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Combustion features from short-lived intermittent occupation at a 1300-year-old Coast Salish rock shelter, British Columbia: The microstratigraphic data

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ABSTRACT

Short-lived occupation sites are the most common component of the archaeological record at the regional scale level, but are often underrepresented due to their low amount of cultural material and greater visibility of larger sites. Small ephemeral sites can however provide unique information regarding land and resource use, travel routes, harvesting practices, group size, food processing, ceremonial activities and chronology of occupation, especially in pre-urban societies. One of the most prominent proxies for short-lived occupation is combustion features, defined as accumulations of ash, burnt bones, heat-altered sediments and stone tools. These features provide insights into behavioral evolution, food consumption, settlement patterns and foraging strategies, and the preservation of the archaeological record. To obtain this information, a microscopic level of investigation is required in order to address the chemical and mineralogical characteristics of combustion features. We deployed such kind of microarchaeological approach to the study of combustion features at the DjRr-4 rock shelter along the Indian River, British Columbia, settled by Coast Salish peoples at least 1300 years ago. Using a combination of micromorphology of sediments, phytolith and diatom analysis, paleobotany, zooarchaeology, lithic analysis and radiocarbon dating, we were able to show that the shelter was used intermittently over short time spans as a base camp for hunting, likely as a station along a trail that connected the coast to interior regions. Our results are consistent with chronological data for the region and with the adoption of bow and arrow by Coast Salish peoples.

1. Introduction

Short-lived occupation sites characterized by a low amount of cultural material are the most common component of the archaeological record at the regional scale level across the globe. These sites are generally underrepresented in archaeological studies, compared to larger, long-lived settlements with greater archaeological visibility (e.g. Ammerman, 1981; Wilkinson, 2000; Conard, 2001; Chase et al., 2011; Fisher et al., 2016). However, these small, ephemeral sites provide insights into land and resource use, travel routes, harvesting practices, group size, duration of occupation, food processing, and ceremonial activities among human groups, especially in pre-urban societies (e.g. Brink and Henderson, 2001; Reimer, 2011; Cuthbert et al., 2017; Potts et al., 2018; Vardi et al., 2018). Occupation of short-lived encampments also shows how landscape use persisted and changed through time (e.g. Potter and Reuther, 2012; Mitchell, 2017). One of the most prominent

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Fig. 1. Map of British Columbia and site location.

features associated with short-lived occupations are combustion features, comprised of distinct accumulations of wood ash, burnt bones, heat-altered sediments and fire-cracked stones (Goldberg et al., 2017). These pyrotechnological materials are securely identified using analytical methods that address their chemical and mineralogical characteristics at the microscopic scale (Weiner, 2010). Combustion features are often found inside rock shelters and caves because of their good preservation conditions, and the materials embedded within (e.g. fuel, bones, artifacts, etc.) offer an opportunity to better understand behavioral evolution (e.g. Berna et al., 2012; Sandgathe and Berna, 2017), settlement patterns and foraging strategies (e.g. Wadley et al., 2011; Shahack-Gross et al., 2014), long-term environmental conditions (e.g. Dibble et al., 2017), and the preservation of the archaeological record (e.g. Weiner et al., 2002).

The study of short-lived settlements is thus crucial to a more complete picture of ancient landscape use and settlement strategies, particularly in remote locations away from major villages (e.g. Chase et al., 2011; Reimer, 2011; Fisher et al., 2016). In southwestern British Columbia, Canada, small short-lived sites such as rock shelters offer important insights into how pre-contact Coast Salish peoples utilized forested belts above valley bottoms and below sub-alpine zones. Coast Salish people are the Indigenous inhabitants of southwestern British

Columbia and northern Washington State on the northwest coast of North America, who all spoke closely related Salishan languages (Suttles, 1987). Socially and linguistically related Coast Salish peoples have lived in the broader region continually for over 12,000 years, since glacial ice receded from valley bottoms (Thompson and Kinkade, 1990; Friele and Clague, 2002a, b; Clague and Turner, 2003; Ritchie et al., 2016).

From at least 3500 years ago, Coast Salish people's subsistence economies involved diversified pursuits, including intensive fishing, shell-fish harvesting, plant cultivation, and also hunting and plant gathering (Matson and Coupland, 1995: 165–177; Clark, 2013: 199; Carlson et al., 2017). Technological sophistication and labor organization employed for subsistence activities enabled the Coast Salish, like other Northwest Coast groups to amass impressive food surpluses that were the basis of populations larger than many agricultural societies, elaborate feasts and grand displays of wealth, craft and ritual specialists, and monumental architecture (Suttles, 1987; Ames and Maschner, 1999; Coupland et al., 2016; Wengrow and Graeber, 2018). Coast Salish peoples were hierarchically organized, with social positions and strategic alliances established, validated and reinforced at interregional ceremonies hosted at major tribal centers. The Tsleil-Waututh, and other Coast Salish peoples lived in settlement clusters comprised of large plank houses along the shoreline and at the confluence of major rivers (Morin et al., 2018). From the large settlements, smaller task groups relocated for short periods in order to harvest and hunt seasonally available aquatic and terrestrial resources across tribal or household owned territories (Suttles, 1987; Morin et al., 2018). These trips would often involve a combination of travel by canoe and overland on trails (Ames, 2002).

Regionally, rock shelters have been utilized by Coast Salish people over many thousands of years for diverse activities (Reimer, 2011; Ritchie and Springer, 2017). Recent studies have revealed a number of important aspects of rock shelter use, including for ceremonial purposes such as spirit questing, mortuary features, terrestrial resource gathering camps, fishing sites, resource processing places, temporary refuges, and nodes along travel corridors (Curtin, 2002; Reimer, 2011; Arnett, 2016; Ritchie and Springer, 2017; Rousseau and Chang, 2017). While some rock shelters indicate a number of these activities occurring (e.g. Ritchie and Springer, 2017), others clearly reflect much more specialized use (e.g. Curtin, 2002; Arnett, 2016). Some of the rock shelters with the oldest components in the region – dating between ~9000–5000 calBP – signal their importance before the establishment of large villages (e.g. Reimer, 2011; Rousseau and Chang, 2017).

In recent years, several rock shelter sites have been found on the slopes of the steep-sided Indian River Valley watershed, located north of Vancouver (Fig. 1), within the traditional homeland of the Tsleil-Waututh-Coast Salish people (Ritchie and Sellers, 2014). In this area, rock shelters are found under large boulders or bedrock outcrops with sufficient overhang to provide shelter from the elements. Generally, activities associated with boulder rock shelters are spatially constrained to small covered areas, allowing archaeologists to observe a relatively complete set of activities, among which fire making for food consumption is central.

Data from rock shelters in the Indian River Valley appear to correspond well with regional trends in demography, settlement, and hunting strategies, suggesting that they are relatively sensitive indicators of change. Extant data consisting of 24 radiocarbon (^{14}C) dates from six rock shelter sites indicates their use intensified between ~650 and 1150 CE, which corresponds with larger populations across the region and greater frequency of deer hunting facilitated by the local adoption of the bow and arrow (Angelbeck and Cameron, 2014; Morin et al., 2018). Apparent hiatuses in rock shelter use similarly correlate with lower overall populations in the region (Ritchie et al., 2016). However, the archaeological record regarding these ephemeral occupations is still fragmentary, and more focused surveys and analyses are required in order to reconstruct past landscape utilization.

This paper is concerned with a detailed examination of combustion features within a boulder rock-shelter (DjRr-4) in the lower Indian River Valley (Fig. 1). Here we examine the stratigraphy of cultural deposits and the preparation technique of combustion features utilizing micromorphological analysis, and the contents of these features through faunal and archaeobotanical analysis of sediment samples. The study at the microscale of sediments within their original depositional context using intact blocks allowed the identification of multiple stacked hearths (e.g. Goldberg and Berna, 2010; Weiner, 2010). The information regarding their contents and formation processes provided context to radiocarbon dates obtained from wood charcoal, and thus enhanced their explanatory power in relation to the absolute age of different occupations. A picture of intermittent human occupation alternating with slow natural sedimentation thus emerged.

2. Materials and methods

2.1. Site overview and excavation strategy

The Indian River Valley is a fjord-head river within the Indian Arm and drains an area of 193 km^2 (Fig. 1). The valley is narrow with steep valley sidewalls rising 1100–1500 m above the valley floor. Post-glacial isostatic depression likely caused the lower Indian River Valley to be inundated by the ocean until ~10,000 years ago; earlier than this the sea would have flooded the valley upstream as far as the confluence with Meslillooet Creek, stocking the upper reaches above the modern bedrock falls with fish (Clague et al., 1982; James et al., 2002; Friele in Ritchie and Sellers, 2014).

The majority of the Indian River Valley is composed of granodiorite, quartz diorite, and Gambier Group volcanic and sedimentary rock (Reddy, 1989). Most of this bedrock geology is not typically conducive to yielding useful toolstone or bedrock rock shelters, with a few possible exceptions. A green andesite that occurs at archaeological sites in Burrard Inlet (Lepofsky et al., 2007; Reimer, 2011; Morin, 2015: 115–121) has been identified in the gravel bars of the Indian River. Reddy (1989) describes numerous andesitic and basaltic dykes that cross the Indian River watershed within the dominant intrusive rocks. Such sources may have been highly desirable for toolstones; however, the locations of these dykes are not precisely recorded.

The DjRr-4 rock shelter is an 8 m diameter boulder situated on a major debris fan that constricted the river valley during the early paraglacial period, providing base-level control for upriver areas (Fig. 2). The boulder likely came down-slope prior to 7750–7585 BCE (2σ calibrated range) with this initial major slide, though it is conceivably related to later debris slide events that appear to have continued in the same location until around 6640–6485 BCE (2σ calibrated range), after which time the barrier formed by the debris fan was breached (Friele in Ritchie and Sellers, 2014). Today, the Indian River base level is controlled by sea level, and the DjRr-4 boulder is located immediately downriver from a series of waterfalls that prevent navigation and present a barrier to anadromous salmon. DjRr-4 is situated within a cluster of other large boulders on the surface of the colluvium-dominated debris fan ~20 m from the Indian River. It is located near three other known rock shelters, DjRr-2 and DjRr-3 (~500 m upriver), and DjRr-5 (~175 m downriver), representing the only presently recorded rock shelters in the Indian River Valley (Ritchie and Sellers, 2014).

DjRr-4 is by far the most spacious shelter in the corridor with over 25 m^2 of covered area and a relatively high ceiling (Figs. 2 and 3). Unlike other nearby rock shelters, DjRr-4 has openings on two sides, a large one from the east (river) and a small one from the west (upslope). We placed a single 40 × 40 cm excavation unit near the large opening of the shelter, underneath the boulder overhang on the side closest to the river. Bulk samples were taken from four visible cultural events, which we assigned feature numbers (Unit 1 to Unit 4). Samples for radiocarbon dating were collected in association with each of these

Fig. 2. Site view from outside.

features, and also from other stratified layers noted during profiling. All remaining excavated matrices were screened through a 5 mm mesh, and all bone and lithic materials were collected. Three micromorphological samples were collected from the east wall for processing at Simon Fraser University.

2.2. Micromorphology of sediments

Three intact and oriented blocks of sediment were carved from the northern section, air-dried for several weeks and oven-dried at 40 °C for three days. Samples were then embedded in a mixture of unpromoted polyester resin (74%), styrene (23%), catalyst (2.4%) and promoter (0.6%) under vacuum. Hardened blocks were sliced with a rock saw to obtain 55 × 75 mm chips, which were shipped to Arizona Quality Thin Sections (Tucson, AZ, USA) for thin section preparation. All the 13 thin sections thus obtained were polished to a thickness of 30 µm. Micromorphological analysis was carried out using an Olympus BX41 petrographic microscope at different magnifications (20×, 50×, 100×, 200×, 400×), in transmitted and oblique incident light. Descriptions and interpretations are based on standard terminology and literature (Courty et al., 1989; Delvigne, 1998; Stoops, 2003; Flügel, 2004; Goldberg and Macphail, 2006; Stoops et al., 2010; Macphail and Goldberg, 2017). The analysis of charcoal in thin section was based on the Microscopic Wood Anatomy online database (Schoch et al., 2004) and specialized reference atlases (Hoadley, 1990; Schweingruber et al., 2006; Forest Products Laboratory, 2010; Schweingruber et al., 2011).

2.3. Botanical macroremains

Six sediment samples (2 L each) were collected from the four observed stratified cultural features. All sediment samples were floated using a modified bucket flotation system at the Archaeobotany Laboratory at Simon Fraser University. Samples were measured and recorded and then placed into a bucket with a pouring spout and floated into a series of nested geological screens. The light fraction was poured off into the 1- and 0.425-mm screens, and the heavy fraction into the

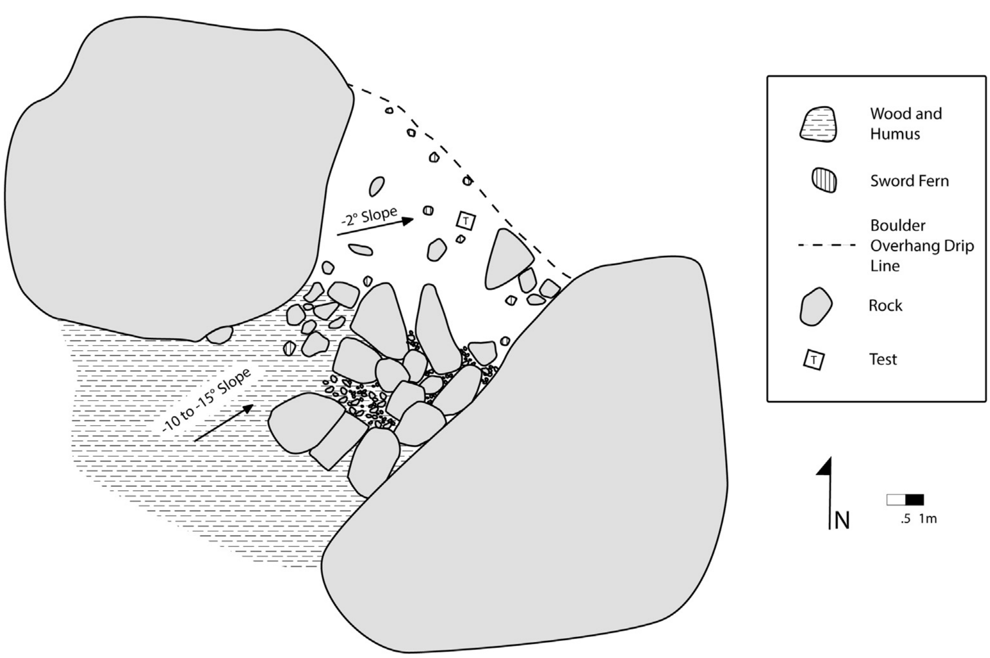

Fig. 3. Plan view of the rock shelter.

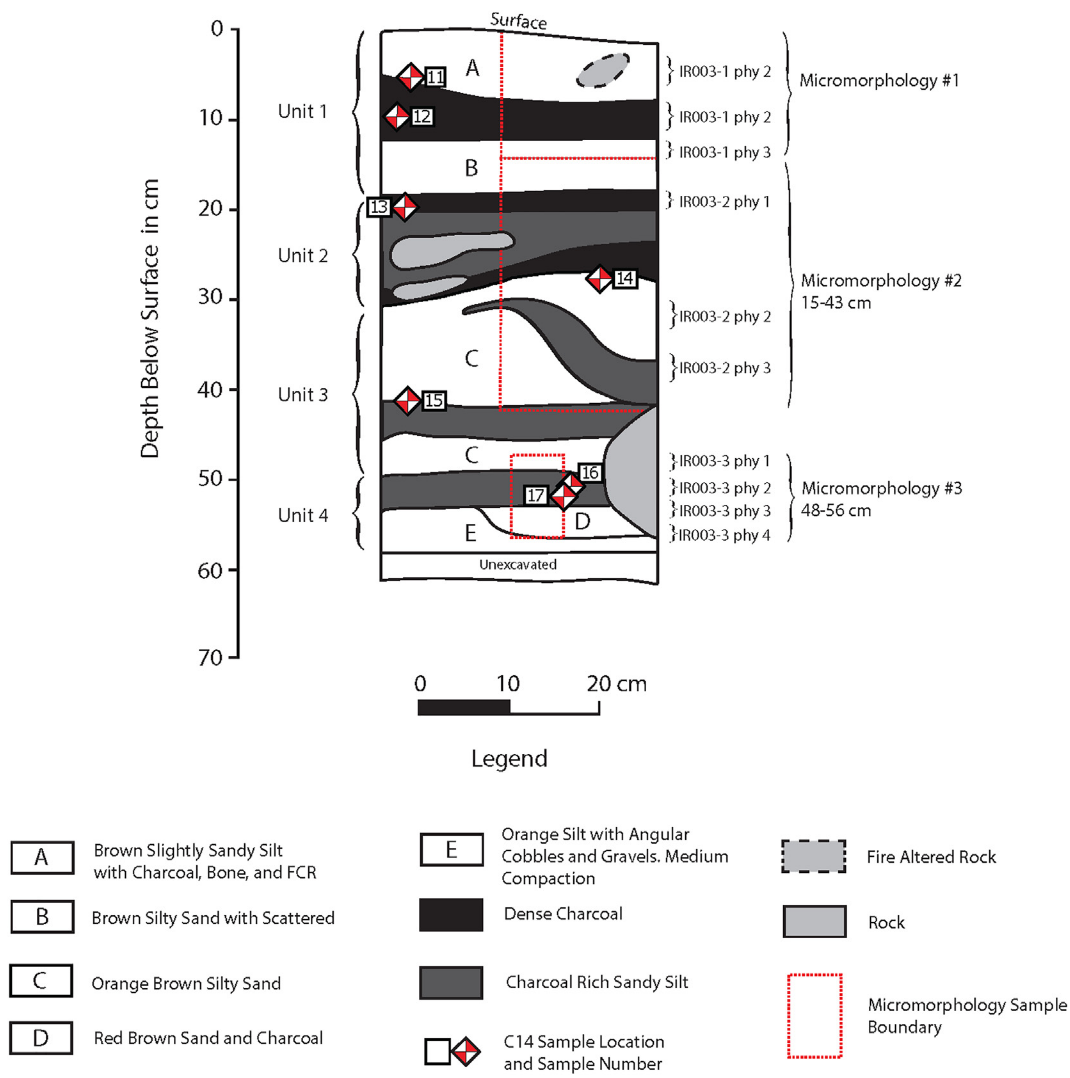

Fig. 4. Section drawing of the stratigraphic sequence uncovered at the DjRr-4 rock shelter.

1 mm screen. The majority of rock shelter sediments are either silty sand or sandy silt, and botanical remains generally floated with little impediment. Light (modern and charred botanicals, some micro-fauna) and heavy (lithics, fauna and sediment) fractions, once separated, were removed to lined drying racks and labeled. Dry samples were split into like-sized fractions (2 mm, 1 mm, 0.425 mm, and catch), weighed, and placed in labeled zip-lock bags for storage and analysis.

Standard palaeoethnobotanical techniques were used in the sorting and identification of all macroremains (Pearsall, 2000). Samples were sorted into their constituent parts under a dissecting microscope (7–30× magnifications). All fractions were sorted in their entirety, except the catch, which is generally too small to recover identifiable macroremains. Plant macroremains recovered include charcoal, needles, seeds, fruit tissue, and modern littermat components including sword fern leaves and moss. Plant remains were identified using the Ursus Heritage Consulting comparative collection, as well as published and digital sources (Martin and Barkley, 1961; Hitchcock and Cronquist, 1973; Montgomery, 1977; Cappers et al., 2006; Klinkenberg, 2008). Macroremains were quantified by count. Charred components are considered clearly archaeological in this analysis, while the relative antiquity of certain uncharred taxa is discussed in ensuing sections. Seed fragments were counted as a '1/2' each to combat the inflation of seed totals. Identifications were made to the highest level of confidence.

2.4. Phytolith and diatom analysis

Phytolith and diatom samples ($n = 10$) were processed and analyzed at the Department of Archaeology, Simon Fraser University. The methods applied are based on chemical extraction of non-siliceous minerals, following the procedure developed by Albert et al. (1999). Morphological identification of phytoliths under the optical microscope at 400× magnification is based upon a modern plant and soil reference collection available at www.phytcore.org, as well as other modern plant reference material from close geographical areas and/or closely related environments (Fredlund and Tieszen, 1994; Carnelli et al., 2004; Strömberg, 2004; Blinnikov, 2005; Piperno, 2006; Blinnikov et al., 2013; McCune and Pellatt, 2014). Where applicable, the phytolith morphotype terminology uses the International Code for Phytolith Nomenclature (ICPN; Madella et al., 2005). Diatoms were identified from the same sample slides under 400× magnification to species level where possible using digital (Diatoms of North America, www.diatoms.org) and published reference guides (Foged, 1981; Krammer and Lange-Bertalot, 1986a, b, c, d). Diatom habitat information was also derived from these sources.

2.5. Zooarchaeology

Faunal remains were recovered from the heavy fraction of the bulk samples described in the section on botanical macroremains.

Table 1
Microfacies types (MFT) identified at the DjRr-4 rock shelter. Descriptions follow the terminology of Stoops (2003). Microfacies defined as in Flügel (2004).

MFT name	Description	Formation process
Sand	**c/f related distribution:** fine to coarse enaulic. **Structure and voids:** intergrain microaggregate microstructure with complex packing voids. **Coarse fraction:** sand-sized sub-angular quartz and feldspar grains (dominant); sand-sized sub-angular biotite and hornblende grains (very few); sand- to gravel-sized sub-angular fragments of granitic rocks (few); sand- to gravel-sized sub-rounded fragments of basaltic rocks (very few); sand-sized angular fragments of wood charcoal (very few); sand-sized fragments of bone (very few). **Fine fraction:** partially decayed amorphous organic matter and brown clay with speckled b-fabric (the latter only in Block 3, Unit 4, at the bottom of the stratigraphic sequence). **Pedofeatures:** absent.	Colluvium
Ash	**c/f related distribution:** coarse enaulic. **Structure and voids:** granular microstructure with complex packing voids. **Coarse fraction:** sand- to gravel-sized angular fragments of wood charcoal (frequent); sand-sized sub-angular quartz, feldspar, biotite and hornblende grains (few); sand- to gravel-sized sub-angular fragments of granitic rocks (few); sand- to gravel-sized sub-rounded fragments of basaltic and metamorphic rocks (few); sand-sized fragments of bone (very few). **Fine fraction:** absent. **Pedofeatures:** absent.	Low-temperature combustion of wood

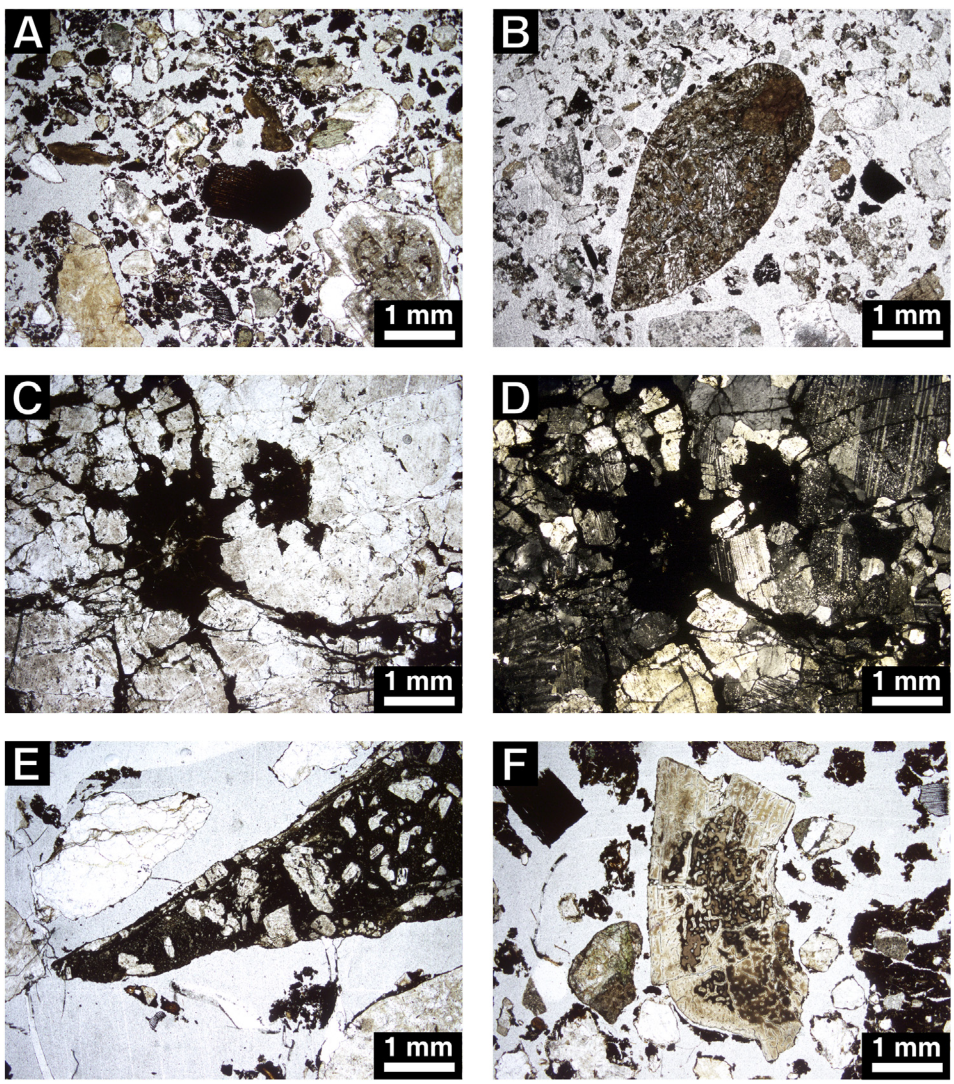

Fig. 5. Photomicrographs of thin sections. A: coarse mineral grains loosely mixed with aggregates of amorphous organic matter and charcoal, plane polarized light (PPL). B: rounded fragment of basaltic rock (PPL). C: altered granite (PPL); note the cracks filled with iron hydroxides. D: same as previous, in cross-polarized light (XPL); note the fractured quartz grains. E: fragment of dacite showing sharp edges, possibly an artifact (PPL). F: fragment of charred bone (PPL).

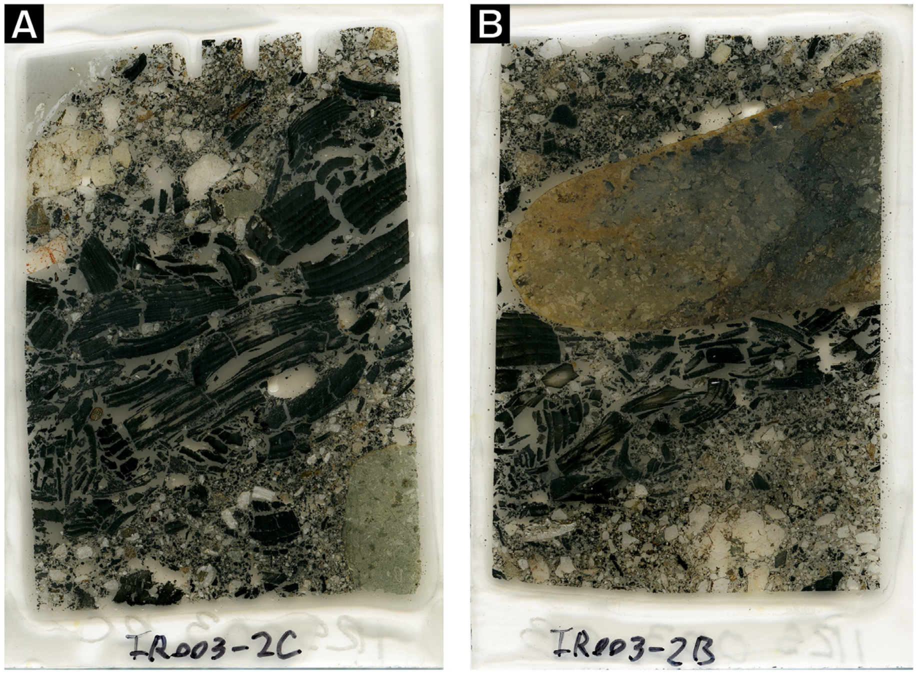

Fig. 6. Scans of representative thin sections from one of the ash deposits in Unit 3 (short side of frames: 5 cm). A: thick layer of wood charcoal. B: same as previous; note the presence of a rounded pebble of metamorphic rock resting directly on top of wood charcoal.

Components larger than 2 mm were analyzed. Specimens were identified using modern comparative materials held by the Department of Anthropology, University of Alberta, and identified to the highest level of confidence possible based on anatomical traits. The majority of faunal remains in all six samples were heavily fragmented, and unidentifiable beyond class (mammal) and animal size (medium-large). Most specimens were fragmented past the ability to identify element, although rib, long bone, phalange, and vertebral fragments were identified.

2.6. Radiocarbon dating

Wood charcoal was collected using metal tools and stored in aluminum foil envelopes. Six samples were shipped to DirectAMS (Seattle, WA, USA) for radiocarbon dating, whereas one further sample was sent to the A. E. Lalonde AMS Laboratory (University of Ottawa, ON, Canada). Samples were treated using a standard ABA procedure, which produced enough material for accelerator mass spectrometry (AMS) measurements. Radiocarbon ages were calibrated using OxCal 4.2.3 (Bronk Ramsey, 1995, 2009) and the IntCal13 calibration curve (Reimer et al., 2013).

3. Results

3.1. Excavation

Our excavation revealed cultural deposits to a depth of 56 cm below surface consisting of a series of finely stratified hearth and occupation deposits (Fig. 4). Beneath a thin surficial layer of non-cultural small pebbles and silty sand, excavation revealed deposits characterized by black, greasy sandy silt with a relatively high frequency of fire-cracked rock. Calcined bone was also evident in the first few centimeters of deposit, consistent with the presence of stratified hearths. A band of charcoal underlay the fire-cracked rock deposit at a depth of 10 cm dbs. Beneath this band of charcoal was a layer of presumably fire-oxidized brown silt with some ash and fire-cracked rock. Underlying, was an approximately 12 cm-thick cultural layer characterized by bands of charcoal both above and below charcoal-rich, silty-sand deposits with fire-cracked rock and fragments of burnt bone. This feature, or series of features, overlays a deposit of predominantly non-cultural orange-brown silty sand containing scattered charcoal fragments. Underlying this deposit are two bands of charcoal-rich sandy silt, interspersed by orange-brown silty sand. Beneath these final charcoal-rich deposits are non-cultural deposits of sandy silt that transitioned into compact orange sandy silt with angular granite cobble inclusions.

The small artifact assemblage from DjRr-4 (n = 12) was entirely composed of < 1 cm flakes, perhaps the products of pressure flaking (i.e. resharpening) bifacial tools, such as projectile points. Several small red mineral accretions – likely used as red ochre pigments – were also recovered during excavation. Light microscopy and Raman spectroscopic analysis of these materials indicate that many of the small pressure flakes are composed of a variety of materials (including quartz crystal), suggesting an array of locally available source materials were used in tool manufacturing processes.

3.2. Micromorphology of sediments

All of the micromorphology samples show similarities in composition and fabric, which allowed the identification of two different assemblages of sediments, called microfacies types (MFT). We use here the concept of "microfacies" as described by E. Flügel, i.e. "*the total of all sedimentological and paleontological data which can be described and classified from thin sections […]*" (Flügel, 2004: 1). This approach to the study of thin sections includes the basic interpretive level of each microfacies type (e.g. Goldberg and Aldeias, 2018). The two different assemblages reflect primarily anthropogenic (ash) vs. non-anthropogenic (sand) deposits. These assemblages, as well as discrete constituents and stratigraphy are described in detail below and in Table 1.

The "sand" MFT is characterized by sand-sized mineral grains and rock fragments, loosely mixed with aggregates of comminuted amorphous organic matter and charcoal (fine to coarse enaulic c/f related distribution; Fig. 5A). Fine mineral fraction is absent, except for a brown clay at the bottom of the stratigraphic sequence (Unit 4). Mineral grains are comprised of mainly quartz, feldspars, hornblende and biotite, whereas rock fragments include different types of altered granite (dominant), basalt and dacite (Fig. 5B–E). Charred bone fragments

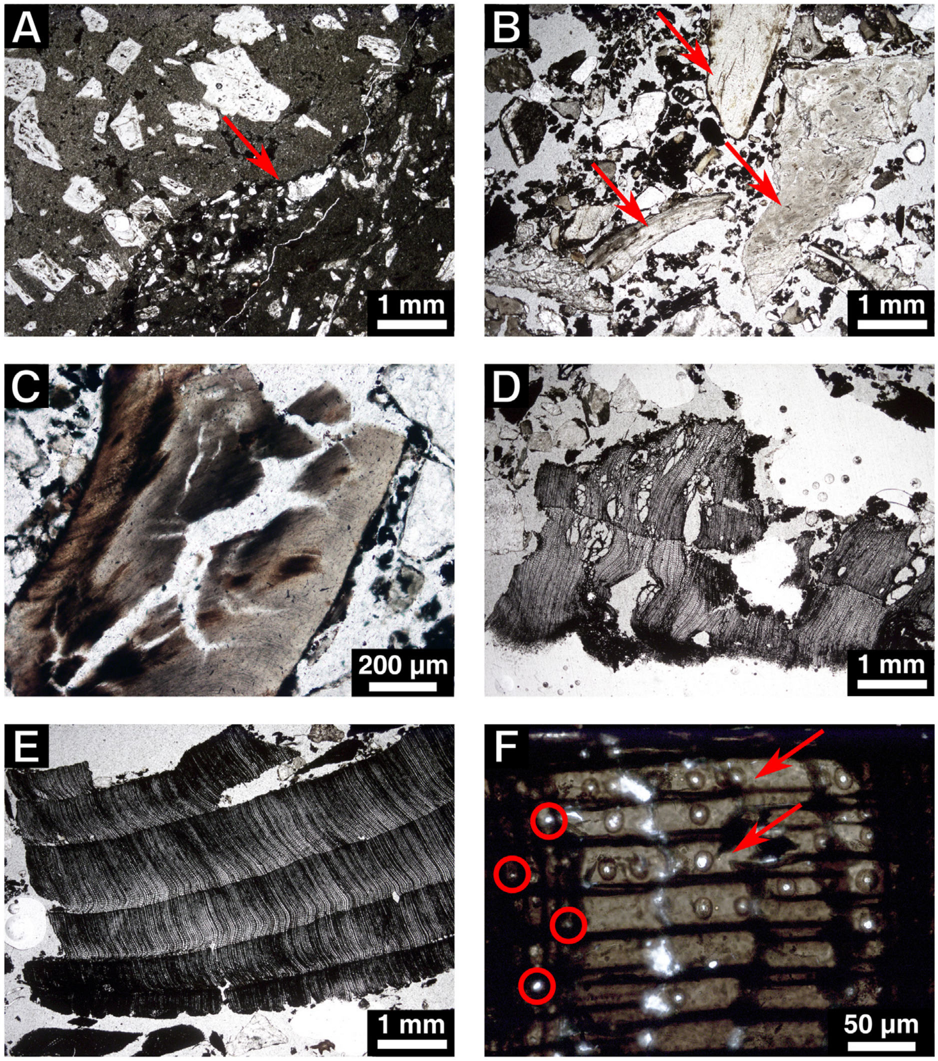

Fig. 7. Photomicrographs of thin sections. A: metamorphic rock generated by contact metamorphism between two different types of dacite (note the plagioclase phenocrysts); the arrow marks the contact boundary (PPL). B: calcined bone fragments (arrows; PPL). C: fragment of dentine (PPL). D: collapsed wood charcoal (PPL). E: well-preserved transversal section of coniferous wood charcoal showing growth rings (PPL); resin canals are absent. F: radial section of coniferous wood showing taxodioid pits in rays (circles) and single rows of bordered pits on tracheid walls (arrows), typical of *Abies* species (PPL).

occur rarely (Fig. 5F). The absence of fine fraction, compaction and bedding, and the chaotic spatial organization of the coarse components, indicate that this assemblage formed through colluvium from upslope.

The "ash" MFT shows the same mineral components as the previous MFT, although in considerably smaller amounts. In fact, most of the coarse fraction is represented by large fragments of wood charcoal (Fig. 6A) and partially charred plant tissues. These remains are consistent with low-temperature combustion of wood (Braadbaart and Poole, 2008). Calcite ash pseudomorphs from biogenic calcium oxalate were not observed, presumably due to dissolution in acidic pH (e.g. Weiner et al., 2002; Weiner et al., 2007), typical of sediments derived from igneous bedrocks. The same chemical environment might have favored charcoal preservation (Cohen-Ofri et al., 2006; Rebollo et al., 2008). Except for Unit 4, all the combustion features show a lenticular shape in section produced by horizontally layered charcoal, and do not appear to have undergone bioturbation or post-depositional reworking, thus suggesting that their contents (wood charcoal and other plant remains) are in primary deposition. At least three different combustion features exhibit also rounded pebbles of metamorphic rock resting directly on top of charcoal (Fig. 6B). These rocks are not part of the local bedrock (Fig. 7A), and their degree of rounding suggests that probably they were deliberately collected from the nearby Indian River. In addition, calcined and charred bones and dentine occur frequently within combustion residues (Fig. 7B–C).

Wood charcoal is characterized by different degrees of preservation, including a dominant portion of collapsed fragments (Fig. 7D), and some well-preserved transversal, tangential and radial sections. The latter all point to one specific plant genus. The absence of vessels and resin canals in transversal sections (Fig. 7E) excludes dicotyledonous wood and most conifers, such as the native species *Pseudotsuga menziesii* (Douglas fir). The pitting observed in rays in radial section is of the taxodioid type (Fig. 7F), which excludes other native species such as *Thuja plicata* (western redcedar) and *Tsuga heterophylla* (western hemlock), characterized by cupressoid/taxodioid and piceoid/cupressoid pits, respectively. In addition, both western redcedar and western hemlock exhibit paired bordered pits on the walls of tracheids, whereas these fragments present only a single row. These lines of evidence narrow down the range of possibilities to the *Abies* genus (fir), and are consistent with the large number of plant macroremains of *Abies* sp. and *Abies amabilis* (Pacific silver fir) found at the site (see Section 3.3). Considering the low degree of preservation and/or the undiagnostic section view of several charcoal fragments, it is not surprising that other species observed macroscopically in the combustion features (i.e. *Thuja plicata* and *Tsuga heterophylla*) are not visible in thin sections.

Table 2
Botanical macroremains assemblage from the DjRr-4 rock shelter.

Taxon	Common name	Frequency (n) by sample[a]					
		Unit 1 0–10 cm	Unit 1 20–22 cm	Unit 2 26–32 cm	Unit 3 32–38 cm	Unit 4 45–48 cm	Unit 4 52–55 cm
Seeds							
Alnus spp.	Alder						(1)
Gaultheria shallon	Salal		(1)				
Labiatae	Mint family	1					
Rosa spp.	Wild rose					(cf. 1)	
Rosaceae	Rose family				1		
Rubus spp.	Raspberry genus	(1)	(2)		1(1.5)	(9)	(14.5)
Sambucus racemosa	Red elderberry	(1)		(4.5)	(0.5)	(0.5)	(1.5)
Sorbus sitchensis	Mountain-ash						(0.5)
Vaccinium spp.	Blueberry genus	(3)					(2)
	Unidentified				1(0.5)	2(1.5)	(1)
Total		1(4)	(3)	(4.5)	3(2.5)	2(12)	(20.5)
Needles							
Abies cf. *amabilis*	Amabilis fir	6				23(1)	2
Abies/Tsuga	Fir/hemlock	3				98	10
Thuja plicata	Western redcedar	2		1(2)		(4)	
Tsuga heterophylla	Western hemlock	13	1	(1)	52(1)	111	22(4)
	Unidentified		1				
Total		24	2	1(3)	52(1)	232(5)	36(4)

[a] Numbers in brackets represent uncharred remains, and those without brackets represent charred remains (cf.: probable designation).

The stratigraphic sequence is thus characterized by the alternation of the two MFTs identified in thin section. At the bottom, a sand layer served as a base for a combustion feature that left a small amount of wood charcoal mixed with the sedimentary matrix (Unit 4). No recognizable fabric or structure was observed. Another sand layer marks the boundary with Unit 3, characterized by a lenticular combustion feature. The latter is again covered by sand, which worked as a base for the lenticular combustion features of Unit 2, further divided by a thin layer of colluvial sand. In both Unit 3 and 2, charcoal occurs in substantial amounts together with charred bones, and it is layered horizontally. In addition, the two uppermost combustion features, which represent Unit 2, exhibit large rounded pebbles of metamorphic origin resting directly on top of charcoal. Unit 2 is topped by a thick layer of colluvial sand, on which the most recent lenticular combustion feature (Unit 1) was set down. In this case, pebbles of metamorphic rocks occur both beneath and above the charcoal accumulation. The stratigraphic sequence ends with a layer of colluvial sand, characterized by the presence of a relatively larger amount of decayed organic matter that suggests the incipient formation of an organic soil horizon.

3.3. Botanical macroremains

The plant macroremains found at DjRr-4 rock shelter are presented in Table 2. The archaeobotanical assemblage from DjRr-4 is primarily comprised of a moderate density of charred conifer needles (28.8/l) (e.g. Lyons, 2017), including *Abies amabilis* (Pacific silver fir), *Tsuga heterophylla* (western hemlock), and *Thuja plicata* (western redcedar), a very low density of charred seeds (0.5/l), including raspberry genus (*Rubus* spp.), mint (Labiatae) and rose (Rosaceae) families, as well as an uncharred assemblage of seeds, mosses and sword fern fronds (*Polystichum munitum*) throughout all occupational levels.

3.4. Phytolith and diatom analysis

Out of the 10 samples analyzed IR003–1 phy 2, the top superficial sample, was the richest in terms of phytoliths (Table 3). The morphotypes identified correspond mainly to the leaves of grasses, probably representing the vegetation growing today in the surroundings of the site. The most common morphotypes are CRENATE, BILOBATE, ELONGATE and ACUTE BULBOSUS (TRICHOME) (Fig. 8A-J). While BILOBATE and ACUTE BULBOSUS cannot be further diagnostic aside from belonging to grasses, the CRENATE type is usually associated to C_3 pooideae grasses (Strömberg, 2004). The ELONGATE may correspond to grasses but also to other monocotyledonous families where it is commonly present. Contrary to this top sample, only a few phytoliths were recovered from underlying anthropogenic sediments IR003-1 phy 1 and IR003-1 phy 3. The assemblage is dominated by grass-leaf phytoliths such as CRENATE, ELONGATE and TRAPEZOID (Fig. 8L). Other phytoliths that showed prominent signs of chemical alteration, which hindered their morphological identification, were also noted. Phytoliths are practically absent from other samples, and the few noted exhibit features caused by chemical alteration. A few undetermined morphotypes, probably from dicotyledonous plants, were also noted in the samples (Fig. 8K and M). Samples IR003-1 phy 2 and IR003-1 phy 1 include siliceous sponge spicules that point to humid conditions favorable to the growth of sponges (Fig. 8N).

Two general observations can be made about the diatoms in the DjRr-4 sediments: the species are all from freshwater habitats such as streams and ponds, or are aerophilic, living on moist rock walls or among mossy plants; and the abundance of diatoms decreases with depth in the excavation unit (Table 3). The most commonly observed specimens are *Eunotia* species, but *Cymbella aspera*, *Diploneis krammeri*, *Gomphonema angustatum*, and *Orthosira roseana* were also identified (Fig. 9). *Orthosira roseana* and *Eunotia subherkiniensis* can both live on moist rock walls, suggesting that they lived and died in the rock shelter. The other diatoms may have lived in pools of standing water that collected when the rock shelter was not in use or have been transported into the shelter as seasonal streams ran through. A few diatoms are present in several of the cultural layers; these may have been tracked into the shelter by people or they were attached to rocks or pieces of wood that were brought from the Indian River (see Section 3.2). The decrease in diatom abundance with depth, coinciding with the decrease in phytoliths with depth is likely simply a result of preservation bias, with mechanical and chemical weathering occurring over time.

3.5. Zooarchaeology

The list of bone fragments unearthed at the DjRr-4 rock shelter is displayed in Table 4. A total of 800 faunal elements were recovered at the site. These elements are highly calcined, fragmentary, and most are only identifiable as medium- to large-sized mammal (99% of the assemblage). Fragmentation of samples appears to have occurred prior to deposition while the bones were fresh, rather than as a result of

Table 3
Phytolith and diatom analysis results. Samples are listed in stratigraphic order, from top to bottom.

Sample name	Description	Phytoliths	Diatoms (relative abundance and possible source habitat)	Other
IR003–1 phy 2	Uppermost modern soil, post abandonment (Unit 1, 0–5 cm)	C_3 Pooideae grass leaves and probably dicots	Present but weathered. Fresh water benthic, epilithic, and epiphytic (lakes, ponds, fens, springs, creeks, and wet walls)	Microcharcoal and clay, Sponge spicule
IR003-1 phy 1	Hearth level, charcoal (Unit 1, 5–10 cm)	C_3 Pooideae grass leaves, probably dicots and weathered	Present but weathered. Fresh water benthic, epilithic, and epiphytic (lakes, ponds, fens, springs, creeks, and wet walls)	Microcharcoal and Sponge spicule
IR003-1 phy 3	Level underneath hearth level (Unit 1, 10–15 cm)	C_3 Pooideae grass leaves, probably dicots and weathered	Present but weathered. Fresh water benthic, epilithic, and epiphytic (lakes, ponds, fens, springs, creeks, and wet walls)	Microcharcoal
IR003-2 phy 1	Charcoal (Unit 2, 15–20 cm)	Very few and weathered	Very few, weathered: fresh water benthic, epipelic	Microcharcoal
IR003-2 phy 2	Grey sediment (Unit 3, 30–35 cm)	n/a	n/a	
IR003-2 phy 3	Light brown sediment (Unit 3, 35–40 cm)	n/a	n/a	Microcharcoal
IR003-3 phy 1	Silty sediment, rock shelter floor (Unit 4, 48–50 cm)	Probably dicots	n/a	
IR003-3 phy 2	Silty sediment with charcoal lenses (Unit 4, 50–53 cm)	n/a	Very few; non-identifiable	Some charcoal and clay
IR003-3 phy 3	Silty sediment with charcoal dispersed (Unit 4, 50–53 cm)	n/a	Very few, weathered; aerophilic, wet rock walls	Microcharcoal
IR003-3 phy 4	Silty sediment with charcoal dispersed below previous one (Unit 4, 54–56 cm)	n/a	Very few; non-identifiable	Microcharcoal

disturbance or excavation damage. Elements include ribs, long bones, phalanges, vertebra, and maxillae. Deer (*Odocoileus* spp.) is the only positively identified mammal, although limited to only two elements. The only other terrestrial mammals of similar size in the region are the black bear (*Ursus americanus*) and mountain goat (*Oreamnos americanus*). Observed differences in robusticity of comparative materials between *Odocoileus* spp. and *Ursus americanus* suggest that most or all of the unidentified remains likely also come from artiodactyls. Site location and intermittent but repeated use history also limit the likelihood of the remains coming from mountain goat, which are found infrequently in subalpine regions. An assemblage dominated by artiodactyl remains also fits Angelbeck and Cameron's (2014) metastudy results that show faunal assemblages in the region are dominated by artiodactyls. In addition to the overabundance of medium- to large-sized mammal, likely artiodactyl, there was no evidence of any small mammals, birds, or fish being processed or cooked at this site.

3.6. Radiocarbon dating

The results of radiocarbon dating measurements show that samples are consistent with their stratigraphic position, except for RC17 (collected from Unit 4), which is clearly inverted (Table 5 and Fig. 10). Given the agreement of the dates in Unit 2 and 3, we ascribe this discrepancy to a sampling error or to a random laboratory error, and we assume RC16 as the age of Unit 4. Therefore, it appears that a first occupation took place around 725 CE, and produced the four combustion features of Unit 2, 3 and 4. A second occupational phase, which is represented by the combustion feature in Unit 1, dates to ca. 1090 CE (RC12). Finally, the most recent occupational phase is centered around 1585 CE, close to the topsoil (RC11).

4. Discussion

4.1. Formation processes, chronology and use of the rock shelter

The micromorphological analysis showed that the DjRr-4 rock shelter was characterized by a pattern of intermittent human occupation for the last 1300 years, with a peak around 725 CE that produced most of the stratigraphic sequence (Unit 2, 3 and 4). Human presence is represented by the occurrence of combustion features rich in wood charcoal, bone fragments (some of which are calcined), and heat-fractured river pebbles. The lowermost combustion feature (Unit 4) appears to be a simple accumulation of charcoal mixed with the sedimentary matrix. This may indicate the presence of the primary combustion feature centered elsewhere in the rock shelter. The following features are structured, and they exhibit a lenticular layout with horizontally layered charcoal that is typical of pre-contact hearths (e.g. Aldeias, 2017). The presence of rounded pebbles of metamorphic rock resting on top of charcoal accumulations suggests that the former were perhaps collected from the nearby Indian River and used as boiling stones. Flat and sharp flakes of metamorphic rock that are located beneath charcoal in the most recent combustion feature (Unit 1) might have been used as a base for a constructed pebble hearth aimed at better retaining heat (e.g. Toffolo, 2011; Gur-Arieh et al., 2012).

The contemporaneity (in radiocarbon dating terms) of the four combustion features observed in Unit 2, 3 and 4 seems to point to single, short-lived firing events that took place during distinct visits to the rock shelter over a relatively short period of time. This conclusion is further supported by the occurrence of colluvial deposits in between combustion features, as evidenced by micromorphological analysis. These thin layers of sand represent periods of non-occupation (e.g. Goldberg et al., 2015). Unit 1 combustion features also likely represent short-term use of these shelters, but over a longer time-span during which very little colluvial sand was deposited. Remarkably, the 10 cm of colluvium that separate Unit 1 and 2 represent a gap of ca. 400 calendar years, as opposed to the seemingly rapid sedimentation process

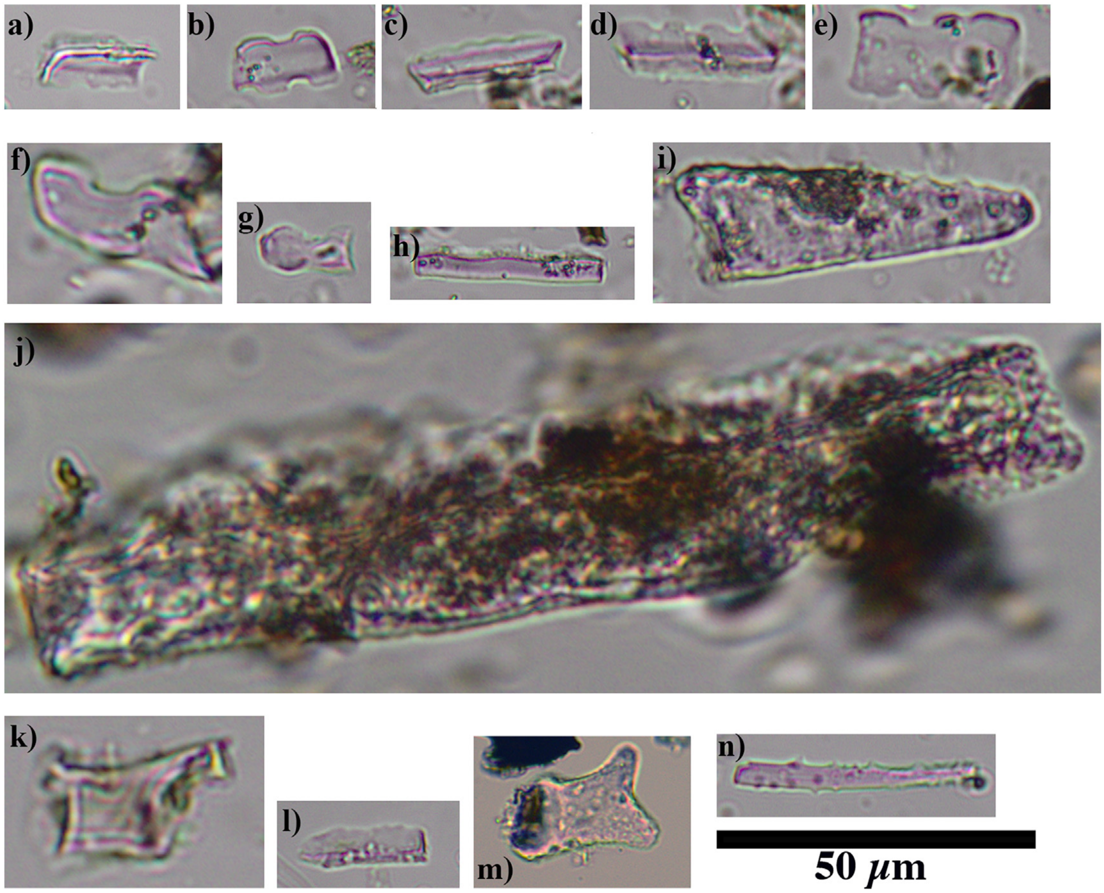

Fig. 8. Photomicrographs of phytoliths, pictures taken at 400 ×. A–F: crenate type probably from C_3 pooideae grass-leaf. G: bilobate from grass. H: elongate. I: acute bulbosus (trichome) probably from grass-leaf. J: elongate. K: undetermined. L: trapezoid probably from grass-leaf. M: undetermined. N: sponge spicule.

that occurred during the formation of Unit 2, 3 and 4. This gap might be a depositional hiatus or the result of slow sedimentation from upslope. Micromorphological analysis does not show evidence of erosion at this locality. Similarly, there is a gap of ca. 500 calendar years between RC11 and RC12, which are divided by 5 cm of sediment. In this case, RC11 might be affected by modern organic carbon from partially decayed plant material, which was identified in thin section (e.g. Väliranta et al., 2014).

It is not possible to draw precise conclusions regarding the heating temperatures reached by the combustion features, as there are no clay minerals that could record this information through heat transfer from the hearth to the subsoil (Berna et al., 2007; Aldeias et al., 2016). Similarly, the absence of calcitic ash hinders a characterization of its degree of atomic disorder, which reflects different temperature regimes (e.g. Regev et al., 2010). However, the presence of well-preserved wood charcoal indicates that overall temperatures must have been lower than 500 °C (Braadbaart and Poole, 2008).

Besides dissolution of calcitic ash in acidic pH, the post-depositional processes that took place at the site include the dissolution of phytoliths and diatoms from the sub-surface cultural layers. Phytoliths are preserved in the uppermost samples and reflect local vegetation growing today in the vicinity of the shelter, with a dominant grass component probably from the C_3 pooideae subfamily, whereas they do not appear in lower layers. The same applies to diatoms. Their absence is likely due to three causes that acted simultaneously. First, the formation of calcitic ash pseudomorphs in each combustion feature buffered the pH of sediments and groundwater to values above 8, which promoted the dissolution of silica phytoliths from fuel presumably shortly after their deposition (Weiner, 2010). Since diatoms are composed of the same mineral as phytoliths, a similar scenario may well apply. Second, the plants used as fuel may have been poor phytolith producers. For instance, in their study of modern reference plants, McCune and Pellatt (2014) showed that *Abies* needles, one of the most common remains identified at the site, are usually poorly silicified, and that *Tsuga heterophylla* does not produce phytoliths. In addition, Carnelli et al. (2004) showed that *Abies* produce much less phytoliths compared to grasses. These are polyhedral morphotypes (blocky), which however do not show up in our assemblages. Third, charred plant material does not release phytoliths as the latter are part of the organic matrix of the plant.

The occurrence of skeletal remains of deer and medium to large mammals suggests that the rock shelter may have been used for butchering, cooking, processing marrow extracted from bones, and obtaining select bones for tools, such as ulna awls or harpoon valves. This indicates the mammals were killed nearby and carried to the shelter where they could be reduced for immediate consumption, tool materials, and preserved stores. In any case, the combustion features appear to have been surface features where both cooking and processing was done over an open fire. Indeed, such homogenous assemblages are indicative of short-term hunting camps (Binford, 1980). The calcined and highly fragmentary nature of the faunal remains suggests that people may have been extracting marrow for immediate consumption or for later use (Holt and Madrigal, 2002). The deer and mammal remains suggest that this rock shelter may have also been utilized during the fall, for hunting.

The archaeobotanical assemblage reflects local harvesting, consumption, and cooking activities. The density of charred needles at the site reflects both site formation – conifer trees surround the site and consistently fall on or near the shelter – and cultural use as flooring and bedding (Turner, 1998); identified taxa represent the same species as

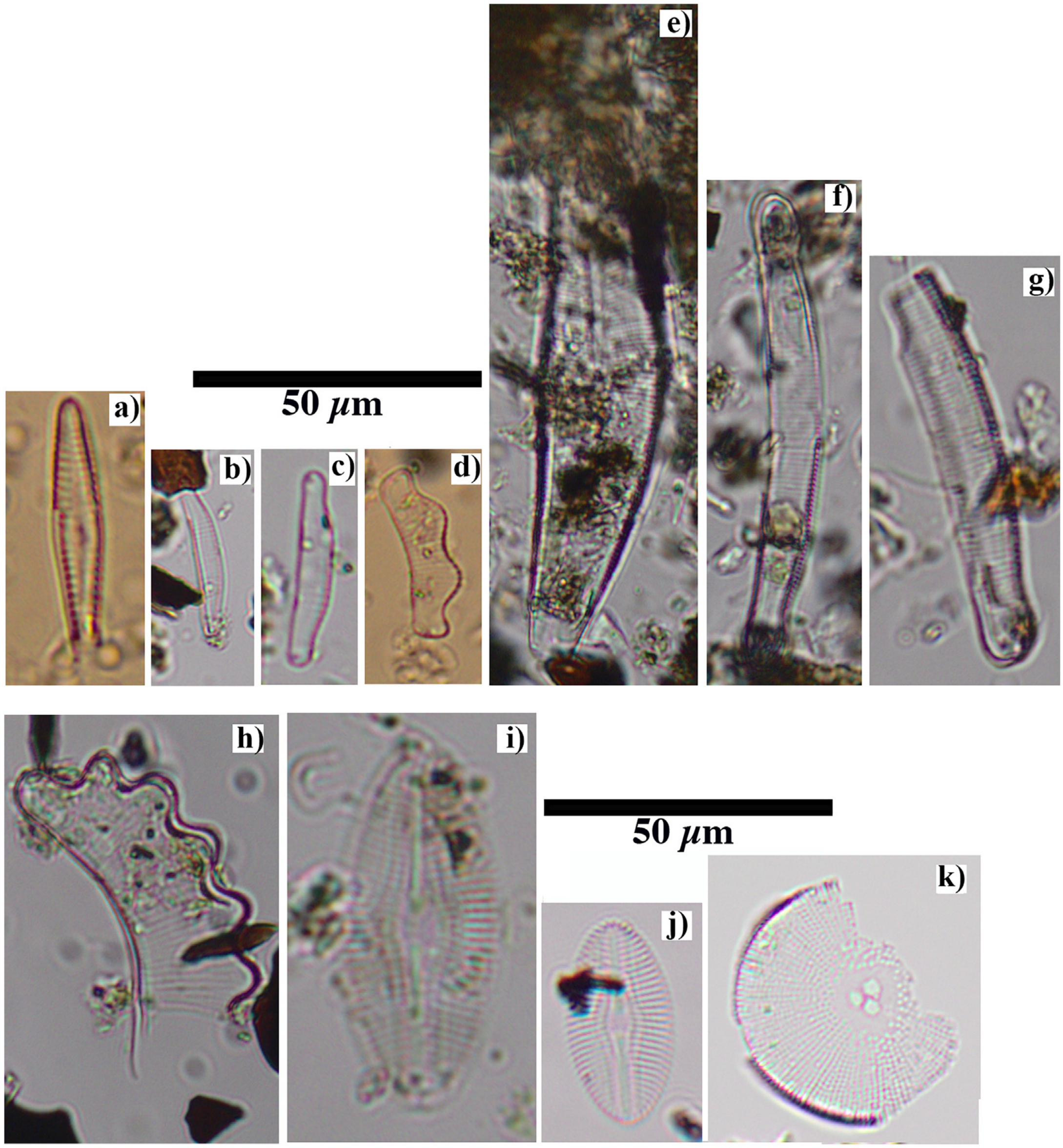

Fig. 9. Photomicrographs of diatoms, pictures taken at 400×. Sample IR003-1 phy 1, A: *Gomphonema angustum*. B: *Eunotia* sp. cf. *minor*. C: *Eunotia minor*. D: *Eunotia* sp. cf. *subherkiniensis* or *E. bigibba*. Sample IR003-1 phy 2, E: *Cymbella aspera*. F: *Eunotia* sp. cf. *lapponica* or *E. lewisii*. Sample IR003-1 phy 3, G: *Eunotia* sp. cf. *lapponica* or *E. lewisii*. H: *Eunotia serra* var. *diadema*. I: *Diploneis krammeri*. Sample IR003-2 phy 1, J: *Diploneis* sp. cf. *ovalis* or *D. krammeri*. Sample IR003-3 phy 3, K: *Orthosira roeseana*.

Table 4
List of faunal remains recovered at the DjRr-4 rock shelter.

Common name	Element	Portion	Number
Unidentified medium-large mammal	Rib	Shaft fragment	8
Unidentified medium-large mammal	Long bone	Shaft fragment	16
Unidentified medium-large mammal	Unidentified	Fragment	769
Unidentified medium-large mammal	Phalanx	Proximal fragment	4
Unidentified medium-large mammal	Vertebra	Fragment	1
Deer	Phalanx	Proximal fragment	1
Deer	Maxilla	Fragment	1

the charcoal thin sections. The charred seed assemblage clearly reflects periodic casual harvesting from late spring to late summer in the absence of intensive processing or storage activities. The uncharred assemblage represents either ancient or modern deposition by natural means (Minnis, 1981). We favor the former interpretation, since the stacked hearth features analyzed here are behind the drip line during heavy rains and micromorphological analysis of sediments and charcoal indicate that very little vertical mixing or bioturbation occurred post-depositionally in these contexts. Further, rock shelter deposits, like middens, can become highly compacted, and, protected from the elements, may result in unusual levels of organic preservation (e.g. Lepofsky, 2004). The uncharred assemblage from DjRr-4 contains a

Table 5
Radiocarbon dating results obtained from charcoal fragments collected at the DjRr-4 rock shelter. Samples are shown in stratigraphic order (pMC: percentage of modern carbon).

Laboratory #	Sample ID	Unit	pMC	Age ± 1σ (uncalBP)	Calibrated range ± 1σ (calAD)
D-AMS009801	RC11	1	96.37 ± 0.28	297 ± 23	1630–1647 (18.4%) 1522–1572 (49.8%)
D-AMS009802	RC12	1	88.84 ± 0.28	950 ± 25	1136–1150 (12.1%) 1084–1124 (38.1%) 1030–1049 (18.0%)
D-AMS009803	RC13	2	85.25 ± 0.30	1282 ± 28	742–766 (27.2%) 680–720 (41.0%)
D-AMS009804	RC14	2	85.16 ± 0.28	1290 ± 26	744–765 (25.6%) 676–714 (42.6%)
D-AMS009805	RC15	3	85.10 ± 0.30	1296 ± 28	744–764 (23.3%) 671–712 (44.9%)
UOC-4274	RC16	4	85.47 ± 0.37	1261 ± 35	688–770 (68.2%)
D-AMS009806	RC17	4	86.62 ± 0.26	1154 ± 24	920–953 (25.0%) 864–901 (29.0%) 827–840 (6.1%) 778–790 (8.1%)

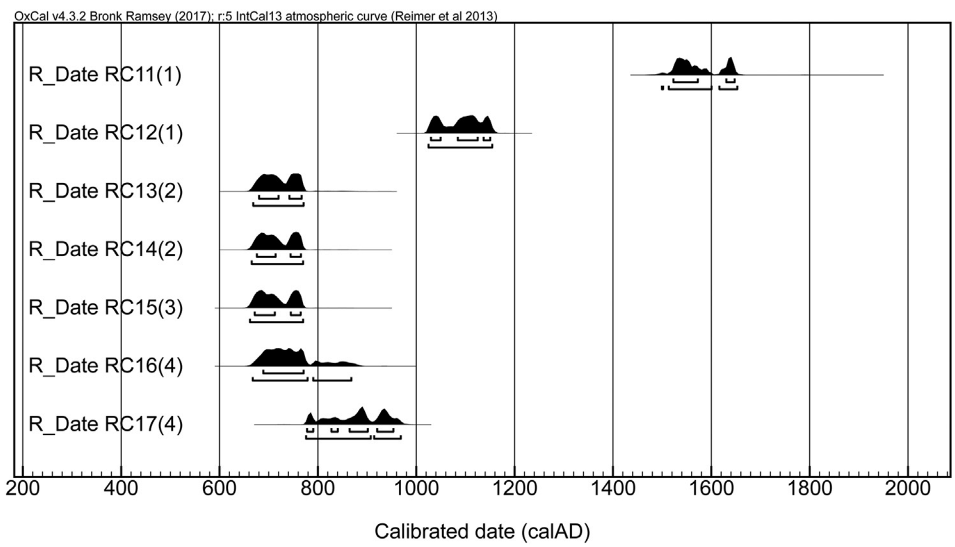

Fig. 10. Radiocarbon dating. Probability distributions of the calibrated radiocarbon measurements, displayed in stratigraphic order (unit number between brackets). Note that RC17 is inverted.

high proportion of edible taxa – most of which are also medicinal – including raspberries (*Rubus* spp.), blue- or huckleberries (*Vaccinium* spp.), salal (*Gaultheria shallon),* red elderberry (*Sambucus racemosa*) and mountain-ash (*Sorbus sitchensis*; Kennedy and Bouchard, 1986; Turner, 1995), suggesting that their growth may have been 'encouraged' either purposely or inadvertently by First Nations occupants (Lyons and Orchard, 2007; Armstrong, 2017).

4.2. Coast Salish population dynamics

Recent regional archaeological studies focused on large village sites have shown that a greater emphasis was placed on large mammals such as deer – relative to other mammals – around 650 CE concurrent with the widespread local adoption of the bow and arrow (Angelbeck and Cameron, 2014). As described by Angelbeck and Cameron (2014: 98-99), this shift in technology was very likely associated with a shift in hunting strategy, from cooperative to more individualistic hunting practices. We suggest that this rock shelter, and other nearby ones like it where we have recovered projectile points, reflect this intensified practice, which in turn illustrates how these sites offer insights into both local and regional social dynamics and practices. Based on the size of the hearths, the cultural remains, and the size of the shelter, we speculate that the number of people using it at any given point would have consisted of 1–3 people. The predominant use of the shelter appears to have been for hunting deer and other medium to large mammals, likely by people living in the nearby Tsleil-Waututh village of Inlailawatash, located 8 km to the south. Data presented here are consistent with Tsleil-Waututh traditional knowledge about hunting deer (and other mammals) and harvesting local plants between late spring and fall in the area, most often by small groups of men (e.g. father-son or uncle-nephew; Morin, 2015).

The nearby village of Inlailawatash—at the mouth of the Indian River—was undoubtedly the primary center of occupation for the entire watershed, and the location from which hunting and gathering trips commenced and terminated. Episodic but ongoing use of the rock shelter indicates that it was an important temporary shelter away from Inlailawatash, and other villages, but likely nearby to established overland trail and travel corridors. These main trails would have connected the Tseil-Waututh villages in Burrard Inlet and Indian Arm with the Squamish villages in the Squamish River Valley and Kwikwetlem villages in the Coquitlam Watershed. Several low passes link these adjacent valley systems. Similarly, 'branch trails' ran perpendicular to the main trail(s) to access alpine zones, lakes, and adjacent valleys.

Because of the interconnections between people, rock shelters, and nearby villages, it is not surprising that the use of rock shelters would mirror broader trends in settlement patterning, demography, land and resource use, and even likely, ceremonialism and warfare. The three primary periods of occupation (~600–800 CE, ~1000–1200 CE, and ~1500–1700 CE) represented at DjRr-4 correspond with periods with relatively higher regional populations (Ritchie et al., 2016). Thus, we interpret this shelter as a reflection of how larger populations overall, and likely at Inlailawatash specifically, resulted in intensified regional landscape use. We see this as part of a larger settlement pattern, as short-term camps are more common in general across the region at these times. This greater intensity may also have been related to other important changes that occurred at these times, including increased interregional trade and interactions, greater mobility afforded by hunting with bow and arrows, and changes in ceremonial practices.

5. Conclusions

Coast Salish peoples have lived in the Pacific Northwest for the last 12,000 years. The Tsleil-Waututh, and other coastal Coast Salish peoples lived in large settlements along the coast and at the confluence of major rivers in British Columbia. In addition, during hunting and harvesting trips they exploited seasonal resources in the interior, especially the forested belts above valley bottoms and below sub-alpine zones. There, evidence of human presence at ephemeral sites is less apparent and mostly confined to rock shelters in the form of combustion features and stone tools. In order to retrieve information regarding human occupation and practices from these limited assemblages, a micro-archaeological approach is required to investigate sediments at the microscopic scale. In this paper we addressed Coast Salish short-lived occupation in southwestern British Columbia by studying the formation and post-depositional processes of a series of combustion features at the DjRr-4 rock shelter using micromorphology of sediments, phytolith and diatom analysis, paleoethnobotany, zooarchaeology, lithic analysis and radiocarbon dating. With this approach we were able to provide context to radiocarbon dates and show that the rock shelter was used for short-lived, intermittent occupations that took place during the early 8th, early 12th and 17th c. CE, in agreement with existing evidence of higher population periods in the region characterized by greater degree landscape settlement. Charcoal, botanical, faunal, lithics assemblages, and possible cooking stones in the context of combustion features point to the exploitation of local resources, and food preparation and consumption. In particular, the large proportion of terrestrial mammal remains is consistent with the adoption of the bow and arrow by Coast Salish peoples starting from the second half of the 7th century CE. The DjRr-4 rock shelter was used as a temporary camp site during hunting trips and thus may offer an example of the intensification of this practice in the region.

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