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Steatite characterization using X-ray fluorescence and insights into Northern Iroquoian interregional interaction

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A B S T R A C T

The research presented here evaluates the applicability of energy-dispersive X-ray fluorescence (EDXRF) for characterizing steatite. We present compositional data from an assemblage of 100 steatite beads and pipes deriving from 11 Northern Iroquoian sites in southern Ontario and New York State. Percentages of major elemental constituents and principal components analysis define two compositional groups and various non-steatite artifacts. Our results suggest that EDXRF is an expedient means of characterizing steatite based on major oxides and trace elements. The results support the assertion that individual Iroquoian communities were involved in distinct interaction networks that linked groups in southern Ontario and the St. Lawrence Valley region.

1. Introduction

Steatite beads and pipes commonly occur on Northern Iroquoian archaeological sites in southern Ontario and the St. Lawrence Valley. While the elemental heterogeneity of this material makes it difficult to link back to its geologic source, individual artifacts can be characterized and sorted into compositional groups to make inferences about how these materials were distributed and transmitted across the landscape. The assemblage considered here includes 100 beads and pipes from 11 Northern Iroquoian sites in southern Ontario and northern New York State dating to ca. 1250–1650 CE. Percentages of major elemental constituents and principal components analysis are employed to define compositional groups. Two compositional groups are chemically steatite and the third is non-steatite soapstone that falls outside common ranges of Mg-Si-Ca for steatite.

Our research has two primary objectives: 1) To evaluate the applicability of energy-dispersive X-ray fluorescence (EDXRF) for characterizing steatite among archaeological materials; and 2) to evaluate how these data contribute to understandings of interregional interaction and exchange, particularly regarding relationships between ancestral and historical Wendat-Tionontaté and St. Lawrence Iroquoian peoples. In the Lower Great Lakes-St. Lawrence region, geological sources for this material originate from the east, in the St. Lawrence Valley and surrounding areas. As such, steatite artifacts have implications for understanding the nature of east-west interaction networks among Northern Iroquoian peoples (Fig. 1).

The results of this study allow us to 1) provide suggestions for best practices in analysis of steatite by EDXRF and 2) investigate patterns of steatite distribution among Northern Iroquoian societies and communities. Our results suggest that EDXRF is an expedient means of characterizing steatite based on major oxides and trace elements. The results also suggest that individual communities were accessing steatite via distinct community-based networks and as such provide new insights on interactions between Iroquoian communities in southern Ontario, northern New York State and the St. Lawrence Valley.

2. Regional context

Sites recognizable as Iroquoian appear in the archaeological record at approximately 1000 CE. The earliest Iroquoian village sites are generally characterized as small, seasonally-occupied base camps (Hart and Brumbach, 2003; Williamson, 1990). Around approximately 1250–1300 CE, these base camps became more permanent, longhouse-based villages which were, for the first time, sustained primarily by maize-based agricultural systems (Dodd et al., 1990; Hart, 2001). Between 1250 CE and 1350 villages were typically not palisaded, with

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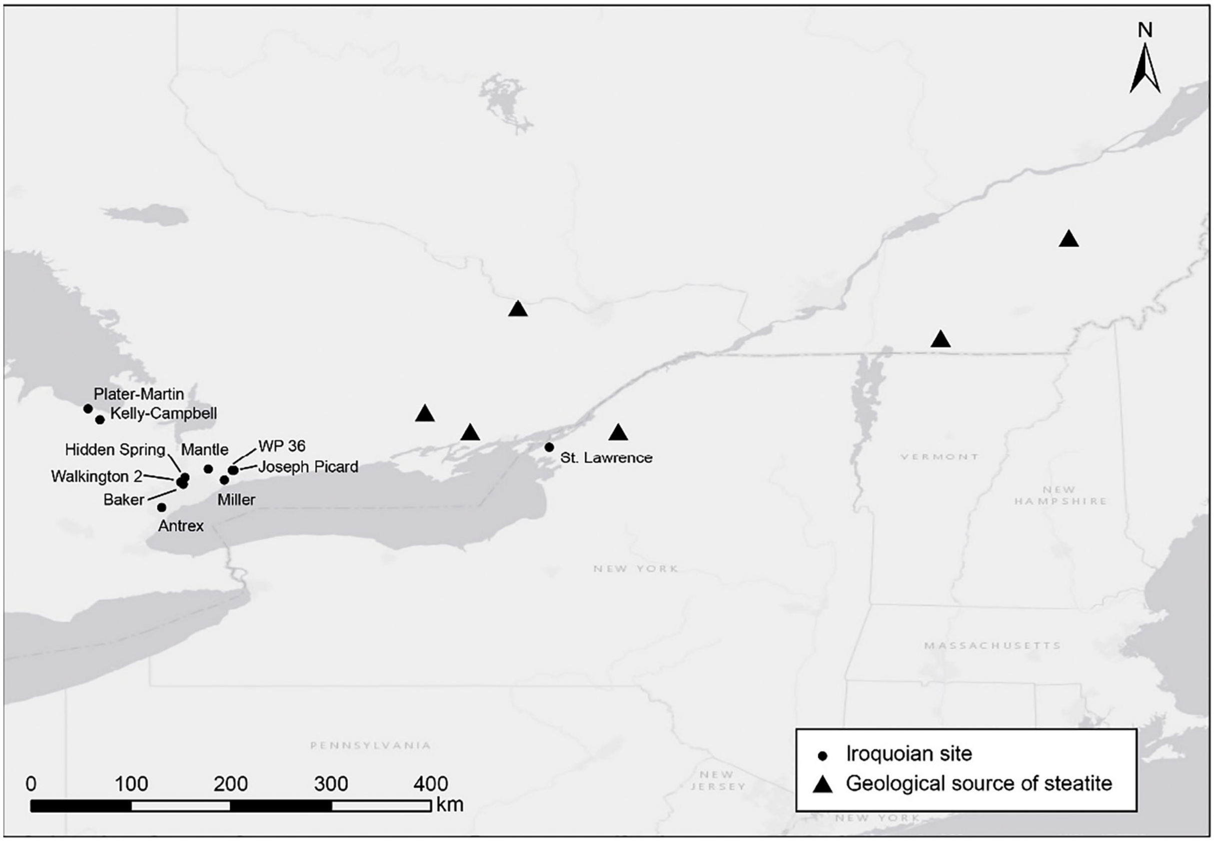


Fig. 1. Map of locations of sites in this study and steatite source locations (after Baron et al., 2016).

populations in the low hundreds (Warrick, 2008). The fourteenth-century was characterized by the development of a recognizably Iroquoian material culture and heightened local and interregional interaction (Birch, 2015). After 1450 CE, village sites in both Ontario and New York State become fewer in number, larger in size, and are surrounded by multi-row palisades, a phenomenon interpreted as signaling the initiation of widespread conflict (Birch, 2012; Williamson, 2007). While it is unclear who precisely was in conflict with whom, the outcomes of regional conflict varied between groups in different sub-regions at different periods. For the ancestral Huron-Wendat and Haudenosaunee, this conflict may have influenced nation- and confederacy-building. For Iroquoian populations occupying northern New York State and the St. Lawrence Valley, conflict may have contributed to the movements of some populations out of the region, resulting in the incorporation of at least some of these populations into what would become nations of the eastern Haudenosaunee and Huron-Wendat confederacies (Engelbrecht, 1995; Ramsden, 2016; Wonderley, 2005). Between the mid-1400s and early 1600s, alliances between nations developed into the historically-documented Haudenosaunee (Iroquois) confederacy in New York and the Huron-Wendat and Neutral confederacies in southern Ontario, each of which were encountered by early European explorers and missionaries in the seventeenth century (Biggar, 1929; Thwaites, 1896–1901).

There is no evidence that the Petun-Tionontaté, Erie, or St. Lawrence Iroquoian populations farther down the St. Lawrence River created formalized political confederations, though these groups also were characterized by alliances between related communities. Sites in the present study belong to ancestral Huron-Wendat (and in one case, possibly ancestral Neutral), Petun-Tionontaté, and Jefferson County St. Lawrence Iroquoian archaeological sub-groups (Table 1). The Petun-Tionontaté were closely allied with the Huron-Wendat in the contact period and these groups share many aspects of their material and cultural patterns. Populations inhabiting the St. Lawrence Valley produced distinctive ceramic vessels and possessed a complex bone tool industry that differs from the chert-based tools common on sites in southern Ontario and upper New York State (Engelbrecht and Jamieson, 2016a, 2016b; Jamieson, 2016). Although there are significant differences in the material culture of ancestral St. Lawrence Iroquoian and Huron-Wendat/Petun-Tionontaté populations, these are archaeological distinctions that have little relevance for contemporary members of the Huron-Wendat Nation who do not consider these criteria to describe the nature of their ethnicity (Gaudreau and Lesage, 2016; Lesage and Warrick, 2016). For them, more than 300 years of oral history identify the St. Lawrence Valley as ancestral Huron-Wendat territory (Richard, 2016) and archaeological data attest to the incorporation of some populations originating in the St. Lawrence Valley into Huron-Wendat communities and nations during the fifteenth and sixteenth centuries A.D. (Ramsden, 1990, Ramsden, 2009, 2016; Williamson et al., 2016). Recent social network analysis (SNA) of pottery decoration from throughout Iroquoia suggests that St. Lawrence Iroquoian populations in Jefferson County were signaling with groups in Ontario and New York State in previously unrecognized ways, acting as intermediaries between ancestral populations in these two regions (Hart et al., 2017).

Within the region, steatite is available from a limited number of sources, all located east of the ancestral Huron-Wendat and Petun-Tionontaté territories, and primarily within or adjacent to landscapes occupied and crisscrossed by the peoples archaeologists have labelled St. Lawrence Iroquoian (Fig. 1). One of the key research questions that this study helps to address is the nature of interaction between groups inhabiting the St. Lawrence Valley and those in south-central Ontario.

Table 1
Sites from which assemblages analyzed in this study derive.

Site	Date (AD)	Affiliation	Ref.
Antrex	1300–1350	Ancestral Huron-Wendat or ancestral Neutral	ASI, 2010a
Baker	1400–1450	Ancestral Huron-Wendat	ASI, 2006
Hidden Spring	1400–1450	Ancestral Huron-Wendat	ASI, 2010b
Kelly-Campbell	1630–1650	Petun-Tionotaté	Garrad, 2014
Miller	1200–1250	Ancestral Huron-Wendat	Kenyon, 1968
Mantle	1500–1550	Ancestral Huron-Wendat	ASI, 2014; Birch and Williamson, 2013
Joseph Picard	1400–1450	Ancestral Huron-Wendat	ASI, in prep.; Williamson et al., 2016
Plater-Martin	1630–1650	Petun-Tionotaté	Garrad 2014
St. Lawrence	1475–1500	Ancestral Huron-Wendat	Abel 2016
Walkington 2	1400–1450	Ancestral Huron-Wendat	ASI 2010c
WP 36 (aka Yatsihsta)	1400–1450	Ancestral Huron-Wendat	ASI, in prep.

Fig. 2. Selected artifacts analyzed in this study and associated site context. **Group 1 steatite** (top row, left to right): polished pebble, Antrex (ANT001); bead preform, Miller (MLR001); bead, St Lawrence (STL025); bead, Joseph Picard (PCD019); bead, Joseph Picard (PCD026); bead preform, Hidden Springs (HDS007); bead preform, Hidden Springs (HDS012); pipe bowl fragment, Hidden Springs site (HDS013). **Group 2 steatite** (middle row, left to right): pipe preform, Hidden Springs (HDS008); pipe, Baker 520–205 (BAK002); effigy pipe, Kelly-Campbell (KCB001); drilled pipe base, Plater-Martin (PLM001). **Non-steatite soapstone** (bottom row, left to right): bead, Joseph Picard (PCD025); bead, Mantle (MNT001); bead, St. Lawrence (STL021); bead St. Lawrence (STL006); bead, St. Lawrence (STL035).

2.1. Steatite distribution patterns and interregional interaction

In the Late Woodland Northeast, artifacts made of soapstone (both steatite and non-steatite) primarily take the form of discoidal beads and pipes (Fig. 2). Steatite artifacts are most common on fifteenth and sixteenth-century sites in northern New York State, southeastern Ontario, and southwestern Quebec (Abel, 2001: 67; Chapdelaine, 2016; Williamson et al., 2016).

At the St. Lawrence site in St. Lawrence County, New York, an elaborate steatite bead industry is evinced by the presence of numerous finished beads, raw material, cut stock, and undrilled preforms (Abel, 2002:67). Similar evidence of a stone bead-making industry has been recovered from the Putnam site. Finished steatite beads have been recovered from nearly every Iroquoian village site substantially excavated in northern New York (Abel, n.d.). In southern Ontario, with the exception of a polished steatite pebble from the late thirteenth-century Antrex site (ASI 2010; Williamson et al., 2016) and two bead preforms and 21 steatite pipe fragments (representing an unknown number of pipes) found at the twelfth-century Miller site (Kenyon, 1968: 49), most steatite artifacts come from sites dating to the fifteenth-century or later. However, these artifacts are not distributed evenly across the region. The majority of steatite artifacts known from southern Ontario have been recovered from mid-fifteenth century sites in the Don River drainage (Baker and Hidden Spring) as well as the contemporary Joseph Picard site some 50 km east on Lynde Creek. Contemporaneous community relocation sequences on the north shore of Lake Ontario, including in the densely populated Humber and Rouge-Duffins drainages, did not yield *any* steatite artifacts (Williamson et al., 2016). These distributions suggest that individuals and communities were involved in differing relations with other communities or groups with access to these raw materials rather than materials being distributed from the source area in a distance-transgressive fashion.

Stone pipes are rare on early to mid-fifteenth century Iroquoian sites in southern Ontario and become more common from the early sixteenth century onwards (Williamson et al., 2016:243). For example, at the Mantle site, pipes include shale, limestone, and steatite/soapstone examples (Birch and Williamson 2013:148–149). The increase in the prevalence of stone pipes occurs concomitantly with the uptake of vasiform-shaped pipe bowls across Iroquoia (Pratt, 1976:210, 222, 225; Sempowski and Saunders, 2001:257–8; Wray et al., 1987:133). Cream-colored steatite vasiform pipes occur in Neutral mortuary contexts (Ridley, 1961; Kenyon, 1982) dating to ca. 1620–1650. It is likely that the cream-to-tan colored steatite pipes in this study have similar origins (see discussion of Group 2 pipes, below). Drooker (2004) argues that portable, wooden-stemmed pipes were used and given as gifts in the context of diplomatic and ceremonial events. An increase in the presence of these pipes on Iroquoian sites can perhaps be interpreted as signaling interactions between trading partners and allies in the context of the development of ties between communities and regional groups during processes of regional consolidation and nation-building (Williamson et al., 2016:243).

3. Previous steatite characterization studies

A number of projects have carried out steatite characterization in North America since the mid-1970s. These prior studies were recently summarized by Baron et al. (2016). Since steatite is a relatively heterogeneous material compared to, for example, obsidian, there has been considerable debate about which techniques are most efficacious for defining geochemical groups. The most common methods utilized in steatite characterization studies include: 1) instrumental neutron activation analysis (INAA), which measures a range of major, minor, trace, and rare earth elements s (Allen et al., 1975; Allen and Edith Pennell, 1978; Archambault, 1981; Harnois, 1995; Rogers et al., 1983; Truncer et al., 1998); 2) laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), which provides a more complete chemical fingerprint (major, minor, trace, and rare earth elements) (e.g., Baron et al., 2016; Bray, 1994; Jones et al., 2007); and 3) various forms of X-ray fluorescence (XRF), including wavelength dispersive X-ray fluorescence (WDXRF), which measures a wide range of elements (including major, minor, trace, and a few rare earth elements) and energy dispersive X-ray fluorescence (EDXRF) (both portable and traditional laboratory systems) which is somewhat more limited than WDXRF (e.g., Bachor, 2011; Tweedie, 2014; Williamson et al., 2016). Each of these methods comes with their own set of advantages and detractors (e.g., elements analyzed, sample size, destructive vs. non-destructive capabilities, cost, and accessibility).

The only studies to date that have evaluated steatite artifacts from Northern Iroquoian contexts are those by Baron et al. (2016), who employed LA-ICP-MS and Williamson et al. (2016) who used EDXRF. Unfortunately, inter-study comparisons are complicated on account of the different analytical techniques used and variability in instrument calibrations. Baron et al. (2016:327) argue that LA-ICP-MS is the best-adapted method for studying small steatite artifacts from archaeological collections because it is minimally destructive and measures a wide range of elements. However, the relative cost, accessibility, and destructive nature (however minimally) of LA-ICP-MS does not always make it a viable technique for archaeologists. Additionally, with heterogeneous minerals such as steatite, microprobe-type analytical techniques (e.g., LA-ICP-MS), oftentimes to do not provide a true measure of the bulk chemical composition of the material being analyzed. Conversely, the completely non-destructive, more commonly available method of EDXRF, together with its ability to measure the elements necessary to discriminate among major chemical groups renders it a more practical option for many researchers interested in characterizing, though not sourcing, steatite artifacts.

3.1. Materials

All artifacts analyzed in this study fall within the geologic category of soapstone. Soapstone is a hydrothermally-altered metamorphic rock composed primarily of the clay mineral talc—a hydrous magnesium silicate [$Mg_3Si_4O_{10}(OH)_2$]—and occurring with varying amounts of other minerals, including chlorite, micas, and carbonates. The sample set consists of 100 soapstone artifacts from eleven Iroquoian sites dating to between the fifteenth and seventeenth centuries A.D. (Appendix A and Table 1). All samples are derived from collections curated at Archaeological Services Inc., Toronto, Ontario, the 1000 Islands Chapter of the New York State Archaeological Association, and the New York State Museum, Albany, New York. No samples were prepared or cleaned prior to analyses as they are from curated contexts.

Samples were analyzed using EDXRF (see methods, below). Flat, smooth surfaces on each artifact were identified for analysis as less topological variation minimizes surface scatter and matrix effects that could affect results. Size, density, and thickness were also considered, as they can affect instrument accuracy (Davis et al., 2011:45–64). For example, some samples did not completely cover the analysis window, which is the 8 mm area through which the X-ray beam strikes the sample causing it to fluoresce. Secondary photons—the characteristic X-rays emitted from a sample and measured by the instrument's detector—also pass through this window. In this instance, some of the X-rays generated by the EDXRF instrument will pass into the atmosphere instead of exciting the sample, thus affecting the instrument's accuracy. As Shackley (2011) notes, samples that do not completely cover the analysis window may not produce fully quantitative results. Samples too small to completely cover the analysis window were still analyzed, however they were identified and evaluated separately from the rest of the sample set first. These samples were then integrated, on an individual basis, into the entire sample set. Most small samples fell within the two chemical groups (G1 and G2) that we originally identified through the analysis of the larger samples. From this, it was determined that artifact size and thickness did not significantly skew results.

3.2. Methods

3.2.1. Instrumentation

A benchtop ThermoScientific ARL Quant'X EDXRF housed at the University of Georgia's Center for Applied Isotope Studies was used for all analyses. The Quant'X has an X-ray tube with a rhodium (Rh) target and beryllium (Be) window. This instrument has an upper limit of approximately 50 watts and utilizes a silicon drift detector (SDD) with a resolution of approximately 145 eV FWHM on the MnKα peak.

EDXRF is a bulk chemical technique that cannot be used to differentiate among mineral phases—a potentially important capability for studying some heterogeneous materials—however, it is still a useful tool for chemical characterization studies, especially when coupled with other techniques such as petrography and/or macroscopic analyses (e.g., Carrano et al., 2009; Hunt, 2012). Although EDXRF lacks the ability to measure many rare-earth elements (e.g., lanthanide and actinide group elements) that are easily measured by other methods such as LA-ICP-MS or INAA, we argue that a resolution of parts per million (ppm) is more than adequate for discriminating soapstone groups. Overall, when compared with other bulk chemical techniques, EDXRF's positive attributes outweigh its shortcomings. First, the cost associated with EDXRF analyses is typically lower than for other methods. LA-ICP-MS and INAA require expensive equipment and maintenance, making these techniques costlier and less accessible to archaeologists. As such, EDXRF generally offers lower costs per-analysis, thereby facilitating the compilation of larger data sets. Second, the larger beam diameter generated by EDXRF (typically 2–8 mm), as compared to LA-ICP-MS (ca. 5–100 μm), allows for more surface area of a sample to be analyzed at one time. This effect is amplified when a sample is analyzed multiple times and includes different areas on the object. This is a highly positive aspect considering the heterogeneity of soapstone. Third, INAA is inherently destructive and requires materials to be ground into a powder, making it undesirable for analyzing culturally significant objects. Whereas LA-ICP-MS is minimally invasive, requiring only microscopic samples, it is still, ultimately destructive and oftentimes larger artifacts must be subsampled in order to place the specimen within the laser ablation cell (e.g., Speakman and Neff, 2005: Fig. 1.1). Conversely, EDXRF is completely non-invasive and non-destructive, allowing for the analysis of non-partible, culturally significant materials. It is important to note that for this specific study, the ability to analyze finished artifacts in a non-invasive, non-destructive manner is especially important. A majority of the artifacts (i.e., groundstone beads and pipes) are relatively rare within Ontario Iroquoian contexts though they are quite plentiful at sites in the St. Lawrence Valley. As such, preserving and maintaining the integrity of artifacts is of the utmost importance.

Table 2
Instrumentation and protocols used in the analysis.

Instrument:	ThermoScientific ARL Quant'X EDXRF
Instrument Configuration:	*X-ray tube*: rhodium (Rh) target and beryllium (Be) window *Detector*: Silicon Drift Detector
Collimator:	8 mm
Environment:	Vacuum – major oxides Open air, no Vacuum – Mid Z and High Z
Calibration:	56 matrix matched, certified and recognized standards
Filters:	No filter – major oxides Copper Thick – Mid Z (trace elements) Palladium Medium – Mid Z (trace elements)
Count Time:	100 s live-time per analyses
Energy:	40 kV/30 μA
Elements Measured:	Mg, Al, Si, P, K, Ca, Ti, Mn, Fe, Zn, Ga, Rb, Sr, Y, Zr, Nb, Ba, La, Pb, Th

3.2.2. Protocols

The protocols used in this study are described in Table 2. Two areas on each artifact were analyzed using three separate protocols, totaling six analyses per sample. Multiple flat sections of each artifact were analyzed in an effort to best capture the heterogeneous composition of the soapstone. By analyzing multiple areas, we hope to achieve a more accurate representation of the elemental makeup each artifact. Only two sections were selected because many of the bead artifacts were not large enough to be analyzed more than twice without overlapping previously analyzed areas.

Each of the three protocols used during the analysis was tailored to analyze the elements falling within different portions of the X-ray spectrum. These protocols use different conditions including energy levels, calibration conditions, and filters that allow the instrument to better calculate elemental concentrations. This technique is the most accurate way to analyze the broadest range of elements possible for EDXRF. This extensive elemental range, in turn, presents a greater possibility for determining the range of elements necessary for discriminating between chemical groups.

3.2.3. Calibration

Proper calibration directly affects the accuracy of results (Speakman and Steven Shackley, 2013). In a sample set, estimating the possible ranges of both elemental makeup and concentrations is imperative, especially when the full range of discriminating elements within a matrix are unknown. Although a previous study by Williamson et al. (2016) presents adequate trace elemental concentrations within their calibration, the calibration itself was originally developed to analyze obsidian and other rhyolitic materials (Shackley, 2005) that are characteristically different from soapstone. That is, obsidian is formed by temporally and geographically discrete geologic events (e.g., volcanism) that create outcrops with distinct chemical fingerprints. Due to the unique geochemical processes related to volcanism, obsidian-specific XRF calibrations often focus on a handful of minor and trace elements (e.g., Mn, Fe, Zn, Rb, Sr, Y, Zr, Nb) as they tend to be the most important for discriminating sources. Therefore, most obsidian calibrations do not account for, or measure poorly, major oxides—the elements that comprise the majority of soapstone (e.g., silica, magnesium, or calcium).

In contrast to the geographically and geochemically distinct nature of obsidians, soapstones form through metamorphism that can create chemically heterogeneous outcrops spanning great distances. Considering the preliminary nature of the soapstone characterization studies presented above, we argue that a global characterization is more effective, due to the differential formation processes and subsequent heterogeneous matrices associated with soapstone. This is not to suggest that other studies do not identify valid groups within their datasets, only that a more extensive suite of calibrated elements may improve the power to discriminate among possible sources. For this study, we utilize a matrix-matched, empirical calibration developed specifically to measure the widest possible range of elements and concentrations found in soapstone matrices. Our calibration consists of fifty-six certified and recognized standards that account for up to 40 elements with varying degrees of major and trace elemental concentrations. The details of this calibration can be found in Hunt and Speakman (2015). We argue such a calibration is warranted, particularly for EDXRF, as it ensures greater accuracy, thus allowing for greater discriminating capabilities.

4. Results

As stated above, all artifacts analyzed in this study are soapstone [$Mg_3Si_4O_{10}(OH)_2$] (n = 100). Of these, most (n = 89) are chemically steatite, a subgroup of soapstone. That is, steatite samples fall within what Baron et al. (2016:330) refer to as the *talc zone*, which is any sample containing between 12 and 50% magnesium (Mg), 45–75% silica (Si), and 0–25% calcium (Ca). Although a range of major oxides and trace elements are included in this study, only the major oxides, with the exception of zirconium (Zr), proved to be beneficial in discriminating among chemical groups. This finding is comparable to Williamson et al.'s (2016:243–247) pilot study that used trace elements to form four preliminary chemical groups. Based on these results, we believe that major oxides are more efficacious in defining chemical groups for soapstones.

Based on concentrations of CaO, MgO, and SiO_2 (Fig. 3a and b) and principal component analyses (PCA) calculated using only the major oxides, MgO, CaO, SiO_2, Al_2O_3, and Fe_2O_3(T) (Fig. 4a and b), we identify two chemically distinct compositional groups and one informal 'group' that consists of soapstone artifacts that do not fall within the talc zone (Table 3).

The most numerically abundant group identified in this dataset is group G1 (n = 87, 87%). This compositional group encompasses all artifacts containing between 12—28% Mg, 0—25% Ca (Fig. 3). G1 comprises 100% of the Antrex site assemblage, 80% of Baker, 88% of Hidden Springs, 100% of Miller, 75% of Mantle, 88% of Joseph Picard, 89% of St. Lawrence, 100% of Walkington 2, and 100% of WP-36 (Fig. 5). In sum, within the dataset presented here (Appendix A), the G1 group constitutes the majority of soapstone artifacts across all sites in this study, with the exception of Kelly Campbell and Plater-Martin which exclusively contained artifacts assigned to G2.

The second group, G2, consists of artifacts containing between 32 and 37% Mg and 0–7% Ca (Fig. 3). These samples also are distinct from samples in the G1 group based on Mg content (Fig. 4). G2 is the smallest numerical group in the dataset (n = 4), containing one artifact each from the Baker, Hidden Springs, Kelly-Campbell, and Plater-Martin sites. Notably, these artifacts are pipes or repurposed pipe fragments (Fig. 2). Three are pipe bowls or bowl fragments from the Baker, Kelly-Campbell, and Plater-Martin sites and one is pipe fragment that was apparently repurposed as a bead (Hidden Spring).

The remaining samples consist of soapstone artifacts whose chemical composition do not fall within the talc zone and are therefore not steatite. We consider these samples an informal group here because they collectively cannot be considered a chemically distinct compositional group. These samples likely represent multiple compositional groups that have yet to be defined. Unfortunately, the current sample size is not large enough to determine the range of chemical variability that would define these groups. For this reason, the remaining samples are classified only as 'non-steatite' specimens. However, based on the multivariate distribution of these artifacts (Fig. 4a), it would appear that these specimens could represent as many as seven additional groups.

The non-steatite specimens consist of eight samples subdivided into two subgroups. The first subgroup is defined by high Zr (see Appendix

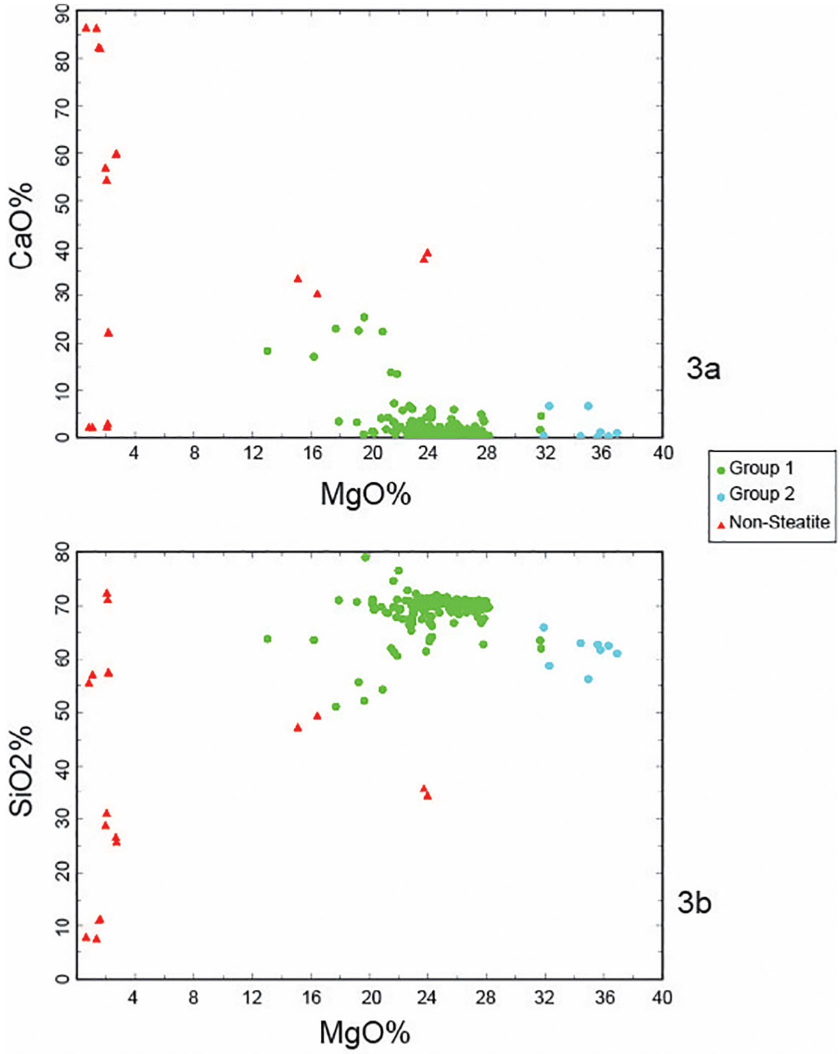


Fig. 3. Bivariate plots of elemental composition based on major oxides a) Mg-Ca, b) Mg-Si.

A). This subgroup consists of three samples from the St. Lawrence (n = 2) and Mantle (n = 1) sites. These samples contain greater than 100 ppm Zr, over twice the amount for any other samples in this study. The second subgroup is artifacts that are chemically dolostones. These artifacts contain high percentages of the mineral dolomite [$CaMg(CO_3)_2$] and stoichiometrically cannot fall within the talc zone. Samples in the dolostone subgroup consist of six samples from the Hidden Springs (n = 1), Joseph Picard (n = 3), and St. Lawrence (n = 2) sites. All artifacts within the non-steatite range can also be separated from G1 and G2 artifacts based on Al and Ca content (see PCA biplots in Fig. 4).

Data generated from our analysis may be affected by diagenesis and/or soil adhesion in some cases. This effect is believed to be present in multiple samples presenting high concentrations of barium (Ba) (Appendix A). We do not believe these effects biased the data generated from the XRF analysis as all samples fell within the acceptable range of steatite. Interestingly, all high Ba samples occur within the Hidden Springs assemblage. Two anomalous samples are also present in the dataset (Appendix A). One sample from the Mantle site (MNT004) and one sample from the St. Lawrence site (STL032). Both exhibit the same pattern whereby one side of each artifact chemically falls into G1 and the other into G2. This may be due to sample size, diagenesis, or soil adhesion; however, without proper geologic source samples from surrounding soapstone sources, it cannot be completely ruled out that these samples represent a range of elemental variation linking G1 and G2 to the same geologic source.

It should be noted that by identifying the chemical differences between soapstone artifacts we do not suggest that geologic classifications had any bearing on the cultural preferences of Iroquoian peoples. Rather, our intent is one line of evidence useful for understanding the significance of objects created from this material and the mechanisms by which they moved across the landscape.

5. Discussion

Proportions of G1 and non-steatite artifacts at the two eastern-most sites: St. Lawrence and Joseph-Picard are very similar. This suggests that non-steatite soapstone may have been circulating in much the same manner as the G1 steatite, perhaps as part of assemblages of finished or unfinished beads. Visually, the non-steatite artifacts are very similar to the G1 artifacts, which are typically dark grey-to-black in color (Fig. 2). On some of the non-steatite artifacts, clear tool marks are visible, suggesting that the material may have been different to work. It follows then, that it was perhaps the properties or qualities of the finished product—for the most part, thin discoidal beads—and not the source or parent material that was important for groups circulating G1 and non-steatite beads. Colors have symbolic associations in the eastern woodlands. White and black provide important complements or contrasts with white (and red) representing sentient and animate aspects of social states-of-being and black being associated with the absence of sentience and animacy, including mourning as a state-of-being (Hamell,

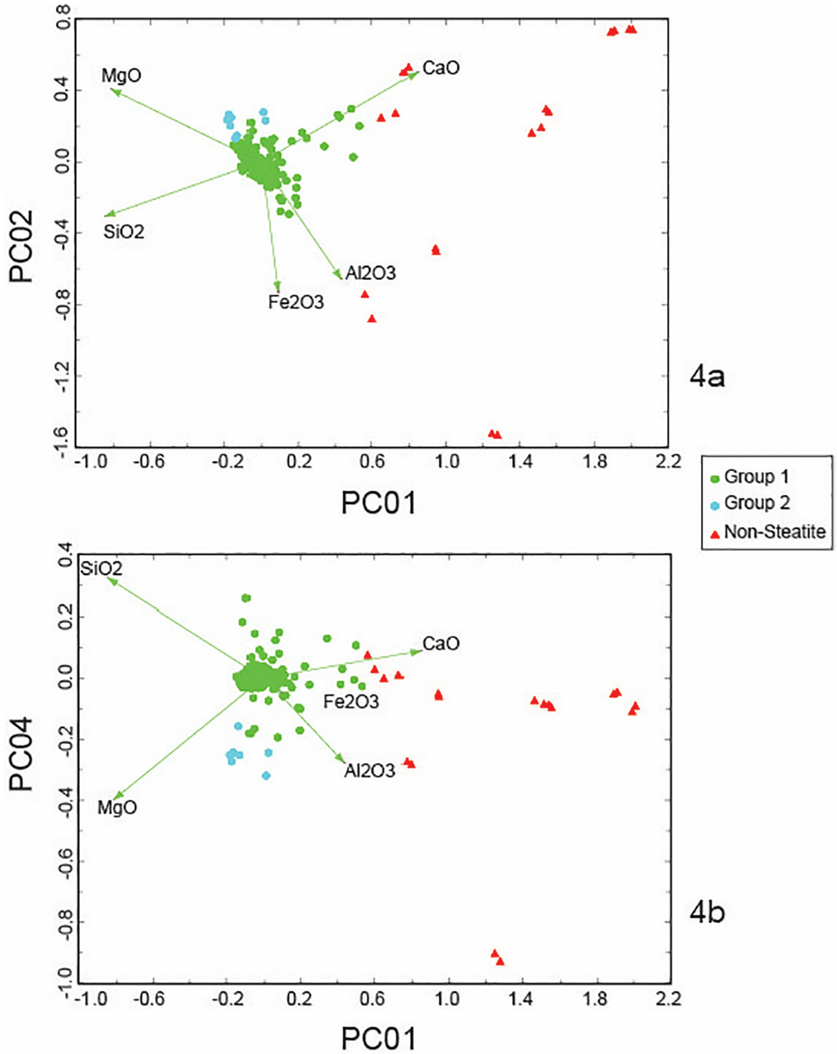


Fig. 4. Biplots of principal components analyses (PCA1, PCA2, and PCA4) derived from the major oxides, Mg, Ca, Si, Aluminum (Al) and Iron (Fe).

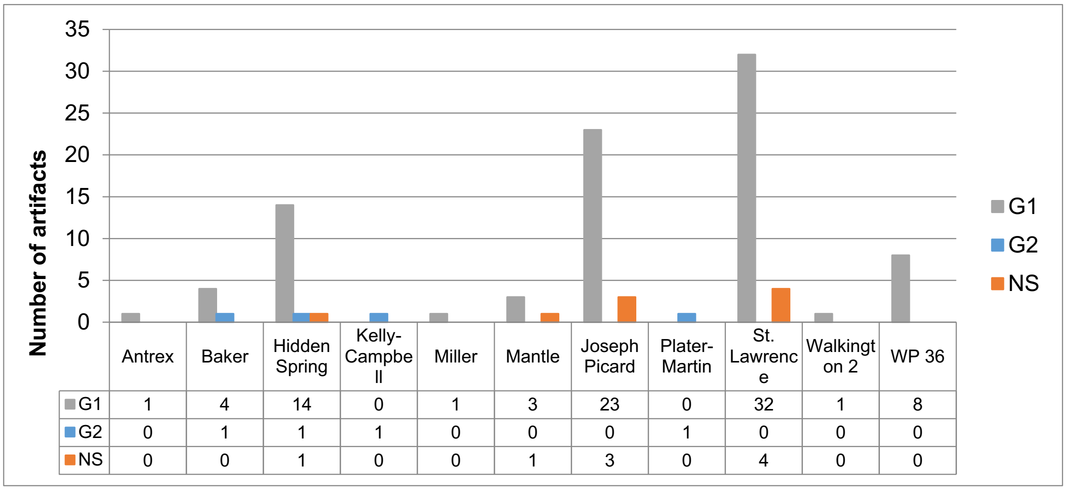
Table 3
Compositional groups identified in this study.

	MgO	CaO
Group 1 (G1)	12–28%	0–25%
Group 2 (G2)	32–37%	0–7%
Non-Steatite (NS)	0–25%	0–85%

1992:457). The shape and form of the majority of soapstone/steatite beads is very similar to wampum. Wampum is typically identified in the form of white, purple ("black"), red, or black shell beads manufactured from *Busycon* or *Mercenaria* shell originating on the Atlantic coast. Wampum may exist as singular beads, in strings, or be woven into more elaborate forms such as belts (Bradley, 2011). However, wampum was defined more by function than material. Haudnenosaunee oral history suggests that, at least for these groups, other materials like sumac, elderberry or basswood twigs, feather shafts or porcupine quills threaded onto strings may have served some of the same functions as wampum beads (Bradley, 2011:26; Woodbury, 1991:xxii-xxm; Beauchamp, 1901:341). Bradley (2011:26) identifies some of wampum's many functions as including summons to council, a medium of ritual, memories of treaties, histories keepers or gift exchange, and a means of personal ornamentation. Given these associations, it seems likely that the steatite/soapstone beads may have served similar functions as, or been a precursor to, wampum.

Geochemical group 1 and the non-steatite group appear to have their origins in eastern sources, and as such may have played a role in interactions between groups or individuals in the upper St. Lawrence Valley and the north shore of Lake Ontario, as discussed by Williamson et al. (2016). Given that the only extensive evidence for bead manufacture comes from northern New York (Abel, n.d.), we must consider it likely that steatite/soapstone beads were produced in the upper St. Lawrence Valley and transmitted or exchanged to southern Ontario as finished and precious products. However, the recovery of a single bead preform from each of the Miller and Joseph Picard sites suggests that some raw material or unfinished blanks may have made their way west. Recent social network analysis by Hart et al. (2017) has identified groups in northern New York as occupying a brokerage position between ancestral Wendat and Haudenosaunee populations. Their analysis views pottery decoration as the medium for signaling behavior. It is possible that steatite/soapstone beads worn as personal ornamentation by people in select communities may have similarly been a signal of affiliation with eastern groups. Another hypothesis would be that St. Lawrence Iroquoians craftsmen may be living among the populations of these villages and were producing beads from the raw material.

The four artifacts belonging to G2 are pipes or repurposed pipe fragments occurring in only the westernmost village assemblages. A number of hypotheses could explain this pattern. One possibility is that G1 material was typically unsuitable for pipe production. For instance,



	Antrex	Baker	Hidden Spring	Kelly-Campbe ll	Miller	Mantle	Joseph Picard	Plater-Martin	St. Lawrenc e	Walkingt on 2	WP 36
G1	1	4	14	0	1	3	23	0	32	1	8
G2	0	1	1	1	0	0	0	1	0	0	0
NS	0	0	1	0	0	1	3	0	4	0	0

Fig. 5. Distribution of compositional groups by site. NS = non-steatite.

typical G1 and non-steatite nodule sizes may have been too small to manufacture pipes. Although four pipes do occur in G1 these are by far the minority (5%) and no pipes occur among the non-steatite artifacts. Another possibility is that G2 material possesses unique or distinct characteristics that make it especially suited for pipe production. Another possible explanation is that G2 artifacts did not circulate in the same way as G1 and non-steatite artifacts. Their distribution strictly among the most western villages (Kelly-Cambell, Plater-Martin, Baker, and Hidden Springs) suggests artifacts from this group did not originate from villages engaged in bead-production to the east (e.g., St. Lawrence). Interestingly, three of the G2 pipe bowls and bowl fragments (with the exception of the engraved pipe from Baker) were the kinds that would have had a detachable wooden stem—very different from the more common elbow-shaped ceramic pipe form.

It requires saying that none of the above possibilities are mutually exclusive and all support the position that G1 and G2 are separate steatite sources. Interestingly, though a much smaller compositional group numerically, G2 contains a greater percentage (50%) of light-colored soapstone artifacts than either G1 (18%) or non-steatite (11%). Bill Fox (personal communication) has suggested that the source of predominately light-colored steatite is further west than the sites identified in this study and was possibly accessed via Algonquian-speaking populations in that region, but the source of the steatite remains unknown. This is in contrast to the G1 and non-steatite that are comprised of predominantly beads being produced at eastern village sites. If true, this would mean that the G1 and G2 sources are located on the eastern and western borders of Northern Iroquoia, respectively. Even though a single example of light-colored steatite was recovered from the Joseph Picard site, it is geochemically part of G1, again indicating the need for characterization studies as a complement to visual discrimination. Further chemical characterization studies of both artifacts and source material will enhance these preliminary interpretations.

6. Conclusions

The goal of this study was to: 1) evaluate the applicability of EDXRF for characterizing steatite artifacts; and 2) consider how these data contribute to understandings of interregional interaction and exchange, particularly regarding relationships between ancestral and historical Wendat-Tionontaté and St. Lawrence Iroquoian peoples.

Regarding the first aim, we believe that the analysis presented clearly demonstrates the viability of EDXRF for the characterization of soapstone artifacts and complements with other geochemical (Baron et al., 2016; Pavlish et al., 2018) and archaeological studies. The implementation of EDXRF in this context is not as straightforward as typical sourcing studies that focus on matching chemical source groups to specific geological sources. However, when utilized appropriately (see Shackley, 2011; Speakman and Shackley, 2013), EDXRF can enhance archaeological questions and interpretations related to heterogenous materials. Further, this study has demonstrated the need to chemically differentiate visually-similar steatites and soapstones into distinct compositional groups. From an emic, Northern Iroquoian perspective, this suggests that properties such as workability and color were more important than parent material or geographic location in the selection of raw material for beads and pipes.

Regarding insights into Northern Iroquoian archaeology and history, this study supports assertions made by other archaeologists (Hart et al., 2017; Ramsden, 2016; Williamson et al., 2016) that groups in northern New York were engaging in processes of interaction and alliance-building with ancestral Huron-Wendat populations during the late 15th century. Population growth and internecine warfare in northern New York may have been an impetus for these activities. Later, in the sixteenth century, groups originating in northern New York coalesced with populations in Ontario, crystallizing a Wendat identity that may have begun to form among northern New York groups prior to population movement. The fact that steatite and non-steatite soapstone artifacts are not distributed in a geographic- or time-transgressive manner reflects the fact that interactions were taking place between individuals and among communities that were constantly negotiating their relative positions in larger social and political landscapes. The distribution of these materials was neither overly generalized nor facilitated by regionally-based political organizations. Instead, these patterns reflect the non-centralized nature of political organization and the processes by which individuals and communities navigated the complexities of the Iroquoian world.

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