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New insights into early paleoindian (Gainey) associations with proboscideans and canids in the niagara peninsula, southern ontario, canada

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ABSTRACT

This paper presents the results of protein residue and use-wear analyses on stone tools recovered during complete salvage excavations of the Mt. Albion West archaeological site, located in the Niagara Peninsula of Southern Ontario, Canada. Mt. Albion West is an Early Paleoindian (Gainey) locality that yielded evidence of four activity foci and dozens of Early Paleoindian stone tools including one complete and several partial fluted bifaces. Organic residue analyses and use-wear data obtained from several tools indicate Early Paleo-Indian associations with proboscideans and canids.

1. Introduction

This paper presents the results of protein residue analyses on stone tools recovered during investigations of Early Paleoindian Gainey occupation(s) at the Mt. Albion West archaeological site located in the Niagara Peninsula of Southern Ontario, Canada (Fig. 1). The site was discovered during a routine cultural resource management study for the City of Hamilton. Following discovery, controlled surface collecting, and subsurface testing was used to evaluate the archaeological potential of the site. After the recovery of Gainey-type fluted bifaces, and because of the rarity of Gainey sites in Ontario, the site was subject to complete salvage excavation to preserve the information it contained from destruction by the building of a multi-lane highway (Archaeological Services Inc., 2007; MacDonald et al., 2017). Excavation was conducted with shovels and trowels, and the zone containing cultural material (disturbed by agricultural plough disturbance and construction activities in some localized areas) was screened through 3 mm mesh. The boundaries of the site (800 m^2) and of activity areas within the site were determined by drop-offs in recovery rates of less than five waste flakes per m^2 (unless tool fragments were present). Since the original report was completed (Archaeological Services Inc., 2007), a spatial analysis of activity areas has been conducted and published (Pilon and Watts, 2020).

The focus of this paper is to report the results of organic residue analyses and use-wear data obtained from several artifacts in the Gainey component. Three tools had positive associations, one with proboscideans and two with canids. These three tools were subjected to detailed use-wear analyses to understand how these specific tools may have been used with these animals. These studies provide new and rare evidence for Early Paleo-Indian associations with proboscideans and canids (in this instance, possibly domestic dog) in the Great Lakes region.

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2. Geographic and temporal context

The site is located on the northeast-facing edge of the Niagara Escarpment, a bedrock cuesta that extends linearly across southern Ontario and into western New York (Fig. 1). The escarpment contains several distinct cherts used as toolstone by Paleoindians. The cuesta is interrupted by the head of a reentrant valley, the Red Hill Creek Valley, which cuts deeply into the Niagara Escarpment, extending from the top of the escarpment northeastward towards Lake Ontario's western basin at its bottom end (Chapman and Putnam, 1984).

The presumed interval of Gainey occupation in southern Ontario, between 11,000 and 10,800 BP, occurs shortly after the beginning of the Younger Dryas cooling event (Fiedel, 2011; Mangerud, 2020), a climate reversal that occurred during the latter part of a regionally recognized pollen zone: the spruce (*Picea*) zone, named after the most abundant tree pollen. Although the basal and terminal dates for this interval are variable, depending on location and exposure, the spruce zone is generally dated between 12,500 and 10,500 (the spruce maximum within that interval also being time-transgressive, depending on location and the rate of vegetation succession from the preceding tundra to the following pine zone; for example, Anderson 1982; Ashworth, 1977; Calkin and McAndrews, 1980; Karrow et al., 1975; McAndrews, 1981; McAndrews and Jackson, 1988; Mott and Farley-Gill, 1978; Schwert et al., 1985; Yu, 2000, 2003).

Based on pollen data, Tinkler and Pengelly (1994) have suggested that protalus ramparts, formed at the base of permanent snowfields on the lower slopes of the Niagara Escarpment date from the time of local deglaciation (beginning shortly before 12,000 BP) and that climatic conditions favorable to their formation may have extended to perhaps 10,500 BP (well into the Younger Dryas). Even without a periglacial environment, however, the north-east facing scarp and talus slopes of the Niagara Escarpment would surely have generated cold microclimates. Combined with the exposed uplands along the crest and backslope of the Niagara Cuesta – today crossed by strong winter storms tracking from the south and west – the Niagara Peninsula may very well have presented harsh environmental conditions for early humans, if not a reversal to the earlier shrub-tundra/treeline environment that existed immediately following deglaciation.

3. Defining the Gainey Component(s) at Mt. Albion West.

3.1. Identification.

Since the archaeological material at Mt. Albion West occurs entirely within the plough zone (rather than in a stratigraphically sealed deposit), the Early Paleoindian component must be identified using several sources of data. The most definitive are a complete fluted biface and three fluted bases (Fig. 2). The four specimens are identified as belonging to the Gainey type because of their roughly parallel lateral margins and relatively deep bases (Deller and Ellis, 1992; Ellis and Deller, 1997; Simons et al., 1984). In this respect, Gainey is quite different from the three other types of fluted bifaces recognized in Ontario – Clovis-like, Barnes and Crowfield. The Clovis-like fluted biface, recently recognized at the Rogers site in the Niagara Peninsula (Deller et al., 2018) is, like Gainey, a parallel-side biface but with differently executed fluting and basal finishing. The Barnes type fluted biface, in addition to being a smaller biface, often exhibits more extensive fluting than either Clovis-like or Gainey bifaces and often

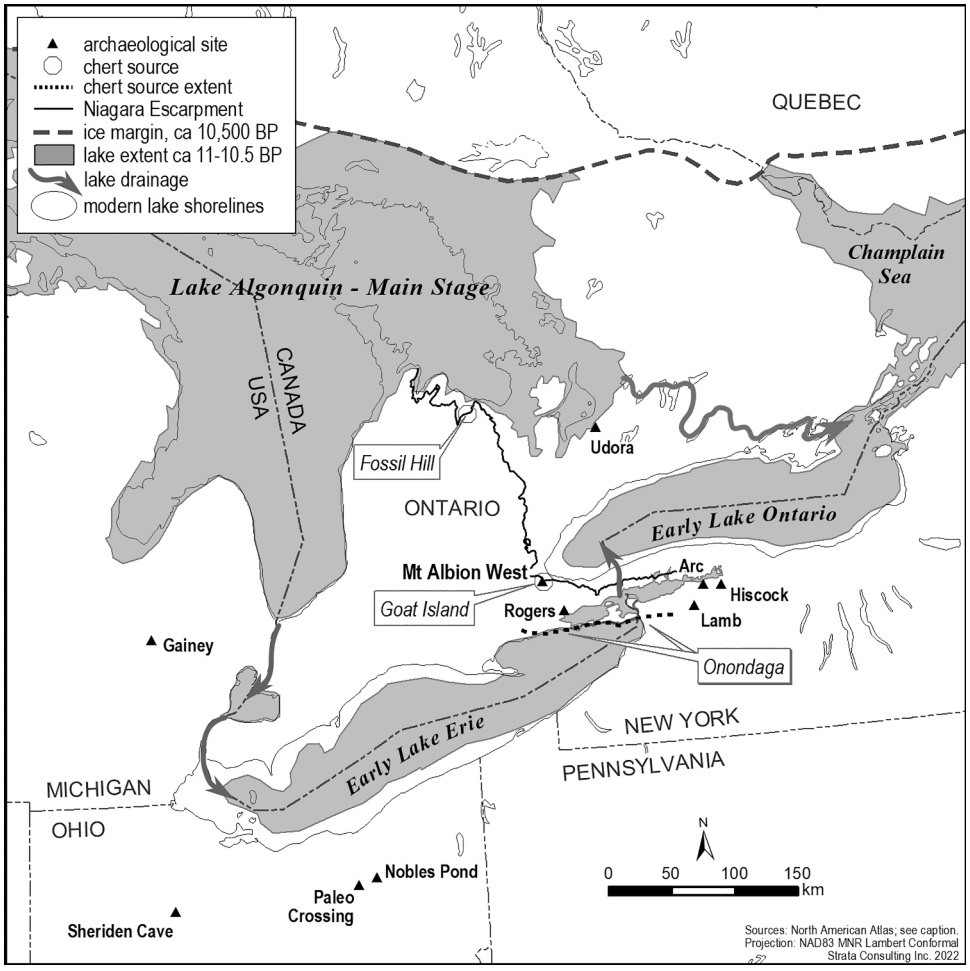

Fig. 1. The Gainey lower Great Lakes showing archaeological sites and sources of toolstones (Eley and von Bitter, 1989) mentioned in text. Also shown are the Late Pleistocene Great Lakes and the margin of the Laurentide ice sheet for the period approximately 11,000 to 10,500 BP (13,000 to 12,100 cal BP). The location of the ice sheet margin is based on Dyke et al., 2003; and Dyke, 2004. The extent of Main Lake Algonquin and Early Lake Erie are based on Karrow et al. 1975; Lewis and Anderson, 1989; Holcombe et al., 2003; and Schaetzl et al., 2016. Early Lake Ontario is shown during the still-stand between 11,000 – 10,400 BP (Anderson and Lewis, 2012; Lewis and Todd, 2019).

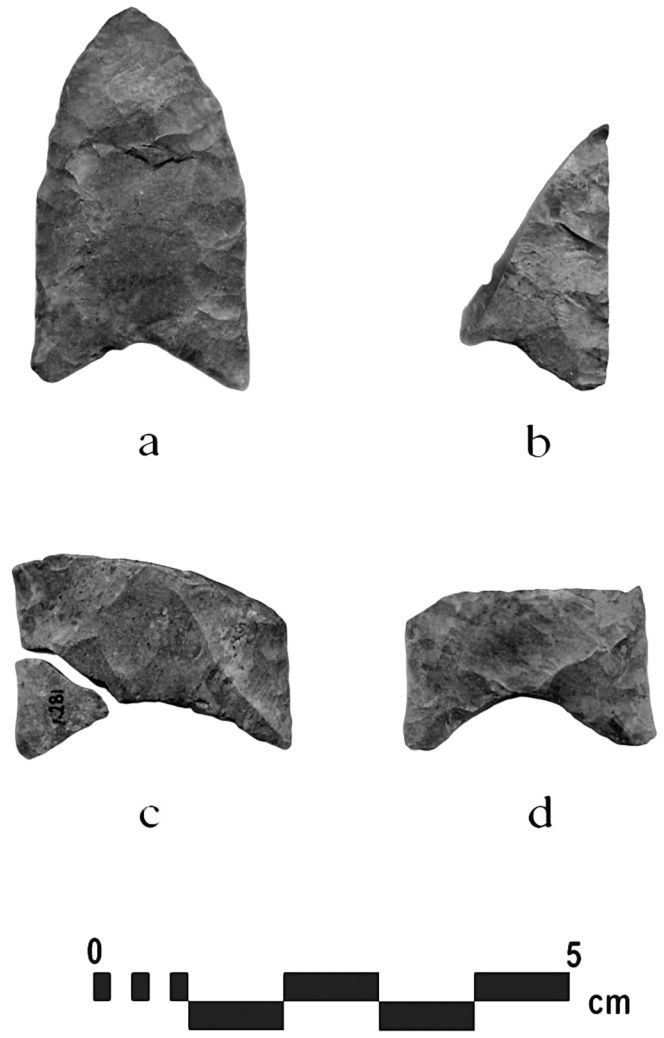

Fig. 2. Gainey-type fluted bifaces, bases and ear fragments from Mt. Albion West: a, complete but resharpened biface (catalogue number 0.258); b, part of lateral edge with ear (0.070); c and d, basal fragments (c: 0.056/0.281; d, 0.264).

exhibits a pronounced narrowing – waisting – slightly above the base (sometimes referred to as a "fishtail"). Although some flaring may be present on Gainey bifaces at the base, this is caused by a slight projection of the ears, not a constriction at the waist as in Barnes. The Crowfield type fluted biface is characterized, in part, by slightly convex lateral margins on a contracting base that is sufficient to distinguish it from the other fluted bifaces mentioned.

Deller and Ellis (1992) note that Gainey fluted bifaces in Ontario are often finished with the so-called Barnes finishing technique (the removal of small rectangular or oval flakes from one or both sides of the flute scar at the base, removing a portion of its lateral margin[s]). This may be accompanied by the removal of a succession of small trimming flakes from the concave base of the biface. All four of the Gainey bifaces from Mt. Albion West exhibit this finishing technique. An attribute not mentioned by Deller and Ellis but that may be important in defining the Gainey-type fluted biface is the configuration of the interior (basal) margin of the ear. On many Gainey bifaces, these inner margins are often slightly convex, changing smoothly to concave at the interior base of the ear as it merges into the base itself (see, for example, Simons, 1998:308). This same ear configuration is present in all three Gainey type fluted bifaces illustrated by Deller and Ellis (1992, Figure 29:35). This attribute is also present on Gainey type points from the Udora site in south-central Ontario (Storck and Spiess, 1994). At Mt. Albion West, two basal fragments of Gainey bifaces and an ear fragment also exhibit this morphology.

The identification of the fluted bifaces as belonging to the Gainey type, and not Clovis, is tentative since the distinction between the two types is based, in part, on when fluting occurred during the manufacturing process and how it was conducted (see, for example, Ellis, 2019; Morrow, 2015; Seeman et al., 1994; for a contrary view as to the validity of the Gainey-type biface, see Eren et al., 2018). These distinctions between Clovis and Gainey, which we regard as valid, are not discernable on the Mt. Albion specimens. Their identification as Gainey is based on the way in which the bases were finished (although some Clovis bifaces exhibit a similar finishing technique) and the relatively deep basal concavities (although, again, sometimes seen on Clovis bifaces). The 42 channel flakes recovered, see below, also support a Gainey identification since channel flakes from Clovis and Clovis-like fluted bifaces are not as easily identified. Regardless of typological distinctions between Clovis, Gainey, and other parallel-sided fluted bifaces (Lothrop et al., 2016), we believe that the technology underlying the fluted bifaces at Mt. Albion West was derived from western Clovis and is a Great Lakes expression of that form which we prefer at this time to identify as Gainey.

In addition to the single complete Gainey type biface and the three Gainey bases from Mt. Albion West, eight other fluted biface fragments were also found but are of undetermined type. Of the forty-two channel flakes, four were bases and 38 mid-section fragments.

Other sources of data used to identify the Gainey component, listed in the approximate order of their reliability, include: (1) three tool classes (single and multiple-spurred flake gravers, tools with graver spurs, and beaked scrapers) that are believed to be characteristic of Paleoindian assemblages, (2) tools of potential Early Paleoindian affiliation (blanks intended for fluted bifaces or recycled after fluting attempts for other uses), and (3) the use of a toolstone exotic to this location, Fossil Hill Formation chert (named after its bedrock source; see Eley and von Bitter, 1989). Several culturally diagnostic artifacts were made of this toolstone: one unidentified fluted point mid-section/basal fragment and two ears, seven spurred tools and a possible burin, two beaked scrapers, and thirteen channel flake mid sections. Fossil Hill chert was not used by Clovis people at the Rogers site, 35 km south of Mt Albion West (Deller et al., 2018), and is not recorded as used by later peoples in the Niagara Peninsula. However, it was used extensively by Gainey and Middle Paleoindians in southwestern and south-central Ontario.

A final consideration concerns the context of four projectile points that post-date the Gainey occupation, ranging in age from the Early Archaic to the terminal Late Woodland period. Three are peripheral to areas A and B (see Figs. 3 and 4; see an explanation of site structure below) and one is within two meters of four Early Paleoindian tools in Area C; all appear to be isolates.

In summary, there is no reason to suspect that Archaic or Woodland peoples also occupied Mt. Albion West. For this reason, and because culturally diagnostic Gainey and Paleoindian tools were made at the site using the two most heavily used toolstones, Onondaga Formation chert and Fossil Hill chert, we believe the excavated assemblage was deposited by Gainey people during a brief occupation(s) at the site.

3.2. *The age of the Component.*

No organic material was recovered for radiocarbon dating from the Mt. Albion West site so the age of the Gainey occupation there, and in Ontario generally, must be inferred from dated sites elsewhere in the lower Great Lakes region.

Radiocarbon dates are available from five Early Paleoindian sites in the lower Great Lakes region. All have produced parallel-side fluted bifaces attributed to Clovis or derived forms: in Ohio, the Paleo Crossing site (attributed to Gainey by Barrish 1995; to possibly a new variant of Clovis called "Remington" by Brose, 1994; and to Clovis by Eren et al.,

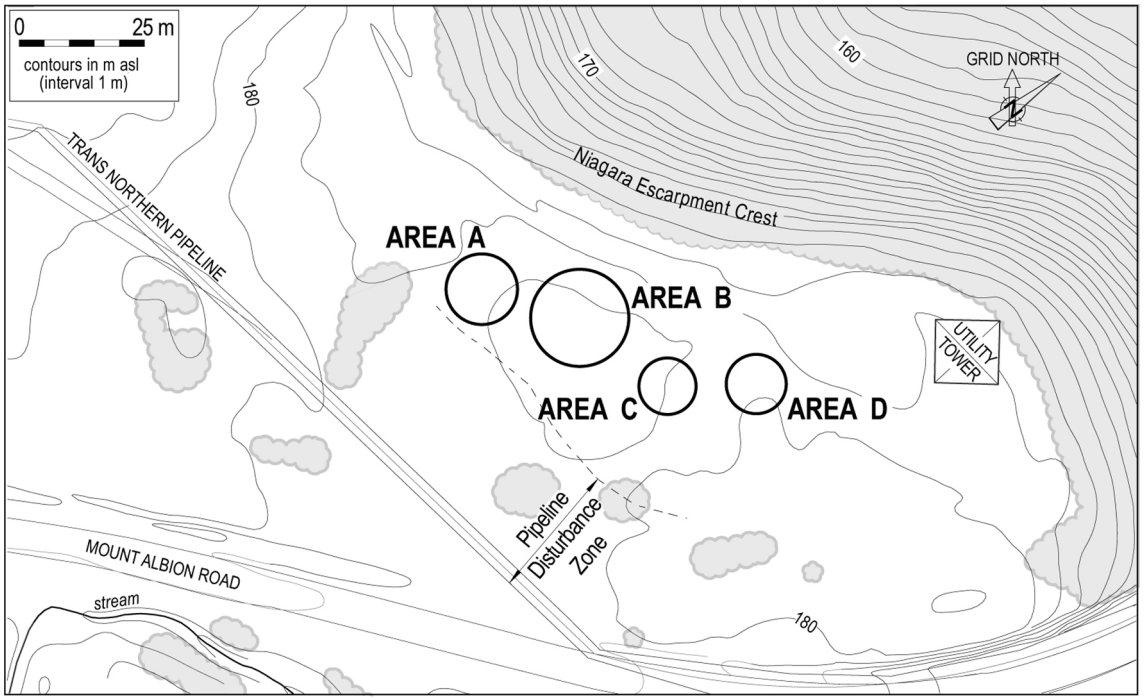

Fig. 3. Detailed location of Mt. Albion West with respect to modern cultural features and the crest of the Niagara Escarpment.

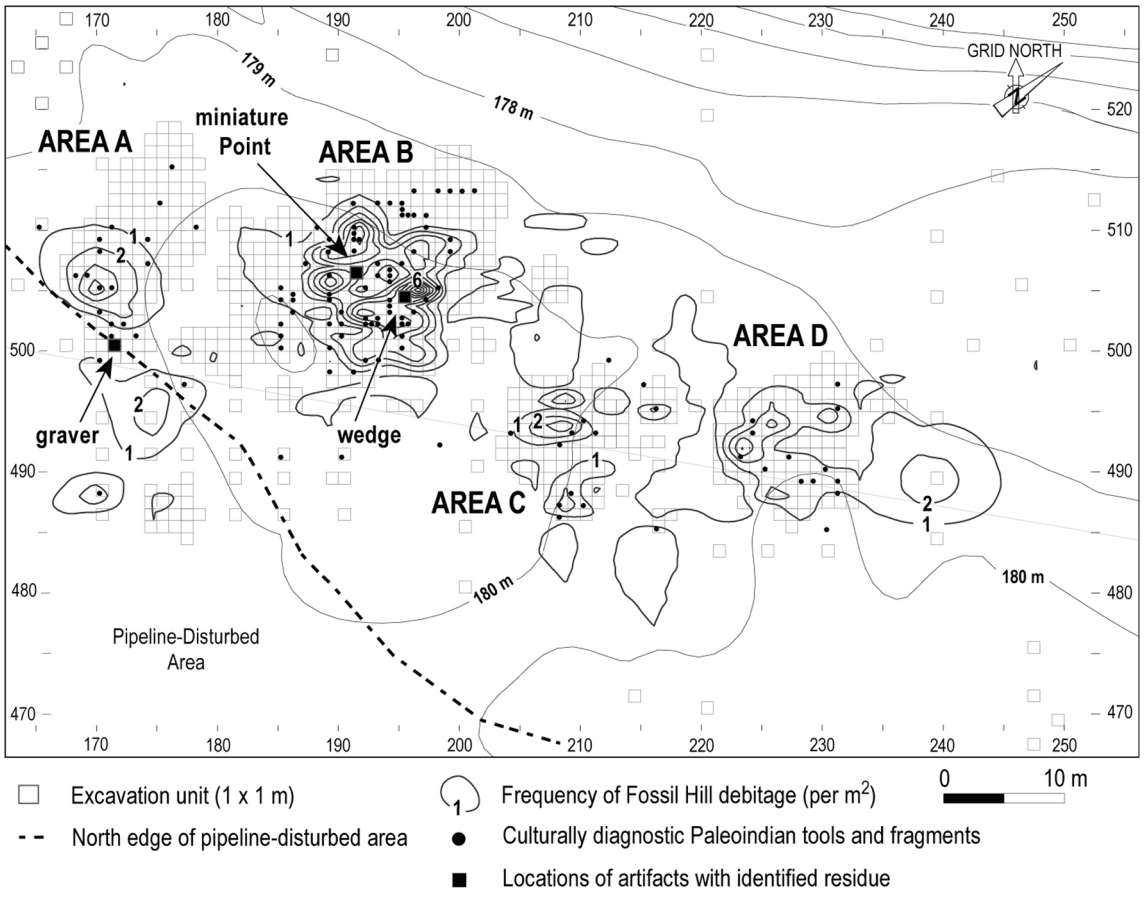

Fig. 4. Concentrations of culturally diagnostic Early Paleoindian tools/fragments and Fossil Hill toolstone. See text for explanation as to why Fossil Hill chert may be culturally diagnostic on this site. The density of Fossil Hill debitage ranged from one to nine objects/square meter and partly determined the direction and extent of excavation in each area.

2018); and Sheriden Cave (attributed to Gainey by Richmond and Tankersley, 2005; Waters et al.. 2009); and, in New York State, at three sites: Arc (with bifaces attributed to both Clovis and Gainey by Tankersley et al., 1997), Lamb (attributed to Clovis by Gramly, 1999; and to Gainey by Ellis and Lothrop, 2019) and Hiscock (seen by Ellis et al., 2003, as comparable to "Clovis-like" fluted bifaces from the Shoop site in Pennsylvania, initially reported by Witthoft (1952). Some of the papers cited, and particularly Lothrop et al. (2016), attempted to infer the relative ages of Clovis and derived forms of fluted bifaces from a variety of technological attributes. However, a sequence of technological change from Clovis through Clovis-like bifaces and variants of Gainey in the Great Lakes region has yet to be corroborated stratigraphically or through radiocarbon dating.

The dates from Arc, Lamb and Paleo Crossing are ambiguous because of the questionable origins of the material dated and/or the context of the dates (for Paleo Crossing, see Waters et al., 2020 and references therein). [Note: in the following discussion radiocarbon dates are presented as reported in the literature.] At Sheriden Cave, a radiocarbon date of 10,915+- 30 RCYBP was obtained from a bone point that occurred in the upper part of a stratum that also contained a Gainey type fluted biface. The age is supported by bracketing ages of 10,600 +- 30 RCYBP (an average of five dates) and 10,920 + -50 RCYBP (an average of two dates) from levels/strata above and below, respectively, the bone point. The dates from Sheriden Cave suggest that the Gainey occupation dates to shortly after 11,000 RCYBP. Two radiocarbon dates from Hiscock, primarily a paleontological site, are from a tanged spatula tool and a socketed handle (dated, respectively, at 10,990 + -100 and 10,810 + -50 RCYBP). The tools were made from proboscidean bone and recovered from the same stratigraphic unit (dated between 16,040 + -70 and 10,515 + -120 RCYBP) that produced the three fluted bifaces with affinities to "Clovis-like" bifaces at the Shoop site (Ellis et al., 2003). We accept the dates on the two bone tools from Hiscock and the likelihood they were made by the people who made the fluted bifaces.

For the purposes of this paper, and for placing Gainey in an environmental context, we infer, largely from the Sheriden Cave dates, that Gainey in the lower Great Lakes region dates roughly between 11,000 and 10,800 RCYBP, and within the Younger Dryas interval (see, for example, Cheng et al., 2020; and Mangerud 2020). People who made Clovis-like fluted bifaces probably date to the earlier part of this interval but are as yet undated in the region. The presence of Clovis itself (as represented by "the classic" fluted biface as seen in western North America) remains controversial.

3.3. *The structure of the Occupation(s).*

The Gainey component at Mt. Albion West consists of 359 artifacts and 9,849 pieces of debitage (Storck, 2007). This assemblage contains two primary toolstones – Onondaga chert (91 % of the assemblage), presumably from the northeastern part of the Lake Erie basin, 40 km south of the site, and Fossil Hill chert (eight percent of the assemblage) from the southern Georgian Bay region, 150 km north of the site. The archaeological assemblage also contains minor amounts of the local Goat Island Formation, which underlies the site and is also exposed along the top edge of the Niagara Escarpment a short distance north of the site, and traces of other cherts from southern Ontario (Fig. 1). The Onondaga Escarpment in New York State could have been the source of Onondaga Formation chert at Mt. Albion West. However, since there are several different members within the Onondaga Formation regionally, each with its own distinct type of chert (Eley and von Bitter, 1989), petrographic, paleontological, and geochemical study would be required to discriminate between chert from the northeastern part of the Lake Erie basin and New York State.

Four concentrations of artifacts and debitage were documented within the site (A through D) (Figs. 3 and 4). Their boundaries were determined by drop-offs in recovery rates of less than five waste flakes per square meter unit (unless tool fragments were present). Peripheral to these areas are locations where single or a few artifacts may represent brief outlying activities.

Area B was the most productive, and possibly most intensively occupied, 240 m^2 in size (much larger than the other areas) yielding 67 % of all the tools from the site. It produced evidence of preform and fluted biface manufacture including nearly half of the preforms from the site, half of the 10 fluted biface fragments, all four of the channel flake bases, and all but one of the 42 channel flake mid-section fragments. Several other activities are indicated by a variety of unifacial tools: end scrapers (27 of the 39 from the site), beaked scrapers, flake gravers and expediently used debitage. One of the beaked scrapers is tentatively identified as made of Knife River flint that occurs in outcrops of the Golden Valley Formation in North Dakota (Kristensen et al. 2018). The size of the artifact assemblage from Area B (three and a half times larger than Area A and nine to ten times larger than Areas C and D) suggests the area was used longer and/or more intensely than the other areas, or possibly even re-occupied.

Areas A, C and D are smaller in extent, ranging from 104 m^2 to 153 m^2, with low tool counts (ranging from 17 in Area C and 19 in Area D to 48 in Area A). Area A is distinguished by containing four of the five tools of the local Goat Island Formation chert from the site, two representing preforms in early stages of reduction.

Attempts at refitting broken artifacts produced no matches between artifact fragments from different areas and, therefore, no direct evidence that two or more areas were used simultaneously; although, as negative evidence this may not fully reflect activities at the site.

Typological analysis of debitage from all areas of the site indicates that knapping activities were skewed toward the later end of the tool making continuum (MacDonald et al., 2007). The bulk of the tool assemblage was based on Onondaga chert, supplemented by tools made of Fossil Hill chert. Most of the Fossil Hill debitage was probably derived from depleted tools that had been in the toolkit longer than those of Onondaga chert and were being re-worked expediently. The use of Goat Island Formation chert, which occurs directly under the archaeological site and at numerous localities along the top edge of the north-facing scarp of the Niagara Escarpment, is skewed toward the production of unifacial tools and the expedient end of the spectrum, although several preforms and the base of a channel flake indicate some primary knapping and limited fluted biface manufacture with this material.

Recently, Pilon and Watts (2021) conducted a GIS and statistically based analysis of the distribution of the artifact assemblage on the site. The analysis was conducted using ESRI ArcGIS 10 with Monte Carlo simulation, Ripley's K function and kernel density estimates to evaluate the artifact clustering suggested by the spatial and frequency distribution of the material, and, if present, its implications. Analyses support the presence of the four distinct occupational areas suggesting they were occupied simultaneously on a single occasion by a small social group, assuming successive occupations would have produced a scatter of debris across the entire site, overprinting earlier visits.

Area B, being the largest area and containing the most diverse tool assemblage, is interpreted as representing a communal workspace, but with spatially discrete loci, one with end scrapers (presumably for hide processing) and with evidence for biface manufacture and possibly re-hafting activities.

Areas C and D, the two smallest areas with low tool diversity, are interpreted as representing dwelling/habitation areas.

Kernel density analysis suggests that, functionally, Area A may have been used more like Areas C and D – as a dwelling/habitation area – with all three areas arranged around Area B.

4. Organic residue and Use-Wear Analyses.

4.1. *Organic residue analyses*

An ambitious previous study of protein residues was conducted for the Gainey phase Noble Ponds site in Ohio (Seeman et al., 2008). In that

study involving analysis of 130 stone tools dominated by end scrapers (74 %), 45 positive reactions were obtained on 40 of the tools analyzed (Seeman et al., 2008:2745). The positive identifications were dominated by Cervidae (n = 17; the Family including such species as deer, elk, moose, caribou, and the extinct stagmoose), rabbit/hare (n = 11) and bear (n = five), with smaller numbers of positive results for a broad range of animals including bovine, cat, dog, chicken, guinea pig, and mouse. The dominance of cervids in the positive samples is consistent with an interpretation that these animals were important first-line resources of Gainey phase populations (Seeman et al., 2008:2747). The authors of the study noted that the second largest category – rabbit/hare – was consistent with the discovery of snowshoe and/or arctic hare (*Lepus* sp.) at the Udora site, the only Gainey phase site that has thus far produced identified mammalian bone (Storck and Spiess, 1994:128).

The occurrence of what appeared to be organic residues on several artifacts from Mt. Albion West provided another opportunity to investigate Gainey subsistence in southern Ontario. As most tools had been left unwashed in the laboratory at Archaeological Services Inc., and some formal tools wrapped in aluminum foil, they still retained the potential for "containing" organic residues. Each of the tools was examined under stereomicroscopy by Andrea Carnevale, at magnifications between 8x and 180x to determine the characteristics, distribution, and directionality of potential residue deposits. Stereomicroscopy was conducted with a modular Nikon SMZ1000. Adhering fibers, organic fragments, and soil sediments specific to the depositional environment were noted and their locations recorded. Each tool was then cleaned under magnification to remove these adhering materials. The potential residue on the tools did not appear fibrous and their colors were distinct when compared to variations in the color of the chert and its inclusions.

All potential deposits of organic residues appeared to be amorphous (smear-like) or globular, evenly distributed on the surface of the tools, with some appearing to bleed into small cavities, inclusions and/or cracks. Deposits were confirmed to occur either along a working edge or near one. Most deposits appeared glossy and/or greasy, were thick, and homogenous in form and texture.

Six tools were identified as possibly exhibiting preserved organic residue in the form of a black material: an end scraper, a denticulated scraper, a three-spurred graver, a combination tool, a utilized flake, and a presumed wedge.

These tools were submitted to Archaeological Investigations Northwest, Inc. (AINW) in Portland, Oregon, for CIEP (cross-over immunoelectrophoresis) by John Fagan and Cam Walker. The CIEP technique has been widely used in forensic laboratories to determine the origin of bloodstains as evidence in criminal investigations and has been adapted for use in archaeology to detect protein residues on pre-contact artifacts. The CIEP technique is based on the immune (antigen–antibody) reaction. Extracts of protein residues from artifacts in an ammonia solution are tested against antisera from known animals. The solutions are placed on a gel substrate and exposed to an electric current which causes the proteins to flow together. An immune reaction between the extract and the antiserum causes a precipitate to form, which is visible after being stained. It has long been known that antibodies, as with most proteins, carry a net negative electric charge (Olitski, 1933), which is important not only for the CIEP technique, but also for emerging medical treatments involving nanoparticles (Prozeller et al. 2020). The net negative electric charge very likely plays a role in the preservation of immunoglobins, as most silicate minerals, such as the lithics in this study, carry a net positive charge providing the potential for a molecular bond likely necessary for their preservation.

Previous studies have shown that immunoglobulin proteins have the potential for long term survival (Nowell et al., 2016 and references cited therein). This is likely due to the proteins being protected by sequestration within surface flaws on lithic implements, and ideal burial conditions. Soils in Ontario are calcareous and afford protection from acidity, which might be present in precipitation, and perhaps acts as a protein degradation factor. Ideally, the proteins in question are further protected by the accumulation of adherent fatty tissues from the exploitation of animal tissues and soil particles after the tool is discarded. As the adherent fatty tissue transforms into adipocere, the coverage of the worked tool edge becomes resistant to microbes and is nearly insoluble, creating an ideal circumstance for long-term preservation. Without this protection, immunoglobulin proteins have only a limited survival period within surficial materials such as soil or sand. Some recent studies have suggested that survival interval is less than two years (Nowell et al., 2016). Furthermore, non-circulating bodily fluids, such as effluence (urine and feces), typically have concentrations of immunoglobulin proteins that are orders of magnitude less than that of fluids in circulation within the body like blood, lymph, and interstitial fluids, such as those in adipose tissue. Furthermore, the pH of urine (5–8) and feces (6–7) is very similar to that of immunoglobulins (pH 5–6) (Prozeller, et al. 2020), making it unlikely for either substance to disrupt the chemical bonds that are pre-existing on the lithic implement in question. Therefore, proteins liberated from lithic tools and subsequently identified are much more likely to be ancient, and isolated from the burial environment.

The CIEP tests were conducted by Cam Walker, laboratory director. The extracts from artifacts were tested against Asian elephant, bovine, deer, dog, and horse antisera. The bovine, deer, dog, and horse antisera are manufactured by MP Biomedicals, LLC. The Asian elephant antiserum was custom produced for AINW by Triple J Farms. The antisera utilized in this analysis are regularly tested for their efficacy and taxonomic specificity against sera from at least 30 taxa. As a matter of course, it should be noted that immunoglobulins are generally unique to the taxonomic level of Family, and in limited cases Genus.

Organic residues were extracted from the six artifacts in a 5 % ammonia solution, utilizing an ultrasonic bath. The artifact extracts were then placed singly into gels and tested against the five antisera with the CIEP technique. To test the efficacy of the antisera in real time, and to guard against the possibility of false positives, positive and negative control sera were run with each gel. None of the extracts analyzed for this project reacted with the negative control, and all antisera reacted with the positive controls. All positive reactions to antisera on an initial run are confirmed by a repeated analysis. As is standard procedure, gels run in this study were viewed under magnification on a light table, and independently verified by two investigators (Fagan & Walker).

There were two positive responses to the selected antisera. The three-spurred graver tested positive against the Asian elephant antiserum which reacts with proteins from the taxonomic order *Proboscidea* (extant and extinct elephants). As with all custom antisera produced for AINW, the elephant antiserum was tested against approximately 30 different animal sera to confirm its specificity prior to its use. The only positive reaction produced was to reserved elephant serum, which was retained as a control.

The wedge tested positive against the dog antiserum. The dog antiserum reacts to proteins from the taxonomic family *Canidae* (extinct and extant species of dog, fox, coyote, and wolf). The positive reactions were confirmed by repeat analysis.

Subsequently, nineteen additional artifacts were tested against Asian elephant, bear, deer, dog, and trout antisera. The new tools included a miniature projectile point, a beaked scraper, five end scrapers of various forms, a five-spurred graver, a single-spurred flaked graver with a cutting/scraping edge, two wedges, three broken tools each with spurs, two drill/piercers and three unifacially worked tools. Additionally, extracts from four artifacts in the first group that previously produced negative tests were tested against only the bear and trout antisera. The bear antiserum was custom produced for AINW by Triple J Farms. The deer antiserum was produced by Bethyl Laboratories, Inc., and the trout antiserum by Cocalico Biologicals, Inc.

There was one additional positive response to the dog antiserum, this occurring from a residue on a miniature projectile point. The positive reaction was again confirmed by repeat analysis.

It was not possible, despite DNA testing of positive washes, to

identify actual species; this work was performed by Meradeth Snow in her laboratories at the Department of Anthropology at the University of Montana, Missoula. This is not surprising given the tremendously smaller nature of immunoglobulin proteins versus an identifiable epitope of DNA.

4.2. Use-Wear Analyses.

The tools that tested positive against the selected antisera were submitted for detailed use-wear analysis by Danielle Macdonald at the Lithic Microwear and Experimental Archaeology Laboratory at the University of Tulsa. Each artifact was first evaluated under stereomicroscopy, ranging from 10x to 100x magnification, to identify microfractures and other large-scale microwear features. Stereomicroscopy was conducted with a Bausch & Lomb StereoZoom 7 microscope. After the identification of larger scale wear features, the artifacts were analyzed using an Olympus BX53 reflected light microscope with 100x to 200x magnification to identify polishes and striations. Microwear traces were recorded on detailed recording forms used by the lab and 'mapped' onto illustrations of the tools. The George Odell Lithic Use-Wear Reference Collection was used as a comparative collection during analysis to aid in the identification of the wear traces.

Each artifact was cleaned with minimally invasive cleaning methods prior to microwear analysis. The tools were washed in an ultrasonic bath for 10 min with distilled water to remove any adhering particles. During analysis, the artifacts were spot-cleaned with ethanol and technical wipes to remove finger grease, dust, and other contaminants.

Each piece was macroscopically assessed for post-depositional alterations prior to microscopic analysis. Of the three pieces, two exhibited macroscopic alterations that can affect the survival of microscopic polish traces, one featured a pink patina and the miniature projectile point was thermally altered.

The widths of the tools' arrises were measured to assess the extent of post-depositional alterations on the assemblage (based on methods developed by Burroni, et al., 2002; Shackley, 1974). Ten measurements were taken across one arris of each tool from images collected with reflected light microscopy at 50x magnification. The resulting measurements were averaged to produce an index of post-depositional alternation related to artifact rounding. These ridge measurement results suggest that both the wedge (mean = 87.30 μm, SD = 62.18 μm) and the three-spurred graver (mean = 74.39 μm, SD = 23.81 μm) have evidence for a moderate level of post-depositional rounding modification, while the miniature projectile point has low levels of rounding (mean = 53.25 μm, SD = 8.58 μm). This interpretation is supported by the general low-gloss polish across the surface of each piece, indicating that they have been subject to surface altering post-depositional processes.

In addition to the post-depositional alternations, both moderately altered tools had been wrapped in aluminum foil during their curation. The foil transferred small pieces of aluminum to the surface of the artifacts, obscuring areas of the surface and appearing as a 'false polish.' As a result of the post-depositional modifications and curation-related alterations, there was a low probability of microwear polish survival. This impacts the ability to identify contact material as well as hafting traces, which are usually identifiable from polish traces. However, microfractures were still well preserved, as were some small areas of polish, which allowed for the identification of use-motion and general interpretations about contact material.

4.3. Evidence of Gainey interaction with proboscideans

Paleontological evidence and radiocarbon dating indicate that large mammals lived around the margins of glacial Lake Iroquois and Early Lake Ontario (and intermediate falling lake stages) in Southern Ontario; indeed, that mammoths and mastodons survived well into the inferred time range of Gainey in the Great Lakes region (see, for example, Boulanger and Lyman, 2014; Feranec and Kozlowski, 2012; Woodman and Athfield, 2009). Isolated teeth and tusk fragments of mammoth and mastodon and bones of moose, wapiti, caribou, and muskox have been reported from bars of Lake Iroquois (Churcher and Peterson, 1982; Coleman, 1937, and references cited therein), roughly 10 km north of the Red Hill Creek Valley. These species – and a new species of cervid, *Torontoceros hypogaeus*, dated at 11,315 ± 325 RCYBP may have lived in the Ontario basin during the late Pleistocene until they died out locally or became extinct. The spring death of the animal reported by Churcher and Peterson (1982) suggests that *Torontocerus* lived in the Ontario basin during the warm seasons, or year-round. Future examination of teeth and tusks of proboscideans and the teeth of other animals reported from the Ontario basin might also reveal season of death and the role of that lowland region in their life cycles.

The artifact with an organic residue that tested positive against the elephant antiserum is a three-spurred graver made of Fossil Hill Formation chert (catalogue number AhGw-131.297; Area A; Fig. 5). The artifact was made on a large squarish flake roughly 4.5 cm long (perpendicular to the striking platform and 4 cm wide. The three spurs, each less than 2.0 mm long, were formed roughly 23 mm apart on a broad, smoothly convex edge of the flake opposite the striking platform. A fourth spur may have occurred between spurs two and three but, if so, has been removed by use-wear.

Use-wear analysis showed the presence of small snap fractures on the edge at the proximal end of the tool (Fig. 5, dots), oriented at an oblique angle to the edge of the tool. These fractures occur along the edge of the tool on both the obverse and reverse faces and are consistent with a longitudinal cutting motion along the tool's long axis. Small patches of weak generic polish (not attributable to origin) were also observed on the reverse margin toward the proximal end of the tool (Fig. 5, triangles).

Protruding areas on the distal end of the tool exhibit isolated patches of rounding (Fig. 5, squares). The reverse face of the left spur (Fig. 5, inset b) exhibits a patch of bright polish consistent with working hard material such as bone, wood, or antler. The reverse face of the right spur (Fig. 5, inset a) exhibits an isolated patch of flat, matte polish which is consistent with contact with a soft material such as hide or leather.

4.4. Evidence of Gainey interaction with Canids

The two artifacts with organic residues that tested positive against dog antisera are a miniature projectile point and a wedge. The miniature projectile point (catalogue number AhGw-131.093; Area B, Fig. 6) was made of Onondaga Formation chert. The artifact is very small: 23.5 mm long (from tip to bottom of ears that project slightly below a concave base), 15.0 mm wide (at roughly mid section) and 2.0 mm thick. The concave base is ca. 2.0 mm deep. There is no apparent grinding on either the lateral margins or the concave base. The artifact was shaped from a small flake entirely by edge retouch, the unmodified broad scars of the dorsal and ventral surfaces of the parent flake covering nearly all of both faces of the projectile point.

A small amount of rounding and crushing is visible on the tip of the projectile point (Fig. 6, inset a, squares) although there are no impact fractures. There is a thin band of weak generic polish associated with rounding on the reverse face, left margin, toward the tip (Fig. 6, triangles). The texture is smooth, with high connectivity and a flat texture. On the obverse face, right margin, there is a small area of rounding and polish on a protrusion (Fig. 6, squares and triangles). The artifact has also been thermally altered which would obscure other potential traces of polish. There is no evidence of hafting. The microwear traces mapped on Fig. 6 are not diagnostic and the polish on the tool could be the result of post-depositional wear. Based on the available evidence, it is unlikely that the point was used as a projectile.

The second artifact that tested positive against dog antiserum is a wedge (catalogue number AhGw-131.079; Area B; Fig. 7). The artifact was made of Onondaga Formation chert and is roughly rectangular in

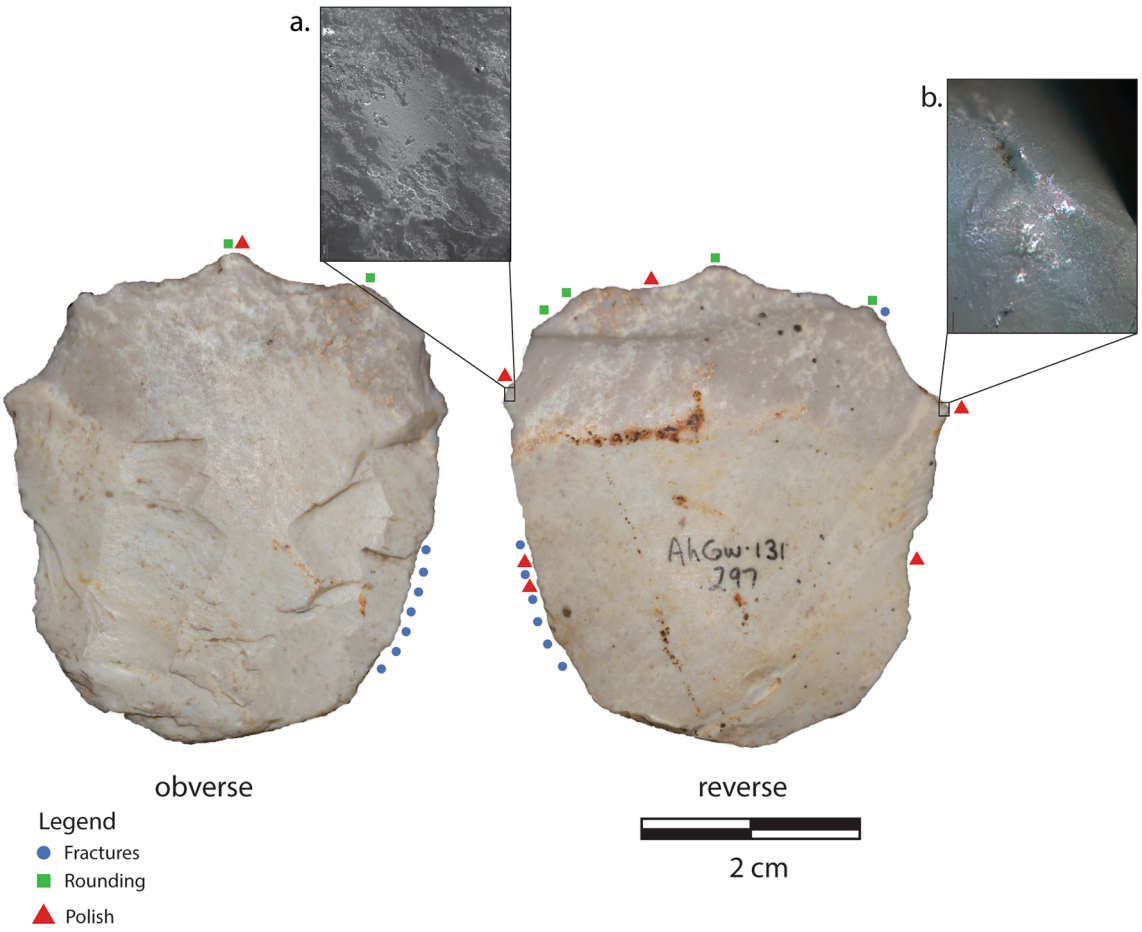

Fig. 5. Three-spurred graver that tested positive against Asian elephant antiserum. Striking platform used in detaching the flake from which the tool was made is near the center at the bottom of the image. Circles indicate locations of fractures, squares show locations of rounding and triangles indicate locations of polish; inset a shows detail of flat dull polish; inset b shows detail of bright polish consistent with working a hard material.

shape, 41 mm long (parallel to the flake removals at both ends of the tool), 32.5 mm wide and 9.5 mm thick. The artifact is identified on morphological grounds as having been used as a wedge because of several flake removals that occurred from forces directed from opposite ends of the long axis of the artifact. At least one of those flake removals truncated a scar from a flake that had been driven off from the lateral edge of the artifact, suggesting that the wedge had been fashioned as a biface or recycled from one. In addition, two corners on the same side but opposite ends of the artifact were knapped in a fashion reminiscent of ears occurring on fluted bifaces. This, together with centrally-located, longitudinal flake removals, suggest that the artifact may have been intended as a fluted biface which, when it failed, was then rotated and used as a practice piece on the opposite end for other fluting attempts until it was no longer useful for this purpose – at which time it was simply used as a wedge.

The locations of microwear traces are shown in Fig. 7. Fractures are located on all edges of the tool but are most concentrated on one edge and at the distal end (Fig. 7, inset a). The fractures are rectangular bending fractures, medium and large in size, with step terminations. They are oriented perpendicular to the edge of the tool. The distal end of the tool exhibits non-diagnostic weak, generic polish, along with a few bright spots (Fig. 7, reverse face, triangles on upper edge of image). The right margin on that same face exhibits two small bright spots of polish with smooth texture and a domed appearance (Fig. 7, triangles), similar to polish produced by contact with hard materials such as bone, wood, and antler. Alternatively, the bright spots could have been produced from contact with a haft although the associated fractures are not consistent with hafting as they are numerous, large, and found on multiple edges of the tool.

The microwear traces indicate that the artifact was used for chopping or percussive wedging, such as splitting or cracking bone for marrow extraction or splitting wood, possibly in connection with re-hafting fluted bifaces as suggested by Pilon and Watts (2021) based on other evidence.

5. Discussion

There is a robust literature on the use of North American Paleoindian tools, and the functional analysis of the Mt. Albion West assemblage helps build on our understanding of the diverse use of material culture from this period. Previous use-wear analyses on lithic assemblages indicate that Paleoindian people engaged with a wide range of subsistence and craft activities, and that tools were often used for multiple functions. This includes points that were used as projectiles and knifes (Smallwood 2020), endscrapers primarily used to scrape hides, but also used for processing plant materials like wood (Loebel 2013, Miller 2014), and gravers used for butchering and drilling/boring hard contact materials (Maika 2012, Tomenchuk and Storck 1997). This variable use of material culture suggests flexibility within the cultural traditions of Paleoindian peoples' tool use.

Previous use-wear studies on Paleoindian gravers from across North American suggest that these tools were used for a variety of functions. Gravers from the Fisher site in Ontario have evidence of use-wear traces on the spurs and the notches, and the traces indicate that the tools were used for working soft materials, like hide, and hard materials such as bone (Tomenchuk and Storck 1997). As well, specialized gravers from

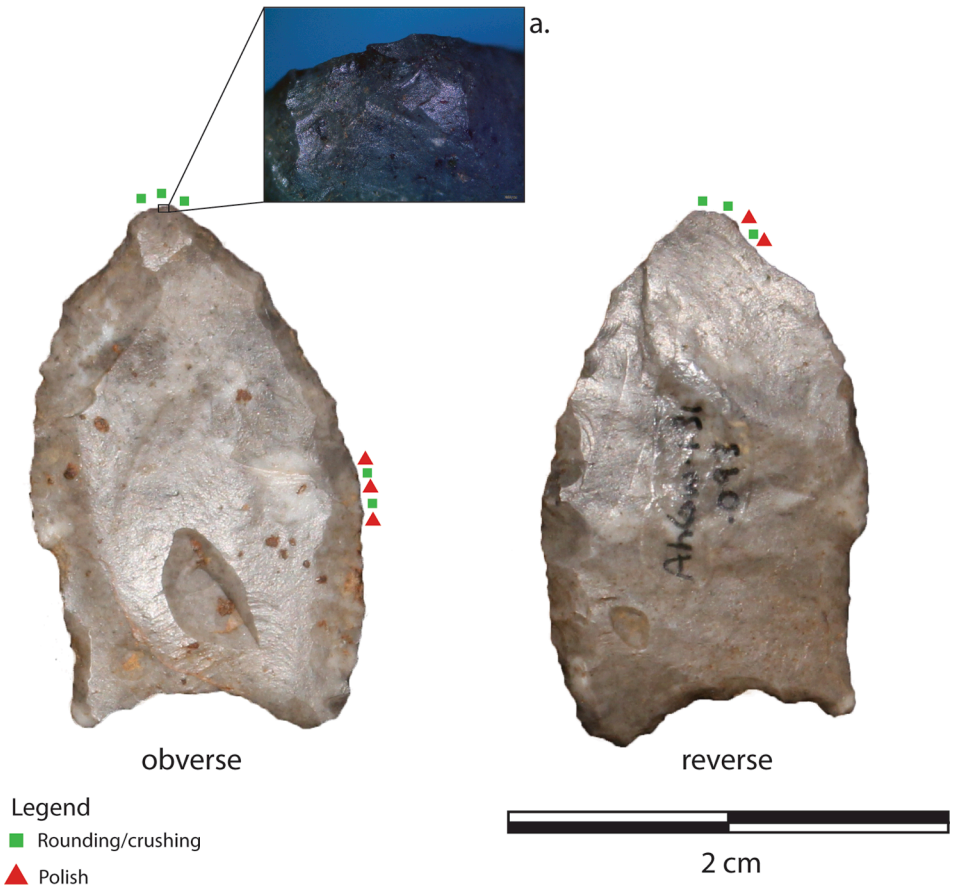

Fig. 6. Miniature projectile point that tested positive against dog. Large flake scars on both faces obscure the original dorsal and ventral faces of the flake from which the tool was made, as well as the striking platform used in detaching the flake although, judging from the thickness of the tip, the platform may have been at that location. Squares show locations of rounding, triangles indicate locations of polish; inset a shows rounding and crushing at the projectile tip.

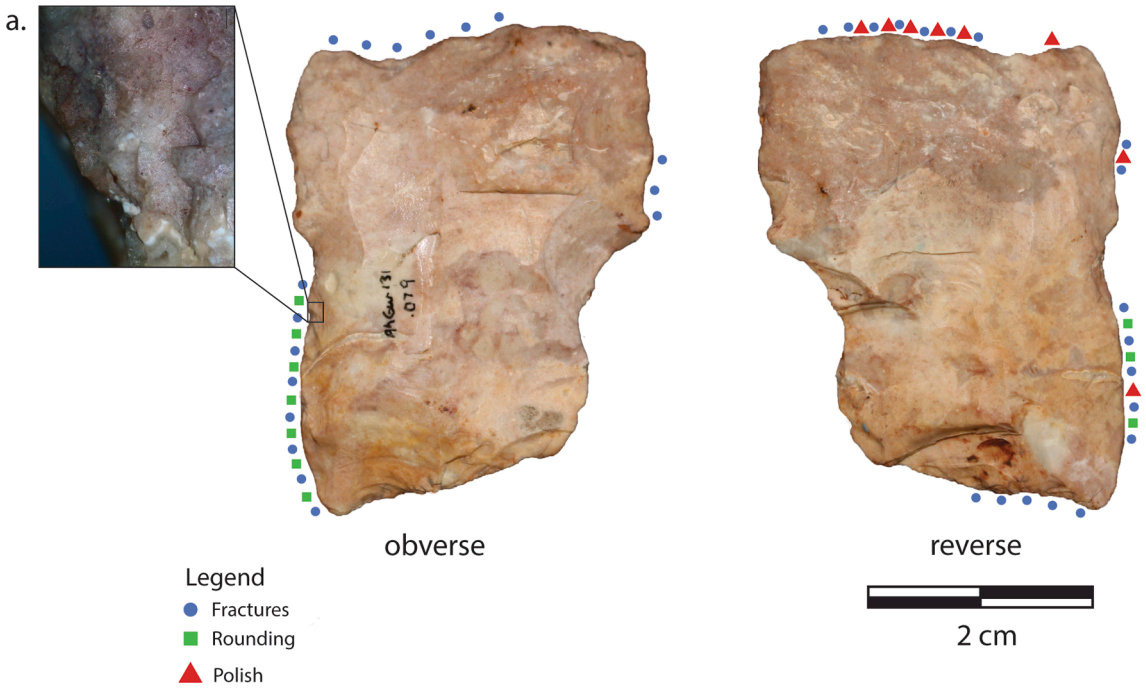

Fig. 7. Wedge that tested positive against dog. Circles indicate locations of fractures, squares show locations of rounding, triangles indicate locations of polish; example of step-terminating fractures shown in inset a.

the site were used for rotary motions (such as drilling or boring) and for engraving in a longitudinal motion, possibly to cut circular bone disks or concentric circles in other materials (Tomenchuk and Storck 1997). More recent work by Maika (2012) showed that gravers from other Ontario sites had similar multifunctional purposes. Evidence for the use of gravers on hard contact materials such as wood, bone, and antler, is seen throughout the Paleoindian chronological sequence in southern Ontario, with the tools being used in boring, drilling, and graving motions, and a small number have traces of having been used in longitudinal cutting (Maika 2012). Early sites, dating to the Gainey and Parkhill phases, also have evidence of gravers being used on animal materials, likely for butchering tasks (Maika 2012). This varied evidence from sites across the region indicate that gravers served multiple functions including to work soft animal materials and harder materials like bone and wood. The three-spurred flake graver from Mt. Albion West appears to have been multi-functional and may have come into contact with both soft and hard material (flesh, hide, and bone), possibly during use as a butchering tool on a mammoth or mastodon, either at Mt. Albion West or a location nearby. This interpretation fits with other findings of graver use during this period, where the tools have been interpreted to be used for a multitude of functions, including butchering and animal processing (Maika 2012, Boast 1983).

If used in cracking bone for marrow, the wedge from Mt. Albion West is an unusual artifact to be associated with canids which presumably would have been valued for their furs (especially fox and wolf), rather than eating. If the identification is that of a domestic dog, however, butchering cannot be discounted since, ethnohistorically, dogs were occasionally eaten by some North American Indigenous peoples for pragmatic reasons (see Fiedel, 2005). Evidence of dogs has not previously been associated with Gainey Early Paleoindians although a wrist bone of an arctic fox was identified at the Gainey site of Udora in south-central Ontario, together with bones of caribou and an arctic and/or snowshoe hare (Storck and Spiess,1994). Canid bones have occasionally been found in Clovis kill/butchery sites in western North America, not surprising since those sites were also visited by scavenging carnivores. Possible evidence of domestic dogs has been reported by Saunders and Daescher (1994) from the Clovis type-site of Blackwater Draw in eastern New Mexico where two caudal vertebrae of a mammoth exhibit gnawing similar to kennel damage produced by "captive or provisioned individuals," and referred to at Blackwater as "tamed wild canids" (Saunders and Daescher, 1994: 23); and, by the same authors in that 1994 publication, at the Murray Springs site in southeastern Arizona, a Clovis kill site, where a mandibular fragment of a possible tamed wild canid was recovered near the partial skeleton of a mammoth; although the Murrary Springs animal has been reported by other paleontologists as probably that of a small wolf or coyote (Haynes, Jr. and Huckell, 2007). A maxilla fragment, identified as that of a wolf-dog hybrid, together with several postcranial fragments have also been reported from a Folsom occupation at the Agate Basin site in northeastern Wyoming (Frison and Stanford, 1982; Walker and Frison, 1982).

Finally, regarding the Paleoindian record, dog bones were also discovered in a Late Paleoindian (Hell Gap) context at the Jones-Miller bison kill site in Wyoming where they were associated with a drilled bone flute and a small but complete projectile point (Stanford, 1978). The Hell Gap complex on the Plains is believed to date from roughly 10,500 to 9,000 BP (11,740–10,390 cal BP; Pelton et al., 2017). The canid bones (not otherwise identified), together with the flute and small projectile point, were discovered near a post mold in the center of a 20 X 30 m bison butchering area. Stanford (1978) suggests, from the location of the post mold and its association with the canid bones/artifacts, that the post may have been a "medicine post" used in ceremonies to attract bison to the kill site. Unfortunately, no detailed comparative study of the purported dog bones appears to have been published so its identification must be regarded as tentative. However, the context of the small projectile point at Jones-Miller reinforces the possibility that the miniature point that tested positive against dog antiserum at Mt. Albion West may also have been used in ceremonial activities.

Currently, the earliest domestic dog remains in North America – identified, in part, through mtDNA studies – are from post-Paleoindian contexts: at Hinds Cave in southwestern Texas (where a mandibular fragment was found embedded in a human coprolite and dated at 9,260 + -170 cal BP; Tito et al., 2011) and at the Koster and Stilwell II sites in southern Illinois where four, isolated, intentional dog burials were dated to between 9,630 and 10,130 cal years BP (Perri et al. 2018).

Although it's likely that domestic dogs accompanied late Pleistocene peoples into eastern Beringia and the Americas (Perri et al., 2018), the associations with Early Paleoindian/Clovis people – and possibly Gainey as well – can only be regarded as provocative and must be confirmed by skeletal remains in a secure context that can also be distinguished morphologically (if not also by DNA) from other canids and, thus, positively identified as Canis familiaris. The evidence from Mt. Albion West lends further support for that search.

6. Conclusions

The Mt. Albion West site suggests, for the first time, that Early Paleoindians in Ontario may have butchered, if not hunted, proboscideans and may also have had domestic dogs that could have played a variety of roles in Paleoindian culture.

The organic residue identifications, combined with use-wear data, also raise questions about apparent incongruities between tool morphology and function – revealed at Mt. Albion West by the association of a multiple spurred graver and wedge with butchering functions, incongruities because multiple spurred gravers, although known to have been used for butchering, have not been examined for their possible use in combing/removing hair for use as fibers; and because wedges have not previously been reported in the Paleoindian literature to have been used in processing the bones of small animals, particularly those of possible ceremonial significance. These seeming incongruities suggest that organic residue analysis and use-wear studies – if performed in collaboration and focused on the specific animals identified and the potential raw materials they would have employed for working into tools and perishable artifacts – might achieve more nuanced identifications of tool function.

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Data Availability Statement.

At the request of Jean-Luc Pilon, Curator (now emeritus) at the Canadian Museum of History, Ottawa, the excavation records and archaeological material from Mt. Albion West were transferred from Archaeological Services Inc. to that institution where the material will be accessible for future research and possibly display.

CRediT authorship contribution statement

Ronald F. Williamson: Conceptualization, Methodology, Supervision, Writing – original draft. **Peter L. Storck:** Conceptualization, Methodology, Supervision, Formal analysis, Writing – original draft. **Danielle A. Macdonald:** Methodology, Formal analysis, Writing – original draft. **Cam Walker:** Methodology, Writing – original draft. **John L. Fagan:** Methodology. **Andrea Carnevale:** Conceptualization, Formal analysis, Writing – original draft. **Andrew Stewart:** Investigation, Resources, Writing – original draft. **Peter H. von Bitter:** . **Robert I. MacDonald:** Resources, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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