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Ethnoarchaeological analysis of Arctic fish processing: chemical characterization of soils on Nelson Island, Alaska

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ABSTRACT

Activity area analysis of archaeological soils using multi-element characterizations can illuminate how subsistence operations are organized and how subsistence behavior has changed over time, and is increasingly common at archaeological sites. However, in many regions it is impossible to examine the elemental signatures in known anthropogenic soil samples in order to compare them with unknown archaeological samples. This ethnoarchaeological study examines the chemical composition of the soils at known fish processing areas in the contemporary community of Tununak on Nelson Island, western Alaska. Using a quadrupole inductively coupled plasma mass spectrometer (Q-ICP-MS), the concentrations of the following elements in the soil extract were recorded in parts per million (ppm): aluminum (Al), barium (Ba), calcium (Ca), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), phosphorus (P), strontium (Sr), titanium (Ti), and zinc (Zn). Fish processing area features are elevated in various elements, including sodium, magnesium, phosphorus, potassium, and manganese, and Ba/Sr, Ba/Ca, and Sr/Ca are also useful in distinguishing between fish processing areas and offsite areas.

1. Introduction

Although archaeologists employ a wide range of scientific methods to analyze the archaeological record of human existence, archaeological sites frequently lack the material and physical evidence needed to answer the deeper questions about these important human behaviors. Activity area analysis of archaeological soils using multi-element characterizations is increasingly common at archaeological sites, and can illuminate how subsistence operations are organized and change over time. However, in many regions it is impossible to examine the elemental signatures in known anthropogenic soil samples in order to compare them with unknown archaeological samples. What, then, are the soil biogeochemical signatures of various activities and how can these markers clearly indicate past activity areas and subsistence activities? How can multi-element characterization of ethnoarchaeological and archaeological soils enable the identification and interpretation of subsistence activities in the archaeological record? Here, we address these questions by presenting new elemental data from ethnoarchaeological soil samples collected from known herring processing areas in the contemporary Yup'ik community of Tununak on Nelson Island in western Alaska (Fig. 1). First, we provide a brief introduction to activity area analysis through soil chemistry, followed by a discussion of the environment, geology and cultural background of Nelson Island, Alaska. We then discuss our field methods, laboratory methods, and our multi-element characterizations of known activity areas at Tununak. Finally, we discuss the utility of these data for characterizing past subsistence activities.

2. Activity area analysis through soil chemistry and biochemistry

Traditionally, archaeologists have used soil chemistry to identify and delineate archaeological site boundaries and certain archaeological features using soil phosphate analysis (e.g. Arrhenius, 1962; Cavanagh et al., 1988; Dauncey, 1952; Eidt, 1977; Holliday and Gartner, 2007; Leonardi et al., 1999; Lillios, 1992; Linderholm, 2007; Lippi, 1988; Moss, 1984; Muñoz Ovalle, 2007; Rypkema et al., 2007; Sánchez et al., 1996; Terry et al., 2000). Although soil phosphate analysis has been very useful for prospection and site identification, chemical analysis of soils using a wider variety of elements and molecules is becoming increasingly common at archaeological sites (e.g. Aston et al., 1998a; Barba, 1986; Bull et al., 1998; Entwistle and Abrahams, 1997;

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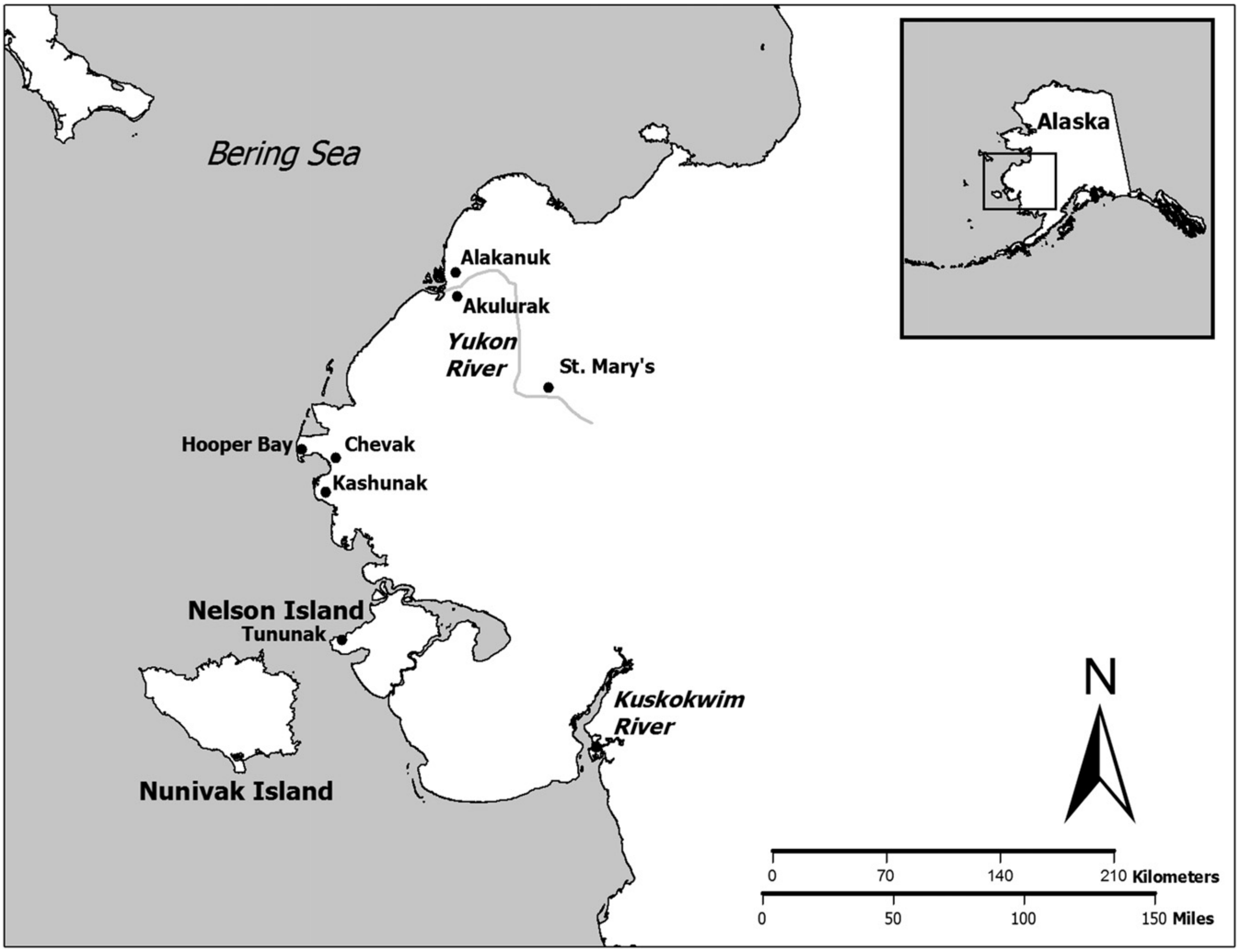

Fig. 1. Location of the study area in western Alaska, including the Yukon-Kuskokwim Delta region and the study site of Tununak on Nelson Island (image from Frink, 2009b).

Fernández et al., 2005; Guttmann et al., 2008; Homsey and Capo, 2006; Isaksson, 1998; Manzanilla and Barba, 1990; Middleton, 2004; Sampietro and Vattuone, 2005; Simpson et al., 1998; Wells, 2004). Multi-element characterization of soils allows archaeologists to move beyond identifying the presence or absence of human activity to identifying specific archaeological activities as part of the holistic study of "cultural soilscapes" (Wells, 2006).

Numerous ethnoarchaeological studies of soils at contemporary sites have shown soil elemental concentrations vary with activity area. Soil elemental signatures of known activity areas have been tested at Arctic fish camps (Knudson et al., 2004), British farms (Wilson et al., 2005, 2006a, 2008, 2009), and Mesoamerican structures (Barba and Ortiz, 1978; Fernández et al., 2002; Middleton and Price, 1996; Terry et al., 2004). Specific activity areas that have been identified in ethnoarchaeological projects include hearths, which have elevated potassium, magnesium, and phosphorus concentrations, and food preparation and/or consumption areas, which have elevated calcium and strontium concentrations if small bones were discarded and integrated into the soil (Middleton and Price, 1996). In addition, human activity areas can be elevated in calcium, potassium, magnesium, sodium and phosphorous as human waste, decaying plant and animal materials or ash from fires are incorporated into the soil (Carr, 1982; Entwistle et al., 2000; Entwistle, 2007; Hayden, 1997; Konrad et al., 1983; Middleton and Price, 1996; Pierce et al., 1998). Soils beneath covered fish drying racks and fish processing areas in the Arctic were elevated in calcium, phosphorus, sodium, and strontium, which likely resulted from fish bones and drippings that were incorporated into the soils (Knudson et al., 2004). Finally, copper mining and smelting result in increased copper, lead, and manganese concentrations in the soil (Pyatt et al., 1999, 2000). These patterns are present in soils from a variety of different geologic zones (e.g., Wilson et al., 2008).

The chemical signatures of these activity areas can be highly stable in a variety of soil types (Wilson et al., 2005, 2008). Metals in soils exhibit speciation, which means that they exist in a variety of chemical forms such as oxides or carbonates, and fractionation, which means that they can be bound in specific ways in the soil matrix and are found in specific soil components (Tack and Verloo, 1995). However, anthropogenic metals are more mobile and bioavailable in the soil when compared to pedogenic or lithogenic metals, so they generally exist in specific soil fractions (Chlopecka et al., 1996). The behavior and concentrations of anthropogenically deposited metals will fluctuate depending on the chemical, biological and physical characteristics of the soil, which can vary widely (Haslam and Tibbett, 2004; Ottaway and Matthews, 1988; Wilson et al., 2006b). For example, in calcareous soils, metals like iron, manganese, and zinc remain stable for long periods of time