Abstract. Inuit people have interacted with northern Labrador’s landscape in countless ways. This research explored their influence on the element compositions of soils beneath winter dwellings at three settlements. The objectives were to expand the range of element enrichments associated with Inuit dwellings and to consider variations within these enrichments, thereby contributing to reconstructions of how these people used indoor spaces. Six dwellings were sampled using a stratified systematic strategy. Multi-element analyses using x-ray fluorescence and inductively coupled plasma-mass spectroscopy identified higher concentrations of phosphorus, sulphur, barium, lead, hafnium, caesium, lanthanum, and europium in archaeological samples relative to background samples. These enrichments relate to peoples’ use of sea mammal oil as lamp fuel, of baleen in sleeping platform construction, of recycled materials for building, and of European goods. Variations in element concentrations between dwellings indicate that cultural soilsapes have potential for identifying processes of stability and change in the use of interior places.


In the past, a northern hunter-gatherer’s way of life, both generally and materially speaking, involved building and maintaining seasonal dwellings, making stone, bone, hide, and wooden tools, preparing food, storing procured goods, and disposing of refuse. People undertook these tasks on a daily basis and some, for material, social, and/or ideological reasons, preferred to do so in specific spaces (Oswald 1984:299).
Archaeological expressions of these preferences include spatial structuring in artifactual and faunal debris, in architectural features, and in other various facilities (Binford 1983:144). Many daily activities also introduce liquid, particulate, and gaseous by-products into soils and sediments that can alter the development of the element compositions of these deposits. Spatially patterned element concentrations in archaeological deposits, in turn, are a function of rhythmic, spatially structured and structuring human activities, and they represent peoples’ various interactions both within and with places (Hodder and Cessford 2004; Wells 2006).

Early studies of archaeological soil/sediment chemistry in Canada were carried out on Huron First Nations settlements in Ontario. Cruickshank and Heidenreich (1969), at the Cahigae Village site, recognized anomalous concentrations of iron and aluminum sesquioxides in midden deposits. At the Robitaille site, Heidenreich et al. (1969), Heidenreich et al. (1971), and Heidenreich and Konrad (1973) defined the locations and dimensions of longhouse, hearth, and midden features using concentrations of phosphorus, calcium, and magnesium. Close to a decade later, Griffith (1980, 1981) revisited Huron based research in Ontario, specifically at the Benson site, where he discovered magnesium, calcium, potassium, and phosphorus enrichments in both midden and dwelling contexts.

Similar studies were undertaken on First Nations sites in western Canada. Sawbridge and Bell (1972) discovered enriched concentrations of phosphorus and calcium in several Kwakiutl shell middens along the coastal islands of British Colombia. Dormaar and Beaudoin (1991), also focusing on refuse disposal, argued that phosphorus enrichments were useful for defining the spatial extent of bone beds at the Calderwood Buffalo Jump in southern Alberta. Taking a household oriented approach, Middleton and Price (1996) identified the spatial organization of features and activities inside a pit-house at the Keatley Creek site in British Columbia. In this case, concentrations of phosphorus, potassium, and calcium in the center of the floor were associated with a hearth and adjacent food storage and preparation areas. High levels of aluminum, iron, and magnesium along the southeast floor perimeter could have represented an accumulation of lithic micro-debitage related to tool manufacturing and maintenance. The sleeping area had low concentrations of phosphorus and calcium that indicated a lack of inputs relating to foodways, in turn signifying that a type of bedding covered the area.

Studies using archaeological soil/sediment chemistry in northern Canada are limited. N. McCartney’s (1979) study of Inuit (Thule) dwellings at the Silimiut and Kamarvik sites on the northwest coast of Hudson Bay, Nunavut was the first undertaken in the Canadian Arctic. She argued that the long-term deposition of organic residues derived from subsistence activities caused enhancements in nitrogen and phosphorus concentrations across the soil sub-floors of winter houses. Derry et al.‘s (1999) research at Arnaquaksaat, an Inuit (Thule) site on Igloolik Island in the Foxe Basin, also indicated that the long-term deposition of anthropogenic organic wastes contributed to the high nitrogen, phosphorus, and magnesium concentrations observed in sediments adjacent to winter dwellings. Farther south in the Canapiscau Region of northern Quebec,
Moore and Denton (1988) recognized a linear pattern of phosphorus, calcium, and magnesium enrichments on a First Nations site, which they interpreted as an axial hearth.

This paper presents the results of x-ray fluorescence (XRF) and inductively coupled plasma mass-spectroscopy (ICP-MS) analyses undertaken on soil samples (N=34) from the Komaktorvik 1 (IhCw–1), Nachvak Village (IgCx–3), and Iglosiatik 1 (HbCh–1) Inuit sites in northern Labrador (Figure 1). Together, the six winter dwellings sampled in this study represent three archaeologically defined periods of Labrador Inuit history: the early fifteenth to late seventeenth century A.D., the eighteenth century A.D., and the nineteenth to early twentieth century A.D. The objectives of this study are to expand and discuss the array of element enrichments associated with Inuit winter dwellings, which will strengthen reconstructions of how indoor space was defined and used. Enrichment factors are used to identify elevated element concentrations in dwelling soils relative to background samples, while one-way between-groups analysis of variance (ANOVA) is used to identify discrepancies in element means between dwellings and between sites. Variations in element compositions between dwellings occupied during specific periods of Inuit history support the argument that cultural soilscapes are useful archaeological indicators of stability and change in the use of internal, nested places over time.

Field Methods and Sampling Contexts

Pedological Contexts
Iglosiatik Island is in Labrador’s Coastal Barrens, which encompasses sheltered inlets and islands between Napaktok Bay and the Strait of Belle Isle. Nachvak Fiord and Komaktorvik Fiord are in the Low Arctic Torngat ecoregion north of the Napaktok Bay tree-line (Bell 2002; Figure 1). Low mean annual temperatures in the Coastal Barrens and Low Arctic Torngats, −3°C and −6°C respectively, are a function of sea ice, the Labrador Current, and cold winds caused by the Icelandic Low Pressure System (Bell 2002; Woollett 2003:85, 92). As a result, vegetation is sparse, consisting mainly of dwarf willow and birch, alpine heath, sedges, and lichens. Short growing seasons and sparse vegetation indicate that local soils would typically have relatively low organic content.

Field Methods and Sampling Contexts

Pedological Contexts
Iglosiatik Island is in Labrador’s Coastal Barrens, which encompasses sheltered inlets and islands between Napaktok
Figure 1. Map of Labrador showing the locations of the sites.
**Sampling Strategy**

Using an Oakfield stainless steel corer, samples were collected from dwelling floors, sleeping platforms, lamp areas, entrance tunnels, and wall berms. The barrel of the corer is 46 cm long with a diameter of 1.3 cm. Several samples were collected from each context, along a transect when possible, and analyzed as representative composites. The flagstones that pave the floors of the dwellings often interrupted the corer. Floor samples were cored from above and between the flagstones. The top five to ten centimeters of each soil column was discarded to avoid testing the highly chemically active modern O horizon. The corer was washed with distilled water between each feature to avoid cross-contamination.

Background samples were collected near each site from areas that appeared unaltered by extensive human and animal activity and that had similar colours, textures, and depths below surface as the archaeological samples (Stein 2001:21). Six composite background samples, two for each site, were collected. All samples were collected in re-sealable plastic bags and stored in a dry, cool, dark place to avoid contamination (Paetz and Wilke 2005:28). Some contexts did not have equal representation in this study. Most houses at the tested sites did not have discernable lamp areas, and wall berm deposits were often too stony to sample. Only one dwelling representing the eighteenth century and one representing the nineteenth/early twentieth century were identified at the study sites.

**Sampling Contexts**

Archaeological data, historic documents, and place names indicate that the ancestors of the Labrador Inuit boated from the southeast coast of Baffin Island to northern Labrador in the fifteenth century (Fitzhugh 1977:31, 38; Fossett 2001:57). Pioneers established settlements at McLelan Strait, the Home Islands, Komaktorvik Fiord, and Nachvak Fiord, which are near either the winter sina (ice edge) or year-round open water (Fitzhugh 1980:601). These places, and others occupied between the fifteenth and late seventeenth centuries, provided seasonal access to interior and coastal resources (Brice-Bennett 1977; Taylor 1974).

Komaktorvik 1 is located in such a strategic place (Figures 1, 2, and 3). Inuit people occupied this area several times between the early fifteenth and early twentieth centuries (Kaplan 1980:648, 1983:710, 741). Three periods of Inuit occupation are visible based on recovered material culture and the architectural styles of the settlement’s 13 winter dwellings: the early fifteenth to late seventeenth century, the eighteenth century, and the nineteenth to early twentieth century (Fitzhugh 1977:31, 38). The architectural form of Labrador Inuit winter dwellings remained consistent between the early fifteenth and late seventeenth centuries (Kaplan 1985). Houses were semi-subterranean, typically ovoid to sub-rectangular in shape, and they had rock and sod wall berms and whale bone, sod, and snow superstructures. Most had interior areas ranging between 12 and 20 m². They had rear sleeping platforms that bisected their interiors. Lamps were typically placed atop stands on floor areas near the corner edges of the platforms. Entrance tunnels were long, narrow, and typically deeper than house floors to create a cold-trap. Some dwellings had two or three rooms (Schledermann 1971:68; Woollett 2003:49).
Figure 2. Komaktorvik.

Figure 3. Komaktorvik 1 site plan.
House 9 at Komaktorvik 1 is a clear example of an early winter dwelling (Figure 4). Its interior measures approximately 15 m$^2$, about 8 m$^2$ of which is occupied by its rear sleeping platform. A group of raised, flat stones and a relative abundance of charred materials in extracted soil columns define a lamp area adjacent to the southwest corner of the sleeping platform. The dwelling’s ovoid form, interior area, single rear platform, and the respective presence and absence of ground stone tools and European goods in test units indicate an early occupation. Samples were cored from the floor, sleeping platform, lamp area, entrance tunnel, and wall berm.

Nachvak Village was settled primarily between A.D. 1450 and 1700 (Kaplan 1980:64; Figures 1 and 5). The site has 15 houses similar to the early period winter houses at Komaktorvik 1 (Figure 6). House 4 is a good example, having a 16 m$^2$ ovoid, semi-subterranean form with a well-defined, flagstone-paved floor, a rear sleeping platform measuring 7 m$^2$, and a lamp area adjacent to the southwest corner of the platform (Figure 7). The tunnel is not well defined, though it appears to open toward the southeast. A large assemblage of slate and nephrite blades and nephrite drill bits along with an absence of European materials indicate an early occupation. Composite samples were taken from the platform, lamp area, and floor.

Inuit pioneers began advancing south by the beginning of the sixteenth century (Taylor 1984:508). They progressed rapidly, arriving at Basque whaling sta-
tions along the Strait of Belle Isle by the mid sixteenth century (Taylor 1984:510; Whitridge 2008:297). Iglosiatik 1, a winter site on Iglosiatik Island in outer Voisey’s Bay, was occupied during this period of southern exploration (Figures 1 and 8). The settlement consists of 16 semi-subterranean sod dwellings primarily built into an arc-shaped terrace (Figure 9). Numerous ground slate blades, nephrite drill bits, and cut mica sheets in several test units, along with an absence of ceramics, glass, and metals, indicate a primary occupation dating between the early sixteenth and early seventeenth centuries.

Houses 2 and 12 were sampled. House 2 is similar in size, shape, and interior layout to the early dwellings identified at Komaktorvik 1 and Nachvak Village (Figure 10). Samples were collected from several locations across the floor, sleeping platform, lamp area,
Figure 7. Nachvak Village, House 4.

Figure 8. Iglosiatik 1.
Figure 9. Iglosiatik 1 site plan.

Figure 10. Iglosiatik 1, House 2.

Figure 11. Iglosiatik 1, House 12.
tunnel, and wall berm. House 12 has two rooms, a design also used by early Labrador Inuit builders (Kaplan 1985:49; Figure 11). Samples were taken from the floors and sleeping platforms of both rooms and from the entrance tunnel.

The eighteenth century was a period of significant change for many Labrador Inuit. People continued living in older, more northerly villages, but they also established new settlements at Hebron and Okak, where they could exploit a greater diversity of terrestrial and maritime resources than in the past (Taylor 1984:517; Woollett 2003:52). They rapidly expanded across the entire coast and its adjacent hinterland. More frequent interactions with Europeans and a growing interest in their commodities contributed to the development of an Inuit middleman trading economy (Taylor 1984:508). This economic shift coincided with the development of large multi-family houses (Woollett 1999). The development of these houses might reflect cooperative economic strategies, but it could also represent the urgency of maintaining social cohesiveness and identity among the increasing presence of European and even Inuit (i.e., catholic converts) strangers (Kaplan and Woollett 2000:357).

Eighteenth century dwellings were semi-subterranean, and they had rectangular or sub-rectangular shapes, internal areas ranging between 40 m$^2$ and 125 m$^2$, multiple sleeping platforms and lamp areas, and cold-trap entrance passages (Woollett 2003:57). Whale elements were sparse in house construction during this period, representing a decline in the socioeconomic and ideological importance of whaling (Schledermann 1971:111). House 11 at Komaktorvik 1 is a useful example of an eighteenth century Labrador Inuit winter dwelling. It has a sub-rectangular shape, an interior area of roughly 50 m$^2$, and sleeping platforms along three of its four walls, each measuring approximately 8 m$^2$ (Figure 12). Several samples were cored from the floor, each platform, and the entrance tunnel.

Faunal assemblages from nineteenth century sites indicate a shift in economy from sea mammal hunting toward caribou hunting, fishing, and fur bearing animal trapping (Kaplan 1980:654). Inland caribou hunting during the late winter and early spring, aided by the acquisition of firearms, increased in popularity throughout the century. People built smaller houses with single rear sleeping platforms, settlements became more dispersed, and southerly settlements became larger. One family typically occupied a house, possibly because of Moravian religious influence or a decrease in cooperative economic strategies. Representatives of the Hudson Bay Company influenced the intensification of a trapping economy, which is apparent in archaeological assemblages from Komaktorvik 1 (Kaplan 1980:652). The contents of test units associated with House 1 at Komaktorvik 1, such as banded annular wares, purple transfer printed wares, and iron trapping equipment, indicate a nineteenth century occupation. Samples were collected from the floor, lamp area, sleeping platform, tunnel, and wall berm (Figure 13).

Laboratory and Statistical Analyses

Sample Preparation

Samples were stored in a dark refrigerator prior to preparation and analyses. Both XRF and ICP-MS require powdered samples. A Plexiglas chamber fitted with an air circulation and HEPA filtration unit facilitated air-drying. Macro
organic matter and large sediments were removed. The soils were disaggregated using a porcelain pestle and mortar. Screening samples through a 2 mm plastic mesh separated the fine fraction. A tungsten carbide ring and puck crusher pulverized these fine fractions into powders (Longerich 1995). Equipment was sterilized using silica sand, ethanol and distilled water between samples to avoid cross-contamination.

**X-Ray Fluorescence**

X-ray fluorescence is a cost effective, easily accessible means of rapidly and simultaneously identifying several major and minor elements in crystalline materials, including archaeological soils and sediments (Garrison 2003:216). Five grams of each powdered sample were mixed with .7 g of phenolic resin, pressed into a pellet using 20 ton/in² of pressure for 10 seconds, and baked at 200°C for 15 minutes (Longerich 1995). A Fisons/Applied Research Laboratories 8420+ sequential wavelength-dispersive x-ray spectrometer identified concentrations (parts per million PPM) of the following elements: sulphur (S), chlorine (Cl), titanium (Ti), vanadium (V), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), gallium (Ga), and niobium (Nb). Oxides of sodium (Na), magnesium (Mg), calcium (Ca), manganese (Mn), iron (Fe), aluminum (Al), phosphorus (P), and potassium (K) were measured in weight percentage and are considered semi-quantitative. The instrument was standardized using repeated measurements of certified geological and sediment reference materials (e.g., DTS–1, BHVO–1, SO–2, PACS–1) provided by the Canadian Certified Reference Materials Project, the United States Geological Survey, and the Japanese Geological Survey. Experimental values were compared with internationally accepted values provided by Govindaraju (1989).
Inductively Coupled Plasma-Mass Spectroscopy

Inductively coupled plasma-mass spectrometry is a rapid means of simultaneously quantifying up to 70 elements (Garrison 2003:229). It is also among the most accurate methods for identifying trace elements, such as the rare earths, because of its low detection limits (Date and Jarvis 1989:51, 53; Entwistle and Abrahams 1997:407). Aggressive acids were used to digest powdered samples into liquids, which is beneficial in archaeological research because a significant quantity of the anthropogenic elemental signal exists within the more resistant soil fractions (Wilson et al. 2008:414). Five hundred milligrams of each powdered sample were mixed with a two to three millilitre solution of concentrated 8 N nitric (HNO₃) and hydrofluoric acids (HF) in Savillex teflon screw cap jars. Jars were capped and placed on a hotplate at approximately 100°C until the solids completely dissolved, which typically takes between 24 and 48 hours (Jenner et al. 1990; Longerich et al. 1990). Nitric acid is the most widely used digestion reagent because of its highly oxidizing properties, meaning it easily dissolves trace elements in most minerals. The HF was combined with HNO₃ to complete the dissolution of metals. Additionally, HF is the only acid that will easily dissolve silica based minerals. This method produced a more completely dissolved solution without destroying trace elements (Jarvis et al. 1992:174, 177, 192). Once dissolution and evaporation were complete, samples were mixed with a two to three millilitre solution of 8 N nitric acid and diluted with Nanopure prepared water to a weight of 90 g. A one millilitre aliquot underwent analysis (Jenner et al. 1990; Longerich et al. 1990).

A HP 4500+ quadrupole ICP-MS instrument identified concentrations (PPM) of the rare earth elements scandium (Sc), yttrium (Y), lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), and lutetium (Lu). Analyses also identified concentrations of lithium (Li), rubidium (Rb), barium (Ba), strontium (Sr), zirconium (Zr), lead (Pb), caesium (Cs), molybdenum (Mo), cadmium (Cd), hafnium (Hf), tantalum (Ta), and thorium (Th). The instrument was standardized using repeated measurements of the certified reference materials identified above. Reagent blanks were also tested to identify their contributions to the samples.

Enrichment Factors and Analysis of Variance

The enrichment factor is a straightforward approach to identifying and comparing geochemical background averages to archaeological samples (Cook et al. 2006:632). It provides a useful alternative when datasets are small and lack the statistical parameters required by more complex multi-variate approaches. Dividing on-site concentrations by their respective off-site means provided an enrichment factor for each element in each sample. For each element, the background sample mean plus two standard deviations divided by the background mean defined the minimum significant enrichment value. Enrichment factors greater than minimum significant enrichment values indicated significant on-site increases (Entwistle et al. 1998:57–58). Enrichments in the archaeological samples were expressed as the percentages to which their concentrations exceed their respective background means.
One-way between groups analysis of variance is useful for identifying statistically significant differences in mean element concentrations between archaeological samples and comparative, background samples, or alternatively, differences between samples from various archaeological contexts (Wilson et al. 2008:416). It is a widely applicable technique, given its modest statistical prerequisites (i.e., independent observations, normally distributed variables, and equal group variances; Rogerson 2001:65). Here, ANOVA was used to identify variation in element means between sites and between dwellings occupied during different centuries. The analysis focused on elements with enriched concentrations in the archaeological samples (N = 28). These elements were the dependent variables, while temporal period and site were the independent, grouping variables. Outliers in these elements can negatively influence the analyses. Box and whisker plots were used to identify outliers whereas F-tests were used to accept or reject the null hypotheses that there was no variation in element means between dwellings and no variation between sites. Quantile-quantile analyses were used to determine whether the data were normally distributed by comparing the observed element distributions to a theoretical normal distribution. Levene’s test identified whether the variances for the element concentrations were homogenous. Tukey and Games-Howell post-hoc tests identified whether element means differ in dwellings occupied during different centuries and whether means differ between sites (Rogerson 2001:65–67). Standardizing the entire dataset using a base 10 logarithm with an added constant of one was necessary because several elements were measured as weight percents, while others were measured in PPM (Shennan 1997:299; Tabachnick and Fidell 2001:35–40). Adding a constant of one was necessary to avoid the production of negative numbers. Analyses were undertaken using the Statistical Package for the Social Sciences Version 16.0.

**Results**

Identified Enrichments and Analysis of Variance

Repeated measurements of certified reference materials and comparisons with internationally accepted values show a negligible amount of error. Concentrations of most tested elements were far above each instrument’s detection limit. Contributions from the digestion reagent did not influence the ICP-MS analyses. Of the 46 elements explored, P, S, Ba, Pb, Cs, Hf, La, and Eu have enrichments in most sampled contexts (Tables 1 and 2). This is fewer elements than expected, a product of using only two background samples from each site. The standard deviations of many elements in these samples are large, thereby inflating minimum significant enrichment values. Nonetheless, enrichments in all of these elements, excluding P, are the first documented on northern hunter-gatherer sites in general and on Inuit sites in particular. The elements P, S, and Cs have enrichments throughout all of the features in the sampled dwellings. Elevated concentrations of La, Eu, and Hf appear only in the fifteenth to late seventeenth century dwellings. Lanthanum and Eu enrichments mainly occur in the sleeping platforms of these dwellings. The elements Ba and Pb have enrichments primarily in the eighteenth and nineteenth century dwellings.
The ANOVA results highlight some differences in mean element concentrations between the three temporally defined dwelling groups. The few identified outliers, like S concentrations in the platform and lamp samples from House 4, are adjusted to values slightly higher than the greatest non-outlier value (Pallant 2005:178). Quantile-quantile analyses indicate that Ba, Pb, and Cs, are not normally distributed. Levene’s test demonstrates that the majority of the elements have heterogeneous variances. Based on these results, the Games-Howell post hoc test provides a more robust analysis of disparities between group means, thereby reducing the likelihood of rejecting the null hypothesis when it should be accepted. However, spatial dependence in the samples could have increased the likelihood of making this error. Barium and Cs have significant F-values, but they are not considered reliable because of their skewed distributions. The F-values for La, Eu, and Hf are significant and they exceed the critical F-value (critical $F = 3.39$; $df = 2, 25$; $p < .05$). Lanthanum has higher means in the fifteenth-late seventeenth century dwellings and lower means in both following periods ($F = 4.17$; $df = 2, 25$; $p = .27$). Europium follows the same pattern, having higher means in early period dwellings relative to those in later dwellings ($F = 4.06$; $df = 2, 25$; $p = .30$). As with La and Eu, Hf has higher means in the fifteenth-late seventeenth century dwellings relative to the eighteenth and nineteenth to early twentieth century dwellings ($F = 3.43$; $df = 2, 25$; $p = .050$). Another analysis of variance using the same eight elements as dependent variables and site as the independent

<table>
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<th>Site</th>
<th>Context</th>
<th>P*</th>
<th>S</th>
<th>Ba</th>
<th>Pb</th>
<th>Cs</th>
<th>Hf</th>
<th>La</th>
<th>Eu</th>
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</table>

*Element concentrations are reported in PPM, except for P, which is reported as weight percent.
Table 2. Significant element enrichments in six Labrador Inuit winter dwellings expressed as percent increases exceeding background means.

<table>
<thead>
<tr>
<th>Context</th>
<th>Sample Location and Element Enrichment Percent</th>
</tr>
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variable highlights considerable differences. All of the F-values are significant and they exceed the critical value. There are, however, issues with heteroscedasticity and normality, which a larger sample size would help address.

**Discussion**

Element enrichments in the tested dwellings indicate that archaeological and background deposits underwent different soil formation processes. Inuit habitation influenced three soil forming factors: topography, inorganic parent material content, and organic matter content. Winter dwelling construction created a depression in which anthropogenic chemical residues could accumulate. Repeated habitation introduced an abundance of new inorganic and organic materials into these depressions, which altered the development of the underlying deposits’ element compositions. The discussion presented here identifies anthropogenic and natural sources for the enrichments documented in the archaeological contexts. The data are also discussed using the concepts of places and soilscapes.

Preucel and Meskell (2004) describe spaces as Cartesian and Euclidean, while places are products of the social process of valuing, attaching memory to, or giving social meaning to spaces. Whitridge (2004), however, argues that this approach to space and place creates a false dichotomy. Instead, he defines place as “...the effect of a general movement of thought and practice that imbricates the real and the representational at complexly layered sites ...” (Whitridge 2004:214). Places are the medium and outcome of the social interactions and routine behaviours that occurred and occur at these layered points (Giddens 1984; Soja 1985).

Interactions among past Labrador Inuit people occurred on land, sea, and ice, within dwellings, and throughout various other places, thereby contracting social prescriptions and proscriptions for behaviours and practices specific to those fields, or what Bourdieu (1990:53) might refer to as “… procedures to follow, paths to take…”. These people, like all people, developed spatially structured dispositions through long-term exposure to specific social, historic, and physical situations. They used mutual knowledge, observations of other people, and memories when deciding how to behave in specific places, or “… how to go on within the routines of social life” (Giddens 1984:4). They saw their families defining places through their daily actions and interactions, they heard stories involving their ancestors doing the same, and they remembered these experiences. They remembered their families practicing and expecting the same interactions, behaviours, and activities in the same places last week, last winter, and the previous winters that compelled them to do the same.

In the past, Labrador Inuit people returned to the same settlements and houses each winter, signifying the importance of these places and their associated narratives in maintaining the economic, social, and ideological persistence of the group (Oetelaar and Meyer 2006; Whitridge 2004). Winter houses were cadre matériel, or humanized, meaningful places connecting past and present people (Halbwachs 1925). They were “emotional watersheds” that also contained innumerable overlapping networks of spatial and social interactions and spatiotemporal rhythms (Whitridge 2004:232). Winter, for instance, “… [was] the social time” in Labrador Inuit society, and houses were
nodes of heightened interaction and activity during these months (Hutton 1904:179). People deliberately and unintentionally mapped their ideologies, histories, and behaviours onto these places, establishing them as structured and structuring mnemonic posts for contextually accepted and expected social fronts and daily activities (Bourdieu 1990; Giddens 1984; Goffman 1959). People drew from the potentialities of the nested places within their dwellings, taking behavioural cues from their constraining and enabling social and physical characteristics, their embedded histories, and the memories they incited (Connerton 1989; Tilley 1994).

The relationship between memories, places, and practices is visible in the archaeological record as reoccurring spatial patterns of material culture (Jones 2008). Some tasks are spatially discrete, and they can introduce specific types of liquid, particulate, and gaseous by-products into underlying soils. These substances modify the elemental chemistry of the deposits, changing them into cultural soilscapes. Cultural soilscapes are spatially patterned physicochemical representations of recursive, spatially dependent, particularistic behaviours generally performed by collectives over periods of either sedentary or repeated occupation (Wells 2006). They reflect rhythmic interactions with places, the experiences and social interactions created by and recreated in these places, and the histories and memories that guided daily life through them (Hodder and Cessford 2004).

Studies of place provide a fruitful means of mapping temporal changes in ideologies, social interactions, and activities (Alcock 2002; Van Dyke 2008). They also provide insight into the temporal persistence of these phenomena. Variation between dwelling soilscapes provides unique data that contribute to identifying these processes of socio-spatial stability and change in the archaeological record. Despite their geographic and temporal persistence, along with changing interactions with Europeans and shifts in economics and other social variables throughout Labrador Inuit history, the tested dwellings have soils with enrichments in some similar elements. These results support the argument that there is some degree of temporal continuity in how Inuit people perceived and used these places. Some of the relationships past Labrador Inuit had with their dwellings, their experiences and interactions with and within them, and their perceptions of how people should “go on” in these places remained stable for centuries. Discrepancies in element enrichments between dwellings occupied during different periods of Labrador Inuit history support the argument that some dwelling-based interactions, routines, and ideologies changed over time. Additional archaeological, ethnoarchaeological, and experimental studies will strengthen this link between place making and cultural soilscapes.

The ANOVA using site as the grouping variable supports the argument that variation in local soil forming processes contributed to the observed differences in element concentrations. Varying concentrations between sites could relate to natural variation in parent material mineralogy. Each site does have similar geologic parent materials and soil systems, but differential weathering imposed upon these parent materials at each site might have contributed to the observed differences. Spatial variations in animal and vegetation activity might have also contributed to the differences. Additionally, differential inputs and preservation
of compounds and elements could factor into the incongruities between periods detected using enrichment factors and ANOVA. Anthropogenic element enrichments in earlier houses may subside over time because they have been exposed to more natural formation processes than those in later houses. The opposite is also true. Higher element concentrations may exist in later houses relative to earlier ones because the soil system has had less time to remove them.

Persisting Lamp Places
Labrador Inuit people commonly lived in semi-subterranean winter houses between late fall and early spring (Kaplan 1985:49). They gathered near lamps, chopping, cutting, grinding, mixing, cooking, and distributing food, warming cold fingers, telling stories, playing games, teaching and showing, discussing past, current, and future events, and crafting various things (Giffen 1930:15). Lamps fuelled with sea mammal oil burned throughout the bitter winter months, constantly producing soot, smoke, and charred by-products. These by-products significantly altered the development of associated soils, indicated by the greasy, consolidated, and charred appearance of lamp area deposits.

Phosphorus, S, and Cs have enrichments throughout the interiors of all the tested dwellings, particularly in floor and lamp areas. The introduction of burned fats and oils would cause P enrichments in dwelling soils (Derry et al. 1999; N. McCartney 1979). Floor and lamp contexts in House 4 at Nachvak, for instance, had oil soaked deposits containing charred fat, and they had respective P concentrations 194% and 94% greater than the background mean. People typically placed lamps near sleeping platforms, because many tasks requiring the use of the lamp, like cooking or using its light to carve a tool, could be done comfortably while sitting on the platforms’ edge (Mathiassen 1927). Consequently, P enrichments might also be found in platform contexts. House 4 has a 135 percent P enrichment in its platform context that relates to the deposition of charred materials produced by the lamp.

Bone tool production is another source of P enrichments in platform, lamp, and floor contexts. Bone tools such as harpoon heads, sled runners, snow knives, mattocks, combs, needle cases, knife handles, and bow drill handles were frequently manufactured inside winter dwellings (A. McCartney 1979:306). During the colder, darker winter months, carving, grinding, and polishing bone into various objects likely required the light and warmth provided by soapstone lamps (Dawson et al. 2007:19). The accumulation and deposition of bone tool debitage would certainly alter the development of underlying deposits. Bone contains approximately 20 percent P, making it a common source of P enrichments in archaeological deposits (Farswan and Nautiyal 1997:253; Griffith 1981:30). Houses 9 and 1 at Komaktorvik 1 and House 4 at Nachvak Village, for example, have substantial P enrichments in lamp, floor, and platform contexts that could relate to the accumulation and deposition of bone particles rendered during tool production. This argument is supported by the presence of bone tools and debitage discovered during excavations at Komaktorvik 1, Nachvak Village, and Iglosiatik 1.

Sulphur enrichments relate to the sea mammal oil used to fuel soapstone lamps. Seals, given their fish-based diet,
ingest large amounts of methionine that is incorporated into their fat (Figge 2007:164). During the combustion of this organic petroleum, \( S \) converts into \( SO_{2(g)} \) via hydrodesulphurization (Sanchez-Delgado 2002:3; Southwick 1996:55). Liquid and particulate by-products from lamp use would concentrate in the platform and floor areas associated with lamps, but \( SO_{2(g)} \) and soot would accumulate throughout dwellings. Enrichments at the three study sites support this argument. All of the tested dwellings have substantial \( S \) enrichments. In House 9 at Komaktorvik 1, for instance, the lamp, floor, and platform have respective \( S \) concentrations of 464 percent, 871 percent, and 232 percent greater than the background mean.

Sulphur enrichments throughout Houses 11 and 1 at Komaktorvik 1 support the argument that people used sea mammal oil fuelled lamps throughout the eighteenth and nineteenth centuries despite access to European alternatives. Of course, the continuous use of wood stoves in Labrador’s treeless north would be impractical. People would have also continued using soapstone lamps throughout the eighteenth and nineteenth centuries for social and ideological reasons. The type of light, smell, and heat produced by oil burning soapstone lamps were emotive, mnemonic, and bound to winter dwelling interiors. The interactions occurring around lamps, along with many other indoor and outdoor places, built and rebuilt social bonds and contracts, relationships with place, and ways of being and doing, thereby contributing to the sociocultural continuity of the group.

Spatial arrangements of food wastes are useful for reconstructing the organization of daily life (e.g., Atalay and Hastorf 2006). Spatial patterns of chemical residues from food-related activities are equally useful. Phosphorus, \( S \), and \( Cs \) enrichments across all of the tested dwellings partially relate to spatiotemporal consistencies in the conjunctive use of the platform edge and lamp stand for food preparation and consumption. Phosphorus enrichments on archaeological sites are commonly associated with the consistent deposition of liquid and particulate residues derived from animal products (Stein 1992:195–199). Inuit people occasionally cooked meat over lamps using skewers or hooks (Maxwell 1985:264). These cooking activities would contribute \( P \) to the soils underlying lamp stands, floors, and platform edges. Caesium and \( S \) enrichments in these dwellings might also derive from the preparation of plant food products (Entwistle et al. 2000:297).

Given their ubiquity, enrichments in \( P \), \( S \), and \( Cs \) could be useful for identifying the locations of pole-ridge tents. These elements could also help reconstruct the organization of common tasks within these and other types of dwellings that typically lack artifactual, faunal, and architectural evidence. However, \( P \) and \( S \) are naturally abundant in soils (Southwick 1996:54). The decomposition of local plants also introduces \( S \) and \( Cs \) into soils (Entwistle et al. 2000:297).

Experimental lamp burning, cooking, food processing and storage, and bone tool manufacturing will help clarify whether these tasks produce liquid, particulate, and gaseous by-products rich in \( P \), \( S \), and \( Cs \). Reference materials analyses undertaken by Wilson et al. (2008), for instance, determined that concentrations of \( Ca \), \( Ba \), \( Cu \), \( Sr \), \( Zn \), \( P \), and \( Pb \) in archaeological deposits from several abandoned farms in the United Kingdom derived mainly from the accumulation of charcoal. An
ethnoarchaeological approach would also help resolve ambiguities concerning the anthropogenic sources of element enrichments on archaeological sites. Research at modern Yup’ik fishing camps in western Alaska identified P, Mg, K, and Fe enrichments in both fish processing and drying areas (Knudson et al. 2004; Knudson and Frink 2010).

**Rebuilding and Refuse Disposal**

Past Inuit people occupied semi-subterranean dwellings for roughly five months of the year, during which they produced a substantial amount of inorganic and organic refuse. People frequently removed these wastes through entrance tunnels as indicated by the large middens typically found adjacent to tunnel mouths. During spring, warmer temperatures would have compromised the structural integrity of winter houses. People likely dismantled their dwellings sometime during spring to avoid the danger of collapse. This would have also provided opportunities for more thorough cleaning. During late fall for instance, it would have been efficient for people to salvage construction materials from previous occupations to rebuild their winter houses (Habu and Savelle 1994:12; A. McCartney 1979:307). Floor sediments and extant refuse from the previous year would have also been useful for fortifying slumping wall berms.

Phosphorus, S, and Cs enrichments in tunnels and wall berms are related to rebuilding and refuse disposal practices. Anthropogenic sources for these enrichments include tool manufacturing, lamp burning, and food preparation. Refuse from these activities would have been scuffed across floors, eventually gathered, and removed through tunnels. Tunnels from all of the tested dwellings have substantial enrichments in P, S, and Cs that relate to the periodic removal of refuse through them. However, dogs often occupied tunnels (Borlase 1993:90) and therefore the observed enrichments could derive from their presence. Sampled wall berms from Houses 9 and 1 at Komaktorvik 1 and from House 2 at Iglosiatik 1 also have relatively large enrichments in P, S, and Cs, supporting the argument that people incorporated sediments and/or refuse from floors into wall berms before reoccupation. Wall berms could have also been built and rebuilt using well-developed, chemically enriched sods from nearby Inuit and/or Dorset dwellings. Lemmings, however, typically burrow into the voids between wall stones. Their presence likely contributed to the observed enrichments.

Consistencies in P, S, and Cs enrichments throughout the tested houses, in lamp placements, in the conjunctive use of lamps and platforms for various activities, and in the means by which houses were cleaned and reoccupied are archaeological representations of temporal stability in how winter dwelling interiors were perceived, defined, and used. Recursive, intergenerational uses of internal dwelling places reflect how people interacted with dwellings as physical, social, and historic media. These attributes of nested dwelling places generated collective expectations for appropriate behaviour, which in turn contributed to establishing particular dwelling-based routines. In navigating through daily life, people constantly defined and redefined these places as appropriate locations for particular activities and interactions. Others witnessed these defining processes and they remembered them when deciding how to behave in certain places. These experiences and memories compelled mimetic behaviour.
This duality of structure or, in Soja’s (1985) terms, this duality of spatiality points to place as the medium and outcome of social behaviour. In turn, structured and structuring behaviours appear in the archaeological record as spatial patterning and/or temporal consistencies in artifacts, faunal remains, architecture, and scapes (Hodder and Cessford 2004; Wells 2006). Differences in element enrichments between the dwellings represent a modification in how their platforms were constructed and changes in the goods that were produced and in dwellings. These changes represent a shift in place making. They represent renegotiations and redefinings of how people interacted with internal dwelling places, of the ideologies they imprinted upon them, and of the routines practiced within them. Redifinitions of internal places created new histories, memories, and ways of going on through daily life in winter dwellings.

**Rare Earths, Platform Bedding, and the Decline of Whaling**

Studies of anthropogenic rare earth element enrichments in archaeological soils and sediments have focused on permanent, agricultural settlements. Entwistle and Abrahams’ (1997) and Entwistle et al.’s (1998, 2000) investigations of former farm sites in Scotland identified rare earth anomalies in cultivated fields that possibly relate to the use of fertilizers comprised of bone, marine plants, mollusc shells, and ash. Cook et al. (2006) suggest that rare earth enrichments in deposits from a Late Classic Maya site in Guatemala might represent accumulations of human detritus such as teeth, hair, fingernails, and skin. Research in northern Labrador provides initial evidence for the presence of enriched rare earths on seasonally occupied hunter-gatherer sites. Enrichments in the rare earths La and Eu were found in sleeping platforms from early period dwellings and they relate to the use of bedding from baleen strips. Baleen is comprised of the protein keratin, which contains the rare earth elements (Rodushkin and Axelson 2000).

A widely told Inuit myth recounts the origin of the winter house. Essentially, a young woman is abducted by a whale who provides his captive with a house built from his bones (Whitridge 2004:242). Inuit people functionally and symbolically incorporated various whale elements into their dwellings (Levy and Dawson 2009). They often, for instance, covered their sleeping platforms with elaborately woven baleen mats (Mathiasen 1930:598; Maxwell 1985:283). Excavations undertaken by Schledermann (1971:36, 41) at the Ikkusik site (IdCr–2) on Rose Island in northern Labrador identified baleen concentrations in the upper layers of a house context that likely relate to roof construction. However, baleen concentrations were also discovered lower in the deposit above the sleeping platform. Excavations undertaken during the present study identified baleen concentrations in platform contexts from of House 4 at Nachvak Village and from House 9 at Komaktorvik 1. These concentrations strengthen the argument that the early Inuit inhabitants of northern Labrador used baleen bedding.

Soils from the platforms of House 2 at Iglosiatik 1, House 4 at Nachvak Village, and House 9 at Komaktorvik 1 have enriched concentrations of La and Eu. The platforms of House 12 at Iglosiatik 1 have enrichments in Eu but not in La. Baleen is a reasonable source
for the La and Eu enrichments found in the sleeping platform deposits from these early dwellings. If these rare earth enrichments relate to the use of baleen in platform areas, they might be absent in dwellings occupied after the decline of both whaling and the use of whale elements in dwelling construction.

People rarely used whale elements for building materials during the eighteenth century (Schledermann 1971:111). It would follow that they also used baleen mats less frequently both during and after this century. Kaplan (1983:248, 353), for instance, discovered that baleen is absent in nineteenth century archaeological contexts. European contact and baleen trading developed along the Labrador coast throughout the eighteenth century (Kaplan 1980:650, 1983:353). This, along with a decline in the availability of whales, contributed to a decline in the use of baleen as a building material. Soil cores from platforms of the sampled eighteenth and nineteenth century dwellings, Houses 11 and 1 at Komaktorvik 1 respectively, did not contain baleen fragments. Lanthanum and Eu enrichments were also absent in the platforms of these dwellings. Differences in La and Eu means between early and later houses are also supported by the ANOVA. These results strengthen the argument that there was a decline in the use of baleen for bedding. A declining use of whale elements in dwelling construction would reflect a diminishing economic, social, and ideological interest in whales among the Labrador Inuit.

Rare earth enrichments on these archaeological sites could also derive from human/animal urine, terrestrial/marine plants, seawater, and/or fish bone (Arrhenius et al. 1957; Bettinelli 2002; Braillard et al. 2004; Brookins 1989). Given the proximity of each site to the Labrador Sea, increases in the rare earths could represent the natural, differential deposition of marine plants and/or seawater. Additionally, the silicate minerals pyroxene, olivine, plagioclase, and amphibole, which are the main constituents of the igneous and metamorphic rocks of Labrador, can contain all of the stable rare earths (Laul and Weimer 1982:534). Rare earth enrichments on Inuit archaeological sites might represent spatial variability in each soil system’s mineralogical parent materials. An experimental study comparing the rare earth compositions of well and poorly preserved archaeological baleen samples will help clarify whether the decomposition of this keratinous material is the source of the rare earth enrichments discovered within the sampled platform deposits.

Adopting European Technologies

Some of the observed element anomalies relate to the adoption of European technologies. Hafnium enrichments occur exclusively in the sampled fifteenth to late seventeenth century dwellings, which is supported by the ANOVA results. The early Inuit inhabitants of Labrador ground their points and blades primarily from slate. Slate typically contains the minerals muscovite, biotite, calcite, pyrite, and apatite. It can also contain zircon, a mineral commonly having moderate amounts of Hf (Dempster et al. 2004). The accumulation and deposition of debitage created during the manufacturing and maintenance of slate tools could contribute Hf to underlying soils. The floor, platform, and lamp areas of
House 2 at Iglosiatik, for instance, have Hf enrichments of 193 percent, 261 percent, and 362 percent respectively. Hafnium is not enriched in the eighteenth and nineteenth century dwellings that were sampled. Elemental analysis of slate from the tested sites will help assess the validity of this interpretation.

Between the middle and late eighteenth century, Labrador Inuit hunters began using firearms (Taylor 1984). The introduction of this technology, along with other metal goods, contributed to a decline in the production and use of ground slate tools, which could explain the absence of Hf enrichments in the tested eighteenth and nineteenth century dwellings. Moreover, lead and Ba enrichments primarily appear in the eighteenth and nineteenth century dwellings. The 101 percent Pb enrichment in the floor of House 1 at Komaktorvik 1 could indicate that shot was casted/recasted and stored in winter dwellings. Lead enrichments in these dwellings might also relate to the adoption of ceramic wares and dwelling windows. The use, repair, discard, and deposition of lead-glazed ceramics and/or lead window caming are plausible candidates for the observed lead enrichments inside Houses 11 and 1. An abundance of shot and ceramics were discovered in test excavations of House 1 and an adjacent midden.

Wilson et al. (2008:418) connects Ba enrichments in archaeological deposits to charcoal. The Ba enrichments discovered in Houses 11 and 1 could derive from the charcoal used to make gunpowder. They could also represent the influence of charred materials from lamps. Again, experimental analyses of the compositions of ceramic glazes, shot, gunpowder, and other European materials would help determine the potential sources of Pb and Ba enrichments in eighteenth and nineteenth century Labrador Inuit dwellings.

**Conclusion**

This project is the first of its kind undertaken in Labrador. It is also one of just a few studies that consider hunter-gatherer influences on soil/sediment development in northern Canada. Inuit archaeological sites in northern Labrador have cold soils with diminished chemical and biological activity, and they typically have high clay contents and slow leaching rates. They are also unaffected by modern land use. These characteristics contributed to the preservation of the anthropogenic element inputs documented in this study. Soils were collected from winter dwellings at Komaktorvik 1, Nachvak Village, and Iglosiatik 1, specifically from floors, platforms, lamp areas, tunnels, and wall berms. Background samples were collected near each site for comparative purposes. Concentrations of 46 elements in 34 samples were identified using XRF and ICP-MS. Phosphorus, S, Ba, Pb, Cs, Hf, La, and Eu enrichments were discovered in archaeological samples using enrichment factors. These results, with the exception of P, expanded the range of elements with documented enrichments on northern hunter-gatherer archaeological sites.

Phosphorus, S, and Cs have enrichments throughout dwellings from each period that relate to lamp burning and food preparation. Enrichments in tunnels and wall berms relate to refuse disposal practices and seasonal rebuilding. Lanthanum and Eu have enrichments primarily in the samples from the sleeping platforms of fifteenth to late seventeenth century dwellings, and they relate to the use of woven baleen mats as bedding. Hafnium has enrichments in early period
houses, perhaps representing the incorporation of debitage produced during slate tool production. Lead enrichments in eighteenth and nineteenth century dwellings reflect the deposition of lead shot and other lead based European products. Archaeological soil/sediment chemistry studies of Inuit dwellings with well-defined internal features and activity areas could provide a comparative dataset useful for reconstructing the use of space inside dwellings, such as pole-ridge tents, that lack artifactual, faunal, and architectural evidence.

The dwellings included in this exploration represent different temporal contexts. The results indicate some degree of symmetry in the practices performed in these houses. Some differences in the use of space over time are also apparent. These variations indicate that cultural soilscapes are potentially useful within archaeological studies concerning the processes of stability and change in how people defined and used places. A larger sample size, equally represented temporal periods, and ethnoarchaeological and experimental research concerning the by-products of particular activities would strengthen this argument. Ethnoarchaeological and experimental research will help resolve ambiguities in element enrichment sources by developing a comparative reference collection of chemical elements and compounds derived from inorganic and organic natural sources, common materials used by northern hunter-gatherers, and common activities practiced among these people. Studies concerning the pedogenic and taphonomic aspects of anthropogenic elemental inputs in northern deposits are also necessary.

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