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ORIGINAL PAPER

Long-distance provenance for obsidian artifacts of Mesoamerica Preclassic and Early Classic periods found in the Los Naranjos Archaeological Park (Honduras)

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Abstract Los Naranjos is one of the most important pre-Columbian human settlements of Honduras related to the south-easternmost border of the Mayan civilization. Although the archaeological site mostly spans from 850 BC to 1250 AD, the present obsidian study was only focused on the Preclassic and Early Classic periods (Jaral, 800–400 BC and Edén, 400 BC–550 AD) where undamaged blades and/or retouched obsidian flakes are rare. In this way, the INAA analyses of 17 obsidian samples, compared with major-trace elements data of Honduran and Guatemalan obsidian sources, are mostly representative of waste flakes. Lithic artifacts of Los Naranjos such as sandstones, basalts, and quartzites come from local geological outcrops; whereas, obsidian provenance has to be searched from sources which are located within a radius up to 300 km far away. San Luis, La Esperanza, and Güinope obsidian sources are located in Honduras while the three most exploited Highland Guatemalan obsidian outcrops, which have been dominating long-distance trade in the Maya area mostly for the Classic-Postclassic periods, are San Martin de Jilotepeque, El Chayal, and Ixtepeque. An Ixtepeque provenance, for all the investigated obsidian samples of Preclassic and Early Classic periods found in the Los Naranjos Archaeological Park, was established, thus emphasizing a long-distance source (180 km). This also confirms that Ixtepeque represents the most important provenance of the obsidian artifacts found in archaeological sites of Western and Central-Western Honduras. The possible role played by some of the most important rivers of Guatemala and Honduras as waterway networks of transport was finally pointed out. New INAA chemical data from the Honduran obsidian source of La Esperanza ("Los Hoyos", 4 samples) are also reported in this paper.

Keywords Obsidian · Provenance · Los Naranjos Archaeological Park · Honduras · Mesoamerica · Ixtepeque

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Introduction

Archaeological background

Los Naranjos Archaeological Park represents, after Copán, the most important human settlement of Honduras related to the Mesoamerica culture (Fig. 1). The archaeological site is referred to the Prehispanic period development (850 BC–1250 AD; Baudez and Becquelin 1973) and predates the Maya city state. It is located in Central-Western Honduras near the northern shoreline of the Yojoa Lake, which has an altitude of about 635 m a.s.l., with a surface of 82.5 km^2 and a maximum depth of 26.5 m (Cruz and Valles 2002; Fig. 1). The Los Naranjos settlement was developed near the Yojoa Lake because of the presence of both prime agricultural land and permanent water sources which were the two fundamental reasons in determining the choice of a settlement build up during the Prehispanic Honduras (Martinez 2010).

From an archaeological point of view, Honduras is located on the northern edge of the Intermediate Area (Martinez 2010) corresponding to the southern periphery of Mesoamerica (Kirchhoff 1943) whose culture historically developed in a span time of 3000 years up to the Spanish conquest (Rovira 2007). In particular, the Mesoamerica chronology is divided in

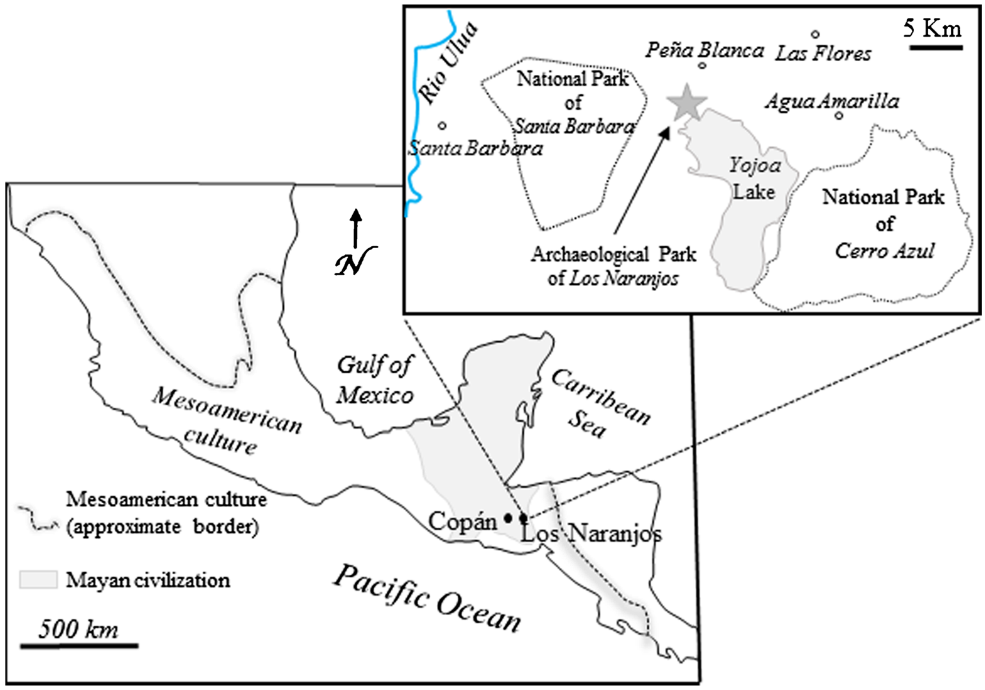

Fig. 1 Los Naranjos archaeological site in the framework of the Prehispanic Mesoamerica culture and the Central-Western Honduras (inset)

the following three main periods: (i) Preclassic (1500 BC–100 AD) starting from little villages to wide built-up areas especially around ritual centers, linked to the fundamental Olmec culture (1200–400 BC) which influenced the development of Los Naranjos settlement (Cruz and Valles 2002; Rovira 2007). (ii) Classic period (100 AD–950 AD) characterized by the Teotihuacan culture, during which the major urban and religious centers were built and traded, and relations with the Maya cities were established. The 600–950 AD period, known as the Late to Terminal Classic one, represented the splendor of the Maya cities, located in the regions of Yucatan, Guatemala, Belize, El Salvador, and Western Honduras, where the city of Copán represents one of the most important centers of this culture. (iii) Postclassic period (950–1500 AD) characterized by a complex urban life with intense trade with the Maya cities of the northern Yucatan. In the Late Postclassic period, an empire in the center of Mexico was born (Toltec and Aztec), and its military organization affected all the Mesoamerica up to the Spanish conquest (Rovira 2007).

Los Naranjos (Fig. 1) developed in a span time of 850 BC–1250 AD; although, some studies performed on the sediments of the Yojoa Lake recognized some human activity even around 3000 BC (Cruz and Valles 2002). In addition, an ancient settlement in the area close to the archaeological site, dating back to the Paleoindio (before 7000 BC) and Archaic (7000–2000 BC) periods was also indicated by Cruz and Valles (2002). Los Naranjos settlement, covering an area of ca. 1.5 Km^2, probably developed under the Olmec culture (Lara 2006) starting from the Jaral period (800–400 BC). On the base of the construction phases, Baudez and Becquelin (1973) recognized different periods during which the settlement moved from the eastern to the northeastern shorelines of the Yojoa Lake. The first structure named "Grupo Principal" is referred to the Jaral period (800–400 BC) followed by the Edén (1 and 2) period (400 BC–550 AD) with the extension of buildings and a new defensive trench. The last phases, termed Yojoa (550–950 AD) and Río Blanco (950–1250 AD) are characterized by the occupation by the inhabitants of the North-Western area of the plain with the abandonment of the ancient "Grupo Principal". Although firstly thought a Maya village, people of Los Naranjos during the Classic period should be considered as belonging to the Lenca-Protolenca culture (Baudez and Becquelin 1973; Cruz and Valles 2002).

Lithic artifacts and geological sources

For the whole chronological phases of the Los Naranjos archaeological site, Baudez and Becquelin (1973) recovered about 2700 "lithic samples", 695 of which are represented by obsidian fragments, flakes, and, in minor amount, blades. The obsidian tools were produced in the Los Naranjos site itself using the lithic reduction by percussion and/or pression and were used as excellent sharp-edged blades. Nevertheless, undamaged blades and/or retouched flakes are rare in the two most ancient Jaral and Edén periods (Baudez and Becquelin 1973) to which the 17 investigated obsidian samples belong. As a matter of fact, obsidian tools, rather than flakes, become more and more abundant in the successive Yojoa and Rio Blanco periods. Other rocks, among which quartzites prevail (Baudez and Becquelin 1973), are represented by sandstones, basalts (also used in some sculptures), rare limestones, volcanic tuffs, and schists. Green stones (not necessarily jadeites) were employed for ornaments and axes (Baudez and Becquelin 1973). Sandstones, basalts, and quartzites generally have a local geological provenance, while obsidian sources used by Mesoamerican people could be identified in various parts of Mexico, Guatemala, and Honduras (Hendon 2004). Among the Precolumbian societies of Mesoamerica, also people of the region of the Yojoa Lake considered the obsidian as a useful raw material for the production of working tools because of its sharp conchoidal fracture surfaces, ornaments, or ceremonial items. During the Prehispanic period, a Mesoamerica obsidian trade was therefore well established (Moholy-Nagy 2003; Nazaroff et al. 2010); and several Guatemalan and Honduran obsidian sources are recognized for most of the lithic artifacts which are found in the archaeological sites of the South-Eastern sector of the Maya civilization (Western and Central-Western Honduras; Hendon 2004; Martinez 2010). These sources are located within a radius up to 300 km far away from Los Naranjos settlement. San Luis (35 km to NW), La Esperanza (70 km to SSW), and Güinope (180 km to SE) are the main Honduran obsidian sources; whereas, the three most exploited Highland Guatemalan outcrops, which have been dominating the trade in the Maya area since at least 400 BC (Moholy-Nagy 2003; Brown et al. 2004) are San Martin de Jilotepeque (260 km), El Chayal (235 km), and Ixtepeque (180 km). Baudez and Becquelin (1973) inferred for three obsidian samples found at Los Naranjos and belonging to the Jaral period, a provenance from San Martin de Jilotepeque in Guatemala (2 samples) and La Esperanza in Honduras (1 sample). This inferred obsidian source regions are, however highly uncertain, being strongly biased by the analytical method (only macroscopic features of the obsidian artifacts).

Instrumental Neutron Activation Analyses (INAA) are considered among the most sensitive analytical methods in unraveling obsidian provenance (Glascock 1994; Pollard et al. 2007; Santi et al. 2010). For this reason, INAA were performed on 17 obsidian samples of Los Naranjos and compared with chemical compositions of Mesoamerica obsidian sources.

The potential source areas of obsidians

Honduran sources

The San Luis area (Fig. 2), located in the Department of Santa Barbára, to the south of the Quimistan Valley, in the middle of the Chamelecón River drainage, is the nearest obsidian source with respect to the Los Naranjos settlement. Aoyama et al. (1999) estimated that the levels containing obsidian cobbles in the San Luis area are represented by 10–20 m thick discontinuous lenses. The INAA analyses (Aoyama et al. 1999) were performed on natural cobbles collected from different sources located very close to the city of San Luis such as San Luis itself, Agua Helada, and El Paraíso. In addition, Agua Sucia samples were derived from the Quimistan Valley, outside the city of San Luis.

La Esperanza obsidian outcrops are located in the South-Western Highlands of Honduras (Fig. 2) in the Department of Intibucà (El Cedral area). The abundant prismatic blades and polychrome ceramics at various sites in the La Esperanza area indicate source utilization at least during the Classic period and likely during the Postclassic as well (Sheets et al. 1990). Sorensen and Hirt (1984) identified six sites where obsidian was either outcropping and/or worked. In fact, in the eastern flank of El Cedral, a large quantity of obsidian nodules ranging from 1 to 30 cm in diameter are present. These water-worn cobbles are found all around the base of El Cedral deriving from the areas locally known as “Los Hoyos”, exploited during the Prehispanic period (Chapman 1982) by means of narrow vertical shafts that directly reached the top of the obsidian lava flow. Two samples from this source were analyzed by INAA (Sheets et al. 1990).

The Güinope source area, located in the Department of El Paraìso, close to the southern border with Nicaragua (Fig. 2), is constituted by abundant water-worn cobbles ranging from 1 to 15 cm in diameter dispersed along the floor of the Quebrada Grande stream. Although the main source lies in the Cerro Grande area, near Cerro Loma de Pie, outcrops are scattered anywhere in the Güinope region. Obsidian apparently occurs only as rock debris and left as erosional float from ancient obsidian flow (Sheets et al. 1990); in fact, no evidence of vertical shaft mines similar to those at “Los Hoyos” (La Esperanza) were never observed or reported in the Güinope area.

Guatemalan sources

Concerning Guatemala, the Prehispanic obsidian sources are Ixtepeque, El Chayal, and San Martin de Jilotepeque (Fig. 2), characterized by relatively different span times of exploitation and trade. In particular, according to Nelson (1985) and Rice et al. (1985), San Martin de Jilotepeque was commonly traded during the Middle Preclassic (1000–350 BC) but declined in use during the Late Preclassic (350 BC–159 AD) through the Terminal Classic period (830–950 AD) when El Chayal area became the dominant source, only to be overshadowed by Ixtepeque obsidians during the Postclassic (950–1500 AD).

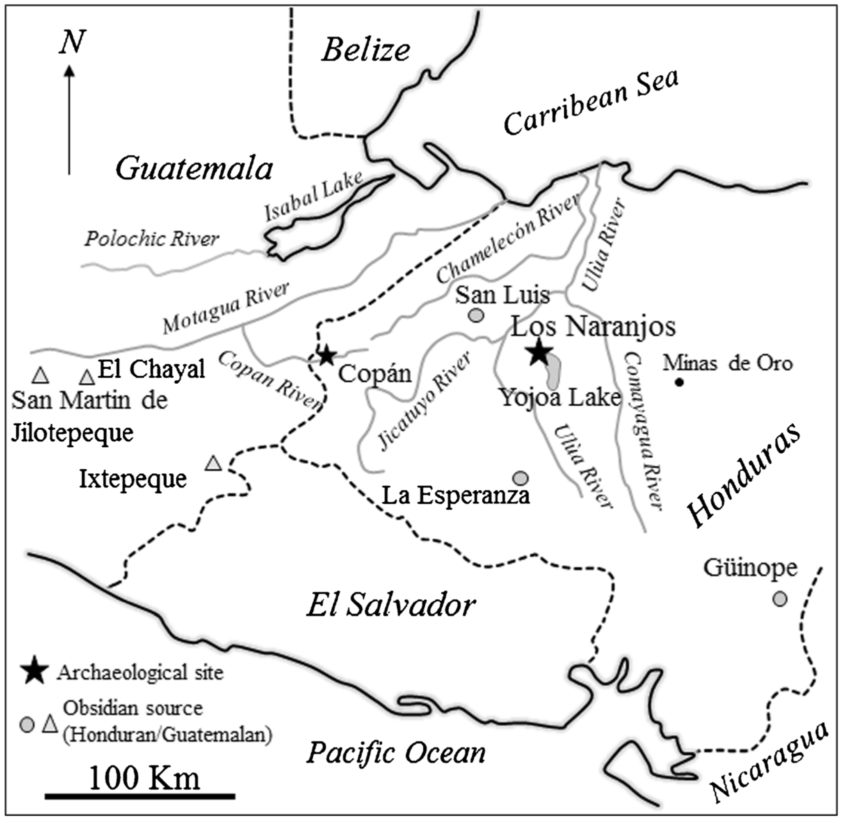

Fig. 2 Map showing the Los Naranjos archaeological site and the obsidian source areas of Honduras and Guatemala (from Aoyama et al. 1999 modified)

Ixtepeque (from the Aztec word for obsidian) represents an obsidian source most probably exploited since Preclassic period (1400 BC–50 AD; Aoyama et al. 1999). Large obsidian lava flows were erupted during the activity of the homonymous volcano (Fig. 2) located in the eastern part of Guatemala in the Department of Jutiapa. One of the main features of this volcano is the large number of obsidian lava flows erupted within the Ipala graben from a NE trending eruptive fissure that passes through adjacent rhyolitic lava domes and basaltic cinder cones. The obsidians of Ixtepeque are generally black in color but a red lithotype was also found. These obsidian flows represent the most important sources for the native of Guatemala, México, El Salvador, and Honduras during the pre-Columbian period. A large quantity of obsidian flakes or small nodules were imported in both Copán Valley and in the region of La Entrada (between Copán and Yojoa Lake) mostly during Classic-Late Classic periods (Aoyama et al. 1999) due to the vicinity of the settlements (86 and 115 km, respectively) and also for the high quality of the geomaterial for blade production. The literature INAA data concern outcropping obsidian deriving from the major quarried area and samples from the collection of the University of California, Berkeley (Asaro et al. 1978).

El Chayal (Fig. 2) is considered one of the largest sources in Guatemala and includes two major quarries: La Joya and Chayal *stricto* sensu (Asaro et al. 1978) and five other outcrops which are comprised within an area that ranges over ca. 100 km^2 (Sidrys 1976).

The obsidian source of San Martín de Jilotepeque (Fig. 2), also known as Río Pixcaya, was primarily exploited during the Preclassic period (Asaro et al. 1978; Braswell and Braswell 1993).

Sampling and analytical methods

Obsidian finds at Los Naranjos Archeological Park

The studied 17 samples come from the inventory of lithic fragments and artifacts of the Los Naranjos Archaeological Park and were provided by the National Institute of Anthropology and History of Honduras in August 2011. They come from excavation points of the Edén (400 BC–550 AD) and Jaral (800–400 BC) periods all located in the easternmost and ancient part of the settlement, identified as the "Grupo Principal" area (Ito et al. 2012). Considering the rare presence of obsidian undamaged blades and/or retouched flakes in the two above ancient periods (Baudez and Becquelin 1973), the representativeness of the 5 samples of Jaral (Structure 6; Fig. 3a) and the 12 samples of Edén (Structures 2–3 and Well 1; Table 1; Fig. 3b) of the present

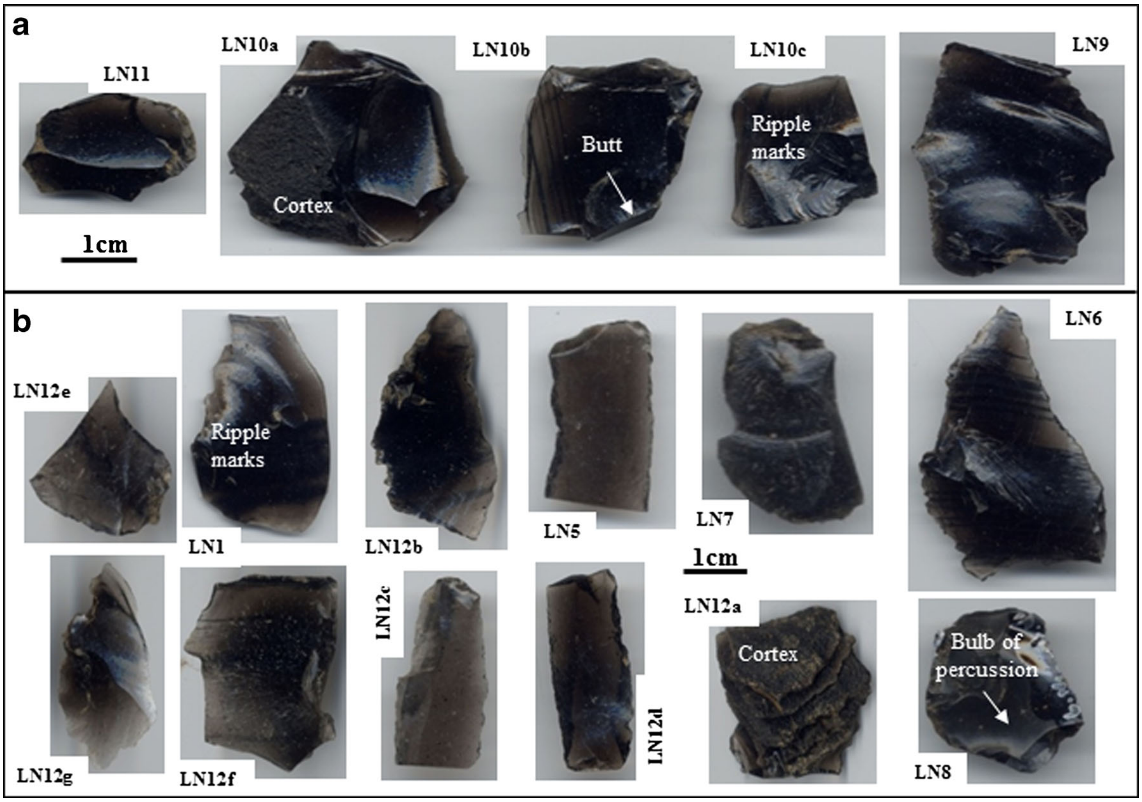

Fig. 3 Macroscopic features of the analyzed obsidian **a** samples from Structure 6, Jaral period, 800–400 BC; **b** samples from Structures 2 and 3 and Well 1, Edén period, 400 BC–550 AD

work, can be mostly related to fragments/waste flakes and very subordinately to tools.

The 17 obsidian fragments are macroscopically black in color, and some of them show some transparency (Fig. 3), and others (LN1, LN6, LN10b and LN12f; Fig. 3) are characterized by a flow banding due to the alternating of millimetric darker layers. Their size is comprised between 1.5 and 4 cm in length. In some samples, knapping traces are well recognizable, such as bulbs of percussion and also butt; in the ventral surfaces, ripple marks are very frequent due to the conchoidal fractures of the obsidian (Fig. 3). Samples LN5, LN12c, and LN12d (Edén period) which are characterized by much thinner thickness, could represent fragments of blades/knives (Fig. 3b). In addition, the presence of the cortex (dorsal surfaces) in some samples could be referred to possible waste flakes or uncompleted tools.

Table 1 Summary of the investigated samples

Los Naranjos obsidian archaeological samples	
LN1	Structure 2–Trench 1 (Edén period)
LN12 a, b, c, d, e, f, g	Structure 2–Trench 3 (Edén period)
LN5, LN6, LN7	Structure 3–Trench 2 (Edén period)
LN 8	Well 1–(Edén period)
LN9, LN10 a, b, c, LN11	Structure 6–Area 1 (Jaral period)
Obsidian source samples	
LAE1a, LAE1b, LAE2a, LAE2b	La Esperanza

La Esperanza obsidian outcrop

Besides the 17 investigated obsidian artifacts of Los Naranjos, in this paper, we also report new compositional data of four obsidian waste flake samples (Table 1) collected from La Esperanza source outcrop ("Los Hoyos"). La Esperanza obsidian source is located in the South-Western Highlands of Honduras (Fig. 2), in the Department of Intibucà. This source area was firstly reported by Lunardi (1948), and, most likely, the major exploitation phase of this outcrop dates back to the Classic period. Chapman (1982) reported large quantities of obsidian near El Cedral, 4 km northwest of the town of La Esperanza where evidence of Prehispanic mining subsurface of such a volcanic lithotype is documented in the area called "Los Hoyos". Following Chapman's (1982) report, the El Cedral area was investigated through a project since 1983, and obsidian outcrops and mining areas, as well as several production centers, were identified at La Esperanza. The exploitation sites in the past periods were represented by narrow holes (vertical shafts) that directly reached the roof of the obsidian flows. More than 30 shafts

Table 2 Si, Ti, Al, Fe, Ca, Na, K (%) and trace elements (ppm) of the Los Naranjos archaeological obsidian samples (INAA).

	Structure 6										Structure 2						
%	LN9	σ	LN10A	σ	LN10B	σ	LN10C	σ	LN11	σ	LN1	σ	LN12A	σ	LN12B	σ	LN12C
Si	35.71	0.04	35.67	0.11	35.67	0.56	35.67	0.04	35.67	0.09	35.39	0.58	35.67	0.09	35.67	0.06	35.67
Ti	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.01	0.19	0.00	0.19	0.01	0.19	0.01	0.19	0.00	0.19
Al	7.38	0.07	7.37	0.02	7.39	0.07	7.37	0.02	7.37	0.01	7.38	0.05	7.39	0.01	7.38	0.02	7.38
Fe	0.89	0.00	0.89	0.00	0.89	0.00	0.89	0.00	0.89	0.00	0.90	0.00	0.89	0.00	0.90	0.00	0.89
Ca	0.73	0.00	0.74	0.00	0.74	0.00	0.73	0.00	0.73	0.01	0.73	0.01	0.74	0.01	0.73	0.00	0.74
Na	2.95	0.01	2.95	0.01	2.95	0.01	2.95	0.01	2.95	0.01	2.96	0.02	2.95	0.01	2.96	0.01	2.95
K	3.78	0.03	3.77	0.09	3.76	0.05	3.78	0.03	3.74	0.02	3.76	0.05	3.76	0.05	3.77	0.07	3.72
ppm																	
Mg	736	0.26	738	0.24	736	0.59	735	0.86	737	0.18	736	0.37	737	0.11	737	0.23	736
Mn	464	1	463	1	463	0.35	463	1	463	1	463	1	464	1	464	0.35	463
Sc	2.05	0.01	2.05	0.01	2.06	0.00	2.05	0.01	2.06	0.00	2.05	0.01	2.05	0.01	2.06	0.01	2.05
Cr	0.71	0.00	0.71	0.00	0.72	0.01	0.71	0.01	0.72	0.00	0.71	0.01	0.71	0.00	0.71	0.01	0.71
Ni	6.56	0.03	6.58	0.02	6.60	0.08	6.57	0.05	6.57	0.08	6.39	0.34	6.59	0.04	6.56	0.08	6.60
Co	1.02	0.01	1.02	0.00	1.02	0.01	1.02	0.01	1.02	0.01	1.04	0.03	1.03	0.00	1.03	0.05	1.02
Zn	28	0.24	28	1	28	0.09	28	0.03	27	0.08	28	0.48	28	0.07	27	0.09	28
Ga	67	0.02	67	0.04	67	0.03	67	0.02	67	0.03	67	0.24	67	0.02	68	0.04	68
As	46	0.18	46	0.29	46	0.27	45	0.19	46	1	46	1	46	0.37	45	0.27	46
Br	2.98	0.08	2.95	0.07	2.96	0.03	2.94	0.04	2.95	0.02	2.92	0.06	2.96	0.07	2.94	0.05	2.95
Rb	100	0.07	100	0.04	100	0.03	100	0.02	100	0.01	100	0.09	100	0.03	95	0.04	100
Sr	154	1	154	0.33	153	1	150	0.39	154	1	154	1	153	1	150	0.31	154
Zr	157	0.20	157	1	156	0.25	156	0.22	156	0.22	156	1	156	0.22	155	0.25	156
Nb	60	0.09	61	1	60	0.04	60	0.08	60	0.02	60	0.14	60	0.05	60	0.14	60
Sb	0.24	0.00	0.24	0.00	0.24	0.01	0.24	0.00	0.24	0.00	0.24	0.01	0.24	0.00	0.24	0.00	0.24
Cs	2.74	0.00	2.74	0.01	2.74	0.01	2.74	0.00	2.74	0.01	2.73	0.03	2.74	0.01	2.75	0.01	2.74
Ba	1057	0.49	1057	7	1058	9	1058	0.32	1057	1	1055	5	1058	0.36	1060	1	1058
La	24	0.38	24	1	25	1	24	0.40	24	0.47	24	1	24	0.25	25	1	24
Ce	43	0.02	43	0.05	43	0.03	43	0.02	43	0.04	43	0.23	43	0.02	43	0.04	43
Nd	17	0.06	18	1	17	0.22	17	0.06	17	0.04	17	1	17	0.05	18	0.09	17
Sm	3.04	0.04	3.05	0.03	3.08	0.03	3.06	0.04	3.08	0.03	3.08	0.06	3.08	0.09	3.09	0.09	3.08
Eu	0.51	0.01	0.51	0.01	0.51	0.01	0.50	0.00	0.51	0.01	0.50	0.00	0.51	0.01	0.51	0.00	0.51
Gd	3.51	0.06	3.47	0.03	3.50	0.06	3.55	0.08	3.48	0.09	3.47	0.03	3.47	0.03	3.46	0.06	3.50
Tb	0.39	0.00	0.39	0.00	0.39	0.00	0.39	0.00	0.39	0.00	0.39	0.00	0.39	0.00	3.89	0.00	0.39
Dy	2.35	0.01	2.35	0.00	2.35	0.00	2.35	0.01	2.35	0.00	2.35	0.01	2.35	0.00	2.36	0.01	2.35
Ho	0.49	0.00	0.49	0.00	0.50	0.00	0.49	0.00	0.49	0.00	0.49	0.00	0.49	0.00	0.49	0.00	0.50
Tm	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19
Yb	1.87	0.00	1.87	0.00	1.87	0.01	1.87	0.00	1.87	0.01	1.85	0.02	1.87	0.01	1.88	0.01	1.87
Lu	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28
Hf	4.66	0.09	4.68	0.03	4.67	0.08	4.66	0.09	4.65	0.02	4.64	0.04	4.67	0.05	4.70	0.02	4.66
Ta	0.81	0.00	0.81	0.00	0.81	0.00	0.81	0.01	0.81	0.01	0.81	0.00	0.81	0.00	0.81	0.00	0.81
Th	6.64	0.01	6.64	0.01	6.64	0.00	6.64	0.00	6.64	0.00	6.64	0.01	6.63	0.01	6.67	0.00	6.64
U	2.29	0.00	2.28	0.06	2.30	0.05	2.29	0.00	2.28	0.01	2.29	0.02	2.28	0.00	2.28	0.01	2.29
Zr/Nb	2.6		2.6		2.6		2.6		2.6		2.6		2.6		2.6		2.6
Rb/Nb	1.7		1.6		1.7		1.7		1.7		1.7		1.7		1.6		1.7
La/Yb	13.0		12.9		13.2		13.0		12.9		13.0		13.1		13.1		13.0

Table 2 (continued)

Structure 2									Structure 3						Well 1	
σ	**LN12D**	σ	**LN12E**	σ	**LN12F**	σ	**LN12G**	σ	**LN5**	σ	**LN6**	σ	**LN7**	σ	**LN8**	σ
0.04	35.67	0.02	35.68	0.02	35.67	0.03	35.67	0.02	35.67	0.06	35.87	0.08	35.47	0.07	35.67	0.13
0.00	0.19	0.01	0.19	0.01	0.19	0.00	0.19	0.01	0.19	0.01	0.19	0.01	0.19	0.01	0.19	0.00
0.05	7.37	0.02	7.38	0.03	7.37	0.03	7.39	0.01	7.40	0.07	7.40	0.03	7.38	0.05	7.40	0.02
0.00	0.89	0.01	0.89	0.00	0.90	0.00	0.89	0.00	0.90	0.01	0.89	0.01	0.89	0.00	0.90	0.00
0.01	0.73	0.01	0.73	0.00	0.73	0.01	0.73	0.01	0.73	0.01	0.73	0.00	0.73	0.01	0.74	0.01
0.01	2.95	0.00	2.95	0.00	2.95	0.00	2.96	0.00	2.96	0.03	2.95	0.01	2.93	0.01	2.96	0.00
0.04	3.77	0.01	3.77	0.01	3.77	0.02	3.77	0.05	3.79	0.03	3.77	0.04	3.79	0.04	3.77	0.03
ppm																
0.28	737	0.14	736	0.12	736	0.15	737	0.12	736	0.02	736	0.39	737	0.34	737	0.28
0.22	463	1	463	0.17	463	1	464	0.17	464	0.3	464	1	463	0	464	0.43
0.01	2.05	0.00	2.05	0.00	2.05	0.00	2.06	0.00	2.04	0.01	2.05	0.01	2.06	0.01	2.05	0.01
0.00	0.71	0.01	0.71	0.01	0.72	0.01	0.71	0.01	0.72	0.00	0.71	0.00	0.71	0.01	0.71	0.00
0.08	6.57	0.08	6.55	0.09	6.56	0.03	6.57	0.09	6.31	0.09	6.59	0.03	6.58	0.08	6.53	0.04
0.02	1.05	0.08	1.02	0.07	1.05	0.06	1.02	0.06	1.05	0.04	1.02	0.01	1.06	0.03	1.05	0.07
0.03	28	0.01	28	0.02	27	0.03	28	0.06	28	0.23	28	0.14	27	1	28	0.45
0.02	68	0.04	67	0.03	68	0.05	67	0.07	67	0.26	67	0.09	67	0.09	67	0.06
0.19	46	0.09	46	0.08	46	0.11	46	0.07	45	1	46	0.48	45	0.42	45	1
0.03	2.96	0.02	2.96	0.09	2.93	0.02	2.97	0.08	2.90	0.07	2.96	0.03	2.94	0.02	2.96	0.05
0.02	100	0.05	100	0.07	100	0.01	100	0.01	100	0.15	100	0.08	99	0.07	100	0.02
0.38	154	0.19	153	1	154	0.21	154	1	154	0.04	154	1	154	0.47	154	0.38
0.26	156	0.18	156	0.16	156	0.43	156	0.39	156	1	157	0.11	157	0.09	156	1
0.09	60	0.04	60	0.04	60	0.06	60	0.04	60	0.22	60	0.09	60	0.22	60	0.36
0.00	0.24	0.00	0.24	0.01	0.24	0.01	0.24	0.00	0.24	0.00	0.24	0.00	0.24	0.01	0.24	0.01
0.00	2.74	0.00	2.74	0.00	2.74	0.00	2.74	0.00	2.74	0.01	2.74	0.01	2.74	0.01	2.74	0.01
0.40	1057	1	1057	0.41	1057	0.33	1057	1	1056	3	1058	0.49	1058	0.42	1058	1
0.38	24	0.33	24	0.12	24	0.22	25	0.33	24	1	24	1	24	1	25	1
0.02	43	0.09	43	0.08	43	0.02	43	0.06	43	0.08	43	0.05	43	0.04	43	0.06
0.07	17	0.06	17	0.05	17	0.09	17	0.05	18	0.31	17	0.21	18	1	18	1
0.04	3.06	0.02	3.06	0.09	3.04	0.02	3.05	0.07	3.10	0.08	3.06	0.05	3.07	0.07	3.09	0.03
0.00	0.50	0.01	0.51	0.00	0.50	0.01	0.51	0.01	0.50	0.00	0.50	0.00	0.50	0.00	0.51	0.01
0.03	3.48	0.06	3.49	0.06	3.47	0.04	3.48	0.02	3.43	0.05	3.50	0.08	3.54	0.07	3.49	0.07
0.01	0.39	0.01	0.39	0.00	0.39	0.01	0.39	0.00	0.39	0.01	0.39	0.00	0.39	0.01	0.39	0.01
0.00	2.35	0.01	2.35	0.00	2.35	0.00	2.36	0.00	2.35	0.01	2.35	0.00	2.35	0.00	2.36	0.01
0.00	0.49	0.01	0.49	0.00	0.49	0.00	0.49	0.00	0.50	0.00	0.49	0.01	0.49	0.01	0.49	0.01
0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00	0.19	0.00
0.00	1.87	0.00	1.87	0.00	1.87	0.00	1.87	0.01	1.87	0.09	1.83	0.04	1.85	0.02	1.89	0.01
0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00	0.28	0.00
0.08	4.67	0.02	4.66	0.01	4.66	0.00	4.66	0.01	4.63	0.02	4.66	0.03	4.67	0.04	4.67	0.04
0.00	0.81	0.00	0.81	0.00	0.81	0.00	0.81	0.01	0.81	0.00	0.81	0.00	0.81	0.00	0.81	0.00
0.01	6.63	0.00	6.64	0.00	6.65	0.00	6.64	0.00	6.65	0.00	6.64	0.01	6.65	0.01	6.64	0.00
0.01	2.28	0.00	2.29	0.01	2.29	0.00	2.28	0.00	2.30	0.07	2.28	0.05	2.29	0.03	2.28	0.00
	2.6		2.6		2.6		2.6		2.6		2.6		2.6		2.6	
	1.7		1.7		1.7		1.7		1.7		1.7		1.7		1.6	
	12.9		13.0		12.9		13.2		12.8		13.2		13.1		13.0	

and shallow depressions were observed covering an area of about 1 ha (Sheets et al. 1990).

Analytical method

In order to determine the composition (major and trace elements) of the investigated obsidian samples, Instrumental Neutron Activation Analysis (INAA) were performed at the laboratory of the University of Pavia according to the techniques described by Oddone et al. (1999). The standards used are the following: Obsidian Rock NIST-SRM 278 (National Bureau of Standard 1981; Bowen et al. 1992), nitric solution of analyzed elements, high purity Al, and Si (semiconductor grade). Irradiations, on 0.200–0.350 g of powdered sample, were performed at the Triga-Mark II reactor of Pavia; induced radioactivity was measured by γ-ray spectrometry using a Ge hyper-pure detector connected to a multichannel pulse height analyzer and personal computer. Data reduction was carried out using software for spectral analyses. The determined elements on the obsidians are Si, Ti, Al, Fe, Ca, Na, K (%), and Mg, Mn, Sc, Cr, Ni, Co, Zn, Ga, As, Br, Rb, Sr, Zr, Nb, Sb, Cs, Ba, La, Ce, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Tm, Yb, Lu, Hf, Ta, Th, and U (ppm). Average precision is generally about 4 %, except for Tb, Lu, Eu, and Sb for which it ranges from 11 to 24 %. Analyses of the Los Naranjos archeological artifacts are reported in Table 2 whereas samples from La Esperanza obsidian source are shown in Table 3.

Results

The archaeological fragments are characterized by a very homogeneous composition showing similar major element concentration (Si, Al, Fe, Ca, Na, K, and Ti; Table 2). The same homogeneous geochemical imprinting is shown by high field strength elements (HFSE) such as Zr (156–157 ppm), Nb (60–61 ppm), Ta (0.8 ppm), Hf (4.63–4.70 ppm), U (2.28–2.29 ppm), and Th (6.6–6.7 ppm); large ion lithofile elements (LILE) such as Rb (95–110 ppm), Cs (2.7 ppm), Ba (1055–1060 ppm), and Sr (150–154 ppm); light rare earth elements (LREE) such as La (24–25 ppm), Ce (43 ppm), and Nd (17–18 ppm); transitional metals such as Zn (27–28 ppm), Ni (6.31–6.60 ppm), and Mn (463–464 ppm), and alkaline earth metals such as Mg (736–738 ppm). All these very similar trace element abundances, together with constant trace element ratios among HFSE (e.g., Zr/Nb 2.6), LILE/HFSE (e.g., Rb/Nb 1.6–1.7), and LREE/HREE (e.g., La/Yb 12.8–13.2), concur in indicating the same source origin for the analyzed archeological samples of the Los Naranjos obsidians.

Concerning the obsidian samples coming from La Esperanza waste flakes, they show totally different composition with respect those from the Los Naranjos Archaeological Park, as can be seen by the representative trace element binary diagrams of Fig. 4. This figure also shows that the obsidian samples from Los Naranjos are also characterized by different trace element distribution with respect the other two well known obsidian source areas of Honduras (San Luis and Güinope), especially for Rb, La, and U. For this reason, the provenance of the Los Naranjos obsidian artifacts should be searched among the Guatemalan source outcrops (San Martin de Jilotepeque, El Chayal, and Ixtepeque). As emphasized in Fig. 4, the Los Naranjos obsidian samples have comparable La abundance with the three major Guatemalan obsidian sources; whereas, La vs Yb diagram (representative of the LREE/HREE ratio) rules out the San Martin de Jilotepeque area. In Fig. 4 an Ixtepeque provenance of the 17 Los Naranjos obsidian samples can be clearly established, as El Chayal samples show Mn and U contents significantly higher and Hf distinctly lower. All the Mexican, Honduran, and Guatemalan obsidian sources, excepting for Ixtepeque, have Th content between 8 and 20 ppm (Fig. 5). The Ixtepeque provenance is, therefore, univocally determined by the lowest content of both Th (6–7 ppm) and Cs (ca. 3 ppm) if compared with all the Mesoamerica obsidian sources (Mexico included; Fig. 5).

Discussion and final remarks

The comparison of the trace element compositions of the Los Naranjos samples with available INAA literature data for the Mesoamerica obsidian source areas represents a powerful tool to define the provenance of the obsidian artifacts and related route network. Chemical sourcing studies demonstrated that long-distance trade of obsidian was an important aspect of Mesoamerica past culture starting at least from 400 BC (Nazaroff et al. 2010 and reference therein). In the pre-Columbian cultures, the obsidian was a material highly appreciated and traded by the Maya and Lenca people. The commercial routes joined the exploitation obsidian areas to the settlements among which the most important in Honduras were Copán and Los Naranjos. In the archeological sites of Western and Central-Western Honduras, the Motagua, Chamelecón, and Jicatuyo Rivers should have represented the most useful SW-NE waterways of transport from the Guatemalan (Ixtepeque, El Chayal, and San Martin de Jilotepeque) and San Luis sources; whereas, Ulùa and Comayagua Rivers should have played a fundamental role for transporting the obsidian from the areas of La Esperanza and Güinope (Fig. 2).

Table 3 Fe, Ca, Na, K (%), and trace elements (ppm) of the La Esperanza obsidian source (INAA)

La Esperanza								
%	LAE1a	σ	LAE1b	σ	LAE2a	σ	LAE2b	σ
Fe	0.894	0.006	0.898	0.008	0.891	0.006	0.898	0.007
Ca	0.789	0.003	0.790	0.005	0.789	0.003	0.790	0.005
Na	2.89	0.03	2.89	0.04	2.81	0.02	2.89	0.07
K	3.70	0.05	3.73	0.06	3.66	0.03	3.70	0.05
ppm								
Mn	539	10	545	18	543	19	540	15
Sc	2.19	0.04	2.52	0.05	2.35	0.04	2.08	0.02
Cr	2.64	0.03	2.69	0.05	2.63	0.07	2.56	0.04
Ni	11.60	0.06	11.23	0.09	11.27	0.03	11.38	0.07
Co	1.61	0.07	1.70	0.05	1.72	0.06	1.70	0.03
Zn	42.6	0.6	43.2	0.4	46.3	0.5	46.4	0.3
Ga	26.96	0.09	26.71	0.05	27.6	0.10	25.78	0.09
As	3.82	0.02	3.85	0.09	3.80	0.03	3.86	0.07
Br	2.97	0.05	2.98	0.06	2.96	0.04	2.90	0.04
Rb	150	0.29	151	0.08	150	0.04	152	0.03
Sr	161	0.03	162	0.06	162	0.07	164	0.08
Zr	166	0.06	167	0.05	167	0.05	169	0.09
Nb	17.1	0.9	17.8	0.6	17.2	0.7	17.1	0.5
Sb	0.247	0.007	0.260	0.008	0.254	0.005	0.241	0.003
Cs	4.32	0.02	4.94	0.04	5.01	0.91	4.98	0.02
Ba	986	34	968	36	986	27	982	36
La	28.26	0.08	28.70	0.06	29.14	0.04	29.70	0.07
Ce	50.08	0.07	51.13	0.07	51.58	0.05	52.29	0.04
Nd	24.46	0.08	24.87	0.03	24.50	0.09	25.86	0.05
Sm	3.24	0.03	3.45	0.08	3.39	0.04	3.34	0.83
Eu	0.54	0.005	0.50	0.008	0.55	0.002	0.56	0.006
Gd	3.10	0.08	3.07	0.08	3.05	0.06	3.04	0.04
Tb	0.820	0.009	0.834	0.007	0.823	0.008	0.841	0.006
Ho	1.19	0.05	1.20	0.06	1.21	0.05	1.23	0.03
Tm	0.43	0.05	0.43	0.02	0.44	0.08	0.43	0.05
Yb	2.10	0.02	2.17	0.06	0.12	0.02	2.15	0.07
Lu	0.302	0.006	0.302	0.002	0.288	0.007	0.290	0.007
Hf	4.89	0.09	4.51	0.04	4.25	0.02	4.44	0.08
Ta	0.981	0.006	0.978	0.006	0.923	0.004	1.004	0.008
Th	11.56	0.07	11.50	0.06	11.40	0.05	11.34	0.06
U	3.60	0.04	3.83	0.03	3.83	0.02	3.90	0.05
Zr/Nb	9.7		9.4		9.7		9.9	
Rb/Nb	8.7		8.5		8.8		8.9	
La/Yb	13.4		13.2		252.1		13.8	

The investigated obsidian samples from the Jaral and Edén periods of Los Naranjos Archaeological Park, mainly representative of waste flakes rather than obsidian tools, show a homogeneous composition, compatible with the same provenance source area. Among the main Honduran and Guatemalan obsidian source areas, the best trace element overlapping is represented by Ixtepeque, a fundamental obsidian exploitation area in Mesoamerica. This Guatemalan source area is also consistent with the time interval of the obsidian artifacts to which Los Naranjos belongs (i.e. Jaral-Edén periods 800 BC–550 AD; Cruz and Valles 2002) as the mining activity at Ixtepeque was entirely performed between the early Preclassic (1800–800 BC) and Postclassic (950–

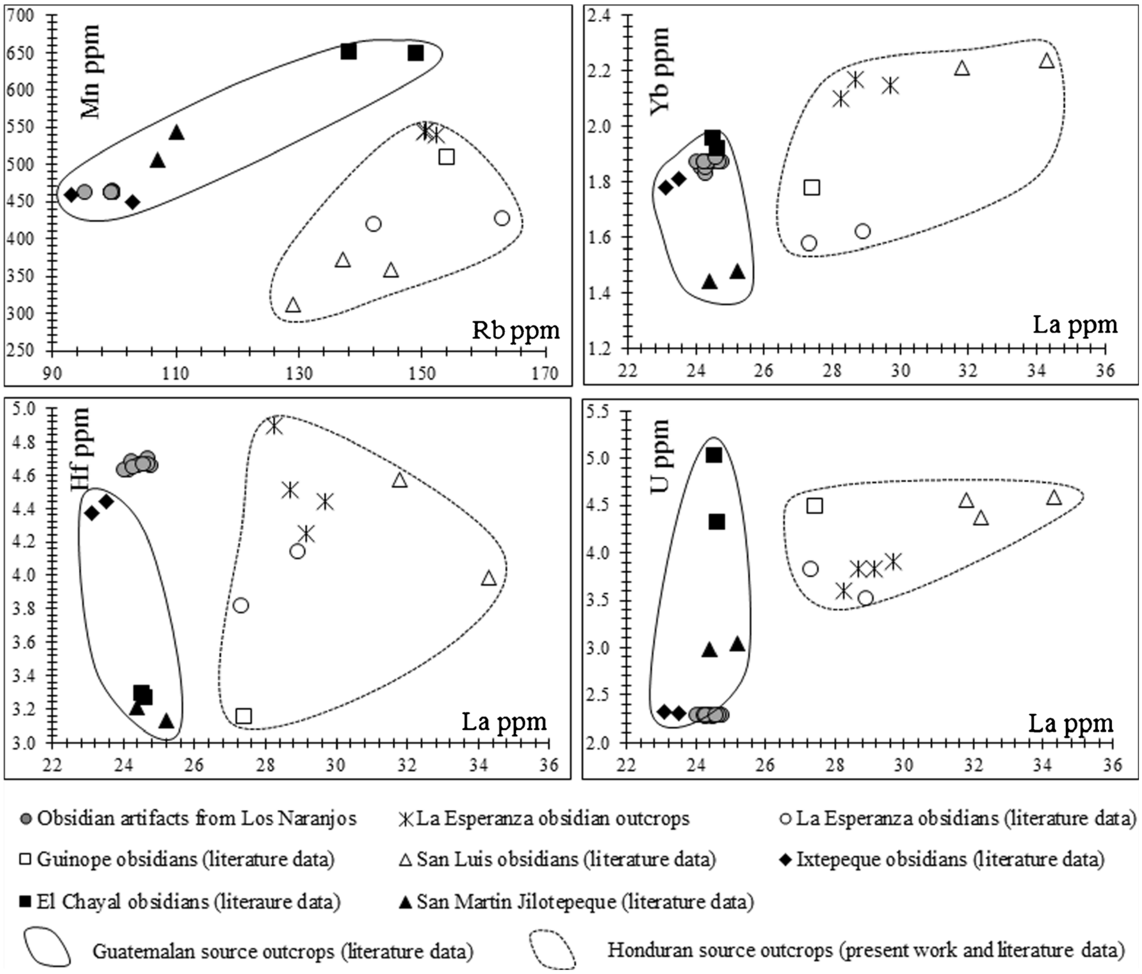

Fig. 4 Binary plots of Mn vs Rb and Yb, Hf and U vs La for the analyzed samples (INAA) of Los Naranjos compared with literature INAA data of Honduras (Glascock et al. 1990; Sheets et al. 1990; Aoyama et al. 1999) and Guatemala (Asaro et al. 1978; Glascock et al. 1990) and new INAA analyses of La Esperanza obsidian source

1500 AD; Asaro et al. 1978; Sheets et al. 1990). According to Aoyama et al. (1999), all households had access to finish prismatic blades made from Ixtepeque obsidian in both the Copán Valley and the region of La Entrada (between Copán and Yojoa Lake) during the Late Classic period. The great majority of these blades were used for domestic purposes, and fewer were used in ceremonial contexts. The results of the microwear analysis,

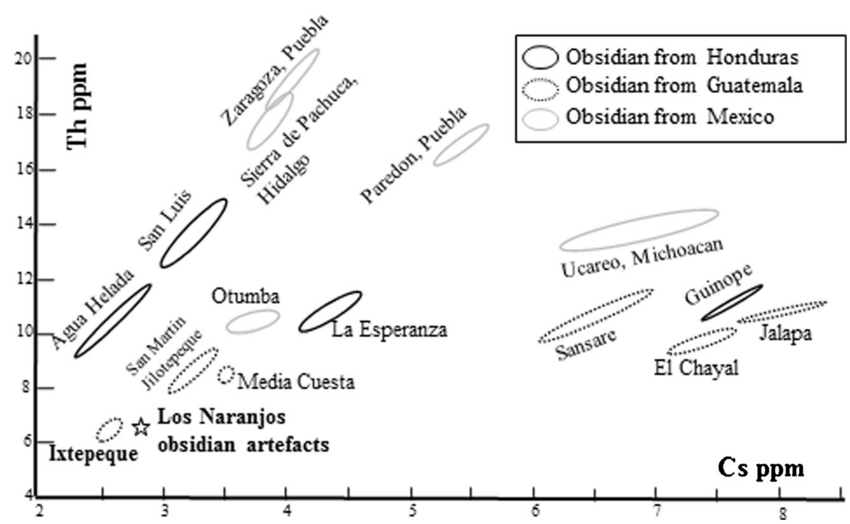

Fig. 5 Th vs Cs binary plot for the obsidian of Los Naranjos archaeological site compared with literature data of obsidian sources of Honduras, Guatemala, and Mexico (from Aoyama et al. 1999, modified)

with a high-powered microscope, indicate that Ixtepeque obsidian artifacts were used for a variety of tasks: cutting or sawing, whittling, and grooving wood or plants; cutting and scraping meat or hide; and cutting or sawing and whittling shell or bone (Aoyama 1996). In other words, Ixtepeque obsidian prismatic blades were not luxury commodities, but rather they were mostly utilitarian supplies. Some of the obsidian flakes, in which no use-wear was identified, however, occur in very small quantities at both elite and non-elite caches, suggesting possible use in household rituals. In the investigated Jaral-Edén periods of Los Naranjos, only few obsidian samples can be clearly related to blades, most of them being waste flakes and unfinished tools. Braswell and Braswell (1993) and Braswell et al. (1995), considering 14 archeological sites, demonstrated that obsidian coming from Ixtepeque dominated the Western sectors of Honduras, whereas in the central area of the country, the provenance was both from La Esperanza and Ixtepeque. Los Naranjos site, located in the Central-Western Honduras, was a candidate area to receive obsidian from both these outcrops. According to Braswell et al. (1995), 98 % of the obsidian found at Copán (from Preclassic to Late Classic) comes from Ixtepeque, whereas in the region of the Ulùa valley, just to the north of Los Naranjos, the proportion of obsidian provenance is ca 83 % from Ixtepeque and 12 % from La Esperanza. To the south of Los Naranjos in the site of Ajuterique (Comayagua), the obsidians provenance shows a proportion of 50 % from Ixtepeque and 50 % from La Esperanza (Braswell et al. 1995). The INAA analyses of the obsidian samples found at Los Naranjos Archaeological Park and related to the Jaral and Edén periods, confirm the above data of Braswell et al. (1995) concerning the high proportion of Ixtepeque source in Western and Central-Western Honduras, and highlight a long-distance provenance (ca.180 km) from this Guatemalan outcrop during the Preclassic and Early Classic periods.

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