (Lago et al., 1999) to detect differences between dolerite samples has been employed. The Ti/Fe values of are very similar between all the samples except sample S10 and S9. In fact, as mentioned above, these two samples were collected in extreme north (Altura) and south (Orihuela) of the studied area. So have already been observed that this Ti/Fe factor is able to discriminate sample provenance in a wider geographical areas compared to the REE values that could help to distinguish samples provenance from narrow range areas (Gallelo et al., 2015).

## REE ratios of dolerite samples

Rare earth elements ratios  $\text{La/Yb}^*$ ,  $\text{La/Gd}^*$ ,  $\text{La/Sm}^*$  and  $\text{Sm/Yb}^*$  were used to observe rock samples chemical weathering processes. Figure 2 shows that samples coming from natural outcrops 'Pinoso' (S4), 'Finestrat' (S1, S2, S3), 'Almansa' (S11, S12, S13) and 'Vinalopó', (S5 and S8 Vinalopó samples) are similarly distributed. On the other hand 'Orihuela' field sample (S9) is farther from the aforementioned group. It is remarkable that 'Vinalopó' field samples S6 and S7 are different than S5 and S8 and other samples recovered in the same area.

The Figure 2 clearly shows that there is an important enrichment on  $\text{La/Yb}^*$ ,  $\text{La/Gd}^*$ ,  $\text{La/Sm}^*$  and  $\text{Sm/Yb}^*$  especially in S10 ('Altura') and S16 ('Ereta del Pedregal') that were collected in two different geographical areas and also show variation between each other.

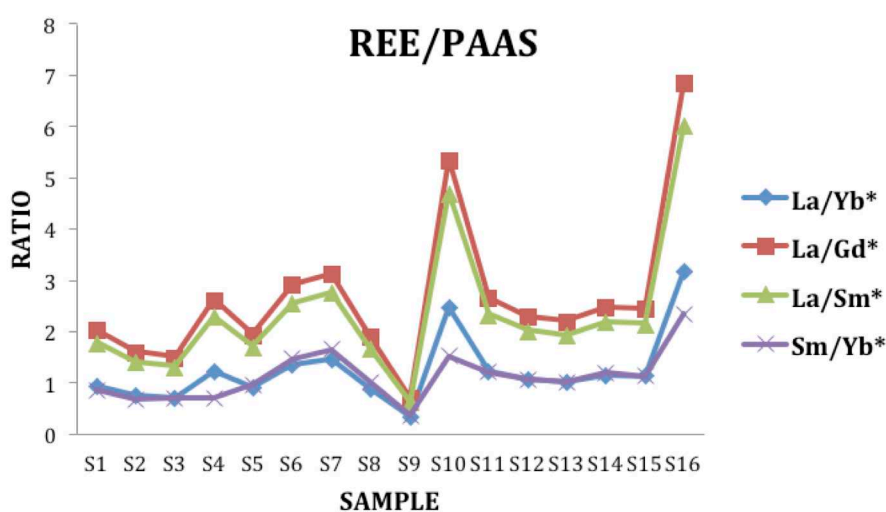


Figure 2: REE/PAAS ratios of the studied samples.

Looking carefully at the relationship between natural outcrops and archaeological materials S1, S2, and S3 samples (Finestrat-Orxeta), S4 (Pinoso-Xinorlet), S5 and S8 (Vinalopó) and S11, S12, and S13 (Almansa) belong all to outcrops that although they are to a certain distance each other, they are in the same geological domain. This fact could justify similarities in the depletion and enrichment REE/PAAS ratio due to similar weathering processes.

More important is the relation that exists between the mentioned outcrops and S14 and S15 archaeological samples. S14 and S15 are tool objects proceeding respectively from Arenal de la Costa and Bancal de Satorre, that seems very similar in its ratios to the Almansa samples (S11, S12, S13). Therefore hypothetically the primary employed materials to manufacture Arenal de la Costa and Bancal de Satorre polished tools could be extracted in any of these outcrops.

Field sample S9 from Sierra de Orihuela contains a depleted REE/PAAS ratio compared to the other samples. Sample S10 from Altura (Castellón) outcrop is clearly different from the other samples due to its enrichment on the REE/PAAS ratio, probably because its different geological origin (Iberic domain) compared to the other source areas (Betic domain).

S16 is an archaeological fragment from an Ereta del Pedregal (Navarrés, Valencia) polished axe. This sample cannot be related to any of the studied outcrop samples and is different than the other archaeological samples due to its higher  $\text{La/Yb}^*$ ,  $\text{La/Gd}^*$ ,  $\text{La/Sm}^*$  and  $\text{Sm/Yb}^*$  ratios.

Two outliers preceding from Vinalopó (Santa Eulalia) outcrops have been found (S6 and S7). Those two have REE/PAAS ratios higher than samples S5 and S8 from the same outcrop. Samples S6 and S7 are positioned closer to Almansa samples (S13, S11, and S12) than the other two samples (S5 and S8). These results confirm hypothesis proposed in a prior published study (Gallelo et al., 2015) that this anomaly may be related to the model of exploitation quarries in Vinalopó, nowadays completely exhausted, and

maybe rocks from a different layer with unlike chemical characteristics have been collected in this case. Therefore the weathered processes that were developed from these rocks were different and this is reflected in the enrichment of REE/PAAS ratios.

As was already shown by prior studies (Gallello et al., 2015), the results confirm that REE analysis enables to distinguish between different outcrops and not less important permit to reconstruct the origin of the primary material for the manufacturing of prehistoric tools. Furthermore our data show that the capacity of rare earth to discriminate outcrops in a very restricted area is related to the high susceptibility of these elements to the chemical weathering processes, in fact those could change between outcrops and cause an enrichment or depletion of REE.

## Conclusions

REE have proven to be useful in relating the primary material of the quarries with the lithic objects, due probably to the particular characteristics of these chemical elements. In fact in this work the employed La/Yb\*, La/Gd\*, La/Sm\* and Sm/Yb\* ratios show that it is the high susceptibility of these elements to the weathering processes that cause an enrichment or depletion of REE that helps to discriminate the different outcrops in a restricted area.

REE seem to be good discriminators to relate quarries with prehistoric lithic objects found in the archaeological sites located in a restricted area. We have been able to associate the dolerite rocks proceeding from natural outcrops with archaeological lithic objects coming from archaeological sites. The archaeological objects found at Bancal de Satorre and Arenal de la Costa archaeological sites may be related to the raw materials collected in quarries located in Almansa outcrops area. On the contrary, the values for the Ereta del Pedregal polished axe cannot be related to the source areas presented in this work.

On the other hand, as has been observed (Gallello et al., 2015) major elements specifically the relation between Ti/Fe may be used to determine differences between dolerite outcrops located in remote geographic areas.

Finally, this REE analysis based proposed method may be able to discern the regional origin of lithic objects belonging to the same classes of rocks (dolerite), bringing a new proposal -that needs to be developed in further studies- about the reconstruction of dolerite primary material transports and exchange of lithic materials in Prehistory.

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