Chemical Analysis of Late Classic Maya Polychrome Pottery Paints and Pastes from Central Petén, Guatemala

Christina T. Halperin, Université de Montréal
Ronald L. Bishop, Smithsonian Institution

Corresponding author: Christina Halperin

Département d'anthropologie

Université de Montréal

Pavillon Lionel-Groulx

3150 Jean-Brillant

Montréal QC H3T 1N8

514-600-6721

christina.halperin@umontreal.ca

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Abstract

This paper examines political-economic relationships among Late Classic (ca. 600-900 CE) political centers in the Petén Lakes region, Guatemala, through the chemical analysis of red paints and pastes of polychrome vessels. Chemical analysis of red paints was conducted using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), and chemical analysis of vessel pastes was conducted using Instrumental Neutron Activation Analysis (INAA). These analyses indicate that a number of political centers along the western shore of Lake Petén Itzá, namely Motul de San José, Tayasal, and Flores, had access to different polychrome pottery production communities. Nonetheless, inhabitants of these Petén Lakes sites moved between, gifted, or exchanged polychrome pottery with each other, indicating that western Petén Lakes region centers closely interacted with each other. We suggest that these sites may have been part of or allied with the epigraphically known Ik' polity. As such, we find that one of the strengths of 'second-tier' polities, such as the Ik' polity, did not depend on an individual site's size or monumental expression, but on the relationships they forged with other centers.

Keywords

Chemical analysis; LA-ICP-MS; INAA; ancient Maya; provincial politics; polychrome pottery; paint recipes; production and exchange; political-economy

1. Introduction

This paper examines political-economic relationships among Late Classic political centers in the western Petén Lakes region, Guatemala, through the chemical analysis of red paints and pastes of polychrome vessels. A growing body of hieroglyphic evidence has revealed that during the Late Classic period (ca. 600-900 CE) small “second-tier” or provincial Maya polities were entangled in complex webs of political alliances, conflicts, and negotiations with prominent regional capitals across the Southern Maya Lowlands. Since the more dominant primary capitals, such as Tikal, Calakmul, Palenque, and Piedras Negras, were responsible for producing a greater proportion of the known texts, our textual understandings of political relations between these large regional capitals and second-tier capitals are better than those between second-tier capitals or between these second-tier capitals and other provincial centers (Marcus, 1976, 1998; Martin and Grube, 2000). For example, textual sources indicate that the relatively small-sized sites of Motul de San José and Zacpetén were subordinate to Tikal during at least part of the Late Classic period (Foias and Emery, 2012; Rice and Rice, 2009). These sites are considered to have been secondary centers possessing their own provincial domains.

While political provinces are often perceived as the strongest and most stable of political units (LeCount and Yaeger, 2010; Marcus, 1998), textual sources are relatively silent on interaction within and between these smaller political centers, such as between Motul de San José and other archaeological sites in the Petén Lakes region of Guatemala. Likewise, little comparative archaeological

research has been undertaken between Late Classic centers of similar size in the Petén Lakes region, such as between Motul de San José and Tayasal. One exception is a ceramic figurine study by Halperin (2014), which indicates that western Petén Lakes region sites (Motul de San José, Nixtun Ch'ich', Tayasal, Flores, Trinidad, Buenavista, and Chäkokot) had political-economic ties with each other. The current study provides evidence for the movement of polychrome pottery and, in some cases the raw materials used to produce such pottery, among the Petén Lakes region centers of Motul de San José, Tayasal, Flores, and Zacpetén, as well as among Petén Lakes centers and the primary capital of Tikal. We suggest that centers along the western shores of Lake Petén Itzá allied or affiliated themselves with one another, serving to strengthen provincial relations.

Iron oxides, such as hematite, magnetite, goethite, and lepidocrocite, are minerals commonly found in red slips and red slip-paints decorating Classic period Maya pottery (Beaudry, 1989; Goodall et al., 2009; Smith, 2013). These slips and slip paints were applied to the vessel before it was fired at approximately 550-1000°C. Because these minerals are thermally unstable (e.g. magnetite and goethite convert to hematite when heated ca. 300-400°C, lepidocrocite converts to maghemite between 275-300°C and maghemite to hematite ca. 700°C) (Cornell and Schwertmann, 2003, pp. 365–377; Goodall et al., 2009; Walter et al., 2001), mineral analysis of red slips or slip paints can be problematic for identifying paint recipes. On the other hand, chemical analysis of vessel paints in conjunction with vessel pastes can provide a high-resolution, multi-component perspective of materials composition useful for identifying pottery production recipes and sources.

While paint and paste composition data may co-vary with each other to offer a robust designation of production source, paint and paste groups may not always co-vary (Backes Jr. et al., 2012; Cecil and Neff, 2006; Vaughn, 2005). Paste recipes and sources may have been shared while paint recipes (or the raw materials used to produce them) were not, or paint recipes (or the raw materials used to produce them) were shared while paste recipes and sources were not. Thus, multiple lines of evidence are garnered here to provide a more nuanced understanding of the composition, trading, and artisan-patron relationships surrounding polychrome pottery and their links to political-economic relations among Late Classic Maya centers.

2. Archaeological and Epigraphic Context

The Late Classic Maya political landscape comprised multiple polities with shifting domains and relations of power (Chase and Chase, 1996; Foias, 2013; Fox et al., 1996; Martin and Grube, 2000; Rice, 2004). These political relations included centralized polities with paramount rulers at regional capitals who were in charge of their own provinces and oversaw, to varying degrees, the political and religious affairs of secondary and tertiary polities and their provinces. In some cases, annexed polities may have broken away from their paramount rulers or co-existed in relative autonomy alongside such dominant powers (LeCount and Yaeger, 2010; Marcus, 1993). In turn, these smaller second- or third-tier polities may have exhibited their own shifting centralized and decentralized relationships on smaller provincial scales. One of the key questions explored here is whether

smaller Late Classic polities forged confederacies or loose alliances with each other and if so, how might we identify such relationships archaeologically?

Polychrome pottery had important political roles (Callahan 2014; Foias, 2007; Halperin and Foias, 2010; LeCount, 1999; Rice, 2009a, 2009b). Elites patronized the production of polychrome pottery, and such pots were gifted or exchanged hands between elite patrons and subordinates or among different noble families as material expressions of dominance, alliance, and affiliation. More than a reflection of elite status and affiliation, however, polychrome pots were also serving vessels for chocolate and corn-based drinks as well as a variety of foodstuffs. As such, they were instrumental in the political obligations and alliances formed through hosting and being invited to feasts.

Current scholarship suggests that the archaeological site of Motul de San José was the capital or one of several capitals of the Late Classic Ik' polity, named for its Emblem Glyph (political titles and designations of rulership) featuring the *ik'* (wind) sign (**Fig. 1**) (Foias and Emery, 2012). It is a relatively small site at approximately 4.2 km² in size with a ceremonial core approximately 1.4 km² and a large Acropolis complex (Group C) that likely served as the site's principal royal court. Some of the richest sources of written evidence on the Ik' polity derives from a corpus of largely unprovenienced polychrome pottery in the Ik' style. Ik' style pottery details the histories and ritual lives of the Ik' royal family (Just, 2012; Reents-Budet et al., 1994, 2012). Because the Ik' style vessels possess multiple sub-styles and derive from multiple paste recipes, Reents-Budet and colleagues (1994, 2012) have suggested that the Ik' polity may have been composed of a

confederation of noble families or multiple political centers who shared or rotated power amongst themselves (see also Rice, 2009a).

Excavations at the northwestern edge of Motul de San José's Acropolis complex provide archaeological evidence that Motul de San José elites patronized the production of polychrome pottery. These excavations uncovered large secondary middens containing debris from a polychrome pottery production workshop or workshops, including paint pots, possible bone painting tools, iron oxide mineral pigments (goethite and hematite) possibly used for the preparation of red paints, ceramic burnishing tools, a figurine mold, burnt clay, large quantities of ash, and wasters of elaborate Ik' style polychrome vessels, non-Ik' style vessels with hieroglyphs and figural scenes, and simple polychrome vessels with abstract or geometric designs (Halperin and Foias, 2010; Smith, 2013). Previous INAA analysis of vessel wasters from this context reveals that the pastes of these wasters chemically match those of unprovenienced Ik' style vessels as well as excavated pottery from the site (Halperin and Foias, 2010; Reents-Budet et al., 2012). While archaeologists have found possible evidence of a polychrome pottery neighborhood at the site of Tikal, direct archaeological evidence of pottery workshops is rare in the Maya area (Halperin and Foias, 2012), leaving current scholarship to turn to the indirect evidence of paste and paint recipes among other analyses of the finished products (Foias and Bishop, 1997; Rice, 1984, 2009a).

In addition to Motul de San José, it is possible that the site of Tayasal was part of or allied with the Ik' polity. Not only is the site located close to Motul de San José, but an Ik' style vessel was excavated from a child's burial at the site (**Fig. 2**).

A member of the Ik' royal family may have given this vessel to an elite family living at Tayasal to foster alliances. Alternatively, Ik' royalty or their close kin may have resided at Tayasal. Tayasal's monumental architecture was similar in size to Motul de San José as its Late Classic ceremonial core zone (centered at the "Main Group") was approximately 1 km² and included a single large Acropolis complex (Chase, 1983; Cowgill, 1963). Likewise, both sites possessed Late to Terminal Classic carved stone stela monuments, suggesting they were both important political seats of power (Barrios, 2010; Morley, 1938, pp. 426–429; Tokovinine and Zender, 2012). Our understandings of the relationships between the sites, however, require further investigations.

Likewise, it is unclear whether the smaller sites of Flores, a small island site (0.5 km²) adjacent to the site of Tayasal, and Zacpetén, a peninsular site (0.23 km²) located approximately 20 km to the east of Motul de San José, were politically tied to Motul de San José during the Late Classic period. Zacpetén and Flores were important political centers during the Postclassic period and may have held prominent roles during earlier times (Rice and Rice, 2009). Less is known about these sites during the Late Classic period, however, since their settlements are largely covered by Postclassic and contemporary period ones.

We propose three possible models of political-economic relationships among Lake Petén region centers, which we examine through the chemical analysis of polychrome vessel paints and pastes excavated from the archaeological sites of Motul de San José and its satellite sites, Tayasal, Flores, Zacpetén, and Tikal. (1) Motul de San José, as the capital of the Ik' polity, was the

principal hub of polychrome pottery production and distribution in the Petén Lakes region, and as such had a tight control over this prestige good. In this sense, we would expect to see polychrome pottery from different Petén Lakes centers with the same chemical paint and paste groups as those from Motul de San José. This model reflects a more hierarchical political-economic relationship between Motul de San José and its neighboring Petén Lakes region sites.

In turn, the movement and exchange of polychrome pottery between Petén Lakes region centers and Tikal may provide further insights into Petén Lakes political dynamics. If Motul de San José was the dominant political capital in the Petén Lakes region, we might expect that Motul de San José elites disproportionately interacted and exchanged pottery with the more prestigious capital of Tikal. Thus, Motul de San José elites may have disproportionately received polychrome vessels from Tikal.

(2) The second model proposes that Motul de San José was one of several Petén Lakes sites where polychrome pottery production occurred. These sites, however, may have been intimately tied to one another through political alliances and shared exchange systems. Although written texts are silent on relationships between these sites, some of the ways in which such political ties may have occurred was in the gifting of polychrome vessels between elite families from Petén Lakes centers, the movement of Ik' royal family members from one Petén Lake center to another (e.g., through marriages), tightly bounded market systems, and the sharing of knowledge or exchange of resources among Petén Lakes sites, such as through polychrome pottery artisans who at the behest of their elite

patrons may have apprenticed or visited polychrome pottery workshops at other Petén Lakes centers. For example, written evidence indicates that some artisans moved to different centers and worked for more than one elite patron (Houston, 2009; Just, 2012). In this sense, each site may exhibit their own paint and paste recipes with some evidence of pottery, raw materials, or knowledge exchanged between them.

(3) The third model proposes that Petén Lakes sites, especially those equal in size to one another, were relatively autonomous from one another. Their production systems may have co-existed, but little to no evidence of gifting, shared knowledge, or exchange of raw materials existed between them. Here we would expect to see each site possessing their own paint and paste recipes with little or no overlap between them. In this case, each site drew on their own local sources of clay and pigments and the knowledge to produce them or had access to their own pottery workshops or artisans whether they were located locally at the site or elsewhere.

In both the second and third scenarios, elites from Petén Lakes centers may have interacted directly with elite patrons, merchants, or artisans from Tikal without the mediation or intervention of Motul de San José elites. Here we would expect to see relatively similar frequencies of Tikal imports at Petén Lakes centers.

3. Materials and Methods

Polychrome pottery analyses consisted of LA-ICP-MS on 143 red paint samples and INAA on 370 paste samples (**Appendices 1, 2, & 3** in supplementary

documents). The red paint samples derived from polychrome vessels were excavated from Motul de San José, Tayasal, Flores, Zacpetén, and Tikal (**Figs. 3, 4**). The samples included both polychrome vessels with hieroglyphic texts and figural scenes (including Ik' style vessels) as well as polychrome vessels with geometric or abstract designs. These latter vessels belonged to Zacatal Cream and Saxche-Palmar polychrome types designated in Maya typology systems (Smith and Gifford, 1966). The samples submitted for paint analyses were dictated by their size, as whole or large partial vessels could not be exported from Guatemala to the U.S. As such, these samples derive from primary and secondary midden contexts rather than caches or burials. Aside from this consideration and a preference for including Ik' style sherds and pottery from the production midden at Motul de San José, all other samples were chosen randomly.

Chemical analysis of the vessel paints was conducted by Halperin using LA-ICP-MS at the Field Museum of Natural History in Chicago. LA-ICP-MS was conducted with an Analytik Jena ICP-MS coupled with a New Wave Research UP213 laser system following the facility's protocols (Dussubieux et al. 2007). The New Wave UP213 laser operates at a wavelength of 213 nm. It operates at 70% of its maximum energy (0.2 mJ) and at a pulse frequency of 15 Hz in order to reach the stability and sensitivity requirements of the laser signal. Helium is used as a gas carrier at a flow rate of 0.50 l/min. Laser ablation is relatively non-destructive since extracted areas are barely visible to the naked eye. Unlike bulk analysis techniques, it can target especially thin layers, such as paint applications. A pre-ablation pass line was conducted to eliminate surface contamination before

extracting the sample for ionization and injection into the quadrupole chamber.

Laser settings were adjusted to target the paint and not pass through into the matrix.

An internal standard, the isotope Si²⁹, was used to correct for possible instrumental drifts or changes in the ablation efficiency. This standard was chosen since the red paints are slip-based paints containing silica in high concentrations. Si was monitored to make sure its signal was in the same intensity ranges as previous paste analyses with detection limits between less than 1 ppb for some elements and 2 ppm for Cu (for detection limits of each element, see Dussubieux et al. 2007:Figure 1). Two National Institute for Standards and Technology (NIST) standard reference materials (SRM), 679 and 610, were used as external standards to quantify the data. SRM 679 (Brick Clay) is a clay powder that is shaped into a pellet and fired at 900 degrees for an hour and is ideal for ceramic-based materials. SRM 610 was used to calculate the trace element concentrations. The methods for calculating concentrations followed those proposed by Gratuze (1999). Ohio Red clay, which is similar to the matrices of the paint samples, was also analyzed several times a day as a control to ensure the precision and accuracy of the readings (see **Appendix 4** in supplementary documents).

Chemical paint groups were identified first by using a hierarchical cluster analysis to sort samples into preliminary groups. Four outliers of the 143 samples were removed. These outliers were likely due to operational errors as one sample chemically matched one of the standards and the others were likely due to extremely thin and eroded paint samples where the ablation may have penetrated

272 past the paint into the paste matrix. All elemental compositions of the remaining
273 139 samples were then converted to Fe ratios. Since Fe was one of the most
274 abundant elements of red paint, Fe ratio conversions were made to eliminate its
275 diluting effect and to better identify the chemical variation inherent in a given iron
276 oxide source (Backes Jr. et al., 2012; Popelka-Filcoff et al., 2007). Bivariate plots
277 of all the element/Fe ratios were then examined to identify the most diagnostic
278 elements (Li, B, Na, Mg, Al, Si, K, Ca, Mn, Co, Ni, Sr, Mo, Cs, Ba, Nd, Sm, Eu, Gd,
279 Ta) (Michelaki and Hancock, 2011). Chemical paint groups were identified based
280 on the initial hierarchical cluster analysis in combination with Principal Component
281 Analysis (PCA) of element/Fe ratios using the 20 diagnostic elements. Component
282 extraction proceeded from a matrix of elemental covariances. PCA was run on
283 both logged (base 10) and unlogged ratios with no significant difference between
284 them. Group belonging occurred at 90% confidence levels.

285 Chemical analysis of the vessel pastes was carried out by Bishop using the
286 Smithsonian Institution's INAA facility at the National Institute for Standards and
287 Technology following routine protocols (see Blackman and Bishop, 2007) with
288 concentrations determined through the use of the comparator standard SRM 1633,
289 coal fly ash (**Appendix 5** in supplementary documents). Not all elemental
290 concentrations were used in the data modeling discussed below. The alkali
291 elements and calcium were excluded due to their variable properties of depletion
292 or enrichment in the tropical environment. Other elements were excluded because
293 of a high number of missing determinations or issues of analytical precision.

294 The paste samples overlap with the polychrome pottery samples chemically
295 analyzed for paint but also include pottery excavated from Motul de San José's
296 satellite centers, such as Buenavista, Chäkokot, Trinidad de Nosotros (hereafter
297 referred to as Trinidad), and Xilil. These satellite settlements are considered to
298 have been subordinate centers to Motul de San José due to their smaller
299 settlement sizes and diminutive monumental expressions (Foias and Emery, 2012).
300 Several paste groups can be defined using the chemical characteristics of ceramic
301 pastes within an initial 1400 sample set assembled for the greater Motul de San
302 José and Tikal regions. Analysis was guided by the interest in seeing if there was
303 evidence for similarity of grouping behavior for the ceramic pastes that might co-
304 vary with the patterns observed for their paint samples.

305 Several statistically refined groups and smaller, distinct but low membership
306 clusters were found in the composition of the paste. Some of these groups or
307 clusters, such as those pertaining to Preclassic and Early Classic decorative
308 expression or with obvious differences in the texture or temper provide little
309 informational value in the present study. Other reference units were formed and
310 evaluated but lacked any of the specimens that were the subject of the paint
311 analysis (e.g. a well-defined Motul de San José group that contained only
312 figurines). To reduce variation that arises from many sources and to retain a focus
313 on the extent of Late Classic period co-variation between polychrome pottery
314 surface paint color and paste composition, we reduced the data set to 307 pottery
315 samples. Thus, the samples for which INAA data are reported here include the
316 grouped data from the analysis of the ceramic pastes, as well as the paste

concentrations for the samples on which the paint analysis was carried out, whether or not they were members of a statistically-refined paste group. After the removal of outlying specimens, the number of samples having both paste and paint data was 124.

The paste groups were formed through average linkage cluster analysis using a matrix of Euclidean distances. These groups were illustrated through the use of discriminant analysis for graphical presentation only and not used to evaluate or assign samples to any group. The statistical evaluation and refinement of the paste groups was at the 95% confidence interval about a multivariate group centroid using a sample's Mahalanobis distance from that centroid (see Bishop and Neff 1989).

4. Results

Results of the chemical paint analysis revealed the presence of 6 statistically significant chemical paint groups (**Fig. 5, Tables 1 & 2**). These groups clustered by archaeological site, indicating that most sites possessed or had access to their own community or closely linked communities of polychrome pottery producers. Groups 1 and 2 comprised red paint on sherds excavated primarily from Flores. Group 3 comprised red paint on sherds excavated primarily from Motul de San José and included all the sampled Ik' style sherds. Group 4 comprised red paint on sherds excavated primarily from Tikal, and Group 5 comprised red paint on sherds excavated primarily from Tayasal. Group 6 had only five specimens from three different sites. More research is needed to identify

a possible source location(s) for this group. A paint group for Zacpetén was not identified as these samples fit in the Flores groups. The remaining eight samples were unassigned.

In turn, the paste analysis identified several paste groups and small, but distinct outlying paste clusters (**Fig.6 & 7, Tables 3, 4, 5**). Identified paste groups refined at the 95% confidence level consisted of Flores (1-Flores), Motul de San José (6-Motul, 9-Motul), Tayasal (12-Tayasal, 13-Tayasal), and Tikal (10-Tikal). Although more groups than these six were identified, only those of relevance for the sample also submitted for paint analysis are mentioned here. The identified clusters may be loosely associated with particular sites, but the membership of the clusters was small and was not statistically significant.

Paste samples from Motul de San José's smaller satellite sites (Buenavista, Chäkokot, Trinidad, and Xilil) were not chemically distinguishable from those deriving from Motul de San José and thus were subsumed under the Motul groups. Such chemical similarity between these sites is not surprising given their close physical location to each other as well as the subordinate status of the satellite sites. It is possible that some of the smaller satellite centers produced their own polychrome pottery but shared their raw materials/finished products with Motul de San José to such an extent that any chemical distinction between pottery produced at the capital and its satellite centers could not be detected. Given the scale of Motul de San José, however, it is more likely that the smaller sites did not produce their own polychrome pottery and received polychrome pottery from Motul de San José where direct evidence of polychrome pottery production exists. Such

possibilities can be further assessed in the future with the analysis and publication of the larger corpus of paste samples deriving from these satellite sites.

Also not surprising are the paint and paste groups designated to Tikal, indicating that it had access to its own polychrome pottery producing community or communities. Interestingly, paint and paste group designations were identified on the site level for Flores and Tayasal indicating that these Petén Lakes centers, in addition to Motul de San José, had access to their own polychrome pottery production workshop or workshops. Since little is known about the political-economic relationships between these Petén Lakes centers, it gives us some indication of their relative autonomy albeit through the lens of polychrome pottery.

Despite the association of chemical paint and paste groups by site, however, these groups also contained sherds excavated from other sites, evidence of which represents the gifting, movement, or exchange of raw materials or finished vessels between sites (**Tables 1 & 3**). These exchanges moved in multiple directions, with polychrome pottery from Motul paste groups excavated from Flores, Tayasal, Tikal, and Zacpetén. Flores paste group pottery was excavated from Motul de San José and its satellite centers as well as Tikal. Tikal paste group pottery was excavated from Motul de San José and one of its satellite centers (Trinidad). Tayasal paste group pottery was excavated from Flores, Motul de San José and one of its satellite centers (Chäkokot), and Tikal. In turn, Motul de San José paint group pottery was excavated from Flores and Tayasal, Flores paint group pottery was excavated from Zacpetén, Tayasal paint group pottery was excavated from Motul de San José, and Tikal paint group pottery was excavated from Motul de San José.

These exchanges included both polychromes with geometric and abstract designs and the finest polychrome pottery with figural scenes and hieroglyphic texts.

Most of the samples with assigned paste and paint groups possessed matching site attributions (69% correspondence; doesn't include paint group 6 of unknown source site) (**Fig. 8, Table 6, Appendix 3** in supplementary documents). For example, the Ik' style pottery sampled here belonged only to Motul de San José designated paint and paste groups. Likewise, the majority of Flores designated paint groups were found on Flores designated paste groups and so on for each site.

Nonetheless, some paint groups did not match the same sites as the paste groups. Such discrepancies may indicate that either (1) potters/painters from these sites were getting clays from other sites but using their own local paints or (2) people were exporting vessels to other sites but using the same paint recipes and raw materials as those from other sites in the Petén Lakes region. The second scenario may be more plausible since ethnographic data indicate that paint pigments tend to travel farther than clays (Arnold, 1985 Table 2.3; DeBoer and Lathrap, 1979). In addition, Maya hieroglyphic evidence indicates that some artisans may have moved and worked for different patrons in different political centers (Houston, 2009; Just, 2012). If this was the case, artisans may have brought their own pigments with them. As mentioned earlier, such discrepancies in paint and paste recipes also have been found in other studies of prehistoric pottery production and exchange, such as among the Postclassic Maya in the same Petén Lakes region (Cecil and Neff, 2006), among the Gulf Coast Olmec

and other Preclassic sites throughout Mesoamerica (Backes Jr. et al., 2012), and among Nasca sites in the Andes of South America (Vaughn, 2005). Even if the paint pigments were more “mobile” between potting communities, both the paint and paste data from the Late Classic Maya polychromes point to the same general pattern: some centers (Flores, Motul de San José, Tikal, and Tayasal) had access to their own polychrome pottery recipes or sources with some evidence of the exchange of raw materials or finished products between them.

5. Discussion & conclusions

The chemical paint and paste analyses do not support the first model of a provincial capital centered at Motul de San José, which served as the primary hub of polychrome production and distribution to neighboring centers, such as Tayasal, Flores, and Zacpetén. Rather, Petén Lakes sites such as Tayasal, Flores, and Motul de San José had their own polychrome production workshops – or at least access to such workshops – as articulated in the second or third models. Petén Lakes political-elites, however, gifted, moved, or exchanged these vessels with each other, a pattern more in line with the second model, in which Motul de San José was only one among other prominent neighboring centers whose political influence was expressed in and through the movement of polychrome vessels. Likewise, although it is clear that Motul de San José had access to Tikal polychrome pottery imports, several Petén Lakes sites (Motul de San José, Flores, and Tayasal) were tied to Tikal through the direct or indirect exchange of their

pottery with this dominant center. More research is needed to clarify the nature of interactions between Tikal and these other Petén Lakes sites.

While Motul de San José does not appear to have dominated the production and distribution of polychrome pottery in the western Petén Lakes region, the evidence presented here does not indicate that Flores, Tayasal, or Zacpetén produced Ik' style vessels. The Tayasal excavated Ik' style vessel and the corpus of unprovenienced Ik' style vessels, however, were not included in the paint analyses. Further paint analyses of these whole vessels would be necessary to better understand the variability of paint recipes of Ik' style vessels specifically. The LA-ICP-MS analyses would require a larger, specialized laser ablation chamber to fit the whole vessels and special permission to move the vessels from the individual museums where the vessels are housed. In addition, it is important to keep in mind that the models do not preclude the possibility that other types of prestige goods were exchanged (e.g. jade, pyrite, sacred wood objects) between these centers and that political relationships may have been forged through other means.

Nonetheless, the polychrome paint and paste analyses presented here support other lines of evidence to suggest that some Petén Lakes centers may have been allied or shared political power with each other. For example, studies by art historians and epigraphers reveal that Ik' style vessels depict Ik' rulers paired side-by-side (Just, 2012; Reents-Budet et al., 2012; Tokovinine, 2013, pp. 84–85). These paired Ik' co-rulers each possessed *k'uhul Ik' ajaw* (holy Ik' lord) royal titles and were paired together within the same ceremonial scene, exhibiting

a display of power-sharing relatively uncommon for Classic period imagery. These visual displays, however, conform with Contact period evidence of the existence of Junior-Senior pairs of Itzá rulers from the Petén Lakes region (Jones, 1998). In addition, multiple rulers from closely located political capitals, such as from Dos Pilas and Aguateca or from Zapote Babal and El Pajal, shared the same Emblem Glyphs (Fitzsimmons 2012; Mathews and Willey, 1991), indicating that political relationships may have been forged as partnerships in addition to dominant-subordinate relations.

Thus, we find that any understanding of the Ik' polity must include a regional focus of multiple sites in the Petén Lakes region in addition to its relations with more distant primary political capitals, such as Tikal. Furthermore, we assert that the strength of these second-tier or provincial capitals did not necessarily depend on their individual size or the grandeur of their monumental expressions, but on the alliances and networks that they forged with each other.

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Endnote

¹ The comparative samples for the INAA portion of the study were submitted by several individuals over the course of several years. The "Motul area" ceramics were ascribed an analytical number consisting of "MSJxxx" and have been subjective to previous interpretations (e.g., Halperin et al., 2009; Reents-Budet et al., 2012). A more recent shipment of pottery for chemical analysis, unfortunately, was given INAA identification numbers that overlapped those previously assigned. Luckily, it did not compromise earlier interpretations. This situation has been reconciled with the registration books but required recoding of some of the sample; thus, "MTJ" appears here and in the data listing for INAA samples (Appendix 3).

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646

List of Figures

Figure 1. Map of settlement hierarchies of Tikal and sites in the western Petén Lakes region (following sizes of triangles) within inset map of Maya area showing location of the Petén Lakes region (right).

Figure 2. Rollout photograph of Ik' style vessel excavated from Tayasal (K2707 © Justin Kerr).

Figure 3. Late Classic polychrome vessels with geometric or abstract designs: (a) MTJ 341; bowl, Saxche-Palmar polychrome, paint group #3 [MSJ]; (b) FRS112, dish, Saxche-Palmar polychrome, paint group #3 [MSJ]; (c) FRS135, bowl/vase, Saxche-Palmar polychrome, paint group #6; (d) ZPN002, bowl, Saxche-Palmar polychrome, paint group #1 [FRS]; (e) TSL122, bowl/dish, eroded polychrome, paint group #3 [MSJ]; (f) ZPN003, tripod dish, Zacatal Cream polychrome, paint group #1 [FRS]; (g) TSL106, bowl, Saxche-Palmar polychrome, paint group #5 [TSL].

Figure 4. Late Classic Polychrome vessels with hieroglyphic texts and/or figural scenes: (a) MTJ252, vase, Ik' style, fragment of rim text [left] with black scalloped interior rim [right], paint group #3 [MSJ]; (b) MTJ320, vase, Zacatal Cream polychrome, ruler's hand extended in front of cloth tribute bundle with scribe or artisan seated below pink and red hieroglyphic bench and holding stylus, paint group #3 [MSJ]; (c) MTJ055, vase, Zacatal Cream polychrome, fragment of rim text, paint group #6 [TIK]; (d) TIK113 dish/plate, Saxche-Palmar, lower torso of dancing deity wearing jaguar attire, paint group #6; (e) FRS104, vase, Zacatal Cream polychrome, fragment of rim text, paint group #1 [FRS]; (f) TIK099, vase, Zacatal Cream polychrome, detail of feathers, paint group #4 [TIK]; (g) FRS124, plate/dish, Zacatal Cream polychrome, seated elderly deity, paint group #1 [FRS].

Figure 5. Two-dimensional plot of PCA1 and PCA2 of red paint samples from Late Classic polychrome vessels. Ninety percent confidence interval ellipses designate principal red paint groups.

Figure 6. Bivariate plot of groups formed using elemental concentrations of the ceramic paste using discriminant analyses 1 and 2. Separation of the paste groups are shown relative to the first two axes derived from a discriminant analysis. The elemental correlations with the axes are given in Table 5. Cluster 5 (represented by the "+" sign) is shown by its projection onto the axes obtained by the analysis of compositional groups 1, 6, 9, 10, 12, and 13. The cluster is similar to group 9 but differs in having elevated concentrations of several elements, especially the light rare earths; members, however, are too few for statistical refinement. Groups were refined at the 95% confidence level but ellipses shown here call attention to the group locations at the 90% confidence level.

Figure 7. Bivariate plot of groups formed using elemental concentrations of the ceramic paste using discriminant analyzes axes 3 and 4. The tendency toward separation among groups 1, 10 and 6, which are overlapped in Figure 6, are shown using discriminant axes 3 and 4.

Figure 8. Bivariate plot showing location of paint groups relative to the groups formed using the INAA data from the ceramic paste. Groups are shown as in Figure 6 except that a symbol for paint group has been used; it is superimposed over its location based on paste chemistry.

List of Tables

Table 1. LA-ICP-MS chemical paint groups from Late Classic polychrome vessels (columns) and archaeological provenience (rows).

Table 2. Descriptive statistics of Late Classic polychrome vessel LA-ICP-MS chemical paint groups (expressed as Fe ratios).

Table 3. Correspondence of select INAA pottery paste groups and clusters (columns) by archaeological provenience (rows). Statistically significant groups indicated by both number and name designations, and clusters indicated by only number designations.

Table 4. Descriptive statistics for groups and cluster formed using INAA chemical concentrations of the ceramic paste.

Table 5. Canonical discriminant function loadings of INAA paste groups normalized by within variance. Note: the elements that were selected for the discriminant analysis are those that were used to form the chemical paste groups.

Table 6. Cross tabulation of LA-ICP-MS paint groups (columns) by INAA chemical paste groups (rows).

Table 1. LA-ICP-MS chemical paint groups from Late Classic polychrome vessels (columns) and archaeological provenience (rows).

	Group 1	Group 2	Group 3 Motul de San Jose	Group 4	Group 5	Group 6 unknow n	Unassigne d	Total
Flores	45	10	2	0	0	2	1	60
Motul de San Jose	0	0	34	2	2	1	2	41
Tikal	0	0	0	7	0	2	4	13
Tayasal	0	0	4	0	16	0	1	21
Zacpetén	3	1	0	0	0	0	0	4
Total	48	11	40	9	18	5	8	139

Table 2. Descriptive statistics of Late Classic polychrome vessel LA-ICP-MS chemical paint groups (expressed as Fe ratios).

Group 1 Flores (n=48)					Group 2 Flores (n=11)				
	Mean	SD	Min	Max		Mean	SD	Min	Max
Si	10.50	0.17	10.11	10.85	Si	10.47	0.10	10.32	10.61
Na	8.27	0.26	7.75	8.93	Na	8.08	0.25	7.62	8.51
Mg	8.80	0.28	8.38	9.99	Mg	8.59	0.17	8.37	9.02
Al	9.87	0.16	9.60	10.18	Al	9.77	0.11	9.58	9.94
K	8.86	0.21	8.39	9.34	K	8.77	0.13	8.57	8.97
Ca	9.29	0.22	8.84	10.09	Ca	9.18	0.13	8.95	9.37
Mn	7.77	0.38	7.19	8.99	Mn	7.26	0.13	7.07	7.48
Li	6.22	0.25	5.74	6.96	Li	6.06	0.13	5.90	6.27
B	6.51	0.21	6.03	7.13	B	6.43	0.14	6.18	6.70
Ni	6.60	0.14	6.34	6.97	Ni	6.41	0.09	6.29	6.57
Co	6.10	0.30	5.65	7.25	Co	5.72	0.10	5.59	5.94
Sr	7.11	0.24	6.67	7.70	Sr	6.93	0.21	6.67	7.24
Cs	5.80	0.29	4.76	6.52	Cs	5.66	0.25	5.07	5.91
Ba	7.89	0.23	7.45	8.48	Ba	7.69	0.24	7.42	8.10
Ta	5.18	0.16	4.88	5.50	Ta	5.20	0.08	5.09	5.33
Mo	5.52	0.25	5.12	6.35	Mo	6.23	0.32	5.46	6.75
Nd	6.33	0.26	5.91	6.98	Nd	6.04	0.11	5.87	6.18
Sm	5.66	0.23	5.24	6.28	Sm	5.36	0.12	5.11	5.52
Eu	5.01	0.22	4.61	5.59	Eu	4.70	0.16	4.48	4.93
Gd	5.58	0.21	5.16	6.17	Gd	5.31	0.13	5.12	5.44

Group 3 Motul de San José (n=40)					Group 4 Tikal (n=9)				
	Mean	SD	Min	Max		Mean	SD	Min	Max
Si	10.35	0.15	10.06	10.70	Si	10.43	0.11	10.28	10.58
Na	7.63	0.22	7.18	8.18	Na	8.86	0.31	8.21	9.26
Mg	8.48	0.29	7.94	9.40	Mg	8.60	0.22	8.33	8.93
Al	9.75	0.16	9.42	10.16	Al	9.82	0.11	9.61	10.00
K	8.18	0.23	7.80	8.65	K	9.05	0.22	8.60	9.34
Ca	9.16	0.20	8.74	9.54	Ca	9.40	0.18	9.25	9.80
Mn	7.62	0.37	6.67	8.36	Mn	8.13	0.48	7.67	9.08
Li	6.47	0.36	5.44	7.05	Li	6.30	0.16	6.03	6.46
B	6.48	0.17	6.06	6.78	B	7.04	0.29	6.57	7.46
Ni	6.61	0.18	6.20	7.10	Ni	6.75	0.13	6.55	6.90
Co	5.97	0.29	5.40	6.53	Co	6.32	0.37	5.96	7.21
Sr	6.42	0.17	6.03	6.88	Sr	6.68	0.16	6.46	6.88
Cs	5.89	0.29	5.38	6.41	Cs	5.48	0.19	5.26	5.84
Ba	7.58	0.16	7.20	7.96	Ba	7.81	0.51	7.16	8.50
Ta	5.12	0.16	4.78	5.38	Ta	5.07	0.12	4.89	5.23
Mo	5.28	0.24	4.99	6.26	Mo	5.33	0.10	5.21	5.48
Nd	6.04	0.16	5.68	6.29	Nd	6.26	0.22	5.89	6.55
Sm	5.37	0.16	5.01	5.66	Sm	5.59	0.22	5.21	5.83
Eu	4.71	0.15	4.34	4.99	Eu	4.93	0.25	4.49	5.20
Gd	5.29	0.15	4.96	5.57	Gd	5.52	0.22	5.15	5.76

Table 3. Correspondence of INAA pottery paste groups (columns with number and site labels) and clusters (columns with number labels) by archaeological provenience (rows).

	1-Flores	6-Motul	9-Motul	10-Tikal	12-Tayasal	13-Tayasal	5	20	21	23	25	27	30
Flores	26	3	3	0	1	0	7	16	0	2	0	0	0
Motul de San José	13	19	39	6	2	0	0	0	0	11	1	0	1
Buenavista (TBV)	1	0	0	0	0	0	0	0	0	0	0	0	0
Chakokot	0	0	3	0	1	0	0	0	0	0	0	0	0
Trinidad	8	3	8	1	0	0	1	0	0	0	0	0	0
Xilil	2	5	0	0	0	0	0	0	0	0	0	0	0
Tayasal	0	1	1	0	8	31	0	0	0	1	0	8	1
Zacpetén	0	1	0	0	0	0	0	3	1	0	0	0	0
Lake Petén	0	0	0	0	0	1	0	0	0	1	0	0	0
Tikal	2	4	0	44	4	0	0	0	0	0	6	0	1

Table 5. Canonical discriminant function loadings of INAA paste groups normalized by within variance.

	Df 1	Df 2	Df 3	Df 4	Df 5	Df 6	Df 7	Df 8	Df 9
Sc	0.254	0.684	0.642	0.754	0.362	0.859	0.075	0.258	0.432
Cr	-0.098	1.140	-0.287	-0.415	0.251	-0.443	0.124	-0.021	-0.086
Fe	-0.154	-0.730	-0.324	-1.119	-0.356	0.335	-0.447	-0.401	-0.357
Sb	-0.185	0.209	0.436	-0.334	-0.291	-0.227	0.441	0.682	0.110
Ba	-0.077	-0.163	0.283	-0.070	0.448	0.059	-0.428	0.043	0.335
La	0.206	-0.210	0.260	-0.474	0.815	-0.223	0.502	-0.243	0.670
Ce	0.487	-0.081	-0.283	-0.045	0.138	0.104	-0.443	0.345	-0.375
Sm	0.430	0.250	0.238	0.323	0.099	0.253	-0.313	0.038	-1.359
Eu	-0.102	-0.087	-0.577	0.362	-0.344	0.338	0.696	0.304	0.698
Yb	0.065	0.184	0.261	-0.231	-0.403	-0.692	-1.020	0.555	0.306
Lu	0.338	-0.063	-0.219	0.070	-0.126	0.084	0.465	-0.944	0.279
Hf	-0.117	-0.083	0.238	-0.002	-0.351	-0.500	0.190	-0.371	0.026
Th	0.062	-0.750	0.366	0.200	0.112	0.070	-0.029	-0.309	-0.502
Cumulative proportion of total dispersion									
	0.590	0.745	0.873	0.959	0.978	0.987	0.995	0.999	1.000

Table 6. Cross tabulation of LA-ICP-MS paint groups (columns) by INAA chemical paste group

	Group 1 Flores	Group 2 Flores	Group 3 Motul	Group 4 Tikal	Group 5 Tayasal	Group 6 Unknown
1-Flores (group)	16	6	0	0	0	1
6-Motul (group)	2	1	6	1	1	0
9-Motul (group)	2	0	7	0	1	0
10-Tikal (group)	0	0	1	1	0	1
12-Tayasal 1 (group)	0	1	3	0	2	0
13-Tayasal 2 (group)	0	0	0	0	1	0
5-Motul (cluster)	4	2	0	0	0	0
Paint group sherds attributed	24	10	17	2	5	2
Paint groups sherds not attribute	18	1	22	7	12	3

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8