Journal of Archaeological Science 38 (2011) 3620–3630

Contents lists available at SciVerse ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

Geochemical characterization of ochre from central coastal British Columbia, Canada

Brandi Lee MacDonald[a,*], R.G.V. Hancock[b,c], Aubrey Cannon[c], Alice Pidruczny[a]

[a] McMaster Nuclear Reactor, McMaster University, Hamilton L8S 4K1, Canada
[b] Department of Medical Physics and Applied Radiation Sciences, McMaster University, Hamilton L8S 4K1, Canada
[c] Department of Anthropology, McMaster University, Hamilton L8S 4L9, Canada

ARTICLE INFO

Article history:
Received 22 June 2011
Received in revised form
24 August 2011
Accepted 25 August 2011

Keywords:
Ochre
Coastal British Columbia
Neutron activation analysis
Iron oxide
Multivariate statistics
Pigments
Geochemical characterization

ABSTRACT

The use of ochre and its presence in archaeological contexts is well documented archaeologically, ethnographically and historically. Elemental analysis of ochre is becoming increasingly common as a method for identifying ancient quarrying and mining practices, and for identifying patterns of resource use, trade and exchange. As this type of work has become more common it has become apparent that two critical issues need to be considered: (1) the need for systematic identification of trends and patterns in ochre geochemistry using appropriate statistical analyses, and, (2) consideration of geographic and geologic scale in relation to ochre chemistry. Because ochre is a heterogeneous material relative to other raw material types, it is necessary to apply multivariate and discriminant statistics to differentiate geochemical groups within a sample set. However, caution must be taken when interpreting statistical results at face value. Local geologic and geomorphologic conditions play a significant role in ochre chemistry and need to be taken into account when interpreting analytical results. The purpose of this project was to determine if geochemically distinct groups of ochre could be distinguished through neutron activation analysis (NAA) of archaeological and geological ochres from the central coast of British Columbia, Canada. The results show that it is possible to satisfy the provenance postulate and to differentiate chemical groups through elemental characterization and using multivariate statistical methods.

1. Introduction

Ochre is common to archaeological sites around the world and is often considered to be a culturally significant material. It was and continues to be used in a variety of contexts, as pigment for rock art and body paint, medicinally, and as a component of ritual and mortuary practices. However, the nature of its acquisition is poorly understood. The elemental analysis of raw materials of all types is continually increasing in frequency and occurrence, and the analysis of ochre for the purpose of determining ancient resource use and trade and exchange practices is an area of growing interest (Manscalco, 1989; Popelka-Filcoff et al., 2005; Smith et al., 1998; Smith and Pell, 1997; Stafford et al., 2003; Tankersley et al., 1995). As this body of knowledge continues to expand it is apparent that a foundation of knowledge of ochre geochemistry and local geological conditions must be established to enable detailed interpretations of ochre-related practices. Ochre is common in archaeological sites in the region of coastal British Columbia, yet no systematic study of its geochemistry, acquisition and distribution currently exists. The focus of this study was to assess the range of geochemical variability within regionally restricted assemblages of archaeological ochres, and to determine if their geochemistry satisfies the provenance postulate: that the geochemical variability between different sources of materials must be greater than the internal variability within any one source (Glascock and Neff, 2003; Weigand et al., 1977). With the exception of one sampled geological source at Sagar Lake the samples included in this study are from archaeological contexts and their geological source(s) locations are unknown. The results of this project are an example of the interpretive potential of the elemental analysis of ochre.

1.1. Definition of ochre

The term 'ochre' broadly refers to earth pigments that range in colour from red to brown to yellow to purple. Most often these pigments are various forms of mineralogical admixtures containing iron oxides that provide produce its colour properties. For the

* Corresponding author. Tel.: +1 905 525 9140x26301; fax: +1 905 522 5982.
E-mail address: macdonbl@mcmaster.ca (B.L. MacDonald).

0305-4403/$ – see front matter
doi:10.1016/j.jas.2011.08.032

purpose of this study we use the term ochre with reference to deposits of iron oxides found within the archaeological record that are suitable for use as pigment based on criteria such as colour richness, texture, friability and presence and type of mineral inclusions. Ochre can form in sedimentary, metamorphic, and igneous conditions, however the most common is derived from weathered sedimentary contexts. Red, brown and purple ochre come primarily from the mineral haematite (Fe_2O_3), while orange–yellow ochre is derived from the minerals goethite ($FeO(OH)$), and limonite ($FeO(OH) \cdot nH_2O$). Haematite is composed primarily of 70% Fe and 30% oxygen (O), and forms in a variety of rock types. For example, it is found in red sandstones as the cementing material that binds quartz grains together, it forms in irregular masses and beds as the result of weathering and oxidation of iron-bearing rocks, it occurs as a sublimation product in connection with volcanic activities, and also in contact metamorphic deposits and as an accessory mineral in feldspathic igneous rocks such as granite (Klein, 2002, p. 281). Goethite is composed of Fe 63%, O 27% and H_2O 10%, with Mn sometimes present in amounts up to 5%, and is most commonly associated with other iron oxides such as limonite and haematite. Goethite is formed by the weathering or hydrothermal alteration of iron-bearing minerals in oxidizing conditions (Battey, 1981, p. 213; Klein, 2002, p. 396). It also forms as a direct inorganic or biogenic precipitate from water, and is widespread as a deposit in bogs and springs (Battey, 1981, p. 213).

Characterization studies typically begin with the analysis of raw materials from local sources, or, with an archaeological assemblage in cases where source materials are not readily available (Shackley, 2008). Samples included in this study are primarily from archaeological contexts, with additional specimens from one geological deposit. In contrast to other ochre characterization studies (e.g. Erlandson et al., 1999), this study examined the geochemistry and distribution of ochre within a relatively restricted geographical extent, and from multiple contexts including villages, camps and a geological outcrop. Where other studies have emphasized long-distance procurement, this project has sought to explore the potential for determining ochre use and the nature of its procurement within a regional settlement system. Careful consideration has been given to the issue of geologic scale with respect to ochre geochemistry. It was expected that ochre outcrops in the central coast of the British Columbia region would be geochemically similar based on the formation processes of ochre and given the local geological conditions. Therefore, to assess the feasibility of attributing archaeological ochres to specific geological deposits within this territory, it was necessary to first identify trends in ochre geochemistry within the available archaeological and geological assemblage. While we use the terms 'source', 'deposit' or 'outcrop' interchangeably to refer to a geochemically characterized group of ochre, it is important to note that we are not referring to the 'sourcing' or attribution of archaeological ochre to a specific outcrop. We subscribe to Shackley's description of 'the sourcing myth' (Shackley, 2008, p. 196), and use the term 'source' to describe a geochemically characterized group of ochre(s) that may be representative of one or more discrete geological deposit(s).

2. Brief review of ochre research

References to ochre use exist within a broad range of ethnographic, historical and archaeological literature and such works illustrate the diversity of ochre use as a utilitarian, symbolic, artistic and medicinal material. It has been described as medicinally useful (Mahaney et al., 1993; Velo, 1984, 1986), symbolically charged (Marshack, 1981; Taçon, 2004), functionally valuable as a filler for adhesive (Lombard, 2005; Wadley, 2005), a preservative (Roper, 1991; Wadley, 2005), as well as pigment for rock art, as house floor deposits, as wall painting or pottery decoration, and in association with burials (Roper, 1991). Ochre use specific to British Columbia has been documented historically and ethnographically as an element of ceremonial practices (Bouchard and Kennedy, 1986, p. 246; Matthews, 1955, p. 47; Olson, 1955), and trade and exchange between culture groups (Mitchell and Donald, 1988, p. 327; and Williams, 2006). Archaeologically, ochre has been documented as a component of mortuary ritual (Ames, 2005; Burchell, 2003), as medium for pictographs (Williams, 2006) and has been found at numerous excavations.

Previous methodological research has played a critical role in determining what is analytically suitable for geochemical and mineralogical characterization of ochre. Notable examples include Popelka-Filcoff et al. (2008) who used NAA to characterize ochres from southern Arizona. Erlandson et al. (1999) were able to geochemically differentiate ochres from eight different locations in western North America using proton-induced X-ray emissions analysis (PIXE). A study by Tankersley et al. (1995) showed that X-ray diffraction (XRD) could be used successfully to determine that ochre from the Hell Gap site in Wyoming was acquired from the Powars II ochre mine (see Stafford et al., 2003). Smith et al. (1998) also demonstrated that it was possible to match archaeological ochres to geological outcrops using a combination of inductively-coupled plasma mass spectrometry (ICP-MS) and SEM-EDS. Collectively, these studies have demonstrated that ochre can be heterogeneous and often difficult to differentiate into discrete geochemical groups without the use of multivariate statistics. Another consideration is that some of these studies analyzed ochre from various outcrops large geographic scales in relation to the present study (e.g. Erlandson et al., 1999; Smith et al., 1998). To build upon the foundation created by previous studies, this project sought to examine the geochemical variability and distribution of ochre at a smaller scale and within a relatively restricted geographical context.

3. Archaeological and geological background

The ochre samples analyzed for this study came from locations in traditional Heiltsuk, Wuikinuxv (Oweekeno), and Nuxalk territories in the central coast region of British Columbia. Collection of archaeological materials from sites in Heiltsuk and Oweekeno territories was conducted by Cannon as part of a regional-scale project focused on settlement patterns and resource use. Sites in Heiltsuk territory include two villages: Namu (ElSx-1), Kisameet (ElSx-3); one smaller residential base camp (ElSx-10), and one geologic deposit at Sagar Lake on King Island. The archaeological sites are described as villages and camps based on a variety of criteria including site size and the density and diversity of faunal remains (Cannon, 2000, 2002, p. 320). Sagar Lake is a freshwater lake located in Codville Lagoon, and is the only known accessible ochre outcrop in the territory. Sites located in the Oweekeno territory include two villages: Cockmi (EjSw-1), and Katit (EkSt-1), and two small camps (EjSv-5 and EjSv-3). Materials from Heiltsuk and Oweekeno territories were collected by bucket auger, washed and sorted through 2 mm mesh screen and analyzed microscopically (10×) to extract fish and shellfish remains, ochre and obsidian. Radiocarbon dates yielded from charcoal or shell from multiple core and auger locations and depths at each site have provided chronologies for the initial and terminal occupations. Samples chosen for analysis were all taken from contexts dating to the final 2000 years of occupation into the European contact period. Sample collection from the geological outcrop at Sagar Lake was completed in 2009 by MacDonald, Cannon, and E. White of Heiltsuk First Nation. Sites located in Nuxalk territory include three villages: Joashila (FaSu-19), Nut'l (FeSr-7) and Stskiutl (FeSq-8). Excavations at sites in Nuxalk territory were directed by Hobler and Bedard, 1988 and materials were acquired with permission from R. Carlson from Simon Fraser University, facilitated by Dr. Barbara Winter and Shannon Wood. See