Bitumen Sourcing in the Olmec Region

Research Year: 2004
Culture: Olmec
Chronology: Early Pre-Classic (ca. 2000-850 B.C., uncalibrated radiocarbon years)
Location: Veracruz, México
Site: Olmec Heartland

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Abstract

Bitumen, found in abundance in Mesoamerica's southern Gulf Coast region in natural seeps and in many archaeological contexts, is an important economic resource and exchange item that has received little consideration in Mesoamerica. The FAMSI-funded investigation reported here is the initial pilot project of a long-term investigation of bitumen exchange among the Olmec. The goal of the pilot project was to locate and sample bitumen seeps in the Olmec region and to compare the chemical signatures of these natural seep materials to archaeological bitumen excavated from sites in the Olmec region. Gas chromatography/mass spectrometry analysis is used to trace archaeological bitumen specimens to their sources and provides data on intra-regional movement of bitumen, shedding light on patterns of material procurement, commodity exchange, intra-regional relationships, and interactions.

Resumen

El betún se encuentra en abundancia en la región de la Costa del Golfo del sur de Mesoamérica, en yacimientos naturales y en muchos contextos arqueológicos, es un recurso económico importante y un artículo de intercambio que ha recibido muy poca consideración en Mesoamérica. La investigación financiada por FAMSI reportada aquí, es el proyecto piloto inicial de una investigación a largo plazo de intercambio de betún entre los Olmecas. La meta del proyecto piloto fue localizar y sacar muestras del yacimiento de betún en la región Olmeca, y comparar sustancias químicas de estos materiales de yacimientos naturales con el betún arqueológico excavado de los sitios de la región Olmeca. Se usan análisis de la cromatografía de gases y los espectrómetros de masas, para rastrear especímenes de betún arqueológico para sus recursos, y proporcionar información sobre movimiento intra-regional de betún, vertiendo luz sobre los patrones de obtención del material, intercambio de mercancía, relaciones intra-regionales, e interacciones.

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Introduction

Although there has been a considerable amount written on the Olmec (Figure 1; Table 1), there are relatively few good data on material procurement strategies, regional exchange, and interaction networks within the Olmec region. Obsidian and clay are among the few commodities utilized in ancient Mesoamerica that have been chemically studied to determine their source location and patterns of exchange (Blomster *et al.* 2005; Cobean 2002; Neff 2003; Stoltman *et al.* 2005). And while bitumen use was common, archaeological studies of sources have never been carried out.

In the present study, I set out to determine if bitumen could be used to help understand the organization of Olmec material procurement systems, and whether archaeological specimens can be related to natural sources. Geochemical data were gathered on bitumen collected from seeps and archaeological sites in the Olmec region. Samples were compared using Gas Chromatography/Mass Spectrometry (GC/MS) to determine if bitumen from natural seeps in the study area is chemically different and if there exists a good correlation between natural seep bitumen and archaeological bitumen. Insights on procurement and trade will allow for the evaluation of hypotheses on intra- and inter-regional exchange and interaction (e.g., Blomster *et al.* 2005; Flannery *et al.* 2005; Flannery and Marcus 2000; Grove 1994; Hirth 1984), which will in turn contribute to our current understanding of the development and organization of regional economic systems.

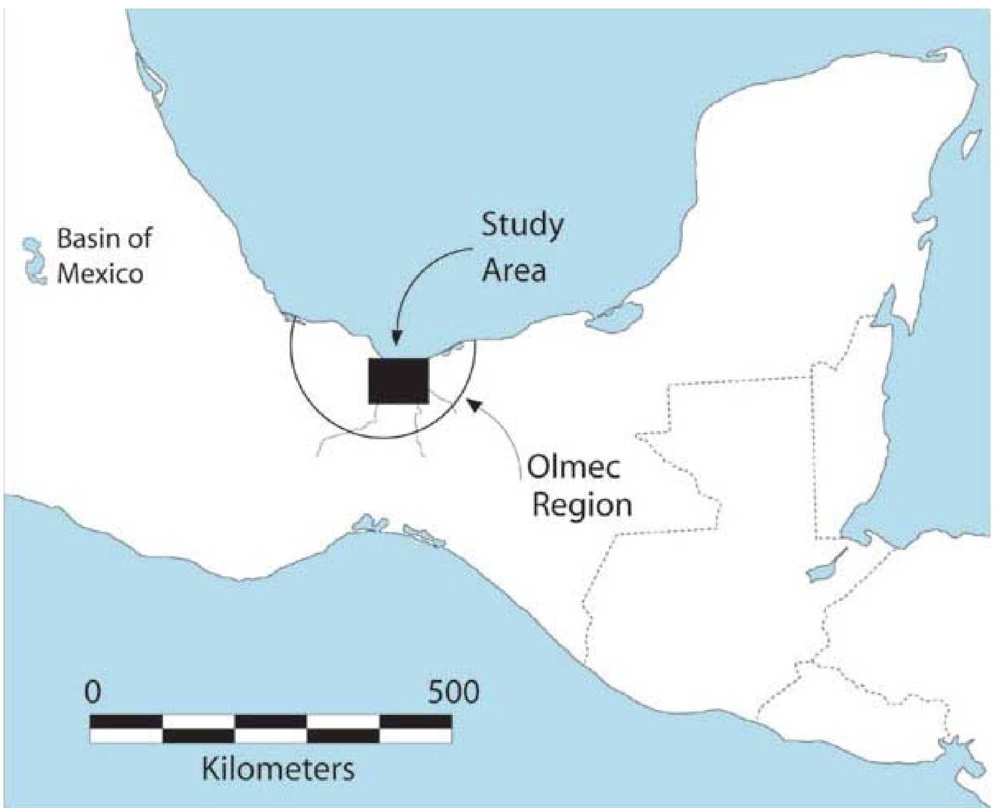

Figure 1. Southern Gulf lowlands of Mesoamerica showing Olmec Heartland and study area.

Table 1. Archaeological Phases and Periods

<table>
<tr><th>Radiocarbon Years (B.C.)</th><th>San Lorenzo Phases (after Symonds et al.2002)</th><th>Mesoamerican Periods</th><th colspan="2">Olmec Culture</th></tr>
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<tr><td>1300</td><td rowspan="2">Ojochi-Bajío</td><td rowspan="3"></td></tr>
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Bitumen in Mesoamerica

Prehispanic Mesoamerican peoples collected, processed, and used bitumen for decoration, as a sealant, and as an adhesive. Among the earliest to do so were the Olmec (1200-500 B.C., radiocarbon years) of México's southern Gulf coastal lowlands. Bitumen (Figure 2; commonly called asphaltum in the United States and chapopote in México) is one of the few naturally occurring substances of potential trading value that is found in the Olmec region. It is unique since it preserves well in the archeological record and is found at all types of Gulf lowland archaeological sites, as well some sites in the Central Mexican Highlands.

Bitumen, chemically made up of a mixture of complex natural hydrocarbons and oxidized products, is what remains of certain crude oils upon the elimination of volatile components. Various analytical techniques including stable isotopic analyses, gas chromatography/mass spectroscopy (GC/MS), compound-specific-isotopic-analysis (CSIA), and gas-chromatography-combustion-isotope ratio-mass spectrometry (GC/C-IRMS) have been successfully used to source archaeological bitumen in ancient Greater Mesopotamia and Egypt where bitumen had an important role in regional economies (Connan 1999; Connan and Deschesne 1992; Connan *et al.* 1998; Harrell and Lewan 2002; Maurer *et al.* 2002; Nissenbaum 1992; Nissenbaum *et al.* 1984; Schwartz *et al.* 2000). These analyses were successful because some of the bitumen hydrocarbons serve as molecular biomarkers, which were useful for 'fingerprinting' the material.

Figure 2. Archaeological bitumen.

In Mesoamerica, natural bitumen seeps occur in pockets along the Gulf coastal plain and offshore in the Gulf of México. In the Olmec region, bitumen seepages are limited to the eastern, low-lying areas, which include the regional centers of San Lorenzo and La Venta. In these locales bitumen could be collected right off the water's surface (e.g., ocean, rivers), from beaches, and from seeps. It was then processed by mixing it with mineral or vegetal additives so it will stiffen upon application and not readily melt in the sun (Wendt 2003; also see Connan and Deschesne 1992; Forbes 1936:42-45).

Archaeological data indicate that the Olmec used bitumen as a sealant (e.g., basalt aqueduct troughs, canoes), an adhesive, a decoration (e.g., on figurines, knife handles), and a building construction material (to coat walls or floors) (Coe and Diehl 1980:152, 260; González Lauck 1996;

O'Rourke 2002; Ortíz and Rodríguez 1989, 1994; Rodríguez and Ortíz 1997; Wendt 2003). I suspect that the most important use, however, was to waterproof canoes and other watercraft (e.g., rafts, reed boats). Because much regional trade, communication, transportation, and subsistence was tied to waterways (Symonds *et al.* 2002), it would have been critical for the Olmec to possess effective watercraft. In post-Olmec Prehispanic times, bitumen continued to be an important commodity in many parts of Mesoamerica, where it was used for decoration, building construction, waterproofing, adhesive, chewing gum, incense, body adornment, paint, and fuel (de la Fuente 1992; Ekholm 1944; Hall 1997; Medellín 1960; Sahagún 1961; Solís 1992; Stark 1977; Tozzer 1941). Today, local people continue to use bitumen for its waterproofing qualities, such as for sealing canoes (with purchased bitumen, however) and for surfacing patios, floors, and roads (in areas near natural seeps).

The distribution of archaeological bitumen in zones located at far distances from seeps indicates that the Olmec and their successors traded the substance within and outside the Gulf region. The small spheres (ca. 2 cm in diameter) and larger cakes found in excavations (Wendt 2003) appear ideal for long-distance trading, and one large bitumen sphere (ca. 12 cm in diameter) found next to the right foot of a 40-45 year-old male skeleton at the Early Pre-Classic site of Tlatilco in the Basin of México (García Moll *et al.* 1991) provides concrete evidence of Pre-Classic period long-distance bitumen exchange.

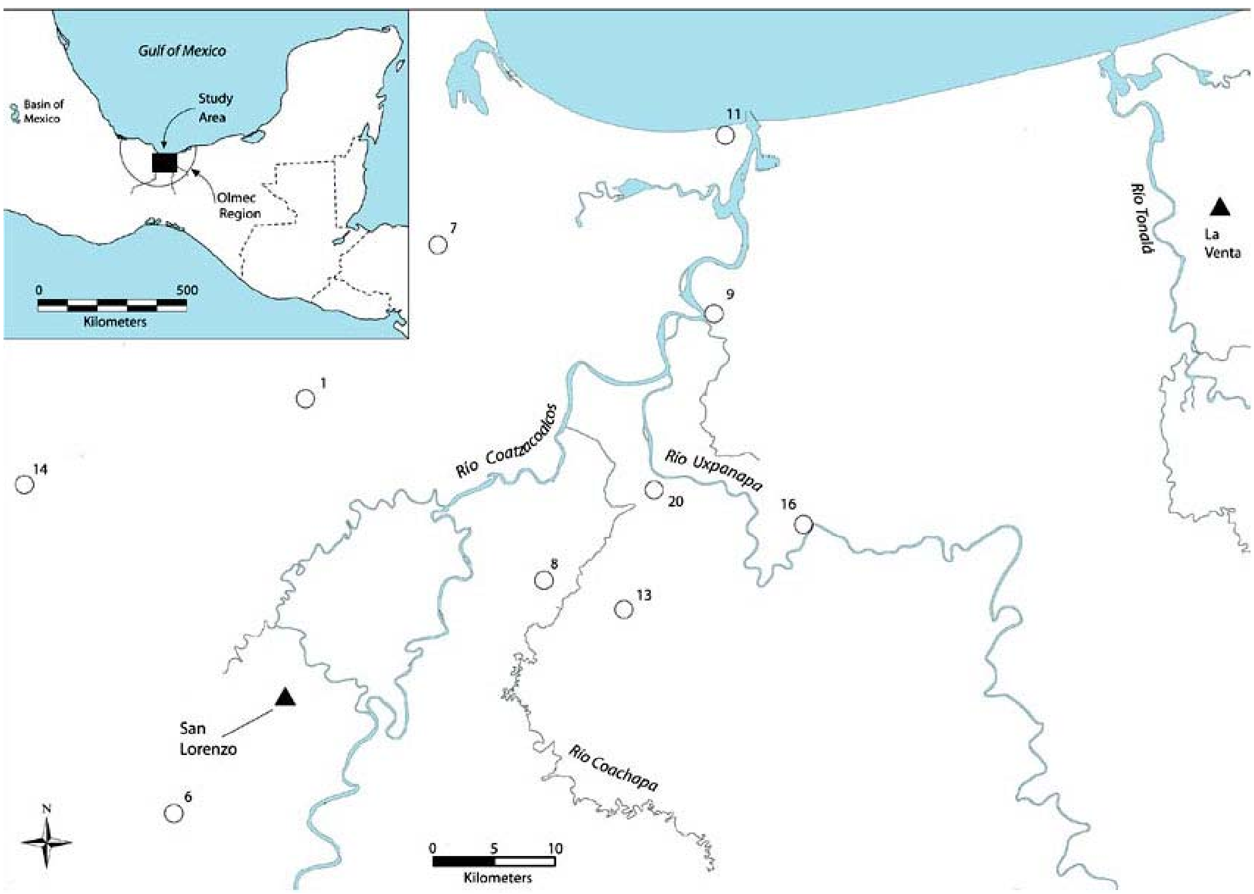

Figure 3. Location of field bitumen sample collections. (1) Jaltipan, seep; (6) La Cangrejera, seep; (7) Rancho Orel, seep; (8) Emilio Carranza, seep; (9) Paso Nuevo, seep; (11) Coatzacoalcos, beach; (13) San Cristóbal, seep; (14) Sayula, well; (16) La Concepción, seep; (20) San Carlos, seep.

Bitumen Procurement and Exchange in the Olmec Region

Geochemical studies in Mesoamerica have shown that petroleum produced in the Mexican Gulf Coast Basin (sampled mainly from deep wells) falls into five major chemically distinct groups, which reflect the environment and age of each formation–Oxfordian (two groups), Tithonian, Early Cretaceous, and Tertiary (Guzmán-Vega and Mello 1999). Wells producing chemically similar petroleum cluster into discrete surface areas (Guzmán-Vega and Mello 1999; Guzmán-Vega *et al.* 2001). In the Olmec region, wells in the eastern portion produce petroleum classified into at least two chemically and spatially distinct groupings belonging to the Tithonian oil family (Guzmán-Vega and Mello 1999).

Figure 4. Bitumen seepage at Jaltipan.

Figure 5. Bitumen seepage at Emilio Carranza.

Initial field location of bitumen seeps was aided by a U.S. Navy report (Shufeldt 1872) that includes information on natural seeps around the Río Coatzacoalcos and its tributaries. I located and collected field samples from seven of the 16 seeps listed in the report, along with five others (Figure 3, Figure 4, Figure 5), using metal spoons and environmental sampling glass jars with Teflon lined closures. Bitumen lumps were also collected from the beach adjacent to the mouth of the Río Coatzacoalcos. Archaeological bitumen samples were acquired from Early Pre-Classic contexts at eight Olmec sites (Figure 6; Table 2).

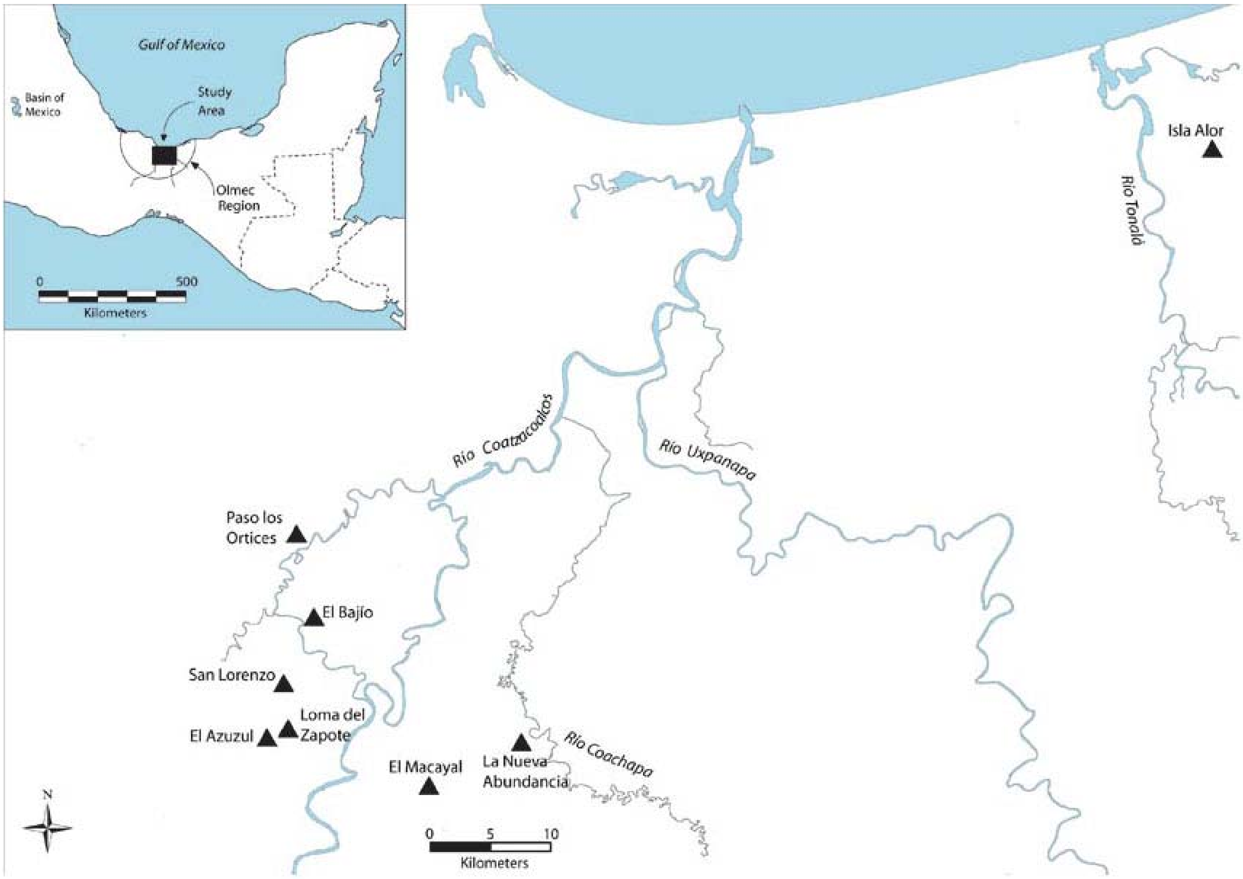

Figure 6. Location of archaeological bitumen samples. (101) El Remolino, El Bajío area, Profile Operation, Domestic Area-2; (102) El Remolino, El Bajío area, Profile Operation, Domestic Area-1; (103) El Azuzul, Represa; (104) Isla Alor, Unit 1; (105) Loma del Zapote; (106) Paso los Ortices, Unit 1, bitumen pit feature; (107) San Lorenzo, A4, Ilmenitas; (108) San Lorenzo, B3-5; (109) San Lorenzo, C3, Monument 14; (110) San Lorenzo, D4-22; (111) San Lorenzo, B3, Monument 57; (112) San Lorenzo, D5-31; (113) El Macayal, Unidad Villaseca; (114) La Nueva Abundancia, Pozo 12; (115) San Lorenzo, C5-6.

Table 2. Archaeological Bitumen Sample Proveniences and Phase Assignments

Sample #	Site	Area	Provenience	Phase/ Period Correlation	Context
101	El Remolino	El Bajío	Lot 12, Stratum H, 270-290 cm	SL	Domestic/habitational (Domestic Area-2)
102	El Remolino	El Bajío	Lot 2, Stratum F, 190-210 cm	SL	Domestic/habitational (Domestic Area-1)

103	El Azuzul	Represa	N10-13, W0-3, Capa IV	SL-B	Occupational surface
104	Isla Alor		Unit 1, 120-140 cm	SL-B	Domestic/habitational
105	Loma del Zapote	Las 30	S0-3, E2-3, Capa III/IV	SL	Floor of ceremonial structure
106	Paso los Ortices	Textistepec	Unit 1	SL	Pit feature
107	San Lorenzo	A4, Ilmenitas	2-5 S, 11-12 E, Capa V	SL-B	Activity zone, associated with productive activities
108	San Lorenzo	B3-5	S1.10-3.10, E2.09-5.09, Capa VI	SL-A	Domestic/habitational
109	San Lorenzo	C3, Monument 14	Unidad 9, 2-3N, 1.5-2.5E, Capa VII-c	SL-B	Ceremonial structure: fill between floors
110	San Lorenzo	D4-22	E11-16.5, S8-10, Capa III-b	SL-B	Domestic/habitational, floor
111	San Lorenzo	B3, Monument 57	N1-S4, E3.30-0.30, Capa XII	SL-A	Red Palace: inside basalt aqueduct
112	San Lorenzo	D5-31	S6-9, E12-15, Capa XI	SL-B	Domestic/habitational, floor
113	El Macayal	Unidad Villaseca	Cuadro S7W9, Elem. 5-6	Early Pre-Classic	Domestic/habitational
114	La Nueva Abundancia	Pozo 12	Capa III, 90-100 cm	Early Pre-Classic	Domestic/habitational
115	San Lorenzo	C5-6	W11-14, S2-5, Capa III	SL-B	Occupational surface

Ten field and 15 archaeological samples were analyzed by GC/MS for biomarker patterns. Bitumen samples were processed in the standard method and analyzed with full scan mode (50-550) and selective ion monitor (SIM) mode, and mass chromatograms of terpanes (*m/z* 191), steranes (*m/z* 217), monoaromatic steranes (*m/z* 253), and triaromatic steranes (*m/z* 231) were obtained.

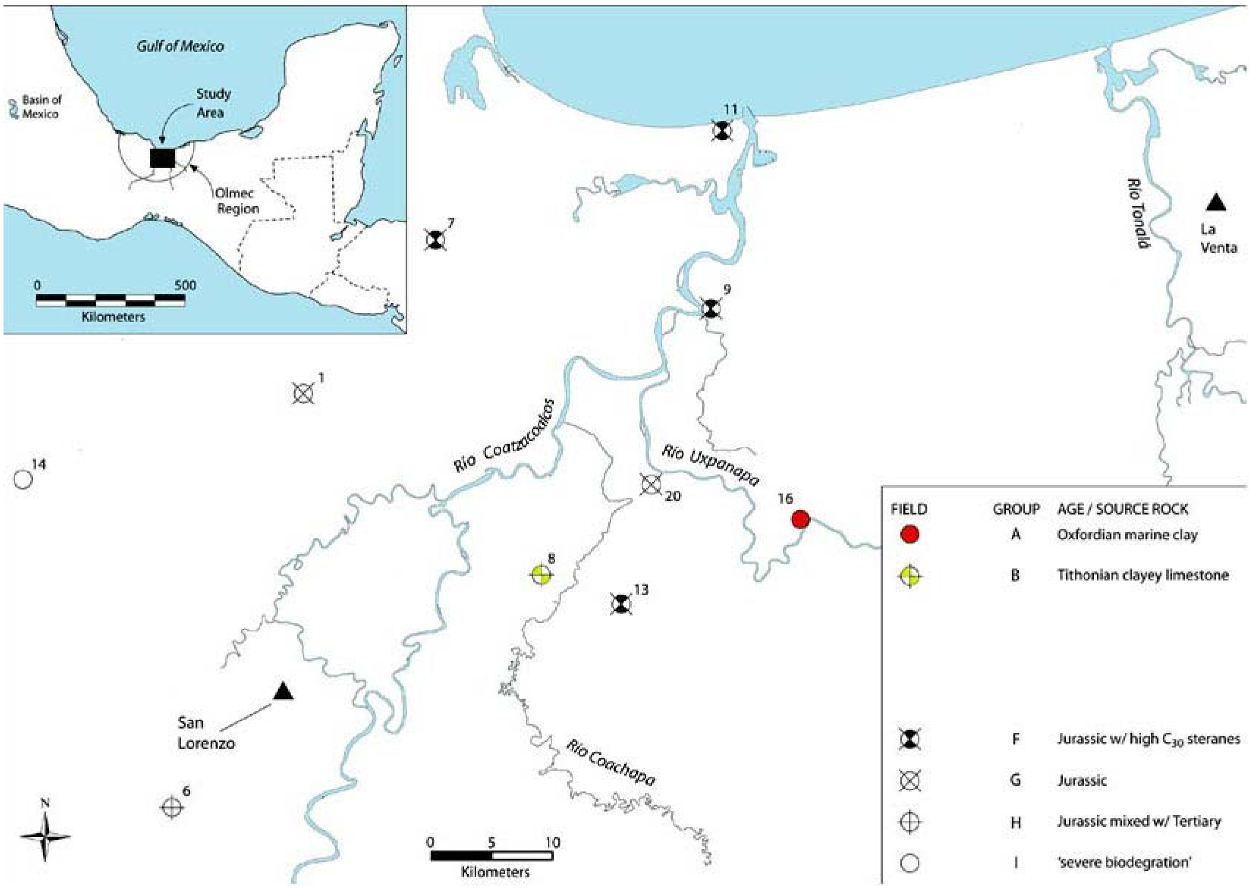

Figure 7. Geochemical classification of field samples.

The distribution patterns of steranes and terpanes in the field samples allows them to be provisionally divided into six groups (Groups A-B and F-I) based on their biomarker features (Figure 7). All but one of the field samples probably derived from Pre-Tertiary source rocks (Upper Jurassic to Cretaceous). In contrast to the field samples, the distribution patterns of steranes obtained from archaeological samples generally look younger (less mature). The 15 archaeological specimens can be temporarily classified into five groups (Groups A-E; Figure 8), based on their biomarker characterizations.

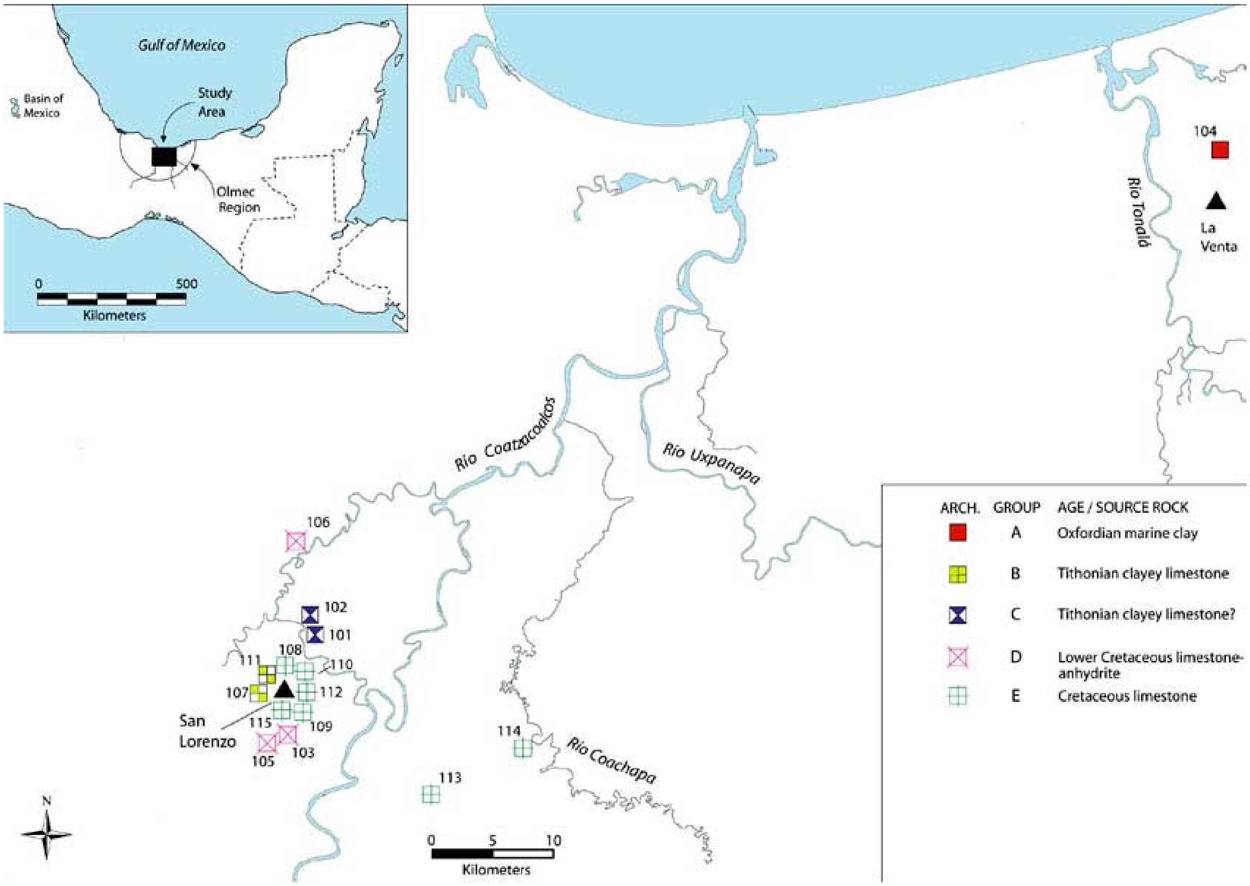

Figure 8. Geochemical classification of archaeological samples.

Some archaeological samples correlate well with their possible source material (seep bitumen) using geochemical features (biomarkers). Figure 9 shows that the distribution pattern of steranes and terpanes obtained from archaeological sample #111 (San Lorenzo, B3, Monument 57), is very similar to that from the field sample #8 collected from Emilio Carranza, and to crude oil produced from Upper Jurassic Tithonian formations (Guzmán-Vega and Mello 1999).

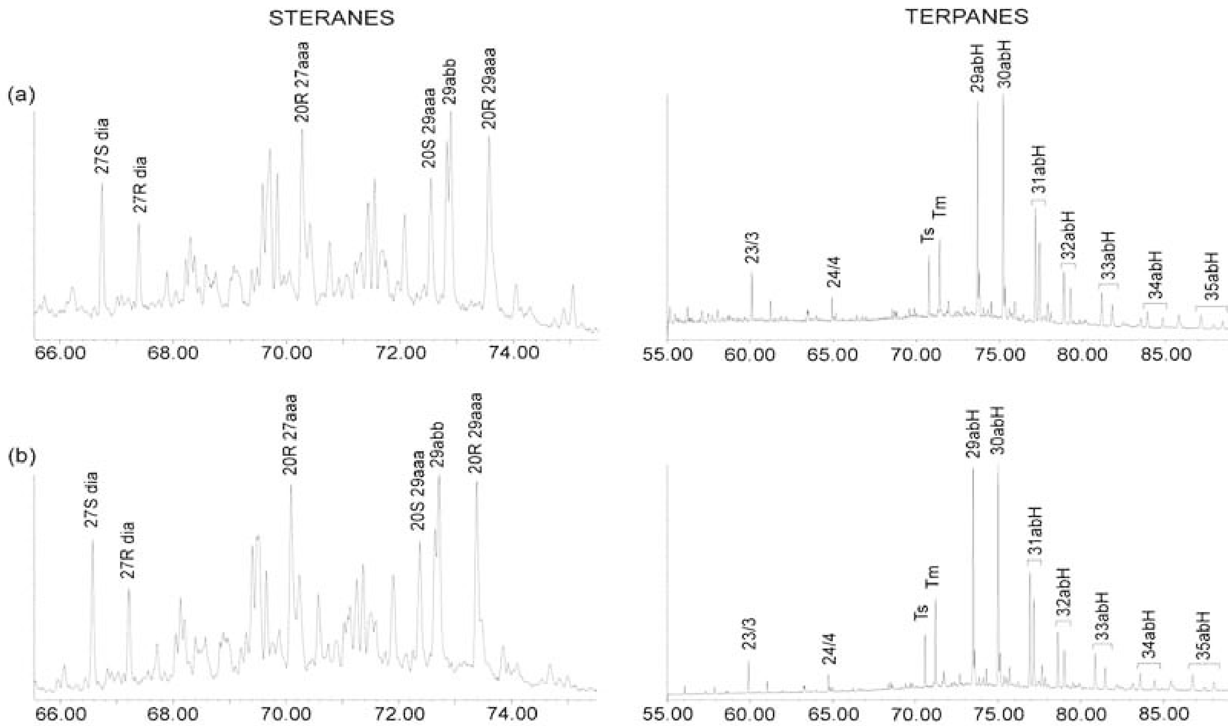

Figure 9. Steranes (*m/z* 217) and terpanes (*m/z* 191) distribution patterns in samples collected from (a) Emilio Carranza (#8, seep) and (b) San Lorenzo (#111, archaeological).

Another correlation can be made for archaeological sample #104 (Isla Alor) and field sample #16 (La Concepción) (Figure 10). Their geochemical features also correlate moderately well with crude oil produced from the Upper Jurassic Oxfordian marine clay source rock collected from deep ocean wells in the southern Gulf of México (Guzmán-Vega and Mello 1999) about 400 km NE of Isla Alor and La Concepción. Geochemical parameters for both field and archaeological samples support their similarity.

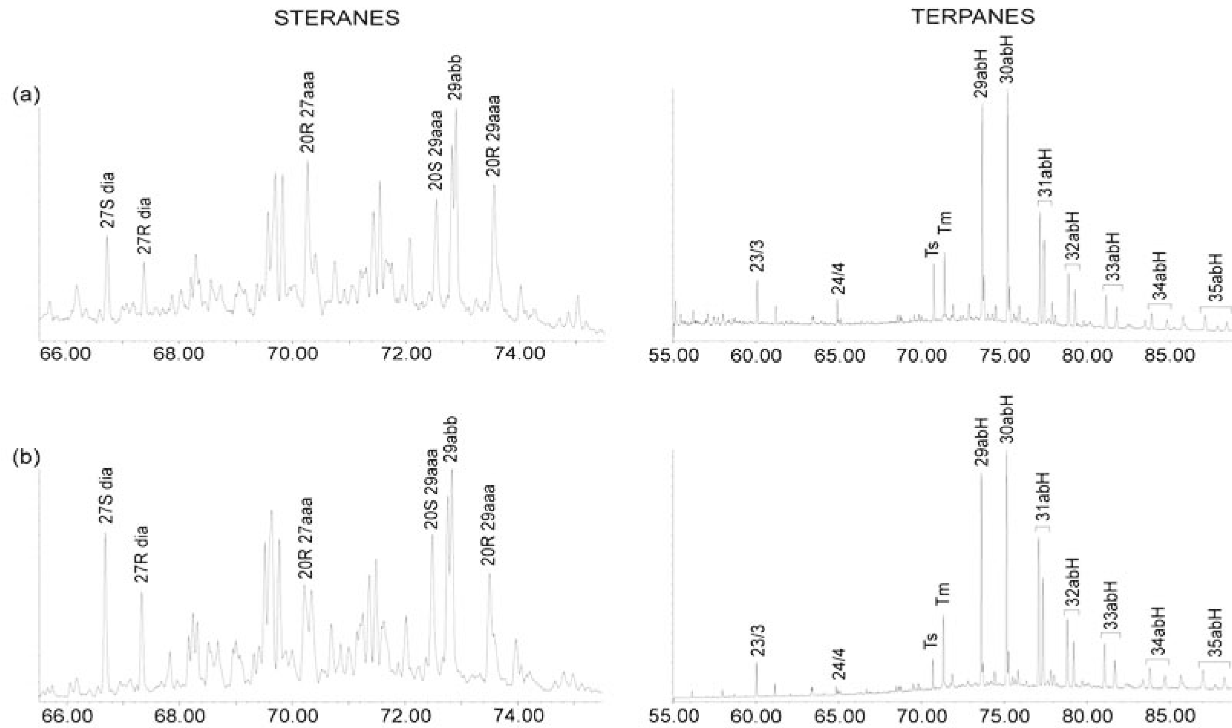

Figure 10. Steranes (*m/z* 217) and terpanes (*m/z* 191) distribution patterns in samples collected from (a) La Concepción (#16, seep) and (b) Isla Alor (#104, archaeological).

Some of the other archaeological samples (Groups D and E) look quite similar to bitumen derived from Cretaceous source rock (Guzmán-Vega and Mello 1999), based on the distribution patterns of steranes and terpanes. I thus believe that there is a good potential to locate seeps containing bitumen dating to the Cretaceous, which will enable us to correlate our results from archaeological bitumen to the potential source material.

It is worth noting that although wells in the Olmec region produce petroleum classified into at least two chemically and spatially distinct groupings belonging to the Tithonian oil family, bitumen from seeps in the same region is much more chemically varied, belonging to the Oxfordian, Tithonian, and Tertiary oil families. What is more, archaeological bitumen data suggest that there are seeps in the region belonging to the Cretaceous oil family.

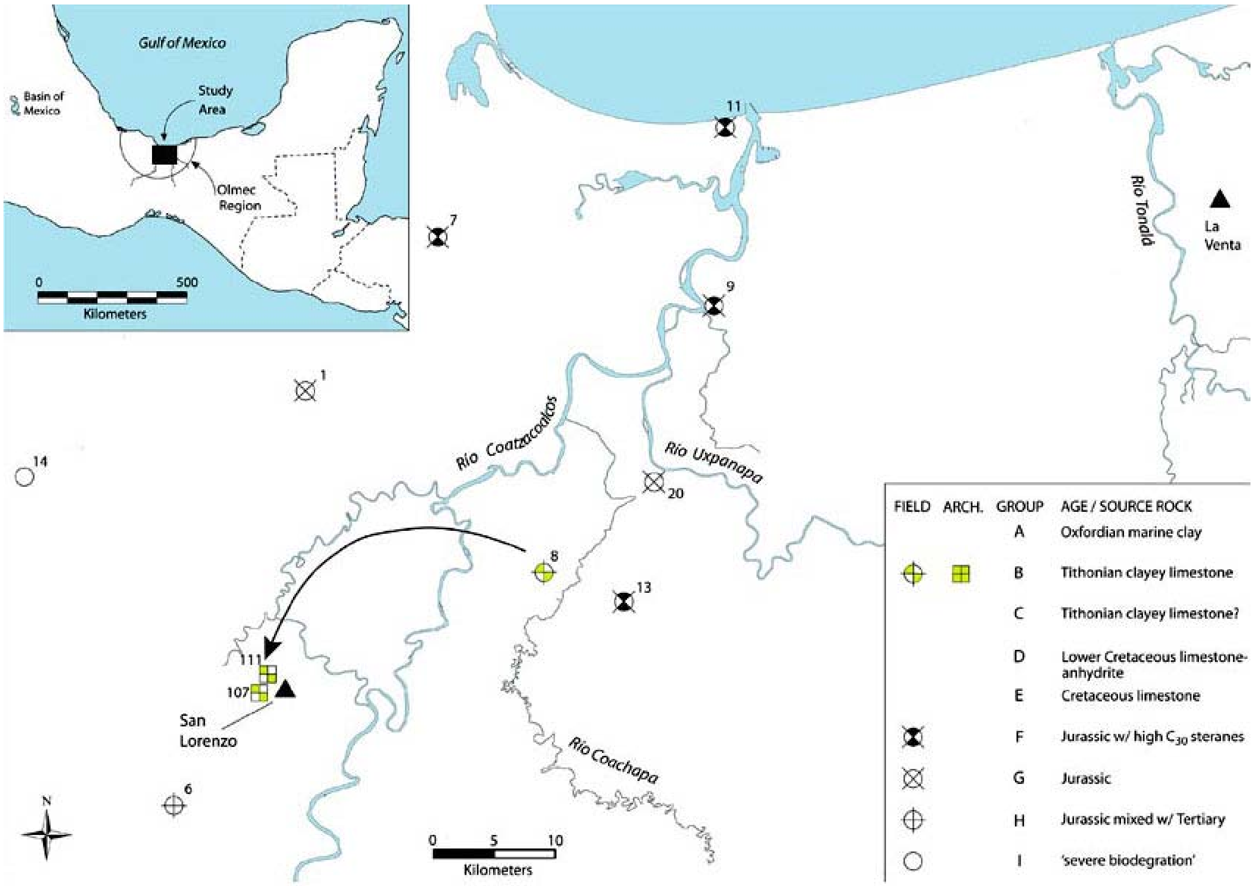

Figure 11. Group B.

Tracing archaeological bitumen to source locations is currently challenging due to the small number of bitumen seeps identified and the few samples collected and analyzed. Nonetheless, the seven archaeological samples from San Lorenzo fall into two groups (B and E). One group (B; Figure 11) with two samples correlates to bitumen collected from the Emilio Carranza seep ~23 km away. The other group (E; Figure 12) with five samples has similar chemical attributes as samples collected from the sites of El Macayal and La Nueva Abundancia. As mentioned above, the sample from Isla Alor (#104) correlates well with La Concepción bitumen (#16) located ~45 km away (Figure 13).

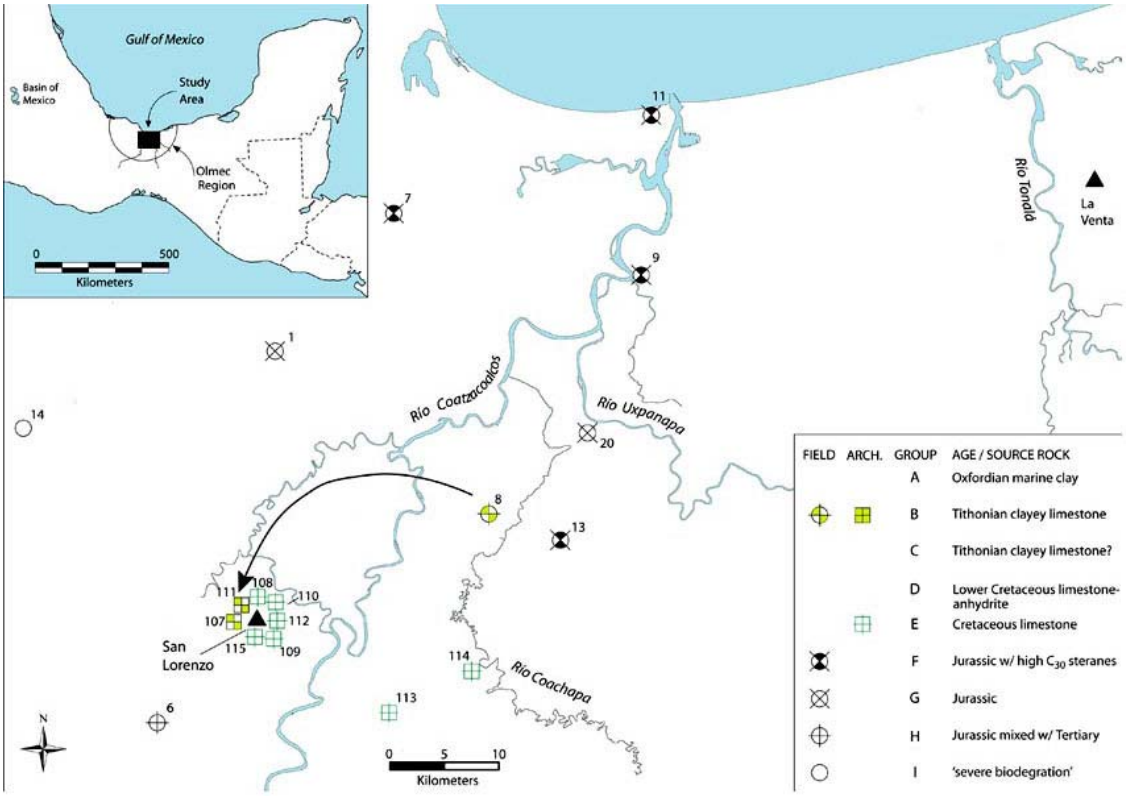

Figure 12. Group E.

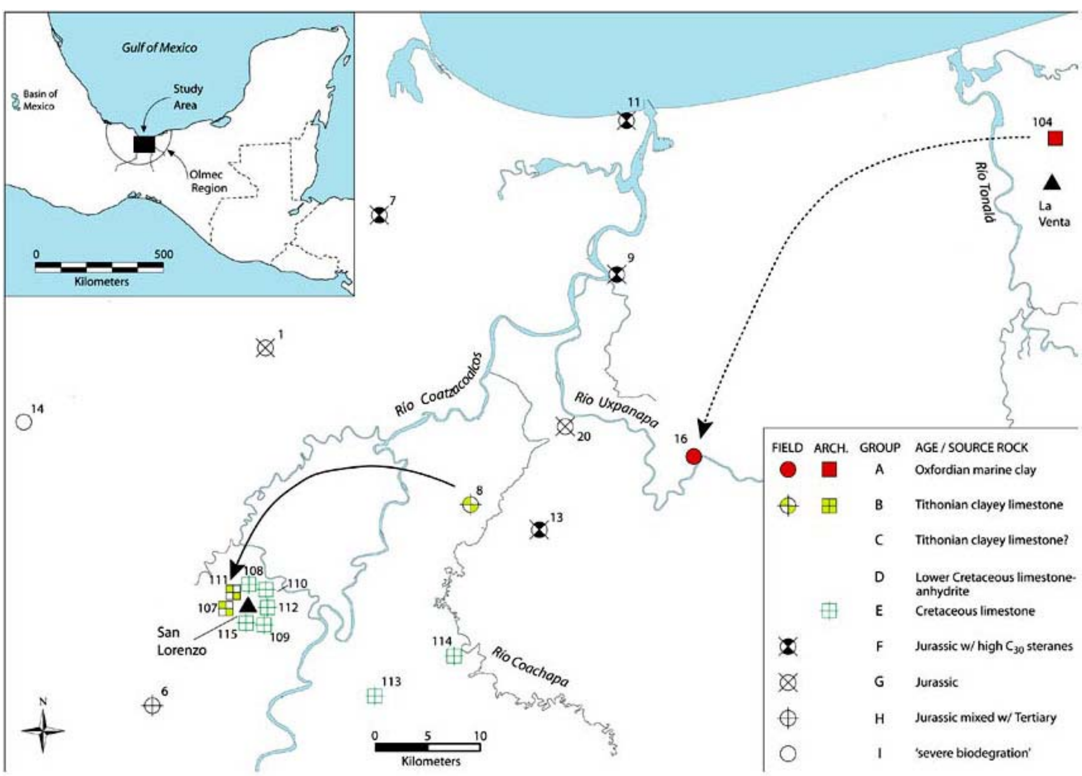

Figure 13. Group A.

While the Isla Alor sample could have been procured from La Concepción, it seems conceivable that it was obtained from an as yet unidentified seep situated closer to the site. The two samples collected from El Bajío are chemically similar to each other (Group C; Figure 14), but do not correlate to any seep material collected or to any published crude oil. The samples collected from Paso los Ortices, El Azuzul, and Loma del Zapote form the final group (D; Figure 15), and cannot currently be correlated to any seep, but I believe with the collection of more field samples there exists a good possibility to locate seeps with bitumen chemically similar to Group D (as well as Group E) archaeological bitumen, both of which appear to have originated in Cretaceous age reservoirs.

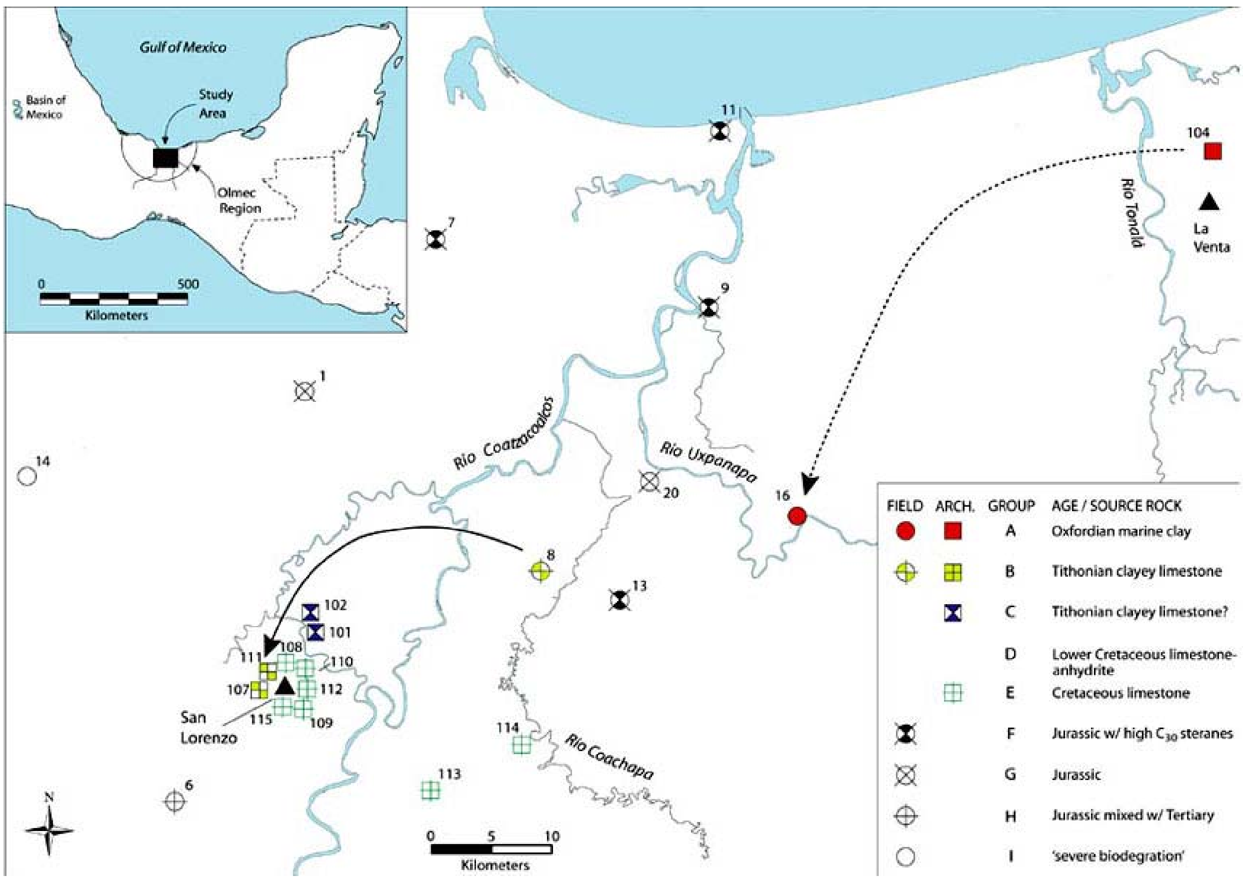

Figure 14. Group C.

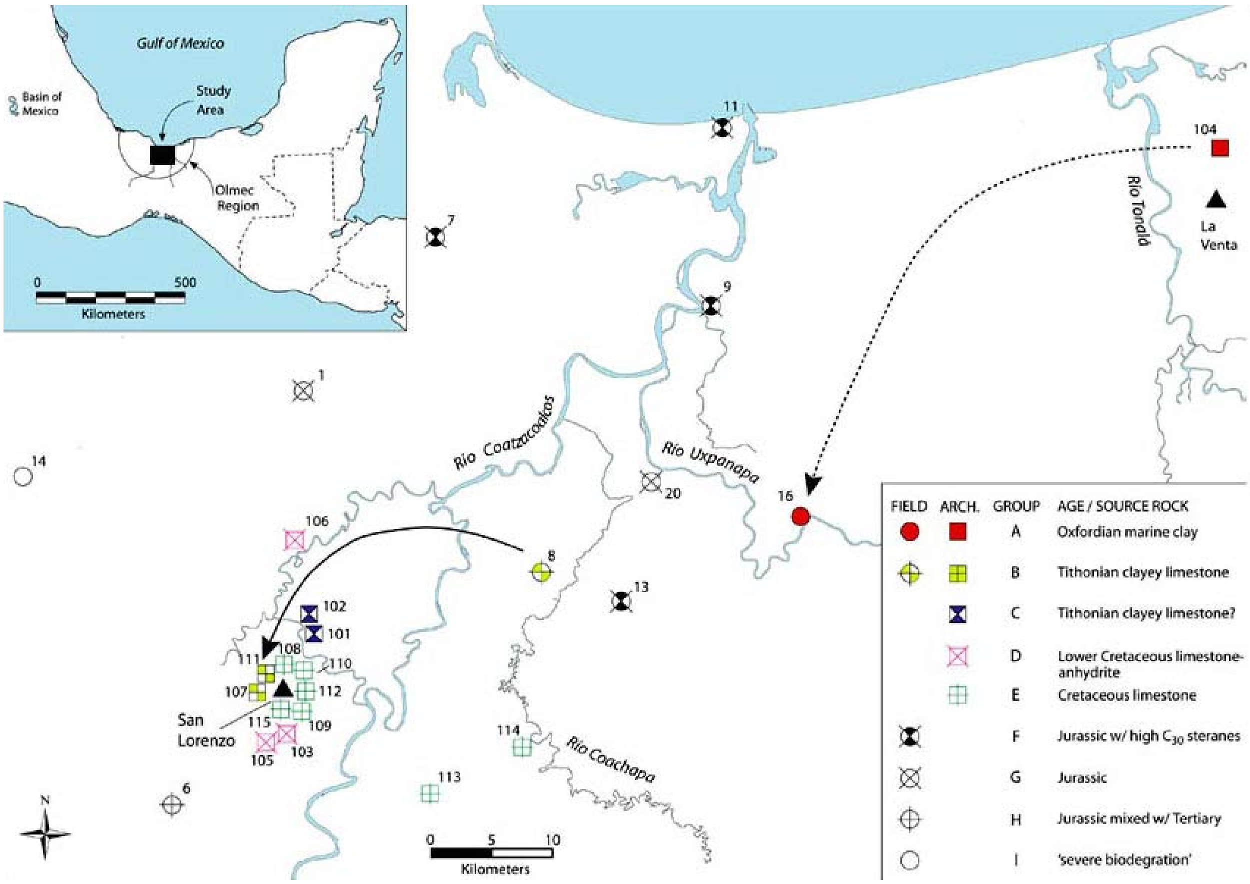

Figure 15. Group D.

During the Early Pre-Classic, Olmec living in sites surrounding San Lorenzo exploited a range of chemically distinct bitumen seeps. Certain seeps may have been preferred and exploited during different Early Pre-Classic phases, or the pattern might indicate that sites surrounding the regional center of San Lorenzo were incorporated in different procurement networks, reflecting a complex regional system of exchange and interaction. Sites with chemically similar archaeological bitumen samples form groups perhaps indicating the presence of at least three San Lorenzo regional networks represented by the following of sites: (i) San Lorenzo, El Macayal, and La Nueva Abundancia (Figure 16); (ii) Paso los Ortices, Loma del Zapote, and El Azuzul (Figure 17); and (iii) El Remolino (Figure 18). These groupings might also reflect some degree of independent procurement, where individuals obtained bitumen from local seeps on personal or group needs. More data are required to evaluate these ideas.

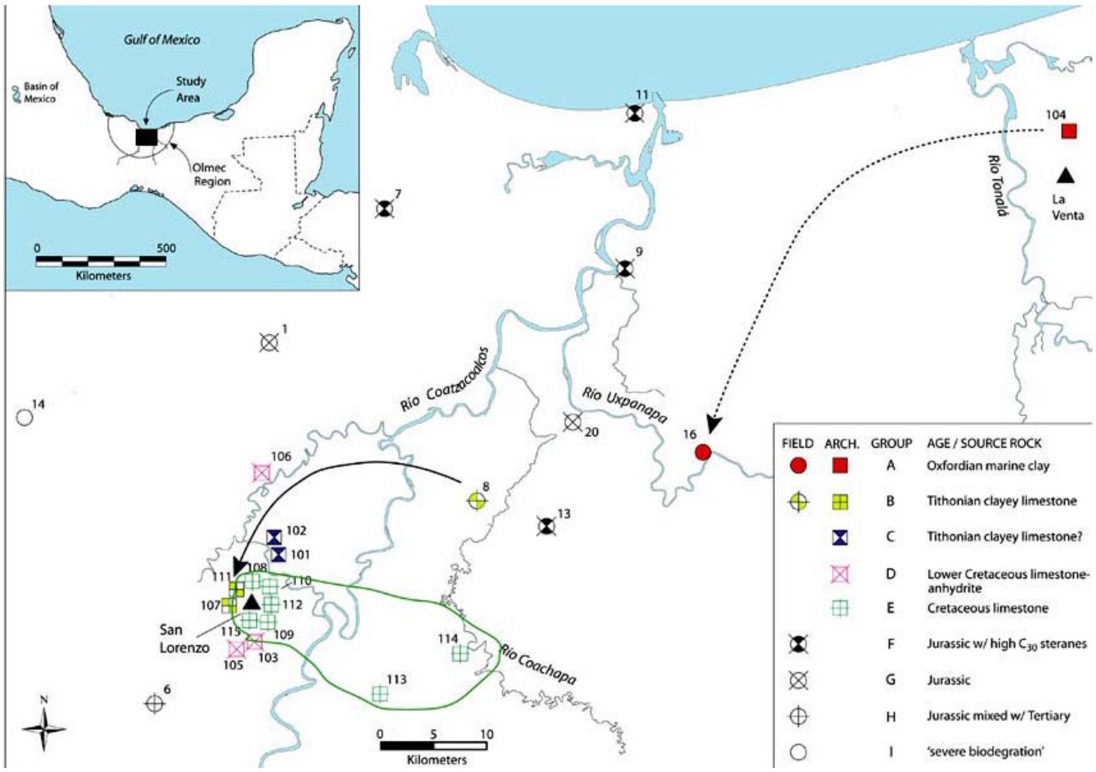

Figure 16. Network 1.

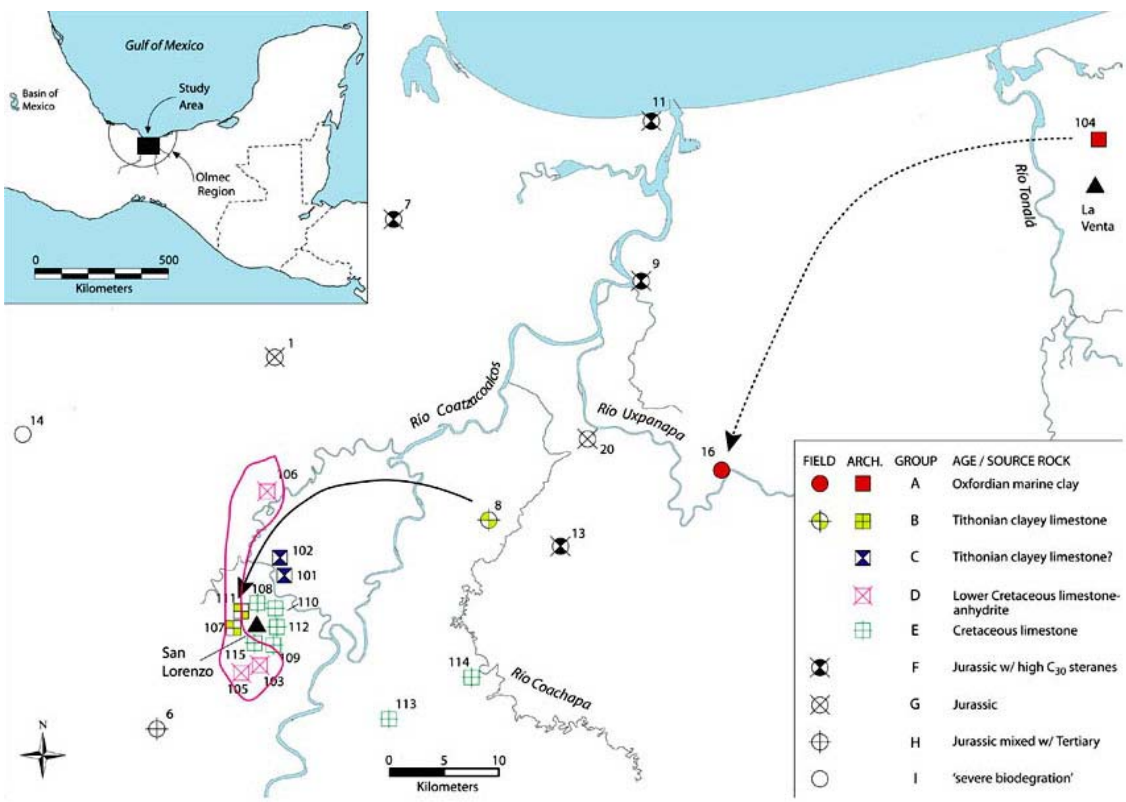

Figure 17. Network 2.

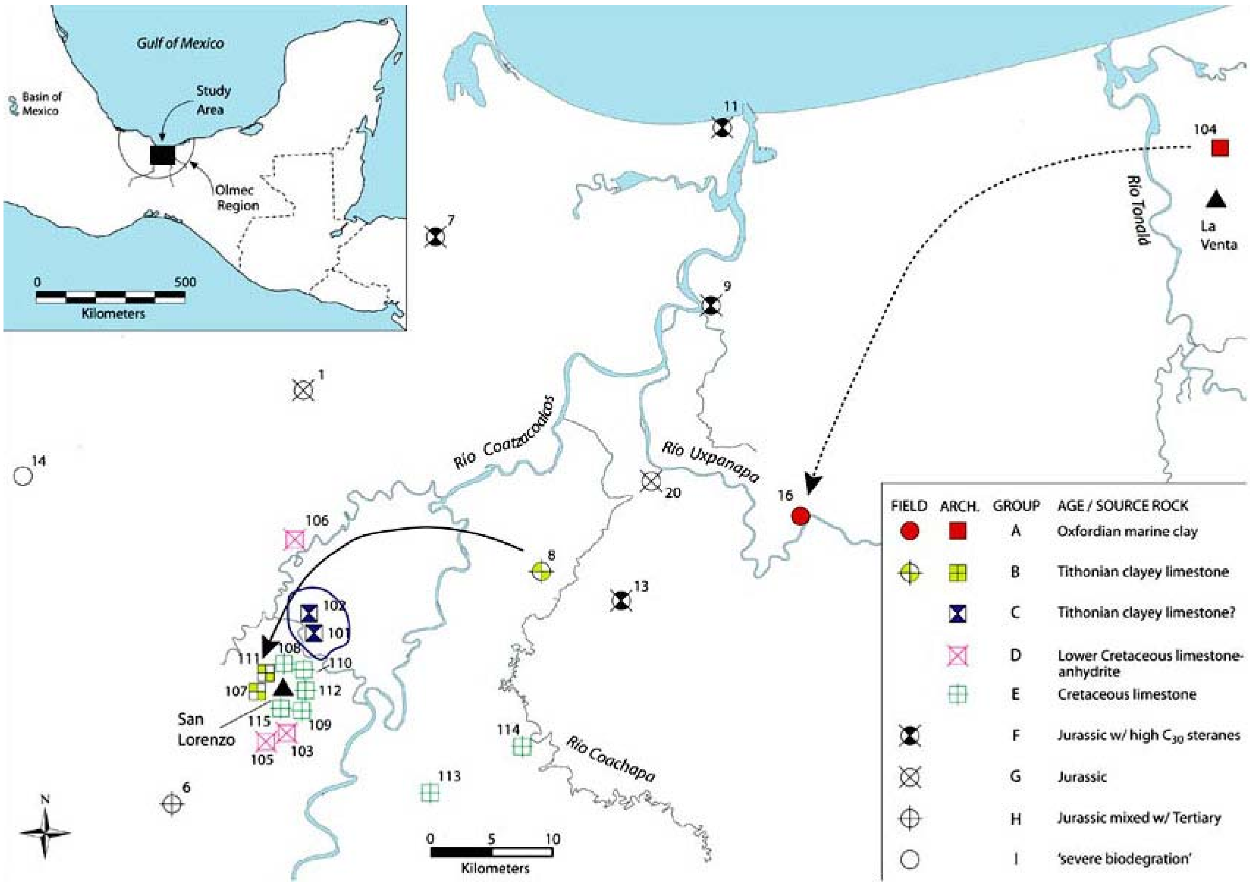

Figure 18. Network 3.

Conclusions

The findings presented here represent the first attempts at studying bitumen, an important economic resource in Mesoamerica. Results of the study demonstrate that sourcing archaeological bitumen is feasible, worthwhile, and has great potential to advance our understanding of Olmec and other prehistoric Mesoamerican economies. Moreover, Mesoamerican archaeologists now possess a new tool in Mesoamerican archaeology that will allow scholars to document the movement of a utilitarian material, which in turn will lead to insight on the everyday workings of ancient Mesoamerican economies.

This pilot project lays the foundation for more detailed bitumen sourcing studies that can investigate Early Formative period bitumen trade on both the intra-regional and inter-regional levels. Data on bitumen trade can be used to help evaluate various hypotheses including David Grove's (1994) ideas on 'zonal complementarity' in the Olmec Heartland, and contribute valuable data to the debates on the nature of Early Formative interregional exchange and interaction (e.g., Flannery 1968; Flannery and Marcus 1994, 2000; Blomster *et al.* 2005; Flannery *et al.* 2005). In order to achieve these objectives, more seep and archaeological bitumen (both inside and outside of the Olmec region) need to be analyzed so that archaeologists can discover exploited source loci, reconstruct patterns of exchange, and identify interaction networks.

Acknowledgements

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