The Functional Interpretation of Quartz and Amethyst Artefacts from the Mackenzie I site (DdJf-9), a 9,000BP site near Thunder Bay, Ontario

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Submitted to the Faculty of Graduate Studies in Partial Fulfillment of the Requirements for the Degree of Masters of Environmental Studies in Northern Environments and Cultures

Declaration:

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person, except where due acknowledgment has been made in the text.

Stefan Bouchard

Acknowledgements

I would like to begin by thanking my supervisor, Dr. Carney Matheson (Dept. of Anthropology, Lakehead University), for introducing me to all the techniques and nuances of residue analysis. It has expanded my knowledge to areas I never considered before and has shown me the true value that each individual artefact can offer.

I would also like to thank my committee members, Dr. Scott Hamilton (Dept. of Anthropology, Lakehead University) and Terry Gibson (Western Heritage Services). Thank you, Scott, for providing guidance for my writing and for being a role model in so many other ways. Thank you, Terry, for allowing me to analyze such a unique assemblage of artefacts and for your input as well. I must also thank my external advisor, Dr. Pat Julig (Dept. of Anthropology, Laurentian University), for his feedback and his earlier contribution to what we know of the Lakehead Complex.

Thank you for all the support I received from the Anthropology Department at Lakehead. Thank you, Jen McKee, for assisting with the paperwork and keeping myself and Carney on track. Thank you, Clarence Surette, for the tireless work you do for the department and for all the assistance you provided during the beginning of this project.

I would also like to thank the staff at the Lakehead Instrumentation Lab. Thank you, Greg Kepka, for running my samples through the GC/MS and thank you, Ain Raitsakas and Mike Sorokopud, for showing me how to use the various equipment and software in the lab. Thank you, Dr. Guosheng Wu, and again to Clarence Surette, for the assistance and guidance on the SEM. It proved to be incredibly valuable to my research.

Thank you to my fellow students for all the help and support. Specifically to Tasha Hodgson for providing guidance as I began to study use-wear analysis and to Russell Cook for helping me with the biochemical tests and general microscopy. Thank you, Breana McCulloch and Gjende Bennett, for the helpful edits you provided. Thank you to my coworkers from Western Heritage Services, Rocky Bay First Nation, and Lake Helen First Nation for the thorough job excavating and cataloguing this vast collection of artefacts.

Thank you to my friends and family who have supported me not only through my Master's Degree, but through my entire academic studies.

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Abstract

Mackenzie I is the largest excavated archaeological site that is attributed to the Lakehead Complex, the first known occupants of the area surrounding modern day Thunder Bay, Ontario. As such, it has garnered much academic interest, including the following research, which analyzes a specific portion of the lithic assemblage to identify the function of quartz and amethyst implements. The methodological approach follows a multi-analytical framework which relies on the strengths of various residue and use-wear techniques to compose the most well-rounded functional interpretations. These techniques include: low power incident light microscopy, high power incident light microscopy, solvent removal designed to capture a wide range of molecules, a variety of biochemical tests, gas chromatography-mass spectrometry, high power transmitted light microscopy, and scanning electron microcopy. Since archaeological residue is often in a degraded state, *in situ* analysis was critical for describing and characterizing residue prior to removal to account for the likelihood that chemical analysis may not produce interpretable results for all artefacts. Despite the observed presence of residue, negative results are possible because the quantity and quality of the residue will differ between samples. In addition, the boreal forest is a harsh environment for the survival of organic material and thus all precautions must be taken to increase the chance that interpretable results are produced. The results from residue analysis were almost exclusively animal, indicating that animal processing was an important function at this site. Use-wear analysis confirmed that many of the analyzed artefacts were used and that functions were quite varied, even when morphological similarities were present. The artefacts themselves proved to be either expedient or informal, which was expected based on the presence of quartz at Lakehead Complex sites adjacent to known sources. Overall, this research proved that quartz and amethyst artefacts were used more frequently than previously understood, and this research is the first indication that amethyst could be used as a tool material by this culture. However, analysis concluded that there was no specific purpose behind the material's use (i.e. the material was used for a variety of tasks), and thus it was likely not sought after for a specific task.

1 Introduction

The Mackenzie I site (DdJf-9) is the largest Paleoindian site excavated in the Lake Superior basin, which dates to ca. 9,000BP. Over 2,500m^2 were excavated to recover 335,701 lithic artefacts associated with the Lakehead Complex (Bennett, 2014). This research summarizes the functional analysis of the quartz and amethyst assemblage. Artifacts composed of quartz and amethyst account for 6,452 items, or roughly 2% of the collection. Quartz artefacts are notoriously nonconformist to standard tool and debitage morphologies, which are based on flint-centric observations, resulting in common misidentification (Driscoll, 2011; Knutsson, 1998; Lindgren, 1998). Quite often quartz flakes were used with little to no modification, increasing the difficulty in understanding this material (Lindgren, 1998). Therefore, more precise analytical methods are required to accurately determine the function of these artefacts.

This project combines residue and use-wear analysis in a multi-analytical approach to more effectively determine tool function. This research question's whether the Lakehead Complex used tools made from quartz and amethyst more frequently than presently understood and whether these tools were produced for specific tasks. Thus, the primary goal is to determine whether an artefact was used by identifying anthropogenic residue and use-wear related damage on its surface. Secondary goals include the specific identification of organic residue/worked material and to improve the depth and value of the functional interpretation. Throughout the study, an emphasis is placed on the importance of archaeological residues and the chemical identification of organic residues. Use-wear analysis primarily serves as a secondary line of evidence to provide context for the residue identifications.

Artefacts included in the study are selected using the sampling process outlined in Chapter 4 that focuses on the presence of visible residue. The underlying theory is that the presence of archaeological residues are complimented by use-wear scars, which may be hidden under said residues. The successful identification of organic material also introduces a new class of "artefact" to an otherwise lithic site.

1.1 The Mackenzie I Site

The Mackenzie I site is located approximately 20km northeast of Thunder Bay. Dating to the earliest occupation period in the region, ca. 9,000BP (Norris, 2012), the artefacts belong to the Lakehead Complex, a Paleoindian culture associated with the Interlakes Composite (Chapter 3). The Lakehead Complex is best known for their procurement and utilization of lithic material from the Gunflint Formation (e.g. taconite) and their minimal use of other lithic material. A recent publication on the Mackenzie I site has acknowledged quartz as a minor lithic material (Markham, 2012b), but the material has received little attention. The large number, albeit low frequency (Chapter 3), of quartz artefacts from Mackenzie I offers an ideal case study to understand the function of quartz (and amethyst) at the site and within the Lakehead Complex in general.

The research and results presented here provide an example of how an often overlooked and analytically challenging raw material can still contribute valuable information to the archaeological record. The analysis of a secondary lithic material can identify whether the material was selected purposefully or out of convenience (i.e. expedient use). The residue and use-wear results will also allow for the interpretation of site function, particularly when combined with spatial analysis results (McCulloch, 2015). Outside of the geographical area, the research presented here will further the field of residue and use-wear applied to quartz artefacts. In addition, the methodology proposed here will be evaluated and recommendations for future projects will be suggested. The remainder of this chapter will introduce the subject matter of each section.

1.2 Chapter Overviews

Chapter 2 discusses research relating to quartz, both geological and archaeological. The geological research focuses on how quartz forms in the environment and the varieties of quartz (e.g. crystal quartz, amethyst, etc.) that can be found. The archaeological research follows two broad subsections. The first discusses archaeological research that focuses on quartz assemblages, which includes how to best catalogue and identify the material (Knutsson, 1998; MacDonald, 1997; Spott, 2005; Driscoll, 2011), determining the source of the material (ten Bruggencate, 2013; ten Bruggencate, et al., 2013; ten Bruggencate, et al., 2014), identifying reduction sequences (Driscoll, 2010; de Lombera-Hermida, 2009), and determining function through use-wear (Knutsson, 1988a; Sussman, 1988) and/or residue analysis (Delagnes, et al., 2006; Lombard & Phillipson, 2010; Petraglia, et al., 1996; Perry, 2002). The latter portion of archaeological research is dedicated to the occurrence of quartz on archaeological sites around the world. Special attention is given to regions and time periods where quartz is the main lithic resource.

Chapter 3 provides a summary of the late Pleistocene and early Holocene environment and the cultures that first inhabited the area around Thunder Bay, Ontario. The discussion of the paleoenvironment includes the deglaciation of the area and formation of major water systems, and the revegetation of the region. Discussion of the cultures describes the characteristics of the Lakehead Complex and the Interlakes Composite. The Mackenzie I site, along with other Lakehead Complex sites, are described with a focus on the quartz (and amethyst) component of their respective lithic assemblages.

Chapter 4 introduces the methodology used for this thesis. This methodological approach begins with sample selection, *in situ* low-power microscopic investigation of specimens, residue removal, chemical characterization and identification of residue, and use-wear analysis.

Chapter 5 presents the results, following the headings of the methodology chapter. Therefore, the results of each major step are presented and critiqued. More effective methodologies are elaborated upon, while less effective methodologies are evaluated to understand their limitations.

Chapter 6 discusses the interpretations of both the residue and the artefacts. The residue interpretations are discussed first since they are important for artefact interpretations. The individual artefact interpretations compose the bulk of the section, which typically consist of four parts. The first describes the artefact and why it was selected. The second identifies what residue was present on the artefact, its distribution and interpretation. The third presents the evidence for use, which includes whether the artefact was used, how it was used, and the probable hardness of the material it was used upon. Lastly, a summary is provided which interprets the artefacts function based on the useable edge, the type of residue, and how the artefact was used. For example, an artefact with a long, steep straight edge shows evidence of a fatty animal residue coupled with shallow striations perpendicular to the working edge was likely used to scrape fresh animal hide.

Chapter 7 is the discussion. Each individual technique from the methodology is critiqued and the overall approach is commented upon for future research. Most of the chapter is devoted to discussing what the residue and artefact interpretations mean to the site and the Lakehead Complex. The analyzed assemblage are grouped three different ways, based on residue classification, identified function, and morphological shape to identify any patterns in the assemblage. The research question (i.e. were quartz and amethyst artefacts used more frequently as tools than presently understood) is answered and discussed. The implications of these results regarding the Mackenzie I site and the Lakehead Complex are discussed (i.e. the role of quartz and amethyst at the site and within the Lakehead Complex). As with any research, more questions are present at the end than at the beginning and future directions of this study are recommended for those interested in continuing this investigation.

2 Quartz and Archaeology

In the past, quartz has received relatively little attention in archaeological discourse. However, publications over time and the increased accessibility of regional publications has drastically changed that reality, as researchers around the world are determined to understand the relationship between quartz and past human cultures. The research followed a general progression, starting with how to properly categorize quartz debitage within a lithic assemblage (Atherton, 1972; Gabel, 1976; Deacon, 1984; MacDonald, 1997). Followed by early use-wear studies of identified quartz tools (Broadbent & Knutsson, 1975; Broadbent, 1979; Knutsson, 1988a; Knutsson, 1988b; Knutsson, 1988c; Knutsson and Linde, 1990; Sussman, 1985; Sussman, 1988), understanding how quartz fractures (Ritchie, 1981; Bisson, 1990; Callahan, et al., 1992; Tallavaara, et al., 2010; Driscoll, 2010) and how to identify quartz artefacts in general (Gramly, 1981; Driscoll, 2011). More recently, researchers have focused again on the functional interpretation of these artefacts (Fernandez-Marchena & Olle, 2015; Knutsson, et al., 2015; Lombard, 2011; Lombard & Phillipson, 2010; Petraglia, et al., 1996; Taipale, 2012; Taipale, et al., 2014; Marquez, et al., 2015; Clemente-Conte, et al., 2015; Olle, et al., 2016; Lemorini, et al., 2014), which tend to be extremely varied.

Throughout these developments, a common trend, or struggle, is apparent; the application of microcrystalline-derived analytical techniques on quartz artefacts is ineffective (see Driscoll, 2010). This fact is echoed throughout quartz-focused studies and the justification for many of the studies to be discussed. The availability of quartz-specific research allows other analysts to better understand this material. This research is the first quartz-based study in the Thunder Bay area. There are other studies from nearby sites that will be discussed, but none have conducted a detailed functional analyses.

First, it is necessary to understand the geological characteristics of quartz (e.g. its composition, how it forms, varieties, etc.) followed by the archaeological research of this material. It is also important to consider the procurement of quartz, how it fractures, and the knapping techniques that can be employed. The challenges within quartz analysis begin with artefact recognition and debitage classification, which have hampered quartz research. Until recently, functional analysis was less often applied to quartz artefacts and when performed, must account for the lack of formal tool typologies by employing a more detailed analysis, such as the approach presented in this study. Positioning this research into the geographical and temporal extent of quartz use and the understanding of any identified trends will contribute to the area of quartz artefact analysis.

2.1 Geological Characteristics of Quartz

The term “quartz” includes a rather broad range of lithic materials, but typically refers to vein or crystal quartz. In geological terms, quartz can refer to a wide variety of lithic material, including chert, flint and agate, because it is an important component of numerous rock types. In fact, quartz is the second most common mineral on earth, next to feldspar. The ubiquitous nature and a hardness of 7 on the Mohs scale has rendered quartz a relatively common raw material for stone tool production and has been found on a variety of archaeological sites. Luedtke (1992) provides the best reference material on the geology of lithic material, including quartz, that is commonly found on archaeological sites.

However, quartz is not a desirable material for manufacturing formal tools because it lacks the elasticity of microcrystalline material and tends to fracture along internal planes, which hinders the production of specific morphological shapes. Therefore, many archaeologists interpret the material as a last resort reserved for expedient tool use. Despite its ability to fracture concoidally, quartz often contains many internal flaws that cause it to flake unpredictably and shatter into fragments. Recognizing authentic quartz artefacts is a known and documented difficulty within archaeology (Driscoll, 2011; Lindgren, 1998; Gramly, 1981). The formation, varieties, and fracture mechanics of quartz are important for the analysis of the Mackenzie I lithic assemblage given the abundance of natural quartz and amethyst at the site, and to improve the ability to validly recognize examples that have undergone anthropogenic modification.

2.1.1 Mineralogy

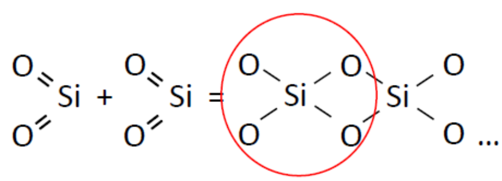


Figure 2-1: SiO_2 bonding within quartz to form SiO_4.
When bonded within quartz, the SiO_2 molecules form into SiO_4 tetrahedra (circled in red). This bond creates a spiral shape. This causes quartz crystals to have that tipped termination, but also causes the crystals to have a lean. The compound is still expressed as SiO_2. See Vos (1976) for a more technical explanation.

The geological formation and composition of quartz, although not of direct relevance for this study, provides important physical and contextual information regarding its geological and geochemical characteristics. Quartz is a naturally forming mineral belonging to the techtosilicate group (silicon dioxide; SiO_2). When silicon and oxygen atoms bond within quartz they form into SiO_4 tetrahedra (one silicon bonding to four oxygen, see Figure 2-1). When linked together the chemical composition is still expressed as SiO_2, or silicon dioxide. This link causes the molecules to form in a spiral motion to form an asymmetrical tip (Vos, 1976). This spiral shape forms into the familiar hexagonal prism that is iconic of crystal quartz.

As a mineral in the silica group (Figure 2-2) quartz can be found in six states. However, only one of these states (α quartz) is solid at surface temperature and therefore relevant to archaeologists. The β quartz, tridymite, and cristobalite are high-temperature forms, while coesite and stishovite are high-pressure forms. These latter five categories are unstable at surface conditions, but will eventually transform into α quartz after filling cracks within other rock and stabilizing. Therefore, quartz is often found in veins within other rock formations. This formation process is why quartz is so ubiquitous (Luedtke, 1992).

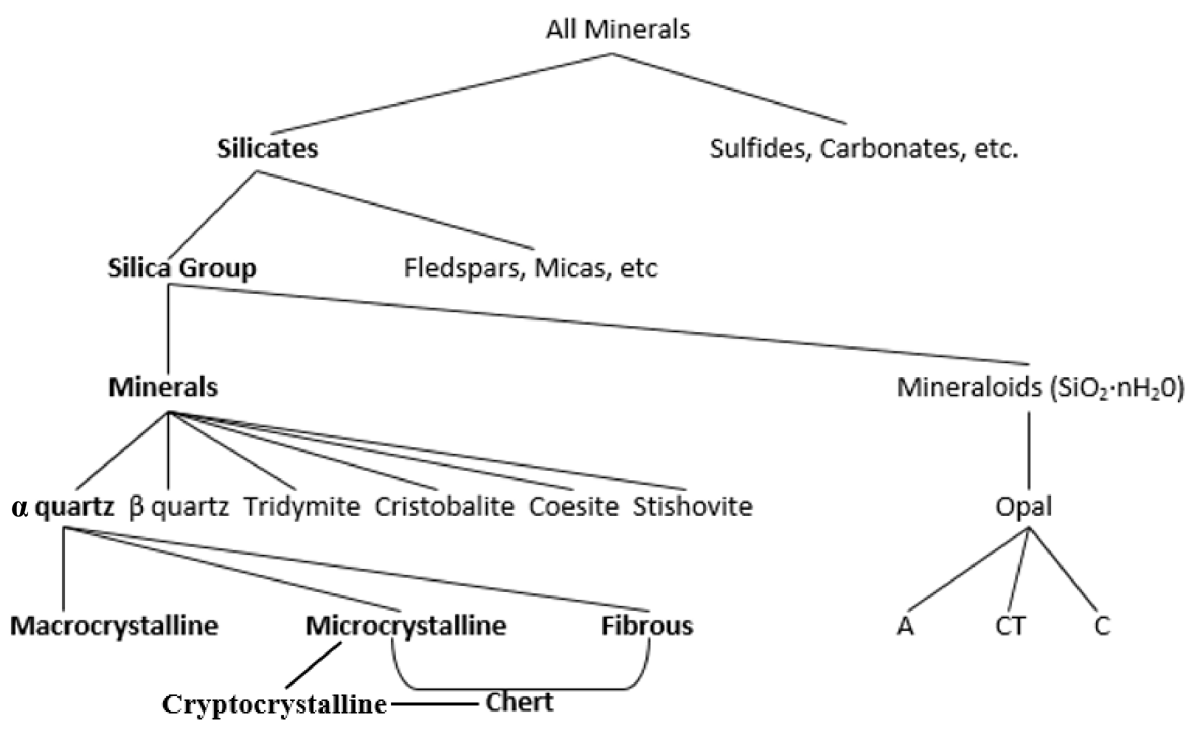


Figure 2-2: Chart of mineral classification.
Note that chert is technically quartz. Adapted from Luedtke (1992).

2.1.2 Terminology

When discussed in the literature, quartz-based lithics are divided into two broad categories: microcrystalline and macrocrystalline (Figure 2-2). These categories are based on the size of the quartz crystals. Macrocrystalline quartz includes material composed of quartz crystals larger than 50µm, such as crystal quartz and amethyst crystals. Microcrystalline quartz includes material composed of quartz crystals that are smaller than 50µm. Microcrystalline material with quartz grains smaller than 2µm are cryptocrystalline, such as fine flints and cherts. Quartz material with fibrous structure are chalcedonies (Luedtke, 1992).

Other terms and classification systems are suggested and sometimes used within the literature, therefore it is important to understand the relationship between these classification systems. Some of the terms used in other classification systems include automorphic or xenomorphic and hyaline or milky (vein) quartz. These terms are similar to the micro- and macrocrystalline dichotomy because one term is identified by a large crystal structure (e.g. hyaline and automorphic are similar to macrocrystalline), but differ in other characteristics.

Like the macro/microcrystalline classification system, the automorphic/xenomorphic system is determined by crystal size. Automorphic quartzes have a visible crystal structure (i.e. crystal faces are visible), thereby including crystal quartz and amethyst and other macrocrystalline varieties. Xenomorphic quartzes have unrecognizable crystal structures (i.e. quartz grains are found in an aggregate), thereby including flints, cherts and other microcrystalline varieties. This system is interchangeable with the macro/microcrystalline classification system, but lacks the ability to isolate finer cryptocrystalline and chalcedonies from other microcrystalline material (de Lombera-Hermida, 2008; de Lombera-Hermida, 2009).

The hyaline/milky quartz classification system only concerns itself with macrocrystalline or automorphic quartzes. Hyaline quartz has translucent or transparent crystals while milky quartzes are opaque (i.e. vein quartz, which is white in colour). However, this system is based on colour and opacity and does not address petrological characteristics nor the knapping qualities of the material.

Overall, the macro/microcrystalline classification system is the most versatile system and is the preferred categorization used here. The auto/xenomorphic classification system is similar but slightly limited in specificity, but its subjectivity (i.e. visible crystals as defining property) can simplify categorizing and still distinguishes between the knapping capabilities of the material. The hyaline/milky classification system is the least useful for archaeological purposes (de Lombera-Hermida, 2009) and is not used in this study.

Table 2-1: Quartz varieties.

Quartz Subcategories	Description
Rock Crystal	Clear, colourless quartz
Amethyst	Purple quartz that can occur in a variety of shades.
Ametrine	Alternating violet and yellow segments (combination of amethyst/citrine)
Blue Quartz	Dull blue quartz
Citrine	Yellow quartz
Green Quartz	Green quartz (found near Thunder Bay); sometimes called prasiolite
Milky Quartz	White, translucent to opaque quartz
Pink Quartz	Pink crystalline quartz
Rose Quartz	Pink, translucent quartz that does not form in crystals
Smoky Quartz	Brown to gray coloured quartz

Adapted from information presented on www.quartzpage.de and minerals.gps.caltech.edu

2.1.3 Variations of Quartz

Quartz forms into a variety of macroscopically distinct crystals including amethyst, a common variant of quartz in the Thunder Bay area (Table 2-1). Amethyst is created by a variety of substances, contaminants, or pigments that are intermixed with pure quartz during formation. Irradiated iron is regarded as the main factor in creating amethyst's purple colour (Vos, 1976). Changes in cooling rates, temperature, and core density affect the characteristics of quartz crystals, including the size and colour. Variation in colour and quality can occur within the same vein. Smaller crystals are typically found on the perimeter of the vein, while the larger crystals are found in the centre where cooling occurs at a slower rate (Shipton, et al., 2012). Therefore, it is possible to have quartz types that vary in both colour and size from the same vein. Vein quartz, rock crystal, and amethyst are commonly accessible near the surface around Thunder Bay.

2.1.4 Summary of the Geological Characteristics

This brief section is important for understanding the fundamental nature of quartz as a material and how the macrocrystalline varieties, which are the focus of this research, differ from the microcrystalline varieties, which are more commonly associated with archaeological lithic artefacts. Macrocrystalline quartzes are large SiO_2 crystals that tend to fracture along naturally occurring fault planes rather than micro/cryptocrystalline aggregates that have a higher elasticity and flake more predictably. Different varieties or quartz are determined by the inclusion of trace elements (e.g. irradiated iron results in amethyst) and other factors during the formation process. Different terminology can be used when differentiating varieties of quartz and each presents its own advantages and disadvantages. For this thesis, the terms macrocrystalline, microcrystalline, and cryptocrystalline are commonly used.

2.2 Archeological Research on Quartz

It is no secret that quartz and archaeologists had a difficult relationship in the past. This resulted from applying a cryptocrystalline-centric framework to a macrocrystalline material (see Driscoll, 2010 regarding the idea of flint-centric approaches) and did nothing but frustrate all parties involved. This sentiment was echoed by countless archaeologists in the past who were left to deal with quartz assemblages (Bisson, 1990; MacDonald, 1997). However, over time archaeologists have identified methods to better explain and classify macrocrystalline materials, like quartz, which allows for archaeologists to better understand these artefacts.

Bisson (1990) describes quartz assemblages as one of the most discouraging tasks for an archaeologist interested in studying lithic reduction sequences. Driscoll (2010) appreciates this sentiment and chose to begin his own PhD thesis by quoting Bisson. Archaeological analysis of quartz has been plagued by misconceptions, assumptions, and a lack of directed analysis. Traditional research has focused on flint and chert artefacts, resulting in the application of these laws and rules to a material that is fundamentally different (Driscoll & Warren, 2007) because of its irregular fracture patterns (Driscoll, 2010; Tallavaara, et al., 2010). This researcher bias has hidden much of the data that quartz artefacts can offer, but, as Spott (2005) appropriately recognizes, many of these assumptions are not made without some hint of truth. It does appear that quartz is more heavily relied upon where flint or chert are absent, but this does not necessarily make it a secondary lithic material. Assumptions such as those will be addressed and discussed in this work.

2.2.1 Quartz Sources and Sourcing

Quartz and quartz varieties are procured from two different sources: veins within bedrock and cobbles. Cobble sources can be found in riverine deposits or as glacial till in fields. The Hoko River site in Washington state (USA) is an example where river cobbles containing quartz were collected to produce lithic tools (Flenniken, 1981). In Sweden, surveys were conducted to identify glacial till cobbles that were mined for quartz to produce tools. However, in the latter example, quartz veins within the bedrock were also mined for raw material (Alakarppa, et al., 1997). Quartz veins come in a variety of sizes and qualities. The Grandfather Quarry in Northern Manitoba's boreal forest is an excellent example of a heavily mined vein quartz quarry (Beardsell, 2013).

Few studies attempt to source quartz to determine the origin of archaeological artefacts. One study, which included the Grandfather Quarry, identified unique trace elements present in known archaeological quartz quarries in Northern Manitoba and compared these elements to quartz artefacts recovered from various sites within Manitoba. Positive correlations between artefacts and quarries indicated the origin of the artefact, which provided evidence of either trade or travel routes. Due to the vastness of the study area (i.e. Churchill Basin), the researchers concluded that the method is best suited for excluding quarries should the elemental composition of quartz differ because not all quartz veins can be tested (ten Bruggencate, et al., 2013; ten Bruggencate, 2013; ten Bruggencate, et al., 2014). This type of analysis is not completed for the area around the Mackenzie sites (i.e. the quartz veins around the Mackenzie River). The presence of quartz and amethyst cobbles in the Mackenzie River and as veins within the bedrock in the immediate area, coupled with the lack of quartz use outside the Mackenzie-River/Sibley Peninsula area, suggest the material is acquired from nearby the site.

2.2.2 Fracture Analysis and Reduction Techniques

Early replicative studies of knapping quartz into usable implements left early archaeologists frustrated, concluding that quartz could only be reduced by bipolar reduction (Dickson, 1977). Although a difficult material to work, the source of frustration derived from expecting results comparable to cryptocrystalline material. Knight (1988) and Hiscock (1982) provide excellent and concise summaries on the qualities of quartz and its flaking properties that concern archaeologists. Archaeological evidence indicates that quartz can be reduced by different methods (e.g. bipolar reduction, platform flaking) depending on the quality of quartz (i.e. high quality quartz fragments more predictably; Hiscock, 1982) and many archaeological sites feature more than one type of reduction method (Shipton, et al., 2012 and Hiscock, 1982 for example).

The difficulty in knapping quartz derives from its tendency to fracture along internal fault planes. The low tensile and compressive strength of quartz, coupled with fault planes, result in fragmentation during reduction (Tallavaara, et al., 2010). Fragmentation refers to non-concoidal and unpredictable shatter or breakage along a fault plane. Fragmentation is unpredictable, but researchers in Scandinavia are developing models based on fracture mechanics, to determine if there is any predictability to quartz reduction (Callahan, et al., 1992; Tallavaara, et al., 2010).

Fracture analysis was developed in Sweden so archaeologists could better understand and interpret the large quartz assemblages found at Mesolithic sites, a period where assemblages are dominated by quartz. Despite its potential use, the difficulty in understanding quartz resulted in a slow development of fracture analysis. In the early 1990's preliminary work suggested that there is some predictability to how quartz can fracture, or at least there are predictable flakes that can be produced (Callahan, et al., 1992).

As part of this study some quartz cobbles were reduced to create a few experimental tools. During this process, a specific flake type was repeatedly produced that is present within the Mackenzie I lithic assemblage and are included in this study (see Chapter 7.2.4.5). This specific flake was modified slightly and turned into a tool. The replication and commonality of this flake lends credibility to the theory behind fracutre analysis. Other researchers have noticed similar trends and are confident that this observation can identify quartz tool blanks or tool blank caches (Rankama & Kankaanpaa, 2011).

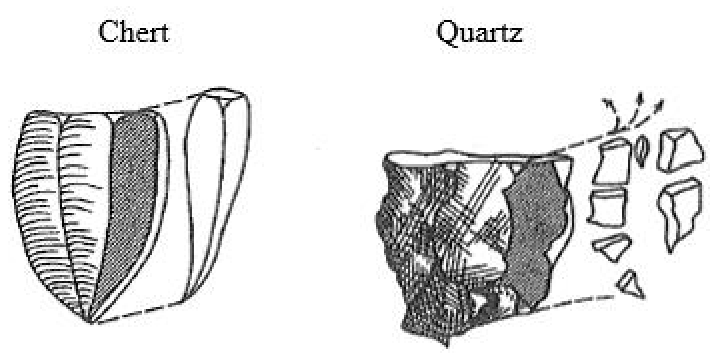


Figure 2-3: Fracture mechanics.
How cherts and other microcrystalline material fractures vs. how quartz typically fractures. Adapted from Knutsson (1998).

The next development in fracture analysis occurred in 2010, when a group of researchers from Sweden critically assessed the earlier study to provide more reliable results and more refined interpretations (Tallavaara, et al., 2010). Their results suggest that there is considerable variation in fragmentation that the original study did not account. These variations include: indenter hardness, relative thickness of flakes, and knapper-related factors. Their study also hypothesizes that quartz flake fragmentation will have a direct impact on the technological organization and reduction strategy employed. This is logical when considering sites with more than one type of knapping strategy (i.e. the quality of the material dictates their approach), although the use of certain reduction techniques can be culturally influenced.

Quartz can be reduced by several different methods, but bipolar and platform reduction are the most common. High quality quartz produces complex artefacts similar to those created from cryptocrystalline materials (e.g. projectile points with concave bases and laurel leaf shapes from Africa (MacDonald, 1997), projectile points from North Carolina (Daniel, et al., 2007), and Paleoindian projectile points from Minnesota/Northwestern Ontario (Mulholland & Mulholland, 2010; Mulholland, 2006)). The Mackenzie I lithic assemblage contains a quartz projectile base with evidence of edge grinding to help produce its shape (Chapter 6.2.46). However the reduction analysis of the quartz and amethyst artefacts from Mackenzie I is not completed.

Archaeologists in other areas have analyzed quartz assemblages in an attempt to determine reduction sequences. In Wisconsin, Archaic sites mostly show evidence of bipolar reduction, but some sites provide evidence of both bipolar and platform reduction (Spott, 2005). In fact, many sites (or series of related sites) around the world exhibit multiple reduction methods used on quartz material (Spott, 2005; Barnes, 1972; Shipton, et al., 2012; Callahan, 1987; Manninen & Tallavaara, 2011; Ballin, 2008; Hiscock, 1982). In some cases, the techniques are contemporary, while in others the change in techinique occurs over time. Examples of the latter comes from India, where archaeologists identified soft hammer reduction of quartz clasts in earlier sites, and bipolar reduction in later sites (Shipton, et al., 2012) and in Scotland, where bipolar reduction was emphasized at earlier sites, while platform reduction was more common at later sites (Ballin, 2008). An example of the former comes from Sweden, where archaeologists believe that quartz reduction commenced with platform reduction and concluding with the bipolar reduction of the exhausted platform core (Callahan, 1987). Archaeologists surmise that platform flaking reduces the risk of fragmentation, while bipolar reduction is most efficient when the core can no longer produce suitable flakes (Manninen & Tallavaara, 2011). This is a very pragmatic approach to a difficult material that varies in quality (Rankama, et al., 2006).

Many archaeologists have performed their own experiments to understand quartz reduction since Dickson's (1977) early attempts. In New England, Boudreau (1981) replicated bifacial Squibnocket triangle points using both pressure and percussion flaking, indicating that knapping principles associated with other cryptocrystalline material (e.g. platform preparation) can be applied to quartz. In South Africa, researchers observed that the reduction sequence must be short (i.e. few steps) or risk breaking the implement. Comparing their experimental observations with archaeological material, they conclude that the purpose of the reduction is to produce uniformly thick flakes that required minimal pressure flaking to thin the working edge (de la Pena, et al., 2013). At the Mackenzie I site, suspected tools show little modification and appear to follow these observations. In Ireland, Driscoll (2010) reduced vein quartz by various methods to understand the different debitage that is produced. He observed that bipolar reduction produced twice as much debitage compared to platform reduction, but also produced more completed flakes. Certain archaeologists produced experimental assemblages to examine quartz for specific scars that are related to specific knapping techniques. Some archaeologists use scanning electron microscopy (SEM) to observe surface and subsurface scars (de Lombera-Hermida, 2009). This is also useful for differentiating manufacturing scars from use-wear scars.

Some archaeologists feel that the reduction technique used on quartz, combined with other lines of evidence, supports the interpretation of quartz as an alternative material to flint (Rankama, et al., 2006). They argue that the application of flint based knapping-strategies to quartz indicates an unfamiliarity with the material, while more efficient methods (e.g. platform/bipolar combination) indicates a greater familiarity with the material. The margin-touched points from Late Mesolithic Finland are an example of a finished product that represents a familiarity with the material. This point typlology is numerous and represents the conservation of higher quality material and an efficient use of vein quartz (Manninen, 2014). Although a reduction analysis for quartz artefacts at the Mackenzie I site does not exist, it is likely that the same reduction method used on taconite is applied to quartz because the material is so rare at Lakehead Complex sites (for the reduction of bifaces see Bennett, 2014).

2.2.3 Identifying Quartz Artefacts

Quartz artefact identification is one of the biggest challenges for archaeologists and begins when quartz is first encountered in the field. Archaeologists from Scotland and Ireland discussed this issue (Driscoll, 2011; Warren & Neighbour, 2004), highlighting how even seasoned archaeologists (including those familiar with quartz) miss artefacts. For example, Driscoll (2011) conducted an experiment at the World Archaeological Congress in 2008 highlighting the difficulty of identifying (vein) quartz artefacts. The results of this study indicated that quartz artefacts are often missed or misclassified. Additionally, the rough, reflective surface of quartz results in the misidentification of retouch (i.e. retouch observed where none exists). In Scotland, a full collection strategy is employed in quartz-rich areas to reduce the risk of missing artefacts (Ballin, 2008; Warren & Neighbour, 2004), but proper lab identification must be in place to not over-represent quartz in the assemblage.

These difficulties result in part from the differential fracture patterns when compared with chert or flint. The tendency for quartz to fragment during reduction creates a greater amount of debitage, much of which has the same characteristics of naturally broken quartz (Gramly, 1981). Moreover, the different structure of the material creates debitage that differs from the more familiar and heavily studied debitage produced from cryptocrystalline material. Depending on the reduction technique (e. g. bipolar reduction), debitage can also be difficult to distinguish from natural quartz (Driscoll, 2010). However, some characteristics typical in cryptocrystalline debitage (e. g. bulb of percussion) are still visible in quartz debitage, but are less pronounced and more difficult to recognize (Driscoll, 2010).

Archaeologists at the Mackenzie I site collected all pieces of quartz and amethyst recovered during excavation. Obviously natural pieces were discarded in the lab during cataloguing. Many pieces were produced from poor quality quartz and amethyst, but the higher quality material clearly displayed anthropogenic characteristics (e.g. bulb of percussion, striking platform).

2.2.4 Organizing and Classifying Quartz Artefacts

One of the greatest inconsistencies with quartz assemblages is the method in which they are catalogued. To date, no standardized approach is developed. Archaeologists debate whether to create a new classification scheme for quartz debitage instead of following a flint-based approach. Many archaeologists are in favour of this approach (Barber, 1981b; Lindgren, 1998; Cornelissen, 2003; Driscoll, 2010; Taipale, 2012). The only opposition by quartz-focused archaeologists comes from Ballin (2008), who worries that this will make cross-lithic comparisons impossible. Certain researchers feel that direct comparions between quartz assemblages and other lithic assemblages (e.g. chert or flint) are not possible (Spott, 2005; Rankama, et al., 2006; Lindgren, 1998), but this is unrealistic because the data must be compared to understand quartz assemblages within the broader picture. Essentially, a classification system for quartz must be developed through experimental reduction that can be “translated” for cross-lithic comparisons.

How to properly classify and catalogue quartz artefacts is an old debate, particularly among archaeologists working in Africa (MacDonald, 1997). Cornelissen (2003) states that the first obstacle in quartz typology is to provide a description of the assemblage. Two common approaches have emerged: to classify by edge type, utilization and the presence of retouch (Gabel, 1976; Deacon, 1984; Broadbent, 1979), or to focus on the reduction stage (Spott, 2005; Salzer & Birmingham, 1981; Callanan, 1981). The present study contains both approaches to some degree. The cultural resource management (CRM) catalogue focuses on the reduction phase of the artefacts, while the sampling process (see Chapter 4) sorted the collection by edge type and identified artefacts with retouch or signs of use.

2.2.5 Tool Identification

Quartz tools, like quartz debitage, are difficult to identify. Because of the different fracture mechanics for macrocrystalline material, quartz tools are often different in appearance to their cryptocrystalline equivalents (Tallavaara, et al., 2010; Ballin, 2008). It is not the typological distinctions that are the issue (e.g. scraper, burin, etc.) because these often relate to a function, but rather the morphological requirements for artefacts to have a considered function (Gramly, 1981). In some cases, quartz assemblages are dominated by informal or expedient tools found within the debitage (i.e. utilized flakes) because a sharp edge was the only criteria for selecting tools (Knutsson, 2014). Ethnographically, quartz is often used with little to no further modification once a sharp-edged flake is detached (Shackley & Kerr, 1985). Experimental tools were produced in a similar fashion with little additional modification (de la Pena, et al., 2013). This means that quartz cannot be worked into as many unique shapes as flint, restricting morphological variation between artefacts that have served different functions. In addition, retouching is more difficult to accurately identify on quartz. For these reasons, microscopic approaches are necessary to positively separate used artefacts from the rest of the quartz debitage.

2.2.6 Quartz and Use-Wear Analysis

Use-wear became a popular approach for identifying tool use after Semenov's research was translated into English in the 1960s (Semenov, 1964). The discipline since then has advanced, refined, and broadened itself greatly. In the past, it was believed that use-wear analysis on quartz would be futile because the material is too hard to produce wear scars (e.g. Flenniken, 1981; Shackley & Kerr, 1985; Kamminga, 1982). Early research proved otherwise (Broadbent & Knutsson, 1975; Sussman, 1985; Knutsson, 1988a; Sussman, 1988).

Research on the development of use-wear on quartz tools was pioneered in many regions around the same time (Scandinavia: Broadbent and Knutsson, 1975, Knutsson 1988a; North America: Sussman, 1987, Sussman, 1988; Africa: Sussman, 1987; and Australia: Kamminga, 1982, Fullagar, 1986, and Hiscock, 1982). Broadbent and Knutsson (1975) developed an experimental scraper assemblage to interpret quartz scrapers recovered from a Mesolithic site in Sweden. Their experiments showed that quartz does in fact wear down through use, even on softer material like fresh hide. They also experimented with different powders to reduce the effect of quartz's reflective surface when using optical light (Broadbent & Knutsson, 1975). Knutsson continued to analyze quartz artefacts for use-wear, first by chemically etching artefacts to enhance wear features (Knutsson, 1988c) and then by using an SEM and acetate peels (Knutsson, 1988a). The latter method was replicated by archaeologists working in Poland (Derndarsky & Ocklind, 2001) and Venezuela (Perry, 2002).

Around the same time as Knutsson's (1988a) research, Sussman (1985, 1988) independently examined use-wear on experimental quartz tools. Sussman's (1985) first publication disproved the hypothesis that use-wear did not form on quartz, which was followed by the full results of her experimental study (Sussman, 1988). Sussman (1988) used both optical light and scanning electron microscopy to analyze the experimental and archaeological quartz assemblages. To counteract the charging effect on quartz in the SEM, Sussman (1988) was required to coat the artefacts in gold. This is obviously undesirable and, with the advances made in recent years, is no longer necessary (Frahm, 2014; Frahm, 2017). Environmental SEM's (ESEM) accommodate a variety of objects, including uncoated artefacts. In addition, many newer SEM's have low vacuum modes that allows for specimens to be viewed without coating (Frahm, 2014; Frahm, 2017).

Outside of these studies, few archaeologists examined quartz for use-wear during the 80s and 90s (Kamminga, 1982; Fullagar, 1986, Petraglia, et al., 1996; Johnson, 1993), but within the last 15 years use-wear analysis on quartz has become much more common (Taipale, 2012; Knutsson, et al., 2015; Derndarsky & Ocklind, 2001; Derndarsky, 2006; Clemente-Conte, et al., 2015; Fernandez-Marchena & Olle, 2015; Lemorini, et al., 2014; Lombard, 2011; Lombard & Phillipson, 2010; Marquez, et al., 2015; Olle, et al., 2016; Perry, 2002; Taipale, et al., 2014; Kononenko, et al., 2010, Borel, et al., 2014). More archaeologists have recognized that it is necessary to analyze how quartz artefacts were used to properly determine function, rather than rely on morphological typologies. These studies commonly employ optical light microscopy (OLM) with a Nomarski prism (to reduce the reflective surface of quartz) and/or SEM (see Borel, et al., 2014 and Olle, et al., 2016).

Most recently, a group of archaeologists began advocating for the combined approach of SEM and OLM microscopy to analyze use-wear (and residue) on stone tools (Borel, et al., 2014; Olle, et al., 2016). Borel, et al.'s, (2014) paper highlights the advantages of each instrument (i.e. SEM adds high resolution images and a large depth of field; OLM provides colour and a better sense of depth), indicating that their strengths are quite complimentary. Olle, et al.'s, (2016) paper focuses on how the combined use of these instruments results in more informative use-wear analyses of quartz based material (i.e. rock crystal, vein quartz, quartzite). In addition, their study aims to better define use-wear terminology on non-chert material.

Regarding the actual use-wear scars, quartz artefacts display many of the wear features (including edge scarring, abrasion, rounding, striations, and polish) commonly associated with other material, but the wear formation differs (Fullagar, 1986). For example, polish does not form through bone working, butchering and hide-scraping on quartz, but it does on cherts and flints (Fullagar, 1986). Striations are the most common wear pattern to form on quartz (Fernandez-Marchena & Olle, 2015). Microchipping is also common, but more difficult to authenticate because it can occur through trampling (Shea & Klenck, 1993; Driscoll, et al., 2015). Therefore, it's interpretive role is to complement other wear patterns (Keeley, 1980). Knutsson's (1988a) and Sussman's (1988) original works offer the most comprehensive tables for interpreting use-wear patterns on quartz and is complemented by a recent study that includes lancets (which are produced by compressive force) as a functional indicator (Fernandez-Marchena & Olle, 2015).

2.2.7 Quartz and Residue Analysis

Very few studies have analyzed residue adhering to quartz artefacts. Most often, it is combined with use-wear analysis (Petraglia, et al., 1996; Perry, 2002; Kononenko, et al., 2010; de la Pena, et al., 2013; Delagnes, et al., 2006; Lombard, 2011; Lombard & Phillipson, 2010; Lombard, 2007; Lombard, 2008). Most of this combined use-wear and residue research has focused on the Sibudu Cave artefacts from South Africa, while the researchers are significantly advancing the field of microscopic residue analysis, they also advocate for non-destructive analytical techniques.

Lombard, one of the residue analysts on the Sibudu Cave project, conducted blind tests on quartz artefacts to evaluate the effectiveness of using *in situ* incident light microscopy to identify microresidues (Wadley & Lombard, 2006). The results of these blind tests indicate that the rock type can affect how the analyst perceives residues, specifically, that the reflective and refractive surface of quartz (and quartzite) produced interpretive errors when using *in situ* incident light microscopy alone (Wadley & Lombard, 2006). Whitish, translucent and birefringent residue (i.e. fat, bone, silica skeletons, or starch grains) are also more difficult to identify with *in situ* incident light microscopy on quartz (Wadley & Lombard, 2006). One additional observation during their experimentation is that residue has difficulty adhering to the smooth surface of quartz, and instead accumulated in cracks on the artefact surface (Wadley & Lombard, 2006). These lessons, when applied to archaeological material, allowed the analysts to positively identify quartz microliths as transversely hafted arrowheads used for hunting (Lombard & Phillipson, 2010; Delagnes, et al., 2006).

Outside of Sibudu Cave only a few researchers applied microresidue analytical techniques to quartz artefacts. Perry (2002) used low power incident light microscopy (LPILM) to identify areas of interest to perform spot removals (using water) to dissolve residue and analyze for starch. Her analysis focused on identifying specific starch grains to test the hypothesis that quartz microliths were used to grind manioc. Petraglia, et al., (1996) conducted immunological and microwear analysis to identify the presence of protein on quartz artefacts from the Piedmont region in the Eastern United States. Out of 72 crystalline artefacts examined, 12 produced positive immunological reactions, while nine produced positive microwear results (using light microscopy with a Nomarski prism at 200x magnification). The Piedmont region is similar to boreal forest in the sense that it has shallow deposition and generally organic material decomposes quickly. The authors do not overlook the importance of this sort of analysis in providing additional data (e.g. informal tools, organic residue) to the archaeological record.

The smooth surface of quartz makes it unlikely that residue will survive the taphonomic processes. The best residue is preserved in cracks in the material. However, the results within this study demonstrate that even in harsh environments (e.g. acidic soil), residue can still adhere to even smooth surfaces (see artefact 24842 in Chapters 5 and 6).

2.2.8 Symbolic or Ritual Attributes of Quartz

Anthropological studies can be used as proxy examples to understand possible symbolic or ritual characteristics that cultures can attribute to quartz or amethyst material. In many cases, cultures associate quartz with spirits (Ernst, 1952). For example, the Nuu-chah-nulth hunter-gatherer culture on North America's West Coast used to use shiny pieces of quartz to represent the power of the Wolf spirit during the Wolf ritual (Ernst, 1952). In South America, shamans of the Warao culture would blow tobacco smoke over many quartz crystals, which were placed one at a time in a hollowed-out gourd. Each quartz piece contained a specific ancestral spirit who would assist the shaman in curing rituals (Wilbert, 1977). These gourds became shakers or rattlers used to cure people afflicted by spirit sickness (Wilbert, 1972). Archaeologically, quartz was recovered from burials in various European locations, suggesting another spiritual connection (Warren & Neighbour, 2004; Ballin, 2008; Driscoll, 2010).

Quartz was commonly included within various ritual bundles, particularly in North America's Southwest. The Apache kept quartz crystals in their medicine bundles (McAllister, 1965). Similarly, in California, the Chumash and Kumeyaay would set quartz crystals into wands, which were occasionally used for healing purposes (Koerper, et al., 2006). The Hopi culture included quartz crystals and seeds within a bag to be left – attached to a puppet holding prayer feathers – at the shrine of Maasaw, the Lord of the Dead, who taught the Hopi of agriculture (Geertz, 1987). The Hopi would also place quartz, or other minerals, on the six directional lines within their spiritual chamber for various ceremonies (Wyckoff, 1986). The Navajo, would place similar pieces of rock crystal within a bundle used for mountain offerings (Wyman, 1970). The Tewa used quartz fragments, specifically shaped so that one may sit atop the other, as part of the naming ceremony a few days after the child's birth (Ortiz, 1969).

These are only a few examples of the ritual or symbolic characteristics of quartz based on anthropological observations. Other examples include: weather control, good luck talismans, the ability to harm (as well as heal, which was discussed), a variety of magical properties (e.g. protection, fast travel, etc.; Koerper, et al., 2006 and cited within), and even used in ceremonies to invoke good fortune to ascend higher within society (Ferreira, 1998). The qualities of quartz are plentiful, making the archaeological interpretation of 9,000 year-old artefacts difficult.

The symbolic properties of quartz or amethyst will not be considered in this project. It is difficult to comment on the symbolic nature of quartz within the Mackenzie I assemblage and to make inferences upon the ideology of the people responsible for the Lakehead Complex. Perhaps in time archaeologists will feel comfortable discussing the symbolism of these artefacts, but the current study is only concerned with function. An amethyst artefact recovered from another Lakehead Complex site was interpreted as a pendant (the Cummins site, Julig, 1994), so it is possible some of the non-functional amethyst artefacts could be pendants instead.

2.3 Quartz within Archaeological Sites

The following section highlights the variety of sites around the world where quartz was a raw material for tool manufacture (Table 2-2). The use of quartz as a raw material for tool manufacture began with some of the earliest examples of anthropogenic lithic modification in the Oldowan and Achulean traditions (Lemorini, et al., 2014; Langejans, 2012). Generally, quartz was favoured in earlier lithic traditions, but was eventually replaced by more predictable and flake-able material (i.e. chert). Regardless, in some areas within Africa quartz persisted alongside the introduction of iron (Atherton, 1972; Switsur, et al., 1994) and is documented ethnographically as late as the 1980s (Shackley & Kerr, 1985). The widespread distribution and universal appearance of quartz allows it to be easily recognized and exploited when inhabiting a new location.

2.3.1 Temporal and Geographic Distribution

2.3.1.1 Africa

Quartz is commonly found within numerous Sub-Saharan archaeological sites. Most of the material published appears to date within the Middle (Delagnes, et al., 2006; Lewis, et al., 2014) and Late Stone Ages (Cornelissen, 2003; Bisson, 1990; MacDonald, 1997; Deacon, 1984). Many of these quartz industries are microlithic in nature (Cornelissen, 2003; de la Pena, et al., 2013; Lewis, et al., 2014; MacDonald, 1997; Gabel, 1976; Seitsonen, 2010; Shackley & Kerr, 1985), and many discuss the arduous task of cataloguing all the debitage (MacDonald, 1997; Bisson, 1990; Chenorkian, 1983; Deacon, 1984; Gabel, 1976; Shaw & Daniels, 1984).

Table 2-2: Archaeological sites with quartz.

Location	Site	Period	Date	Reference[1]
South Africa	Sterkfontein	Old./Ach.	2M-1.5MBP	1
	Sibudu Cave	MSA	~64kBP	2, 3, 4, 5
	Diepkloof	MSA	-	6
	Rose Cottage	MSA	-	7
	-	LSA	-	8
Sierra Leone	Kamabai Rock Shelter	-	1,050-550BP	9
Nigeria	Kariya Wuro Rock Shelter	-	950-750BP	10
	Iwo Eleru	LSA	-	11
Namibia	Central Namib desert	MP	-	12
Cameroon	Shum Laka	LSA	30k-10kBP	13
Zambia	Luano Spring	LSA	16k-200BP	14
Mali	Korounkorokale	LSA	20k-12kBP	15
Liberia	-	-	-	16
Ivory Coast	-	-	-	17
Kenya	Kanjera South	Old.	2MBP	18
	Kansyore sites	LSA	8k-1,500BP	19
Portugal	-	Pal.	-	20, 21, 22
Poland	Morovia	UP & Mes.	-	23
	Lurgrotte	MP	-	24
Spain	Navalmaillo Rockshelter	Moust.	75kBP	25
France	Le site de Payre	MP	250k-125kBP	26, 27
Belgium	Les Merveilles, Wincqz	Mous.	-	28
Scotland	-	Pal. & CH/B	-	29
Ireland	-	Mes. – Neo.	-	30
Scandinavia	Finland & Sweden	Mes.	11k – 3,850BP	31, 32, 33, 34
Korea	-	Pal.	-	35
China	-	UP & MP	-	36
India	Sanganakallu-Kupgal site	Mes. & Neo	11k – 3,900BP	37, 38
Sri Lanka	-	LP	-	3
Australia	Open-air site, Arumvale	EH & MH	-	39
Tasmania	-	-	~ 16,000BP	40
Ecuador	Chanduy	-	-	41
Venezuela	Pozo Azul Norte-1 site	-	1,520 – 1,170BP	42
Brazil	Vale da Pedra Furada	LPs	20k – 13kBP	64
Canada	Labrador/Eastern Arctic	AP	-	43, 44
	British Colombia	-	-	45
	Ontario	PP	-	46, 47
	Northwestern Ontario	PP	-	48
	Grandfather Quarry, Manitoba	AP	-	49, 50
United States	New England	-	-	51
	Naima site, New York	LAP	-	52
	Virginia	EAP – LWL	-	53
	Poverty Point, Louisiana	LA	2,950BP	54, 55, 56
	California	-	-	57
	Hoko River site, Washington	-	2,800BP	58
	Wisconsin	AP	-	59
	Minnesota	PP	-	60, 61
	Minnesota	AP	-	62, 63

This is not a complete list of sites but a representation of the available literature. Abbreviations: Old. = Oldowan; Ach. = Achulean; LPs – Late Pleistocene; MSA = Middle Stone Age; LSA = Late Stone Age; Pal. = Paleolithic; UP = Upper Paleolithic; MP = Middle Paleolithic; LP = Late Paleolithic; Mes. = Mesolithic; Neo = Neolithic; Mous. = Mousterian; CH/B = Chalcolithic/Bronze Age; EH = Early Holocene; MH = Middle Holocene; PP = Paleoindian Period; AP = Archaic Period; EAP = Early Archaic Period; LAP = Late Archaic Period; LWL = Late Woodland

[1]References: 1) Langejans, 2012; 2) Delagnes, et al., 2006; 3) Lewis, et al., 2014; 4) Lombard, 2011; 5) Cochrane, 2006; 6) Charrie-Duhaut, et al., 2013; 7) Soriano, et al., 2007; 8) Deacon, 1984; 9) Atherton, 1972; 10) Switsur, et al., 1994; 11) Shaw & Daniels, 1984; 12) Shackley & Kerr, 1985; 13) Cornelissen, 2003; 14) Bisson, 1990; 15) MacDonald, 1997; 16) Gabel, 1976; 17) Chenorkian, 1983; 18) Lemorini, et al., 2014; 19) Seitsonen, 2010; 20) Aubry, et al., 2004; 21) Almeida, 2007; 22) Almeida, 2006; 23) Sachanbinski, et a., 2008; 24) Derndarsky, 2006; 25) Marquez, et al., 2013; 26) Moncel, et al., 2008; 27) Hardy & Moncel, 2011; 28) MacCurdy, 1931; 29) Ballin, 2008; 30) Driscoll, 2010; 31) Rankama, et al., 2006; 32) Manninen, 2014; 33) Taipale, 2012; 34) Sandquist, 2013; 35) Seong, 2004; 36) Huang & Knutsson, 1995; 37) Rajala, et al., 2009; 38) Shipton, et al., 2012; 39) Dortch & McArthur, 1985; 40) McNiven, 1994; 41) Markham, 1864; 42) Perry, 2002; 43) Rast, 2011; 44) Rast & Arbour, 2013; 45) McLaren, 2003; 46) Burke, 2006; 47) Sonnenburg, et al., 2011; 48) Bouchard, 2017; 49) Beardsell, 2013; 50) ten Bruggencate, 2013; 51) Barber, 1981a; 52) Mazeau, 2015; 53) Petraglia, et al., 1996; 54) Johnson, 1993; 55) Lauro & Lehmann, 1982; 56) Lehmann, 1982; 57) Koerper, et al., 2006; 58) Flenniken, 1981; 59) Spott, 2005; 60) Mulholland, 2006; 61) Mulholland & Mulholland 2010; 62) Bakken, 2011; 63) Mulholland, et al., 2011; 64) Boëda, et al., 2014.

Regarding quartz, the best documented lithic tradition is the Howiesons Poort from South Africa. Several rock shelters associated with this tradition have been excavated, including Diepkloof (Charrie-Duhaut, et al., 2013), Rose Cottage Cave (Soriano, et al., 2007), and Sibudu Cave (Delagnes, et al., 2006). This lithic industry is the earliest microlithic industry discovered (Lewis, et al., 2014). Most recent publications focus on the ca. 64,000 year-old quartz backed-microliths from Sibudu Cave. Researchers observed that quartz microliths are smaller than those produced from other lithic material (Delagnes, et al., 2006; de la Pena, et al., 2013; Lombard & Phillipson, 2010; Lombard, 2011; Lewis, et al., 2014; also Hiscock, 1982). Quartz use is documented across sub-Saharan Africa with the common use of both rock (i.e. crystal) quartz and milky (i.e. vein) quartz (Delagnes, et al., 2006; MacDonald, 1997). Although formal tools are rare (Gabel, 1976), they are still observed in some locations, including heavily retouched concave base and laurel leaf points from Uganda (MacDonald, 1997).

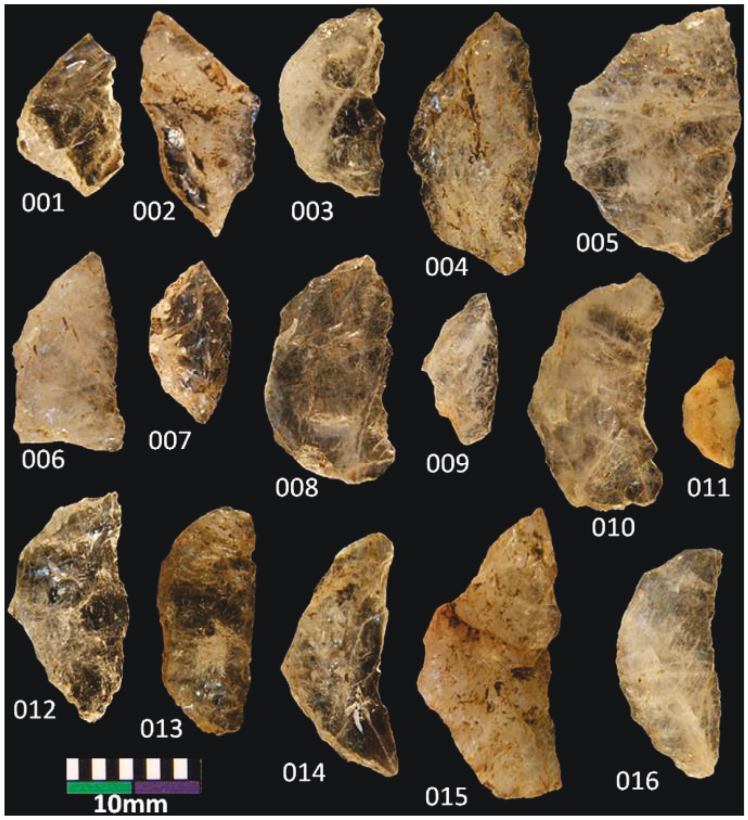


Figure 2-4: Quartz backed artefacts from Sibudu Cave.
From Lombard, 2011.

2.3.1.2 Europe

The temporal distribution of quartz in Europe is similar to Sub-Saharan Africa. Quartz artefacts are more common in earlier Paleolithic contexts, but unlike Africa, the functional use of quartz does not overlap as long with the introduction of metal tools (Ballin, 2008). Quartz artefacts are present at Neanderthal sites, including Mousterian sites in Belgium (MacCurdy, 1931), France (Moncel, et al., 2008; Hardy & Moncel, 2011) and Spain (Marquez, et al., 2013; Marquez, et al., 2015). In the latter case, archaeologists surmise that quartz was specifically chosen over local flint and the reduction technique identified is more suitable to quartz. Paleolithic sites in Portugal are dominated by quartz, composing up to 99% of the assemblage at some sites (Aubry, et al., 2004; Almeida, 2007; Almeida, 2006). Paleolithic and Mesolithic quartz artefacts were also recovered from Poland (Sachanbinski, et al., 2008; Derndarsky, 2006).

Recently, the British Isles received a lot of attention regarding quartz lithic assemblages. Ballin has spearheaded quartz research in Scotland, documenting quarry sites (Ballin, 2003; Ballin, 2004) and quartz components of lithic assemblages dating to the Paleolithic (Ballin, 2008), late Mesolithic (Ballin, 2014; Ballin, 2001; Ballin, 2008), early Neolithic (Ballin, 2008), Chalcolithic/Bronze Age (Ballin, 2011; Ballin, 2008), and the Iron Age (Ballin, 2008). His most notable publication focuses on typology, technology, chronology and inter- and intra-site spatial patterns (Ballin, 2008). Quartz is the main lithic material in the north, northwest, and highland regions of Scotland where both crystal quartz and vein quartz were used. After the introduction of metals, quartz is primarily found in burial contexts, which occasionally includes quartz tools (Ballin, 2008).

In Ireland, quartz use was widespread throughout Irish prehistory (Driscoll & Warren, 2007; Driscoll, 2010). Quartz is naturally found throughout the island, making its exploitation unsurprising (Woodman, et al., 2006), but is generally associated with expedient tools produced using bipolar reduction (Woodman & Scannel, 1993). Quartz use was most common during the Mesolithic and Neolithic, but is not exclusive to these periods (Driscoll, 2010; Driscoll & Warren, 2007). Driscoll (2010) provides the most detailed and recent account of quartz use in Ireland.

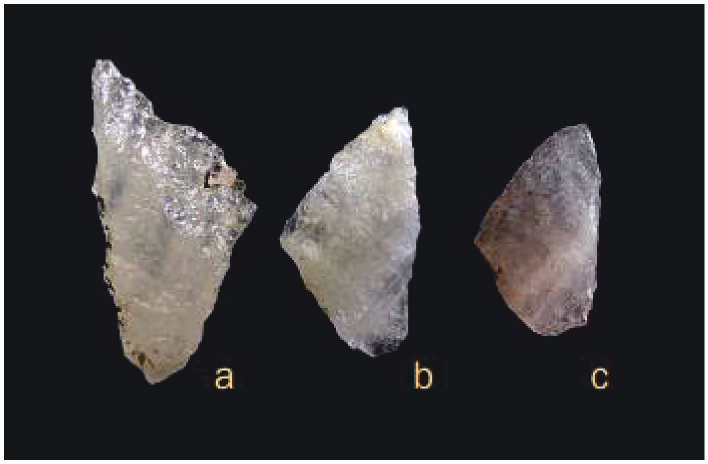


Figure 2-5: Oblique points made of quartz, Finland.
From Manninen & Tallavaara, 2011.

Quartz artefacts dominate assemblages in Scandinavia from at least 9,000 to 1,900 cal BCE (Rankama, et al., 2006) and an increase in the use of vein quartz is attributed to the late Mesolithic period (Manninen, 2014; Taipale, 2012). In Southern Finland, where chert is unavailable, quartz is the primary lithic material (Manninen & Tallavaara, 2011). In Sweden, quartz artefacts are most common in the Mesolithic period (Sandquist, 2013). Manninen and Tallavaara (2011) also identified a quartz lithic typology common in this region: the oblique point (Figure 2-5). This point-style is not a traditional formal tool typology, but the rough morphology and specific flake blank used to create these points is consistent.

2.3.1.3 Asia

Quartz use in Asia is published on sites for Paleolithic Korea (Seong, 2004), Middle and Upper Paleolithic China (Huang & Knutsson, 1995), Paleolithic Sri Lanka (Lewis, et al., 2014) and Mesolithic India (Shipton, et al., 2012; Rajala, et al., 2009). In Korea, Seong (2004) states that most Paleolithic artefacts, including small tools, are produced of either quartzite or vein quartz accounting for 90% of Paleolithic artefacts. A decrease in quartz is indicative of later industries (Seong, 2004).

Microlithic industries dominated Mesolithic and Neolithic complexes in India (Shipton, et al., 2012; Rajala, et al., 2009). Quartz tools were used alongside cherts and chalcedonies, functioning primarily as scraping and grooving implements (Rajala, et al., 2009). The Sanganakallu-Kupgal site complex, dating to the Mesolithic period (ca. 10,950 – 3,900BP) featured the highest frequency of quartz artefacts, which gradually declined until ca. 3,350BP (Shipton, et al., 2012). This decline is associated with a change in microlithic production (Shipton, et al., 2012). Microliths dating to the pre-Ashmound phase (10,950-3,900BP) were struck from a single platform core with evidence of retouch on complete flakes (Shipton, et al., 2012). This transitioned into multiplatform cores used to produce bladelets and backed artefacts (Initial Ashmound; 3,900-3,800BP), which by the Main Ashmound phase (3,800-3,650BP) were primarily made of chert (Shipton, et al., 2012). In nearby Sri Lanka microlithic industries also dominated. Emphasis on quartz occurs earlier, during the Late Paleolithic period, when small (often less than 20mm) geometric and non-geometric microlithic quartz flakes were used (Lewis, et al., 2014).

2.3.1.4 Australia and the Pacific Isles

In Australia, quartz is commonly found at archaeological sites across the continent (Dortch & McArthur, 1985; Gaynor, 1997; Hughes, et al., 2014; Dickson, 1977; Kamminga, 1982; Fullagar, 1986). The earliest evidence of quartz use dates to somewhere between the middle and early Holocene (Dortch & McArthur, 1985; Hiscock, 2015). Kun-Kundurnku is an example of a Holocene site where most lithic artefacts are quartz (71%), which were reduced by bipolar percussion (Hiscock, 2015). Archaeological survey along the south coast of New South Wales identified six sites where lithic assemblages were over 80% quartz with evidence of bipolar and platform reduction (Hiscock, 1982). Quartz is often used to create backed artefacts (Hughes, et al., 2014), similar to South Africa (Pargeter, et al., 2016).

The high frequency of quartz artefacts prompted Dickson (1977) to experiment with quartz knapping to understand this material. He concluded that bipolar reduction is the only way to deal with quartz, but based on other studies and archaeological examples, this is clearly not the case (section 2.2.2 Fracture Analysis and Reduction Techniques). However, bipolar reduction is common (Hiscock, 2015) and an increase of this reduction technique is associated with an increase in quartz use in Australia's southeast (Attenbrow, 2007). Hiscock (1982) criticized Dickson's (1977) generalizations on quartz reduction because of the variability in quality of the material and the significant impact the quality has on reduction success. Kamminga (1982) and Fullagar (1986) both experimented with functional analysis of quartz to identify archaeological quartz tools recovered in Australia.

In nearby Tasmania, the use of quartz (and Darwin Glass) has been attributed to the end of the glacial maximum (ca. 18,000-16,00BP), although only where chert is absent (McNiven, 1994). Functional analysis was also used on quartz artefacts from Vanuatu, Southwest Pacific (Kononenko, et al., 2010).

2.3.1.5 South America

Fewer publications (at least in English) have been found for quartz, or amethyst, use in South America. One very early report describes crystal quartz artefacts from Ecuador that were interpreted as cutting implements (Markham, 1864). In Venezuela, starch analysis of a quartz microlithic grinder from the Orinoco Basin in Venezuela provided evidence of manioc grinding dating from 1,520-1,210BP (Perry, 2002). Quartz flakes dating to ca. 9,020BP were also recovered from this region and the use of quartz is suggested as an adaptation to drier conditions (Barse, 1990). In Argentina, near Buenos Aires, quartz flakes dating to ca. 6,550BP were discovered near La Moderna (Orquera, 1987).

More recent research in Brazil identified quartz tools from several different sites where it is the main lithic raw material (Boëda, et al., 2014; Clemente-Conte, et al., 2015). One of these sites, Vale da Pedra Furada, dates to c. 12,700±90BP. Similar to the Mackenzie I site, this area is rich in natural quartz and archaeologists working in the Vale da Pedra Furada also had to differentiate natural quartz pieces (i.e. geofacts) from anthropogenically modified pieces (i.e. artefacts). Quartz is recovered from other sites in Brazil where utilized quartz flakes were used for cutting and scraping (Melo, 2007; Vialou, 2005; Pugliese, 2007; Bueno, 2010; Magalhaes, 2005; Bueno, et al., 2013).

2.3.1.6 North America

Quartz was used extensively across North America throughout various time periods and geographical regions. It was commonly used during the Archaic period in Labrador (Rast & Arbour, 2013) where quartz crystals provided convenient microblade cores for paleoeskimos (Rast, 2011). Quartz microblades are commonly found on Dorset sites, but rarely in Thule sites (Arundale, 1980). Rast (2011) observes that quartz artefacts tend to be smaller than their chert counterparts. In Quebec, the Droulers/Tsiionhiakwatha Iroquoian village (Woodland period) produced 1,085 quartz artefacts, including 18 tools, which was 30% of the lithic assemblage

(Milmore, 2015). Milmore (2015) states that although quartz is present throughout Quebec's prehistory, it was never to this extent.

In certain locations along the east coast of the United States, quartz represents the only suitable lithic material that is locally available. This reality, as well as a lack of analytical quartz literature, prompted Barber (1981c) to edit a compilation of quartz-related articles; titled *Quartz Technology in Prehistoric New England*, a location where quartz is the most common lithic material (Barber, 1981c). This volume addresses a broad range of topics including: experimental replication and knapping techniques (Boudreau, 1981; Ritchie, 1981), heat treating (Leveillee & Souza, 1981), the characteristics of debitage and challenges of recognizing/classifying quartz artefacts (Luedtke, 1981; Callanan, 1981; Gramly, 1981; Rogers, 1981), and highlights the high frequency of quartz artefacts recovered from archaeological sites (Barber, 1981c; Barber, 1981b; Nicholas, 1981).

Quartz has been recovered extensively throughout the rest of the Eastern United States. It is a common material in New York at sites like the Naima Site, which dates to the Late Archaic and provides evidence of knapping quartz nodules into tools (Mazeau, 2015). In Virginia, and elsewhere in the mid-Atlantic United States, quartz again represents the most commonly utilized material, particularly in the Piedmont regions (Petraglia, et al., 1996). In Louisiana, quartz crystal artefacts (including points, drills, and plummets) have been found at certain Poverty Point sites (Johnson, 1993; Lauro & Lehmann, 1982; Lehmann, 1982), dating to the Late Archaic (ca. 1,200BP). Johnson's analysis of crystal drills from the Slate site are important because of amethyst crystals presence at the Mackenzie I site. Over half of the 46 drills at the Slate site show wear at the tip and 30 show wear at the midpoint, which were interpreted as evidence of drilling and hafting (Johnson, 1993).

Quartz has also been widely used along North America's West Coast. It has a long history of use in California (Koerper, et al., 2006), where archaeologists have postulated its shamanistic properties. In Washington (USA), the Hoko River site (ca. 2,800BP) produced an entire lithic system based on vein quartz. Bipolar flaking technique was applied to create microliths, which were hafted for use (Flenniken, 1981). In the Stave River Valley, British Columbia, evidence of a quartz reduction industry is also present (McLaren, 2003).

Focusing closer to the study area, quartz artefacts have been recovered across Ontario but typically in more isolated finds. In the Early Paleoindian period, quartz is recognized as an occasionally utilized material in the lower Great Lakes for point manufacture (Burke, 2006; Sonnenburg, et al., 2011), including a fluted quartz point from near Newcastle (Roberts, 1985). Examples of projectile points were discovered in Northwestern Ontario along the boundary waters, indicating that quartz in the area can be used to manufacture larger implements (Mulholland, 2006). Quartzite is more commonly used, including hixton silicified sandstone, which was recovered from Mackenzie I. These quartzites were widely traded during the Late Paleoindian period are were common in other areas of Northern Ontario (e.g. Sheguiandah site, Manitoulin Island; Julig, 2002). In the Lakehead basin, the exploitation of material other than taconite or gunflint silica is more often attributed to the Archaic period (Fox, 1975), but quartz is recognized as a minor lithic material for Late Paleoindian period (Markham, 2012b).

In Minnesota and Wisconsin, a similar trend has been observed where quartz use blossoms during the Archaic (Spott, 2005; Bakken, 2011; Mulholland, et al., 2011). In Minnesota, examples of quartz projectile points believed to date to the late Paleoindian period are documented (Mulholland, 2006; Mulholland & Mulholland, 2010; Stoltman, 1991). Mulholland (2006) published on seven unfluted Late Paleoindian points made from vein quartz, recovered near the Minnesota/Ontario border, and on two Early Paleoindian (either Clovis or Gainey) points recovered in Pine County, Minnesota (Mulholland & Mulholland, 2010)**.** Flambeau Phase sites and Minocqua Phase sites from Northern Wisconsin (Figure 3-3), dating to the Late Paleoindian period, have a small quartz component to their sites (Salzer, 1974)

Boreal forest Manitoba lacks an abundance of cryptocrystalline material and thus quartz was valued for stone tool production. Recent research at the Grandfather Quarry and the surrounding area (Beardsell, 2013; ten Bruggencate, 2013; ten Bruggencate, et al., 2014; ten Bruggencate, et al., 2013) has drawn attention to the importance of quartz as a raw material in this region. Quartz has been transported over great distances in this region, as indicated by trace elemental analysis, implying its importance to the inhabitants of the area (ten Bruggencate, 2013).

3 Background – The Mackenzie I site and the Lakehead Complex

The Mackenzie I site (DdJf-9) is regarded as one of the earliest known occupations in Northwestern Ontario (ca. 9,000BP), based on its association with glacial Lake Minong's ancient shoreline (Fox, 1975; Markham, 2012a; McCulloch, 2015). Glacial activity heavily influenced the environment by altering vegetation, lake levels and lake distribution, creating a vastly different environment than in the present day. Only after the Laurentide Ice Sheet (LIS) retreated from the area could plant, animal, and human life establish (or re-establish) itself, each forced in their own way to adapt to changing environmental conditions. For humans, this meant locating and identifying resources for survival (e.g. food, shelter, and lithic material).

The present paradigm identifies the Lakehead Complex as hunter-gatherers who followed their main subsistence resource (i.e. caribou) into the newly released land after tundra vegetation established itself on outwash and till deposits (Fox, 1975). While the vegetation and animal resources were like other post-glacial environments in the vicinity, the landscape was unique and lithic resources for tool manufacture needed to be identified. As a global trend, quartz artefacts are common either in newly occupied areas (until they become more familiar with local chert deposits) or regions devoid of finer chert (Chapter 2). Quartz is commonly found in veins within bedrock formations and as cobbles in riverbeds. Its common appearance and ubiquitous occurrence result in the early acquisition and use of quartz by various cultures until material more suitable to the knapper's desire and design are located.

In the case of the Lakehead Complex, an abundant supply of taconite was encountered upon entering the region, which is reflected in the almost exclusive use of the material. By contrast, quartz plays a minor role in only a handful of Lakehead Complex sites, while amethyst has only been identified as having cultural significance once, in the form of a pendant (Julig, 1994). The environmental context of the deglaciation and paleoenvironment of the study area is important to understand the context of quartz exploitation and use, to allow a discussion to be made on the availability and use of quartz artefacts in the region. The Lakehead Complex, and other nearby complexes, are described and their respective use of quartz (and amethyst) is discussed. The Mackenzie I site with its catalogued lithic assemblage is introduced along with the other collectively termed Mackenzie Sites.

3.1 Environmental Setting

The Lakehead region was occupied by the LIS during the Last Glacial Maximum (Dyke, 2004). Regional glaciation comprised a series of advances and retreats that restricted continual human activity and effectively erased any evidence of earlier human occupation (Shultis, 2012). The most significant re-advance - the Marquette re-advance - occurred ca. 11,400BP, extending south just beyond the extent of modern day Lake Superior (Breckenridge, et al., 2012). Deglaciation of the Thunder Bay region occurred immediately following the Marquette re-advance, but it was not until 10,100BP that the land south of Lac Seul and Lake Nipigon was uncovered. Around 9,300BP the glacier was north of Lake St. Joseph, and was well north of this location by ca. 7,000BP (Bjork, 1985).

Glacial meltwater formed two major bodies of water, creating a peninsula whose boundaries are delineated by the colossal Lake Agassiz to the west, Lake Minong (the ancestor of Lake Superior) to the east, and the retreating LIS to the north. Breckenridge, et al., (2012), provide clear maps detailing the chronology of deglaciation of Northwestern Ontario. The earliest occupation of the region correlates to the middle and late phases of Lake Minong when shorelines are documented at an elevation of 230m asl. Based on radiocarbon dating of preserved wood, this shoreline dates to ca. 9,380 ± 150BP and provides the associated dates for these early archaeological sites (Boyd, et al., 2012).

As the glacier retreated, vegetative species reclaimed the landscape. The paleoenvironment changed frequently between 12,000/11,500BP and 8,000BP when environmental conditions stabilized (Prest, 1970; Bjork, 1985). The land relinquished by the glacier began as tundra with scattered stands of spruce, ash, and elm. The ash and elm disappeared from 11,100 to 10,200BP, suggesting a cool period, after which the climate warmed again, allowing for the northward expansion and diversification of floral species. These species include spruce, larch, birch, and jack/red pine which are the dominant vegetation during the occupation of the Mackenzie I site. Prairie pollen reached its peak ca. 8,000-7,000BP, while white pine reached its peak shortly after 6,500-6,000BP and likely extended north a further 150-200km than its present location (Bjork, 1985). By the Archaic period, ca. 7,500/7,000BP, the boreal forest greatly resembled what it was just prior to European contact (Kuehn, 1998).

Paleoindian populations began to migrate (Figure 3-1) into the region following deglaciation with the earliest occupation dating to ca. 9,000BP. Two possible migration routes have been suggested (Ross, 1995). One route suggested migration beginning in the Dakota's, travelling east and then northward along the Lake Agassiz shoreline. This migration route is based on the Lakehead Complex's projectile point morphology resembling Plano cultures from the west. The other route suggested migration from Wisconsin along the shoreline of Lake Minong. The presence of Hixton Silicified Sandstone, a material found only in Wisconsin, on numerous Lakehead Complex sites in addition to similarities in projectile point morphology are justification of this migration route (Ross, 1995). It should be noted that these migration routes are not mutually exclusive and both are likely to have been used (Ross, 1995). It is believed that migration into the area was a result of following caribou herds for subsistence (Fox, 1975).

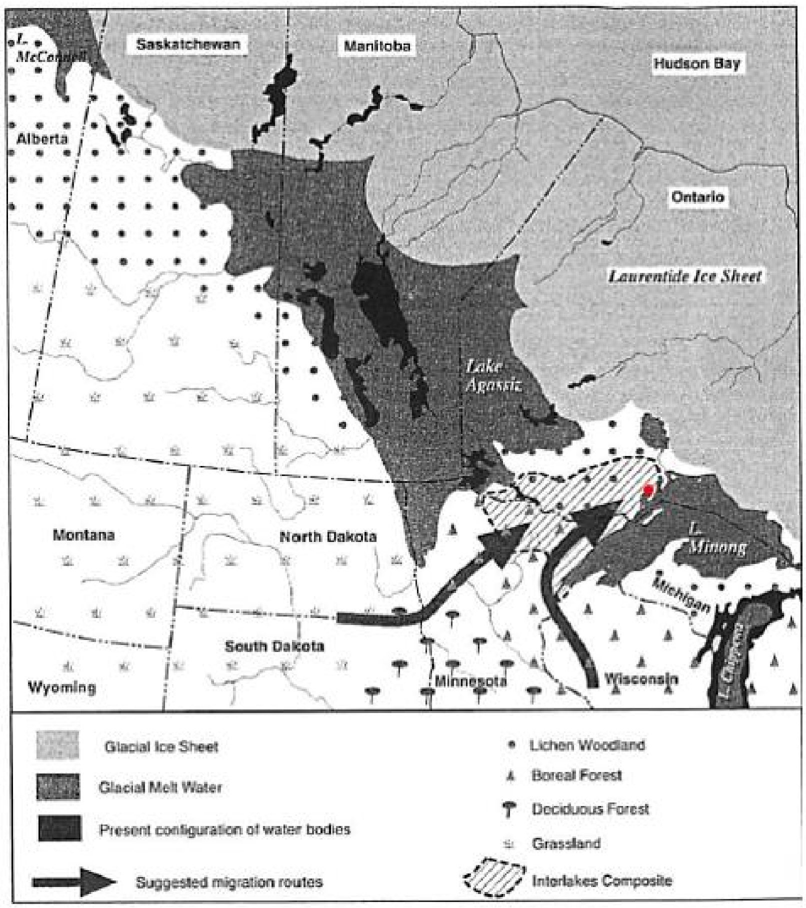


Figure 3-1: Migration routes into Lakehead region.
Modified from Ross, 1995. The red dot is the approximate location of the Mackenzie sites

Regardless of the proposed migration route, the early inhabitants encountered the Gunflint Formation early in their exploration of the region (Figure 3-2), which is why the material is so prominent on all Lakehead Complex sites. The Gunflint Formation stretches across approximately half of the width of the peninsula and many of the early sites are situated around the formation. Therefore, the use of quartz does not follow either of the trends discussed in the opening of this chapter (i.e. quartz is the first material used by early pioneers in a region or quartz is used in the absence of finer siliceous material). There is a third trend identified in archaeological literature that describes quartz as an expedient tool material (i.e. immediate use and discard). This third trend is considered throughout this research.

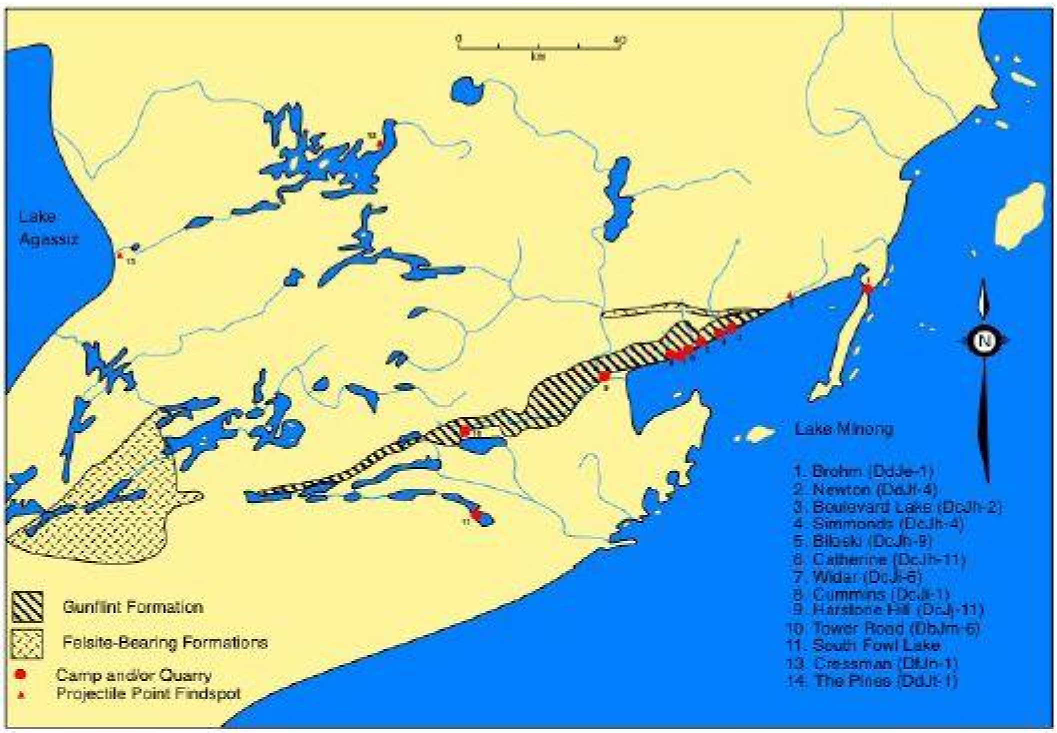


Figure 3-2: Gunflint Formation and Lakehead Complex site distribution.
Migration routes heading north into the peninsular would have encountered the Gunflint Formation early on. Modified after Fox, 1975 and Bennet, 2014.

3.2 Lakehead Complex Subsistence

Before discussing the subsistence strategy of the Lakehead Complex, it is important to consider earlier hunters in North America. Prior to deglaciation in Northwestern Ontario, Plano cultures across the American plains hunted big game species and megafauna, such as bison and mastodons. More generalized, lower risk subsistence methods, such as fishing, small game hunting and foraging, occurred in areas lacking an abundance of large game (Kuehn, 1998; Kelly & Todd, 1998; Hill, 2007). Mastodon and other megafauna were extinct by 10,000BP (Meltzer & Mead, 1983; Martin & Klein, 1984) and changing environmental conditions restricted the range of bison, forcing cultures to adapt to other subsistence strategies (Frison, 1998; Hill, 2007). Early Paleoindian occupation, characterised by fluted point typologies is not present in the archaeological record of the study area, but was present to the south and west of Lake Minong where fluted points were recovered from the Reservoir Lakes area of Northwest Minnesota (Ross, 1995), and the Assiniboine Delta, along the west flanks of glacial Lake Agassiz (Boyd, 2007). Bennet (2014) identified common features in the reduction technique of Clovis and Lakehead Complex lithic assemblages (e.g. oblique overshot flakes). This suggests a continuation of lithic reduction strategies from the Early Paleoindian period into the Late Paleoindian period (Bennet, 2014). In all likelihood, the Early Paleoindian tradition ended before the study area became habitable.

The focus of early pioneers in the Lakehead region was on acquiring basic needs for survival (e.g. food, water, clothing and shelter). Water is obviously abundant, but our understanding of how other needs were met is based on archaeologists' assumptions. As hunter-gatherers, food was acquired through hunting/fishing of wildlife and gathering edible or medicinal vegetation. The specifics (i.e. what species of plants and animal) remain largely unknown because of the decomposition of organic material. Archaeologists suspect that caribou played a significant role by providing meat for food, bone for tools, and hide for clothing and possibly shelter. The meat portion of their diet was likely supplemented with fish and small game

(Fox, 1975; Dawson, 1983). Residue analysis of organic material can answer these questions, or at least provide a stronger interpretation by introducing organic artefacts into the archaeological record.

The recovery of calcined caribou bone provides indirect evidence supporting a caribou-based subsistence strategy. Caribou antlers recovered from Steep Rock Lake near Atikokan, Ontario, produced a radiocarbon date of 11,400cal (9,940±120^{14}C) BP (Jackson, 1989), which supports the presence of caribou in the vicinity close to the time of early human occupation. Calcined caribou remains from the Cummins site provides the direct link between caribou and human activity (Julig, 1994). Opposing theories explore the possibility that environmental conditions were more favourable for bison than for caribou. Immunoassay results from artefacts recovered from the Cummins site (ca. 7,500BP) indicate positive results for blood residue from both the *cervidae* and *bovidae* families (Newman & Julig, 1989). However, at the time this approach was criticized for its inaccuracy and inability to replicate the results. This criticism, combined with the possible presence of both species, is unable to overturn the present paradigm.

3.3 The Interlakes Composite

Ross (1995) identified the Interlakes Composite based on shared characteristics between projectile point typology and other commonalities observed at widely scattered Paleoindian sites within the Agassiz-Minong Peninsula after deglaciation. Ross (1995) proposed that this reflected geographically discrete, but technologically and culturally related, groups of Paleoindian migrant populations who were moving northward into the Agassiz-Minong Peninsula (Figure 3-1). These groups include the Lakehead Complex, the Lake of the Woods/Rainy River Complex, the

Quetico-Superior Complex, and the Reservoir Lakes Complex. These complexes are differentiated by their preferred lithic material, but share certain traits regarding projectile point manufacture. Parallel oblique flaking, basal and lateral grinding, and morphologically similar lanceolate shapes are the most prominent characteristics shared by these Complexes. An additional connection between these Complexes is the use of Hixton Silicified Sandstone, a material originating in South-Central Wisconsin, which suggests some form of interaction. The limited amount of Hixton debitage recovered from these sites also suggests initial manufacturing closer to the lithic source (i.e. Wisconsin) before being transported (Ross, 1995).

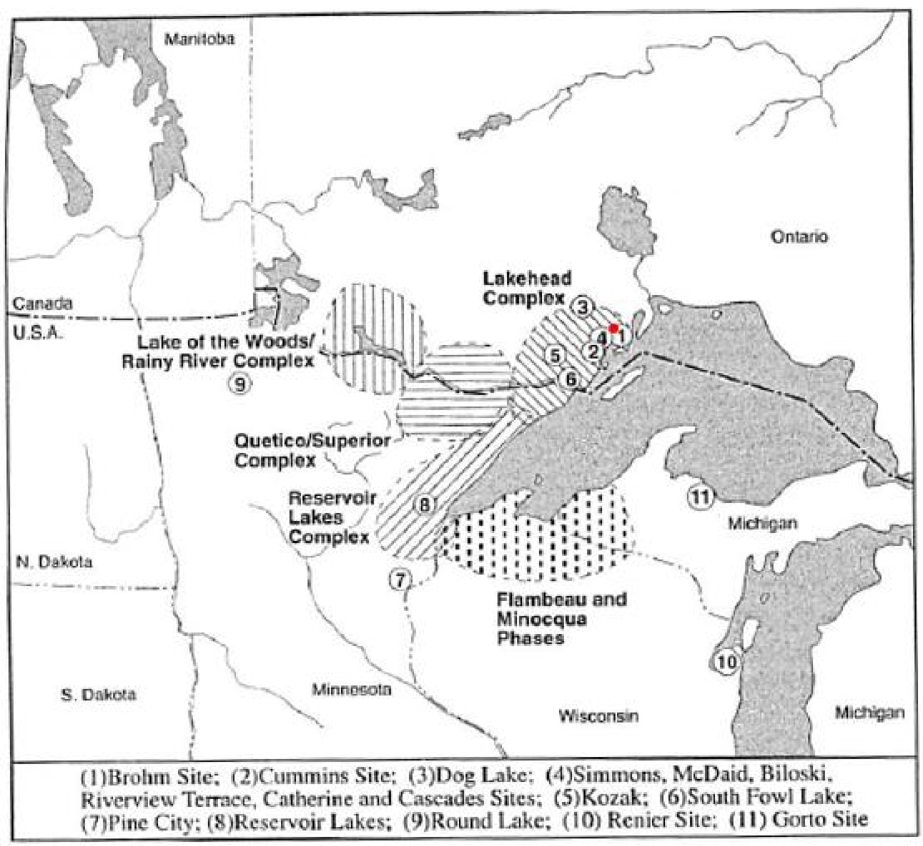


Figure 3-3: The Interlakes Composite.
Modified from Ross, 1995. The red dot represents the approximate location of the Mackenzie sites.

The Interlakes region encompasses the Mackenzie sites and the artefacts recovered from the site, feature characteristics diagnostic of the Lakehead Complex. This has led to the perspective that they also form part of the Interlakes Composite (Markham, 2012a; Bennett, 2014). Quartz and amethyst artefacts do not play a critical role in the archaeological definition of any of these groups. Few other Interlakes Composite sites have yielded quartz artefacts, and when they do they are often projectile points. The lithic assemblages attributed to the Reservoir Lakes Complex consists of about 3.2% quartz, a higher percentage than what is typically found at Lakehead Complex sites (Bakken, 2011). Both the Quetico/Superior and the Lake of the Woods/Rainy River Complexes are mostly derived from sparse surface finds. Four quartz points are attributed to the Lake of the Woods/Rainy River Complex (one of which was recovered from the Sandmoen site) and two can be attributed to the Quetico/Superior Complex (Mulholland, 2006; Reid, 1980). Only the Lakehead Complex has yielded amethyst artefacts. The use of quartz and amethyst at Lakehead Complex sites is discussed below.

3.4 The Lakehead Complex

The Lakehead Complex includes archaeological sites belonging to the earliest known inhabitants of the Lakehead region (Figure 3-2; Figure 3-4). These sites are characterized by their location on or near Lake Minong beach ridges or lithic outcrops, a raw material preference for Gunflint Formation varieties (e.g. taconite), and an assumed generalized subsistence strategy with emphasis on caribou (Fox, 1975). Lakehead Complex sites have also been discovered inland along major waterways (Fox, 1975; Hamilton, 1996). Fox (1975) argues that the Lakehead Complex is contemporary to the middle-late phases of Lake Minong, based on the close association of archaeological sites to the ancient beach ridges that date to 9,380 ± 150BP and an elevation of 230m asl (Boyd, et al., 2012). Sites situated away from the shoreline are generally located along the Gunflint Formation near taconite outcrops or secondary lithic deposits (Fox, 1975).

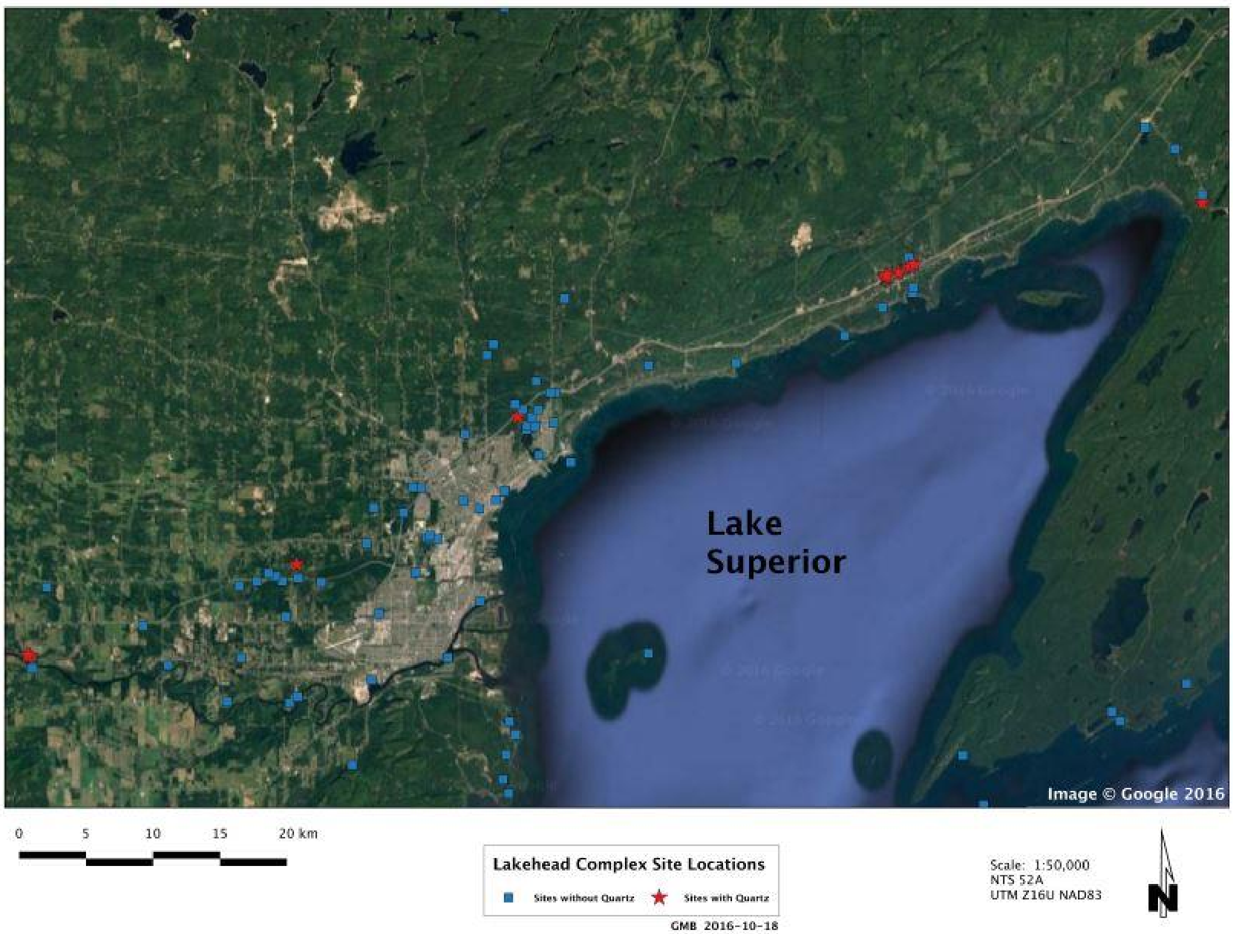


Figure 3-4: Lakehead Complex site distribution.
Map showing the distribution of Lakehead Complex sites in the Thunder Bay area. Sites containing quartz are in red and are (from West to East): Kam Delta Survey (DcJj-23, DcJj-22), Cummins (DcJi-1), Simmonds (DcJh-4), Woodpecker I-III (DdJf-11, DdJf-12, DdJf-14), RLF (DdJf-13), Mackenzie I (DdJf-9), Mackenzie II (DdJf-10), and Brohm (DdJe-1-). Map courtesy of Gjende Bennett.

Formal tools are often bifacially knapped and parallel oblique flaking (i.e. long, thin flakes stretching across the width of the artefact) is common (Bennet, 2014; Fox, 1975). Projectile points are lanceolate in shape and basal-lateral edge grinding is present. The latter characteristic is common on Paleoindian formal tools and is considered indicative of Paleoindian formal tool manufacture (Hinshelwood & Weber, 1987; Julig, 1994; Markham, 2012a). Bennet (2014) identified two types of lithic reduction. The thicker pieces of mixed or poor quality material were reduced by standard bifacial reduction techniques, while the thinner, higher quality flakes were reduced to produce blades. Their approach to the material suggests (as is expected considering their almost exclusive preference for the material; Fox, 1975) a great familiarity with Gunflint Formation material (e.g. taconite, gunflint silica), which is showcased by their ability to produce complex tool morphologies from difficult and often flawed material. The aspects that make taconite a difficult material to work are similar to quartz (e.g. flaws and early stage fragmentation), but the materials are still vastly different to work and likely explains why quartz use is largely isolated to areas where it is naturally abundant. Quartz use is more common during the Archaic period in the region when cultures begin to more frequently use material (e.g. chert, quartz) other than taconite (Fox, 1975). Quartz use also increases greatly in Minnesota during the Archaic period (Bakken, 2011; Mulholland, et al., 2011).

3.5 Interpretations of Quartz Use by the Lakehead Complex before the Mackenzie Excavations

The Lakehead Complex relied heavily on taconite, gunflint silica and Knife Lake siltstone (Fox, 1980). The overwhelming presence of these materials overshadows other lithic material (e.g. quartz and amethyst, other cherts). Currently, there is little documentation of quartz use by the Lakehead Complex. Prior to the excavation of the Mackenzie sites and the Highway 11/17 project, very few quartz artefacts were recovered (Table 3-1). The Brohm site has the highest frequency of quartz artefacts (n = 88; 2.78%), including two unifacial scraping tools (Hinshelwood, 1990; Julig, 1994). Other sites only feature a handful of quartz artefacts and only one amethyst artefact has been attributed to the Lakehead Complex; an amethyst pendant recovered from the Cummins site (Julig, 1994).

Table 3-1: Lakehead Complex quartz prior to the Mackenzie sites.

Site	Vein/Crystal Quartz	Amethyst	Quartz Total	Lithic Total	%	Tools	References[1]
Brohm (DdJe-1)	88	0	88	3,160	2.78	1	1, 2
Cummins (DcJi-1)	0	1	1	2,268	0.04	0	2, 3
Simmonds (DcJh-4)	-	-	-	-	0.15	-	4
Kam River Delta sites (DbJi-5 to 9; DcJi-18 to 32; DcJj-15 to 27)	2 From: DcJj-22 DcJj-23	0	2	633	0.32	0	5

Sites without any known quartz artefacts are not listed. Julig (1994) lists 39 identified sites and Bennet (2014) provides the most updated list of Lakehead Complex sites. The table above only lists those with quartz.
[1]References: 1) Hinshelwood, 1990; 2) Julig, 1994; 3) Dawson, 1983; 4) Halverson, 1992; 5) Hamilton, 1996

3.6 The Mackenzie Sites and the Mackenzie I Site

This research focuses on the analysis of quartz and amethyst artefacts from the Mackenzie I lithic assemblage. The Mackenzie I site dates to ca. 9,000BP and is one of six recently (2010 – 2012) excavated archaeological sites (the Mackenzie sites) located approximately 20km northeast of Thunder Bay, Ontario. These sites represent the earliest occupation period in the region, and include the Mackenzie I site, the Mackenzie II site, the RLF site, and the (Electric) Woodpecker I-III sites. The Woodpecker sites, clustered tightly together, are situated approximately 1.2km west of the Mackenzie River. While there are no completed excavation reports for the Woodpecker sites to date, an ongoing study of unifacial tools from Woodpecker II provides comparative insight into these sites (Hodgson, 2016; Hodgson, 2017). The RLF site is a small, relatively undisturbed site located approx. 0.7km west of the Mackenzie River (Langford, 2015). The Mackenzie II site is located on the eastern bank of the Mackenzie River (Norris, 2011).

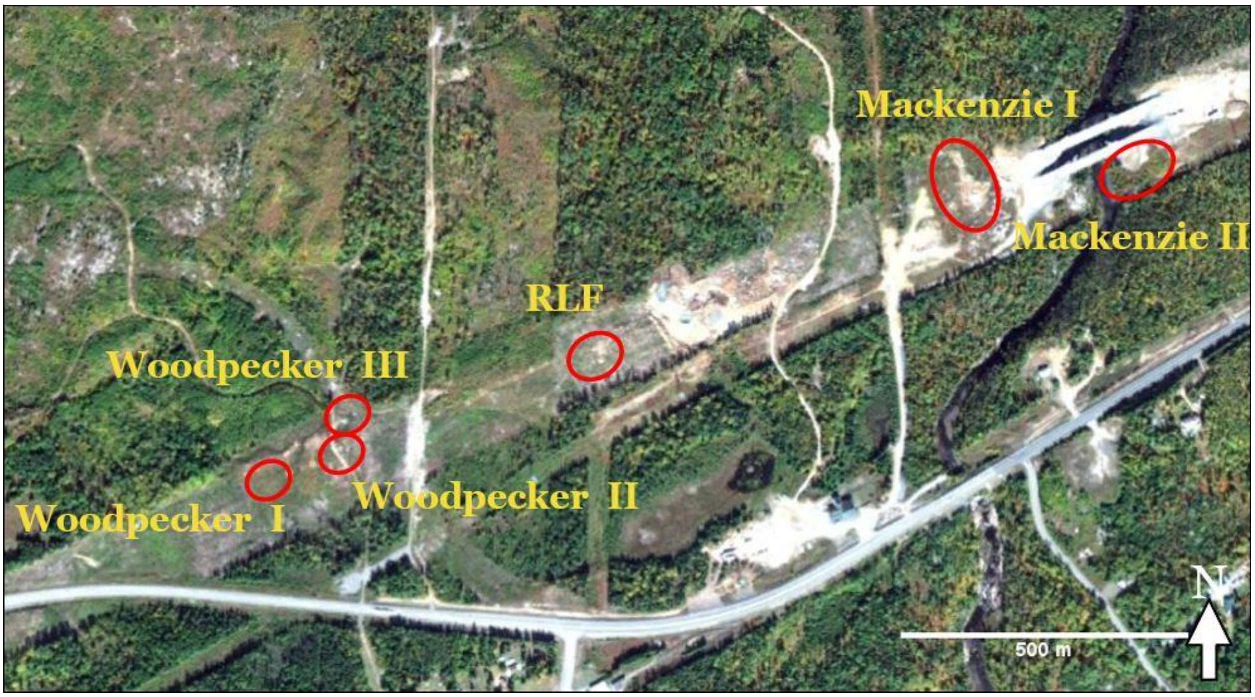


Figure 3-5: The Mackenzie sites

The Mackenzie I site is located on the upper edge of the western bank of the deeply incised Mackenzie River. This site has proven to be rich in formal tools, particularly projectile points, and is the largest site excavated ($2539m^2$) in the region for this period (Bennett, 2014; McCulloch, 2015; Markham, 2012a). This site is unique for producing a significant number of tools and tool preforms. Debitage patterns and artefact recovery suggest repeated occupation of the site and evidence for multiple activities (Bennett, 2014; McCulloch, 2015). These activities include, but are not limited to, domestic habitation, meat and hide processing, and the manufacture of stone tools (McCulloch, 2015). Additionally, the Mackenzie I site contains the highest number of quartz and amethyst artefacts from a Lakehead Complex site to date.

3.6.1 Quartz Use at the Mackenzie I Site

The quartz component of the Mackenzie I lithic assemblage is a small portion (<2%) of the overall assemblage, but consists of 6,452 artefacts. Despite its small relative frequency, the high number of quartz and amethyst artefacts dwarf that of any other quartz assemblage from a Lakehead Complex site. This presents the ideal opportunity to select artefacts for analysis from a much larger suite of materials. The following section details the presence of quartz in the study area, field collection strategies that were employed, and the method and limitations of artefact identification in the catalogue.

3.6.1.1 Presence of Quartz in the Study Area

The area surrounding the Mackenzie River is a common location for contemporary amethyst hunters to indulge their hobby. The area is rich in surface and river deposits of quartz and amethyst, and is likely why so many quartz and amethyst artefacts were recovered from the Mackenzie I (and Mackenzie II) site. Outside of the Mackenzie sites, the only other Paleoindian assemblage with similar characteristics is the Brohm site, which also benefits from the abundance of nearby quartz. Although the source of the material is not known, the material likely originates from nearby bedrock sources and from waterworn deposits.

3.6.1.2 Field Strategies

The Mackenzie I site was excavated between 2010 to 2011 by Western Heritage Inc. following the *Ontario Standards and Guidelines for Consultant Archaeologists* (MTCS 2011) for Stage 4 excavations. The block excavation used $1m^2$ units divided into quadrants and excavated by 5cm levels. Using 5cm levels and dividing the units into four quadrants greatly increased the spatial resolution of the units while working within the time constraints of cultural resource management (CRM) archaeology. In addition, the sandy soils made stratigraphic excavation impractical (see Shultis, 2012). Artefacts were bagged by quadrant, level, and unit to maintain this resolution (Bennett, 2014; McCulloch, 2015).

Recognizing the difficulty in identifying quartz and amethyst flakes and formal and expedient tools in a field context, Western Heritage employed a full collection strategy for these materials. This also reflects consideration of the variable level of training and experience of the crew members employed on the project. Whether intentionally or not, this follows the guidelines used in Northern Scotland where quartz is a common material (Warren & Neighbour, 2004; Ballin, 2008). This approach results in the collection of natural fragments of quartz and passes the responsibility of authenticating the artefacts to the lab technicians. While going through the Mackenzie I collection to determine the study sample, it was noted that clearly waterworn pebbles remained part of the assemblage, something consistent with the field collection strategies employed by Western Heritage. Throughout the analysis this issue has been addressed, with care taken to identify non-artifacts and remove them from further consideration. This culling process is reflected in the numbers presented here.

3.6.1.3 The Assemblage

Table 3-2: Mackenzie I quartz component.

Artefact Type	Quartz Artefact Total	Assemblage Total	Percentage of Quartz
Core	56	460	12.17%
Debitage	4,039	261,717	1.54%
Microdebitage	2,039	70,840	2.88%
Other lithic	278	348	79.89%
Preform	2	417	0.48%
Tool	38	1,919	1.98%
Total	**6,452**	**335,701**	**1.92%**

Quartz and amethyst artefacts are included under quartz. Some artefact classes are missing from the table.

Table 3-3: Mackenzie I identified tools and preforms.

Tools and Preforms	Quartz Artefact Total	Assemblage Total	Percentage of Quartz
Biface (Stage 1-5)	8	979	0.82%
Drill	1	97	1.03%
Perforator	2	4	50%
Projectile	3	481	0.62%
Retouched Flake	20	448	4.46%
Scraper	4	88	4.55%
Undetermined Tools	2	29	6.90%
Total	**40**	**2,336***	**1.71%**

Quartz and amethyst artefacts are included under quartz. Some artefact classes are missing from the table.
*Only categories with quartz and amethyst tools and preforms are shown. The total amount for assemblage tools represents the actual total, not the total of values displayed here.

Table 3-4: Quartz and amethyst tools vs. lithic assemblage tools.

Tool Type	Quartz Totals	Amethyst Totals	Assemblage Total	Percentage of Quartz and Amethyst
Biface (Stage 1-5)	6	0	853	0.70%
Drill	0	1	67	1.49%
Perforator	0	2	4	50%
Projectile	3	0	294	1.02%
Retouched Flake	20	0	448	4.46%
Scraper	3	1	75	5.33%
Undetermined Tools	0	2	15	13.33%
Total	**32**	**6**	**1,919***	**1.98%**

*Only categories with quartz and amethyst tools and preforms are shown. The total amount for assemblage tools represents the actual total, not the total of values displayed here.

Cataloguing the lithic assemblage is only recently completed. This analysis was conducted using the earlier incomplete catalogue, and therefore may exhibit some limitations. However, at the time of analysis, a substantial portion of all the recovered artefacts had been catalogued (an estimated 85% based on box counts) allowing for analysis to occur. Despite the incomplete status of the catalogue, all available quartz and amethyst artefacts were included in the selection process used to generate the analytical sample (see Chapter 5). The CRM catalogue (see Table 3-2, Table 3-3, and Table 3-4 for various breakdowns of the catalogue) is simply a guide for artifact quantity and will act as a comparison to highlight the increase in available data when functional analysis is taken beyond artefact morphology and the identification of retouch to include more in depth residue and use-wear analysis. Cataloguing technique used the same identifying terms for macrocrystalline and microcrystalline materials, although quartz artefacts were catalogued accounting for differences between the materials.

3.7 Use of Quartz by the Lakehead Complex after the Mackenzie Excavations

With the completion of the Mackenzie excavations, our understanding of the role of quartz within the Lakehead Complex's lithic tradition has changed, although not drastically (see Table 3-1 and Table 3-5). There is a higher number of quartz artefacts (n = 5,009) and more amethyst artefacts than ever encountered on a Lakehead Complex site (n = 1,448). However, it should be remembered that proportionally the Mackenzie I site (quartz = 1.92%) does not differ greatly from the Brohm site (quartz = 2.78%). What is particularly interesting regarding the Mackenzie sites is the much higher percentages of quartz and amethyst artefacts at Mackenzie I and II, which are located along the river. Either many geofacts (unaltered, naturally occurring pieces) remain in the catalogue, or the material is collected from the river for immediate use.

When comparing Table 3-1 and Table 3-5, the most obvious relationship between the presence or absence of quartz at Lakehead Complex sites is the geographical location. Apart from a handful of artefacts, all the quartz and amethyst artefacts attributed to the Lakehead Complex have been recovered from the Mackenzie River – Sibley Peninsula region (Figure 3-4). Even then, quartz often comprises less than 5% of the total lithic artefacts recovered and continues to play a minor roleTable 3-2: Mackenzie I quartz component. . However, the excavation of the Mackenzie sites more than doubled the number of Lakehead Complex sites with quartz artefacts.

Table 3-5: Quartz and amethyst artefacts and tools at the Mackenzie sites.

The Mackenzie Sites	Quartz	Amethyst	Quartz Total	Lithic Total	%	Tools	Reference[1]
Mackenzie I (DdJf-9)	5,009	1,448	6,457	336,589	0.92%	29	
Mackenzie II (DdJf-10)	216	32	247	5,057	0.88%	0	1
RLF (DdJf-13)	13	4	17	14,742	0.12%	0	2
Woodpecker I (DdJf-11)	16	0	16	18,843	0.08%	0	3
Woodpecker II (DdJf-12)	221	28	249	139,817	0.18%	-	3
Woodpecker III (DdJf-14)	81	4	85	31,678	0.27%	-	3

Quartz total includes amethyst.
[1]References: 1) Norris, 2011; 2) Langford, 2015; 3) Western Heritage Report, n.d.

The important implication of these recent findings is the confirmation of quartz as a secondary lithic material for the Lakehead Complex. With multiple sites containing a low quartz frequency in the same location, it can be concluded that quartz is used as a pragmatic lithic material. Often, this is referred to as an ‘expedient tool material’, a designation frequently applied to quartz artefacts. Expedient tools are fashioned quickly for immediate use and discard, and consist of unmodified flakes. Quartz is often used in an unmodified state and therefore is automatically considered expedient. This generalization, however, overlooks the possibility that although the artefact is simple to produce, it may not be immediately discarded and more effort may have been taken in hafting the implement. Applying a generalized term to this material overlooks the difference in the material itself. That is not to say that quartz artefacts cannot be expedient tools, as many are, but rather that quartz should be first considered outside of the expedient umbrella.

The term 'pragmatic' is applied here because it implies that the material is used as efficiently as it allows. This is a term that has been used by Scandinavian archaeologists when discussing the lithic reduction method in quartz-rich areas of Sweden (see Chapter 2). Here it is applied to quartz tools. Quartz fractures differently than cryptocrystalline material, such as taconite (Callahan, et al., 1992; Knutsson, 1998; Lindgren, 1998). It tends to fracture unpredictably during reduction because of internal faults, and can only receive a small amount of modification (de la Pena, et al., 2013). Unless very high quality quartz is used, knappers cannot overwork the material (i.e. hammer the material too many times or risk fragmentation). This results in a simpler tool kit, but not necessarily one to be immediately discarded after use.

3.8 Summary

In summary, the Mackenzie I site is an excellent case study to analyze quartz and amethyst artefacts belonging to the Lakehead Complex. This material is not well understood for this period, particularly since the Brohm site had the only significant quartz presence prior to the Mackenzie excavations. In addition, the Mackenzie I site has an incredibly high number of quartz artefacts (n = 6,452). It is also the only site in the area with an abundance of amethyst artefacts that may have served as a functional implement rather than having a purely symbolic or decorative purpose.

The use of quartz appears to be concentrated in the Mackenzie River – Sibley Peninsula region where quartz and amethyst are commonly found. This suggests that the material is used out of convenience and likely as an expedient tool. Although this term should be used with caution when referring to quartz. Quartz cannot be worked as intensively as cryptocrystalline and microcrystalline material, resulting in more basic tool morphologies. This does not imply that the tools are discarded after use because of their simplistic nature, hence the term pragmatic.

4 Methodology – Combining approaches

The purpose for this research was to understand how the Lakehead Complex used quartz (and amethyst) as a functional material. As discussed in Chapter 2, many researchers focused their investigation on quartz reduction methods (Callahan, et al., 1992; Driscoll, 2010; Bisson, 1990; Flenniken, 1981; Tallavaara, et al., 2010; Ballin, 2008). Understanding the reduction sequence of quartz artefacts could indicate how familiar the Lakehead Complex knappers' were with producing quartz tools. Other researchers have focused on sourcing quartz (ten Bruggencate, 2013; ten Bruggencate, et al., 2013; ten Bruggencate, et al., 2014; Ballin, 2015), which can indicate the value of the material based on the distance between the source and where it was deposited. Although reduction analysis and lithic sourcing could both add valuable data to this study, the scope of the project is focused on use-wear and residue analysis.

Residue and use-wear analysis were used in a multi-analytical approach to identify quartz artefacts that showed signs of use. Emphasis was placed on residue analysis to interpret the source material of the residue (i.e. what the artefacts were used on), while use-wear indicates the mode of use (i.e. how artefacts were used). This methodology has demonstrated how easily some utilized artefacts could be missed through conventional cataloging methods, since even seasoned archaeologists may have difficulty identifying quartz artefacts (Driscoll, 2011). Collecting function-related data provided valuable insight into activities undertaken at the Mackenzie I site and quite possibly indicate whether quartz was chosen for a specific purpose. This introduced the post-processual notion of using archaeological analysis to make interpretations beyond the materialistic remains that are recovered. Although it will be difficult to make any comparative conclusions until the other lithic materials at the Mackenzie I site are similarly analyzed, the most important aspect of this approach was the introduction of new data to the site record. While both use-wear and residue analysis introduced new lines of evidence to interpret activity areas, residue analysis also introduced organic "artefacts," which were otherwise lost to the acidic soils of boreal forest environments.

The following sections explain the methodology used to collect the data. Data collection involved the sampling strategy, the analytical techniques used, and the order in which these techniques were performed. Both the procedure and decision behind each step are detailed in this chapter. In following chapters, the effectiveness of each step is discussed and the entire approach is critiqued overall.

4.1 Sampling Strategy

All the artefacts examined in this study were recovered from the Mackenzie I site (DdJf-9), a pre-contact site dating to ca. 9,000BP. Located approximately 20km northeast of Thunder Bay, Ontario, the Mackenzie I site is one of six sites situated along the shoreline of glacial Lake Minong near the Mackenzie River that were excavated as part of a CRM project by Western Heritage. Excavations at the Mackenzie I site occurred in 2010 and 2011 and involved many archaeologists and local First Nations (approximately 80 individuals combined). Due to the unpredicted extent of the site, as well as the resulting budget and time constraints, cataloguing was incomplete until the end of 2016. However, many artefacts including quartz and amethyst were catalogued, allowing for detailed analyses to occur (Bennett, 2014; Markham, 2012a; McCulloch, 2015). Although these artefacts were not a true representative sample of the site – due to the incomplete catalogue – only around 1,500 quartz and amethyst artefacts were missing from the catalogue or stored in offices outside of Ontario (i.e. 1,500 quartz artefacts were identified and catalogued from the Mackenzie I site but were not included in this analysis as they were stored elsewhere and not available for inclusion). In addition, by treating each artefact as site (see Loy, 1993), valuable information could still be gathered regardless of sample circumstances.

Due to the difficulty of identifying quartz artefacts and the more rigid typological requirements that can constrain Paleoindian tools in North America, all quartz and amethyst artefacts available were considered in the sampling strategy. Western Heritage employed a 'total collection strategy' for collecting quartz and amethyst providing an ample supply of artefacts, both anthropogenic and natural, to sort through. The following sections describe the process that began with the complete lithic assemblage and ended with a small, specific collection of artefacts (Figure 4-1).

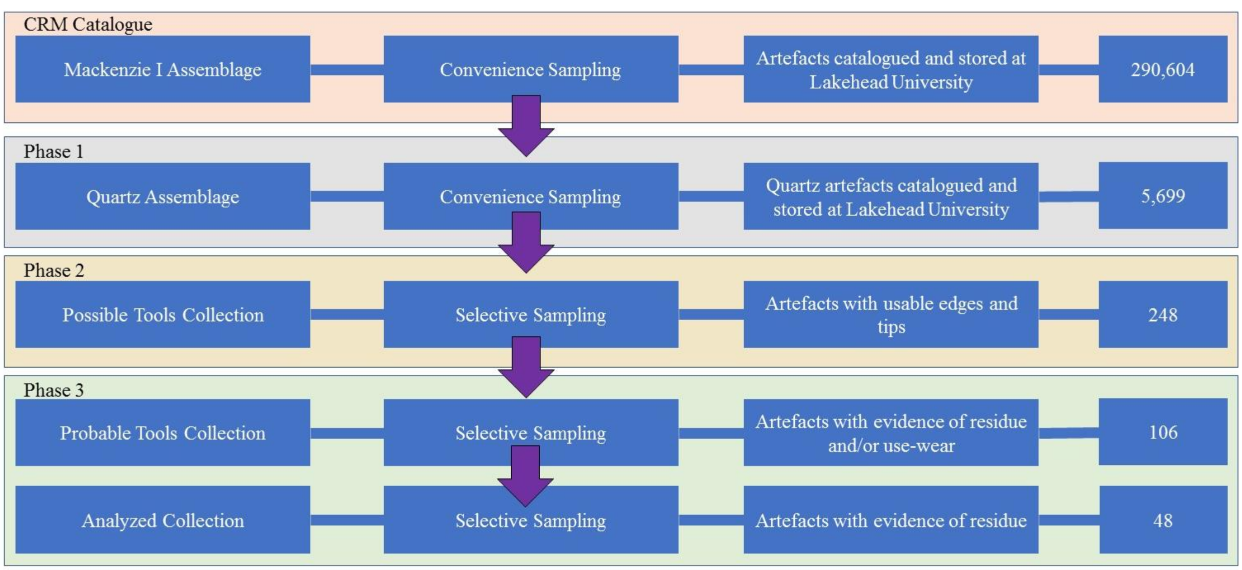


Figure 4-1: Sampling strategy.
Artefact counts for each assemblage collection are included here to demonstrate how the process reduces the artefacts to size manageable for analysis.

4.1.1 Phase 1 – The Quartz Assemblage

At the time this project began, most of the catalogued Mackenzie I assemblage was stored at Lakehead University. This allowed for the collection to be rigorously studied and analyzed through time intensive examination of all the artefacts by a single analyst to maintain consistency in artefact selection. Quartz artefacts – particularly tools – are difficult to identify (see Driscoll, 2010). Therefore, rather than selecting the artefacts from the CRM catalogue, all quartz and amethyst artefacts were directly examined to produce the quartz assemblage for analysis. At the time this process began, the catalogue consisted of 290,604 lithic artefacts; 5,700 of which were identified as either quartz or amethyst (see Table 3-2 for final catalogue values). Although quartz did not comprise a substantial portion of the assemblage (roughly 2%) it did provide a higher number of artefacts than at any other Lakehead Complex site in the area and provided for a large population to sample for the quartz assemblage.

Different sampling strategies (convenience and selective) were employed to deal with the circumstances surrounding the state of the collection (Figure 4-1). Convenience sampling (phase 1) was chosen out of necessity to define the parameters of the catalogued quartz and amethyst artefacts in the Mackenzie I assemblage. The quartz assemblage was defined by those artefacts that were catalogued and stored at Lakehead University, and therefore accessible. Selective sampling (phase 2 and 3) was applied to the available collection of artefacts to produce a study set of artefacts more likely to test positive for residue and use-wear (i.e. useable edges or tips were required). The specific steps used are elaborated upon below.

The catalogued artefacts were stored in separate bags that relate to their recovery location. Most CRM excavations require more efficient and expedient excavation protocols. The Mackenzie I site was excavated by one metre square units, divided into four quadrants and 5cm levels to improve resolution. Therefore, catalogued artefacts were stored in bags representing the quadrant, level, and unit that they were recovered. Phase 1 consisted of separating all quartz and amethyst artefacts from the rest of the lithic assemblage to produce the quartz assemblage.

4.1.2 Phase 2 – The Possible Tools Collection

The second phase serves two functions. Where phase 1 isolated the quartz artefacts by eliminating all other raw materials, phase 2 isolated quartz artefacts, specifically those with usable edges or points, from the rest of the quartz component (i.e. selective sampling). The second function was to categorize these artefacts based upon a broad typological system. The quartz artefacts were classified by edge type, as recommended in the literature (see references within MacDonald, 1997 and Spott, 2005). Although these edge types did not affect the analyzed assemblage, it allowed for more similar artefacts to be examined sequentially during the following phase (e.g. all artefacts with a straight edge were examined one after another because they shared similar morphological characteristics). This phase was conducted using macroscopic observations with the assistance of a low powered incident light stereomicroscope where required. Paleoindian artefacts can be subjected to rigid morphological requirements, a by-product of point typology playing such a key role in identifying different cultural groups. Researchers in Northern Ontario, such as Julig (1994), have broadened the definition of what constitutes a Paleoindian artefact, and academic and professional archaeologists have recognized the use of utilized flakes and other expedient tools in their cataloguing system. This study, although focused on a single raw material, will help to widen our understanding of the definition of Paleoindian tools.

The artefacts selected in phase 2 were photographed and documented prior to phase 3 using a Canon Eos Rebel T5 DSLR camera with a stock 18-55mm lens. A white canvas screen is used to reduce the reflectivity of the artefacts when applicable. Photographing each artefact at this stage allowed for additional inspection of the artefact to recognize morphological features and signs of potential use.

4.1.3 Phase 3 – Producing the Analyzed Collection

Phase 3 represents the first stage of detailed analysis but was included within the sampling process because only a selection of the artefacts was further analyzed. All artefacts from phase 2 were examined using LPILM (magnification<100x) to identify the presence or absence of residue and/or use-wear. Rather than using a traditional microscope, the same camera from phase 2 was equipped with a 40mm macro lens and multiple lens extension tubes (12mm, 20mm, and 36mm to equal 68mm total) for photographic documentation and investigation. Although the result was a camera with only 20x magnification, built in software allowed for a greater depth of field while viewing and an even greater depth of field after the photograph was taken because of automatic stacking capabilities. The lower magnification was acceptable because the purpose of this phase was to scan for potential tools by the presence of use-wear or residue rather than characterizing the use-wear or residue.

Artefacts were then placed into two categories: included or rejected. The category of included artefacts consisted of artefacts with possible residue and/or use-wear and was referred to as the probable tools collection. This category was then divided into residue and use-wear categories. The residue analysis in this research was then performed on a subset of artefacts, the analyzed collection, which were those assigned to this residue category. This study focused primarily on the residue aspect of the combined methodology. Therefore, any artefacts displaying residue were assessed for use, which may be used to support the interpretations. Verifying that the artefact was used strengthens the origin of the residue as anthropogenic. Also, because this study focused primarily on residue and analyzing use-wear where residue was present, artefacts with both residue and use-wear were included, while artefacts with only potential use-wear were not analyzed further.

4.2 Analytical Methods for Residue Analysis

Combining analytical methods required a methodological approach to be determined (i.e. the order in which techniques were used to analyze the artefacts). This decision ultimately depended on the specific techniques used within each methodology and what impact each step would have upon subsequent methods. Residue techniques were performed first because residue adheres to the artefact's surface, while use-wear scars were located on the artefact's surface. Therefore, the adhering residue would obscure evidence of use-wear and must first be addressed.

It is a common practice of use-wear analysts to clean the artefacts before analysis so that evidence will not be obscured (Broadbent & Knutsson, 1975; Derndarsky, 2006; Sussman, 1988; Sussman, 1985; Taipale, 2012). Rather than clean the artefacts for a singular purpose (i.e. use-wear analysis), artefacts should be cleaned with the dual purpose of preserving residue for analysis as well as to fully reveal the surface topography of the tool.

The following sections outline each of the methodological steps in the order they were performed; this order was determined through a study of the literature and the specific circumstances of the study sample. This section focuses on the residue methodology, while the following section (4.3) explains the use-wear methodology.

4.2.1 Multi-Method Approach to Residue analysis

Veall and Matheson (2014) advocate for a multi-method approach to residue analysis, using a variety of the techniques listed in Table 4-1 to acquire an interpretation. Each method available has its own strengths and weaknesses and an understanding of these traits allows an analyst to more accurately and consistently identify archaeological residues. However, this multi-method approach when executed fully, requires extensive experience and accessibility to a wide variety of techniques and laboratory equipment.

Table 4-1: Residue techniques – three basic divisions

Pre-Removal Techniques (*In Situ* Analysis)	Ultraviolet Luminescence *In Situ* High Power Incident Light Microscopy *In Situ* Scanning Electron Microscopy
Removal Techniques	Dry vs Spot vs Soak vs Sonication Water vs Solution vs Mixture
Post Removal Techniques (Characterization)	Biochemical Tests Gas Chromatography Mass Spectrometry High Power Transmitted Light Microscopy Histological Staining

Adapted from Veall and Matheson, 2014.

The best way of organizing the residue methodological process was to divide the techniques into three categories focused around residue removal. The rationale behind this process was to start with the least destructive, more descriptive methods and work towards the more analytical and quantifiable. The removal process is destructive and it is critical to be as detailed as possible prior to this step. Therefore, all qualitative analyses must be complete with confidence before proceeding to the chemical analysis of the residue. Table 4-1 groups the techniques used in this study into their respective categories: pre-removal techniques (*in situ* analysis, characterization), removal techniques, and post- removal techniques (biochemistry, characterization; see Veall and Matheson, 2014).

Throughout this process, a series of six questions were asked to confidently reach an appropriate level for residue interpretations (Figure 4-2). The first question asks whether residue is present or absent. If present, a residue can clearly be observed adhering to the surface of the artefact. With quartz, precaution must be taken against identifying inclusions within the transparent material as a residue.

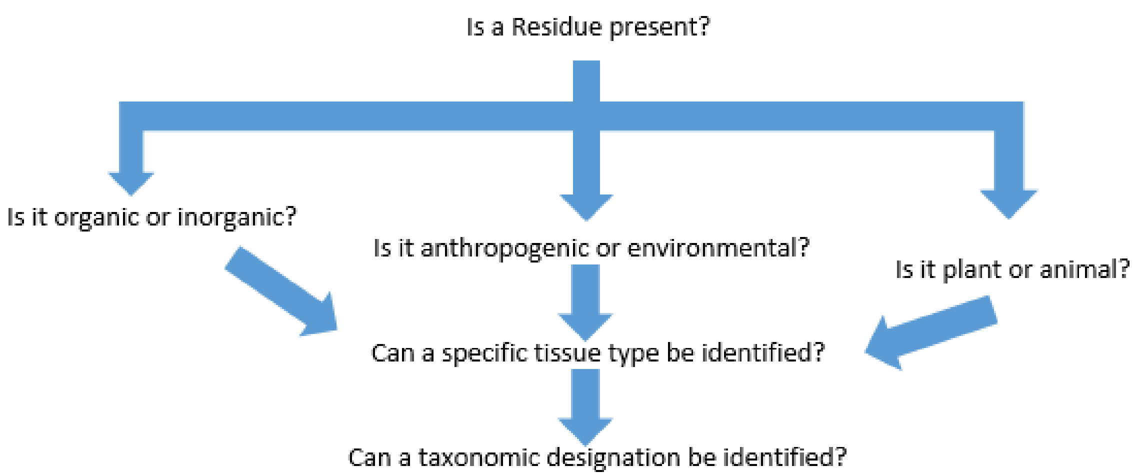


Figure 4-2: Inquisitive process for residue.
Adapted from Veall and Matheson, 2014.

Once the presence of residue was established, three critical and basic questions were addressed: was it organic or inorganic, anthropogenic or environmental, and was it plant or animal (see Figure 4-2). Organic residues were more likely derived from human activity/processing, but could also be environmental contamination. Inorganic residue was likely the matrix sticking to the surface of the tool, but could also be an inorganic ingredient during processing (e.g. the use of ochre as a binding agent). The most important of these questions was whether the residue was anthropogenic or environmental. If the residue was an environmental contaminant, then it was not of immediate interest. Environmental contaminants can be identified in soil samples collected from the excavation unit/level, thereby limiting the chance of incorrect interpretations. In addition, the distribution of the residue was important for this interpretation. Manufacture related residue (e.g. hafting related residue) would likely be located on the hafting end of the tool (i.e. opposite the working edge or edge not suitable for use) and nowhere else. Use-related residue would be concentrated around the working edge, but depending on the source material, the distribution could be broader. Both residues would be distributed on the ventral and dorsal surface of the artefact. Uni-surface distribution, although possibly a result of taphonomy, raises doubts regarding the anthropogenic nature of the residue (e.g. dead bison hypothesis). The third question, plant or animal, was the first means of identifying the type of residue and inferring the function of the artefact (i.e. was it used for animal processing, plant processing, or both?).

The final two questions represented the ideal interpretive level of residue analysis. If a specific tissue was identified, the residue's origin could be more confidently and specifically identified. The taxonomic designation was the pinnacle of residue identification, which indicated the specific plant and allows for the most complete and confident interpretation. See Table 4-2 for an example of this process.

Table 4-2: Example of the inquisitive process.

Question	Observation
1 – Is Residue Present?	Yes. There is an amorphous residue that is clearly not part of the lithic material.
2 – Is it Organic or Inorganic?	Organic. The residue in question is has no distinct shape or structure to its components that suggest it is inorganic.
3 – Is it anthropogenic or environmental?	Anthropogenic. The residue is found across the tool but is concentrated along the suspected working edge suggesting more frequent contact.
4 – Is it Plant or Animal?	Plant. Cellulose fibres embedded in the residue suggest it is plant based, unless plant fibres encountered the residue after it where used. However, the fibre is clearly embedded and suggests a relation between it and the residue.
5 – Can a specific tissue be identified?	No. The amorphous shape of the residue makes specific identification difficult. No distinct cell structures are visible. Chemical analysis is required to more accurately interpret the residue.
6 – Can a taxonomic identification be identified?	No. Chemical analysis is required to more accurately interpret the residue.

The methodology follows a specific order of operations (Figure 4-3). These are the same methods listed in Table 4-1, but organized to show the progression of the data collection and to include the placement of use-wear methodologies. The use-wear methods are discussed in chapter 4.3. The following sections summarize the residue techniques that were applied, in order from pre-removal, removal, to post-removal methods.

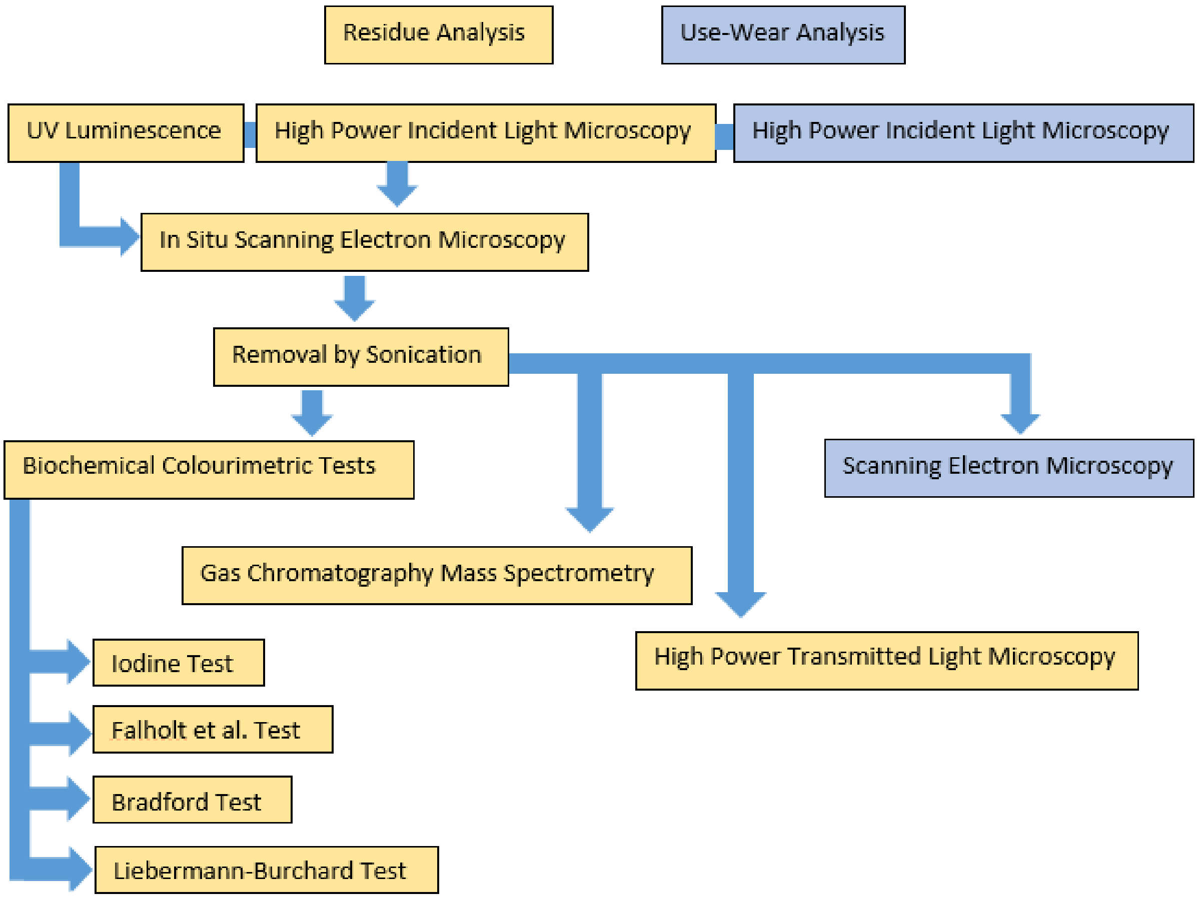


Figure 4-3: Multi-analytical approach to residue and use-wear analysis.

4.2.2 Ultraviolet Luminescence

Ultraviolet luminescence (UVL) was used to expose residue that is otherwise invisible to the unaided eye. Long wave UV light (265nm) is used in a dark room to scan the surface of the tool. Certain residues fluoresce, thereby exposing additional residue to record. This technique has the potential to identify utilized artefacts and account for residue characterized by post-removal methods. For this study, however, this technique was only used to map residue that may otherwise go unnoticed. The UVL is still being studied for the application of residue identification based on which colour the residue fluoresces.

4.2.3 High Power Incident Light Microscopy

High power incident light microscopy (≥100x; HPILM) was multi-purpose, but most importantly, it allowed the analyst to confirm the presence of residue. When residue was confirmed on the surface of the artefact, HPILM was used to describe, characterize, categorize, and record the location of residue on the artefacts. This information becomes invaluable during interpretation. The location of the residue on the artefact may suggest whether it was related to tool manufacture (e.g. hafting) or use related (e.g. animal or plant processing). Residue categorization increased the effectiveness of chemical characterization by allowing positive chemical results to interpret other residues sharing the same qualitative characteristics. Artefacts were not analyzed further in this study when residue was not confirmed.

An Olympus BX-51 research microscope, in conjunction with an Olympus DP 70 camera, was used to record any findings. A 10x optical lens and 10x, 20x, and 50x long working distance objective lenses were used to achieve high power magnifications. The micrographs produced were Z stacked using Image Pro software to produce images with an extended depth of field. Areas of greater potential, identified by LPILM, received more attention. These areas include possible working edges, hafting areas, or where residue was observed.

4.2.4 Scanning Electron Microscopy (*In Situ*)

Scanning electron microscopy was used for both residue analysis and use-wear analysis. *In situ* SEM was used for producing high resolution images of archaeological residue. The time commitment and cost of SEM limited this approach to only those artefacts that required higher resolution images. These artefacts were identified during HPILM and were those where fibres or other features were observed embedded within the residue. Using SEM to image embedded fibers provides documentation on the association of the fibers with the residue on the surface of the artefact.

A standard practice of SEM is to coat samples in a thin layer of gold or carbon to reduce the charging. Charging affects the resolution image and resulting photographs. However, because the archaeological residue is still on the surface of the tool, coating was not employed. Instead, artefacts were examined uncoated, which results in more charging and lower resolution, but does not impact the residue.

4.2.5 Removal Strategy

Sonication was chosen as the removal technique for several reasons. One of the concerns raised by other researchers regarding quartz was that residue would not adhere well to the flat crystal surfaces (Delagnes, et al., 2006), indicating that there will likely not be enough residue to perform a spot removal. Since an ultrasonicator was available this method was chosen over simply soaking the artefacts in solution.

A tri-mixture of equal parts distilled water, acetonitrile, and ethanol was used as the removal solution (Cook, 2015). In his thesis, Cook (2015) describes the theoretical advantages of using this mixture. Acetonitrile and ethanol, as well as other organic solvents, effectively removed hydrophobic components of the residue (i.e. lipids) when mixed with water (Lin, et al., 2007). Water, when added to a solvent, increased the overall polarity of the solution, increasing the likelihood that oxidized organic compounds would dissolve. Ethanol was selected for its ability to dissolve resinous residues (Matheson & McCollum, 2014). Acetonitrile effectively dissolved fatty and amino acids, was low in toxicity (Mastovska & Lehotay, 2004) and was compatible with a range of analytical techniques, including gas chromatography-mass spectrometry (GC/MS). This made it an advantageous solvent to use when employing multiple methods.

Some researchers believe other solvents, such as dichloromethane, should be used instead of acetonitrile (see Evershed's work on removing organic residue from ceramic surface's; Evershed, 2008; Evershed, et al., 2008). However, dichloromethane, as well as other common solvents (i.e. chloroform and acetone), are not miscible with water and therefore lacks the advantage of being used in a tri-mixture. In addition, Lin, et al., (2007) have demonstrated acetonitrile was more effective than chloroform and ethanol, while Mastovska and Lehotay (2004) were concerned about the toxicity of dichloromethane and other chlorinated solvents. Cook (2015) also pointed out that the tri-mixture solution was used by biologists to study the same biomolecules as we study in organic residue analysis.

The tri-mixture solution was placed in glass vessels, the size of which was determined by the artefact. This practice allowed for more removals to occur simultaneously and reduced the amount of solution needed per removal, cutting down costs and limiting the degree of dilution. The specific section of the artefact (i.e. the working edge) was then submerged in the solution to preserve contextual information. The glass vessel, with solution and artefact, was placed in the water-filled basin of the ultrasonicator. The water transferred sonic waves from the ultrasonicator to the artefacts, but caution was used regarding the volume of water so that it did not spill over the edge of the glass vessels and contaminate the removal step. The ultrasonicator ran for 36 minutes. The resulting solution, the combination of the tri-mixture with removed residue, is now referred to as the post-removal solution.

4.2.6 Post-Removal: Biochemical Colourimetric Tests

Four biochemical tests were used to identify a variety of biomolecules. These tests involved adding reagent(s) to a small amount of post-removal solution. A positive reaction indicated the presence of the specific molecule. These tests were adapted by Veall and Matheson (2014) from other fields and redesigned specifically for use on archaeological artefacts (also see Fullagar, et al., 2015). Cook (2015) used four biochemical tests in his thesis, three of which were part of this project (Iodine, Bradford, and DPC/Cu-TEA). Cook (2015) also worked on refining the Lieberman-Burchard test, but the work was not published. The original procedures were altered to function with small concentrations of residue and thus an absorbance spectrophotometer (AS) was necessary to indicate positive results. Each test performed also included a positive and negative control sample to compare with the archaeological readings. A Bio-Tech Epoch Micro Plate Spectrophotometer was used to measure the absorbance at wavelengths specific to each test.

4.2.6.1 Iodine Test for Starch

The iodine test was used to identify the presence of starch within an archaeological residue. Iodine produces various colours when reacting with polysaccharides. The colour is determined by the chemical structure and specific type of carbohydrate being tested. This test was designed to detect a blue colour change, indicating the presence of complex carbohydrates and coiled starch structure (Briuer, 1976). The test must be performed on aqueous solutions so the tri-mixture removal solution was removed (step 2) before the test was carried out (typically through evaporation or the use of a freeze drier). Positive results appeared blue, or produced AS readings above the negative control sample and within the positive control sample range. The procedure used is as follows:

1. Pipette 5μL of sample (post-removal solution) into 0.5mL centrifuge tube.
2. Allow to evaporate.
3. Add 5μL double distilled water to tube.
4. Heat at 60°C for 15 minutes.
5. Add 5μL of 0.12M KI solution.
6. Add 5μL of 0.01M I solution.
7. Measure at A595nm in the AS.

4.2.6.2 Bradford Test for Protein

The Bradford test identified the presence of protein within an archaeological residue. Bradford (1976) based this test on the theory that Coomassie Brilliant Blue G-250 dye will bind with protein molecules. The dye will result in absorbance changing from 465nm to 595nm. The test is miscible in both water and acetonitrile, but no mention is made regarding ethanol. Although ethanol likely evaporated from the solution used for removals, the tri-mixture solution is evaporated (step 2) for consistency. Positive results turned blue, or produced AS readings above the negative control or within the positive control sample range. The procedure used is as follows:

1. Pipette 5μL of sample (post-removal solution) into 0.5mL centrifuge tube.

2. Allow to evaporate.
3. Add 5µL of double distilled water to tube.
4. Add 1µL of Bradford Reagent.
5. Vortex (Mix).
6. Heat at 25°C for 20 minutes.
7. Measure at A595nm in the AS.

4.2.6.3 Diphenylcarbazide/Copper Triethanolamine Test for Fatty Acid

The diphenylcarbazide/copper triethanolamine (DPC/Cu-TEA) test identified the presence of fatty acids in archaeological residue. Falholt, et al., (1973) originally developed the test to identify the presence of free fatty acids in blood plasma. Adjustments were made to the test that allow for phospholipids, a component of red blood cells, to be identified as well (Cook, 2015). The test is based upon the bond that is formed between copper triethanolamine and the fatty acid, which then reacts with diphenylcarbazide to produce a colourimetric reading. The test is miscible in acetonitrile and therefore the post-removal solution was evaporated in a freeze drier (step 2). Positive results turned purple, or produced AS readings above the negative control and within the positive control sample range. The procedure used is as follows:

1. Pipette 5µL of sample (post-removal solution) into 0.5mL centrifuge tube.
2. Allow to evaporate.
3. Add 5µL of acetonitrile.
4. Add 20µL of Cu-TEA.
5. Add 5µL of DPC.
6. Let sit for 15 minutes.

7. Measure at A550nm in AS.

4.2.6.4 Liebermann-Burchard Test for Resin

The Liebermann-Burchard test identified the presence of resin acids in archaeological residue. This test was recently adapted and needed fine tuning. The test is performed with ethanol because of its ability to dissolve resin. The tri-mixture solution was freeze dried and ethanol was added to the vial (Step 2 and 3). Positive samples were supposed to produce a minor violent reaction (a pop) and turn brown. An AS measurement will soon be established (Cook, n.d.). The procedure used is as follows:

1. Pipette 5µL of sample (post-removal solution) into 0.5mL centrifuge tube.
2. Allow to evaporate.
3. Add 5µL of ethanol.
4. Add 5µL of acetic anhydride.
5. Add 5µL of sulfuric acid.
6. Let sit 5 minutes if reaction is not immediate.

4.2.7 Gas Chromatography-Mass Spectrometry

Samples were prepared by freeze drying the post-removal solution until completely evaporated. An aliquot of liquid chromatography-mass spectrometry (LC/MS) grade acetonitrile (1000µL; Sigma-Aldrich) was added to the vial, mixed, and particulate matter was allowed to settle. A volume of 900µL was pipetted out and transferred into a new vial, effectively leaving behind any particulate material that can damage the GC/MS. A volume of 100µL of derivatizing agent, BSTFA ((bis(trimethylsilyl)trifluoroacetamide) with 1% TMS (trimethylchlorosilane; Sigma-Aldrich)), was added to the solution and purged of oxygen using high pressure nitrogen. The vial was capped with an air tight seal using Teflon-coated septa and then heated at 140°C for 30 minutes using a Baxter Scientific Multi-Block heat block. Samples were analyzed within 24 hours (Cook, 2015).

A Varian model 450 gas chromatograph coupled with a Varian model 300-MS quadruple mass spectrometer using a FactorFour^{TM} capillary column. A Varian 300 GC/MS was used to identify organic compounds within archaeological residue. Samples were transferred from the preparation vial using an autosampler in splitless mode, with helium as the carrier gas, and an injection port temperature of 270ºC. Initial column temperature was set at 50ºC for two minutes, after which temperature increases at 8ºC/minute until 155ºC was reached. At this point, temperature increased by 40ºC/minute to a maximum temperature of 275ºC, which was held for 9 minutes. The ion source was set at 200°C under electron ionization conditions, producing ionization energy of 70eV and scanning from 40 to 500m/z. The GC/MS interface temperature was set at 266°C (Cook 2015).

The data was interpreted by Varian Microsoft Workstation version 6 software using the NIST98 Mass Spectral Database. Peaks in the GC/MS spectra were identified by the analyst and compared to the database. Results with a probability match of 75% or greater were accepted, while those below the threshold were manually examined to determine a positive match. Chemicals belonging to common contaminants, such as propanoic acid were removed from the interpretation (Bojar and Holland, 2002). Compounds that have multiple sources like palmitic acid which can be found in plant, animal, the environment and from handling contamination were also removed from the list of those interpreted in this study. All other positive results were cross-referenced to determine potential sources that may lead to archaeological interpretations.

4.2.8 High Power Transmitted Light Microscopy

The final residue analytical method employed was high power transmitted light microscopy (HPTLM). The particulate material that remained at the bottom of the original removal vials was pipetted out and mounted onto microscope slides. The slides were then examined for identifiable particulate matter, including microfossils (pollen grains, starch grains, etc.) and fibres (cellulose, hair, etc.). Identifiable features such as surface texture, size, and birefringence were added as further interpretable data towards identifying the residue.

Histological staining was used where applicable to confirm the type of particulate material. Certain dyes can permeate specific biological compounds, thereby confirming or refuting the qualitative assessment. This technique was mostly used to differentiate between plant and animal fibres using Toluidine Blue. This stain is metachromatic and will stain specific tissues different colours. Amino acids, including proteins (i.e. animal fibres) are stained blue, while polysaccharides (i.e. plant fibres) will stain either pink or red.

4.2.9 Additional Method – Haemoglobin Specific Chemical Reagent Test Strips

Where appropriate, Haemoglobin specific chemical reagent test strips (Hb-CRTS) were used to support the presence of blood within the residue. For this study, Siemens Hemastix® strips were used (an evaluation of different brands can be found in Matheson & Veall, 2014).

The test was not applied to all samples and is not part of the overall methodology. It was only used on specific samples to provide an additional line of evidence where blood was suspected. Where positive results occurred, the test was retaken with sodium ethylenediaminetetraacetic acid (EDTA), which chelates with iron (Matheson & Veall, 2014). The EDTA will neutralize any false positives caused by iron within the soil (iron must have a concentration >55,000ppm to react; Matheson & Veall, 2014). However, if the haemoglobins within the blood residue are sufficiently degraded, EDTA can chelate the molecule a variety of ways. Therefore, should the presence of EDTA not affect the result, the interpretation of blood residue is strengthened. If EDTA does affect the result, it does not automatically imply a false positive occurred, but rather that the test reacted to the soil, degraded hemoglobin, or both. Thus, the HPILM images are crucial for determining the likelihood that a false positive occurred. Based on the soil composition of the region, a negative result is expected when EDTA is used.

4.2.10 Additional Method – Scanning Electron Microscopy-Energy Dispersive Spectroscopy

Scanning electron microscopy-energy dispersive spectroscopy was used on residue still adhering to the artefacts after solvent removal. The SEM beam was increased to 10kV and specific locations were selected for elemental analysis. This technique provided an additional means of supporting the anthropogenic origins of residue, or at least that suspected residue was not mistaken for soil.

4.3 Analytical Methods of Use-Wear Analysis

As stated previously, this study concentrated on residue analysis. This was largely because there were a greater variety of techniques available and the available expertise at Lakehead University. Therefore, only two methods of use-wear analysis were employed; HPILM and SEM. The HPILM component was conducted in conjunction with the *in situ* HPILM (for residue analysis) rather than a separate technique post solvent removal. These two techniques are known to be complimentary for use-wear, particularly on quartz (Borel, et al., 2014; Olle, et al., 2016).

4.3.1 High Power Incident Light Microscopy

The use of HPILM for use-wear analysis on quartz artefacts was a somewhat futile effort. Many researchers have noticed how the reflective surface of quartz obscures signs of use-wear and in the past, this, along with the hardness of the material, has caused archaeologists to doubt the presence of use-wear on quartz (Sussman, 1985). For this reason, HPILM was not fully exploited in this study. Rather, during HPILM for residue, any signs of use-wear were documented and photographed. This means that HPLIM cannot be used on its own as an analytical method, but can provide supporting evidence toward interpreting the function of these artefacts when combined with SEM. An Olympus BX-51 research microscope, in conjunction with an Olympus DP 70 camera, was used to record any findings.

4.3.2 Scanning Electron Microscopy

Scanning electron microscopy was the primary method of use-wear analysis. As discussed in Chapter 2, SEM analysis was used on quartz in past studies (Sussman, 1985; Sussman, 1988; Perry, 2002; Knutsson, 1988a; Broadbent, 1973; Johnson, 1993), but advances in SEM technology (Frahm, 2014) resulted in archaeologists revisiting the technique (Borel, et al., 2014; Olle, et al., 2016). Using a Hitachi SU-70 Schottky Field Emission SEM, artefacts were analyzed without coating of any kind. This model was capable of ultra-high resolution, reduced charge-up imaging, and ultra-low voltage imaging.

The previously identified areas (i.e. working edges) of each artefact were examined in the SEM. Use-wear marks for each artefact were recorded in Table 5-9. These marks included: striations, flake scars, pits, comet tailed pits, edge damage, linear grooves, “melting snow” surface texture, and ridge wear (see Table 4-3 for descriptions of each feature). These features were identified based on experimental studies produced by other researchers (Broadbent, 1973; Broadbent & Knutsson, 1975; Knutsson, 1988a; Sussman, 1988; Taipale, 2012; Olle, et al., 2016; Fernandez-Marchena & Olle, 2015). Although incredibly beneficial, an experimental component was beyond the scope of this study, particularly with use-wear supporting the residue interpretations rather than serving as the main line of evidence. Informal experiments were conducted to observe the difference between unused and used lithics, but access to the SEM was too limited to conduct an experiment large enough to provide useful data.

Artefacts were then organized into a table based on the SEM and HPILM observations. The first table (see Table 5-10) indicates the degree of identifiable use-wear. Use-wear was either identifiable (i.e. interpretations are possible), indeterminate (i.e. interpretations may be possible, but without much confidence), and unidentifiable/absent (i.e. either use-wear is absent, undiagnostic, or too difficult to separate from non-anthropogenic/taphonomic wear). Artefacts from the first two columns were analyzed further.

Table 4-3: Use-wear types and descriptions

Type	Description
Striations	Narrow, shallow linear marks. Also, known as sleeks.
Linear Grooves	Wide, deep linear marks. Also, known as furrows.
Flake Scars	Micro-flakes removed from the edge of a tool through use.
Edge Damage	Rounding and chipping on the edge of a tool (not including flake scars).
Ridge Wear	Rounding and chipping on ridges of the tool.
Pits	Round depressions on the artefacts surface.
Comet Tailed Pits	Pits with a long tail on one end.
“Melting Snow” Polish	Surface texture with the appearance of melted snow or melted plastic.

These artefacts (i.e. those with identifiable or indeterminate use-wear) were organized into two tables to produce interpretive data. The first table (see Table **5-11**) identified the hardness of the source material based on the nature of the use-wear scars compared to observations made by other researchers. Source material was either hard (e.g. bone, antler, hard wood), medium (e.g. soft wood, dry hide), or soft (e.g. fresh hide, softer plant material). Interpretations will be made based on what locally available material could produce such a wear.

The second table (see Table 5-12) identified the mode of use (i.e. the direction of use) for each artefact. Broadly speaking, examples of mode of use include perpendicular motion and parallel motion. Perpendicular motions are those where the used edge contacts the worked surface with its broad side. An example of this is scraping, where the wide working edge is pulled along the surface of the worked material. Perpendicular motions include pulling actions (e.g. scraping), pushing actions (e.g. whittling), both pushing and pulling actions (e.g. different approaches to plane wood), and, if the working edge is a point, puncturing (e.g. on fresh and dry hide), engraving (e.g. on harder materials).

Parallel motions are when the thin section of the working edge is used on the worked surface (i.e. cutting or sawing motions). This type of motion was divided into further categories: push, pull, push and pull, twisting. Pushing and pulling motions are unidirectional. Striations from a pushing motion are (i.e. movement away from the body) are obtuse to the distal end of the tool, while pulling motions are acute. Artefacts with both, indicate bidirectional movement, which can indicate sawing, while unidirectional striations indicate cutting. Twisting motions (i.e. drilling) occur on pointed working edges.

The results compiled from the use-wear analysis were used to contextualize the organic residue. For example, animal-based residue found on an amethyst crystal with a heavily worn tip with deep linear grooves could imply the tool was used for graving bone or antler. Alternatively, the same animal-based residue found on an amethyst crystal with a rounded tip and some striations could imply the tool was used as an awl on fresh hide, possibly to help hang the hide prior to dry scraping. The complementary nature of residue and use-wear analysis will become apparent in the following two chapters.

5 Results

5.1 Sampling Strategy

5.1.1 Phase 1 – The Quartz Assemblage

The sampling strategy sorted through the available Mackenzie I assemblage and selected all quartz and amethyst pieces (quartz assemblage; Figure 4-1). Out of the lithic assemblage catalogued, 5,699 of the 290,604 artefacts were either quartz or amethyst. These numbers represent the incomplete catalogue and not all catalogued artefacts were available at the time of analysis (although most were). Final catalogue numbers can be found in Table 3-2 and are 6,452 quartz and amethyst artefacts out of 335,701 total lithic artefacts. Phase 1 separated all quartz and amethyst artefacts available from the rest of the Mackenzie I assemblage to produce the quartz assemblage. Exact numbers were not recorded, since phase 2 would further reduce the sample numbers, but were less than 5,699.

5.1.2 Phase 2 – The Possible Tools Collection

The quartz assemblage was reduced in size by identifying artefacts with usable edges and points to produce the possible tools collection (Figure 4-1). The subjective nature of this phase could not be avoided. Artefacts with usable edges were placed in one pile, while artefacts with usable tips were placed in another. This grouped more similar objects together. Artefacts with no useable edge were not analyzed further. These were typically blocky artefacts with no thin straight edges or pointed tips. Only 248 quartz and amethyst artefacts were deemed to have usable characteristics that warranted further analysis. All 248 artefacts were photographed before performing LPILM.

5.1.3 Phase 3 – The Analyzed Assemblage

Low power incident light microscopy was used in phase 3 (Figure 4-1) and served to identify and separate artefacts with potential residue and use-wear (n = 48) and artefacts with only use-wear (n = 58) from those without use-wear or residue (n = 142; see Table 5-1: Artefacts with potential residue and use-wear. Table 5-1 for a list of artefacts with potential residue and/or use-wear). Combined, these artefacts composed the probable tools collection (n = 106). The artefacts with potential residue were selected as the analyzed collection for this study, while those with possible use-wear were recorded for future consideration. Two of these artefacts were removed during a later stage of analysis, leaving only 46 artefacts. Unless otherwise stated, only these 46 artefacts with potential residue are subjected to the following analytical steps.

Table 5-1: Artefacts with potential residue and use-wear.

Potential Residue (and Use-Wear)				Potential Use-Wear			
3646	**3885**	4184	8995*	**3884**	**4436**	5107	**8104**
9942	14288	**15096**	15295	8713	10977	11640	12091
15387	16208	16528	20503	14378	14837	**15016**	16261
24506	**24842**	25073	27600*	**19233**	21493	**24066**	**24679**
27868	31322	31322-2	33622	**26602**	27476	28029	**28321**
35330	**39056**	42413	44139	28617	28634	29538	29666
46541	46551	49249	51849	29802	31894	32136	32171
51943	51944	**52053**	56557	33436	**34135**	34817	**36092**
56627	57679	57953	63769	37522	39580	40849	40983
69290	70265	70283	**71653**	42757	43505	44442	**46064**
71676	72526	76189	77023	46484	46534	47893	51623
77176	86944	Point 1	Point 2	51896	51986	52137	58186
				62455	65479	69936	71487
				71671	**71698**	71962	72045
				76322	84378		

* indicates artefacts that were not further analyzed; **bold** text indicates amethyst.

5.2 Ultraviolet Luminescence

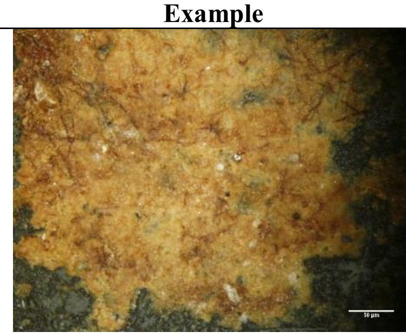
Screening artefacts for residue that reflected under UVL produced no positive results. Blue specks were visible on the tool surface, but these were not adhering to the surface and were interpreted as contamination. These specks were visible on nearby desks, paper, and even clothing. One possible positive result was noted on tool 16208, which resembled fat residue/polish observed on experimental tools, but this technique needs further refinement for a reliable interpretation. During a demonstration of this technique prior to analysis, an experimental tool made from a different material had large sections of invisible residue fluoresce under UVL. This did not happen on any of the quartz or amethyst samples analyzed in this study.

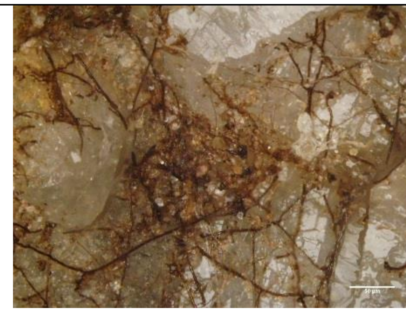
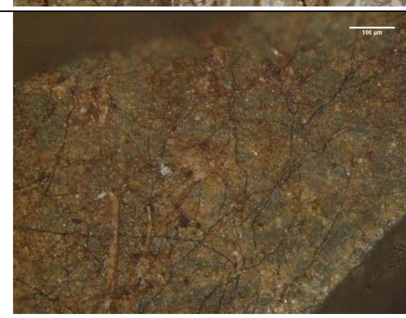
5.3 High Power Incident Light Microscopy

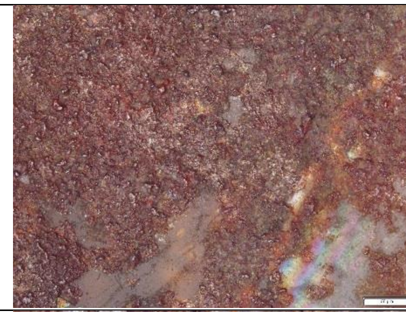
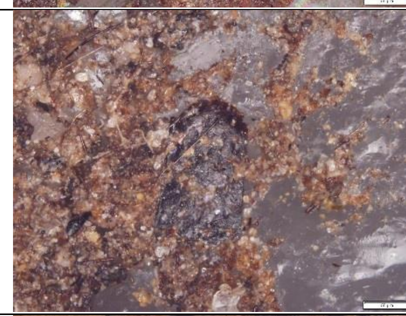
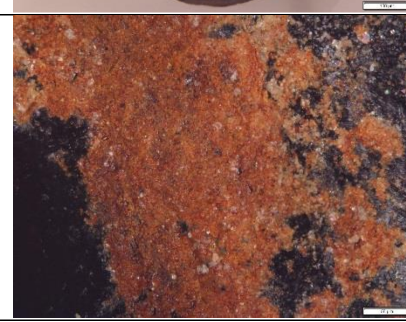
High power incident light microscopy served two purposes; to confirm and locate any visible residue and to eliminate artefacts without visible residue from the sample set for further analysis. Two tools (8995 and 27600) were removed from the study after no visible residue could be observed on the tool's surface. The remaining 46 tools had visible residue adhering to their surfaces. There were 132 residues documented and categorized, resulting in 19 different categories. These categories were determined by categorizing the residues based on their visual characteristics. Variables include shape, primary colour, secondary colour, and texture. Of the classifications in

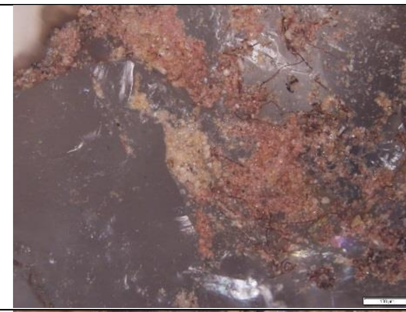
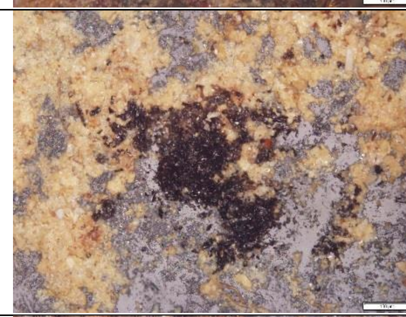
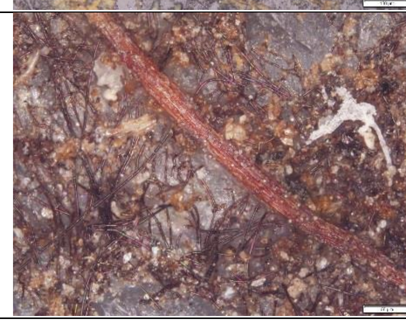
Table **5-2**, 17 account for amorphous residues (i.e. residues without any distinct morphological characteristics). The remaining two categories account for fibres observed on the surface of the tool and residues that have too little quantity for confident classification.

Table 5-2**: Residue classifications.**

Class.	**Description**		**Tools**	**Example**
1	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Light yellow Red/brown Slightly bumpy Medium gloss Amorphous	3885* 27868 31322 39056 51943 57679 57953 71653 71676 72526 76189 Point 2	
2	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Dark brown/red Light brown/yellow Globular High gloss Amorphous	4184* 15096 24842 31322_2 46551 49249 63769 71653 72526 77023	
1/2	This classification group consists of both Class 1 and Class 2 residue occurrences. This suggests that these two residues may be related		4184 39056*	
3	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Bright red Light brown Smooth and globular Medium high gloss Amorphous	14288*	

4	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Light brown Yellow Smooth and globular Medium gloss with areas of higher gloss Amorphous	14288* 15295 46541 46551 51849 51943 71653 77023 86944 Point 2	
5	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Dark brown and red; mostly hyphae Transparent residue Webbing N/A Amorphous	15096* 15387 16208 16528 33622 42413 70265 70283 72526	
6	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Dark brown Lighter brown Slightly rough; lots of hyphae Medium gloss Amorphous	15387* 24506 77176 86944	
7	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	White Yellow Grainy Medium gloss Amorphous	16208* 20503 52053	
8	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Yellow Black Mud-cracked Medium - Low gloss Amorphous	24842* 25073	

9	Primary Colour:	Very dark brown	35330* 42413	
	Secondary Colour:	Lighter brown		
	Texture:	Smooth and globular		
	Gloss:	Very high gloss		
	Shape:	Amorphous		
10	Primary Colour:	Red	39056*	
	Secondary Colour:	Purple		
	Texture:	Rough		
	Gloss:	Medium gloss		
	Shape:	Amorphous		
11	Primary Colour:	Dark purple	42413* 51943	
	Secondary Colour:	Black		
	Texture:	Smooth		
	Gloss:	Low gloss		
	Shape:	Ovoid		
12	Primary Colour:	Dark brown/purple	44139 63769 Point 1*	
	Secondary Colour:	Light brown		
	Texture:	Mud cracked		
	Gloss:	Low gloss		
	Shape:	Amorphous		
13	Primary Colour:	Orange	51944*	
	Secondary Colour:	Red		
	Texture:	Grainy		
	Gloss:	Medium gloss		
	Shape:	Amorphous		

14	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Pink White Grainy Medium gloss Amorphous	56627*	
15	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Bright red Light brown Smooth Medium-high gloss Amorphous	57679*	
16	Primary Colour: Secondary Colour: Texture: Gloss: Shape:	Black White/yellow Smooth Low gloss Amorphous	71676*	
Fibres	Two fibres were observed; a clear cellulose fibre (visible in class 7 image) and a long red fibre that appears to be composed of a bundle of smaller fibres.		16208 42413*	
Unclassified	Residue images from 15 artefacts featured residue with too little quantity to determine which classification it belongs too. Four of these artefacts have residue only in this classification.		15 artefacts	

The classification number, associated description, the number of tools it was discovered on and a picture serving as an example. A complete assembly of pictures for each residue classification can be found in Appendix A.

The highly reflective nature and irregular topography of quartz's surface, combined with the presence of residue, limit the application of HPILM for the dedicated identification of use-wear patterns. That being said, any indication of use-wear observed while examining residue was recorded. Four artefacts – 4184, 14288, 46541, and 77023 – displayed obvious signs of use-wear that were recorded during HPILM (Figure 5-1). These images are interpreted in their respective interpretation section.

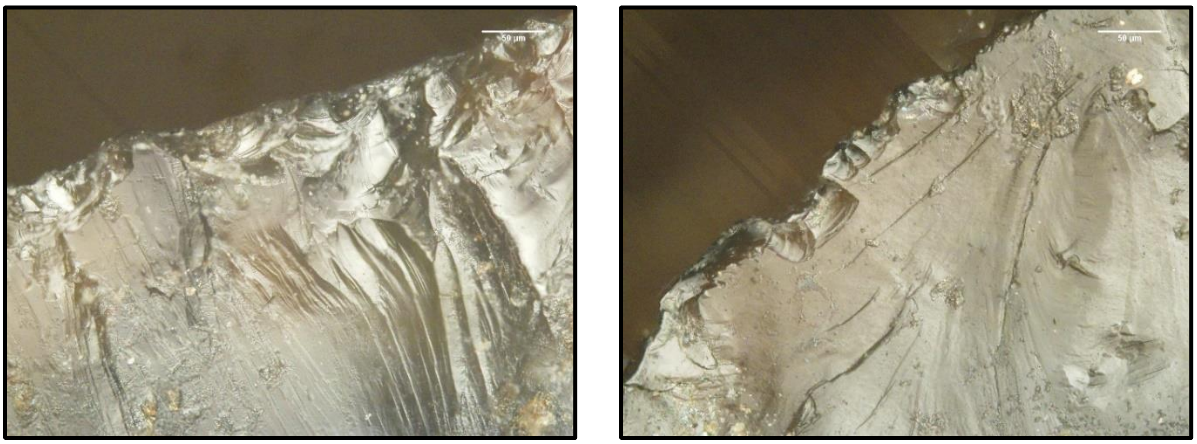


Figure 5-1: Evidence of use-wear under HPILM.
Artefact 4184. A – Artefact 4184, dorsal surface with half-moon scars. B – Artefact 4184, ventral surface with scalar scars.

5.4 Scanning Electron Microscopy (*In Situ*)

Two artefacts with observed fibres were analyzed using SEM to acquire higher resolution micrographs of the fibres. Artefact 42413 had two fibres of interest, but one was removed and placed on a slide for HPTLM because it was too exposed to risk losing from handling. This left the remaining fibre on artefact 42413 and the fibre on artefact 15387 to analyze. However, artefact orientation was different between the light microscope and the SEM, and landmarks proved difficult to use in these circumstances and neither fibre could be located.

5.5 Removal

The success of residue removal was not quantified for this study. The amount of residue available for extraction from most samples was minimal. Quartz has been criticized as a poor material for chemical residue analysis because of its lack of cracks and fissures to harbor and protect residue from microbial and chemical decay (Delagnes, et al., 2006). Additionally, its smooth surface suggests residue is less likely to adhere. However, this study proved that residue could still adhere to quartz's smooth surface (see HPILM results), although the lack of GC/MS results indicated poor preservation or difficulty removing residue from the quartz surface.

It was observed during solvent removal from two artefacts (#15387 and #42413) that the effectiveness of the solvent removal varied greatly. The residue adhering to artefact #15387 was visibly resistant to the tri-mixture solution, while the residue adhering to artefact #42413 was easily removed. These observations were not made for other artefacts and in most cases the residue was so minimal that these observations were difficult to see.

As per the methodology, extraction was directed towards the suspected working edge rather than completely submerging the artefact. The purpose of this was to separate potential hafting residue from residue related to use. In hindsight, the low quantity of residue warranted a more aggressive approach. The desire for preserving the context of the residue should have been abandoned for a full artefact removal.

5.6 Biochemical Tests

A series of biochemical tests were performed to screen for the presence of biological molecules; specifically starch, protein, and fatty acids. These tests are colourimetric (i.e. positive results produce a reaction causing the solution to turn a specific colour). However, because archaeological specimens contain such low quantities, absorbance spectrometry (AS) was used to identify positive and negative results. Blank positive and negative tests were performed to establish a baseline for interpretations. The most important test is the negative control, which shows what results are truly negative. The positive control demonstrates the expected range of positive results and confirms they will differ from the negative results. In most cases, there is a grey area between the two control samples where archaeological specimens can be found. This likely indicates a positive result with simply a lower concentration than in the control sample and thus considered weak positive results. Some of the AS readings were abnormally high for positive results and this coincides with particulate material contaminating the analyzed sample. The following sections will summarize these results by individual test and then as a whole.

5.6.1 Iodine Test for Starch

The Iodine Test for starch produced few definite positive results. The results are listed in Table 5-3 and positive and weak positive results are highlighted. Figure 5-2 visually organizes the data to better understand the relationship of the results. The reason for few positive results is that the positive and negative control samples greatly overlap. With that being said, there appear to be two distinct groups within the data set. The first group includes results below the median line of the negative control sample. These results generally have a tighter range and are considered true negative results. The second group are above the median line of the negative control and clustered around the median line of the positive control. Very few values are outside of the negative control and two of these values are suspected of being false positives. These false positives are a result of particulate material in the solution, which was unavoidable due to the small amount of solution available, and are highlighted in yellow.

Table 5-3: Iodine test for starch results

Positive result, Weak Positive, Particulate Matter

Sample	Run 1	Run 2	Average	Sample	Run 1	Run 2	Average
S_3885	0.071	0.100	0.086	S_51943	0.039	0.044	0.042
S_4184	0.045	0.061	0.053	S_51944	0.048	0.059	0.054
S_9942	0.039	0.045	0.042	S_52053	0.055	0.051	0.053
S_14288	0.049	0.061	0.055	S_56557	0.053	0.041	0.047
S_15096	0.056	0.082	0.069	S_56627	0.073	0.070	0.072
S_15295	0.051	0.040	0.046	S_57679	0.071	0.099	0.085
S_16208	0.103	0.069	0.086	S_57953	0.046	0.063	0.055
S_16528	0.070	0.100	0.085	S_63769	0.039	0.061	0.050
S_20503	0.045	0.057	0.051	S_69290	0.044	0.060	0.052
S_24842	0.039	0.044	0.042	S_70265	0.059	0.231	0.145
S_24506	0.048	0.061	0.055	S_70283	0.051	0.041	0.046
S_25073	0.056	0.053	0.055	S_71653	0.074	0.121	0.098
S_27868	0.052	0.040	0.046	S_71676	0.068	0.098	0.083
S_31322	0.103	0.069	0.086	S_72526	0.045	0.058	0.052
S_31322_2	0.069	0.099	0.084	S_76189	0.044	0.052	0.048
S_33622	0.045	0.059	0.052	S_77023	0.047	0.054	0.051
S_35330	0.039	0.045	0.042	S_77176	0.073	0.104	0.089
S_39056	0.048	0.058	0.053	S_86944	0.045	0.057	0.051
S_44139	0.058	0.072	0.065	S_P1	0.040	0.046	0.043
S_46541	0.051	0.041	0.046	S_P2	0.048	0.059	0.054
S_46551	0.095	0.069	0.082	Io_Neg	0.040	0.114	0.064
S_49249	0.069	0.102	0.086	Io_Pos	0.056	0.139	0.082
S_51849	0.046	0.059	0.053				

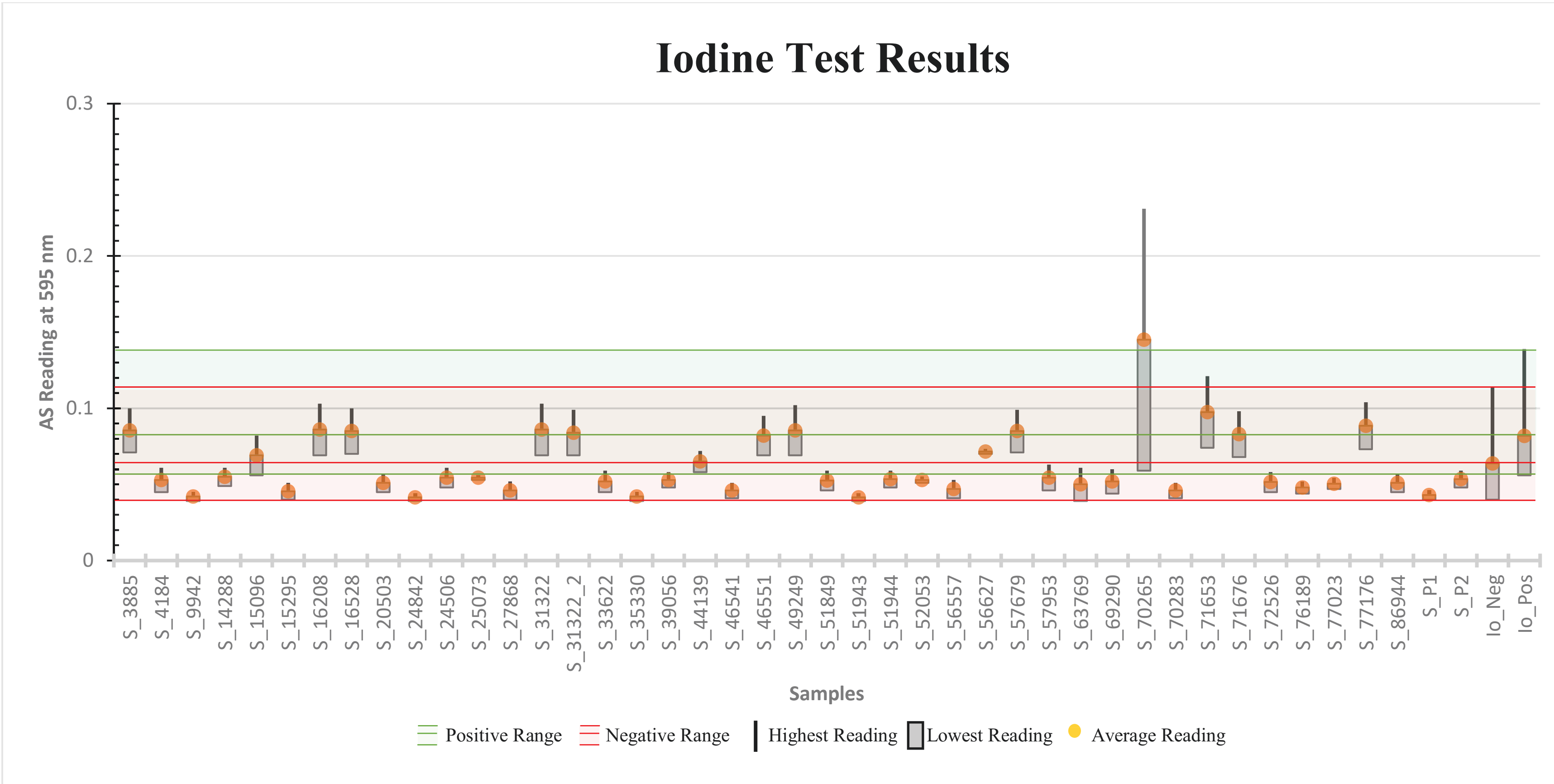


Figure 5-2: Iodine test for starch results.
The green line represents the average of the positive control results, while the red line represents the average of the blank (negative) control results. The data from these control readings is displayed in the same format as the sample data

5.6.2 Bradford Test for Protein

The Bradford test produced 26 positive results from 18 artefacts (Table 5-4 and Figure 5-3). One additional positive result was skewed by particulate material in the solution (highlighted in yellow). There were 18 results from 13 artefacts that fell within the area between the positive and negative control samples and are considered a weak positive. When positive and weak positive results are combined, 27 of the 44 artefacts tested can be considered positive for protein residue.

Table 5-4: Bradford test for protein results

Positive result Weak Positive Particulate Matter

Sample	Run 1	Run 2	Average	Sample	Run 1	Run 2	Average
S_3885	0.109	0.110	0.110	S_51849	0.167	0.137	0.152
S_4184	0.088	0.096	0.092	S_51943	0.345	0.298	0.322
S_9942	0.063	0.064	0.064	S_51944	0.079	0.075	0.077
S_14288	0.078	0.077	0.078	S_52053	0.083	0.246	0.165
S_15096	0.108	0.119	0.114	S_56557	0.085	0.066	0.076
S_15295	0.088	0.072	0.080	S_56627	0.111	0.121	0.116
S_15387	0.129	0.131	0.130	S_57679	0.166	0.142	0.154
S_16208	0.101	0.088	0.095	S_57953	0.116	0.152	0.134
S_16528	0.133	0.141	0.137	S_63769	0.077	0.103	0.090
S_20503	0.066	0.079	0.073	S_69290	0.060	0.066	0.063
S_24842	0.056	0.061	0.059	S_70265	0.075	0.069	0.072
S_24506	0.082	0.152	0.117	S_70283	0.086	0.089	0.088
S_25073	0.169	0.134	0.152	S_71653	0.081	0.165	0.123
S_27868	0.079	0.063	0.071	S_71676	0.238	0.122	0.180
S_31322	0.120	0.088	0.104	S_72526	0.136	0.125	0.131
S_31322_2	0.177	0.180	0.179	S_76189	0.143	0.183	0.163
S_33622	0.067	0.082	0.075	S_77023	0.088	0.077	0.083
S_35330	0.058	0.101	0.080	S_77176	0.220	0.163	0.192
S_39056	0.082	0.083	0.083	S_86944	0.119	0.084	0.102
S_42413	0.143	0.143	0.143	S_P1	0.728	0.282	0.505
S_44139	0.265	0.090	0.178	S_P2	0.094	0.109	0.102
S_46541	0.081	0.069	0.075	Br_Neg	0.057	0.102	0.076
S_46551	0.244	0.093	0.169	Br_Pos	0.134	0.428	0.248
S_49249	0.116	0.113	0.115				

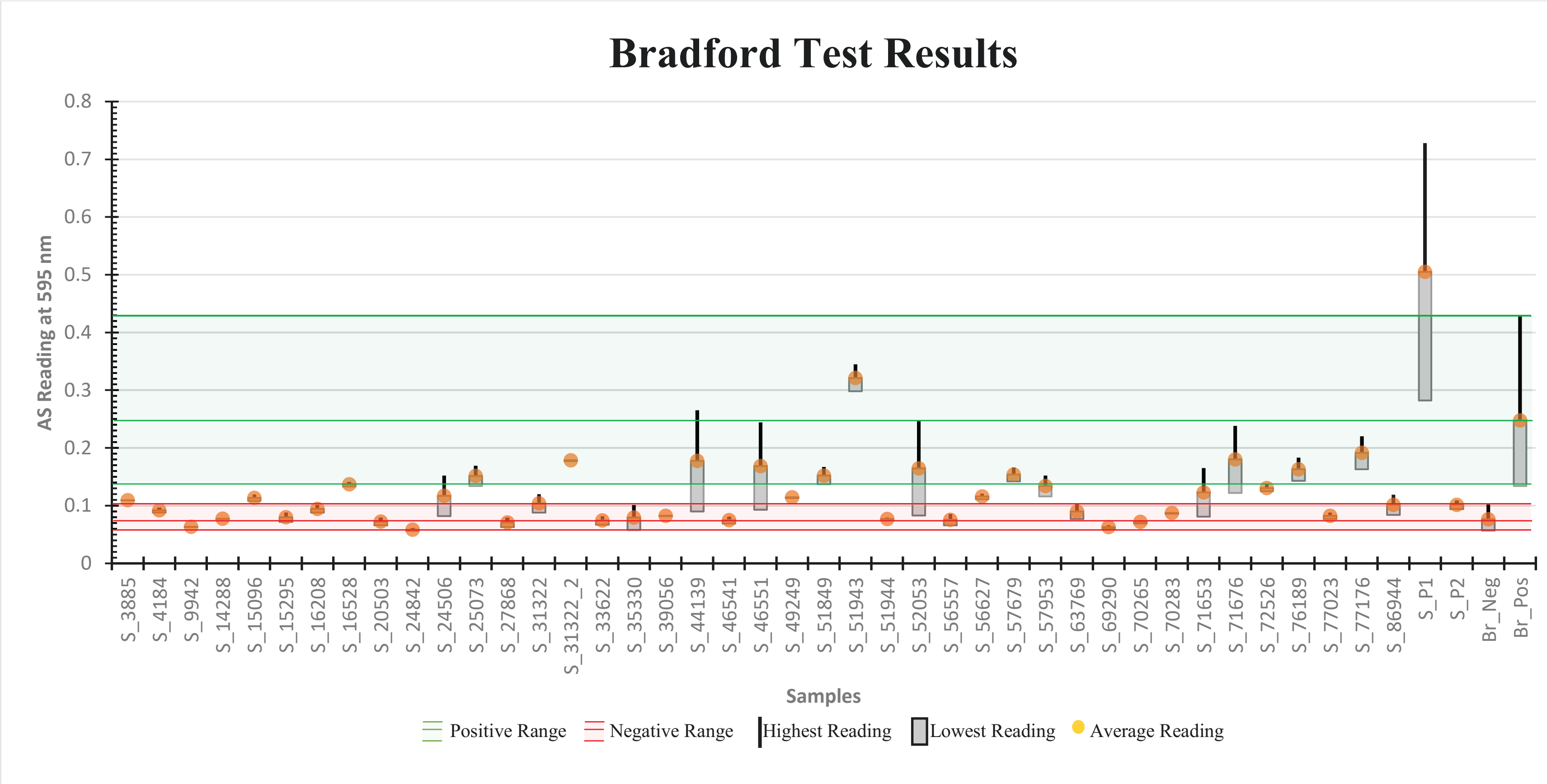


Figure 5-3: Bradford test for protein results.
The green line represents the average of the positive control results, while the red line represents the average of the blank (negative) control results. The data from these control readings is displayed in the same format as the sample data. Not shown in the graph are 15387 (0.129; 0.131) and 42413 (0.143; 0.143).

5.6.3 Diphenylcarbazide/Copper Triethanolamine Test for Fatty Acid

The DPC/Cu-TEA Test for fatty acid produced 21 positive results from 16 artefacts (Table 5-5 and Figure 5-4). There were 26 weak positive results from 22 artefacts that fell between the two control samples. These samples are considered weak positive because they exceed the values observed in the negative sample. The values below the positive sample can be assumed to have a lower quantity than the positive control sample. Between these two categories, 30 out of the 45 artefacts have residue with fatty acid present.

Table 5-5: DPC/Cu-TEA test for fatty acid results

Positive result; Weak Positive; Particulate Matter

Sample	Run 1	Run 2	Average	Sample	Run 1	Run 2	Average
S_3885	0.262	0.271	0.267	S_51849	0.564	0.417	0.491
S_4184	0.180	0.207	0.194	S_51943	0.354	0.268	0.311
S_9942	0.249	0.475	0.362	S_51944	0.174	0.282	0.228
S_14288	0.518	0.524	0.521	S_52053	0.354	0.220	0.287
S_15096	0.192	0.280	0.236	S_56557	0.166	0.163	0.165
S_15295	0.141	0.378	0.260	S_56627	0.295	0.437	0.366
S_15387	0.170	0.111	0.141	S_57679	0.158	0.191	0.175
S_16208	0.153	0.170	0.162	S_57953	0.504	0.253	0.379
S_16528	0.166	0.213	0.190	S_63769	0.137	0.158	0.148
S_20503	0.179	0.172	0.176	S_69290	0.226	0.183	0.205
S_24842	0.122	0.131	0.127	S_70265	0.145	0.141	0.143
S_24506	0.143	0.144	0.144	S_70283	0.291	0.189	0.240
S_25073	0.133	0.137	0.135	S_71653	0.205	0.257	0.231
S_27868	0.159	0.132	0.146	S_71676	0.197	0.172	0.185
S_31322	0.229	0.253	0.241	S_72526	0.306	0.362	0.334
S_31322_2	0.300	0.241	0.271	S_76189	0.145	0.211	0.178
S_33622	0.197	0.187	0.192	S_77023	0.202	0.294	0.248
S_35330	0.133	0.172	0.153	S_77176	0.408	0.193	0.301
S_39056	0.232	0.648	0.440	S_86944	0.488	0.140	0.314
S_42413	0.116	0.119	0.118	S_P1	0.122	0.153	0.138
S_44139	0.509	0.274	0.392	S_P2	0.154	0.147	0.151
S_46541	0.239	0.140	0.190	Fa_Neg	0.101	0.195	0.134
S_46551	0.383	0.439	0.411	Fa_Pos	0.294	0.582	0.361
S_49249	0.203	0.203	0.203				

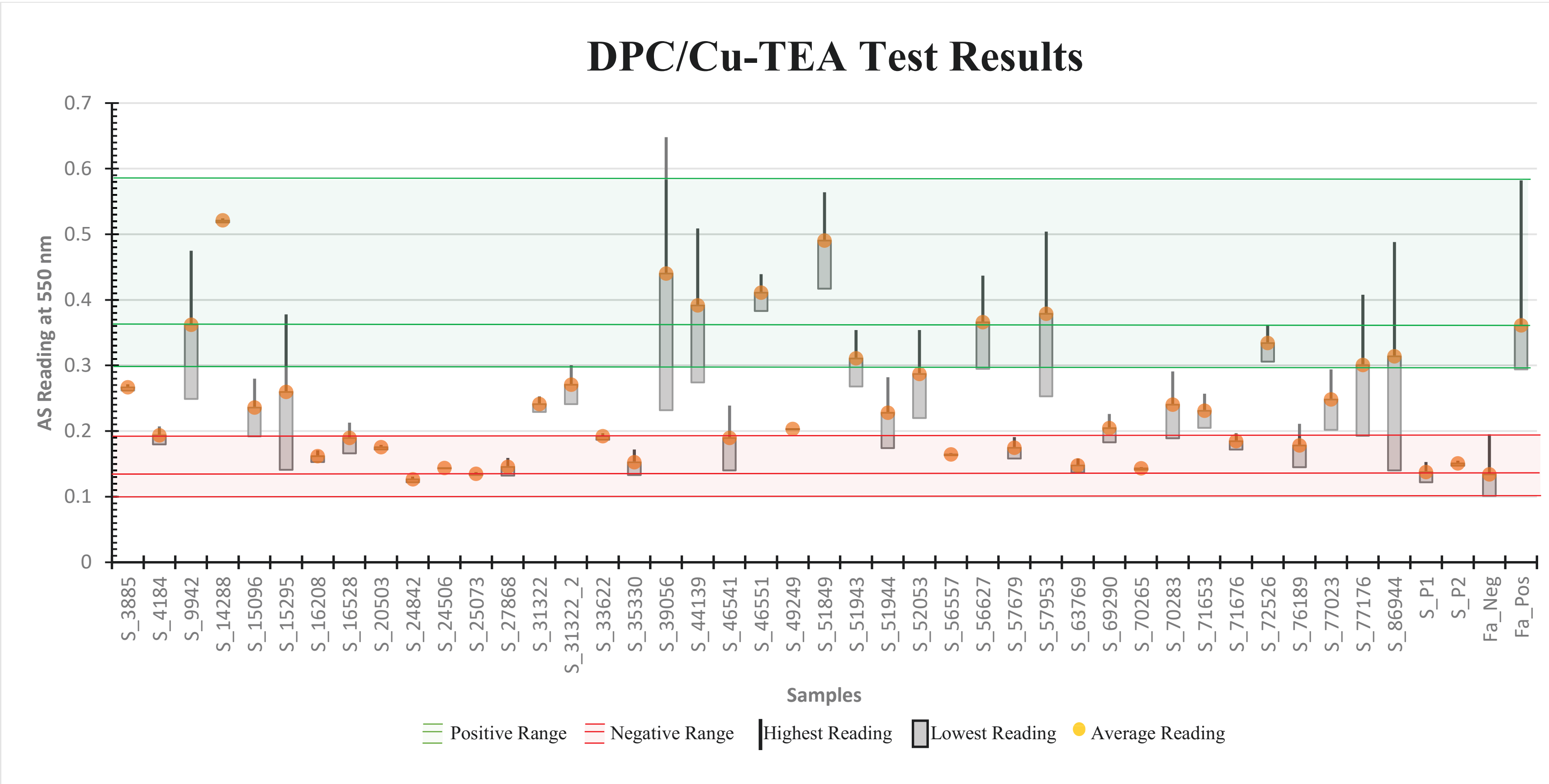


Figure 5-4: DPC/Cu-TEA test for fatty acid results.
The green line represents the average of the positive control results, while the red line represents the average of the blank (negative) control results. The data from these control readings is displayed in the same format as the sample data. Not shown in the graph are 15387 (0.170; 0.111) and 42413 (0.116; 0.119).

5.6.4 Liebermann-Burchard Test for Resin

The Liebermann-Burchard test for resin requires further refinement. An AS reading has not been determined, making it difficult to analyze positive results following the same procedure as the other three tests. Additional difficulties were encountered when all samples produced a popping reaction (believed to be indicative of a positive result) but none turned brown. In the end, the results of this test were not included within this study.

5.6.5 Summary of Biochemical Results

Table 5-6 presents a summary of the Biochemical tests. There are seven artefacts with no positive results, 14 artefacts with only weak positive results, and 24 artefacts with at least one positive result. None of the artefacts show positive results for all starch, protein, and fatty acid, although there are 10 artefacts with at least weak positive results. However, because of the overlap in the positive and negative control samples, the results for starch will be disregarded in favour of the protein and fatty acid results.

There are nine artefacts with positive results for both protein and fatty acid, which increases to 17 when including weak positive results. There are 17 artefacts with positive results for protein, and 16 for fatty acid. These values increase to 19 artefact with both residue, 26 artefacts with protein, and 29 artefacts with fatty acid when weak positive results are included.

Table 5-6: Summary of the biochemical tests' results

- Negative Result ~ Weak Positive + Positive Result / Particulate Matter

Sample	Starch	Protein	Fatty Acid	Sample	Starch	Protein	Fatty Acid
S_3885	~	~	~	S_49249	~	~	~
S_4184	-	-	~	S_51849	-	+	+
S_9942	-	-	+	S_51943	-	+	+
S_14288	-	-	+	S_51944	-	-	~
S_15096	~	~	~	S_52053	-	+	+
S_15295	-	-	+	S_56557	-	-	-
S_15387	n/a	~	-	S_56627	~	~	+
S_16208	~	-	-	S_57679	~	+	-
S_16528	~	+	~	S_57953	-	+	+
S_20503	-	-	-	S_63769	-	~	-
S_24842	-	-	-	S_69290	-	-	~
S_24506	-	+	-	S_70265	/	-	-
S_25073	-	+	-	S_70283	-	-	~
S_27868	-	-	-	S_71653	/	+	~
S_31322	~	~	~	S_71676	~	+	-
S_31322_2	~	+	+	S_72526	-	+	+
S_33622	-	-	~	S_76189	-	+	~
S_35330	-	-	-	S_77023	-	-	+
S_39056	-	-	+	S_77176	~	+	+
S_42413	n/a	+	-	S_86944	-	~	+
S_44139	~	+	+	S_P1	-	/	-
S_46541	-	-	~	S_P2	-	~	-
S_46551	~	+	+				

5.7 Gas Chromatography-Mass Spectrometry

The GC/MS analysis produced very few results. Any identifiable peaks are either a product of the derivatization agent or a contaminant. Negative results are likely due to the low quantity of residue adhering to the tools or that the residue itself is a mixture of material consisting of a low percentage of organic material. Either way, the GC/MS results are not useful for interpreting the residue.

5.8 High Power Transmitted Light Microscopy

The particulate material remaining at the bottom of the vials was transferred onto microscope slides to be identified since it was possibly missed by either GC/MS or biochemical testing. The HPTLM also helps to characterize the residue which may allow interpretation to distinguish between plant and animal residues. Most of the particulate material transferred onto the slides remains amorphous and unidentifiable. The most commonly identified microfossils were either plant fibres (e.g. cellulose) or animal fibres (e.g. collagen). Table 5-7 shows which artefacts have evidence either plant and/or animal as a component of the residue.

Table 5-7: The HPTLM results

Artefact	Plant	Animal	Artefact	Plant	Animal
3646	X		46551		
3885		X	49249		
4184		X	51849		
9942		X	51943		
14288			51944		
15096	X		52053		
15295		X	56557		
15387			56627		
16208			57679		
16528			57953		
20503			63769		
24842			69290		
24506			70265		
25073			70283		
27868			71653		
31322			71676		
31322_2			72526		
33622			76189		
35330			77023		X
39056			77176		
42413		X	86944		
44139			P1		
46541			P2		

5.9 Additional Method – Haemoglobin Specific Chemical Reagent Test Strips

Only certain artefacts were tested using this method. This included artefacts 3885, 4184, 15387, 24842, 25073, 44139, 51943, 52053, 63769, 77176, and residue classifications categories 1, 2, 6, 8, 12 and sediment control samples to test for false positives. These control samples did not produce positive results, indicating the soil was unlikely to produce a false positive (Table 5-8).

Table 5-8: The Hb-CRTS results

Artefact	Residue Class.	Result	With EDTA
3885	1	0	-
4184	2	1	0
15387	6	2	0
24842	8	0	-
25073	8	1	0
44139	12	1	0
51943	Sediment Control	0	-
52053	Sediment Control	0	-
63769	12	1	0
77176	6	0	-

Class 1 residue was tested using Hb-CRTS to support the suspected presence of blood. The residue was tested because of the red secondary colour mixed within the yellow, amorphous residue. Artefact 3885 had the largest quantity of residue available in this class and produced a weak positive result for the Bradford biochemical test. However, Hb-CRTS produced negative results (scored a 0; Table 5-8; Matheson & Veall, 2014). This test was performed after sonication and physical removal, so residue quantity was low.

Class 2 residue was tested using Hb-CRTS to support the suspected presence of blood. Artefact 4184 had the largest quantity of residue, although it tested negative for protein residue. The first Hb-CRTS test proved negative (Table 5-8). This test was performed after sonication and physical removal, so residue quantity was low. A second attempt was made where the same solvent was used on two different locations (i.e. was drawn into the pipette from the one location and deposited on anther to increase the quantity of residue). This second attempt scored a 1 on the Hb-CRTS test, indicating a trace amount of blood (Matheson & Veall, 2014).

Class 6 residue was tested using Hb-CRTS to support the suspected presence of blood. Artefact 15387 had the largest quantity of residue, which seemed unaffected by solvent removal. Biochemical tests produced weak positive results for protein residue. The Hb-CRTS test scored a 2 (positive), which indicates a weak amount of blood residue (Table 5-8; Matheson & Veall, 2014). The test was applied a second time using EDTA and the artefact scored a 0 (negative). Based on the HPILM images, a false positive is not suspected and it is more likely that the blood within the residue is sufficiently degraded.

Class 8 residue was tested using Hb-CRTS to support the suspected presence of blood. Artefacts 24842 and 25073 were both tested. Although from the same class, the residue on artefact 24842 does not seem as well preserved, which may explain why biochemical tests were negative for 24842 but positive for 25073. Likewise, the Hb-CRTS test scored a 0 for artefact 24842, but a 1 for artefact 25073, which indicates a trace amount of blood in the residue (Table 5-8; Matheson & Veall, 2014). The test was applied a second time to artefact 25073 using EDTA and the artefact scored a 0 (negative). Based on the HPILM images, a false positive is not suspected and it is more likely that the blood within the residue is sufficiently degraded. Therefore, residue 8 is suspected as a blood residue.

Class 12 residue was tested using Hb-CRTS to support the suspected presence of blood. Artefacts 44139 and 63769 were both tested. Biochemical tests produced a weak positive for 63769, but a strong positive for 44139, likely because the latter had a much higher concentration of residue. The Hb-CRTS test scored a 1 for both artefacts, which indicates a trace amount of blood in the residue (Table 5-8; Matheson & Veall, 2014). The test was applied a second time to both artefacts using EDTA and both scored a 0 (negative). Based on the HPILM images, a false positive is not suspected and it is more likely that the blood within the residue is sufficiently degraded. Therefore, residue 8 is suspected as a blood residue.

5.10 Scanning Electron Microscopy

Scanning electron microscopy proved to be a very useful method employed in this study. The topographic sensitivity, high resolution, and high depth of field of this instrument allowed for the highly-detailed analysis of surface scarring created by use, manufacture, or taphonomy. Experimental studies found in the literature helped to identify the source of these scars (Broadbent & Knutsson, 1975; Knutsson, 1988a; Sussman, 1988). The most difficult obstacle to overcome was the effect of charging resulting from electrons building up within the sample. Coating a sample in carbon or gold could reduce these effects but was undesirable on archaeological samples. The effect of charging was reduced by using a lower voltage, such as 5KV, which was also a suitable voltage for producing surface topography. The higher the voltage, the deeper the penetration of the beam into the sample, which is more useful for elemental analysis.

Table 5-9: Use-wear results.

Artefact	Striations	Linear Grooves	Flake scars	Edge Damage	Ridge Wear	Pits	Comet Tailed Pits	“Melting snow”
3646		X		X		X (N)		
3885	X (=)			X		X		
4184	X		X	X				
9942			X	X				X
14288	X		X	X		X		
15096				X				
15295		X (S)	X	X				
15387	X	X	X	X				
16208	X		X	X	X			X
16528	X		X	X	X			
20503	X		X	X				
24506	X		X	X	X		X	
24842	X	X	X	X		X		
25073	X		X	X				
27868				X		X (N)		
31322	X?							
31322-2	X		X	X				
33622			X	X				
35330	-	-	-	-	-	-	-	-
39056				X				
42413								
44139	X			X				
46541			X	X				
46551	X?		X	X				
49249	-	-	-	-	-	-	-	-
51849	X		X	X				
51943								
51944	X		X	X				
52053			X		X	X		
56557	X		X	X				
56627	X		X	X				
57679			X	X	X			
57953	X		X	X				
62455								
63769	X		X	X				
69290	-	-	-	-	-	-	-	-
70265			X	X				
70283			X	X		X		
71653			X	X				
71676			X	X				
72526	X		X	X				
76189				X	X			
77023	X		X	X				
77176								
86944	X		X	X				
P1				X				
P2	X		X					

= indicates parallel striations. N indicates natural. S indicates short. – indicates no results because sample was too large for SEM.

Out of the 46 artefacts subjected to SEM, three artefacts were too large to safely fit within the chamber, while two artefacts (15387 and 42413) were examined before and after residue removal. Table 5-9 shows the results of the use-wear analysis, while Table 5-10 categorizes the results into three distinct groups; those with identifiable wear-patterns (i.e. the function can be identified), indeterminate wear patterns (i.e. function cannot be identified, but use-wear is evident), and indeterminate/no use-wear (i.e. there is minimal to no use-wear).

Table 5-10: Degree of identifiable use-wear.

Identifiable Use-Wear	Indeterminate Use-Wear	Unidentifiable/Absent
3646	9942	15096
3885	16208	20503
4184	16528	27868
14288	25073	31322
15295	31322-2	**35330**
15387	46541	33622
24506	56557	39056
24842	56627	42413
44139	57679	46551
51849	63769	**49249**
52053	71653	51943
57953	86944	51944
72526	Point 2	*62455*
77023		**69290**
		70265
		70283
		71676
		76189
		77176
		Point 1

Artefacts in **bold** were too large for the SEM chamber and not analyzed. Artefacts in *italics* were only subjected to SEM analysis as a comparative sample.

The most commonly observed wear patterns include striations, edge flaking, and edge rounding (Table 5-9). Artefacts 31322, 42413, 62455, and 77176 show no use-wear and are grouped with artefacts where possible use-wear was unidentifiable (Table 5-10). These results are not very informative regarding the source material (i.e. what these artefacts were used on)

Table 5-11: Source material hardness.

Hard	Medium	Soft
3646	3885	4184
3885	14288	9942
4184	15295	25073
9942	51849	31322_2
14288	52053	44139
15387	56627	46541
16208	57679	51849
16258	57953	56557
24506	63769	56627
24842	71653	57953
52053	77023	72526
		77023
		86944

Artefacts may fall under more than one category. Interpretations mostly based off Knutsson, 1998a.

Table 5-12: Mode of use.

Artefact	Type of Movement	Functional Interpretation
3646	Perpendicular with slight angle– pushing motion (puncture)	Awl or burin
3885	Parallel with slight curve – twisting motion	Drill
4184	Parallel (striations) – push or pull	Scraper
9942	Perpendicular (lancets) – pulling?	Graving?
14288	Parallel and perpendicular (striations)	Multiuse cutting and/or sawing
15295	Perpendicular (striations) – push/pull	Scraping
15387	Concave edge - perpendicular - pull	Scraping
	tip edge - unsure	Other
16208	Perpendicular – push or pull	Scraping?
16528	Tip edge – perpendicular	Graving?
	Straight edge – perpendicular - push/pull	Scraping?
24506	Perpendicular and perpendicular – twist or push/pull	Drill or graver
24842	Parallel and angled - twist	Drill
25073	Perpendicular – push/pull	Scraper?
31322-2	Angled - pull	Cutting
44139	Parallel and perpendicular (striations)	Cutting and scraping
46541	N/A	N/A
51849	Parallel and perpendicular – twist and puncture	Awl/drill/burin
52053	Perpendicular – puncture	Awl
56557	Perpendicular	Scraper/plane?
56627	Parallel	Cutting
57679	Perpendicular – puncture	Awl (dry hide)?
57953	Perpendicular and parallel	Cutting and scraping
63769	Perpendicular (hafting?)	Projectile or spokeshave
71653	Perpendicular – puncture	Awl
72526	Perpendicular	Scraper/plane?
77023	Perpendicular and parallel	Cutting
86944	Perpendicular and parallel	Cutting
Point 2	Perpendicular to edge (hafting related)	Point base

Artefacts in *italics* are those with indeterminate use-wear.

and can only indicate the hardness of the material (Table 5-11) rather than a specific material. The residue results provide the most specific results on source material. For this study, use-wear analysis is most useful for confirming that the artefact was used, indicating the hardness of the source material, and indicating the mode of use (i.e. how it was used/motion; see Table 5-12). The observations made in Table 5-9, Table 5-10, Table **5-11** and Table 5-12 are expanded upon in the following chapter where the individual artefacts are interpreted.

6 Residue and Artefact Interpretations

The methodology behind this study uses multiple techniques to produce as accurate an interpretation as feasible for artefact function. Chapter 5 presented the results of the methodology, which is combined below to interpret the residue classifications identified using HPILM and then to interpret the function of each individual artefact. Each residue classification is interpreted by combining all the data from the varied residue analytical techniques (e.g. HPILM, biochemical tests, GC/MS, and HPTLM). Following this, each artefact is interpreted individually based on the results from the residue and use-wear analysis. For some artefacts, results are lacking from one or both analyses and the interpretation of the artefact is therefore limited. In any case, each artefact is evaluated and interpreted to the highest degree possible. Each interpretation includes macroscopic observations (e.g. size, colour, shape), an explanation on why it was selected for the study, an interpretation of the residue, an interpretation of the use-wear, and lastly a summary interpretation of the overall interpretation of the artefact. The authentication of residue (i.e. how to determine anthropogenic vs. contaminant) is addressed for each artefact.

6.1 Residue Interpretations by Classification

The residue classifications identified in Chapter 5 must first be interpreted based on the results from the different residue analytical techniques. As explained in Chapter 4, the purpose of visually classifying the residue was to allow for positive results to speak for samples that produced no results. These interpretations are then used in the individual artefact interpretations below.

During analysis 16 different amorphous residues were identified using HPILM (17 counting the stratified occurrence of two residues). Eight of these classifications are single occurrences, making trends difficult to identify. The lack of GC/MS results and the ambiguity of the Iodine test for starch limits the ability to interpret the residue beyond the presence or absence of protein and fatty acid residue.

Table 6-1 and Table 6-2 summarize the results for the protein and fatty acid biochemical tests by residue classification. Starch is not included within this list as the results were inconclusive. The number of artefacts where each residue class was observed is in the second column. Table 6-1 includes only the positive results, while Table 6-2 also includes the weak positive results (i.e. those that fell between the positive and negative control samples). The difference between the tables shows how much stronger the data appears when all values above the negative control are considered positive. The positive control established that the test works properly, but because the control protein is fresher and likely in higher concentrations, it can produce higher results than the archaeological sample. Both tables have two columns of data for each test. The first column provides the percentage of positive results by artefact. The second column provides the percentage of positive results total (each artefact produced two readings). See Table 5-4 and Table 5-5 for the results from these tests.

Class 1 residue was white/yellow with red undertones (although possibly related to the presence of hyphae) throughout the residue. Although amorphous, the texture appeared globular. This residue resembled a fatty residue described in the literature (i.e. white/yellow amorphous residue with some globular pieces and brown or red inclusions; see Lombard, 2008). Biochemical tests strongly indicated the presence of both fatty acid and protein within the residue. The Hb-CRTS could not support that the red component was blood. The visual and chemical data both are consistent with an animal residue.

Table 6-1: A summary of the biochemical test results by residue class.

Class.	#	Protein		Fatty Acid	
1	12	58%	42%	33%	21%
2	10	40%	25%	40%	30%
1/2*	2	0%	0%	50%	25%
3	1	0%	0%	100%	100%
4	10	40%	30%	70%	50%
5	9	33%	22%	11%	11%
6	4	50%	38%	50%	25%
7	3	33%	17%	33%	17%
8	2	50%	50%	0%	0%
9	2	50%	50%	0%	0%
10	1	0%	0%	100%	50%
11	2	100%	100%	100%	25%
12	3	67%	33%	33%	17%
13	1	0%	0%	0%	0%
14	1	0%	0%	100%	100%
15	1	100%	100%	0%	0%
16	1	100%	50%	0%	0%

*This category denotes a mixture of class 1 and 2 residues.

Table 6-2: A summary of the biochemical test results by residue class.

Class.	#	Protein		Fatty Acid	
1	12	83%	71%	75%	67%
2	10	70%	55%	80%	70%
1/2*	2	0%	0%	100%	75%
3	1	0%	0%	100%	100%
4	10	60%	40%	90%	75%
5	8	56%	56%	56%	33%
6	4	100%	75%	50%	25%
7	3	33%	17%	33%	33%
8	2	50%	50%	0%	0%
9	2	50%	50%	0%	0%
10	1	0%	0%	100%	100%
11	2	100%	100%	100%	50%
12	3	100%	67%	33%	33%
13	1	0%	0%	100%	50%
14	1	100%	100%	100%	100%
15	1	100%	100%	0%	0%
16	1	100%	100%	100%	50%

*This category denotes a mixture of class 1 and 2 residues.

Class 2 residue was dark brown or red with the occasional yellow or brown inclusion (possibly class 1 or 4 residue). This amorphous residue was composed of thick, globular occurrences and was highly reflective. The colour and gloss of the class 2 residues were consistent with a blood residue described in the literature (i.e. reflective, yellow to red/black colour depending on thickness, see Lombard, 2008), but they lacked the dehydration and desiccation cracks (mud cracking) that is more typical for blood residues. The Hb-CRTS result support this interpretation because artefact 4184 scored a 1 (weak positive). Like class 1, the biochemical tests supported the presence of both protein and fatty acid. The absence of desiccation cracks in this class of residue could be due to the presence of fatty acids preventing their formation. The concentrations of fatty acids and protein varied slightly from the class 1 residues but this could be due to preservation or from sampling. The residue resembled the red inclusions of class 1 residues, suggesting a possible relationship. The class 2 residues were interpreted as an animal based residue.

Two artefacts analyzed showed a stratified relationship between class 1 and class 2 residues, where class 1 was situated on top of the class 2 residue. This supported the observation that the two are likely related. Interestingly, the biochemical results presented a strong positive for fatty acid and negative results for protein. This could indicate a limitation for the biochemical tests when residue is stratified.

Class 3 residue was a bright red residue with a yellow secondary colour (either sediment of class 1 or 4 residue). The amorphous residue was glossy and somewhat globular. It was only found on artefact 14288 opposite to the working area and thus the distribution suggests hafting related. Unfortunately, artefact 14288 was too small for an edge specific removal and thus the biochemical test results for this artefact are attributed to the more abundant class 4 residue on its working edge. Therefore, the origins of this residue were not interpretable.

Class 4 residue was an amorphous residue with yellow colour and globular inclusions. Some areas were browner, but this might be a result of hyphae. It was not very glossy, although certain areas were more reflective. This residue was similar to class 1, but lacked the red/brown secondary colour, suggesting class 4 residue is unilocular adipose tissue (i.e. fat), while class 1 residue is multilocular adipose tissue (i.e. contains more blood; Lombard, 2008). The biochemical results indicated a very high percentage of fatty acid and a small concentration of protein. Both visual identification and biochemical analysis support an animal-based fat residue.

Class 5 residue was an amorphous, dark brown/red residue that was transparent when thin. It was mostly composed of hyphae growth, which may indicate that residue was once present, and the residue was sparsely distributed. Hyphae was common throughout the different residues, but was the most defining characteristic for class 5. The biochemical tests produced weaker results, but protein and fatty acid were still present (see Table 6-1 and Table 6-2). It is possible that this class was a more degraded, hyphae-filled occurrence of class 2 residue. Therefore, this residue was likely still animal-derived.

Class 6 residue was a thin, darker brown amorphous residue with lighter brown inclusions. Hyphae was abundant and the residue had a medium gloss, although higher magnifications increased the reflectiveness. Globular inclusions were also abundant and in some cases dehydration and desiccation cracks typically found in proteinaceous residues (e.g. blood) were present. Therefore, multilocular adipose tissue and blood may be components of this residue. The Hb-CRTS results strongly support blood residue, based on artefact 15387's score of 2. Biochemical analysis produced strong results for protein and fatty acid. Plant exudates have a very low protein content thus the residue was interpreted as animal based that was consistent with blood and thus an animal based residue.

Class 7 residue was amorphous and granular in texture. It was white in colour, with the occasional yellow hue. Resembling sediment, the presence of globular inclusions (unilocular adipose tissue) hinted at the possibility that a small amount of archaeological residue was mixed with sediment. Only one of the three artefacts, artefact 52053, with this residue produced positive biochemical results, meaning interpretations of the other two residues were based on this result. The biochemical tests for 52053 indicated the presence of protein and fatty acid, suggesting an animal-based residue.

Class 8 residue was yellow and black in colour and amorphous in shape. Dehydration and desiccation cracking was abundant throughout the low-medium gloss residue. The residue appeared burnt and almost resembled burnt corn on the cob. A small piece of class 2 residue was visible on artefact 24842 and artefact 25073 resembled class 2 in some locations. Thus, there is a relationship between class 2 and 8 residues. The cracking texture indicated blood residue, although the dull gloss does not support this interpretation. The Hb-CRTS results from artefact 25073 support this interpretation. Biochemical tests produced few results, but included a positive result for protein residue. The lack of results could indicate poor preservation, burnt residue, a low concentration of residue, or unsuccessful solvent removal, but the interpretation still supports the possibility of blood and thus animal residue.

Class 9 residue was dark brown and highly glossy. Hyphae was abundant and the smooth texture had globular inclusions. The residue was fairly similar to class 2 and 5 and was likely related. This type of residue was only present on two artefacts, one of which produced positive results for the protein biochemical test. It is suspected to be animal based, but the biochemical results are limited and provide less support for this interpretation.

Class 10 residue was red with purple hues and amorphous in shape. Slightly glossy, the residue accumulated in a thin layer with a rough texture. It was only present on artefact 39056, which also had class 1 and 1/2 residue in greater abundance. Therefore, the positive fatty acid result cannot be attributed to this residue and thus the residue cannot be interpreted at this time.

Class 11 residue is a dark purple/black, ovoid residue with a low gloss and smooth surface. One occurrence of the class 11 residue appeared thicker than the other and thus it was difficult to confidently class them as the same. However, both occurrences of this residue were unique features associated with other residues on two artefacts. Their biochemical results may not be an accurate representation of this residue. They are more likely a result of the associated residues because the class 11 residue was too small to independently test. Therefore, class 11 residue cannot be interpreted at this time.

Class 12 residue is consistent with blood residue because of its dehydration and desiccation cracking, colour and gloss. This dark purple/red residue was found on three different artefacts, including one (arguably two) projectile points. The Hb-CRTS produced weak positives for artefacts 44139 and 63769, supporting the interpretation that the residue was blood. Biochemical tests produced strong positives for both protein and fatty acid for one artefact. The other artefacts within this category relied on the interpretations from the analysis of this artefact.

Class 13 residue was bright orange with a hint of red. This amorphous residue had a medium gloss and grainy texture. It was only present on artefact 51944, which had a greater abundance of class 2 residue. Therefore, biochemical test results were attributed to class 2 residue and visual identification could not interpret this residue.

Class 14 residue was slightly glossy, light pink and white. This amorphous residue was grainy in texture and resembled class 7 residue. It was only present on artefact 56627, which also had either a class 2 or 5 residue in greater abundance. Therefore, the biochemical test results are attributed to these other residues and class 14 residue could not be interpreted.

Class 15 residue was a bright red residue surrounded by class 1 or 4 residue. It was amorphous in shape and highly glossy. It was only present on artefact 57679, which also had class 1 residue. Therefore, biochemical test results were attributed to class 2 residue and visual identification could not interpret this residue.

Class 16 was a black residue surrounded by class 1 or 4 residue. It had a low gloss and was amorphous in shape. It could easily be the result of an errant marker during field collection. It was only present on artefact 71676, which had a larger abundance of class 1 residue. Therefore, biochemical test results were attributed to class 1 residue and visual identification could not interpret this residue.

Unclassified residue is an additional class for those residues where there may not be enough present to characterize or where the residue is discolouration that may be due to the lithic material itself. Artefacts 3646, 9942, 69290 only had unclassified residues. Biochemical tests were not performed on artefact 3646. Artefact 3646 produced negative results for protein and positive results for fatty acid. Artefact 69290 produced negative results for protein and one weak positive for fatty acid. The interpretations for these artefacts are discussed below. Interpretations of unclassified residues on artefacts with identifiable and classifiable residue were not attempted because these other residues were present.

6.2 Individual Artefact Interpretation

6.2.1 Artefact 3646

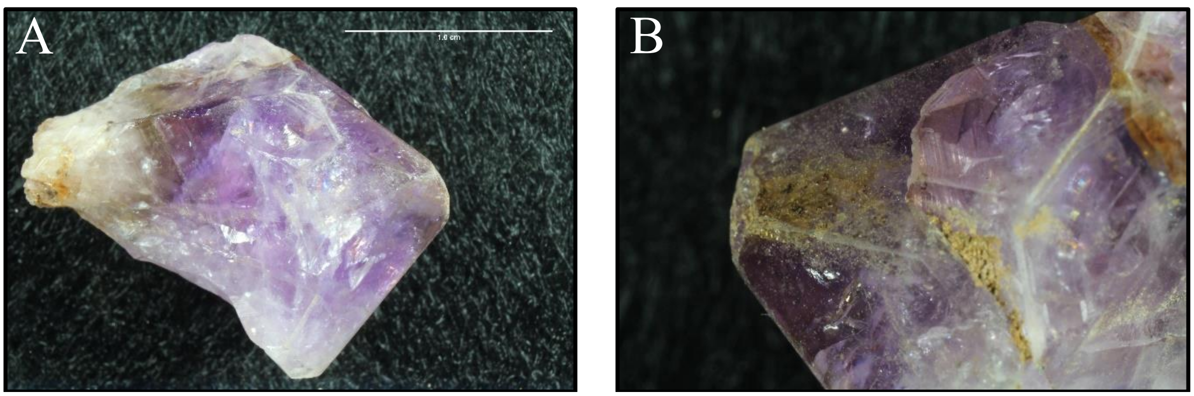


Figure 6-1: Artefact 3646
A – Macro image of artefact3646. B – The blunt tip and suspected residue at 20x magnification.

Artefact 3646 (Figure 6-1A) was a small amethyst crystal measuring 21mm x 16.5mm. This artefact was selected for its crystal shape and worn tip. Upon closer inspection, a small amount of possible residue was visible within pits on the crystal face with suspected residue near the blunt tip (Figure 6-1B). See Figure 6-4 for the location of each micrograph.

The highly reflective surface made light microscopy difficult. The residue was white and amorphous, but too little was present for a confident classification (Figure 6-1C). Residue was still visible on the surface of the tool when viewed using the SEM, despite the earlier solvent removal. Organic residue was confirmed using elemental analysis (SEM/EDS), but the SEM provided more detail showing two unidentified biconcave-discoidal-shaped organic objects,

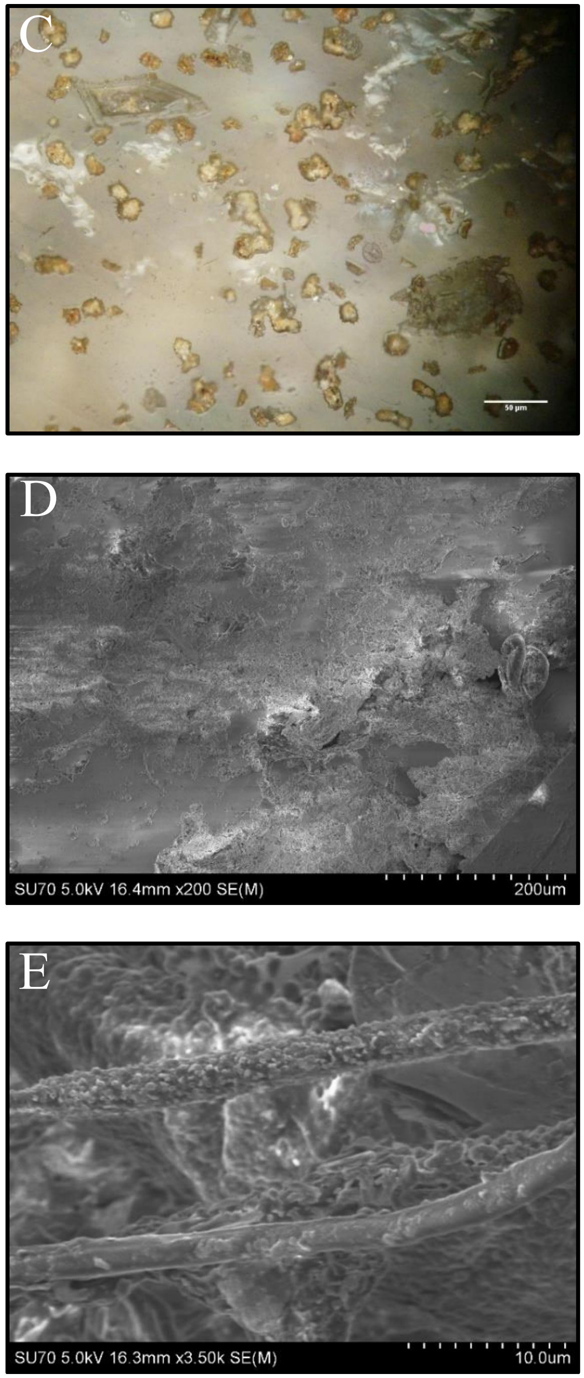


Figure 6-2: Residue on artefact 3646
C – Residue Micrograph. D – A SEM image of organic residue on crystal surface. E – Different fibres within the residue.

measuring 60-70μm in length and less than 20μm in width (Figure 6-2D). The biconcave-discoidal-shaped objects could not be characterized further to differentiate it as either plant or animal. Smaller fibres were visible within this residue. Located near the base of the crystal were two more fibres, suspected of being cellulose (Figure 6-2E). This correlates to the plant material identified using transmitted light microscopy. Sinew (for hafting) was ruled out because neither fibre was consistent with collagen. Unfortunately, GC/MS analysis produced no significant results and biochemical tests were not performed on this artefact and therefore cannot aid in the interpretation (Table 6-3; Table 6-4).

Table 6-3: Residue and use-wear results summary for artefact 3646.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
Unclassified	N/A	N/A	Plant	Linear Grooves Edge Damage Pits	Identifiable	Hard	Push or Puncture

Table 6-4: Inquisitive process for artefact 3646 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. There is an amorphous residue that is clearly not part of the lithic material. However, its quantity is too little for proper classification. Limited characterisation was possible using an SEM/EDS.
2 – Is it Organic or Inorganic?	Organic. The residue was confirmed to be organic using an SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. The residue is mostly concentrated around the suspected working area, suggesting it is use related.
4 – Is it Plant or Animal?	Plant. Fibres identified using the SEM and visible during HPTLM both suggest plant. However, the fibres visible under SEM are not located near the working area and could represent either plant based hafting or just an area with better preservation.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

As stated previously, the tip of the artefact appeared worn and pits are present on the crystal face (Figure 6-3F; the same crystal face from Figure 6-1B), but based on comparative examples of unused crystals the pitting is likely natural. Along the edge of the artefact (near the tip) were rounded edges with deep, wide linear grooves. These grooves were oriented nearly perpendicular to the tip, which indicated a pushing or puncturing motion (Figure 6-3G). These features were identified as use-related. The width and depth of the linear grooves are indicative of a harder material (Knutsson, 1988a). There was no evidence of hafting-wear.

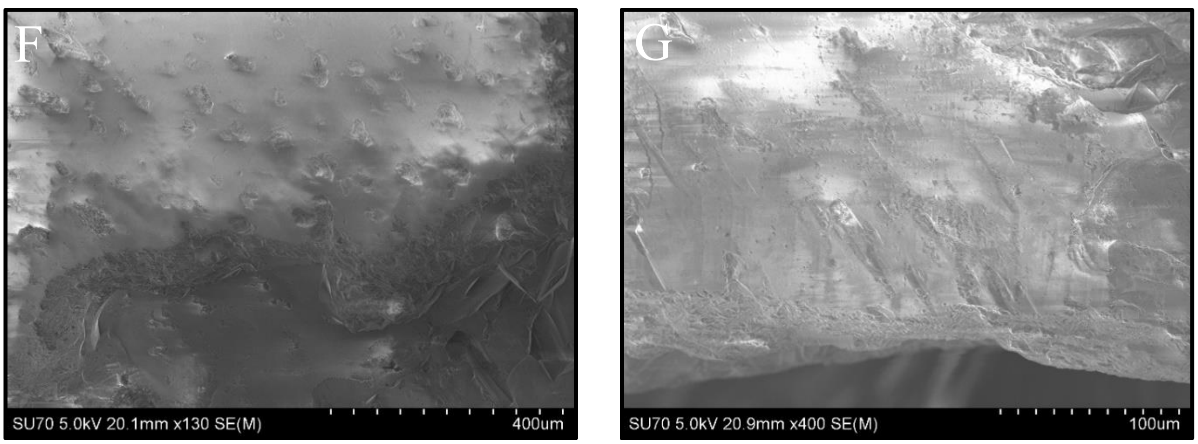


Figure 6-3: Artefact 3646 use-wear
F – Edge abrasion, possibly form use, and natural pitting on crystal surface. G – Wide and deep striations identically oriented. Edge abrasion is also present.

Overall, it can be concluded that the artefact was used. The use-wear suggested a pushing or piecing action rather than a twisting or drilling action. The deep linear grooves suggest a harder material, such as bone or antler (Knutsson, 1988a), but taphonomy can cause archaeological wear patterns to be more exaggerated than their modern, experimentally produced counterparts (Knutsson & Linde, 1990). The limited evidence for residue suggests plant material. The only evidence for hafting are the possible cellulose fibres located distally from the crystal face. The residue is anthropogenic based on its accumulation near the working edge, which is supported by the presence of use-wear in the same location. The fibres cannot be authenticated because there are no other lines of evidence to support hafting. Therefore, it can be concluded that this artefact was likely used for working hard wood.

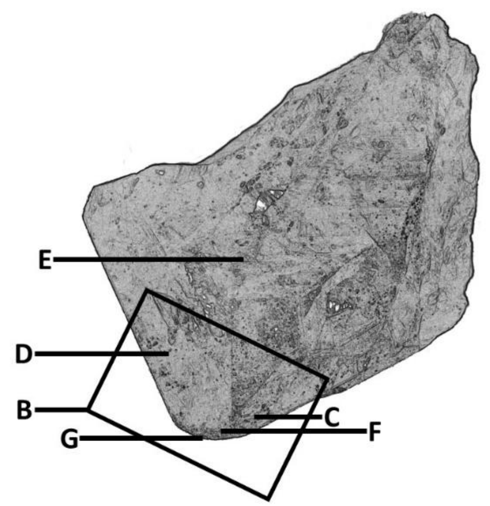


Figure 6-4: Image locations for artefact 3646.

6.2.2 Artefact 3885

Artefact 3885 (Figure 6-5A, B) was a long amethyst fragment measuring 34mm long and 13mm wide. It was selected for its worn tip and the presence of a darker residue near the suspected working point. Upon closer inspection, the tip appears purposely modified as it comes to a point at the tip of the distal end (see Figure 6-5C, D). See Figure 6-8 for the location of each micrograph.

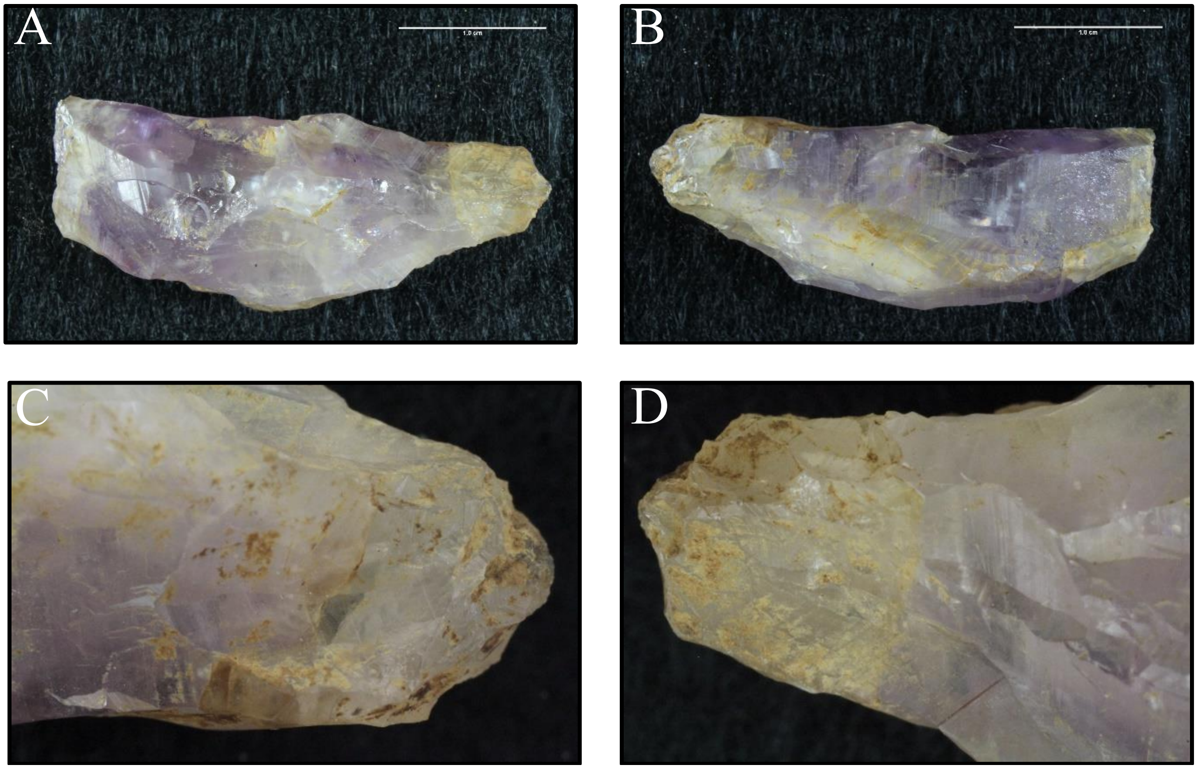


Figure 6-5: Artefact 3646
A, B – Macroscopic photographs of artefact 3885. C, D – Suspected working tip with residue.

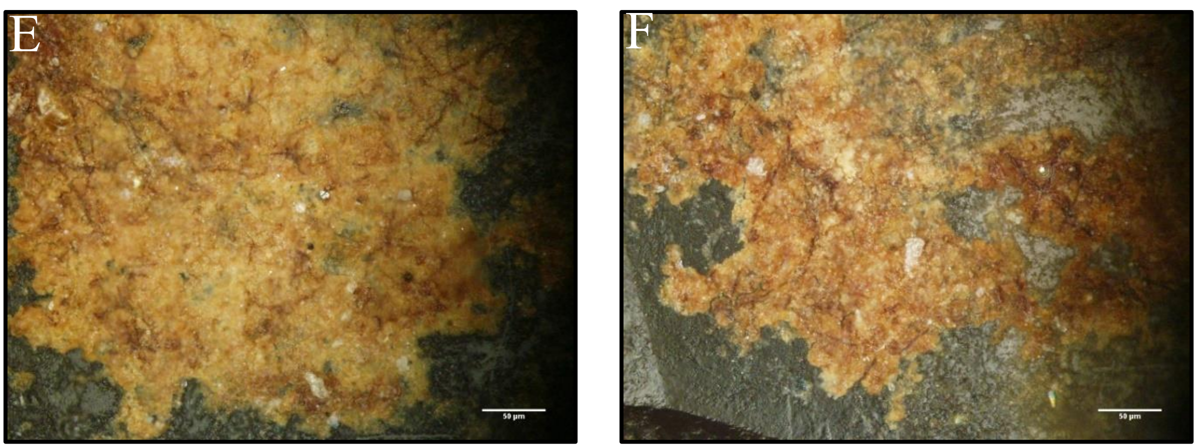


Figure 6-6: Residue on artefact 3885.
E, F – Two of three images showing class 1 residue on artefact 3885. It is animal-derived.

High power micrographs produced three images of class 1 residue (i.e. fatty residue; Figure 6-6) which suggested animal origin (Wadley, et al., 2004). Biochemical tests supported this with weak positive results for both protein and fatty acid. These weaker results could be from a lower concentration of archaeological residue compared to the positive test control. The Hb-CRTS results (score of 0) could not support the presence of blood in the residue. The GC/MS analysis produced no significant results. The SEM/EDS analysis confirmed the residue was organic. Transmitted light microscopy identified animal fibres, further supporting the other lines of evidence for an animal-derived residue (Table 6-5; Table 6-6).

Table 6-5: Residue and use-wear results summary for artefact 3885.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1	Weak	Weak	Animal	Striations Edge Damage Pits	Identifiable	Hard	Push and twist

Table 6-6: Inquisitive process for artefact 3885 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. There is an amorphous residue that is clearly not part of the lithic material.
2 – Is it Organic or Inorganic?	Organic. The amorphous residue lacks the structure of inorganic material. The SEM/EDS analysis confirmed the residue is organic.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the suspected working edge suggests it originated from a specific activity.
4 – Is it Plant or Animal?	Animal. Biochemical tests and high power microscopy (incident light *in situ* and transmitted light on slides) all suggest animal origins.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Artefact 3885 exhibited some of the most interesting use-wear evidence from the analyzed artefacts. The working tip was rounded, worn and featured striations parallel to the working point. This suggested a twisting motion or a drilling function. Upon closer examination, the striations were slightly curved and organic residue in the vicinity. The striations themselves were not very wide, but were deep, suggesting a harder material (Figure 6-7).

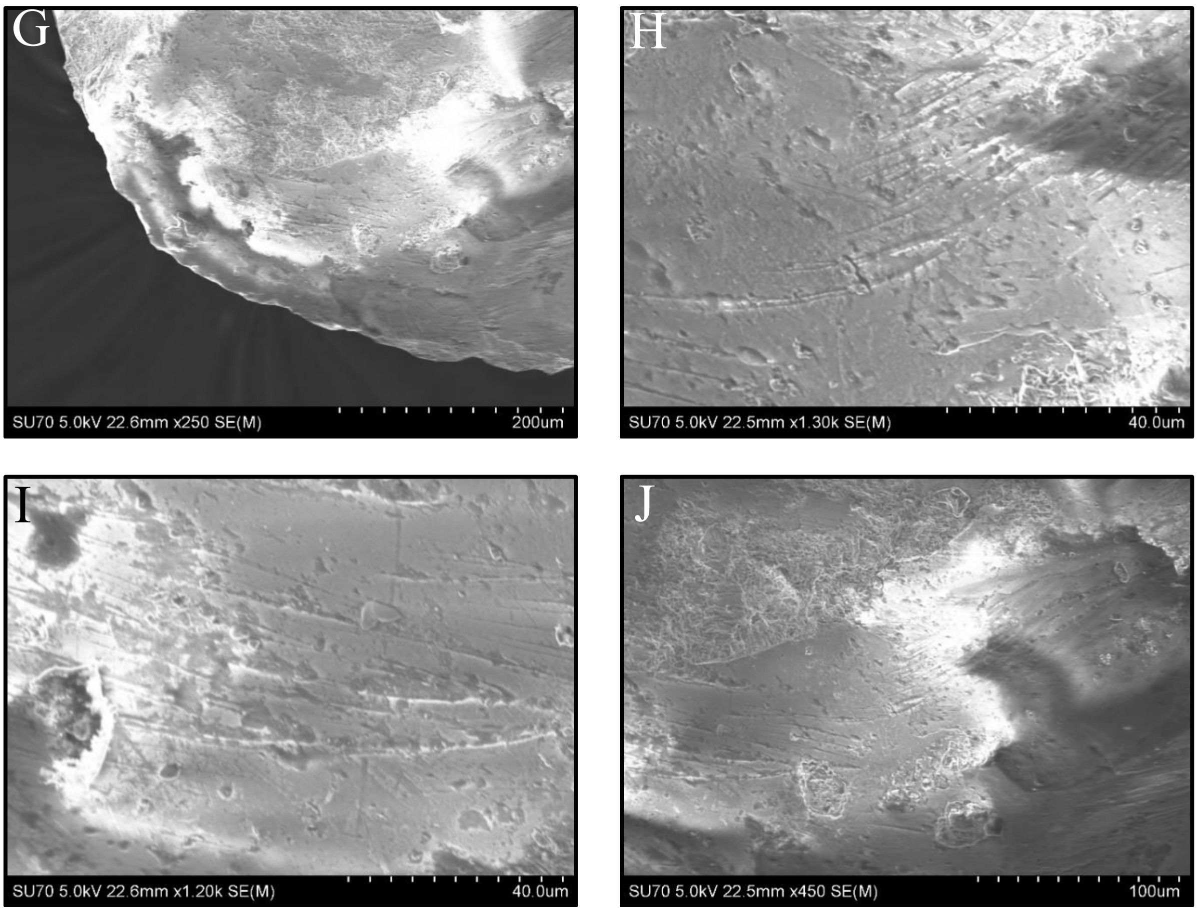


Figure 6-7: Use-wear on artefact 3885.
G – Overview of area with striations. H – Striations exhibit a slight curve. I – Close-up on striations. J – Organic residue near curved striations.

In summation, artefact 3885 showed a strong presence of both residue and use-wear. The residue was concentrated near the working edge, which was supported by the presence of use-wear. Transmitted and incident light microscopy and biochemical tests all indicated an animal based origin for the residue. Use-wear analysis indicated the artefact was used in a twisting or drilling motion. The artefact was most likely used to drill through fresh animal bone or antler (because of the protein in the residue) and is large enough to be used by hand. If a bow drill were used the wear patterns would be more uniform around the tip. See Johnson (1993) as a comparison.

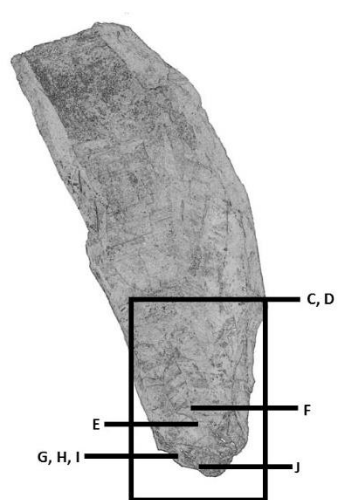


Figure 6-8: Image locations for artefact 3885.

6.2.3 Artefact 4184

Artefact 4184 (Figure 6-9A, B) was a quartz implement measuring 26mm long and 20mm wide. The quartz was clear and transparent in some areas, and white and translucent in others. This flake was selected for the visible residue located along a thin edge, which was scalloped (i.e. alternating concave and convex curves). Figure 6-9B shows the residue adhering to the dorsal surface of the artefact. See Figure 6-12 for the location of each micrograph.

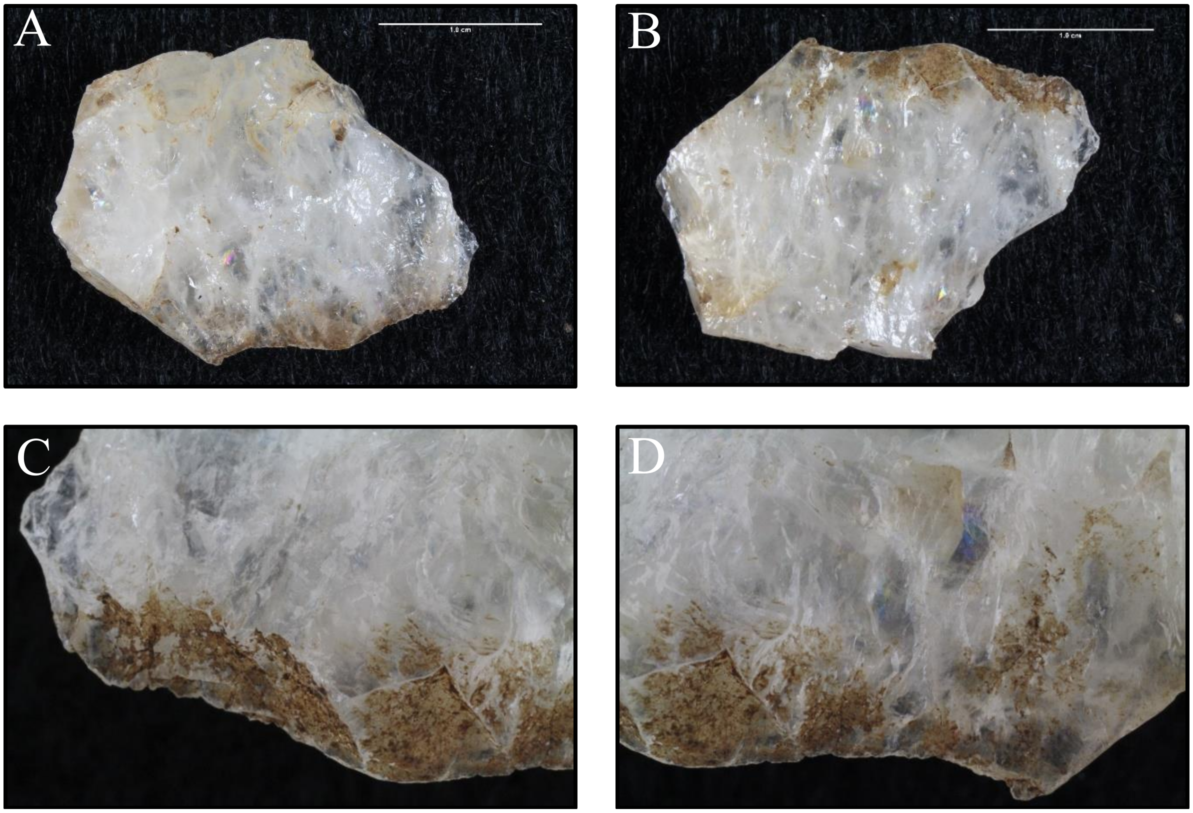


Figure 6-9: Artefact 4184.
A – Ventral surface. B – Dorsal surface. C, D – Low power incident light images of residue adhering to dorsal surface of the working edge.

The HPILM identified two types of residue; class 2 and a mix of class 1/2 (Figure 6-10). Visually, class 2 residue appears to be animal in origin, possibly blood based on its glossy finish, globular distribution, and some possible dehydration and desiccation cracks. The class 1/2 residue appears to be stratified, with the class 1 residue (also of animal origin) situated on top of the class 2 residue. Biochemical analysis produced one weak positive for fatty acid and could not confirm the presence of protein in the residue. However, the tests from other artefacts with class 2 or class 1/2 residue suggest they are both animal-derived. In addition, Hb-CRTS produced a weak positive (score of 1), indicating the residue may contain blood. The GC/MS analysis produced no significant results. The particulate materials removed from the artefact and examined using HPTLM are also consistent with an animal origin (Table 6-7; Table 6-8).

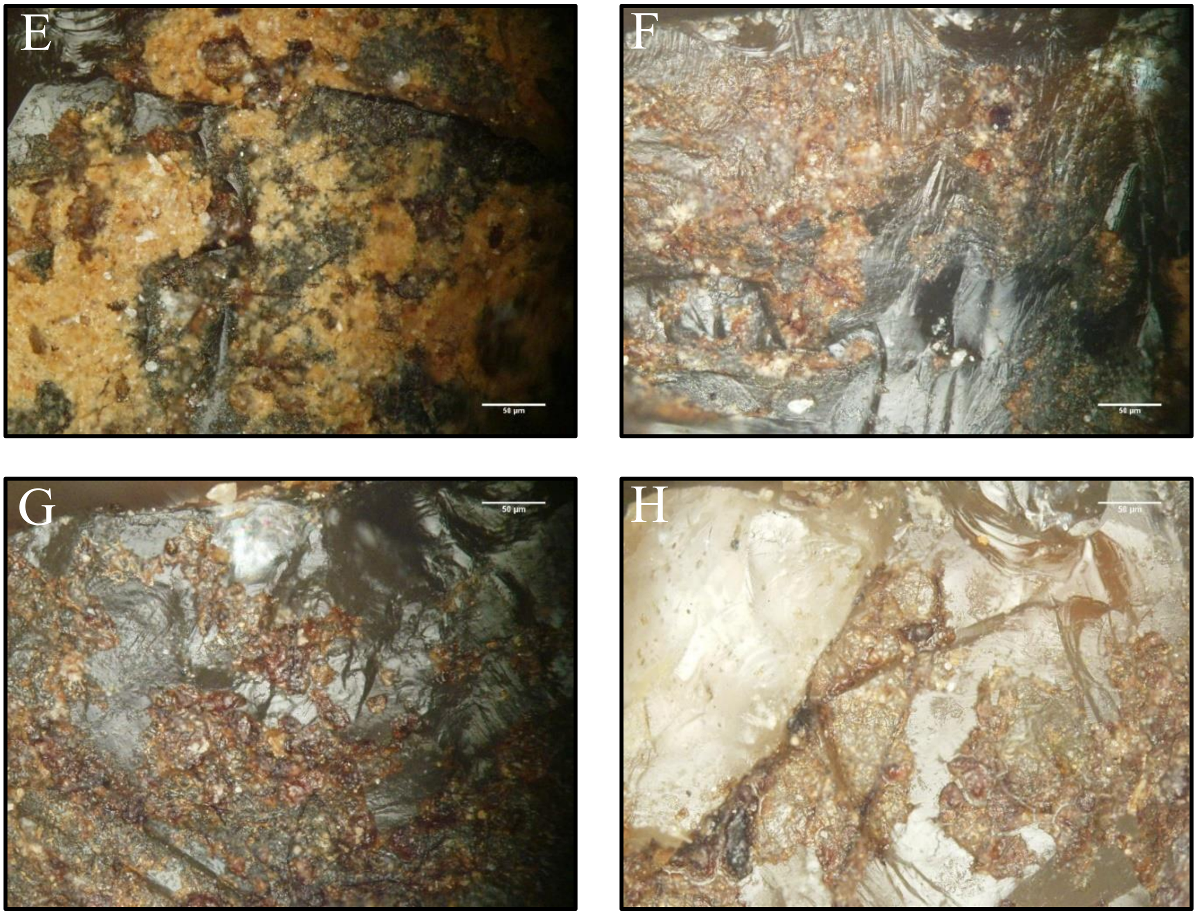


Figure 6-10: Residue on artefact 4184.
E – Class 1/2 residue. F, G, H – Class 2 residue.

Artefact 4184 was the only artefact to show clear evidence of use under HPILM (Figure 6-11I, J). Trapezoidal and half-moon scars were present on the ventral and dorsal surface, indicating use on a harder material, such as bone or antler (Sussman, 1988). The type of scars and their orientation indicated force perpendicular (i.e. pushing or pulling motion) to the working edge (Sussman, 1988). Striations oriented perpendicular to the working edge support this interpretation. The SEM images were highly affected by charging, due to the remaining organic residue and thinness of the artefact, but the flake scars were still noticeable (Figure 6-11K, L). The edge was well worn.

Table 6-7: Residue and use-wear results summary for artefact 4184.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2; 1/2	No	Weak	Animal	Striations Flake Scar Edge Damage	Identifiable	Soft/Hard	Push or pull

Table 6-8: Inquisitive process for artefact 4184 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. There is an amorphous residue that is clearly not part of the lithic material.
2 – Is it Organic or Inorganic?	Organic. The amorphous residue lacks the structure of inorganic material. The SEM/EDS analysis confirmed the residue is organic.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the suspected working edge suggests it originated from a specific activity.
4 – Is it Plant or Animal?	Animal. Biochemical tests and high power microscopy (incident light *in situ* and transmitted light on slides) all suggest animal origins.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Artefact 4184 was clearly a tool; a utilized flake more specifically. Residue analysis strongly indicated that this tool was used for animal processing. A large amount of residue accumulated along the working edge, supporting the authentication of the residue. Interestingly though, the residue only accumulated on one side, which is expected from scraping tools (see Chapter 7). This suggested unequal preservation of residue that is dependent on the orientation of the tool in the depositional environment. Unfortunately, it is unknown which side faced down, but it can be assumed that the dorsal side with residue faced downward, thereby protecting the residue. Use-wear indicated either a pushing or pulling motion where force is directed perpendicular to the edge. This translates to either a scraping motion. The hard material that the tool encountered is most likely bone. Therefore, artefact 4184 was either used to scrape dry and fresh hide and/or to scrape bone or antler.

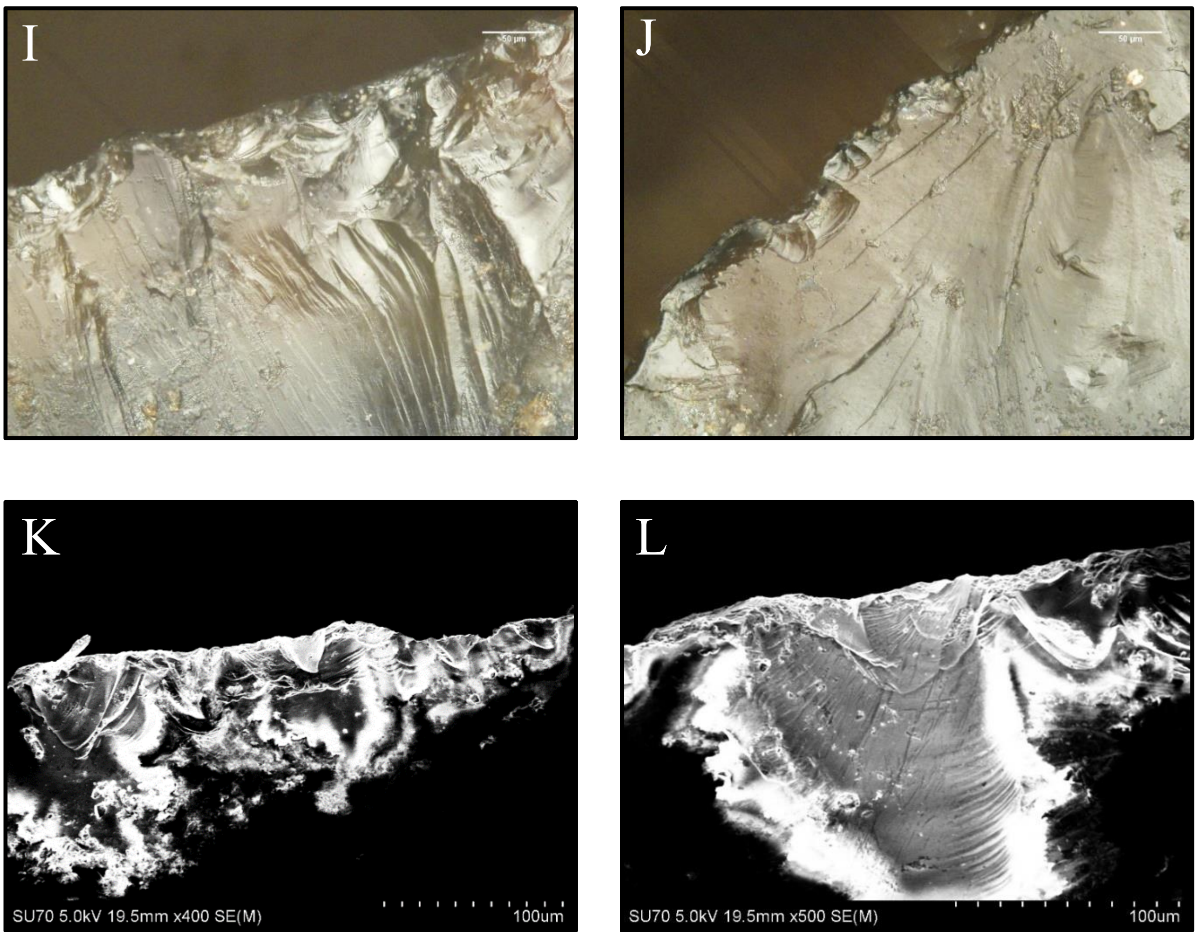


Figure 6-11: Use-wear on artefact 4184
I – Dorsal side use-wear scars. J – Ventral surface use-wear scars. K – Use-wear scars under SEM. L – Striations perpendicular to the working edge.

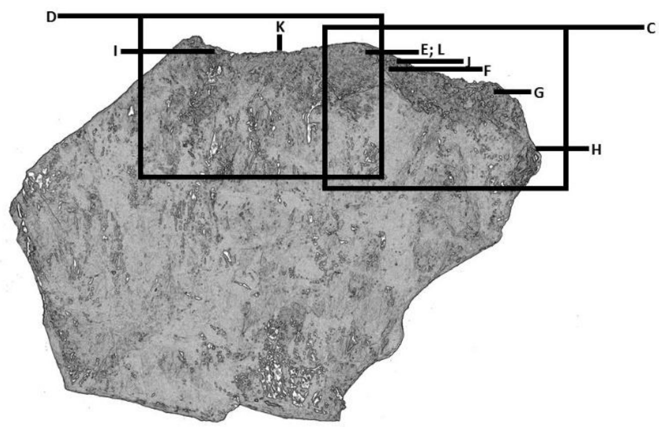


Figure 6-12: Image locations for artefact 4184

6.2.4 Artefact 9942

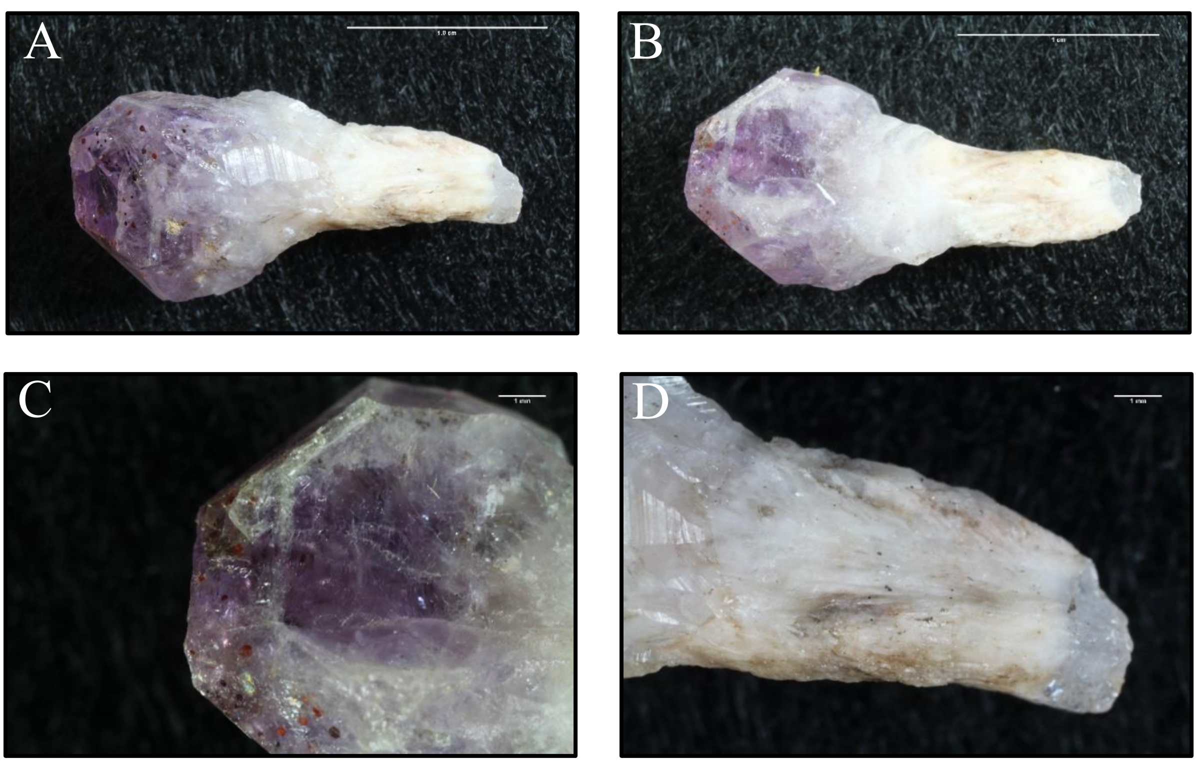


Figure 6-13: Artefact 9942.
A, B – Macro photos of 9942. C – the wide, flat working edge. D – Long stem ideal for hafting. Modification is suspected.

Artefact 9942 (Figure 6-13A, B) was a small amethyst crystal, measuring 23mm long and 11mm wide. This artefact was chosen for its tapered base (Figure 6-13D) and worn, flat tip. The flat tip was particularly interesting since most crystals in the collection came to a point. The flat tip measured nearly 4mm in length (Figure 6-13C). This morphological difference would impact the function of the tool (e.g. as an engraver rather than a drill). See Figure 6-16 for the location of each micrograph.

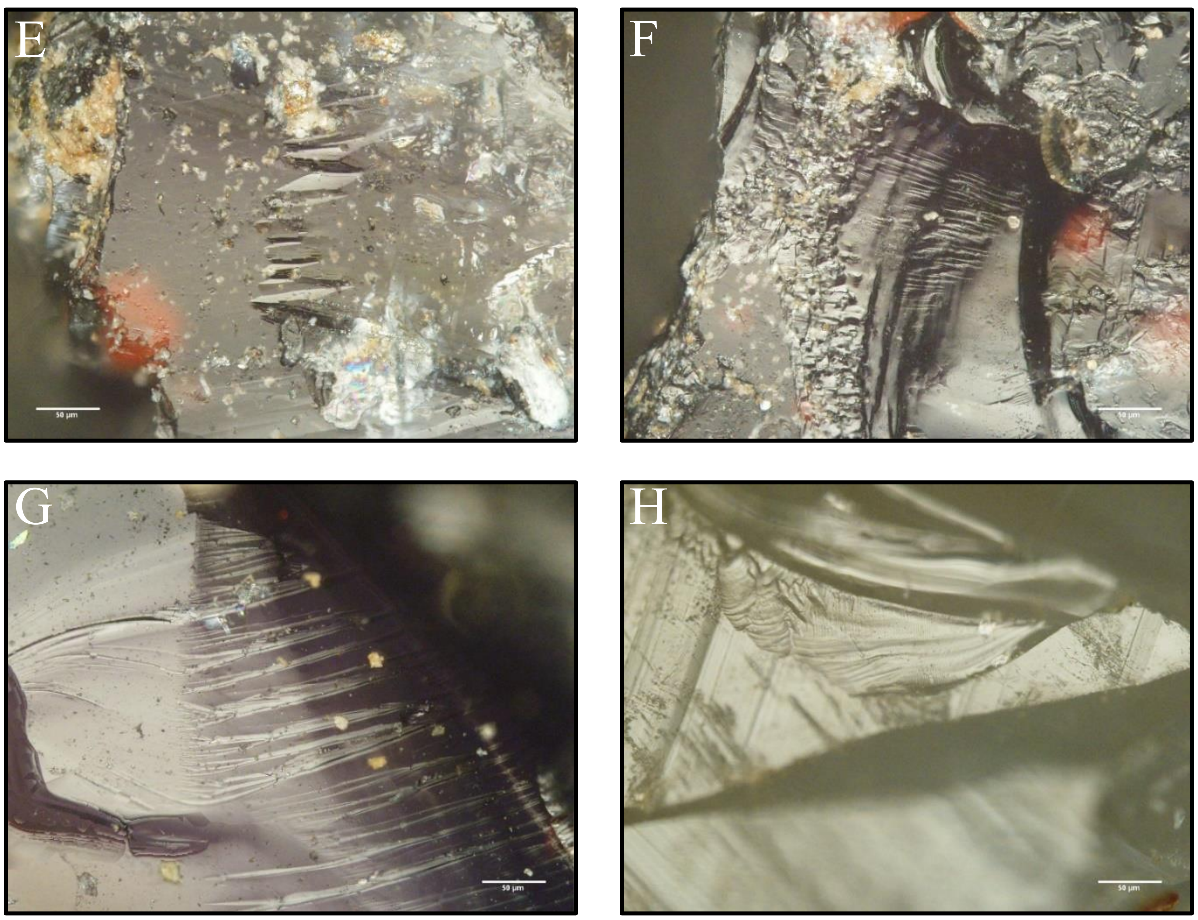


Figure 6-14: Residue on artefact 9942.
E – Small amount of residue, either Class 1 or 4. F, G – Lancets visible using HPILM. H – Two micro-flakes may indicate modification for hafting.

Residue remained largely elusive under HPILM (Figure 6-14), but the uniqueness of the artefact warranted further analysis. The potential residue that was visible was too sparse to confidently classify, but was similar to either class 1 or 4. The SEM only detected a small amount of organic residue as well. Biochemical tests produced positive results for only fatty acid. The GC/MS analysis produced no significant results (Table 6-9, Table 6-10).

Table 6-9: Residue and use-wear results summary for artefact 9942.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
Unclassified	No	Yes	Animal	Flake Scar Edge Damage Melting Snow Lancets	Indeterminate	Soft/Hard	Push or pull

Table 6-10: Inquisitive process for artefact 9942 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Although there is too little to classify.
2 – Is it Organic or Inorganic?	Organic. The SEM/EDS analysis confirmed the residue is organic.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the small amount of residue near the suspected working edge suggests it originated from a specific activity.
4 – Is it Plant or Animal?	Animal. Biochemical tests and high power microscopy (incident light *in situ* and transmitted light on slides) all suggest animal origins.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Both HPILM and SEM analysis showed a high number of stress related lancets located perpendicular to the suspected working edge (Figure 6-14G, Figure 6-15L, M, N). Fernandez and

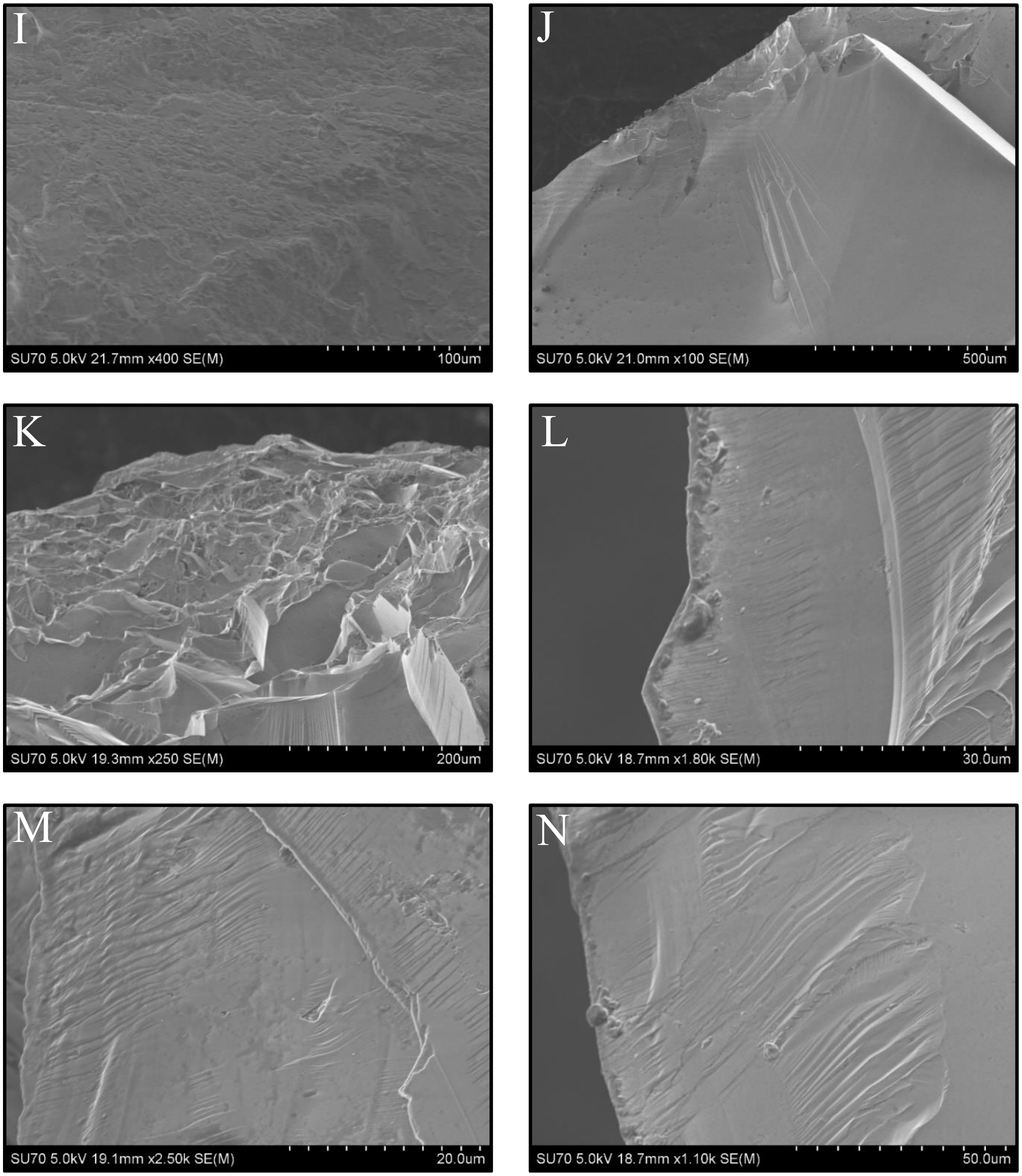


Figure 6-15: Use-wear on artefact 9942.
I – Hafting related polish. J – Micro-flakes along working edge. K – Higher magnification of working edge. L – Small amount of residue on working edge and many lancets perpendicular to working edge; M – Lancets perpendicular to working edge. N – Embedded fragment. Note the location of the fragment in relation to its groove indicates a pulling action.

Olle (2015) discuss how lancets could be interpreted as products of manufacture or use. Based on the branching of the lancets on artefact 9942, it was used in both a pushing and pulling action. One SEM image (Figure 6-15N) showed an embedded object on the surface that occurred through a pulling action. The tip itself appeared crushed in one section with multiple micro-flakes, but the lack of use-wear across the entire tip questions the suspected anthropogenic origin of the damage. Modification of the base for hafting was also suspected. The texture in this area resembled “melted snow,” suggesting it was hafted in either bone or antler (Figure 6-15I). Alternatively, the texture may be a result of a change in the artefact’s material, although SEM/EDS elemental analysis did not detect a change in composition. Two micro-flakes were visible under high-power light microscopy, supporting the interpretation of manufacturing activity at the base (Figure 6-14H). The use-wear evidence can only be considered indeterminate since lancets and a singular striation represent the strongest evidence of use (Table 6-9).

In summary artefact 9942 was a tool. Residue analysis only indicated the presence of fatty acid and therefore little was known about what it was used on, although animal is suspected. The high number of lancets indicated a large amount of force was used and the tool was pushed and pulled across the worked material. The shape of the working edge and mode of use suggest the artefact functioned as a precise scraping implement or a graver. Hafting was suspected and this interpretation was supported by the polish and micro-flakes present at the hafting end.

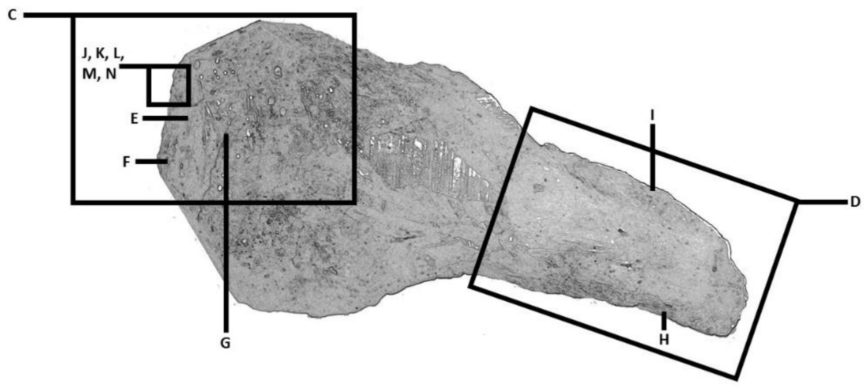


Figure 6-16: Image locations for artefact 9942

6.2.5 Artefact 14288

Artefact 14288 was a small quartz artefact measuring 23mm long and 11mm wide (Figure 6-17). The material is both transparent and milky. This artefact was selected because a brown residue was found along the working edge (Figure 6-17C, D) and a red residue was visible on the opposite end of the tool (Figure 6-17E). Residue was only visible on the dorsal side. The shape of this flake (i.e. tool blank) was consistent with other artefacts analyzed in this study (see Chapter 7). See Figure 6-20 for the location of each micrograph.

The HPILM showed a modified edge in the suspected working area where the yellow/brown residue (class 4) was visible (Figure 6-18H, I, J). A red residue (class 3) was visible opposite the working edge and is suspected to be hafting-related (Figure 6-18G). This is the only occurrence of the latter residue in the assemblage. Unfortunately, GC/MS analysis produced no significant results. Biochemical testing produced positive results for fatty acid only, but this result is common with class 4 residue and likely originates there, rather than with the class 3 residue (Table 6-11, Table 6-12). Although fatty acids do occur in plant material, the white globular pieces and yellow colour of the residue were interpreted as unilocular adipose tissue (i.e. animal residue).

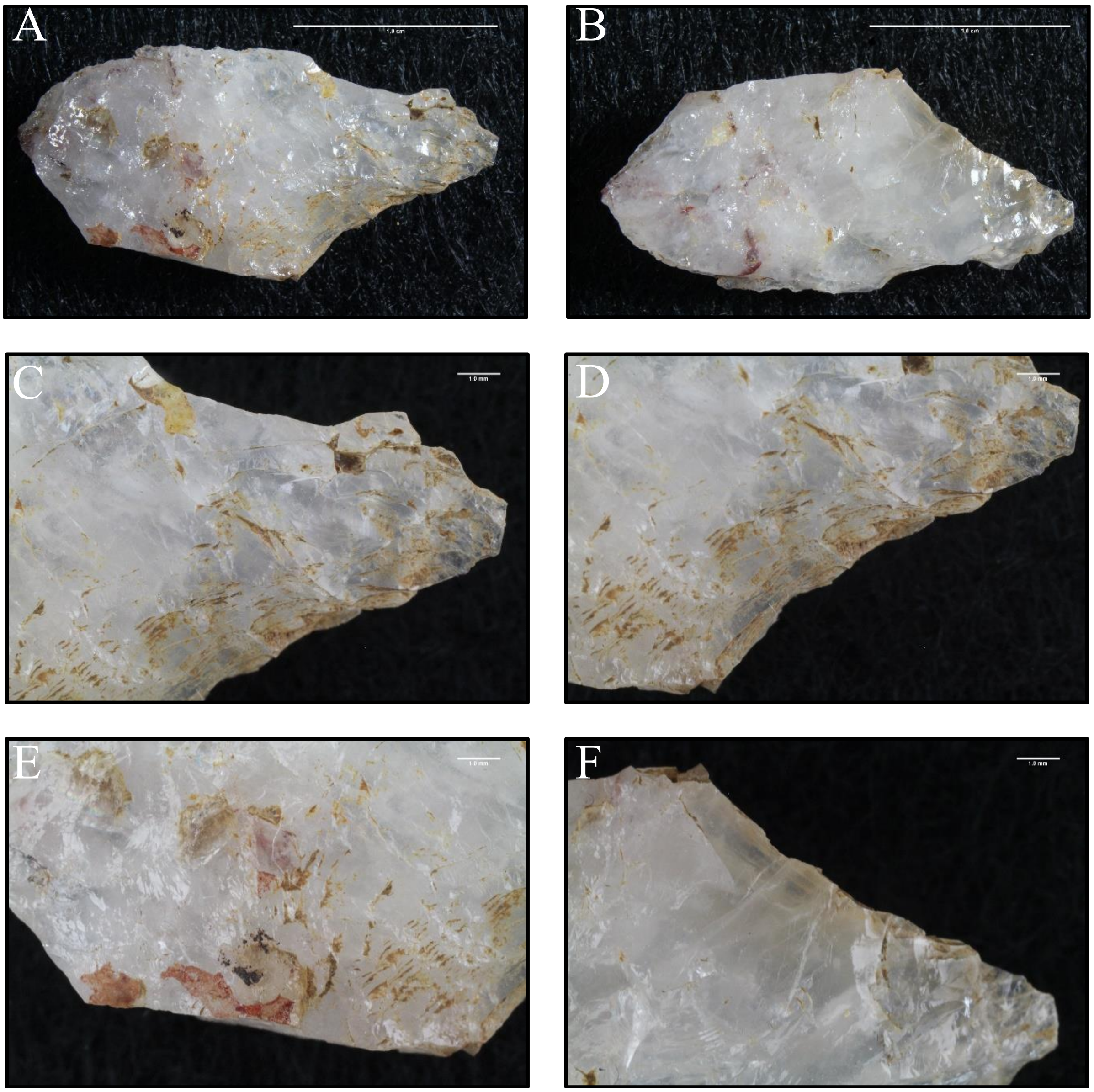


Figure 6-17: Artefact 14288.
A – Macro photos of 14288 dorsal surface. B – Ventral surface. C, D – Manufactured edge at 20x magnification. E – Possible hafting residue (class 3). F – Ventral surface of manufactured edge.

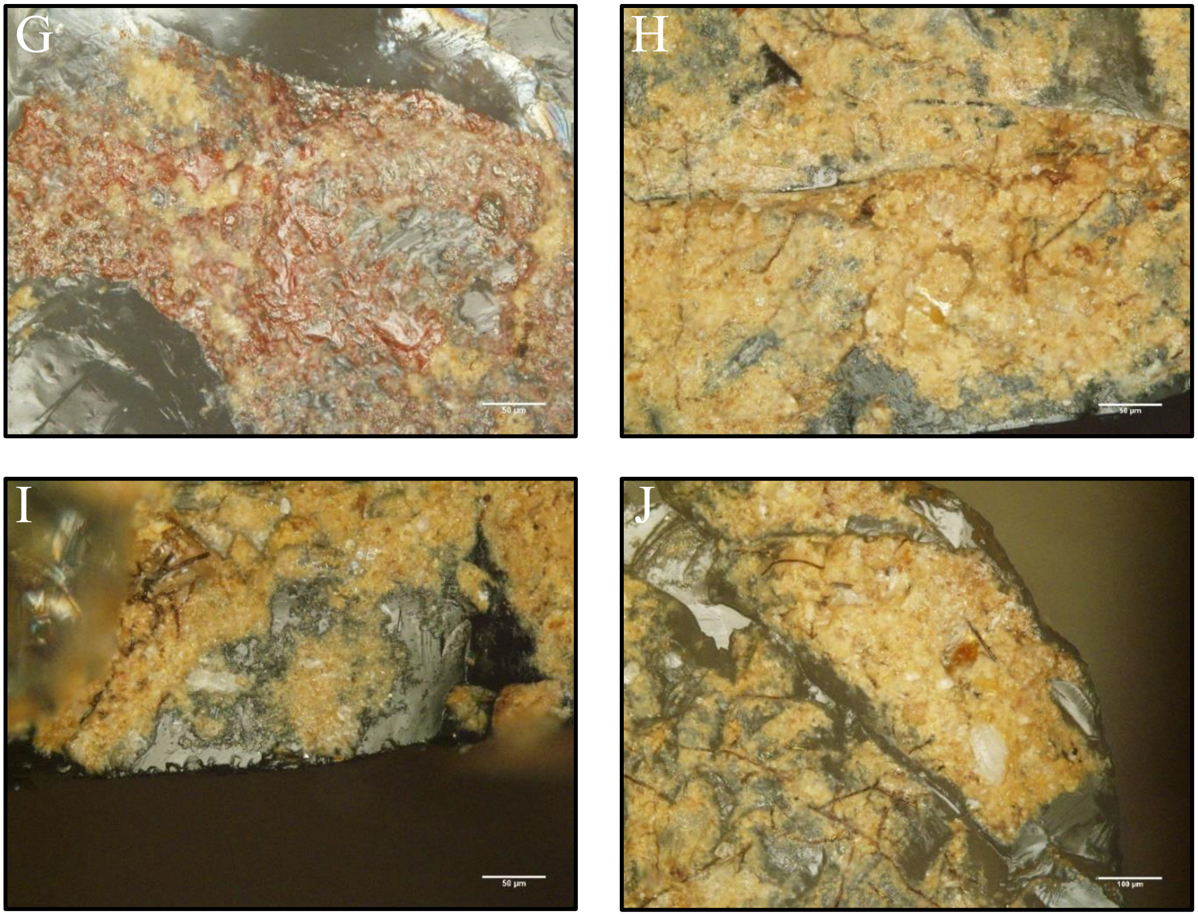


Figure 6-18: Residue on artefact 14288.
G – Class 3 residue located opposite the working edge. H, I, J – Class 4 residue (animal fat) and are all situated along the manufactured edge. The bottom left image also shows micro-flaking from use and the bottom right has a large white glob embedded in the residue.

Table 6-11: Residue and use-wear results summary for artefact 14288.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
3, 4	No	Yes	N/A	Striations Flake Scar Edge Damage Pits Lancets	Identifiable	Medium/Hard	Multi-use

Both HPILM and SEM analysis indicated the artefact was used (Table 6-11). Lancets and micro-flakes were visible along the worked edge near the tip of the artefact (Figure 6-19O). The

SEM micrographs showed a high number of striations (in three dominating directions), along with pitting and edge flaking (Figure 6-19K, L, M). The direction of the striations was perpendicular to the modified edge, perpendicular to the tip, and perpendicular to the edge opposite the modified edge. The edge with modification showed micro-flakes cause by use within the manufacturing flake scars (Figure 6-19N).

Table 6-12: Inquisitive process for artefact 14288 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. There are two types of residue visible.
2 – Is it Organic or Inorganic?	Organic. Both residues are amorphous and do not resemble inorganic fragments. The SEM/EDS analysis confirmed the residue is carbon based.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the small amount of residue near the suspected working edge suggests it originated from a specific activity. The other residue is suspected of being hafting related since it lies opposite the working edge.
4 – Is it Plant or Animal?	Animal (class 4). Biochemical tests and high power micrographs (*in situ*) suggest fatty residue originating from an animal. Unknown (class 3). Suspected of being a plant residue associated with hafting, a lack of data limits the interpretation to speculation.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

This tool was heavily used and likely served multiple functions. Striations suggest the tool was used as an engraver or an awl. The edge damage supports the engraver interpretation, which would have been used on harder material. The residue associated with the working edge was identified as animal fat. The class 4 residue is authenticated by its accumulation along the modified edge, although it is only present on the dorsal surface. The red residue remains unidentified but is suspect to be hafting related. However, this residue's anthropogenic origin cannot be authenticated.

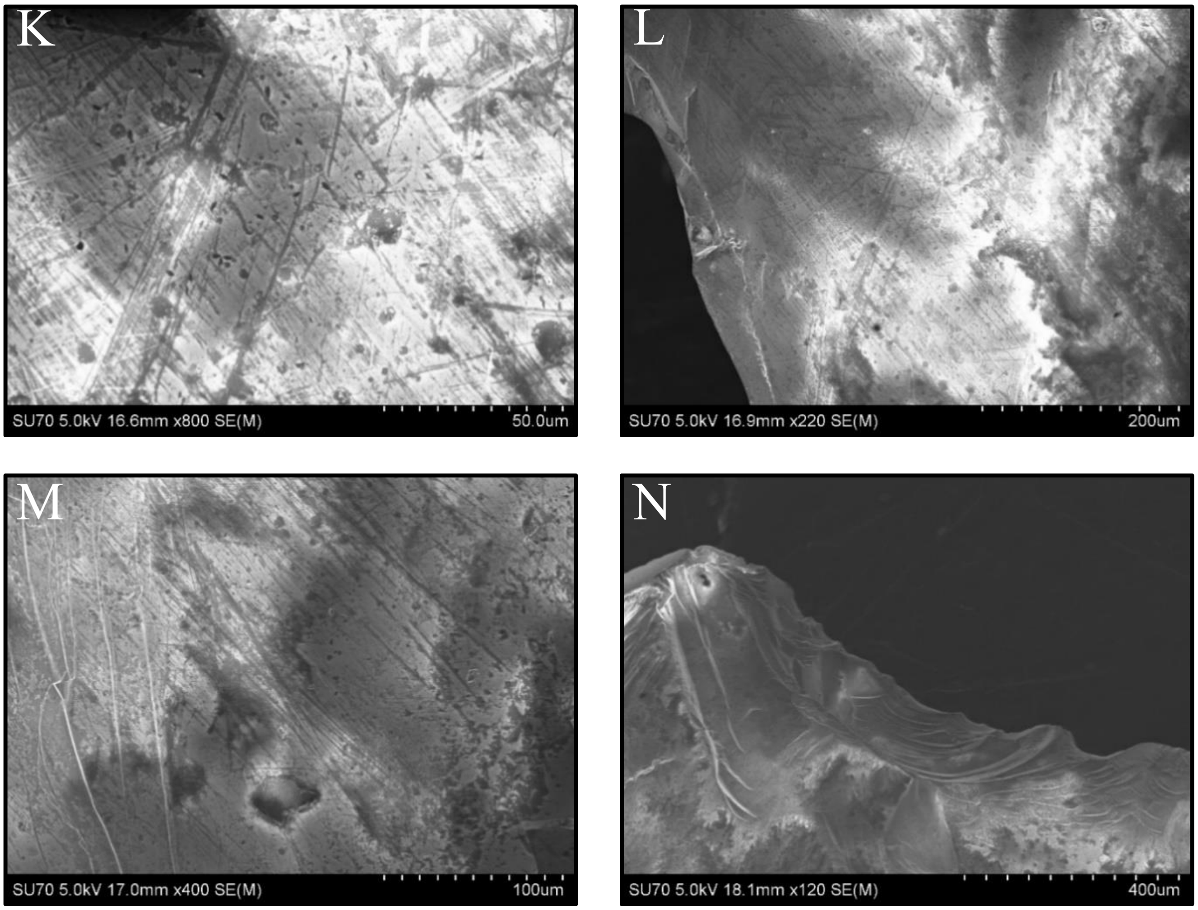


Figure 6-19: Use-wear on artefact 14288.
K, L, M – Striations located on the edge opposite the modified edge near the tip. This area of the tool is flat and shows the best evidence for use. N – Large flake scar from manufacture with smaller flake scars from use within.

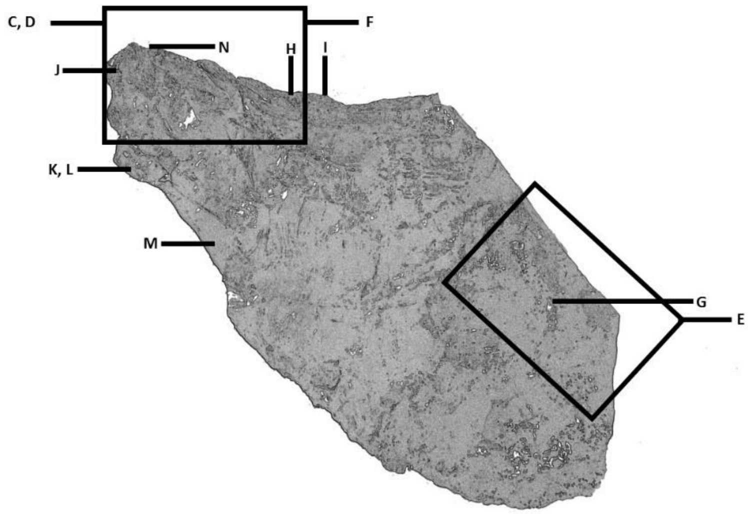


Figure 6-20: Image locations for artefact 14288.

6.2.6 Artefact 15096

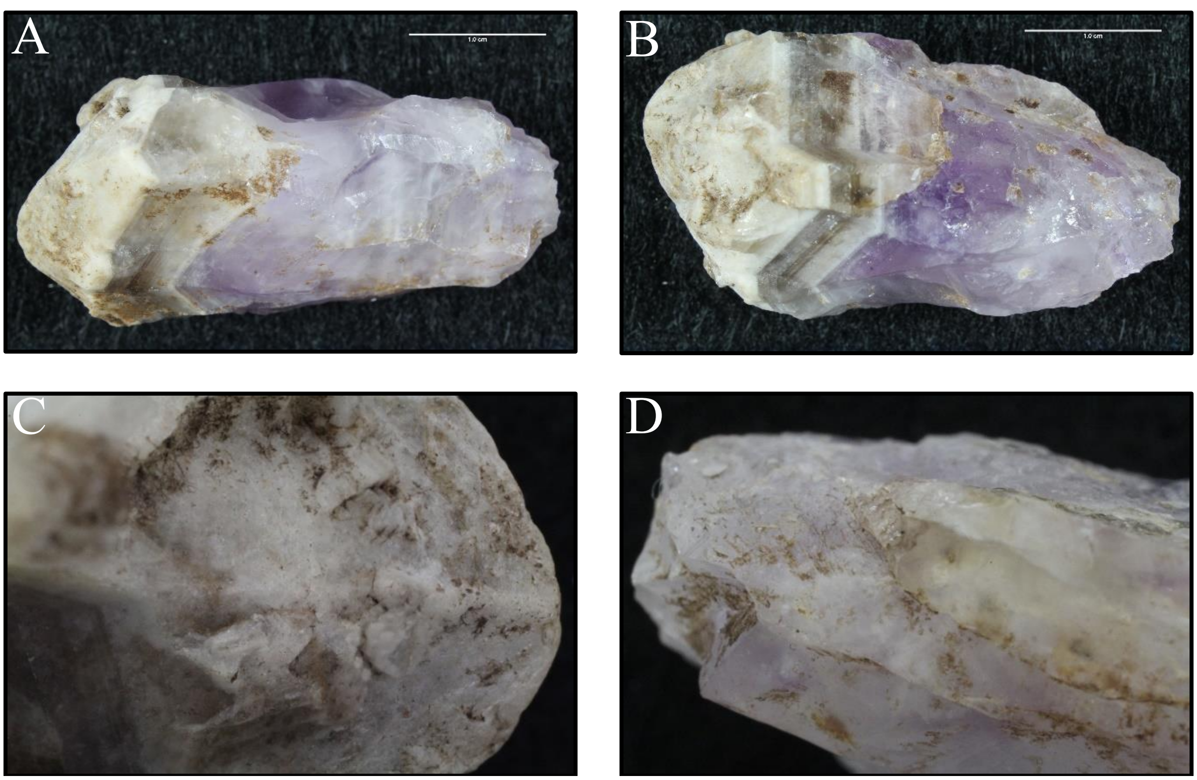


Figure 6-21: Artefact 15096.
A, B – Macro images of 15096. C – Dark, fibrous residue around the tip. D – More residue, but less concentrated, located on the opposite end.

Artefact 15096 was a large, pale amethyst crystal that measured nearly 40mm in length and 21mm in width (Figure 6-21). This artefact was selected because of the dark residue situated across the artefact, but concentrated around the blunt tip (Figure 6-21C). Under LPILM the dark residue appears to be fibrous in nature. The tip was made of cortex material common on many amethyst artefacts from the site. See Figure 6-24 for the location of each micrograph.

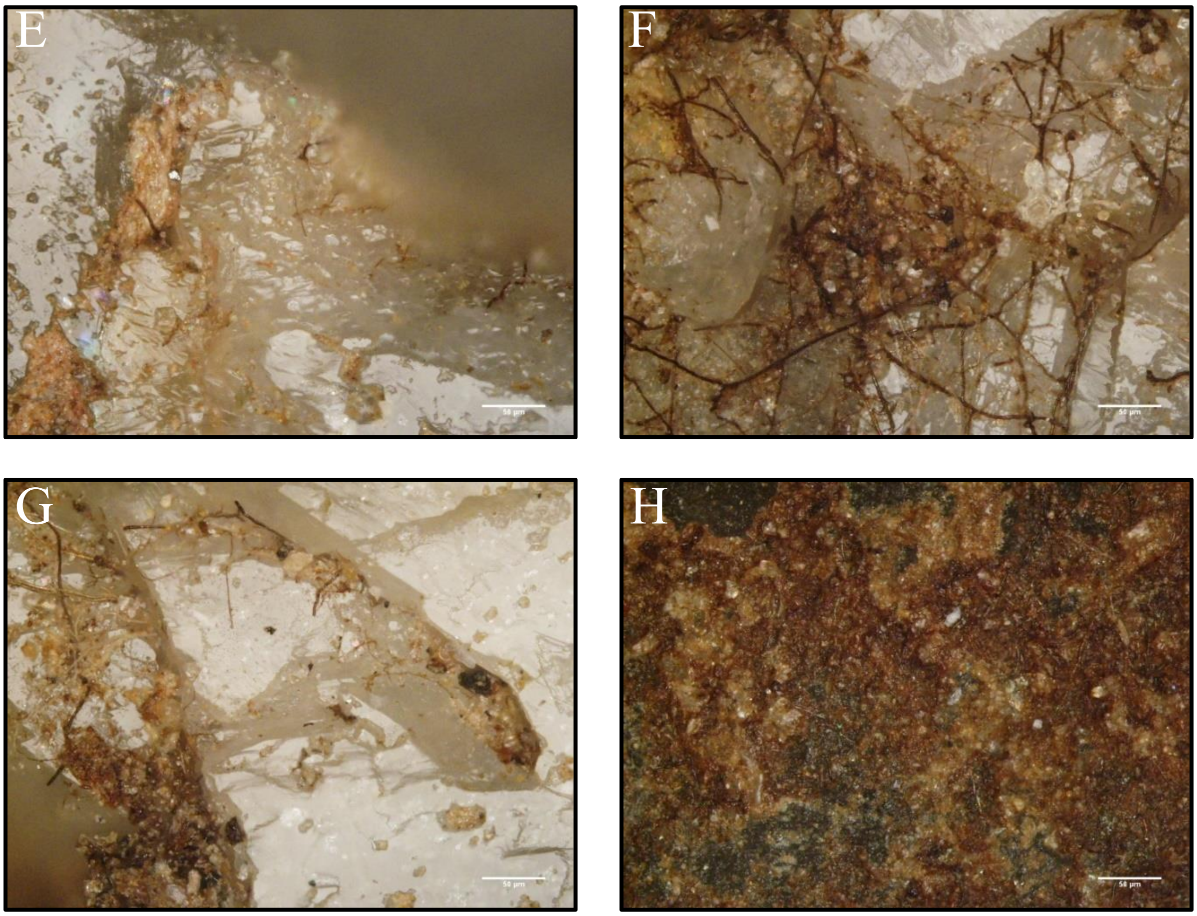


Figure 6-22: Residue on artefact 15096.
E, F, G – Class 5 residue. This is the most common residue on the artefact and consists mostly of hyphae. H – Class 2 residue located near the tip.

The HPILM showed two residue classifications present; class 2 and class 5 (Figure 6-22). Despite its wide distribution, the residue was sparsely concentrated. The class 5 residue was most common and consisted largely of hyphae and white fibres. The class 2 residue was dark red and yellow-white with a glossy and globular texture. The SEM images showed an accumulation of organic residue near the tip of the artefact (Figure 6-23). In some areas, the residue was rather thick, but remained amorphous and unidentifiable. Spherical microfossils with pores across the surface were present but too small to be pollen, measuring just over 2µm in diameter (Figure 6-23M). Starch grains measuring 4-6µm in length were also observed, but were likely contamination (Figure 6-23K, L). Biochemical testing produced weak positives for protein and fatty acid. Class 2 residue was interpreted as animal, but class 5 remained a mystery. The HPTLM produced evidence of plant material, which was commonly found in the SEM images, but believed to be contamination (Table 6-13: Residue and use-wear results summary for artefact 15096.Table 6-13, Table 6-14).

Table 6-13: Residue and use-wear results summary for artefact 15096.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2, 5	Weak	Weak	Plant	Edge Damage	Unidentifiable	N/A	N/A

Table 6-14: Inquisitive process for artefact 15096 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. There are two types of residue visible.
2 – Is it Organic or Inorganic?	Organic. Both residues are amorphous and do not resemble inorganic fragments. The SEM/EDS analysis confirmed the residue is organic.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue around the tip suggests it is anthropogenic. However, use-wear analysis could not confirm this artefact had a function.
4 – Is it Plant or Animal?	Both. Biochemical tests and HPILM suggested animal, while SEM images and HPTLM suggested plant.

5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

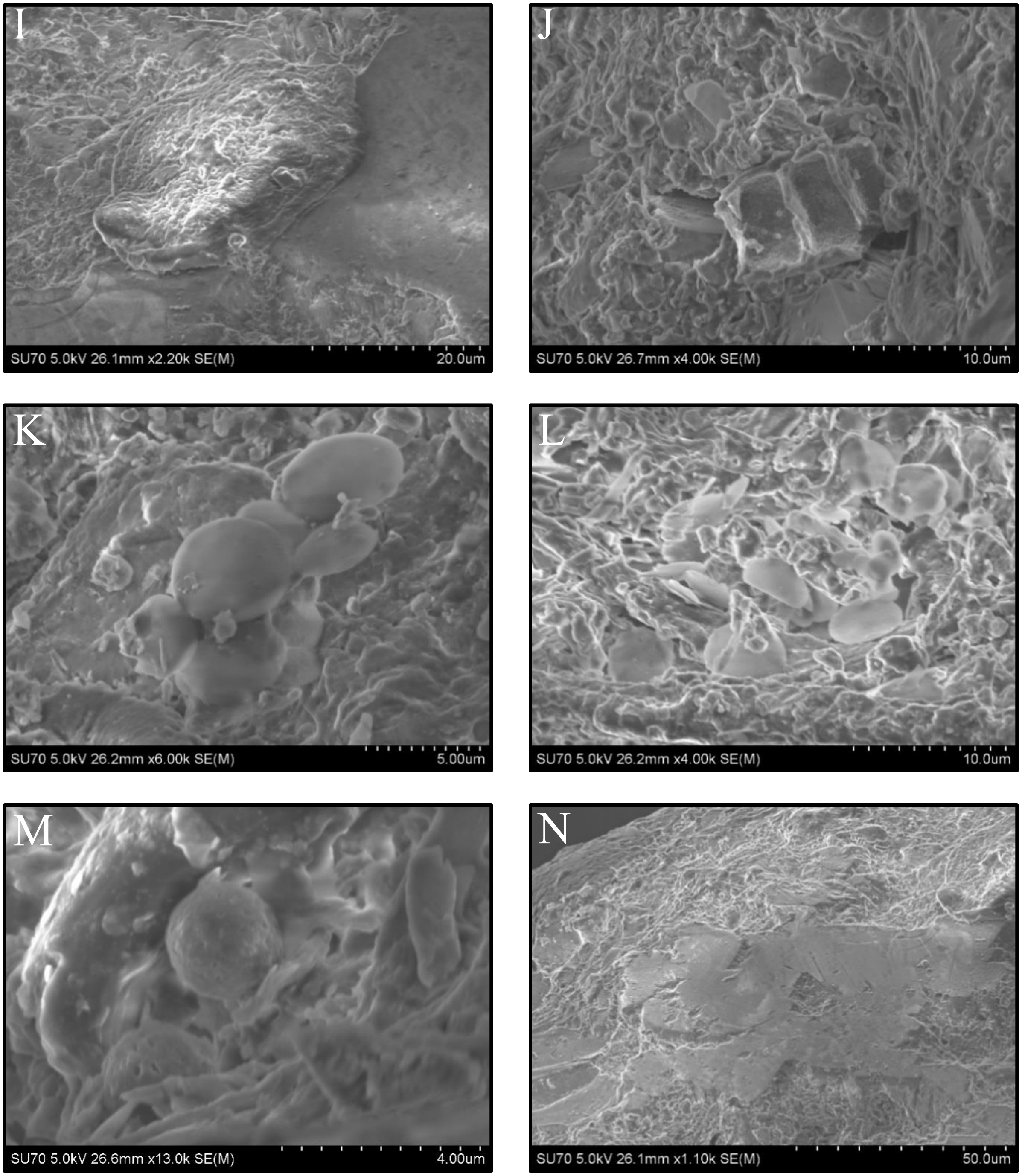


Figure 6-23: Residue on artefact 15096 using SEM.
I – Organic residue near the working tip. J – An unidentified contaminant. K, L – Starch grains that are likely contaminants, based on their preservation. M – Possible pollen, although too small. N – Extensive crushing to the tip.

Use-wear analysis produced unidentifiable results (Table 6-13). The tip was heavily battered and remained covered in residue (Figure 6-23). There were faint striations visible on flat surfaces, but these could not be attributed to use. The most convincing use-wear was simply the extensive crushing and wear of the tip itself, but on its own was inconclusive.

Overall, this artefact could not confidently be described as a tool. The concentration of residue near the tip and the extensive damage in this area suggest that it could have been used, but more analysis would be necessary to confidently support a functional interpretation. If this artefact were utilized, it would have served as a blunt percussion implement, either to crush bone or pulverize plant material. Unfortunately, this interpretation remains speculation at best.

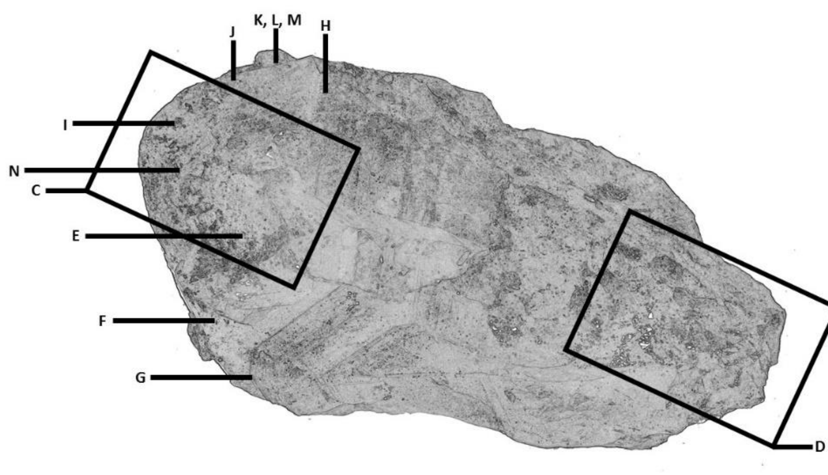


Figure 6-24: Image locations for artefact 15096.

6.2.7 Artefact 15295

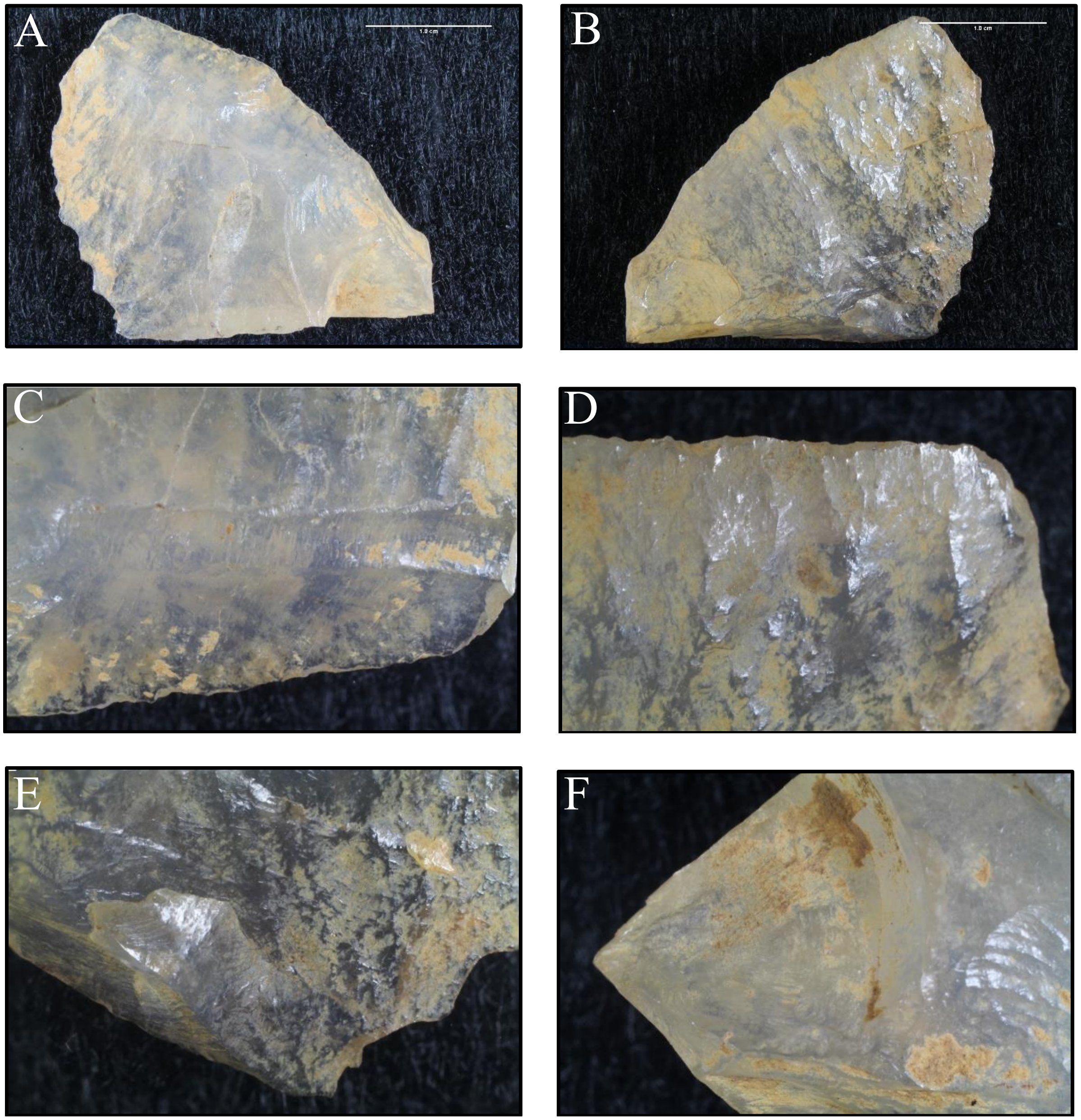


Figure 6-25: Artefact 15295.
A – Ventral surface. B – Dorsal surface. C – Possible edge wear at 20x magnification, dorsal surface. D – Possible edge wear at 20x magnification, ventral surface. E – Suspected class 4 residue at 20x magnification, ventral surface. E – Suspected class 4 residue near sharp tip at 20x magnification, ventral surface.

Artefact 15295 was a thin quartz flake, measuring approximately 30mm in length and 27mm wide (Figure 6-25). It was selected for its thin shape and possibly utilized edge. At first, residue appeared absent because it seemed that only sediment was present. However, under closer examination (using a low power incident light stereomicroscope), it appeared that a residue was hidden under the sediment. See Figure 6-28 for the location of each micrograph.

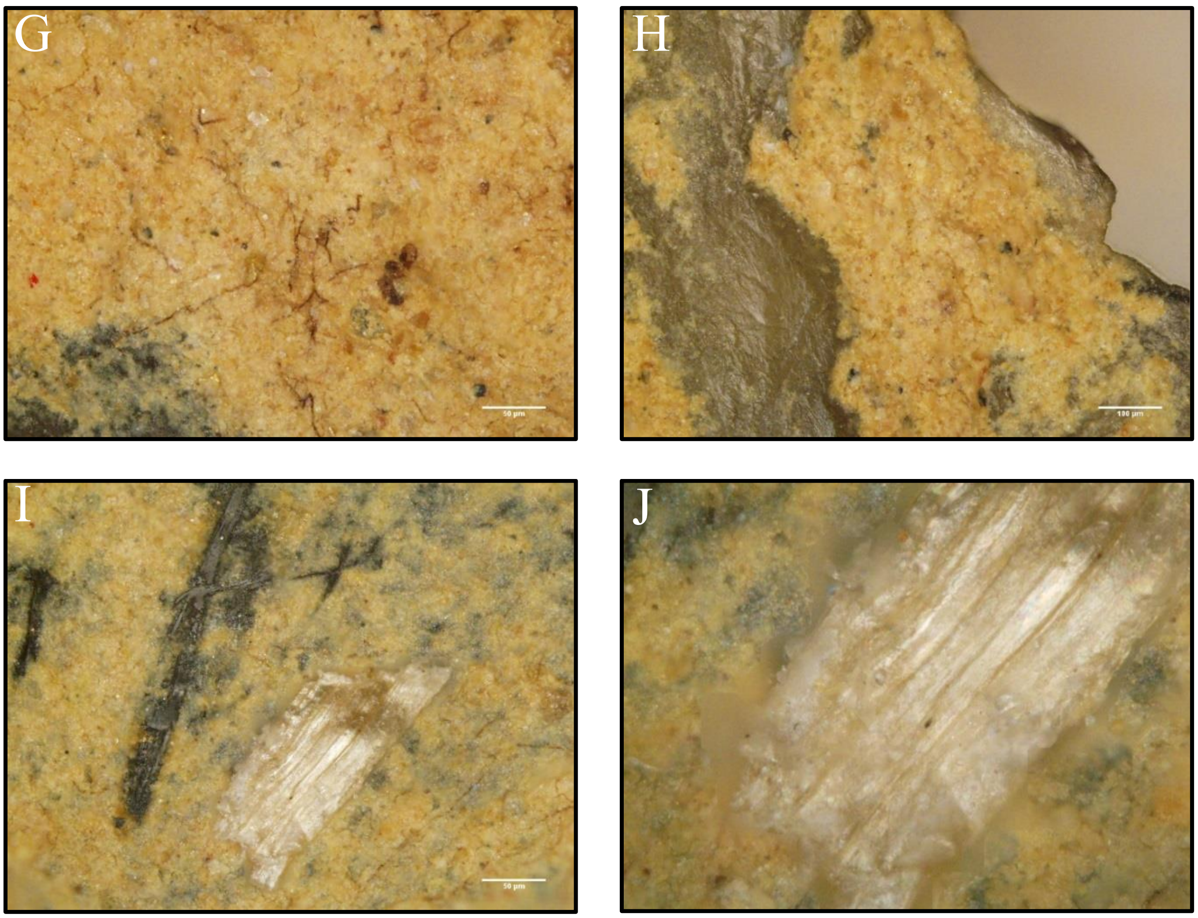


Figure 6-26: Residue on artefact 15295.
G, H – Class 4 residue located near the working area, dorsal surface. I, J – White fragment embedded in class 4 residue, dorsal surface.

Using HPILM, the class 4 residue appeared to be more than just the initially suspected sediment (Figure 6-26). The residue was not grainy and was nearly homogenous in appearance. This type of residue was quite common (found on 10 different artefacts) and was visually interpreted as animal fat. This artefact supported this identification with a positive biochemical test for fatty acid and animal fibres identified under HPTLM (Table 6-15, Table 6-16).

Table 6-15: Residue and use-wear results summary for artefact 15295.

	Residue				Use-Wear		
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
4	No	Yes	Animal	Linear Grooves Flake Scars Edge Damage	Identifiable	Medium	Push or Pull

Table 6-16: Inquisitive process for artefact 15295 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. A residue is present underneath the sediment.
2 – Is it Organic or Inorganic?	Organic. It is amorphous and SEM/EDS analysis confirmed the residue is organic.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue around the working edge suggests it is anthropogenic.
4 – Is it Plant or Animal?	Animal. The residue resembles fat residue and animal-derived fibres are visible using HPTLM. Biochemical tests were positive for fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

The LPILM identified micro-flaking along one edge on both the dorsal and ventral surface (Figure 6-25C, D). The SEM micrographs showed more detailed scarring consistent with use (Figure 6-27). Linear grooves were situated perpendicular to the working edge, suggesting a push or pull motion (Table 6-15: Residue and use-wear results summary for artefact 15295.). These were consistent with dry hid scraping, based on Knutsson's (1988a) experimental tools.

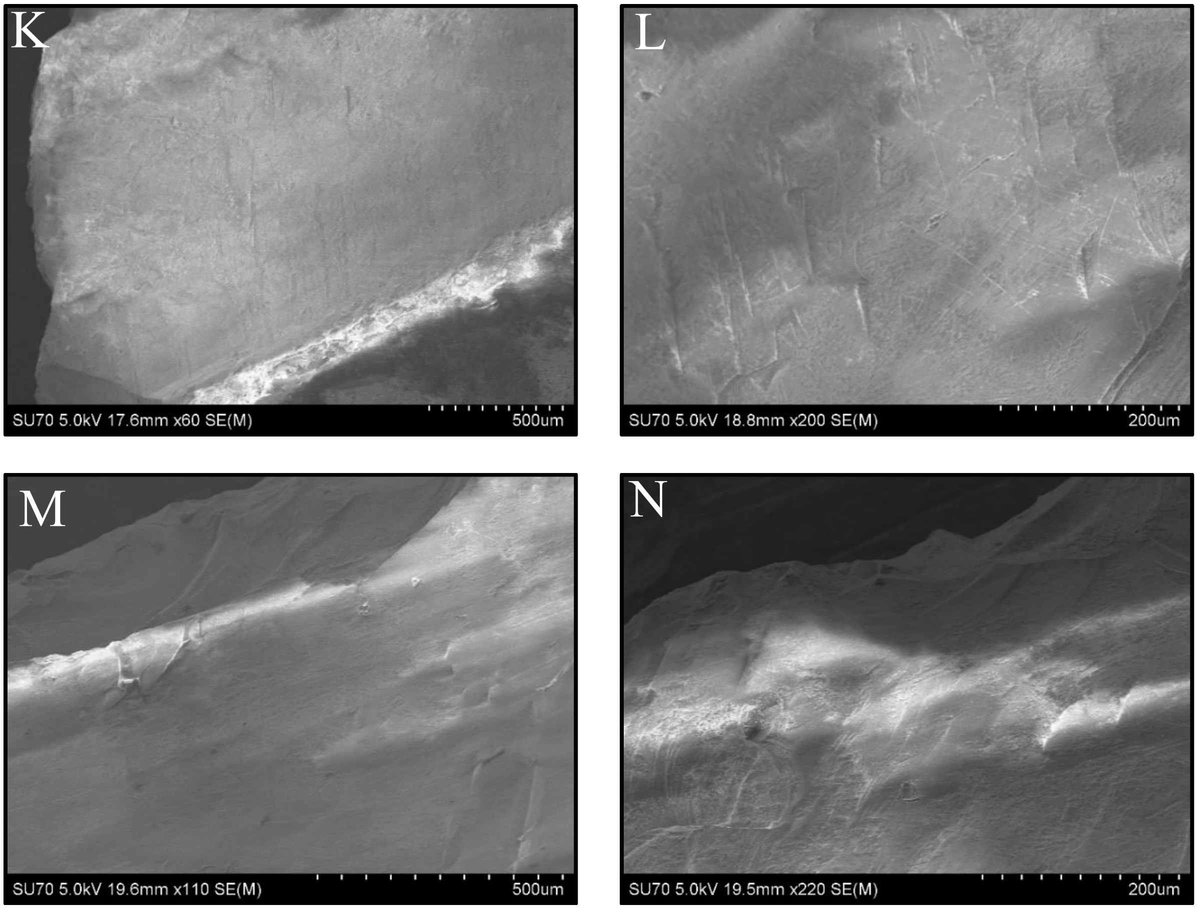


Figure 6-27: Use-wear on artefact 15295.
K, L – Furrows perpendicular to the working edge, which indicates a push or pull motion. M, N – Micro-flakes along the working edge.

In summation, artefact 15295 had a short, straight working edge. Residue analysis suggested animal processing of some manner, leaning towards fresh hide because of the fatty residue. However, use-wear analysis suggested the artefact was used on dry hide (because of the number of linear grooves) but this does not exclude it from being used on both fresh and dry hide. The orientation of the grooves perpendicular to the working edge strongly indicated a pulling commonly associated with hide scraping.

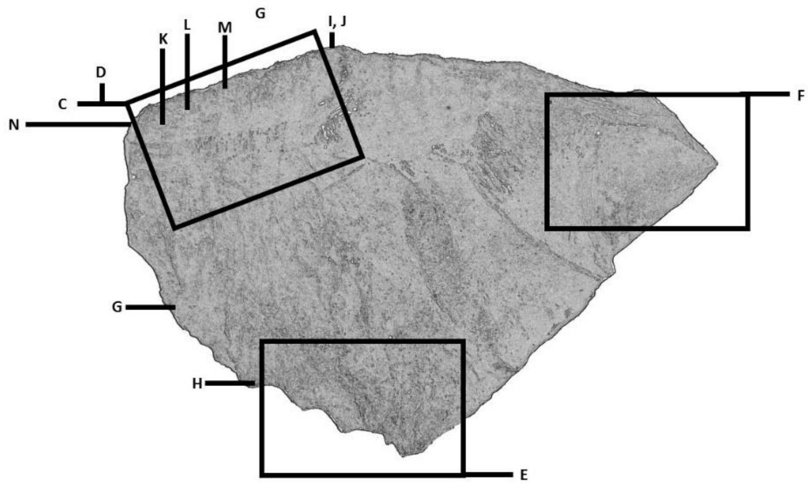


Figure 6-28: Image locations for artefact 15295.

6.2.8 Artefact 15387

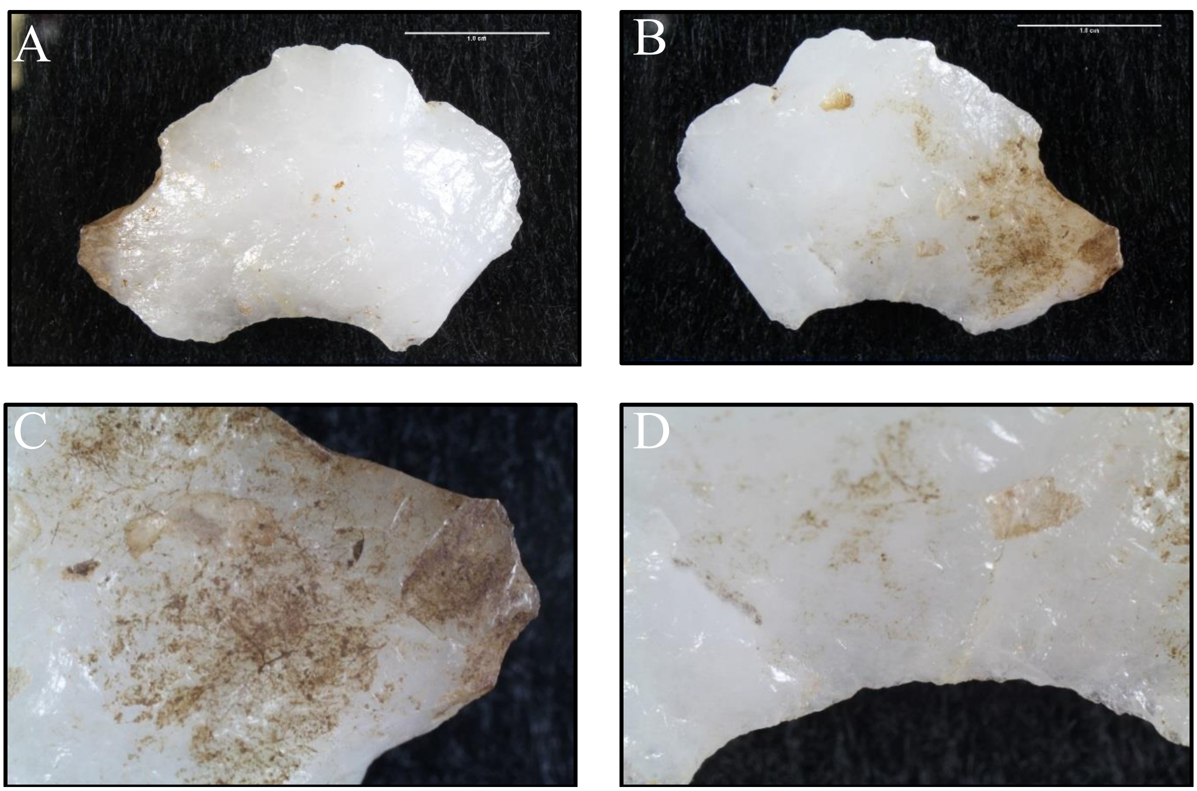


Figure 6-29: Artefact 15387.
A – Ventral surface. B – Dorsal surface. Note the large amount of residue located near the broken tip and the concave edge. C – Visible residue located at the broken tip at 20x magnification, dorsal surface. D – Concave edge at 20x magnification, dorsal surface. Note how modification and use are difficult to see.

Artefact 15387 was made of milky quartz and measured 32mm in length and 22mm wide (Figure 6-29). It was selected for its concave working edge and the residue concentrated around the broken tip. Using LPILM, fibrous residue (likely hypha) was visible around a darker residue. A similar looking residue on a different artefact identified small concentrations of iron when subjected to elemental analysis using an SEM/EDS. See Figure 6-32 for the location of each micrograph.

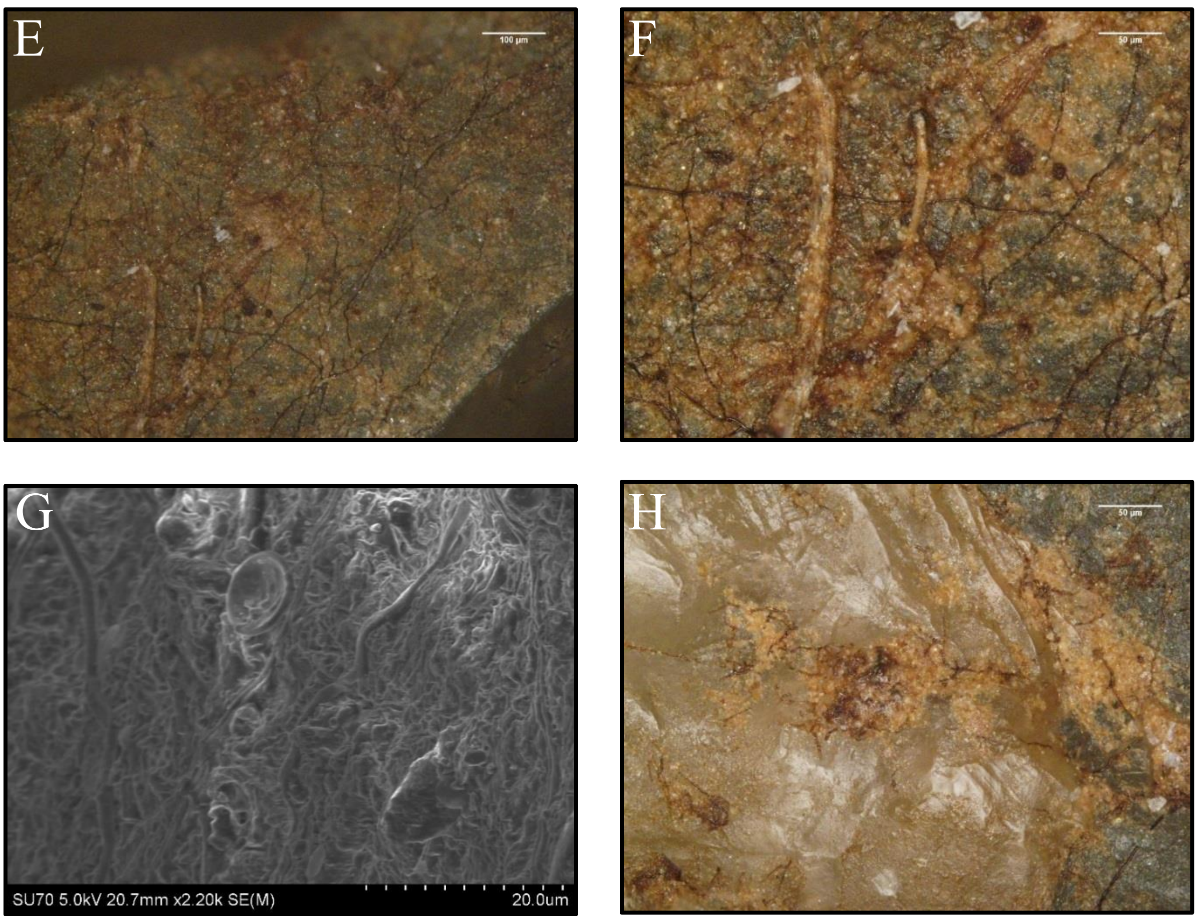


Figure 6-30: Residue on artefact 15387.
E, F – Class 6 residue located near the tip. Fibres are visible, but these exact fibres could not be located under SEM. G – Fibres and oval residue (possible RBC) visible within the amorphous residue (class 2). H – Class 5 residue.

The HPILM identified two residues: class 5 and class 6 (Figure 6-30). Most of this was located around the broken tip, suggesting a relationship between these residues. In this instance, this could indicate that class 6 was a more concentrated occurrence of class 5. The residue was located on the ventral surface, again indicating differential preservation of residue. This artefact was examined with a SEM prior to removal. Of particular interest was the concave ovoid specimen reminiscent of a red blood cell (RBC), measuring 6μm in length (Figure 6-30G). If this was a RBC, it was an appropriate size for humans, but it did not resemble other desiccated RBCs in the literature (Hortola P. , 1992; Hortola, 2002; Hortola, 2005). The Hb-CRTS test produced a positive result (score of 2), the strongest out of all artefacts tested, supporting the interpretation of blood residue. After solvent removal, SEM imagery continued to show a large amount of residue still situated near the tip. Biochemical tests produced possible positive results for protein, but negative results for fatty acid. The GC/MS analysis and HPTLM produced no significant results (Table 6-17, Table 6-18).

Table 6-17: Residue and use-wear results summary for artefact 15387.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
5, 6	Weak	No	N/A	Striations Linear Grooves Flake Scars Edge Damage	Identifiable	Hard	Push or Pull

Use-wear was most noticeable in the concave area of the tool (Figure 6-31: Use-wear on artefact 15387.L). Deep, long and irregular striations and linear grooves were very common, along with some pitting. This wear is consistent with a pulling (or pushing) motion on hard material (Table 6-17). The working edge was abraded and rounded, but micro flaking was not as common as expected (Figure 6-31). No use-wear could be confirmed for the tip, although it appeared that a significant portion of it was missing.

Table 6-18: Inquisitive process for artefact 15387 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Two residues are present.
2 – Is it Organic or Inorganic?	Organic. It is amorphous and SEM/EDS analysis confirmed the residue is organic. Some inorganic components (iron) supports the interpretation of blood residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue around the broken tip suggests it is anthropogenic.
4 – Is it Plant or Animal?	Animal. The residue resembles a protein rich animal residue based on its gloss and colour. Biochemical tests produced weak positives for protein.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Overall, this tool was clearly used and likely multifunctional. The observed residue and use-wear were likely unrelated since the use-wear comes from the concave edge and the residue is associated with the tip (i.e. the residue was concentrated around the used tip, but no associated wear patterns allowed for a functional interpretation). Since the tool was multi-functional, there are two functional interpretations to be made. Firstly, the residue suggested the artefact was used on an animal, either to puncture hide or to engrave bone. The distribution of the residue more strongly supports a deeper intrusion into the worked material and a messier job than engraving. Alternatively, the shape of the tip area resembles a gut hook to make the initial incision in the animal’s abdomen, but the edge in the curved area of the tip was not suitable. Unfortunately, the interpretation for the tip remained speculative. The concave edge resembled a spokeshave and was 11-12mm wide and 2mm deep. The use-wear supported this interpretation because of the long, deep striations and linear grooves situated perpendicular to the edge, which suggests a pulling (or pushing) motion. The wear suggests a harder material, such as bone or antler, rather than any type of wood (Knutsson, 1988a), although spokeshaves are generally used on wood.

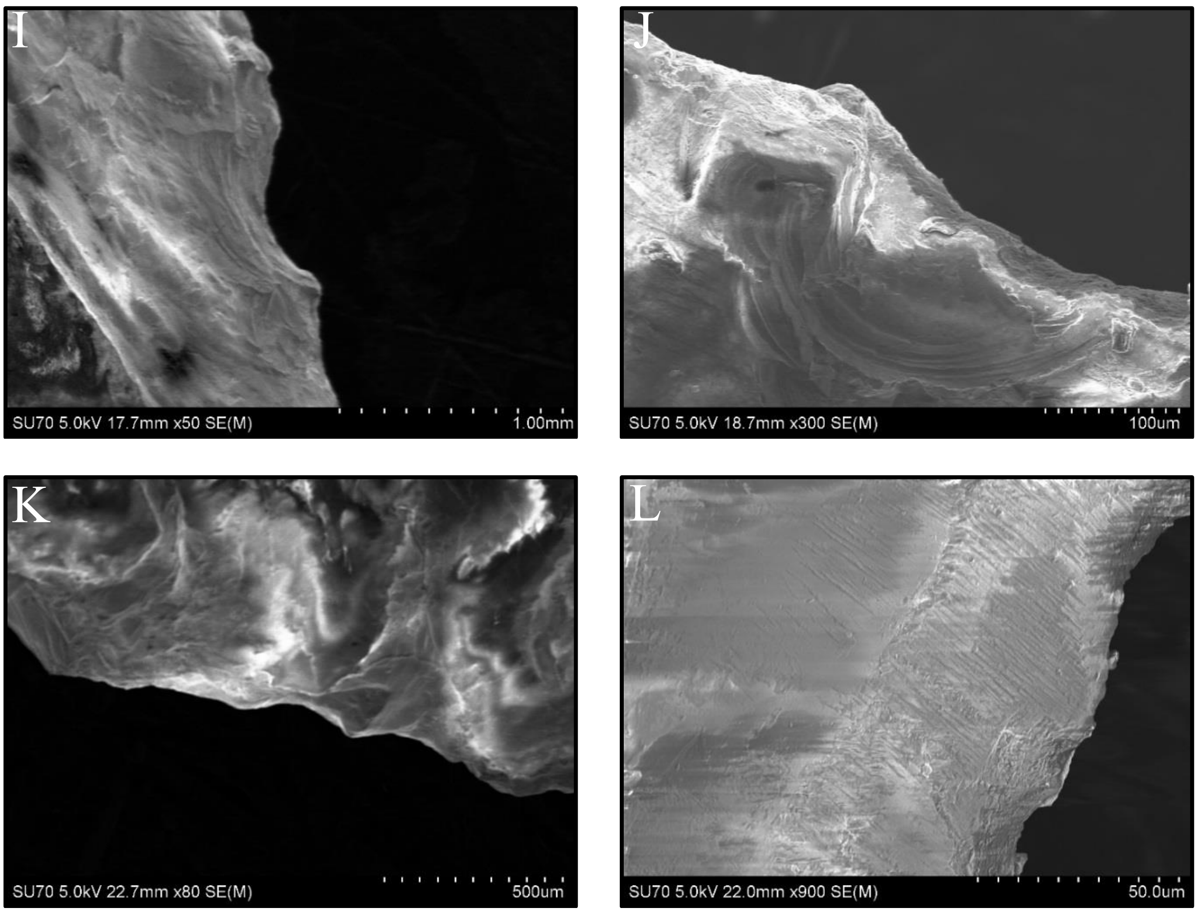


Figure 6-31: Use-wear on artefact 15387.
I, J, K – Micro-flakes caused by use on various edges of the tool. L – Concentration of striations perpendicular to the concave edge.

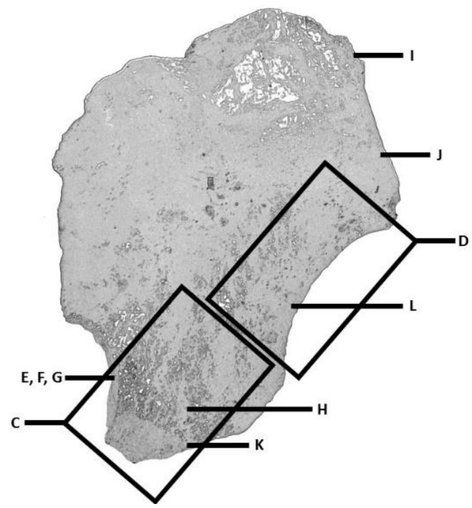


Figure 6-32: Image locations for artefact 15387.

6.2.9 Artefact 16208

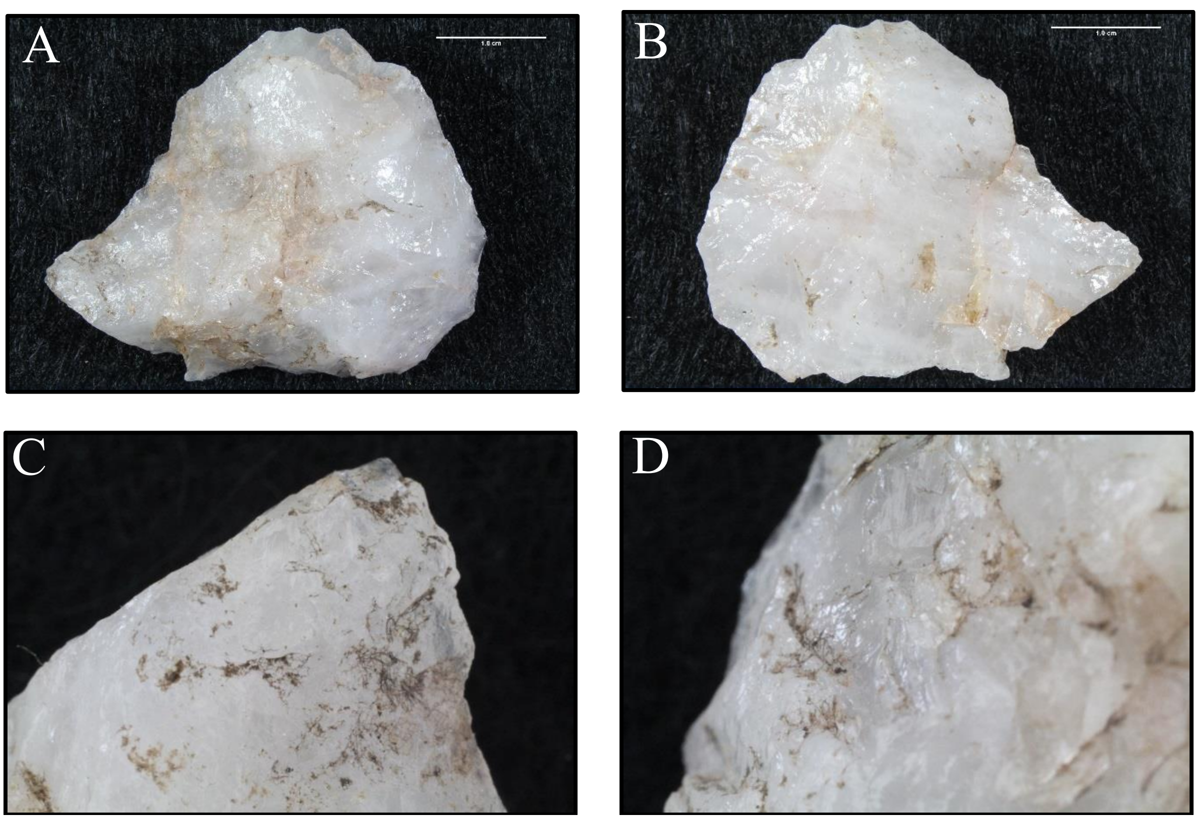


Figure 6-33: Artefact 16208.
A – Dorsal surface. B – Ventral surface. C, D – Residue located opposite the working edge.

Artefact 16208 was made of milky quartz and measured 40mm long by 32mm wide (Figure 6-33). This artefact was identified as a scraper in the CRM catalogue and selected for this study because of its straight edges and the presence of a dark, fibrous residue. The residue is found on the dorsal side of the artefact near the pointed end, rather than near the straight edges. See Figure 6-38 for the location of each micrograph.

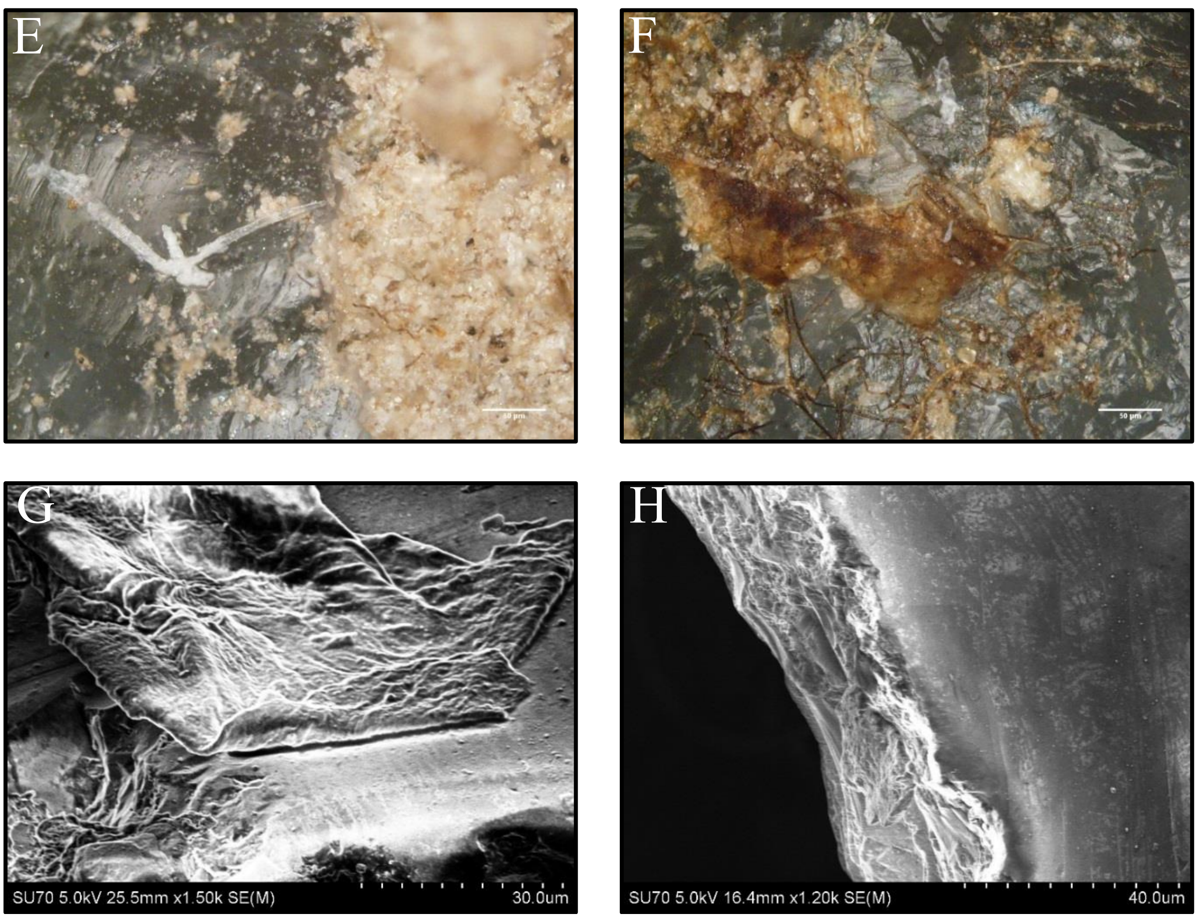


Figure 6-34: Residue on artefact 16208.
E – Class 7 residue. F – Class 5 residue. G – flat, organic residue peeling of the surface. H – organic residue adhering to thick edge.

The HPILM identified two amorphous residues, class 5 and class 7, as well as a clear cellulose fibre that could not be authenticated (Figure 6-34E, F). Both amorphous residues offer littler interpretive value and the plant-based fibre is not embedded in any residue and could easily be a product of environmental contamination. The SEM micrographs showed residue adhering to the surface of the tool near the suspected scraping edge (Figure 6-34H) and the tip (Figure 6-34G). Biochemical tests produced negative results for both protein and fatty acid, which is unsurprising based on how little residue was present. Overall, both residue classifications produced low results for protein and fatty acid. The GC/MS analysis produced no significant results. Therefore, the residue portion of the interpretation offers little value (Table 6-19, Table 6-20).

Table 6-19: Residue and use-wear results summary for artefact 16208.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
5, 7	No	No	N/A	Striations Flake Scars Edge Damage Ridge Wear "Melting Snow"	Indeterminate	Hard	Push or Pull parallel and perpendicular

Table 6-20: Inquisitive process for artefact 16208 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Two residues are present.
2 – Is it Organic or Inorganic?	Organic. Both are amorphous and SEM/EDS analysis confirmed the presence of organic residue. However, one residue (Class 7) could be inorganic as it appears grainy
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue (SEM micrographs) around the working edge suggests it is anthropogenic.
4 – Is it Plant or Animal?	Undetermined.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

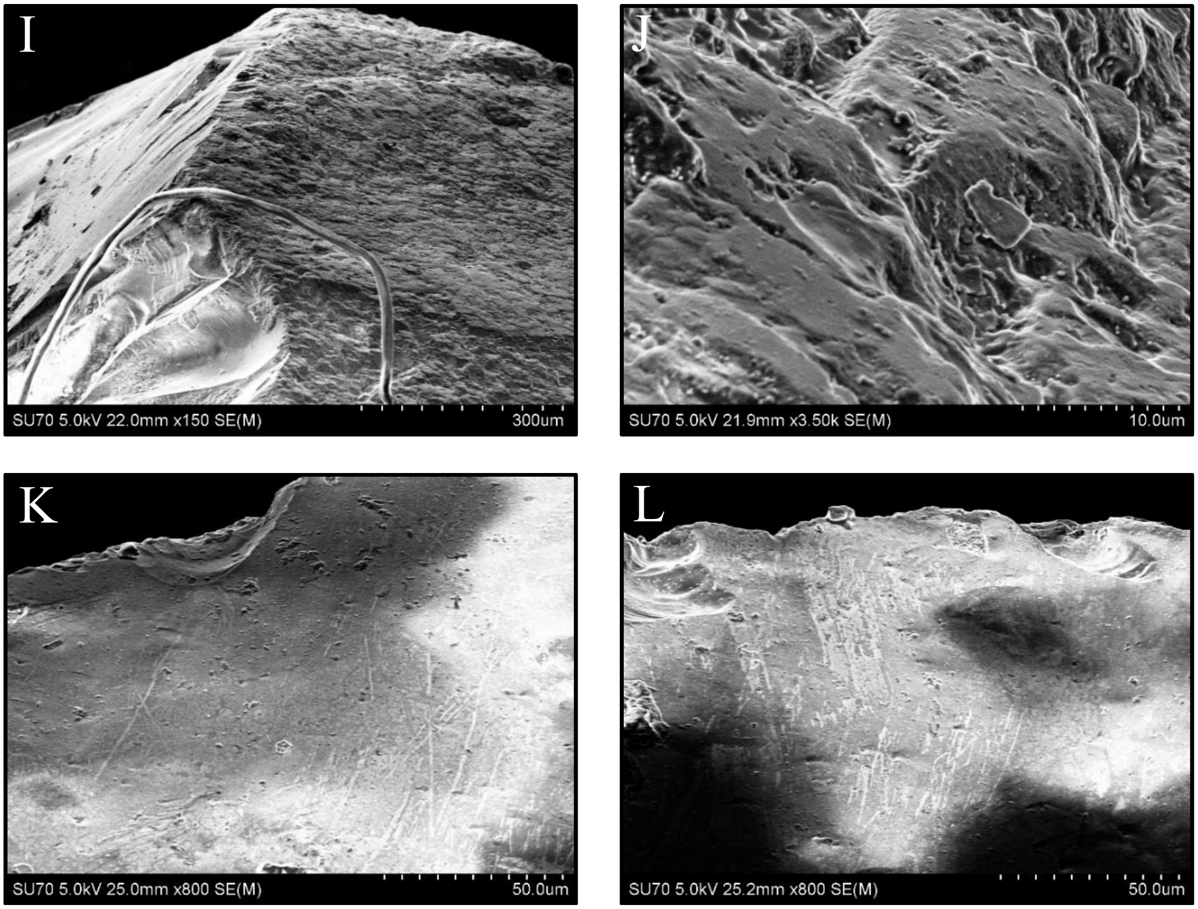


Figure 6-35: Use-wear on artefact 16208.
I, J – Possible polish from hafting. K, L – Edge damage and faint striations.

Use-wear analysis indicated that the straight edge was used. The SEM images showed a high number of striations perpendicular to the working edge, indicating a push or pull motion (Figure 6-37W, X). Less frequent, but present were parallel striations indicating a sawing or cutting motion. Therefore, this edge was likely multifunctional. In addition to the striations, extensive step fracturing was also present in this area (Figure 6-37S, T, U, V). Step fracturing was present on other edges of the tool, including the tip where the residue was located (Figure 6-35K, L; Figure 6-36). This indicated the tool was multi-functional. On the ventral surface, near the tip, the surface of the artefact was polished, possible indicating it may have been hafted (Figure 6-35I, J).

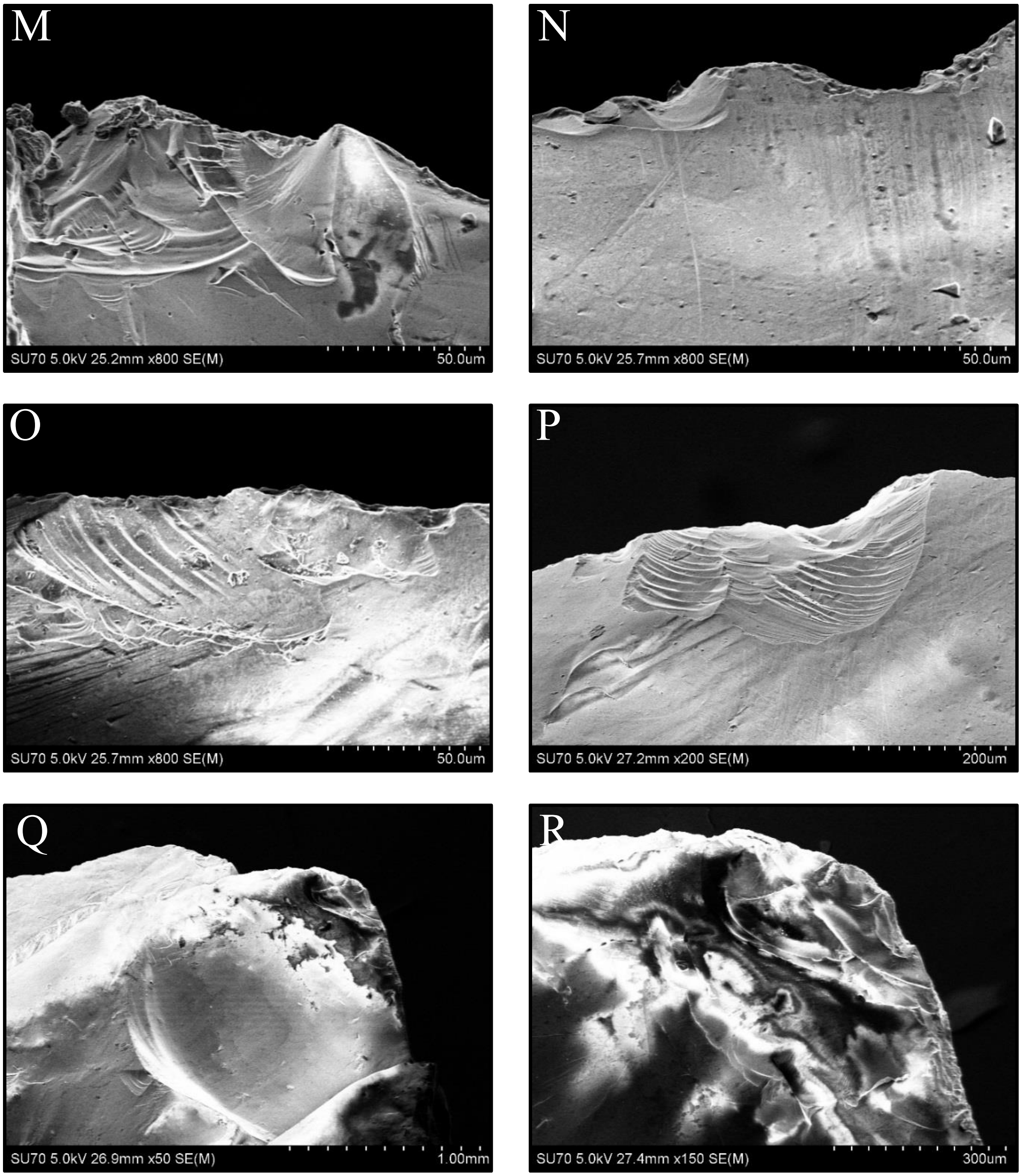


Figure 6-36: Use-wear on artefact 16208.
M – Extensive micro-flaking. N – More definitive striations perpendicular to the edge. O, P – Flake scars near tip. Q, R – Edge damage at the tip where residue was found.

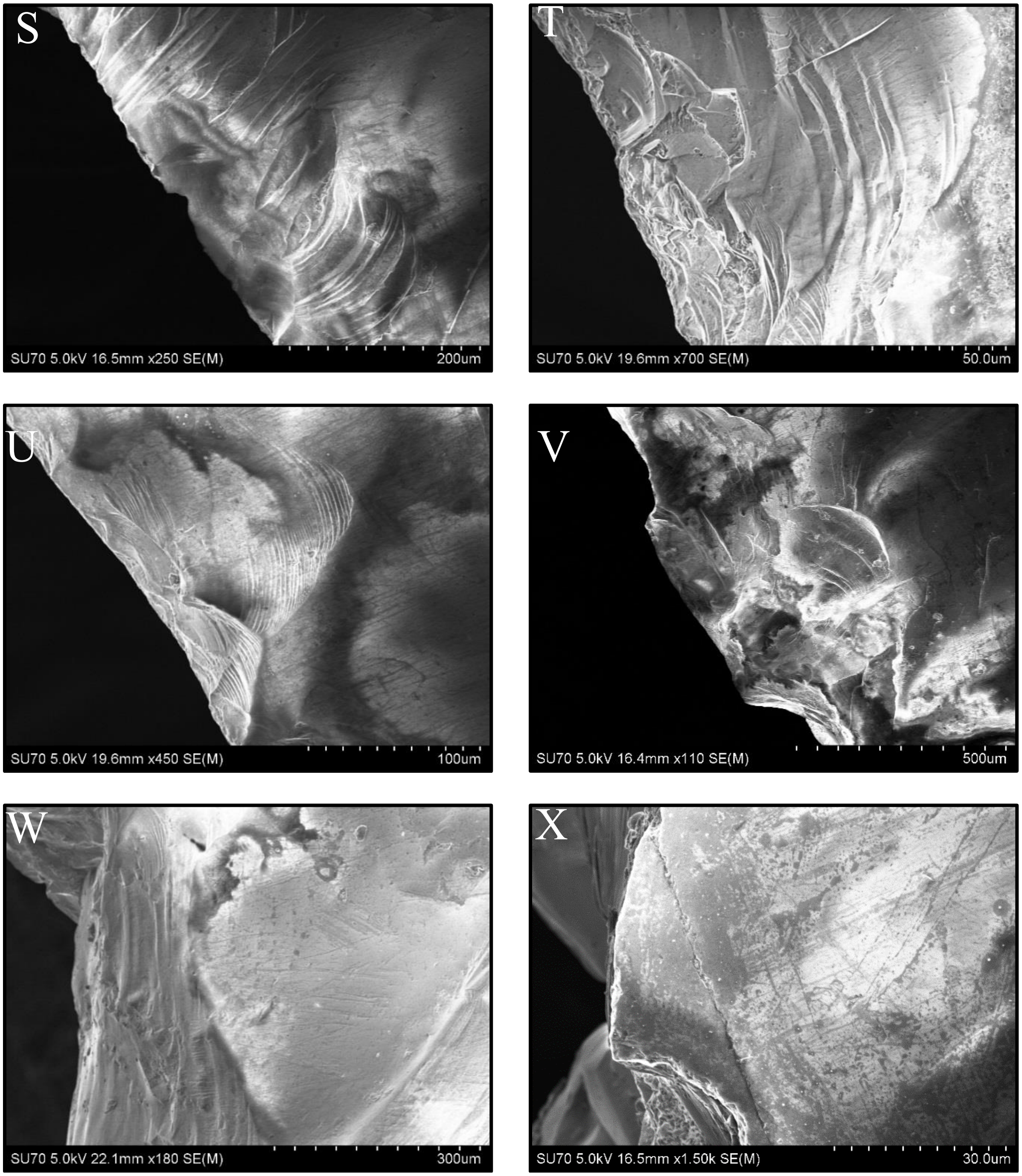


Figure 6-37: Use-wear on artefact 16208.
S, T – Edge damage along the straight edge interpreted as the scraping edge of the tool. U, V – Use-wear along the straight edge. Note the layers of micro-flakes. W – More definitive perpendicular striations. X – Striations are visible in multiple directions.

In conclusion, artefact 16208 relied on use-wear to interpret function because the residue results were insufficient. The edge identified as a scraping edge also had striations that ran parallel to the working edge, indicating that this part of the tool was infrequently used in a cutting motion. The large micro-flakes are more common on hard material, but the striations were more consistent with experimental tools used to scrape dry hide (Knutsson, 1988a).

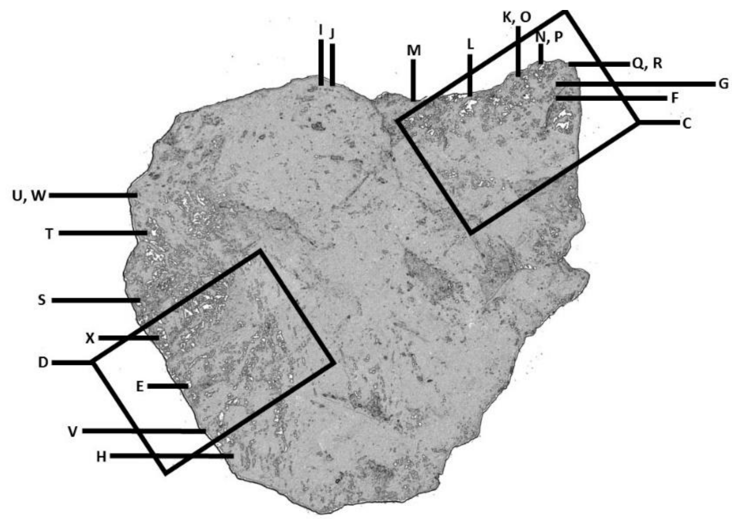


Figure 6-38: Image locations for artefact 16208.

6.2.10 Artefact 16528

Artefact 16528 was a clear quartz flake with milky inclusions within, creating almost a webbed internal texture (Figure 6-39). The artefact measured 32mm by 18mm. It was selected for residue visible on the dorsal surface, it’s straight and worn edge, and the presence of two possible engraving protrusions. See Figure 6-43 for the location of each micrograph.

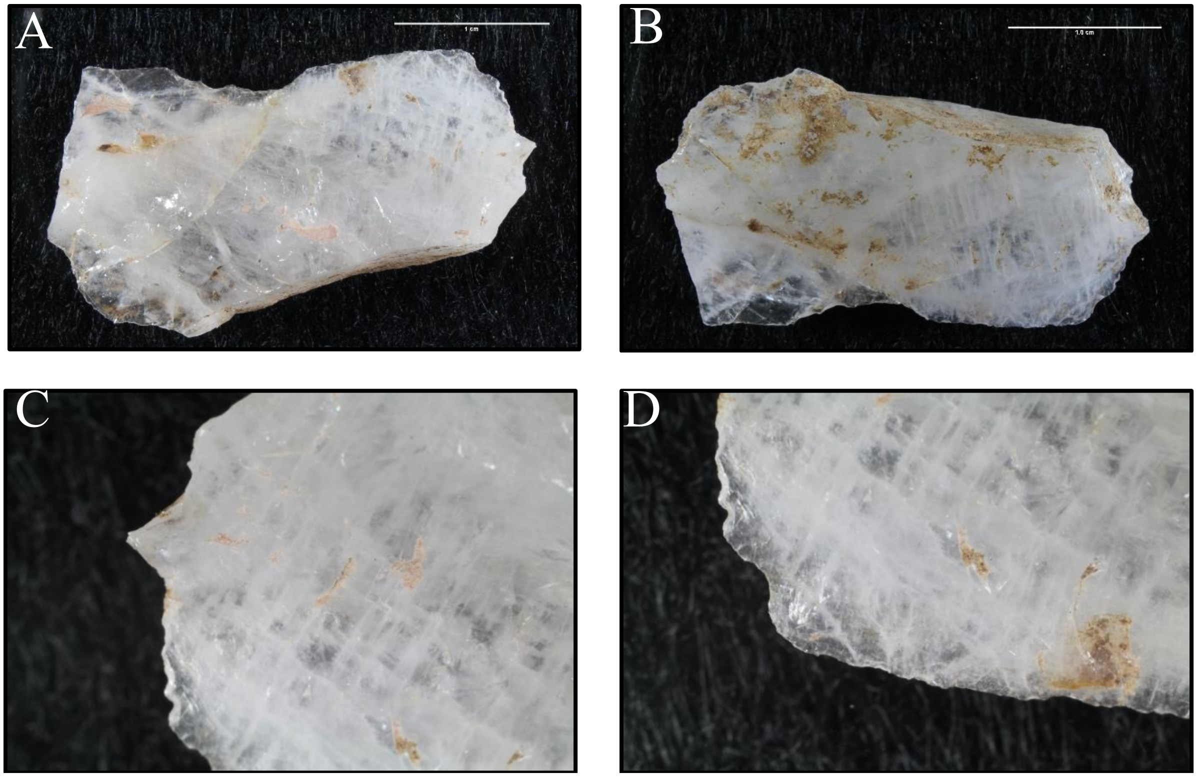


Figure 6-39: Artefact 16528.
A – Ventral surface. B – Dorsal surface. C – More pronounced protrusion at 20x magnification, ventral surface. D – Damage along utilized edge at 20x magnification, ventral surface.

The HPILM only identified class 5 residue (Figure 6-40G, H). Again, the residue was only located on the dorsal surface, suggesting differential preservation (Figure 6-40E, F). Biochemical tests produced one weak positive and one strong positive for protein, and one weak positive for fatty acid. The HPTLM and GC/MS analysis produced no significant results. Based on the classification and positive results for protein and fatty acid, the residue was animal-derived (Table 6-21; Table 6-22).

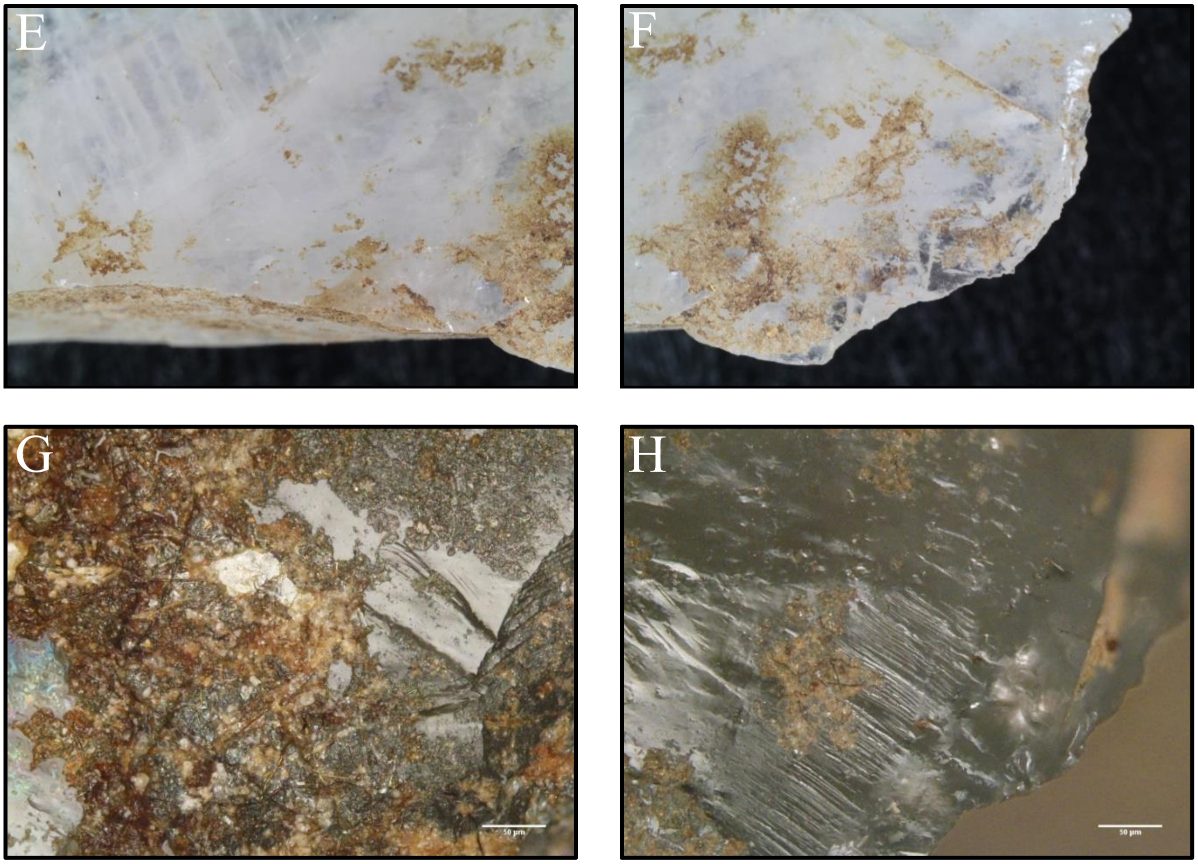


Figure 6-40: Residue on artefact 16528.
E, F – Residue at 20x magnification, dorsal surface. G – Class 2 residue. H – Small amount of residue in association with lancets.

Table 6-21: Residue and use-wear results summary for artefact 16258.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
5	Yes	Weak	N/A	Striations Flake Scars Edge Damage Ridge Wear	Indeterminate	Hard/Medium	Push or Pull

Use-wear analysis produced evidence of use for both the straight edge and both protrusions (Figure 6-41; Figure 6-42). Half-moon flake scars were present along the straight edge, suggesting perpendicular force and therefore a pulling or pushing motion. The more pronounced protrusion on the artefact (visible on the right side of Figure 6-39A) showed more evidence of wear than the other protrusion (Figure 6-39A left side), which only had minor edge damage. The former protrusion (Figure 6-39A right side) and extensive and patterned damage along the ridge and one deep striation. This protrusion was pulled along a hard material.

Table 6-22: Inquisitive process for artefact 16258 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue is located on the dorsal surface.
2 – Is it Organic or Inorganic?	Organic. The residue was amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue along the working edge suggests it is anthropogenic.
4 – Is it Plant or Animal?	Animal. Based on the classification and presence of protein and fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

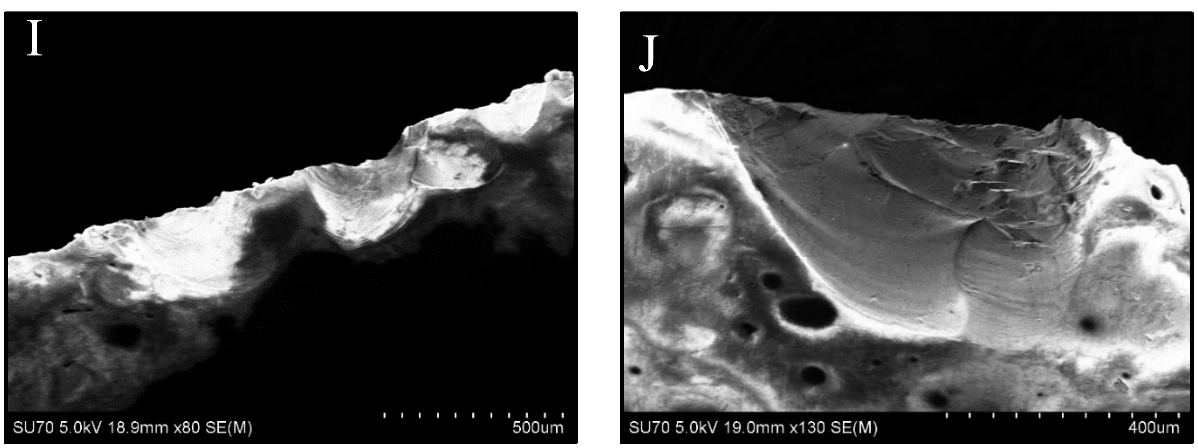


Figure 6-41: Use-wear on artefact 16528.
I, J – Micro-flakes along the straght edge.

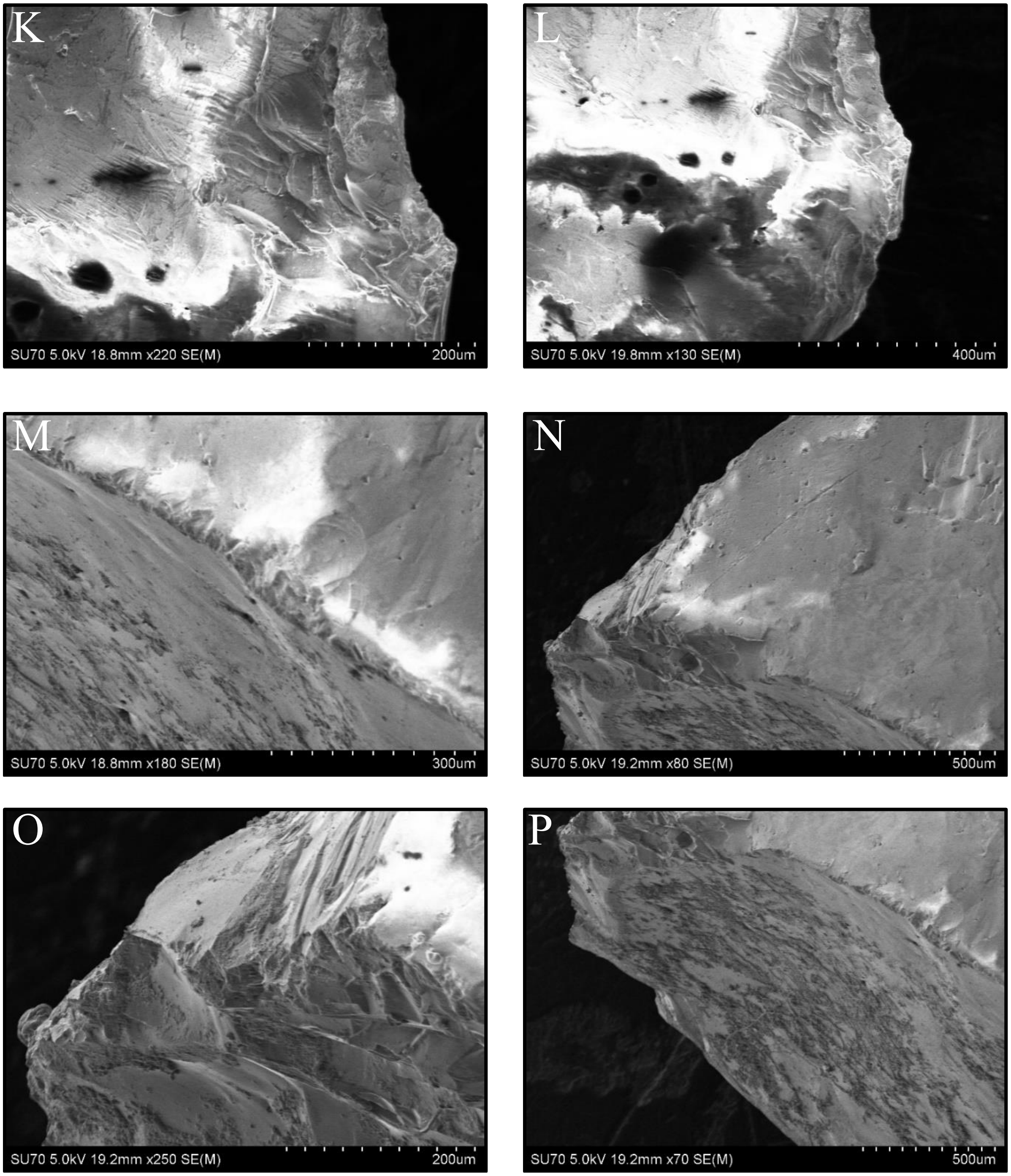


Figure 6-42: Use-wear on artefact 16528.
K, L – Micro-flaking at other protrusion. M, N, O, P – Edge and ridge damage on more pronounced protrusion.

In conclusion, artefact 16528 was a multi-functional implement. Based on the residue and scarring along its straight edge, it was likely used to scrape dry hide. The two protrusions were used as engravers on hard material, such as antler or bone. There was no evidence of plant processing.

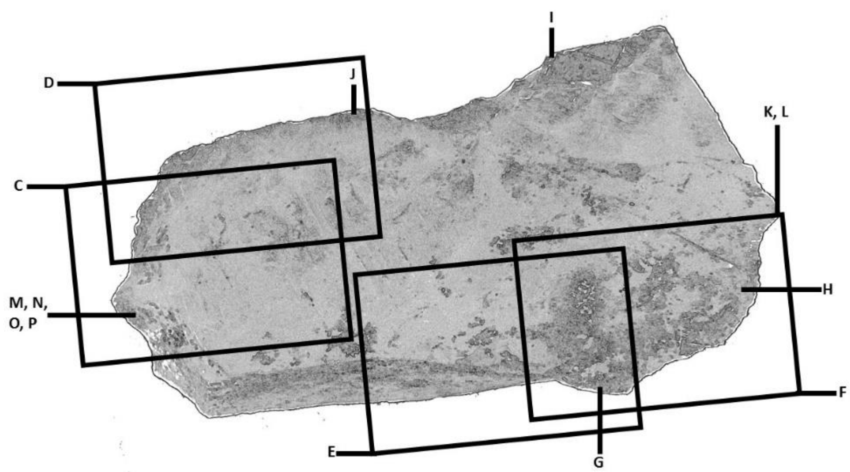


Figure 6-43: Image locations for artefact 16528.

6.2.11 Artefact 20503

Artefact 20503 was a clear and milky quartz flake, which measured 38mm long and 22mm wide (Figure 6-44). This artefact was selected for the presence of residue on its dorsal surface and the straight, thin edge located adjacent to the residue. Under LPILM, the residue was similar to that identified on other artefacts within the sample. See Figure 6-47 for the location of each micrograph.

The residue was identified as a class 7 residue, which only occurred on two other artefacts, because of its grainy texture (Figure 6-45). This residue may not be authentic, or it could just have a larger portion of sediment mixed in since it is more granular. In either case, neither biochemical tests, GC/MS, nor HPTLM produced any significant results (Table 6-23; Table 6-24). Therefore, only use-wear analysis can interpret whether this artefact was used.

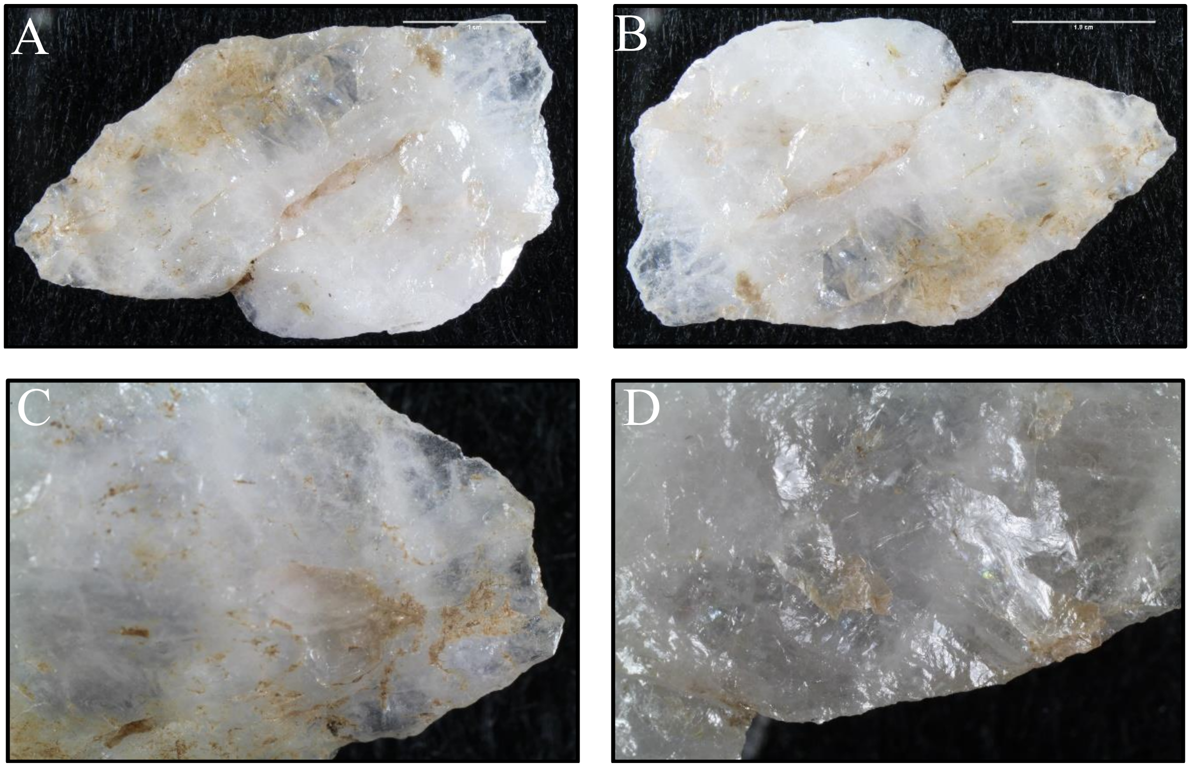


Figure 6-44: Artefact 20503.
A – Dorsal surface. B – Ventral surface. C – Tip of working edge at 20x magnification, ventral surface. D – Working edge at 20x magnification, ventral surface.

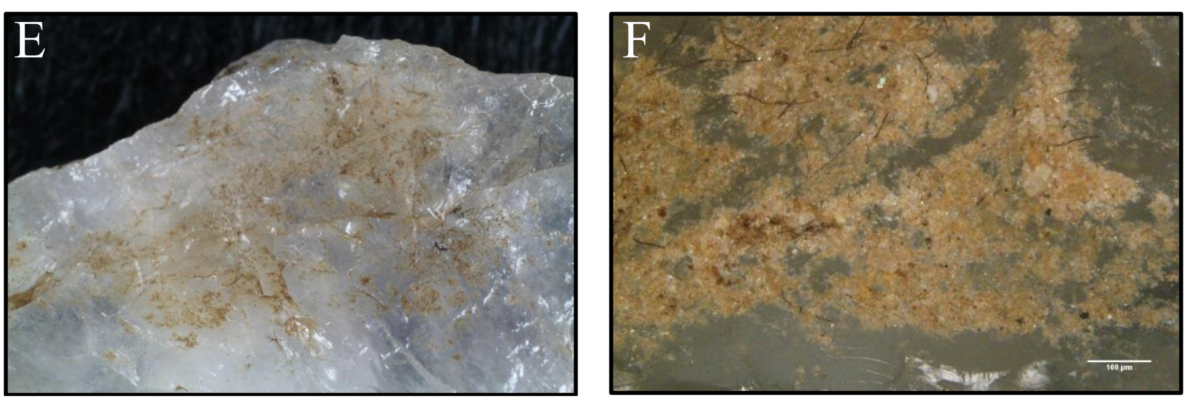


Figure 6-45: Residue on artefact 20503.
E – Residue at 20x magnification, dorsal surface. F – Residue at 100x magnification.

Table 6-23: Residue and use-wear results summary for artefact 20503.

	Residue			Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
7	No	No	N/A	Striations Flake Scars Edge Damage	Unidentifiable	N/A	N/A

Table 6-24: Inquisitive process for artefact 20503 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. One residue is present.
2 – Is it Organic or Inorganic?	Organic. The residue is amorphous and SEM/EDS analysis confirmed the presence of organic residue. However, the residue (Class 7) could be inorganic as it appears grainy
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue along the working edge suggests it is anthropogenic.
4 – Is it Plant or Animal?	Undetermined.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis produced little evidence as well. Although edge damage in the form of micro-flaking was present, along with a few short striations, use-wear was deemed unidentifiable (Figure 6-46). The only evidence of use was found near the tip of the artefact (see Figure 6-46I).

In conclusion, little interpretation can be offered for artefact 20503. Neither residue analysis nor use-wear analysis could provide any interpretable data. If this artefact were indeed used, as the potential use-wear may suggest, then it was used briefly.

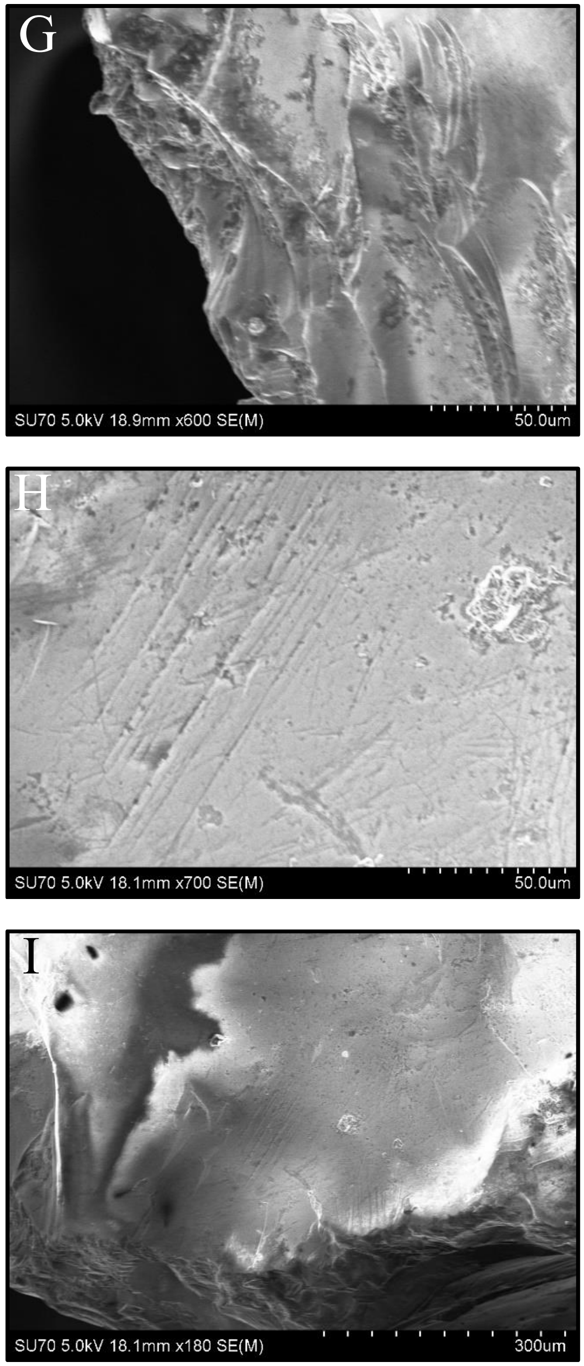


Figure 6-46: Use-wear on artefact 20503.
G – Micro-flaking at broken tip of artefact. H – Short striations roughly perpendicular to the tip. I – Striations at a lower magnification than the image I.

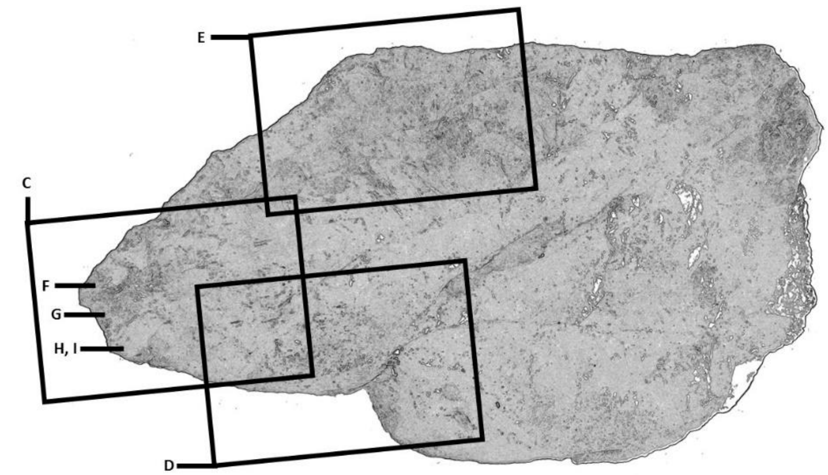


Figure 6-47: Image locations for artefact 20503.

6.2.12 Artefact 24506

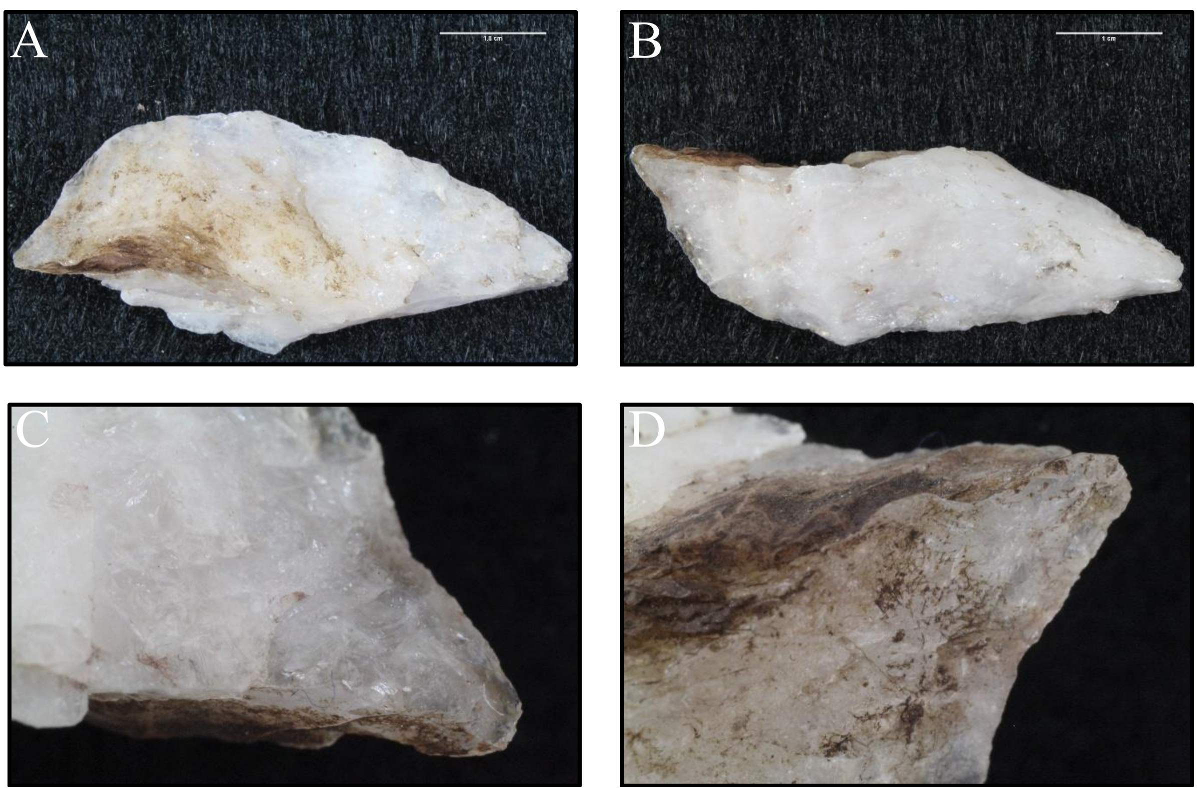


Figure 6-48: Artefact 24506.
A – Dorsal surface. B – Ventral surface. C – Ventral surface of tip at 20x magnification. D – Dorsal surface of tip at 20x magnification.

Artefact 24506 is a long, skinny milky quartz fragment, which measured 52mm long and 19mm wide (Figure 6-48). It was selected because of the large amount of dark brown residue located on the dorsal surface and near a possible working tip. Again, the residue is only found on the dorsal surface of the artefact. See Figure 6-51 for the location of each micrograph.

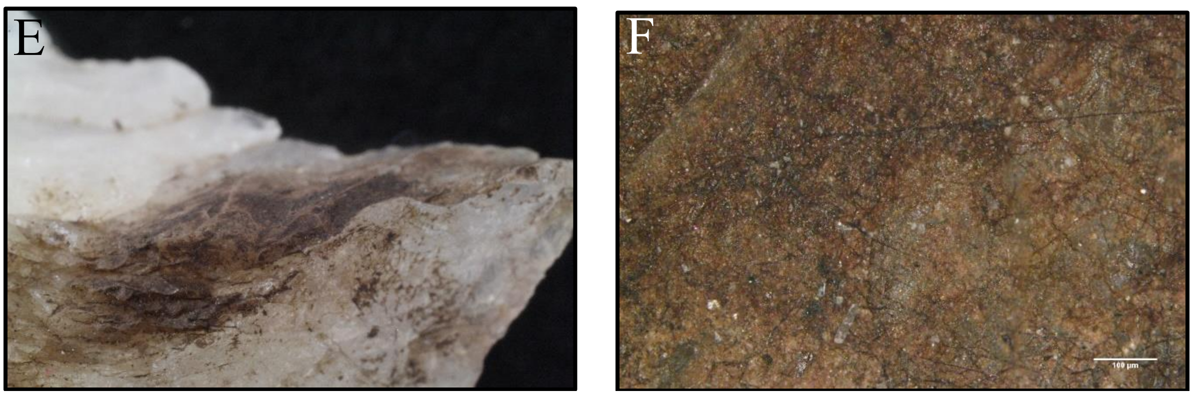


Figure 6-49: Residue on artefact 24506.
E – Residue at 20x magnification, dorsal surface. It almost appears burnt. F – Class 6 residue at 100x magnification.

Using HPILM, the residue was identified as class 6 (Figure 6-49). Biochemical results produced one weak positive for fatty acid (Table 6-25; Table 6-26). However, results from the other artefacts within class 6 produced positives for both protein and fatty acid, indicating this was likely an animal-derived residue. The GC/MS analysis and HPTLM analysis produced no significant results.

The use-wear analysis proved to be more enlightening. The edges around the working tip exhibited a large amount of micro-flaking that indicate this artefact was indeed utilized (Figure 6-50). Striations and comet-tailed pits were oriented perpendicular to the edge, but parallel to the working tip. The pits indicate force towards the edge, but rather than a pushing motion, a twisting motion most likely caused these scars (Table 6-25). The presence of this kind of pitting also suggested the work material must be either bone or antler (Sussman, 1988). Therefore, it can be concluded that this artefact was used by hand to drill into either bone or antler.

Table 6-25: Residue and use-wear results summary for artefact 24506.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
6	No	Weak	N/A	Striations Flake Scars Edge Damage Ridge Wear Comet-Tailed Pits	Identifiable	Hard	Twist or push/pull

Table 6-26: Inquisitive process for artefact 24506 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. One residue is present.
2 – Is it Organic or Inorganic?	Organic. The residue is amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working tip suggests it is anthropogenic.
4 – Is it Plant or Animal?	Undetermined. However, the other Class 6 residues are animal-derived based on their protein content.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

In conclusion, artefact 24506 was indeed a tool. It functioned as a hand drill and was used on either bone or antler. Although the residue analysis did not produce much data for this artefact specifically, artefacts with similar residue strongly suggest it originated from an animal. In addition, the use-wear present is rather unique to working either antler or bone (Sussman, 1988).

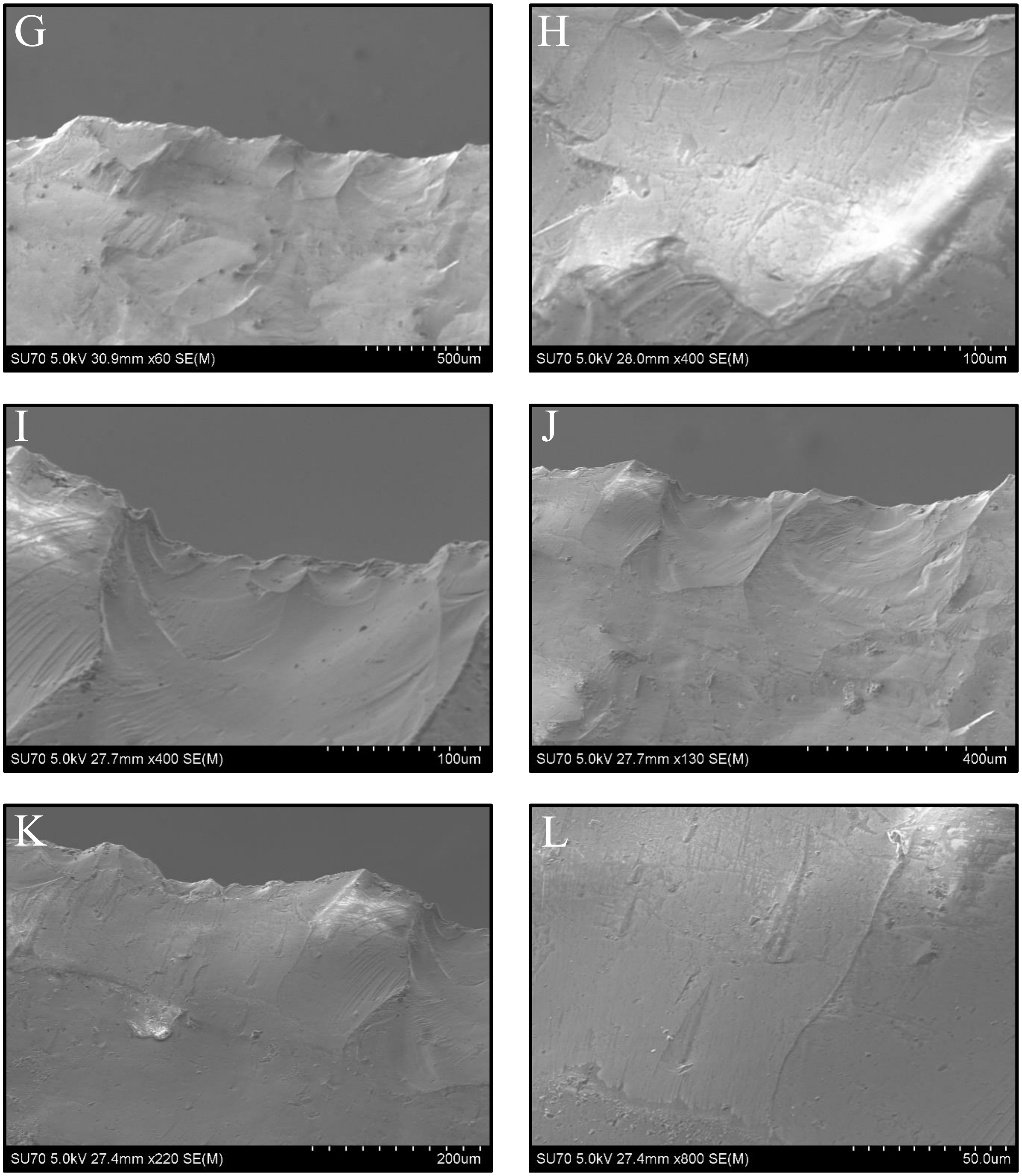


Figure 6-50: Use-wear on artefact 24506.
G – Striations perpendicular to edge, but parallel to tip, located within a flake scar. H, I, J – Multiple use-derived micro-flakes along the edge of the tool near the working tip. K, L – Comet-tailed pits that indicate a twisting motion because the tails point towards the edge of the tool.

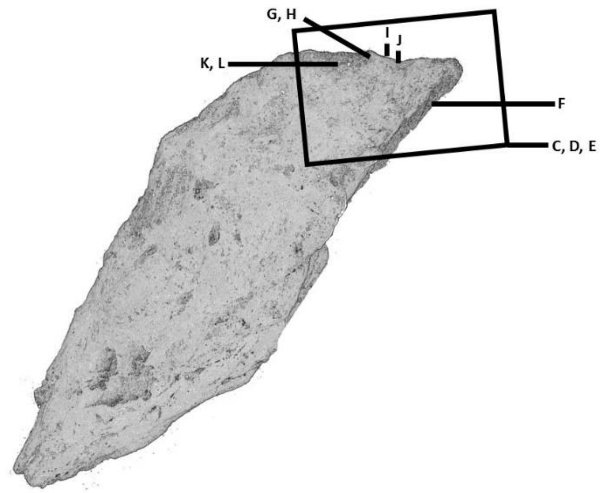


Figure 6-51: Image locations for artefact 24506.

6.2.13 Artefact 24842

Artefact 24842 was one of the more unique specimens. It was a small amethyst crystal, which measured 25mm long and 10mm wide, and had a long taper to the proximal end (Figure 6-52). It was chosen in part because of this taper and overall interesting shape but also for the residue adhering to the crystal face near the tip of the artefact. See Figure 6-55 for the location of each micrograph.

The residue visible using HPILM proved to be very interesting as well. Two different locations on the same crystal face were recorded. Both residues were classified as class 8 residue. A small amount of class 2 residue was also present. The class 8 residue was black and yellow with a large amount of dehydration and desiccation cracking for texture (Figure 6-53). It almost bore resemblance to slightly burnt corn on the cobb. Based on the texture, blood residue is suspected. However, biochemical tests, GC/MS, and HPTLM provided no significant results (Table 6-27; Table 6-28). In addition, Hb-CRTS did not support the presence of blood on this artefact. Artefact 25073 also had class 8 residue and tested positive for protein residue and produced a score of 1 using the Hb-CRTS, which, along with the presence of class 2 residue, supports an animal interpretation for the residue.

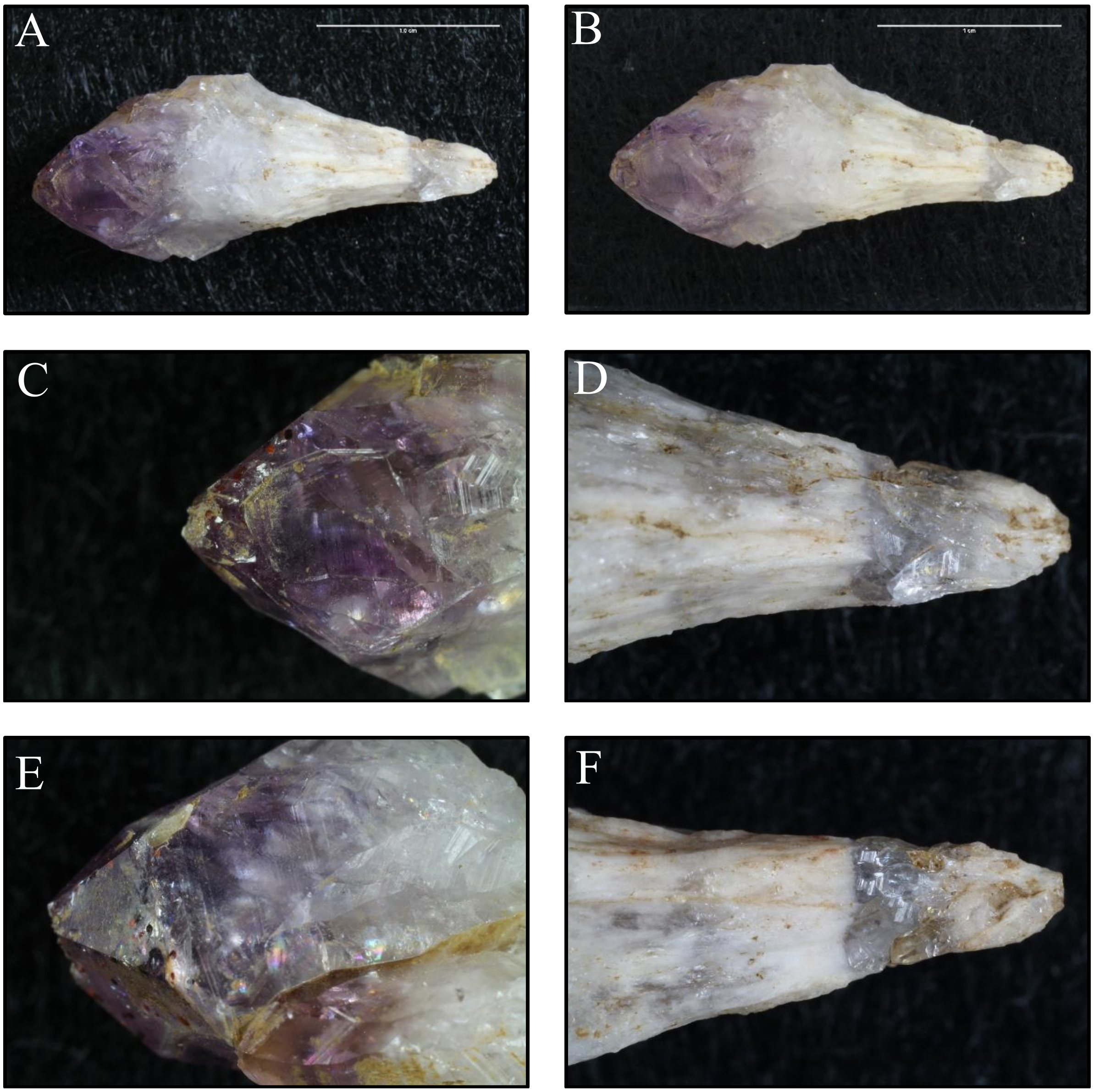


Figure 6-52: Artefact 24842.
A, B – Macro photos of two different crystal faces. C, D – Low power incident light images of the distal and proximal ends of the image A. 20x magnification. E, F – Low power incident light images of the distal and proximal ends of the image B. 20x magnification. Note the residue adhering to the crystal face.

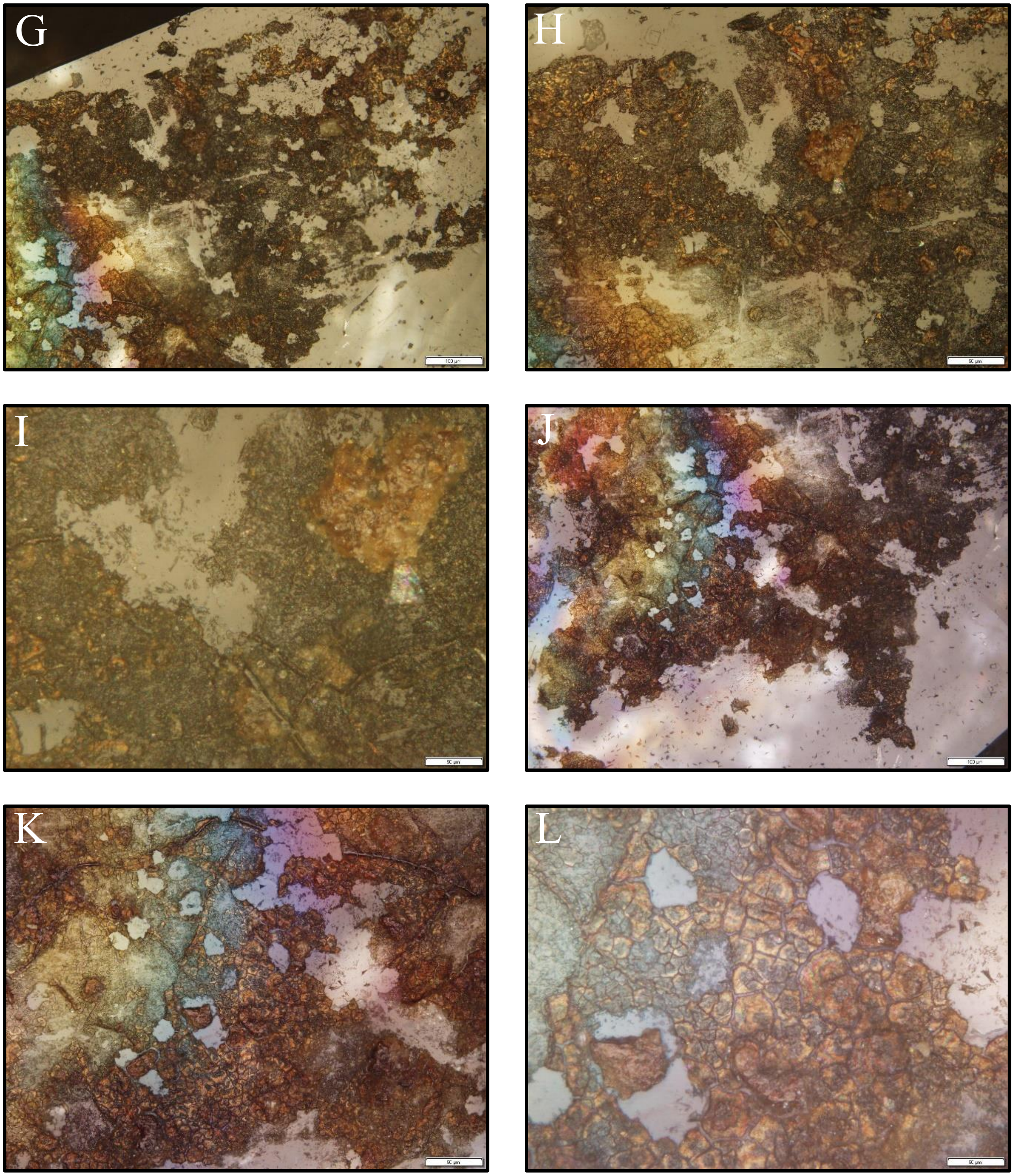


Figure 6-53: Residue on artefact 24842.
G, H, I – The same residue at 100x, 200x and 500x magnification respectively. J, K, L – A different location on the same face showing the same residue at 100x, 200x and 500x magnification respectively.

Table 6-27: Residue and use-wear results summary for artefact 24842.

	Residue				Use-Wear		
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
2, 8	No	No	N/A	Striations Linear Grooves Flake Scars Edge Damage Pits	Identifiable	Hard	Twist

Table 6-28: Inquisitive process for artefact 24842 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Two residues are present.
2 – Is it Organic or Inorganic?	Organic. The residue is amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working tip suggests it is anthropogenic.
4 – Is it Plant or Animal?	Animal. Despite the lack of chemical data, the HPILM images and the overall results of classes 2 and 8's biochemical tests support an animal-based interpretation.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis showed the extensive damage to the used tip in conjunction with deep, long striations and linear grooves that were oriented parallel to the tip (Figure 6-54). This orientation suggests a twisting motion is being used (Table 6-27). The depth and width of the linear grooves suggests a harder material, such as bone or antler (Knutsson, 1988a).

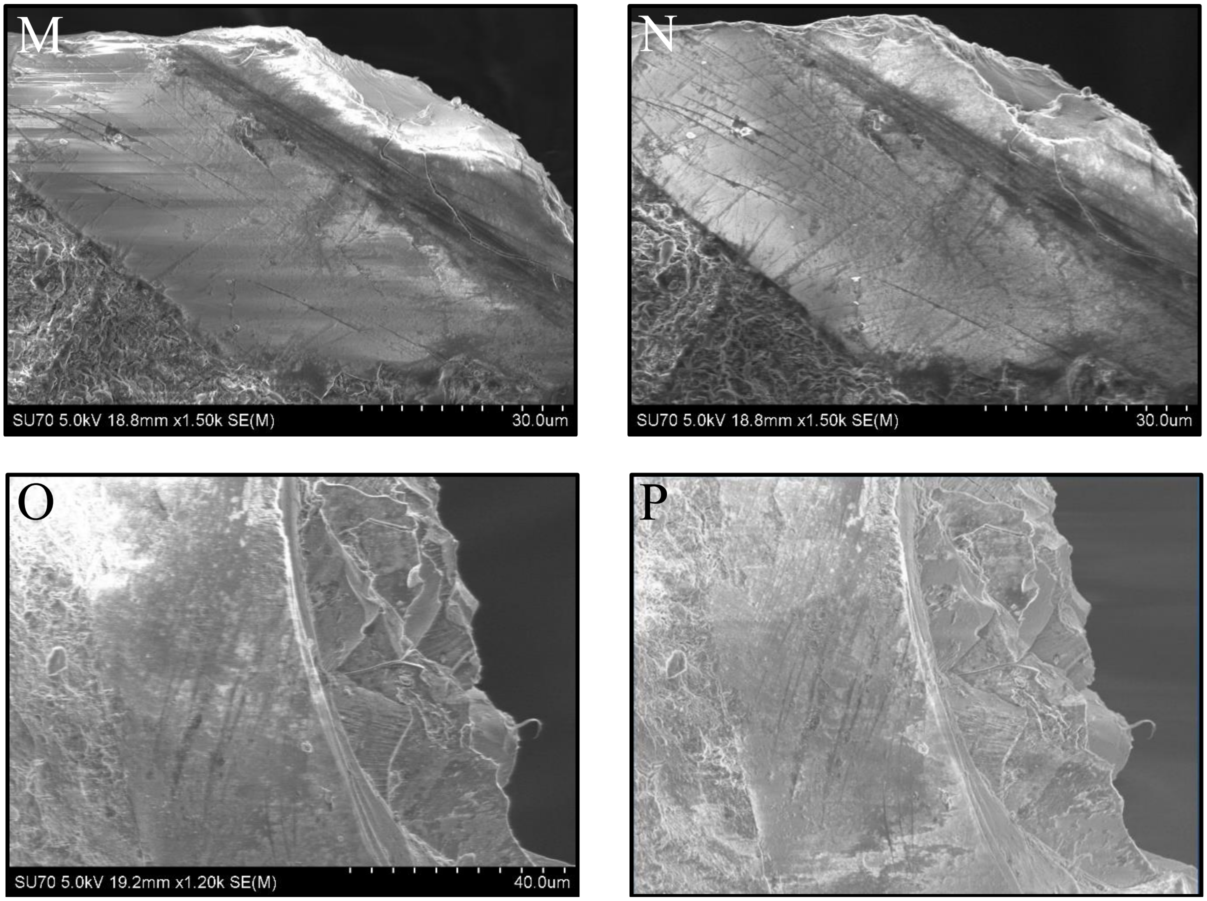


Figure 6-54: Use-wear on artefact 24842.
M, N, O, P – All four images show parallel striations and linear grooves that indicate a twisting or drilling motion. O and P also shows edge crushing.

In conclusion, artefact 24842 was clearly used. The use-wear indicates a twisting, or a drilling, motion with scars indicative of a harder material (e.g. bone or antler). The residue data, although somewhat limited, suggests an animal-derived residue. Therefore, both residue and use-wear analysis support the interpretation that this artefact was used to drill bone and/or antler.

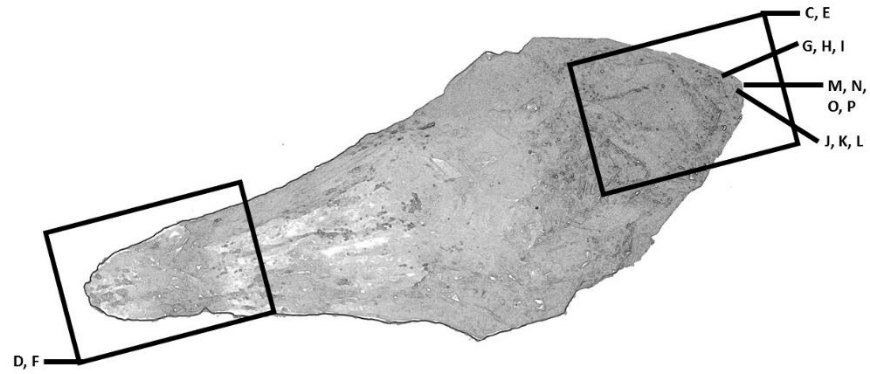


Figure 6-55: Image locations for artefact 24842.

6.2.14 Artefact 25073

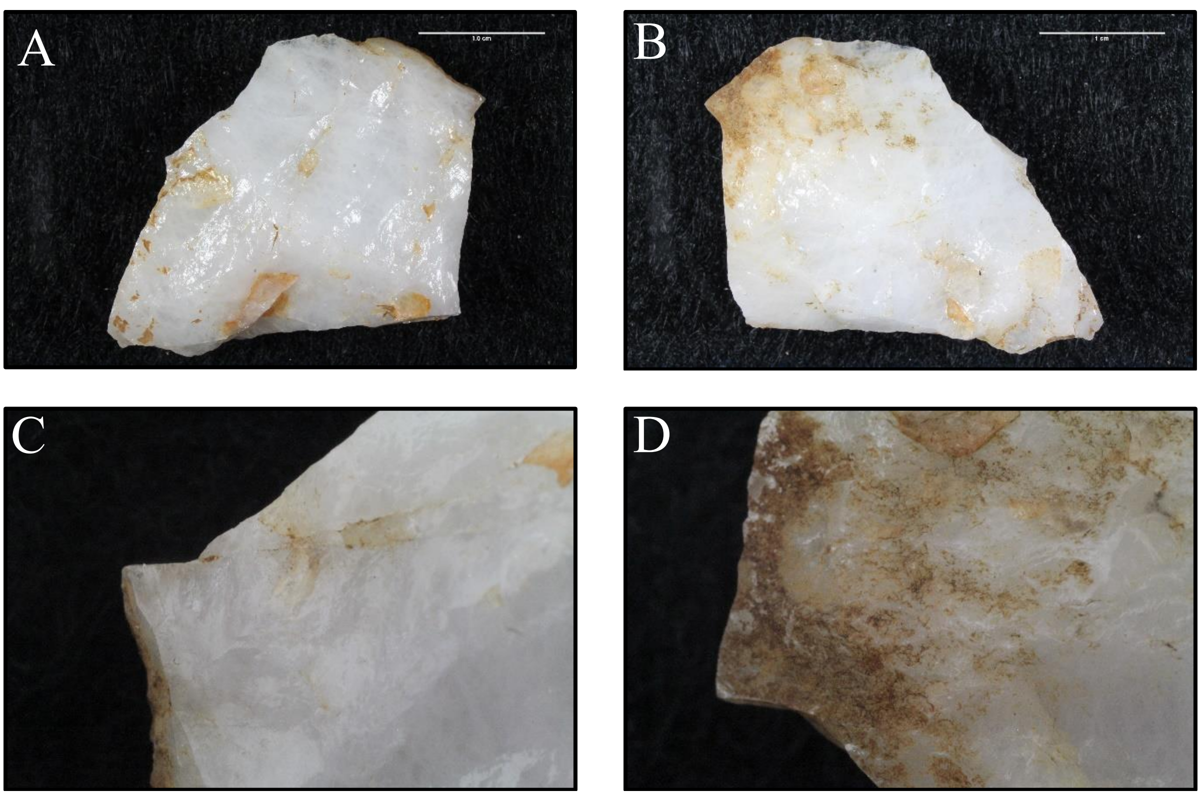


Figure 6-56: Artefact 25073.
A – Dorsal surface. B – Ventral surface. C – Broken edge, dorsal surface at 20x magnification. D – Broken edge, ventral surface at 20x magnification.

Artefact 25073 was made of milky quartz and measured 32mm long by 42mm wide (Figure 6-56). It was selected for the presence of residue adjacent to what was thought to be a possible engraving protrusion. However, upon closer examination, a break was identified. Thus, the residue was associated with this straight edge, part of which was adjacent to the engraving tip. See Figure 6-59 for the location of each micrograph.

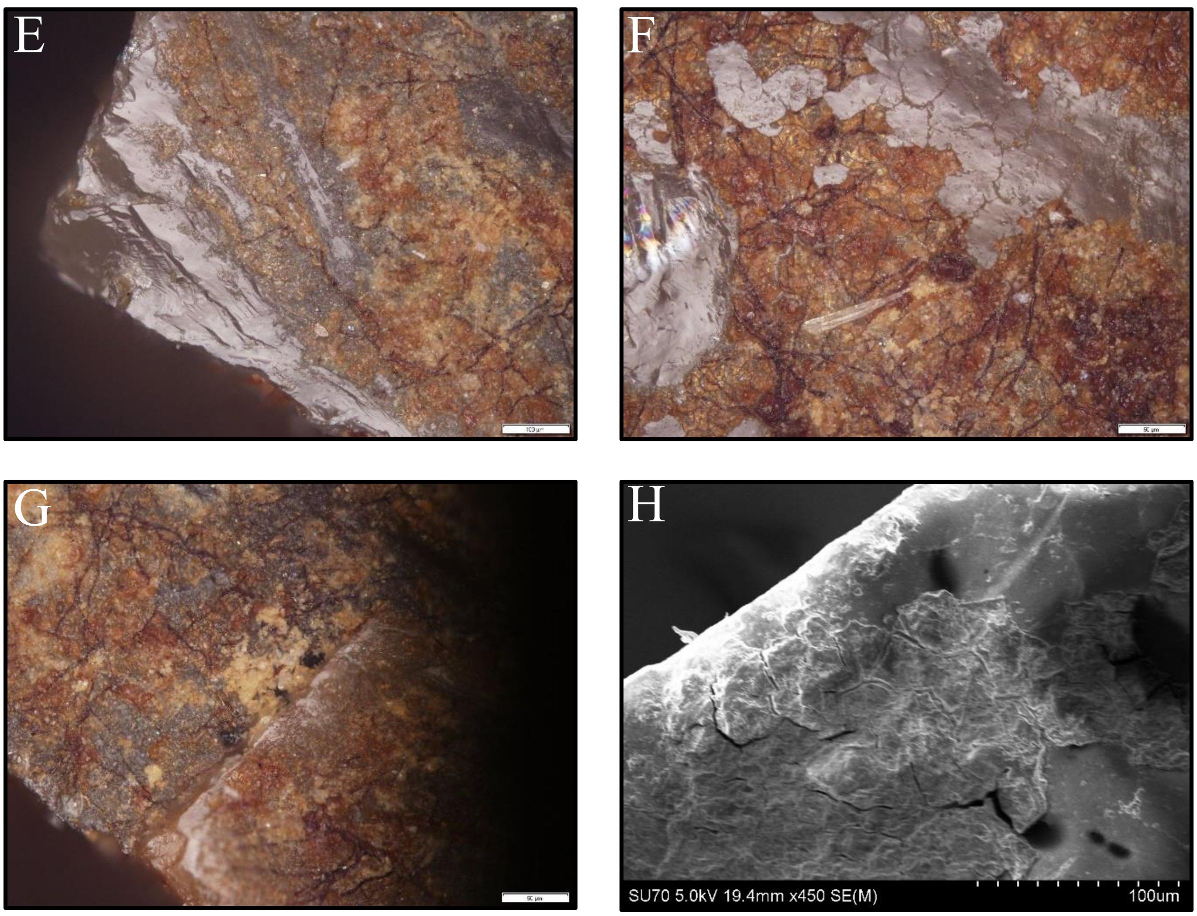


Figure 6-57: Residue on artefact 25073.
E – Class 8 residue at 200x magnification. F – Class 8 residue at 500x magnification. G – Class 8 residue at 200x magnification. H – Class 8 residue under SEM at 150x magnification.

The HPILM identified class 8 residue. Although it did not look burnt, like on artefact 24842, the residues are considered the same because of their pronounced dehydration and desiccation cracking (Figure 6-57). In addition, class 1 residue appeared to be a component of class 8 residue, suggesting a relationship. Biochemical tests produced positive results for protein, suggesting the residue was animal-derived. The Hb-CRTS tests produced a score of 1, supporting the interpretation of blood residue. The GC/MS and HPTLM analysis produced no significant results (Table 6-29; Table 6-30). Overall, the residue on artefact 25073 is identified as animal.

Table 6-29: Residue and use-wear results summary for artefact 25073.

	Residue			Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
8	Yes	No	N/A	Striations Flake Scars Edge Damage	Indeterminate	Soft	Push or Pull

Table 6-30: Inquisitive process for artefact 25073 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. One residue is present near a suspected working edge.
2 – Is it Organic or Inorganic?	Organic. The residue is amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working tip suggests it is anthropogenic.
4 – Is it Plant or Animal?	Animal. Biochemical testing suggests animal based on strong protein indicators. Also, the HPILM and SEM images show a mud-cracked texture, typical of blood residue.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis did not produce strong results, although enough wear is visible to support a weak interpretation. The suspected working edge displayed minor micro-flaking and faint striations situated perpendicular to the working edge (Figure 6-58). This suggests the tool was used in a pulling or pushing motion (e.g. scraping; Table 6-29). Striations were also present at the opposite engraving protrusion, but there was not enough evidence to conclude the tip had been used.

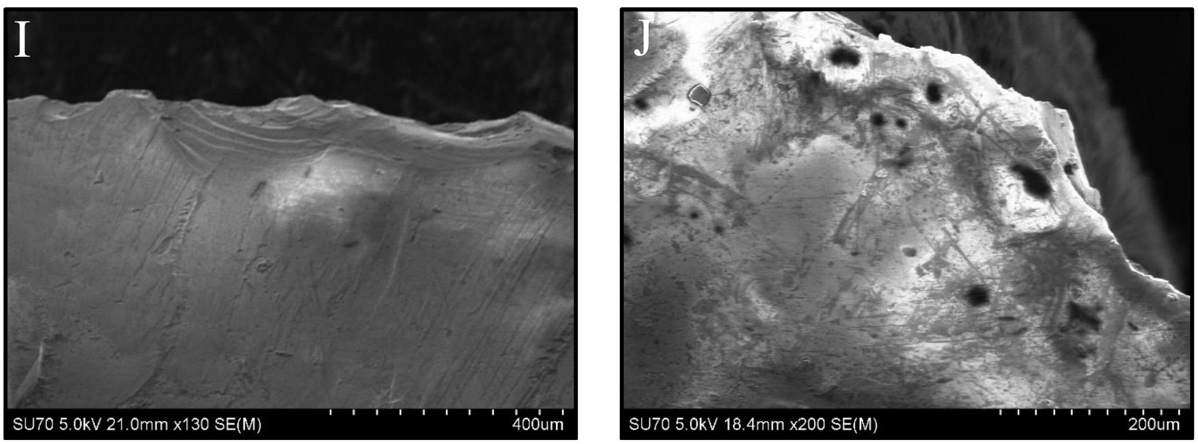


Figure 6-58: Use-wear on artefact 25073.
I – Micro-flaking and faint striations. J – Faint striations.

In conclusion, although not overly strong, the use-wear data suggested this artefact functioned as a scraper. Most of the working edge was missing, leaving little behind to analyze. The residue data indicated the residue originated from an animal. Therefore, artefact 25073 was likely used to scrape fresh hide.

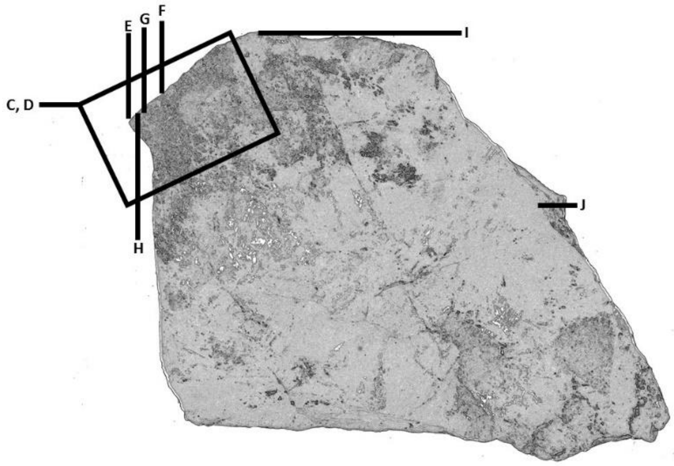


Figure 6-59: Image locations for artefact 25073.

6.2.15 Artefact 27868

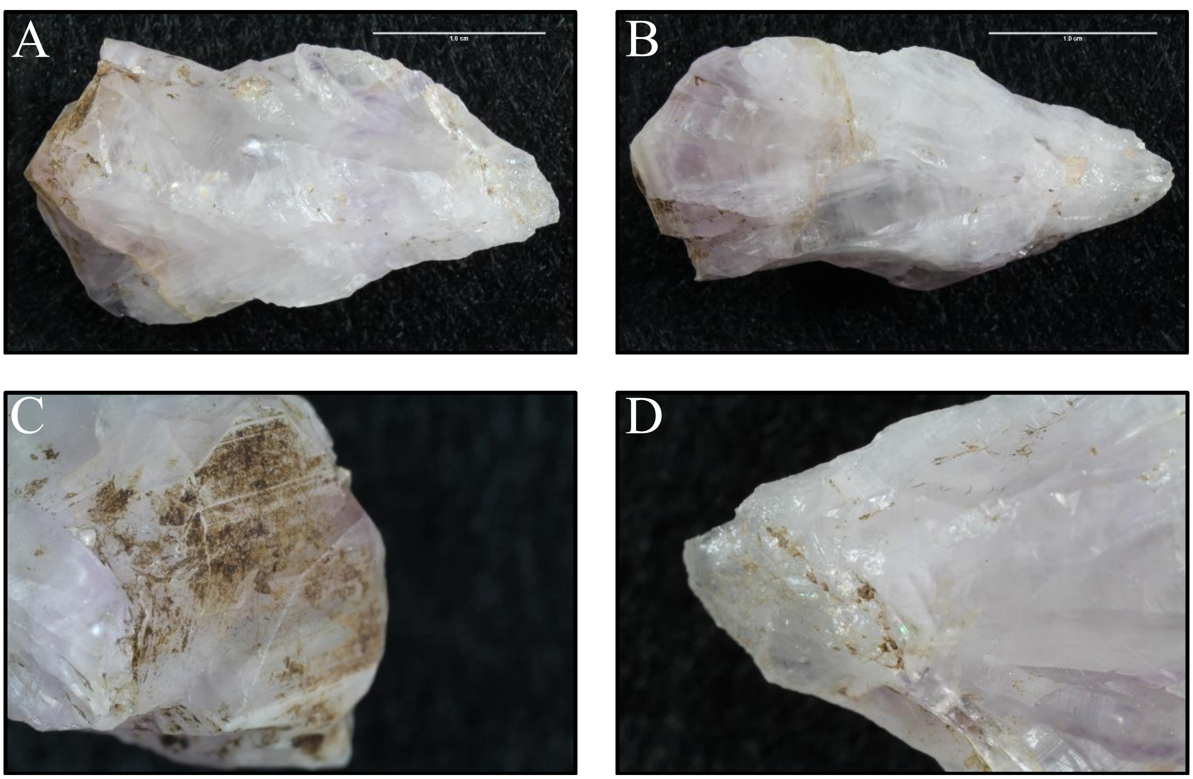


Figure 6-60: Artefact 27868.
A, B – Macro images of artefact 27868. C – Residue on distal end at 20x magnification. D – Proximal end at 20x magnification.

Artefact 27868 was a pale amethyst fragment, which measured 32mm long and 15mm wide (Figure 6-60). It was selected for the visible residue located on its distal end. The distal end did not resemble a very functional end and the proximal end was determined to be more functional. See Figure 6-63 for the location of each micrograph.

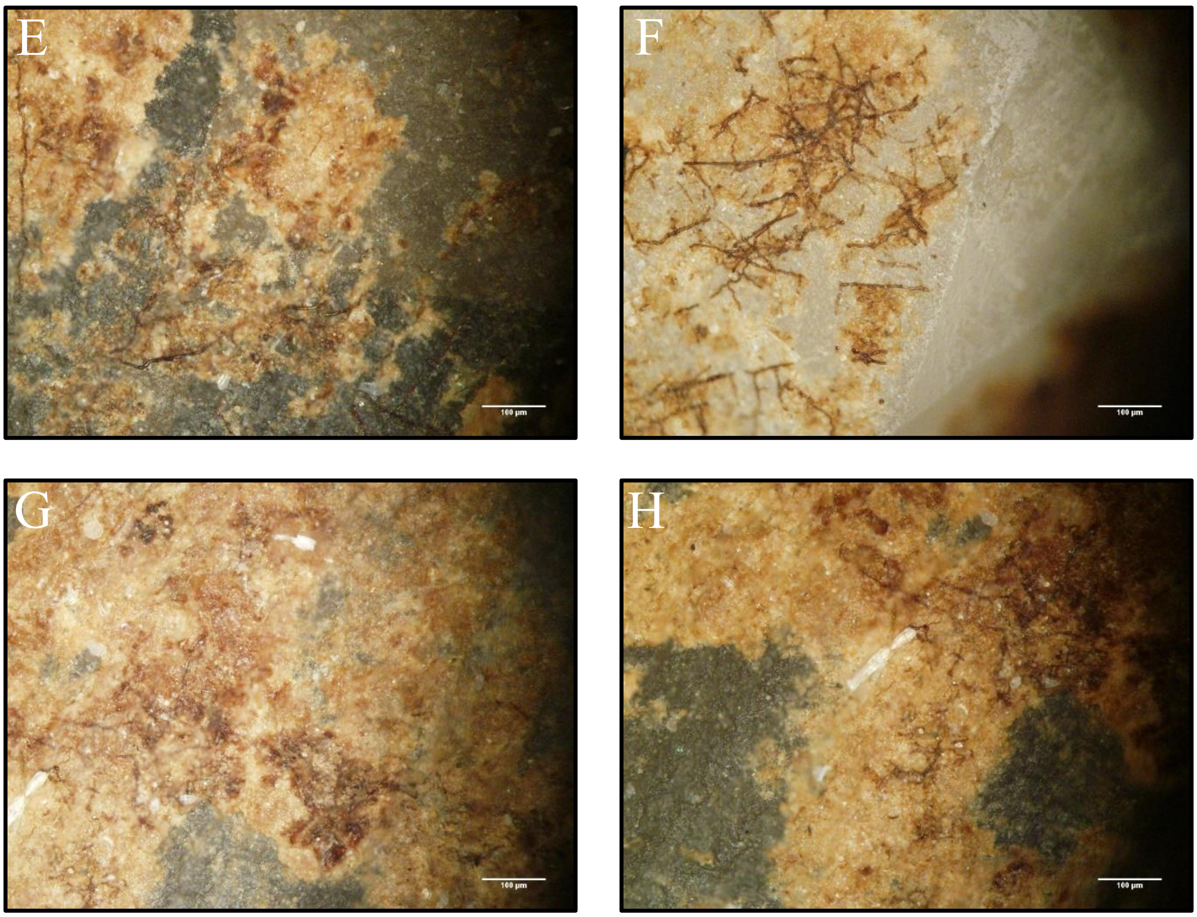


Figure 6-61: Residue on artefact 27868.
E, F, G, H – Class 1 residue. Image F is similar to class 5, but remained designated as a class 1 residue because of its yellow amorphous component.

The residue on artefact 27868 was located at the distal end. It was exclusively a class 1 residue, which was interpreted as an animal-derived residue (Figure 6-61). However, one location was almost scarce enough to be class 5 (Figure 6-61F). This suggests a relationship between class 1 and class 5 residue. Biochemical tests, GC/MS, and HPTLM produced no significant results (Table 6-31; Table 6-32). Therefore, this residue was interpreted as animal based on the proxy results of the other artefacts within this class.

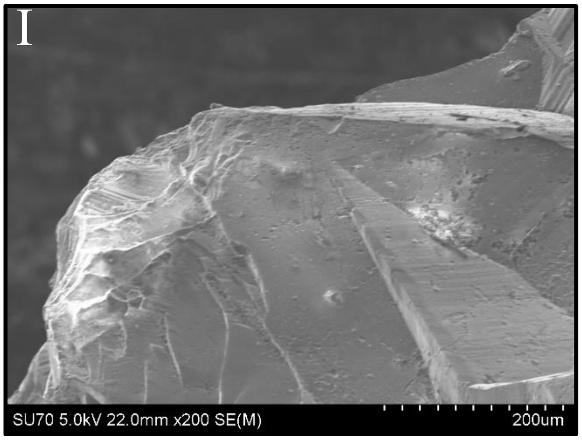
Table 6-31: Residue and use-wear results summary for artefact 27868.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1	No	No	N/A	Edge Damage Pits	Unidentifiable	N/A	N/A

Table 6-32: Inquisitive process for artefact 27868 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. One residue is present.
2 – Is it Organic or Inorganic?	Organic. The residue is amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Undetermined. The residue was not located on a functional edge or tip.
4 – Is it Plant or Animal?	Animal. Based on results from other artefacts with similar residue.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Regarding use-wear, artefact 27868 again produced disappointing results (Table 6-31). No use-wear was present in the location of the residue. The proximal end showed some edge damage and pits, which may be natural (Figure 6-62).



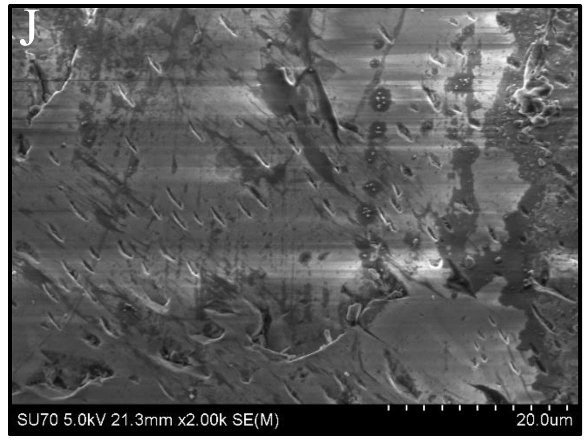


Figure 6-62: Use-wear on artefact 27868.
I – Some edge damage at proximal end. J – Lots of pitting, but likely natural.

In conclusion, artefact 27868's function could not be identified. Despite the presence of residue, residue analysis beyond *in situ* HPILM produced no results and any evidence of use-wear was absent. The presence of residue was either accidental or the product of environmental contamination or the product of very expedient use.

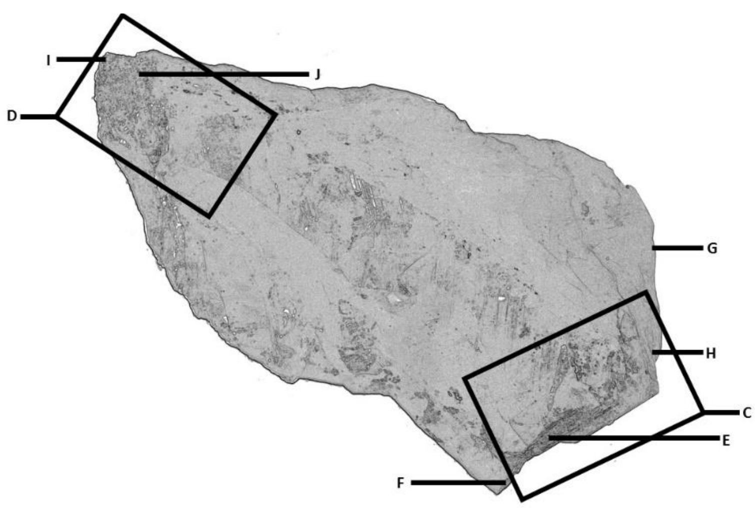


Figure 6-63: Image locations for artefact 27868.

6.2.16 Artefact 31322

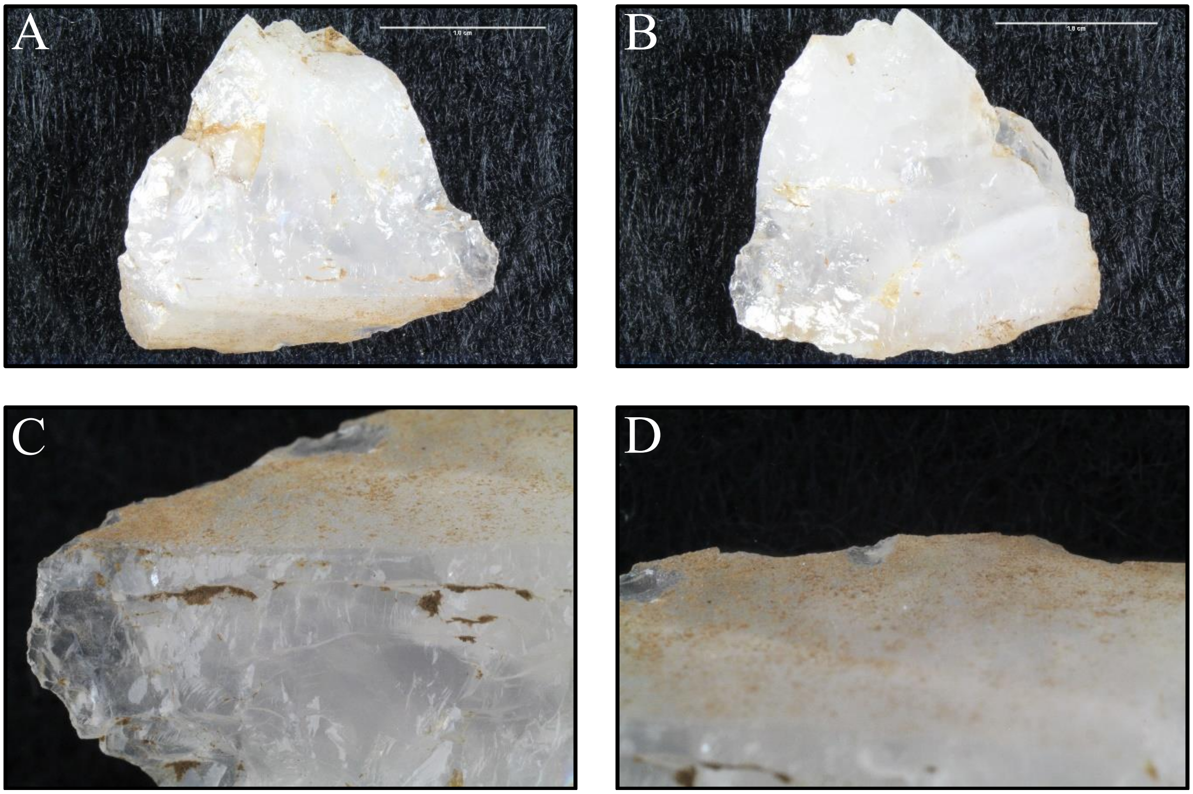
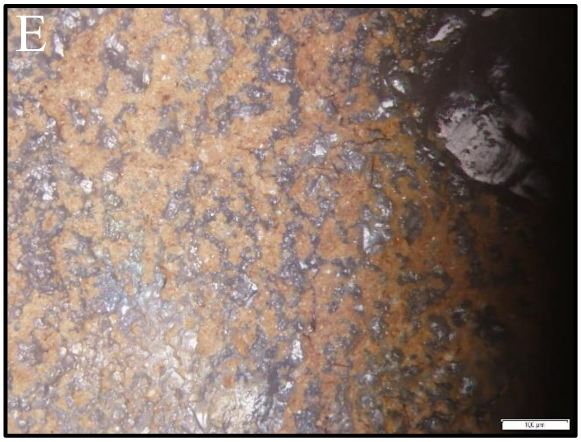


Figure 6-64: Artefact 31322.
A – Dorsal surface. B – Ventral surface. C – Dorsal surface at 20x magnification. D – Suspected working edge of dorsal surface at 20x magnification.

Artefact 31322 is a clear and milky quartz fragment with part of a weathered cortex surface (Figure 6-64). It measured 23mm long by 22mm wide. It was selected for its straight, but slightly curved edge along its weathered surface. This edge featured a few flakes visible macroscopically (Figure 6-64C, D). When examined with a stereomicroscope, the material adhering to the surface was thought to be residue. See Figure 6-67 for the location of each micrograph.



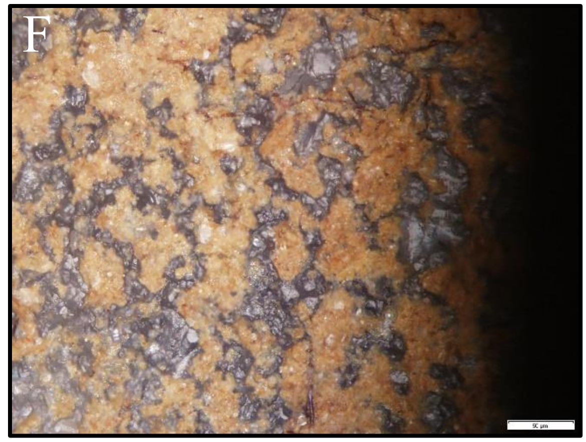


Figure 6-65: Residue on artefact 31322.
E, F – Class 1 residue.

The residue on artefact 31322 was classified as class 1, although it was borderline class 4 (Figure 6-65). This suggested there was a relationship between these two residues. Biochemical tests produced weak positives for both protein and fatty acid. Class 1 residue generally tested positive for both these molecules, suggesting the residue is animal-derived. The GC/MS and HPTLM analysis produced no significant results (Table 6-33: Table 6-34).

Table 6-33: Residue and use-wear results summary for artefact 31322.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1	Weak	Weak	N/A	Flake scars Striations?	Unidentifiable	N/A	N/A

Use-wear was essentially non-existent. Although present, the flake scars were inconsistent and likely a product of taphonomy rather than use. Possible striations were visible, but could be part of the material rather than a result of use (Figure 6-66). The utilization of this artefact could not be confirmed (Table 6-33).

Table 6-34: Inquisitive process for artefact 31322 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. One residue is present near a suspected working edge.
2 – Is it Organic or Inorganic?	Organic. The residue is amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working tip suggests it is anthropogenic.
4 – Is it Plant or Animal?	Animal. Biochemical testing suggests animal based on strong protein indicators. Also, the HPILM and SEM images dehydration and desiccation cracking, typical of blood residue.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

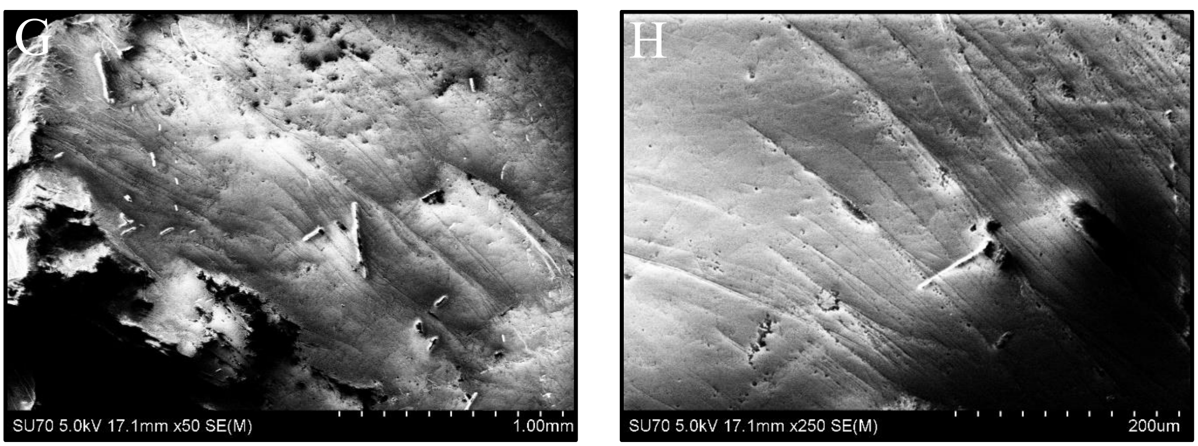


Figure 6-66: Use-wear on artefact 31322.
G, H – Possible striations which were more likely a product of the material rather than use.

In conclusion, use-wear analysis could not confirm that artefact 31322 was ever used. The potential residue resembled other animal based residues identified more confidently on other artefacts, but only produced weak positive results. Based on the lack of conclusive data, this artefact's function could not be identified.

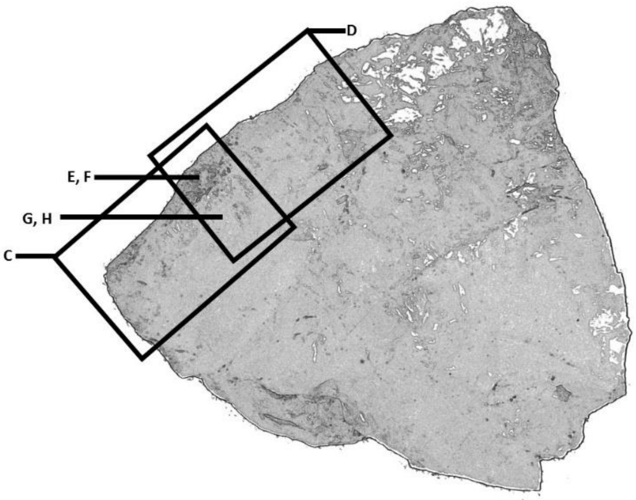


Figure 6-67: Image locations for artefact 31322.

6.2.17 Artefact 31322-2

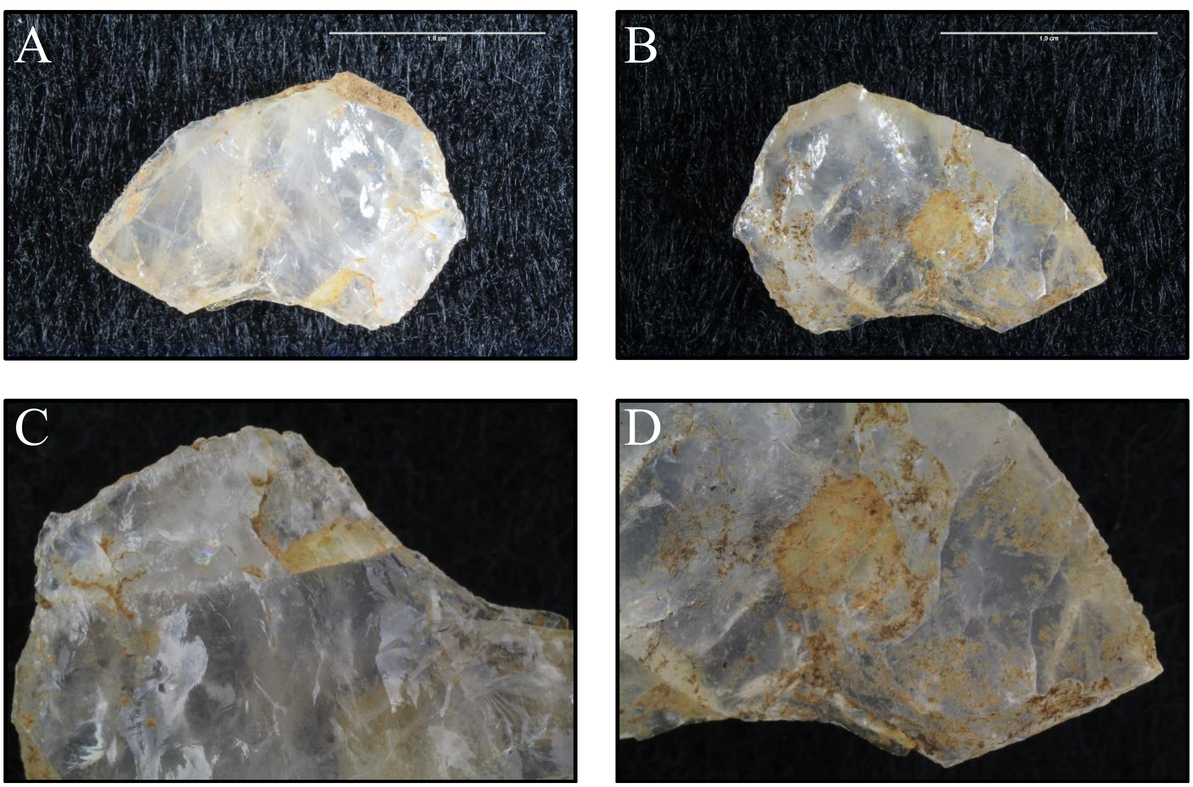
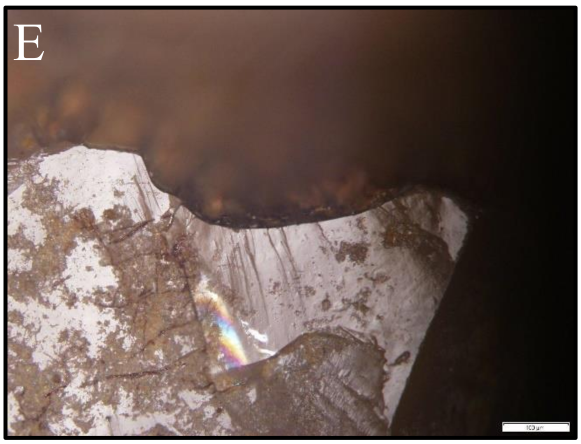


Figure 6-68: Artefact 31322-2.
A – Ventral surface. B – Dorsal surface. C – Ventral surface near working edge at 20x magnification. D – Dorsal surface near working edge at 20x magnification.

Artefact 31322-2 was a small translucent quartz, which measured 18mm long and 13mm wide (Figure 6-68). It was selected for its small, concave edge and associated residue. It was catalogued under the same number as 31322, hence its unique tag for this analysis. See Figure 6-71 for the location of each micrograph.



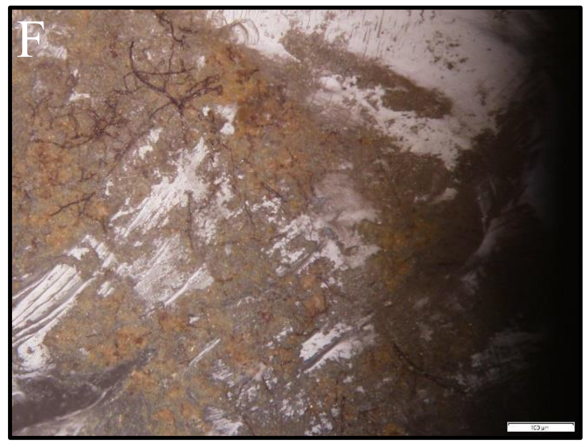


Figure 6-69: Residue on artefact 31322-2.
E, F – Class 2 residue.

Under HPILM one type of residue was identified (class 2; Figure 6-69). Although designated class 2, it was borderline class 1 because of the yellow colour. However, class 1 residues were typically more abundant, while class 2 residues were not as thick. Biochemical tests produced positive results for both protein and fatty acid, a result that was more typical of class 1 residues. Either way, this residue was animal-derived. The GC/MS and HPTLM analysis did not produce any significant results (Table 6-35; Table 6-36).

Use-wear analysis produced positive results as well (Figure 6-70). The concave edge displayed a high number of half-moon micro-flakes along the working edge. Striations associated with this edge were oriented at an angle, but more perpendicular than parallel. This suggested a cutting motion (i.e. pulled towards the user) or a whittling motion (pushed away from the user). The scars were smaller and the striations were shallow, indicating the worked material was softer (Table 6-35).

Table 6-35: Residue and use-wear results summary for artefact 31322-2.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2	Yes	Yes	N/A	Striations Flake Scars Edge Damage	Indeterminate	Soft	Pull

Table 6-36: Inquisitive process for artefact 31322-2 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near a suspected working edge.
2 – Is it Organic or Inorganic?	Organic. The residue was amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Biochemical testing suggested animal based on strong protein and fatty acid indicators.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Based on the residue and use-wear results, artefact 31322-2 was likely used as a microlith knife to cut meat or dry hide (Knutsson, 1988a). Residue analysis strongly indicated that the residue was animal-derived, while use-wear analysis confirmed it was utilized in a cutting motion on soft material. The tool was very small and must have been hafted to be used effectively. However, there was no evidence that the tool was hafted.

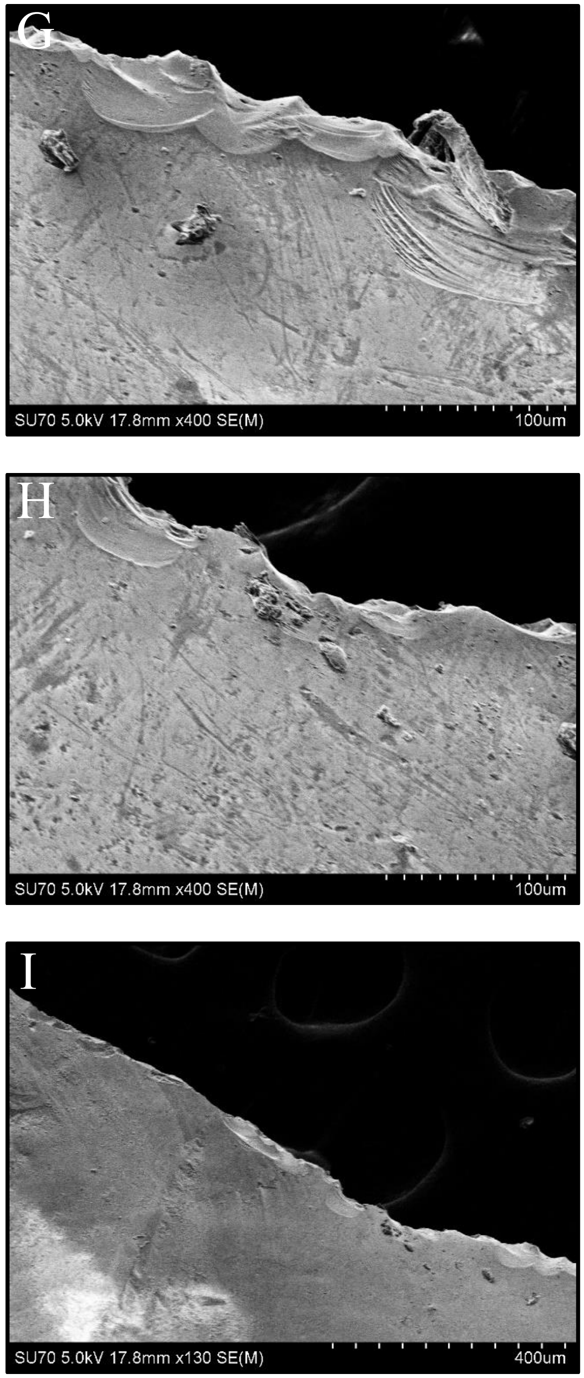


Figure 6-70: Use-wear on artefact 31322-2.
G, H, I – All four images show micro-flaking along the concave working edge with striations oriented at approximately 45 degrees to the working edge, which indicated a pulling/cutting motion.

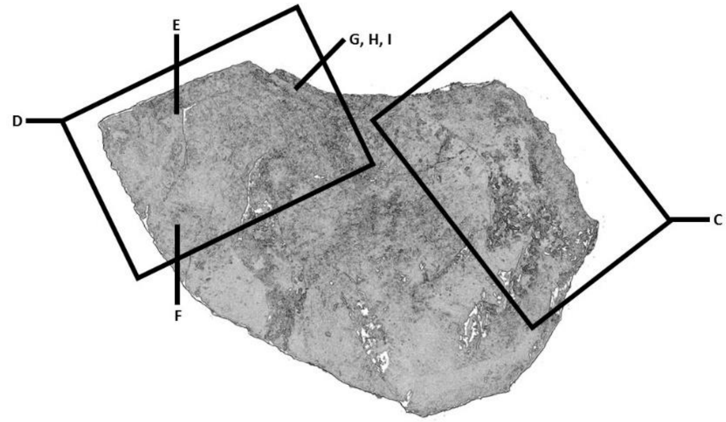


Figure 6-71: Image locations for artefact 31322-2.

6.2.18 Artefact 33622

Artefact 33622 was a small milky quartz flake, which measured 30mm by 20mm (Figure 6-72). It was selected because of the residue located near a thin edge and broken tip. The edge was retouched in this area as well. The shape of the artefact suggested it was manufactured from a specific flake blank that reoccurs throughout this analysis. This is discussed in the following chapter. See Figure 6-75 for the location of each micrograph.

Only a class 5 residue was identified adhering to artefact 33622 (Figure 6-73). Its distribution near the tip suggested it was authentic. Biochemical tests, GC/MS and HPTLM all produced negative results (Table 6-37; Table 6-38). Class 5 residue produced limited results in general because it is mostly just hyphae. A weak connection to animal-derived residue has been suggested since roughly one third to one half of the artefacts with this residue tested positive for protein.

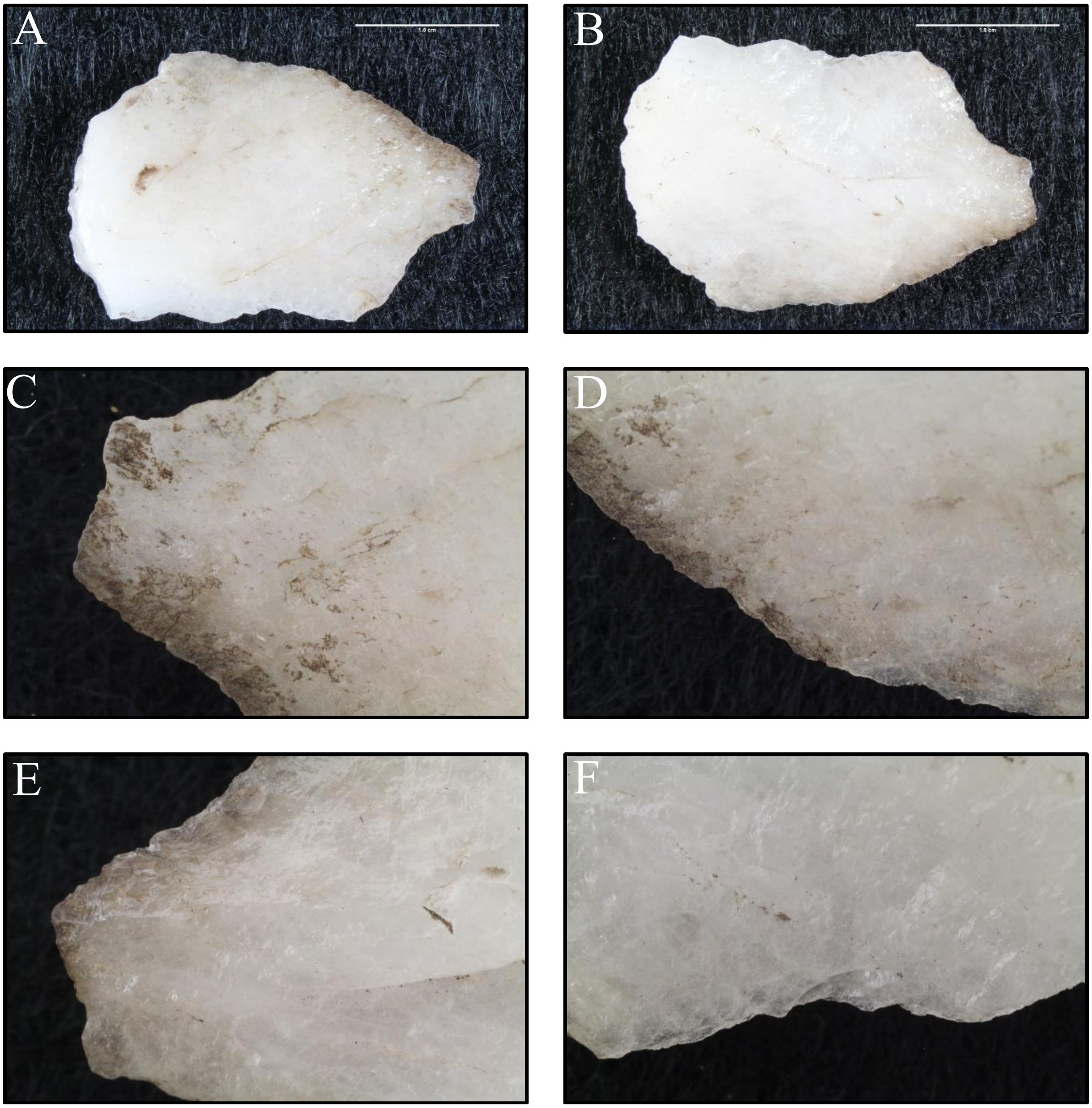


Figure 6-72: Artefact 33622.
A – Dorsal Surface. B – Ventral surface. C, D – Utilized area of dorsal surface with residue at 20x magnification. E, F – Utilized area of dorsal surface at 20x magnification.

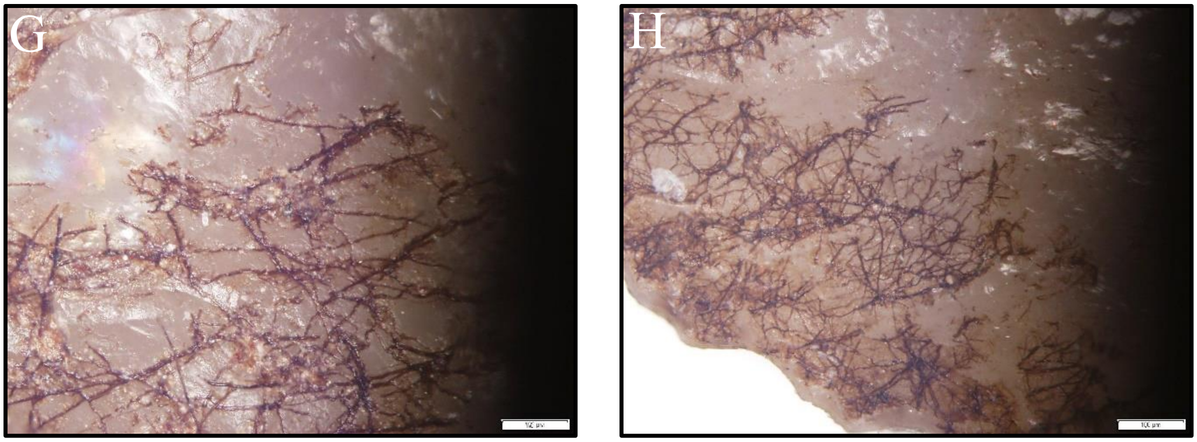


Figure 6-73: Residue on artefact 33622.
G, H – Class 5 residue.

Table 6-37: Residue and use-wear results summary for artefact 33622.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
5	No	No	N/A	Flake Scars Edge Damage	Unidentifiable	N/A	N/A

Table 6-38: Inquisitive process for artefact 33622 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near a suspected working edge.
2 – Is it Organic or Inorganic?	Organic. The residue was amorphous and SEM/EDS analysis confirmed the presence of organic residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Based on the results of other artefacts with class 5 residue, although only 33-56% tested positive for protein residue.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis produced few results as well (Table 6-37). Flake scars were observed on the proximal end of the tool (i.e. opposite the working edge), but these were manufacturing scars and likely formed prior to the detachment of this flake from the core (Figure 6-74I). In the actual working area, only slight edge damage was observed (Figure 6-74J). Therefore, use-wear analysis could not confirm the utilization of this artefact.

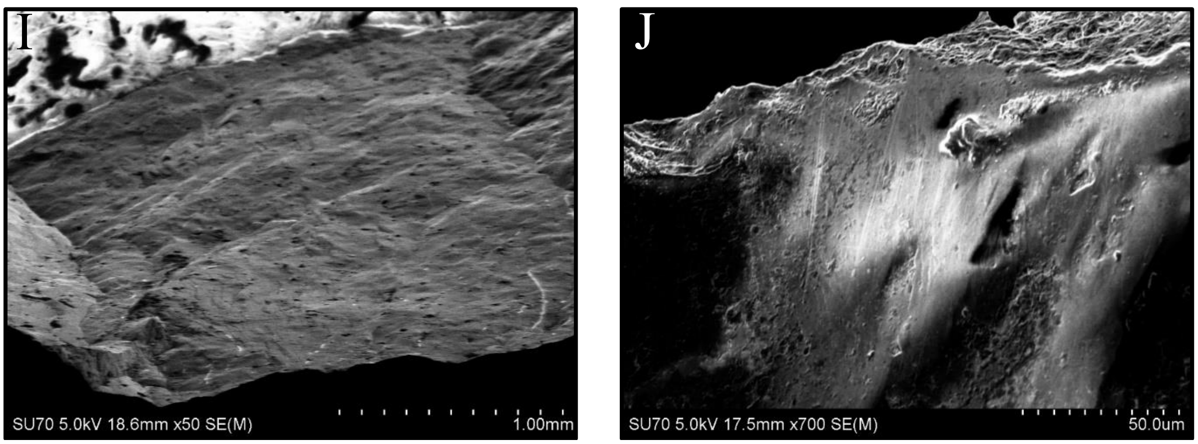


Figure 6-74 Use-wear on artefact 33622.
I – Although not use-wear, these flake scars are evidence of manufacturing this artefact. J – Slight edge damage, possibly caused by use.

Overall, neither residue analysis nor use-wear analysis could confirm that artefact 33622 was used. Residue analysis failed to produce any positive results, thereby relying on the weak proxy interpretation of animal residue based on the results from other artefacts with class 5 residue. Use-wear could only produce concrete evidence that this flake was part of a core that was purposefully worked prior to the detachment of this piece. Also, retouching was present on either side of the tip, indicating that this artefact was intended for use.

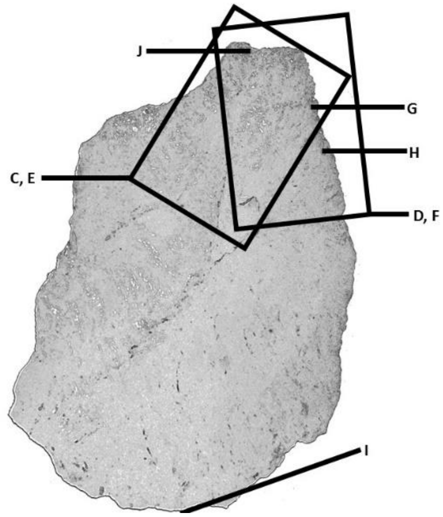


Figure 6-75: Image locations for artefact 33622.

6.2.19 Artefact 35330

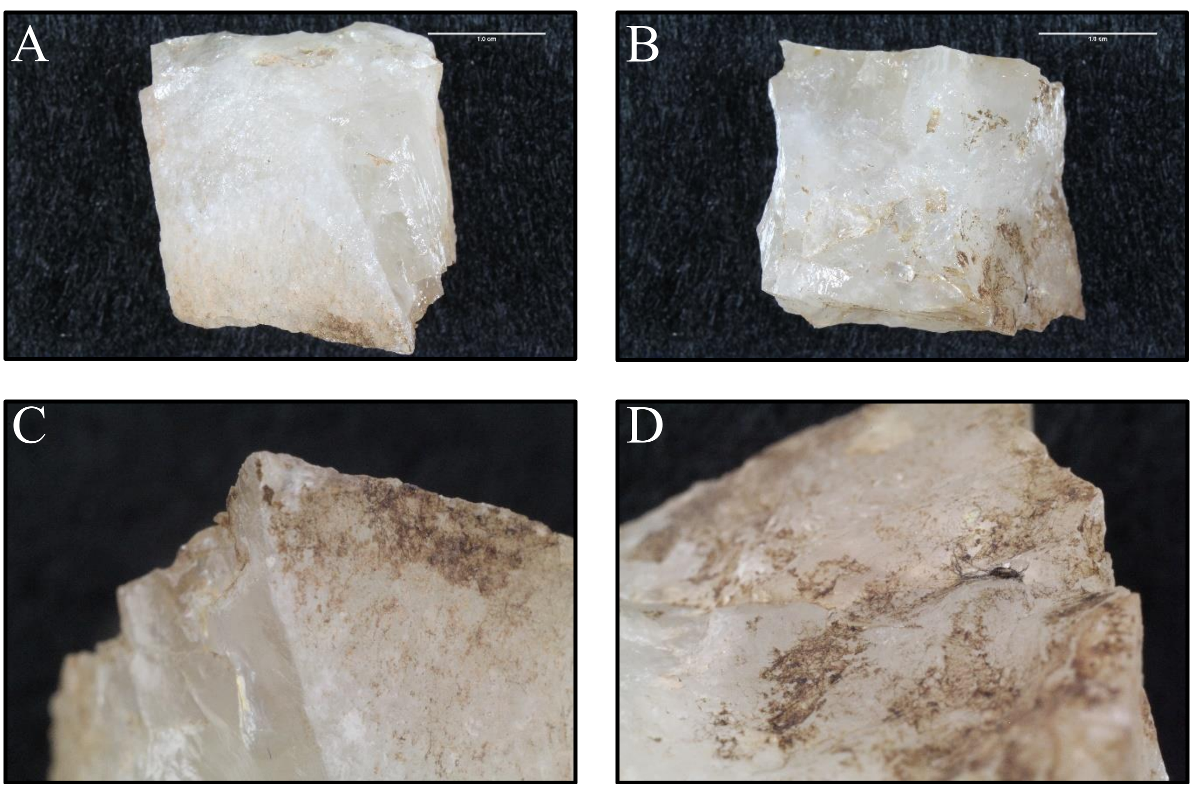


Figure 6-76: Artefact 35330.
A – Dorsal surface. B – Ventral surface. C – Residue near corner on dorsal at 20x magnification. D – Residue on ventral surface at 20x magnification. Same location as image C.

Artefact 35330 was a blocky piece of milky quartz, which measured 30mm long and 26mm wide (Figure 6-76). It was selected because of the presence of residue along a straight edge that terminated at a sharp corner. This corner could have been a useable protrusion. See Figure 6-78 for the location of each micrograph.

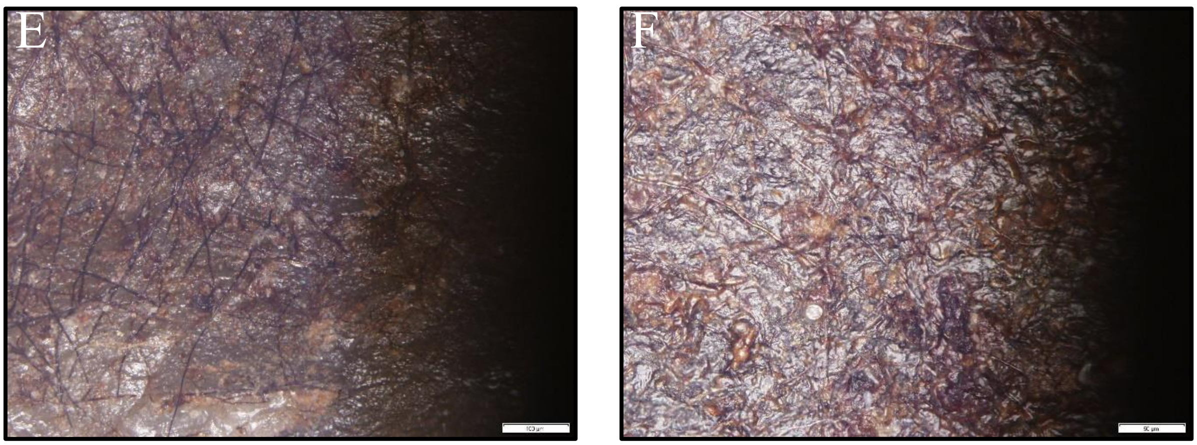


Figure 6-77: Residue on artefact 35330.
E, F – Class 9 Residue.

The HPILM showed a dark brown and very glossy residue, classified as a class 9 residue (Figure 6-77). Neither biochemical testing, GC/MS analysis, nor HPTLM provided any significant results (Table 6-39; Table 6-40). Artefact 42413 was the only other artefact with class 9 residue. It tested positive for protein, which indicated animal origins.

Table 6-39: Residue and use-wear results summary for artefact 35330.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
9	No	No	N/A	N/A	N/A	N/A	N/A

Unfortunately, this artefact was too bulky to fit within the SEM. The LPILM showed possible edge damage in the area of the residue, but this could not be confirmed. In conclusion, the artefact 35330 could not be confirmed as a tool. Residue analysis did not produce any positive results. Identifying this residue as animal-derived was only possible by using artefact 42413's results as proxy, based on their shared visual characteristics.

Table 6-40: Inquisitive process for artefact 35330 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near a suspected working edge.
2 – Is it Organic or Inorganic?	Organic. The residue was amorphous and appeared similar to residue identified on another artefact where SEM/EDS analysis confirmed its organic composition.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Based on the results of the other artefact with Class 9 residue.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

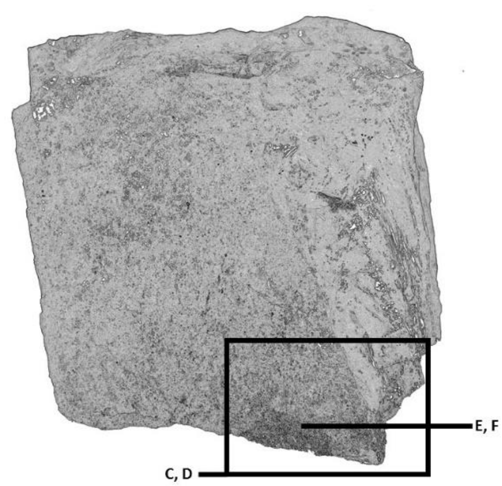


Figure 6-78: Image locations for artefact 35330.

6.2.20 Artefact 39056

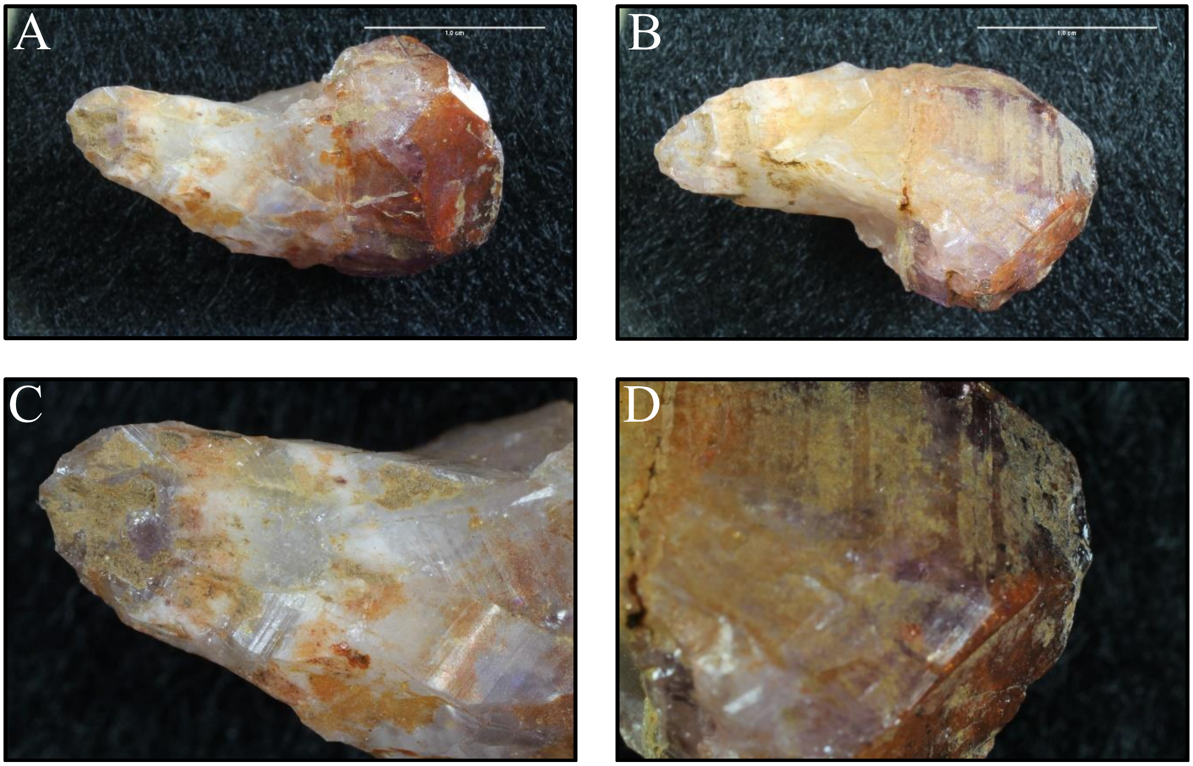


Figure 6-79: Artefact 39056.
A, B – Macro images of artefact 39056. C – Proximal end at 20x magnification. D – Distal end at 20x magnification.

Artefact 39056 was a small amethyst crystal with more of a red colouring than purple (Figure 6-79). It measured 25mm long and 12.5mm wide. This artefact was selected for its worn tip and possible residue adhering to its crystal faces. In addition, this artefact served as a good comparison for artefact 24842. See Figure 6-82 for the location of each micrograph.

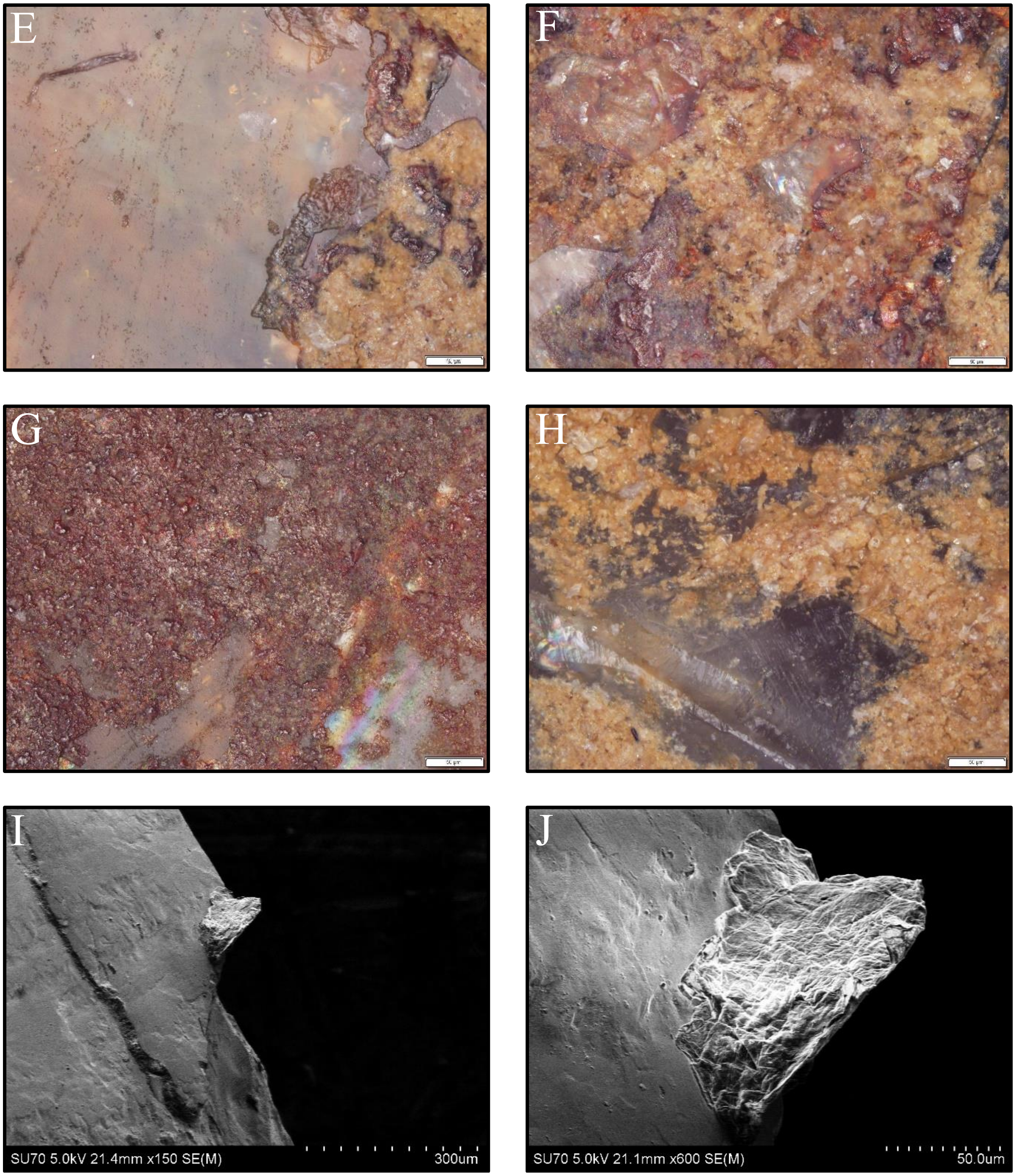


Figure 6-80: Residue on artefact 39056.
E, F – Class 1/2 residue. G – Class 10 residue. H – Class 1 residue. I, J – Organic residue, SEM.

The HPILM showed what appeared to be class 1 residue situated on top of class 2 residue (Figure 6-80E, F). Class 1 residue was visible on its own elsewhere on the artefact (Figure

6-80H), along with a red/purple residue (class 10; Figure 6-80G). Biochemical tests produced negative results for protein, but positive results for fatty acid. The GC/MS analysis and HPTLM produced no significant results (Table 6-41; Table 6-42). Organic residue was visible in the SEM despite sonication removal (Figure 6-80I, J). This residue appeared plant-based, but could not be authenticated as archaeological. The residue was therefore identified as animal-derived, based on the visual similarities of the residue to other animal-derived residues and the positive result for fatty acid.

Table 6-41: Residue and use-wear results summary for artefact 39056.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
1, 1/2, 10	No	Yes	N/A	Edge Damage	Unidentifiable	N/A	N/A

Table 6-42: Inquisitive process for artefact 39056 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Three types of residue were present near a suspected working edge.
2 – Is it Organic or Inorganic?	Organic. The residue was amorphous and SEM/EDS confirmed it as organic.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Based on the results of the other artefact with similar residue and the positive test for fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

The SEM analysis shows extensive edge damage (crushing) on the tip (Figure 6-81). However, on its own this is not indicative of use. Many natural crystals showed damage on the tip because they are so exposed. Without additional wear scars the utilization of this artefact cannot be confirmed (Table 6-41).

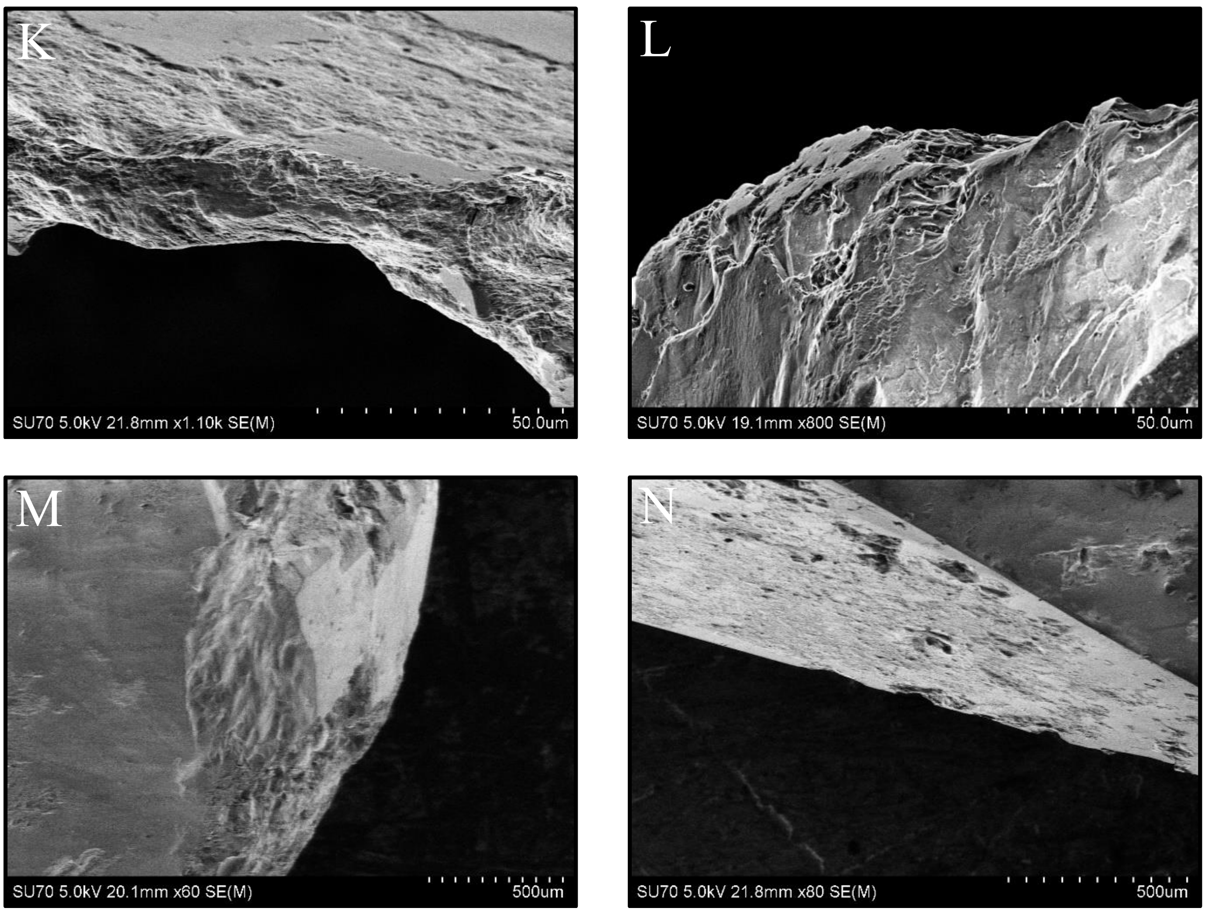


Figure 6-81: Use-wear on artefact 39056.
K, L– Edge damage, possibly caused by use. M – Crushed tip. N – Notches on edge between two crystal faces.

In conclusion, artefact 39056 was not confirmed as a tool based on the lack of use-wear data. However, there was animal residue present on the tip of the artefact. Therefore, it was possible the artefact could have been used briefly on soft, animal material (i.e. puncture hide), but unfortunately this interpretation remains speculation at best because of insufficient data.

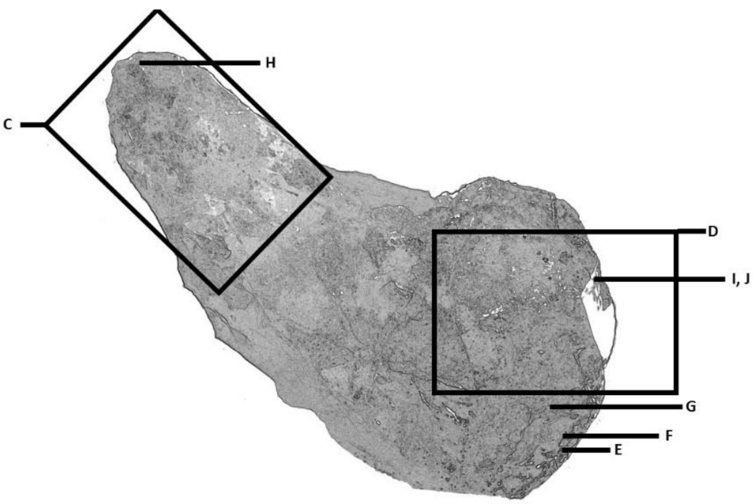


Figure 6-82: Image locations for artefact 39056.

6.2.21 Artefact 42413

Artefact 42413 was a square milky quartz fragment, which measured 29mm long by 28mm wide (Figure 6-83). Originally catalogued as a unifacial scraper, this artefact was selected for dark brown residue located on the surface of the tool somewhat near the suspected working edge. See Figure 6-86 for the location of each micrograph.

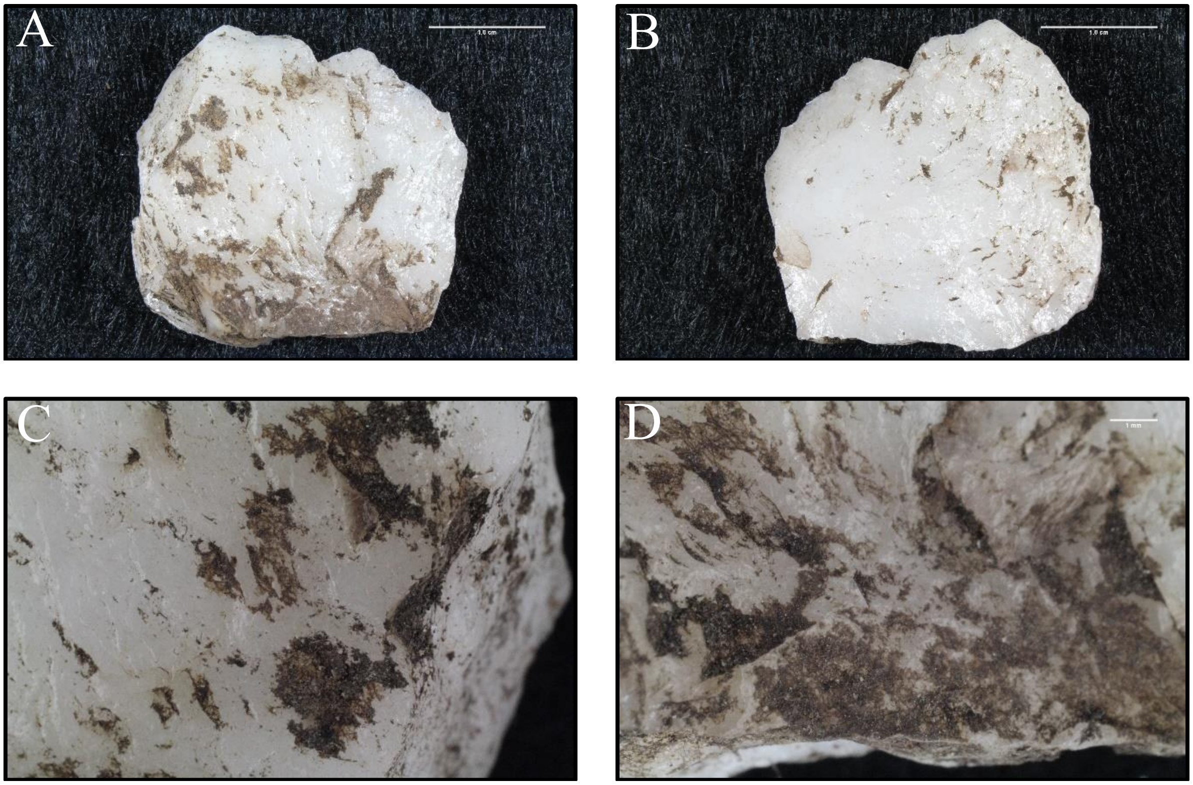


Figure 6-83: Artefact 42413.
A – Dorsal surface. B – Ventral surface. C, D – Residue on dorsal surface at 20x magnification

Under HPILM class 5, 9 and 11 residues were observed (Figure 6-84E, F). Hyphae was very common on this artefact. A small, textured (almost like a fingerprint) fibre was observed and SEM analysis was used prior to removal to produce better resolution images (Figure 6-84G, H). Unfortunately, the fibre could not be located. A long red fibre, which was composed of many smaller fibres, was adhering to the surface of the tool along the suspected scraping edge (Figure 6-84I). This fibre was interpreted as animal-derived because it resembled collagen. Biochemical tests produced positive results for protein. The GC/MS analysis produced no significant results (Table 6-43; Table 6-44). The HPTLM was used on the red fibre to identify it as animal (Figure 6-84J).

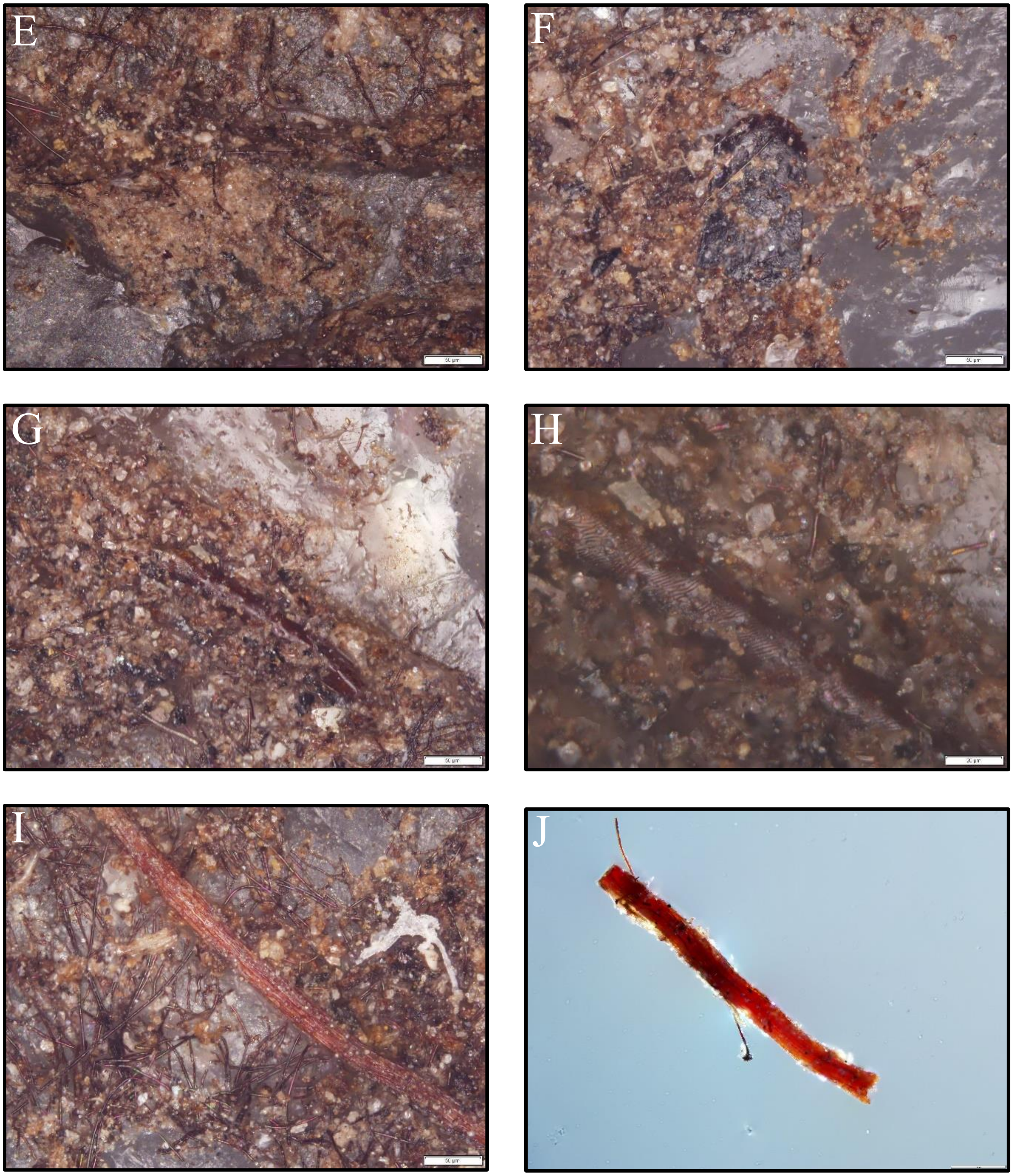


Figure 6-84: Residue on artefact 42413.
E – Class 9 residue. F – Class 11 residue. G, H – Small fibre with "fingerprint" texture. I – Red "bundled" fibre at 200x magnification. J – Red fibre under HPTLM, 200x magnification.

Table 6-43: Residue and use-wear results summary for artefact 42413.

	Residue			Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
5, 9, 11	Yes	No	Animal	None	N/A	N/A	N/A

Table 6-44: Inquisitive process for artefact 42413 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Three types of amorphous residue were present, along with two fibres.
2 – Is it Organic or Inorganic?	Organic. Two were fibres and SEM/EDS analysis confirmed the organic composition of two amorphous residues. Class 11 residue was not confirmed.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Based on the presence of protein and animal fibres.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis produced few results. Some striations oriented perpendicular to the working edge hint that artefact 42413 may have been used, but few striations were noticeable (Figure 6-85). Therefore, the utilization of this artefact could not be confirmed (Table 6-43). The suspected working edge was not very straight, but may have suffered damage from use, thereby ridding itself of use-wear evidence as well.

In conclusion, the biochemical tests, fibre identification, and visual appearance of the residue all suggest the artefact was used to work animal material. The morphology of the artefact suggests it functioned as a scraper, but use-wear analysis could not confirm it was used. Therefore, although speculative, artefact 42413 was likely used to scrape hide.

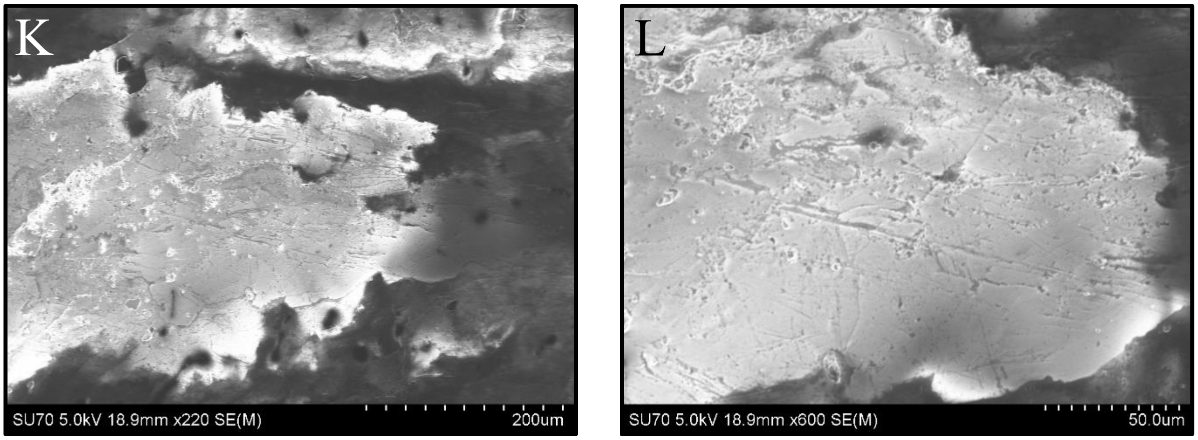


Figure 6-85: Use-wear on artefact 42413.
K, L – Striations that were the only indication of use. Not strong evidence on their own.

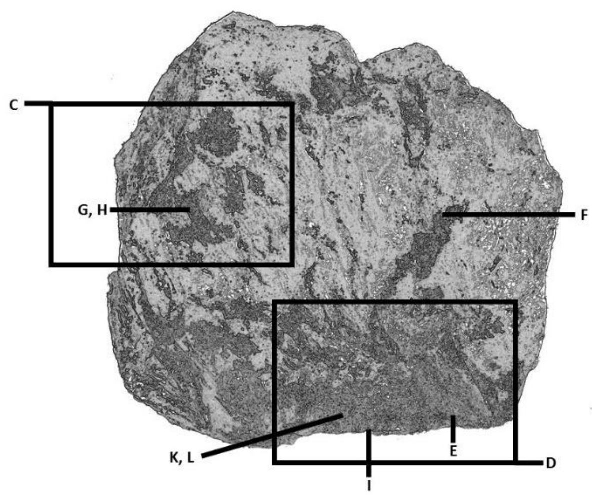


Figure 6-86: Image locations for artefact 42413.

6.2.22 Artefact 44139

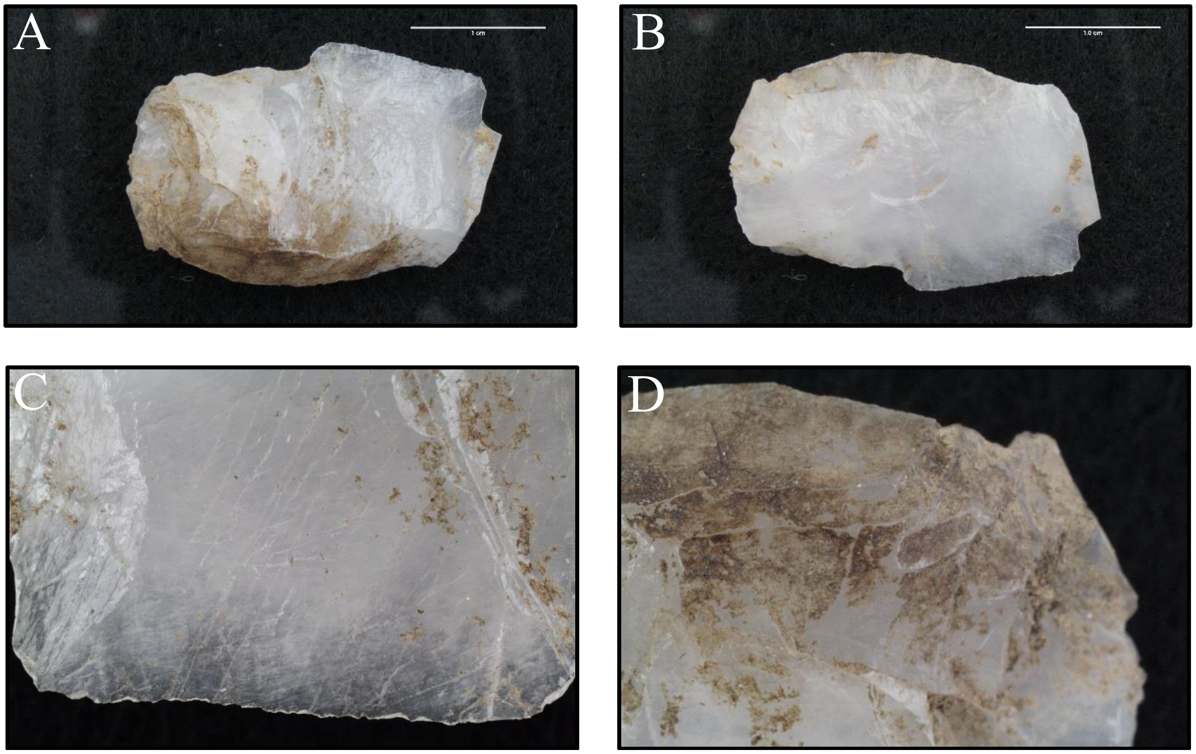


Figure 6-87: Artefact 44139.
A – Dorsal surface. B – Ventral surface. C – Thin, damaged edge at 20x magnification. D – Suspected working edge with residue at 20x magnification.

Artefact 44139 was made of milky and clear crystal quartz, which measured 28mm long by 18mm wide (Figure 6-87). Originally catalogued as a retouched flake, this artefact was selected for its retouched edge and residue adhering to the surface of the artefact. The residue is dark brown and appears to be adhering strongly to the surface of the tool, but again only on the dorsal surface. See Figure 6-90 for the location of each micrograph.

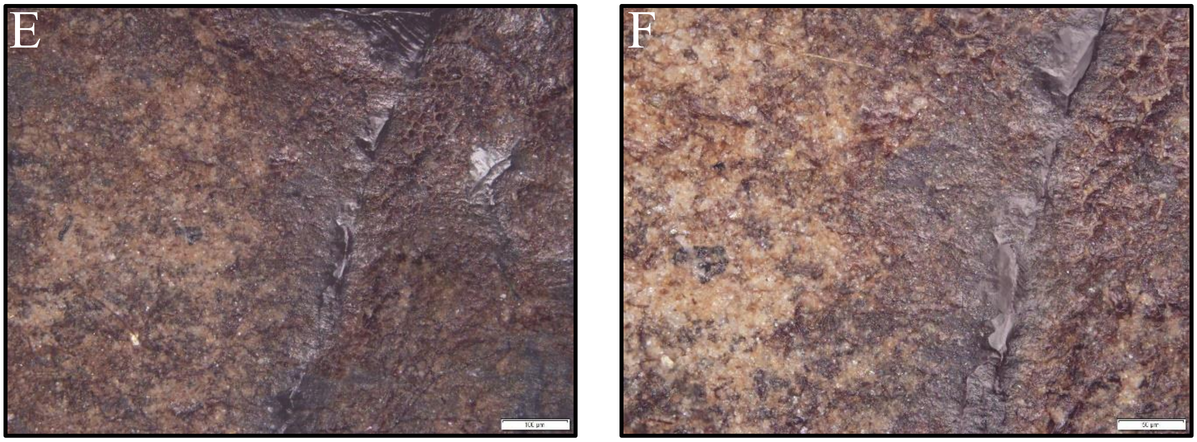


Figure 6-88: Residue on artefact 44139.
E – Class 12 residue at 100x magnification and F – at 200x magnification. Note the mud-cracked texture.

Under HPILM, the residue was amorphous, dark red/brown in colour with dehydration and desiccation cracking (class 12), which suggested the residue was blood (Figure 6-88). The Hb-CRTS produced positive results (score of 1), supporting this interpretation. Biochemical testing produced positive results for protein and fatty acid, indicating an animal origin for the residue. Neither GC/MS analysis nor HPTLM produced significant results (Table 6-45; Table 6-46).

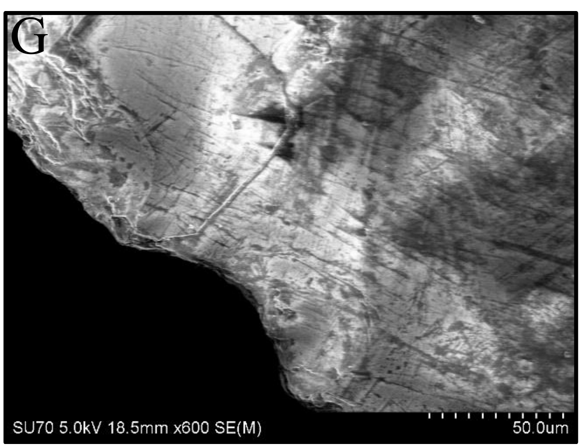
Table 6-45: Residue and use-wear results summary for artefact 44139.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
12	Yes	Yes	N/A	Striations Edge Damage	Identifiable	Soft	Push/Pull; Cut/Scrape

The edge where residue was distributed resembled a scraping edge. Opposite to this edge was a thin, broken edge with consistent micro-flaking. The SEM analysis showed rounded edges and striations oriented both parallel and perpendicular to the scraping edge (Figure 6-89). The parallel striations were shallow, but deeper than the perpendicular striations, and suggest the artefact was used to cut (Table 6-45). The perpendicular striations were discontinuous and very shallow, almost superficial. These striations were interpreted as narrow, plastic deformations (sleeks; see Knutsson, 1988a). The thin, broken edge showed no wear and damage is assumed to be natural or caused by taphonomy.

Table 6-46: Inquisitive process for artefact 44139 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was strongly adhering to one edge
2 – Is it Organic or Inorganic?	Organic. Dehydration and desiccation cracking suggests blood residue. The SEM/EDS confirmed organic composition.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Based on the presence of protein, fatty acid, and cracked texture.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.



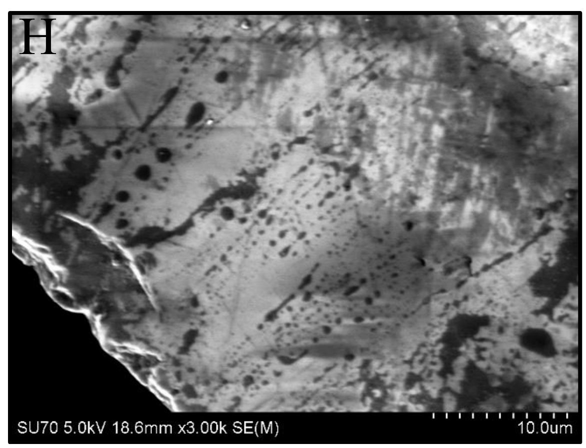


Figure 6-89: Use-wear on artefact 44139.
G – Parallel striations and edge rounding. H – Perpendicular striations (narrow plastic deformations/sleeks).

In conclusion, artefact 44139 was a tool based on the concentration of residue along an edge that showed use. The residue itself was animal-derived and resembled blood residue based on its texture and presence of protein. Positive results for fatty acid supported this as well. Based on the edge rounding and perpendicular striations (sleeks), it was likely used to scrape fresh hide. The more defined, but isolated, parallel striations also indicate a cutting motion, which indicated this tool served different functions. Both functions were likely related to animal processing (e.g. skinning and butchering).

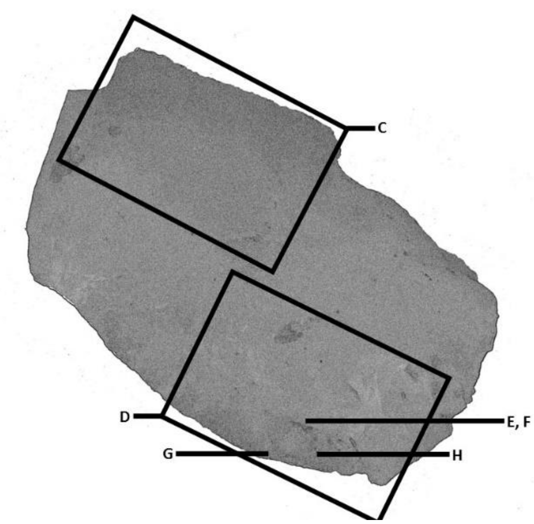


Figure 6-90: Image locations for artefact 44139.

6.2.23 Artefact 46541

Artefact 46541 was a milky/clear quartz flake, which measured 28.5mm long and 22mm wide (Figure 6-91). Mechanical cortex was present along the suspected working edge. This artefact was selected for its long straight edge, which appears used, and the tapered distal end that is suitable for hafting. The material adhering to the cortex surface was suspected to be residue, but even under LPILM it seemed unlikely. See Figure 6-94 for the location of each micrograph.

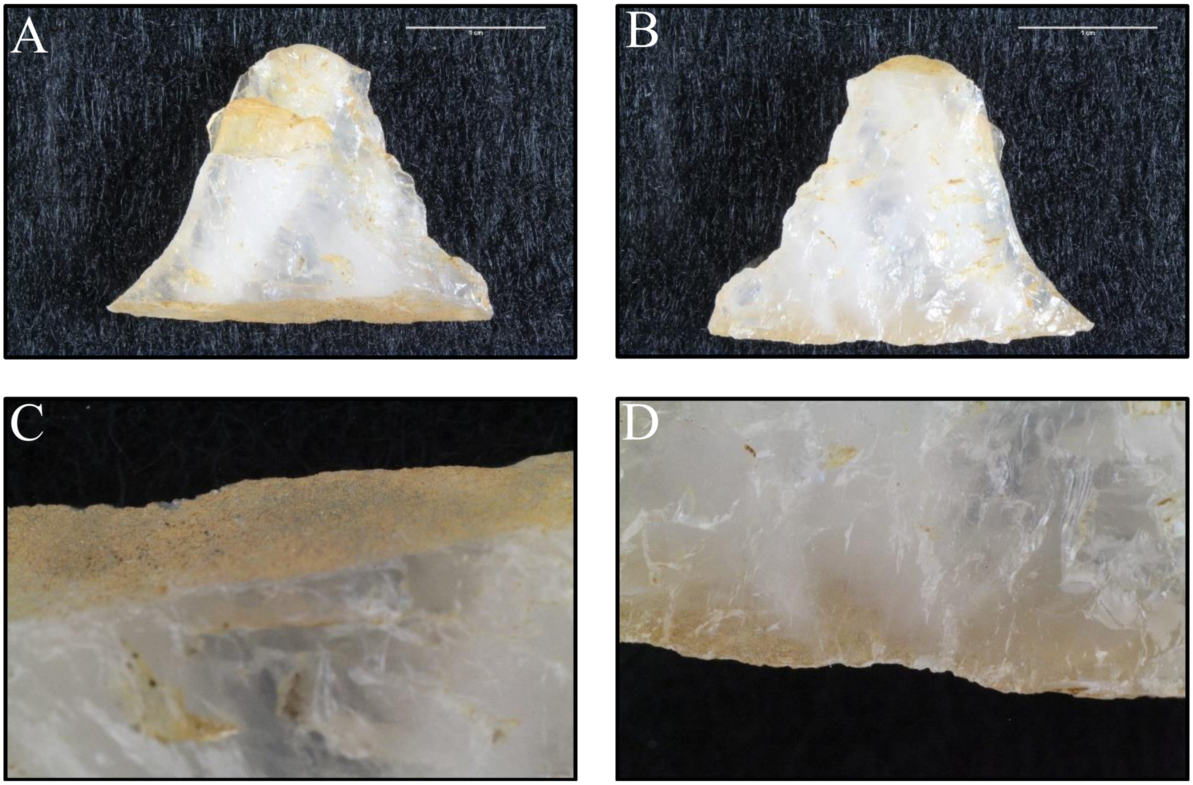


Figure 6-91: Artefact 46541.
A – Ventral surface. B – Dorsal surface. C – Suspected working edge, dorsal surface, at 20x magnification. D – Suspected working edge, ventral surface, at 20x magnification.

The potential residue appeared fattier under HPILM and was classified as class 4 residue (Figure 6-92). Biochemical testing produced negative results for protein, with one weak positive for fatty acid. The GC/MS and HPTLM analysis produced no significant results (Table 6-47; Table 6-48). Therefore, the interpretation that this residue was fat-based is only weakly supported.

The SEM and HPILM analysis shows edge damage and micro-flaking along the suspected working edge (Figure 6-92E; Figure 6-93). The consistency of wear suggested the damage was use-related. The lack of other wear patterns indicated that either the artefact was barely used and/or used on soft material (Table 6-47).

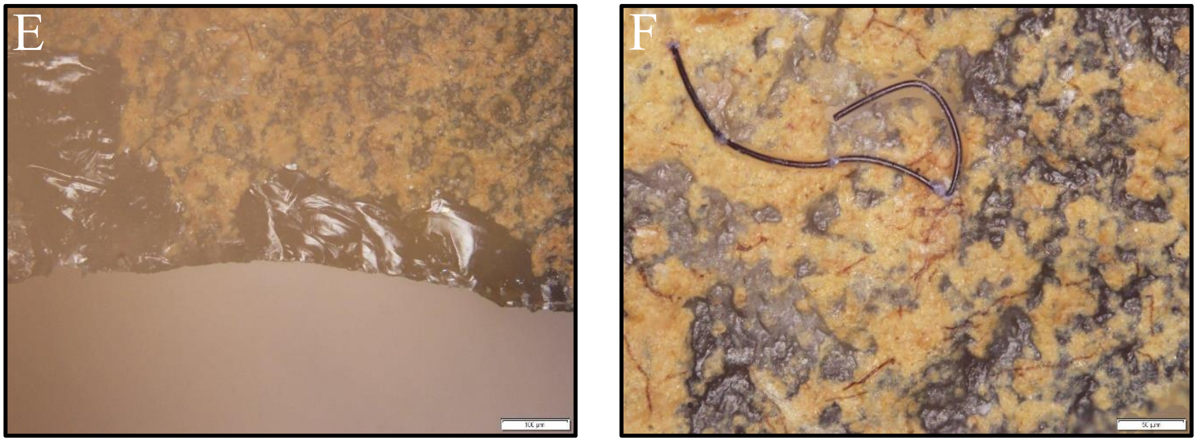


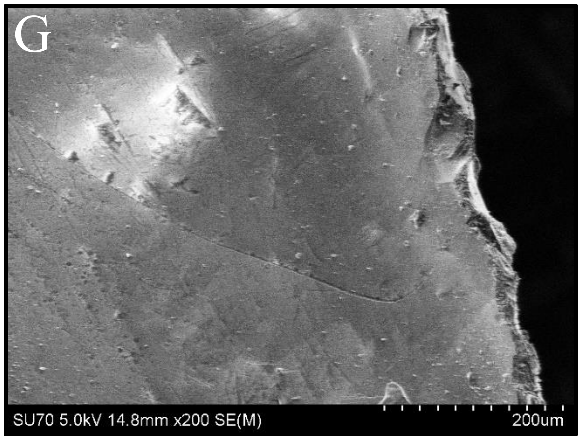
Figure 6-92: Residue on artefact 46541.
E – Possible use-wear scars associated with class 4 residue. F – Class 4 residue.

Table 6-47: Residue and use-wear results summary for artefact 46541.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
4	No	Weak	N/A	Flake Scars Edge Damage	Indeterminate	Soft	N/A

Table 6-48: Inquisitive process for artefact 46541 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Although it required HPILM to be positive.
2 – Is it Organic or Inorganic?	Organic. It appeared fatty. The SEM/EDS confirmed its organic composition.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Appeared fatty and biochemical testing weakly supported this.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.



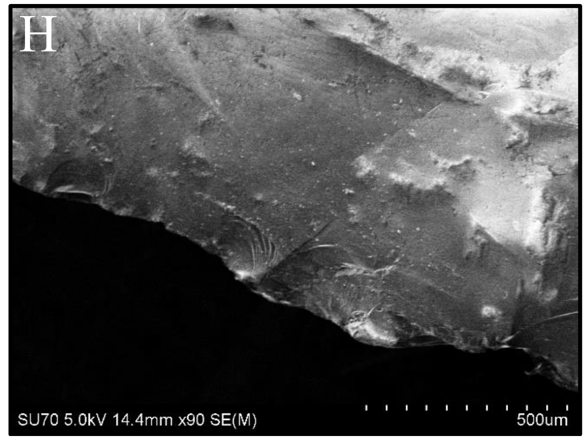


Figure 6-93: Use-wear on artefact 46541.
G, H – Edge damage and micro-flaking.

In conclusion, artefact 46541 can be identified as a tool. The lack of use-wear suggested it likely worked a soft material for a short period. Although no direction or type of movement was indicated in the wear patterns, the morphology of the artefact suggested it functioned as a scraper. This correlated with the fat residue (class 4) adhering to the rougher, cortex surface of the artefact.

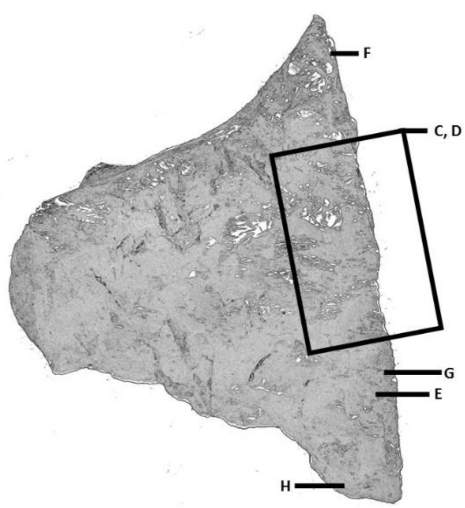


Figure 6-94: Image locations for artefact 46541.

6.2.24 Artefact 46551

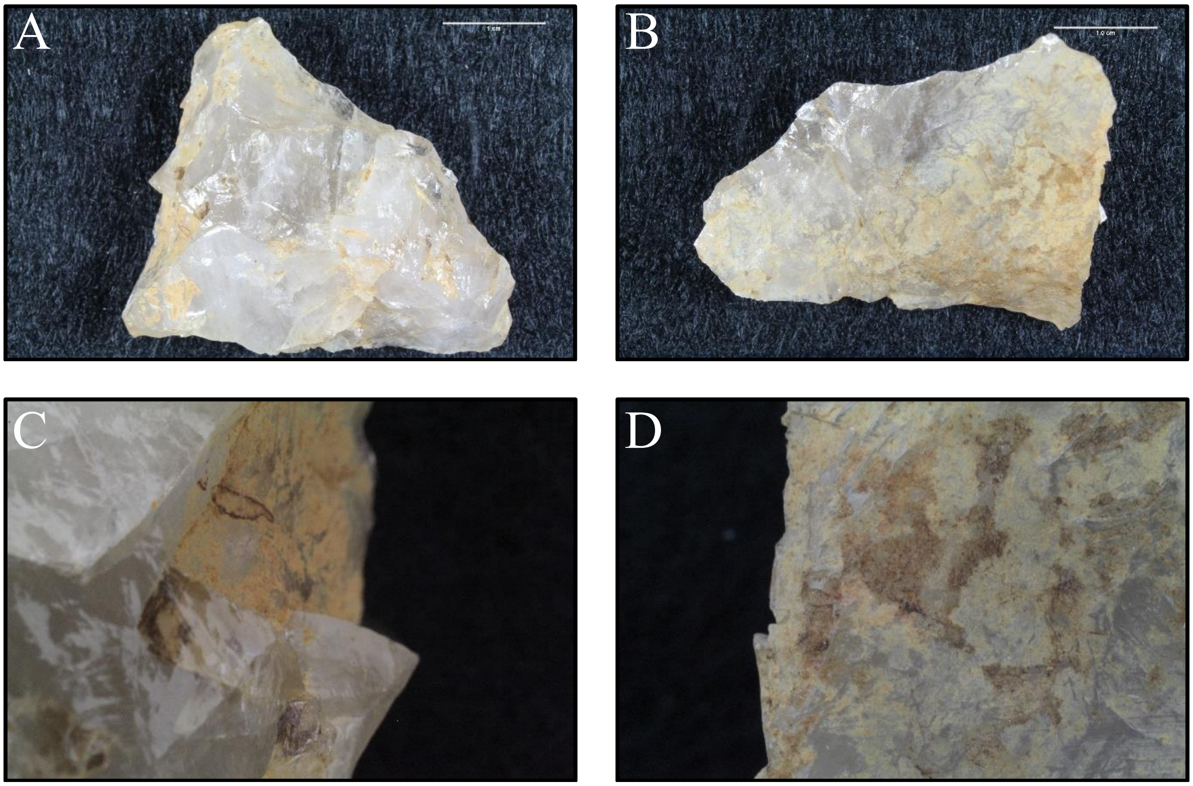
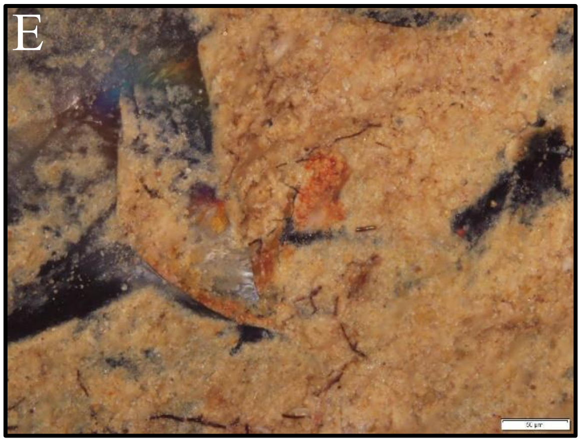


Figure 6-95: Artefact 46551
A – Dorsal surface. B – Ventral surface. C – Residue near protrusion at 20x magnification. D – Residue on ventral surface at 20x magnification.

Artefact 46551 was made of milky and clear quartz and measured 42mm long and 29mm wide (Figure 6-95). This artefact was selected because of the darker residue adhering to its surface. The residue was located near a straight edge suitable for scraping, except for a small, sharp protrusion. Upon closer inspection, the protrusion may be the result of a break and would not have impacted its original function. See Figure 6-98: Image locations for artefact 46551. for the location of each micrograph.



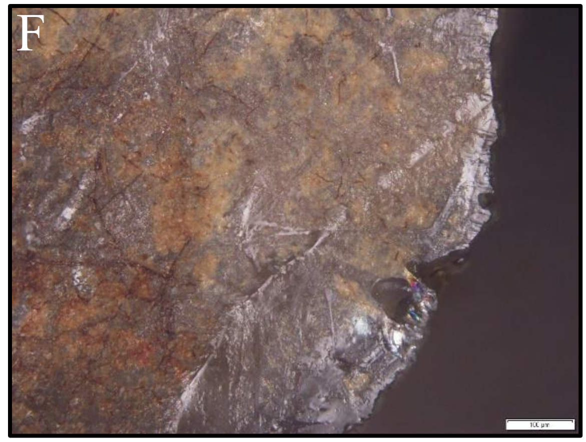


Figure 6-96: Residue on artefact 46551
E – Class 4 residue. F – Class 2 residue.

Under HPILM, both class 2 and class 4 residue were present (Figure 6-96), suggesting the artefact was used on animals. Positive results for protein and fatty acid biochemical tests supported this interpretation. The GC/MS and HPTLM analysis produced no significant results (Table 6-49; Table 6-50).

Table 6-49: Residue and use-wear results summary for artefact 46551.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2, 4	Yes	Yes	N/A	Striations? Flake Scars Edge Damage	Indeterminate	N/A	Push/pull?

The SEM analysis showed evidence of edge damage along one edge (Figure 6-97). Small micro-flakes were present and the edge was slightly rounded. Short striations were present and roughly perpendicular to the working edge. However, these striations were not common enough to be positively identified (Table 6-49).

Table 6-50: Inquisitive process for artefact 46551 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Two are present.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and SEM/EDS analysis confirmed the organic composition of the residue.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Resembled other residue classified as animal and biochemical testing produced positive results for both protein and fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

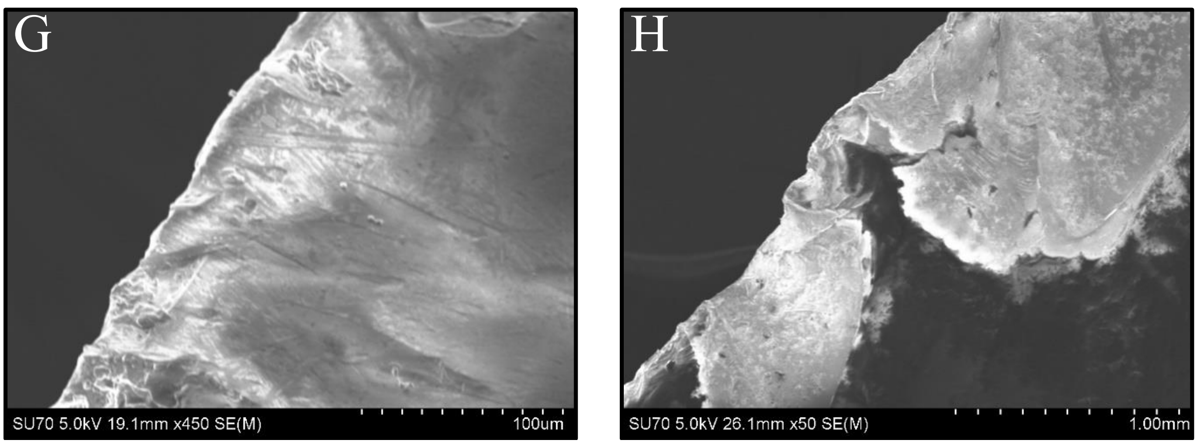


Figure 6-97: Use-wear on artefact 46551.
G – Edge damage and rounding. Small flake scars and possible striations. F – Edge damage and rounding.

In conclusion, the use-wear data was able to suggest the artefact was used. However, analysis could not confidently identify the hardness of the material nor the mode of use. What is clear, though, is that the artefact was either used on or came in contact with animal material. Residue analysis strongly indicated that the residue was animal-derived, based on the biochemical test results and visual correlation (i.e. residue classification) to other residue.

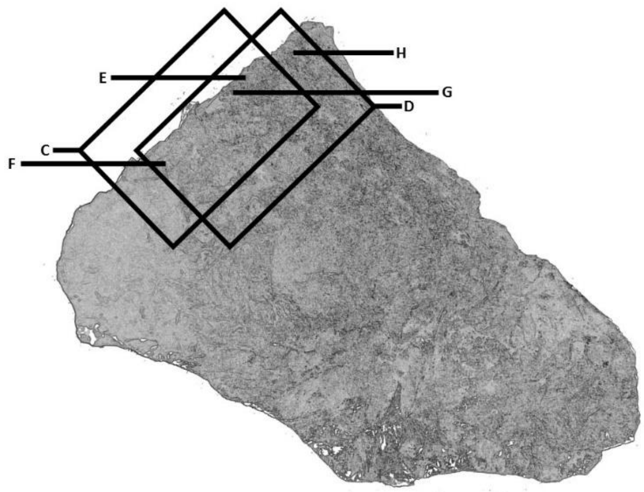


Figure 6-98: Image locations for artefact 46551.

6.2.25 Artefact 49249

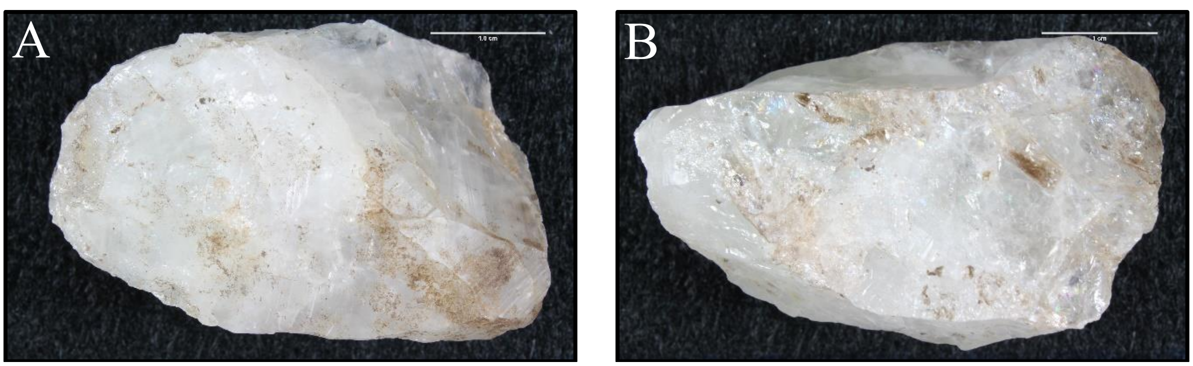


Figure 6-99: Artefact 49249.
A, B - Macro photos. This artefact was a large fragment with residue near a blunt tip.

Artefact 49249 was a large piece of milky quartz, which measured 45mm long and 27mm wide (Figure 6-99). This artefact was selected because of the residue located near the blunt tip. The residue was dark brown and resembled residue identified on other artefacts that were more likely tools. See Figure 6-101 for the location of each micrograph.

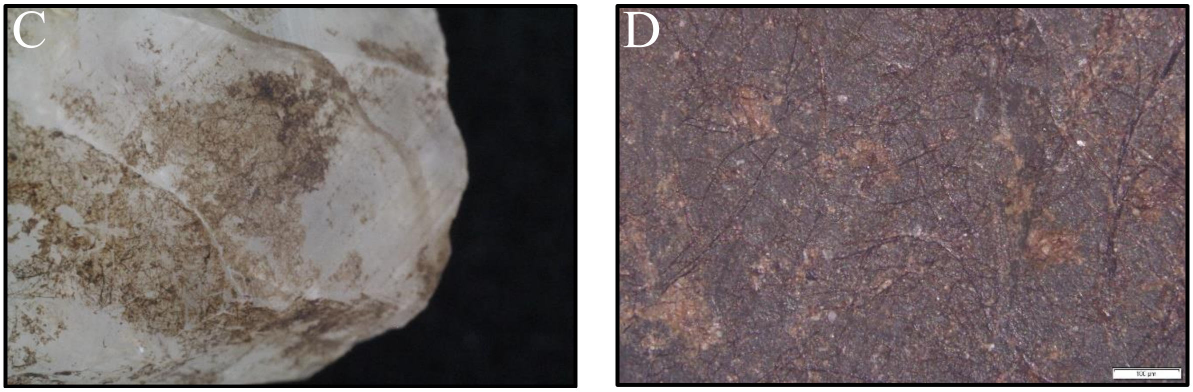


Figure 6-100: Residue on artefact 49249.
C – Residue near blunt tip at 20x magnification. D – Class 2 residue at 100x magnification.

Under HPILM, this residue was identified as class 2 residue (Figure 6-100), indicating the artefact came in contact with animal material. Biochemical testing supported this by testing positive for both protein and fatty acid. The GC/MS and HPTLM analysis produced no significant results (Table 6-51; Table 6-52). The artefact was too bulky to fit within the SEM chamber and therefore use-wear analysis was not performed.

Table 6-51: Residue and use-wear results summary for artefact 49249.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
2	Weak	Weak	N/A	N/A	N/A	N/A	N/A

In conclusion, the function of artefact 49249 could not be confirmed. Its overall morphology did not suggest it was a tool, but it encountered some sort of material at some point. The fact that the residue was located near a possible blunt edge (which could in theory crush bone to access marrow) suggests the residue was authentic (i.e. anthropogenic). The residue was animal-derived, which supports the functional interpretation presented here. However, this interpretation remains speculative at best until further data can be presented.

Table 6-52: Inquisitive process for artefact 49249 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near a blunt tip.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and resembled other residue confirmed to be organic by elemental analysis.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Resembled other residue classified as animal and biochemical testing produced positive results for both protein and fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

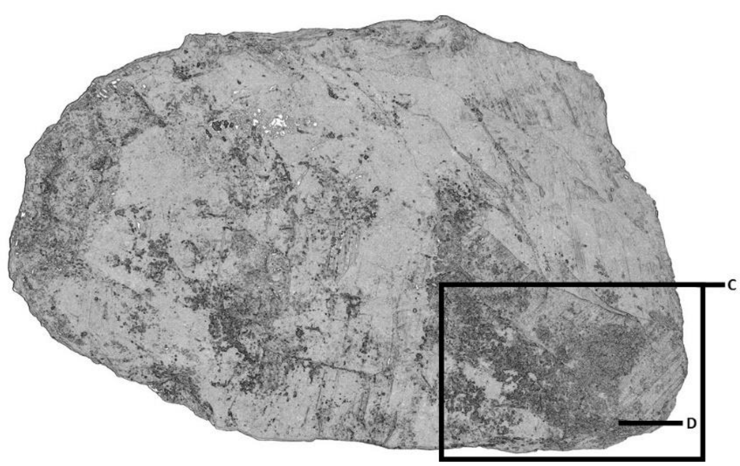


Figure 6-101: Image locations for artefact 49249.

6.2.26 Artefact 51849

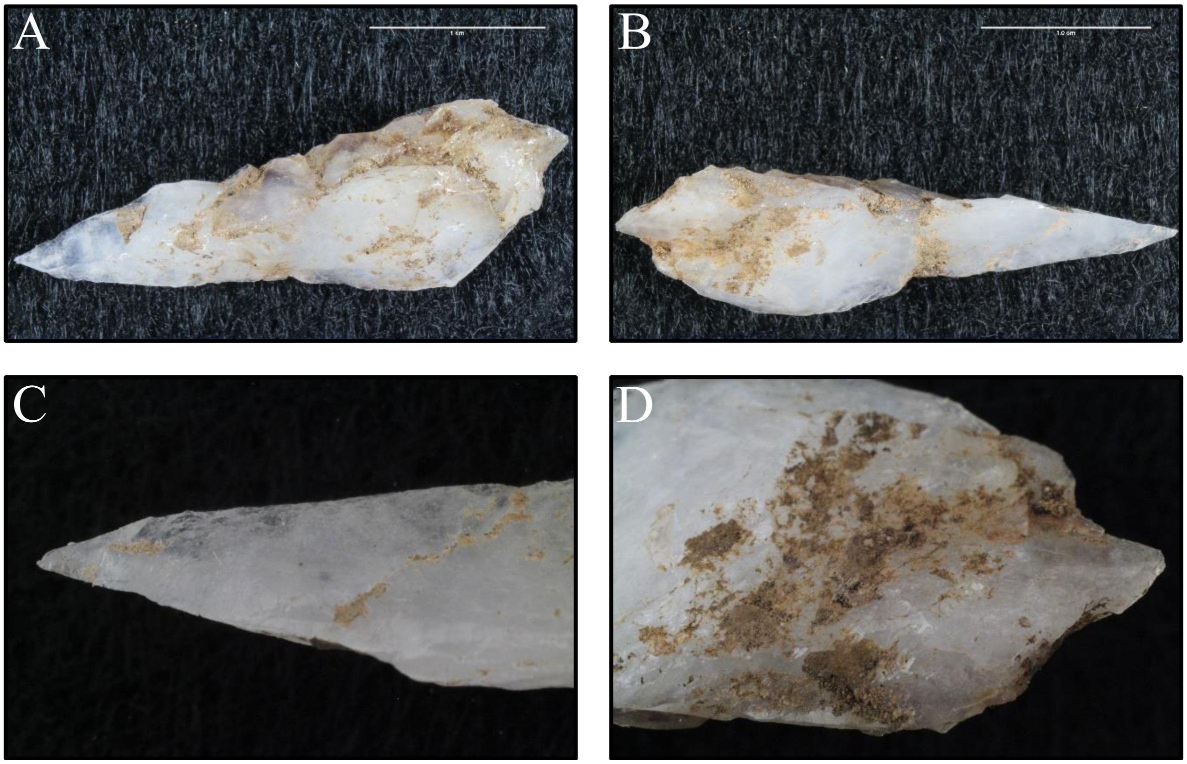


Figure 6-102: Artefact 51849.
A – Dorsal surface. B – Ventral surface. C – Narrow tip at 20x magnification. D – Broad, retouched tip at 20x magnification.

Artefact 51849 was a long, thin milky/clear quartz fragment, which measured 34mm long and 8.5mm wide (Figure 6-102). Originally catalogued as a retouched flake, this artefact was selected for the residue located near the broader, retouched tip. The morphology was also suitable for an awl or burin style tool. See Figure 6-105 for the location of each micrograph.

A class 4 residue was identified using HPILM (Figure 6-103E), which suggested an animal-derived residue. Biochemical testing supported this interpretation by producing positive results for both protein and fatty acid. The GC/MS and HPTLM analysis produced no significant results (Table 6-53; Table 6-54).

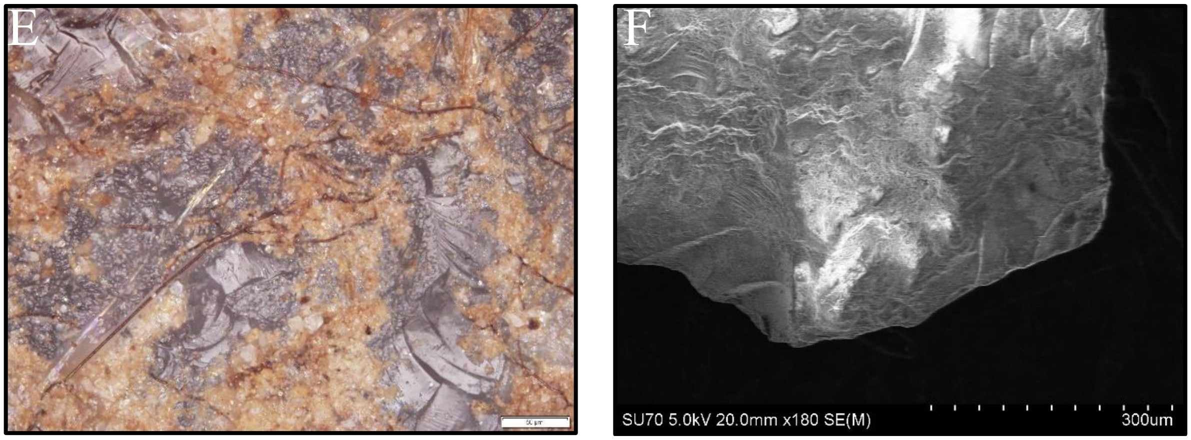


Figure 6-103: Residue and use-wear on artefact 51849.
E – Class 4 residue. F – Retouching on broader, but broken, tip. No use-wear was present.

Table 6-53: Residue and use-wear results summary for artefact 51849.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
4	Yes	Yes	N/A	Striations Flake Scars Edge Damage	Identifiable	Medium	Twist/ puncture

Table 6-54: Inquisitive process for artefact 51849 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the broad tip.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and were confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue near the working edge suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. Resembled other residue classified as animal and biochemical testing produced positive results for both protein and fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

The SEM images clearly showed retouching at the broad tip where residue was located (Figure 6-103F). Unfortunately, the tip appears broken and no identifiable use-wear remained. However, the other narrower tip featured extensive use-wear (Figure 6-104). The edges were rounded and notched, striations were parallel to the tip (i.e. twisting action), and fewer striations were perpendicular to the tip (i.e. puncturing action; Table 6-53).

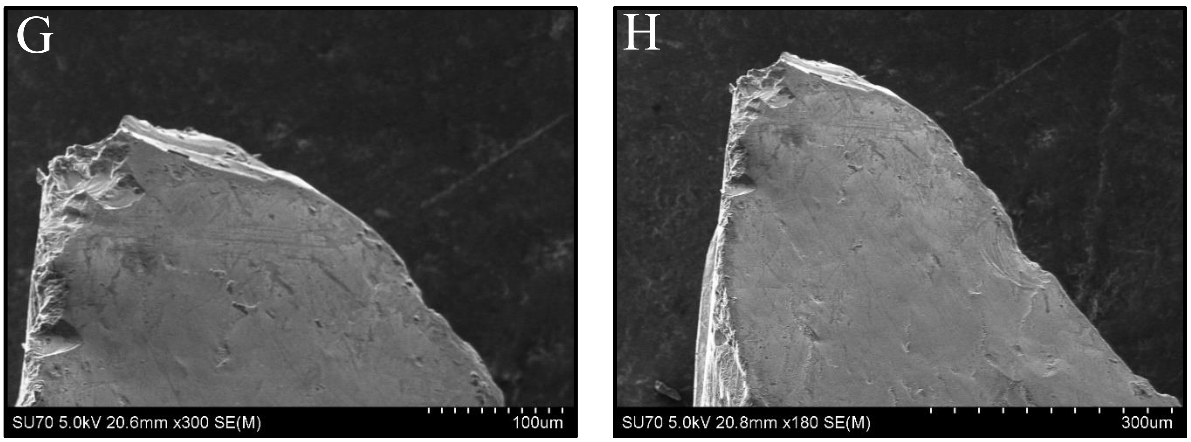


Figure 6-104: Use-wear on artefact 51849.
G, H – Edge rounding, perpendicular and parallel striations, and edge chipping on the narrow tip.

In conclusion, the use-wear indicates a twisting and a puncturing motion on a medium hardness material. Residue analysis provided evidence that the material was animal-based. Therefore, a reasonable conclusion was that artefact 51849's narrow tip was an awl used on dry hide, which could require a twisting motion to pierce the material.

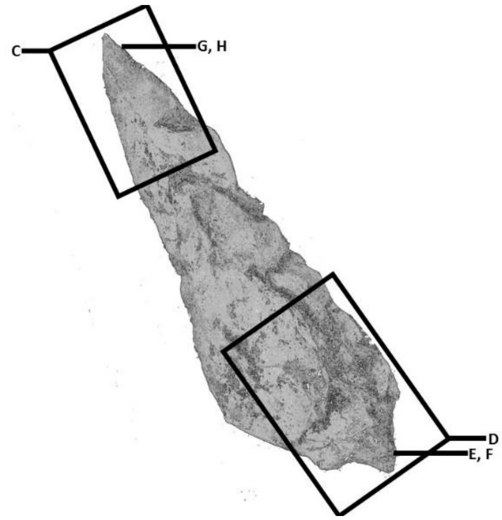


Figure 6-105: Image locations for artefact 51849.

6.2.27 Artefact 51943

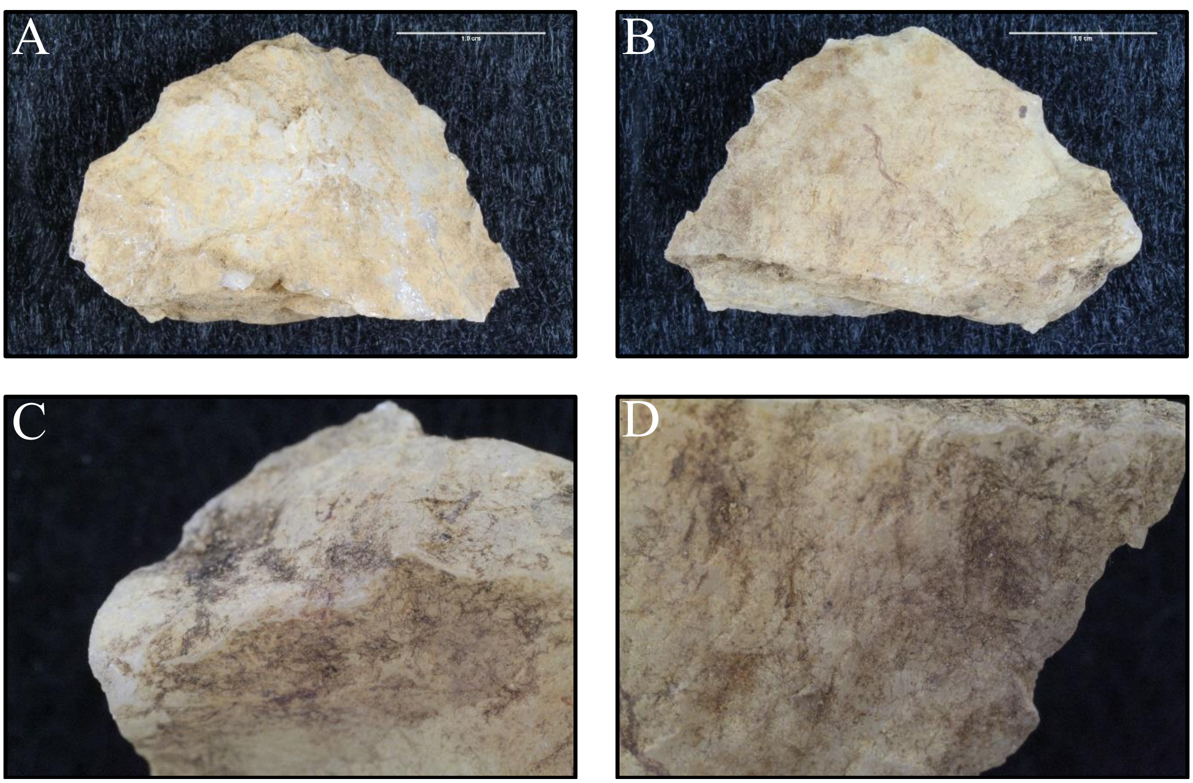


Figure 6-106: Artefact 51943.
A – Dorsal surface. B – Ventral surface. C, D – Suspected residue at 20x magnification

Artefact 51943 was a piece of milky quartz, which measured 33mm long and 19mm wide (Figure 6-106). Originally catalogued as a retouched flake, this artefact was selected for possible retouching and potential residue across the surface of the artefact. Potential residue was covered by sediment and across both the dorsal and ventral surfaces of the tool. See Figure 6-109 for the location of each micrograph.

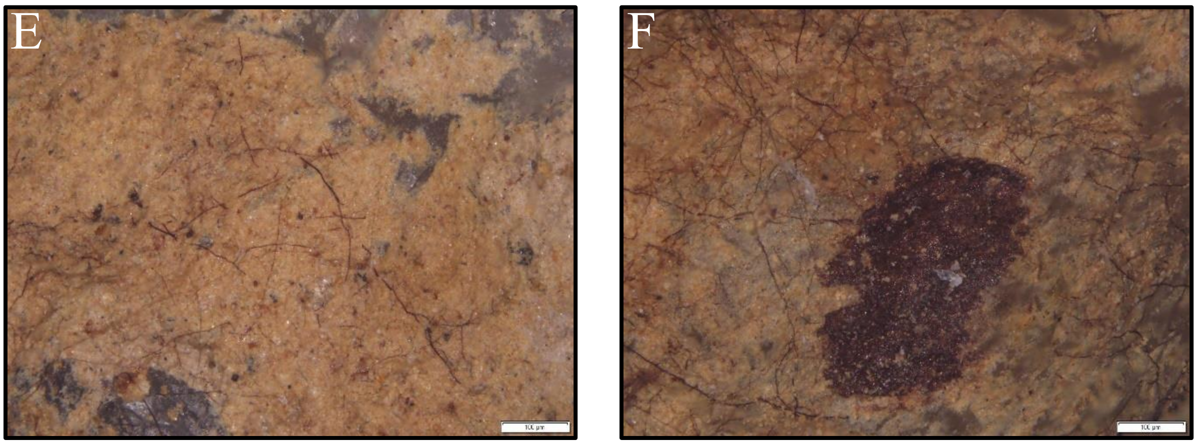


Figure 6-107: Residue on artefact 51943.
E – Class 1 residue. F – Class 11 residue.

The HPILM identified three different residues (classes 1, 4 and 11; Figure 6-107). Classes 1 and 4 were similar, except that red is a secondary colour in class 1 and hyphae was preset. Class 11 was an unidentified dark spot that was too small to get specific results for. Biochemical tests produced positive results for both protein and fatty acid. The classification and biochemical tests support an animal-derived residue. The GC/MS and HPTLM analysis produced no significant results (Table 6-55; Table 6-56).

Table 6-55: Residue and use-wear results summary for artefact 51943.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1, 4, 11	Yes	Yes	N/A	Striations Flake Scars Edge Damage	Unidentifiable	N/A	N/A

Table 6-56: Inquisitive process for artefact 51943 to authenticate and identify residue.

Question	**Observation**
1 – Is Residue Present?	Yes. Residue was distributed across the artefact.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and were confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Environmental. The residue was present across the entire artefact.
4 – Is it Plant or Animal?	Animal. Resembled other residue classified as animal and biochemical testing produced positive results for both protein and fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis produced no results (Table 6-55). The identified retouching was natural and/or taphonomy induced rather than intentional retouch or use-related flaking (Figure 6-108). Therefore, this artefact was not a tool.

In conclusion, the use-wear data could not identify the function of the artefact. Despite the lack of use-wear, residue analysis produced strong results for animal residue. This question's the authenticity of the residue in general, or presents a scenario where the artefact was in the presence of animal processing activities, but not actively engaged (i.e. lying underneath a carcass as it was gutted or in the vicinity of butchering activities).

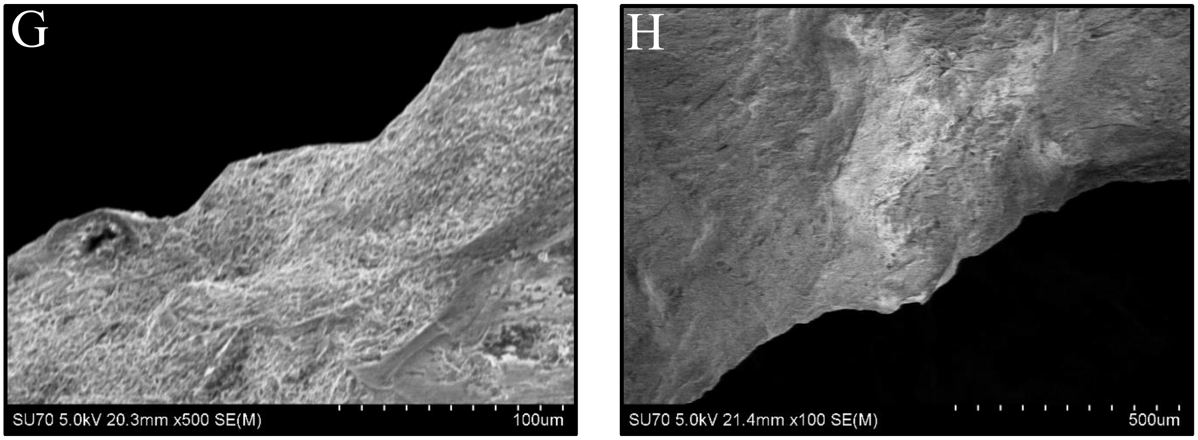


Figure 6-108: SEM images of artefact 51943.
G, H – Natural or taphonomy-derived damage to edge that can be confused with use-wear.

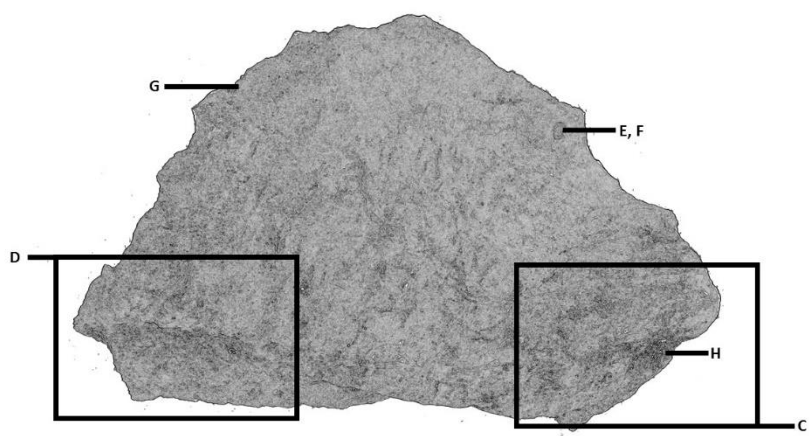


Figure 6-109: Image locations for artefact 51943.

6.2.28 Artefact 51944

Artefact 51944 was a smoky and translucent quartz flake, which measured 45mm long and 30mm wide (Figure 6-110). This material was rather unique and only one other artefact (77023) in the analyzed sample was of similar material. This artefact was selected for the presence of a dark brown residue on the dorsal surface, located near a possible working edge. See Figure 6-113 for the location of each micrograph.

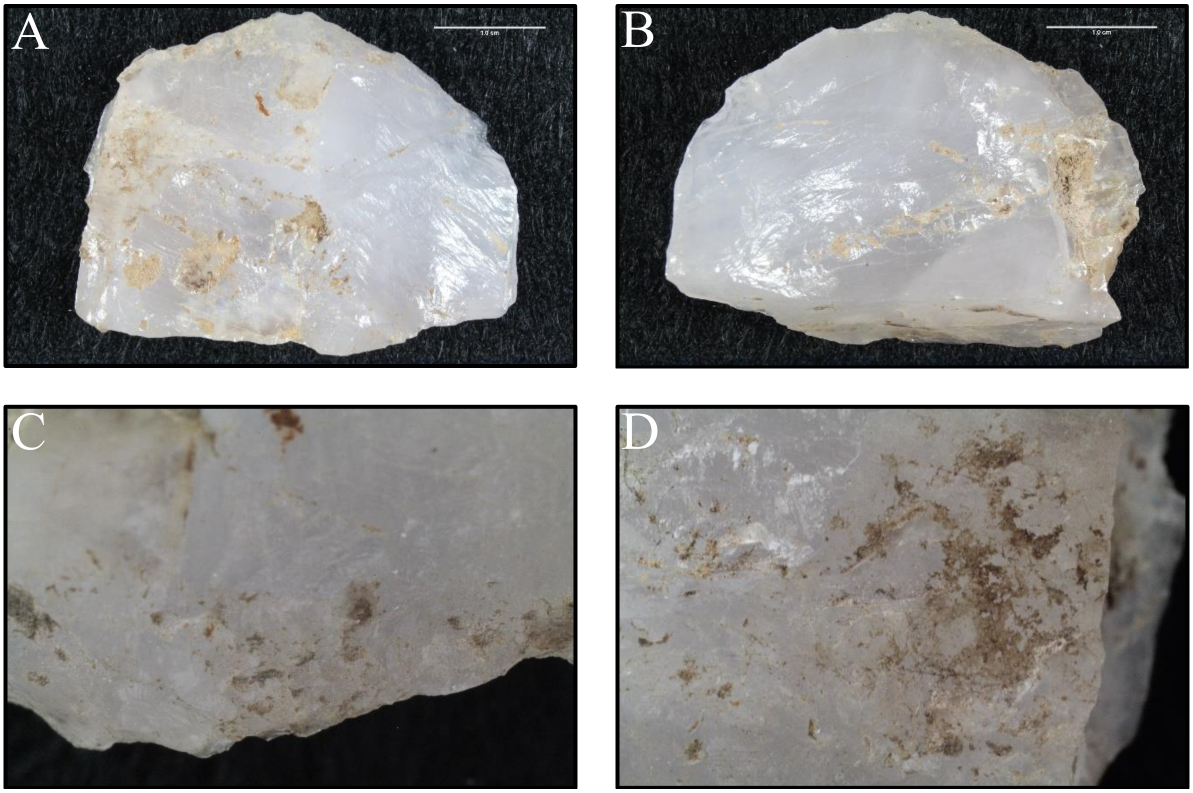


Figure 6-110: Artefact 51944.
A – Dorsal surface. B – Ventral surface. C – Possible working edge, dorsal surface at 20x magnification. D – Residue on dorsal surface at 20x magnification.

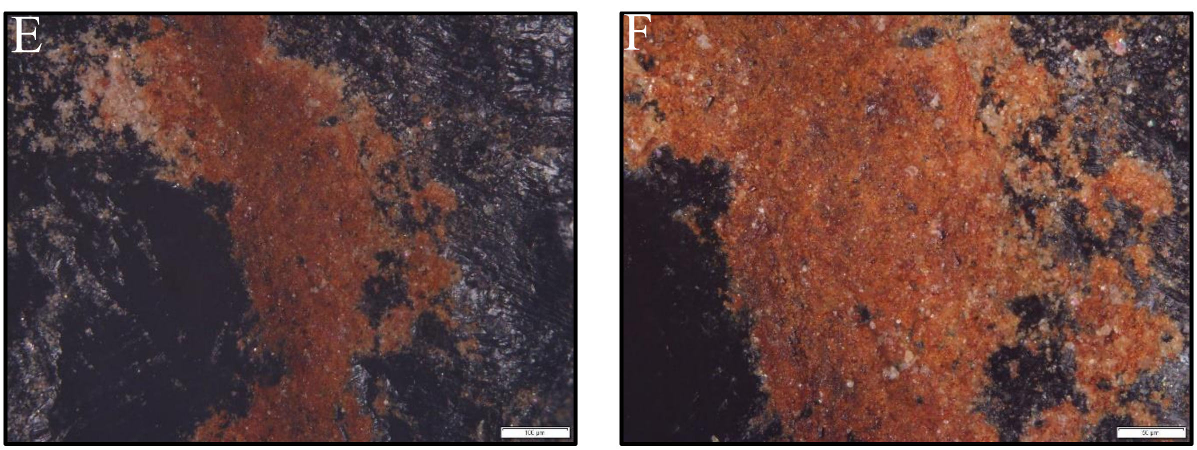


Figure 6-111: Residue on artefact 51944.
E, F – Class 13 residue.

Under HPILM, class 2 residue was present, although no photo was taken. An orange residue (class 13; Figure 6-111), which was a singular occurrence, was also present. Biochemical tests produced one weak positive result for fatty acid. The GC/MS and HPTLM analysis produced no significant results (Table 6-57; Table 6-58). Therefore, residue analysis indicated a weak interpretation for animal residue.

Table 6-57: Residue and use-wear results summary for artefact 51944.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2, 13	No	Weak	N/A	Striations Flake Scars Edge Damage	Unidentifiable	N/A	N/A

Table 6-58: Inquisitive process for artefact 51944 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was sparsely distributed on the dorsal surface. Another orange residue was found in one location.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and were confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Environmental. The residue was present across most the artefact.
4 – Is it Plant or Animal?	Animal. Resembled other residue classified as animal and biochemical testing a weak positive for fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

The SEM microscopy showed potential striations oriented perpendicular to the working edge (Figure 6-112). The edge was rounded and showed some edge damage, particularly a large flake scar with smaller scars within. Unfortunately, use-wear was too infrequent to be identified and artefact 51944 could not be confirmed as a tool (Table 6-57).

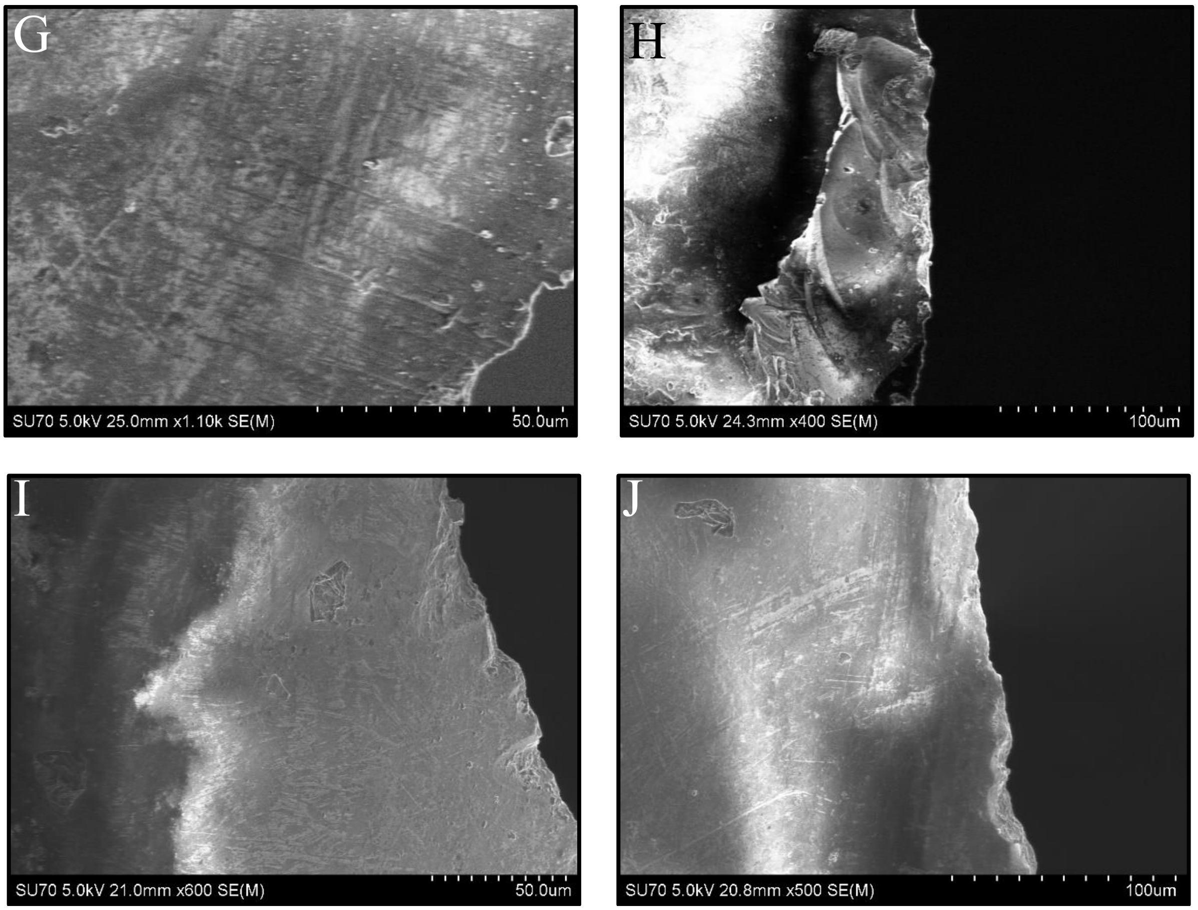


Figure 6-112: Use-wear on artefact 51944.
G – Perpendicular striations. H, I – Flake scars. J – Edge damage.

Overall, artefact 51944 lacks enough use-wear and residue evidence to identify the artefact's function. Residue analysis weakly supported an animal residue, but could not confirm the authenticity of the residue. Use-wear data was not strong enough to confidently identify use, but did suggest a scraping motion if the artefact was used.

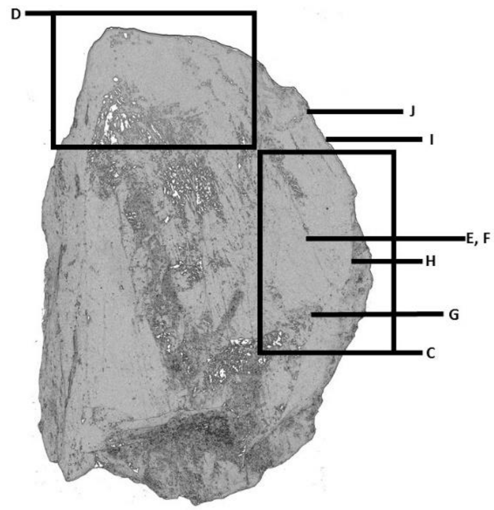


Figure 6-113: Image locations for artefact 51944.

6.2.29 Artefact 52053

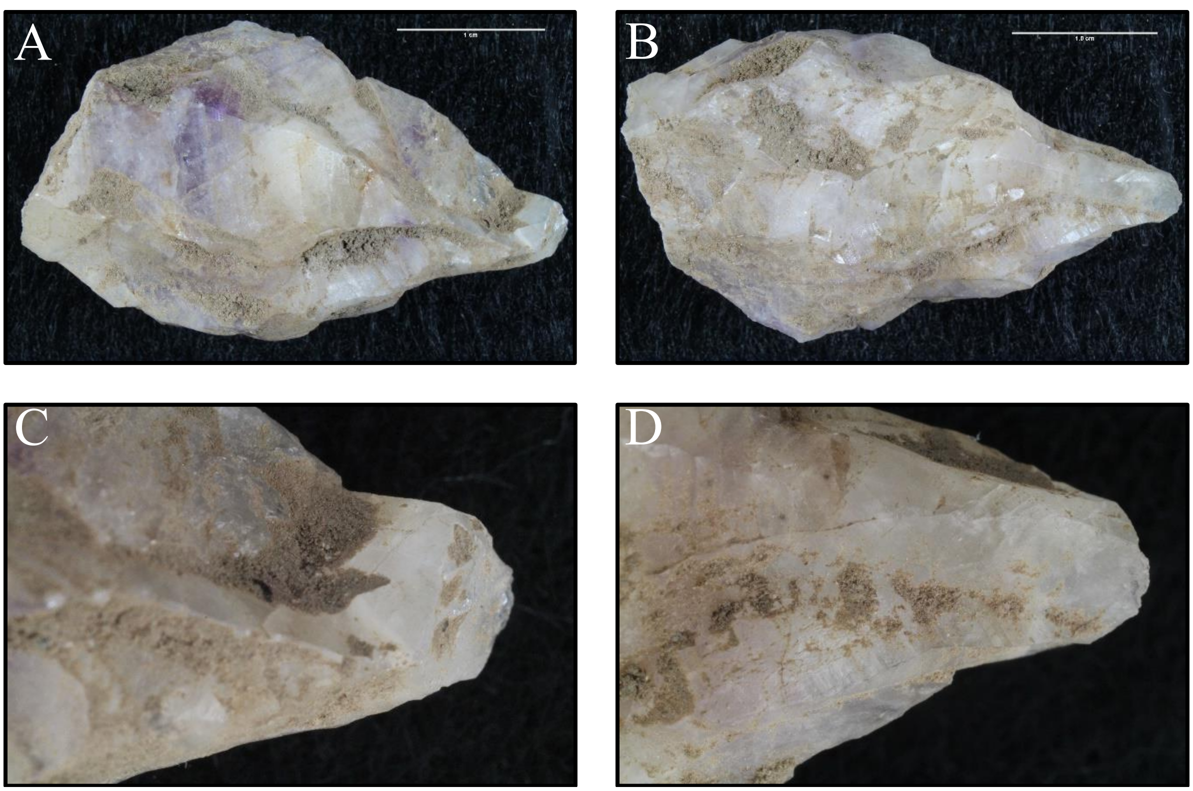


Figure 6-114: Artefact 52053.
A, B – Macro photos. C – Tip, side A at 20x magnification. D – Tip, side B at 20x magnification.

Artefact 52053 was a larger piece of amethyst, although only a small portion of the artefact was purple (Figure 6-114). It measured 39mm long and 22mm wide and was originally catalogued as a perforator. This artefact was selected because of the residue located in cracks and crevices near the tip, which appeared to be manufactured. See Figure 6-117 for the location of each micrograph.

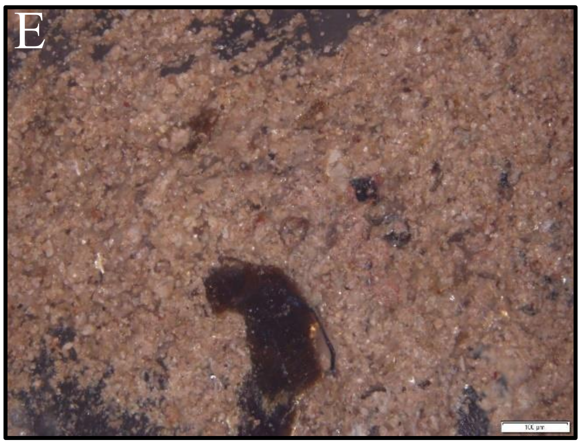


Figure 6-115: Residue on artefact 52053.
E, F – Class 7 residue with embedded flake.

The HPILM mostly shows sediment that was mixed with residue (class 7; Figure 6-115). In addition, a small lithic flake was embedded in this residue. Removal with tweezers was attempted, but unsuccessful. Biochemical tests produced positive results for protein and fatty acid. The GC/MS and HPTLM analysis produced no significant results (Table 6-59; Table 6-60). The biochemical tests strongly indicated an animal-derived residue.

The most notable use-wear feature visible with the SEM were the two large flakes removed from the tip of the artefact (Figure 6-116G). At first, their size was thought to suggest they were manufacturing related, but their location strongly indicated that they were a product of use. Their orientation suggested a twisting motion caused the break. Counter to this motion were numerous striations (Figure 6-116I, J). These were wide, but very shallow. Therefore, there is evidence of a twisting (i.e. drilling) motion used on hard material, but also a puncture action on a softer material (Table 6-59).

Table 6-59: Residue and use-wear results summary for artefact 52053.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
7	Yes	Yes	N/A	Flake Scars Ridge Wear Pits	Identifiable	Hard/Medium	Twist and Puncture

Table 6-60: Inquisitive process for artefact 52053 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the tip.
2 – Is it Organic or Inorganic?	Organic/Inorganic. Residue was grainy, suggesting it was inorganic. However, organic material was confirmed by SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. The residue was concentrated at the tip.
4 – Is it Plant or Animal?	Animal. Biochemical testing produced positive results for both protein and fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

In conclusion, residue analysis indicated that the artefact was a tool used on animal material. Use-wear analysis produced two different interpretations. The first indicated that the artefact was used with a twisting motion on a hard material. Two large, parallel flake scars found on the tip were a product of this action. The second indicated that the tool was used to puncture a material, most likely hide. The width, length, and depth (or lack thereof) of these striations suggested the hide was dried (Knutsson, 1988a). Therefore, the CRM cataloguer was correct in identifying the artefact as a perforator, but more detailed functional analysis proved the artefact served more than one function.

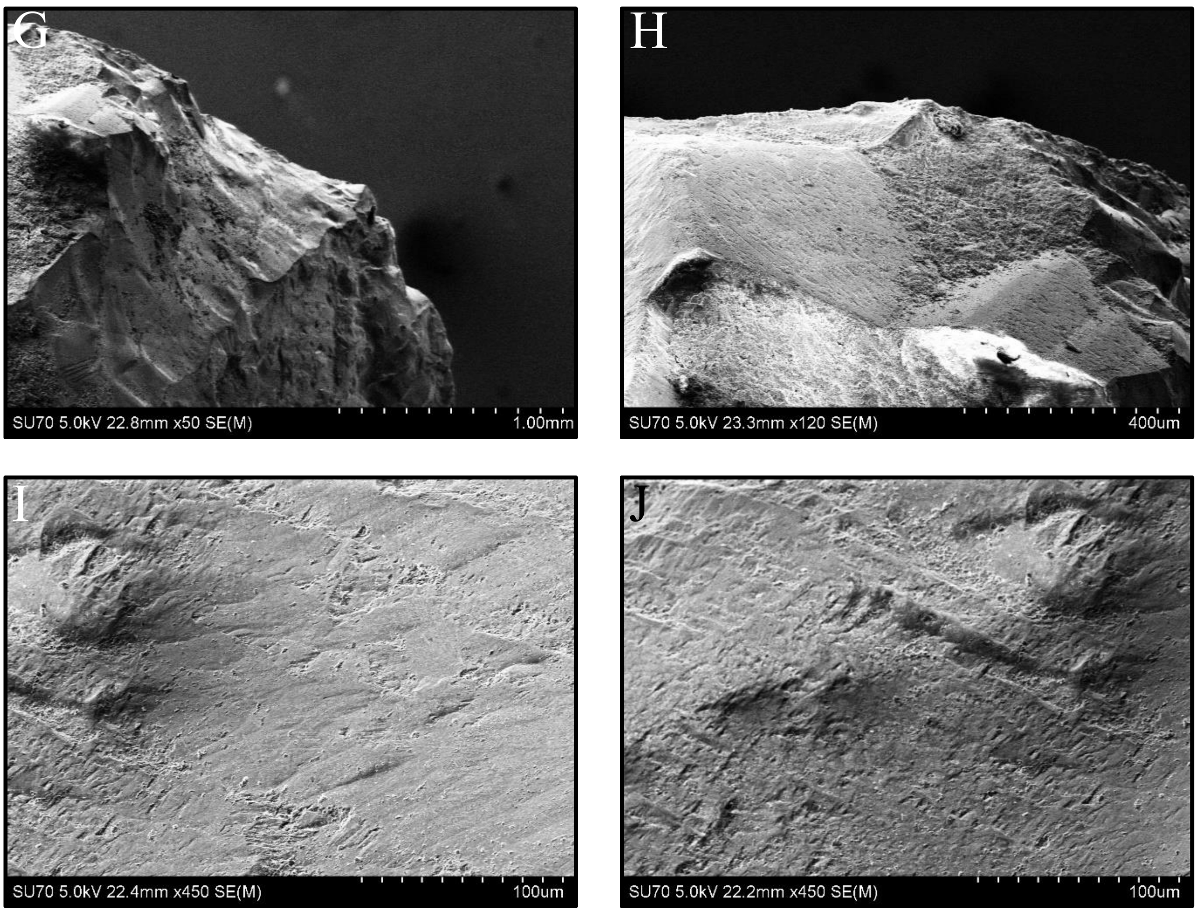


Figure 6-116: Use-wear on artefact 52053.
G – Large flake scars near tip. H – Ridge near tip that was rounded. I, J – Wide, shallow striations.

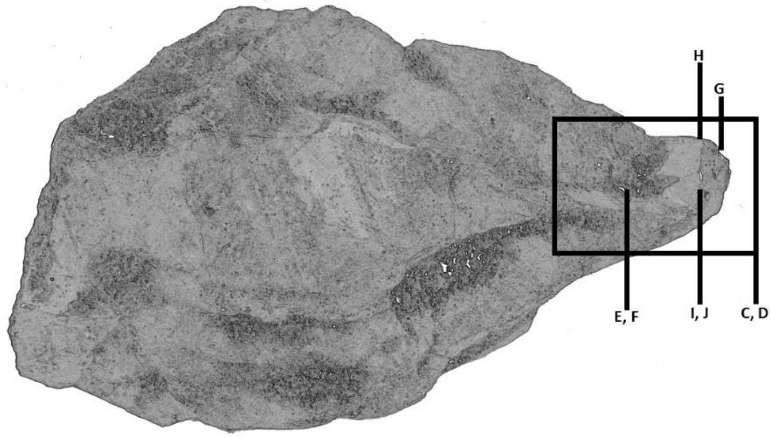


Figure 6-117: Image locations for artefact 52053.

6.2.30 Artefact 56557

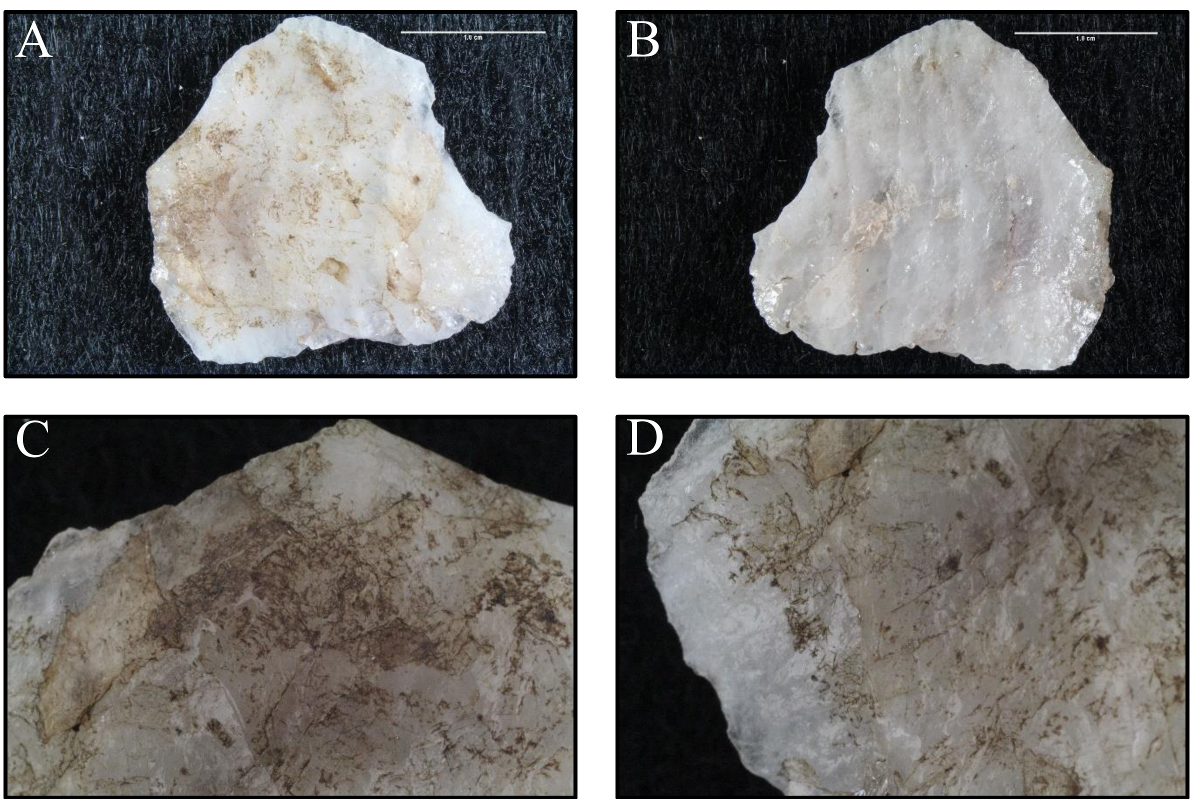


Figure 6-118: Artefact 56557.
A – Dorsal surface. B – Ventral surface. C, D – Residue on dorsal surface at 20x magnification.

Artefact 56557 was a milky/crystal quartz flake and measured 27mm long by 25mm wide (Figure 6-118). This artefact was selected for the large amount of residue present on the dorsal surface. In addition, the artefact had many straight edges that may have been used. See Figure 6-121 for the location of each micrograph.

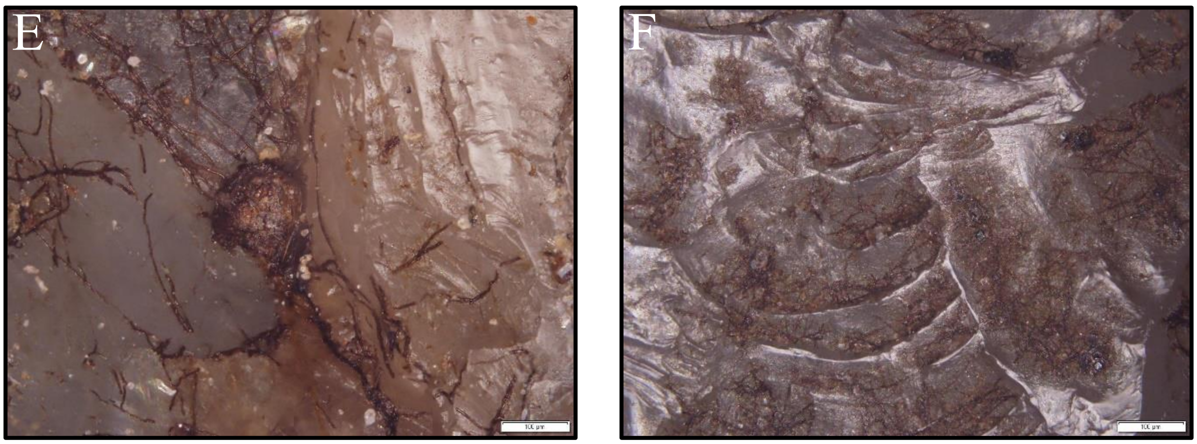


Figure 6-119: Residue on artefact 56557.
E, F – Residue was too sparse to confidently identify, but was either class 2 or 5.

Under HPILM, the residue was amorphous and rather sparsely concentrated, which was unexpected because of the amount of residue visible macroscopically (Figure 6-119). Therefore, too little residue was available for a confident classification that would place it in a specific category. However, for interpretations sake, the residue was either class 5 or class 2. Both residues were considered animal-derived. Neither biochemical tests, GC/MS, nor HPTLM produced any significant results (Table 6-61; Table 6-62).

The SEM microscopy showed edge damage (rounding) and micro-flaking (Figure 6-120). Striations were present but very sparse. However, they were situated perpendicular to the edge in a few locations, suggesting use (pulling and/or pushing). The presence of shallow, discontinuous striations and little other wear indicated that the artefact was used on a soft material (Table 6-61).

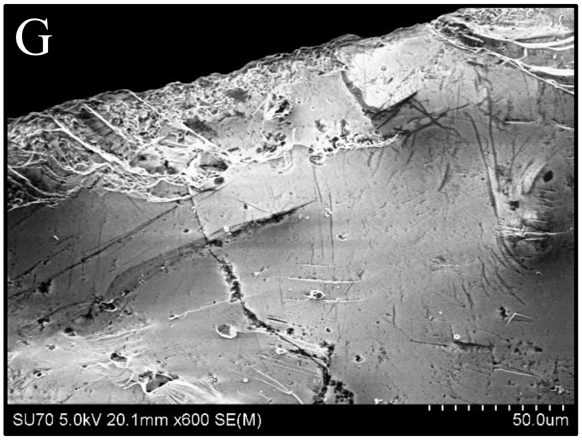
Table 6-61: Residue and use-wear results summary for artefact 56557.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2 or 5	No	No	N/A	Striations? Flake scars Edge Damage	Indeterminate	Soft	Pull/push

Table 6-62: Inquisitive process for artefact 56557 to authenticate and identify residue.

Question	**Observation**
1 – Is Residue Present?	Yes. Residue was across the dorsal surface of the artefact. However, under higher magnification the residue was not densely distributed.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and resembled other residue confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Environmental. The distribution of the residue across the dorsal surface does not support an anthropogenic interpretation. However, some activities were messy and residue could be widely distributed in this way.
4 – Is it Plant or Animal?	Animal. The residue resembled other residues classified as animal.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

In conclusion, use-wear analysis suggested this artefact was used on a soft material. Residue analysis suggested an animal-derived residue, although this interpretation was not strongly supported. Based on the mode of use it likely functioned as a scraper and therefore was used to scrape fresh animal hide. However, neither use-wear analysis nor residue analysis produced very confident results.



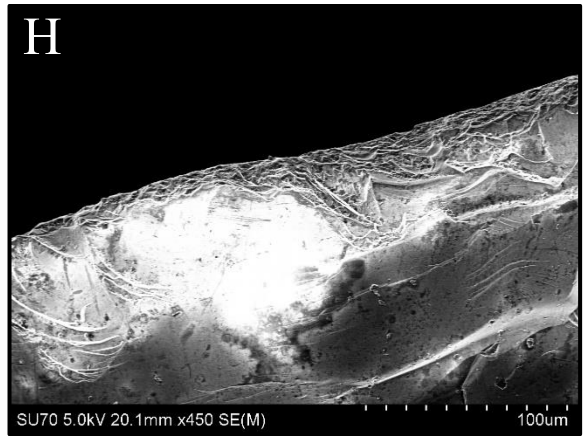


Figure 6-120: Use-wear on artefact 56557.
G – Edge damage and possible striations. H – Edge damage and micro-flaking.

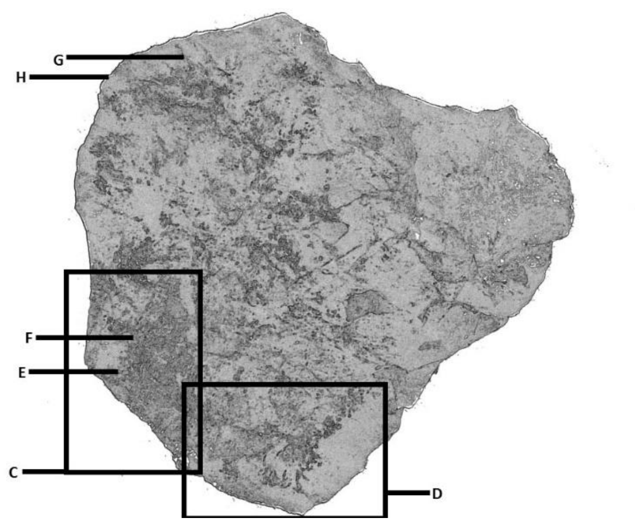


Figure 6-121: Image locations for artefact 56557.

6.2.31 Artefact 56627

Artefact 56627 was a small crystal quartz flake, which measured 20mm long and 12mm wide (Figure 6-122). This artefact was selected because of a large amount of brown residue located on the dorsal surface of the artefact. The residue is located near a curved edge that shows possible use-wear under LPILM. However, most of the residue is located opposite the working edge. See Figure 6-125 for the location of each micrograph.

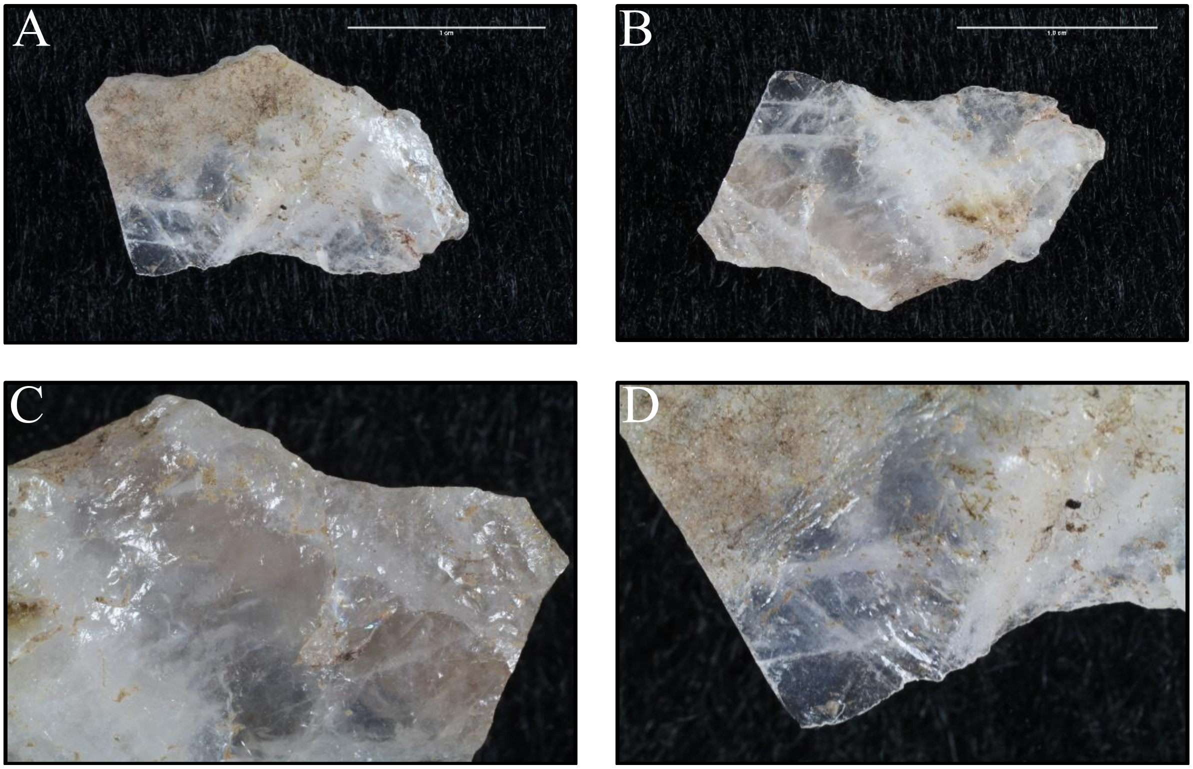


Figure 6-122: Artefact 56627
A – Dorsal surface. B – Ventral surface. C – Possible working edge, ventral surface at 20x magnification. D – Residue at 20x magnification, dorsal surface.

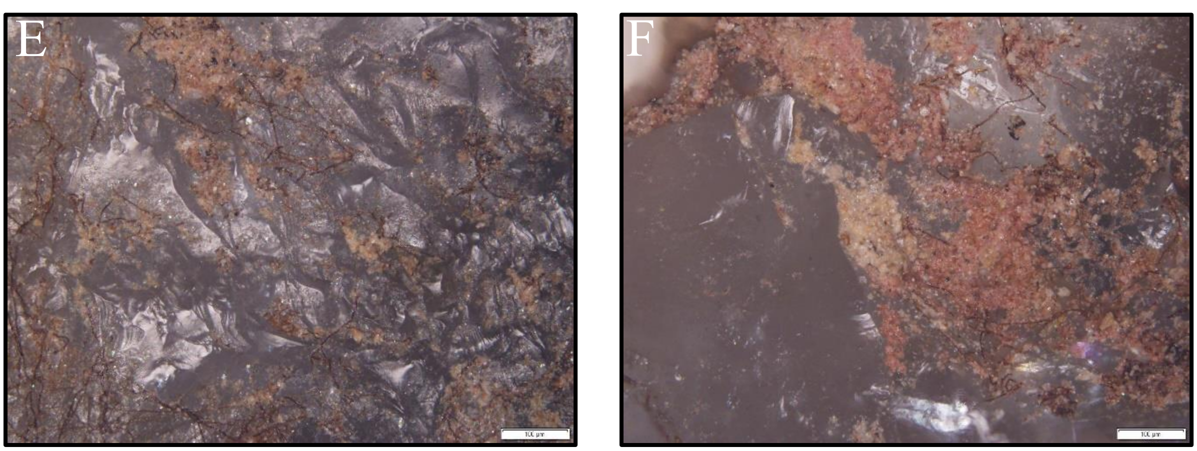


Figure 6-123: Residue on artefact 56627.
E – Possibly class 2 or 5 residue. Too little to be certain. F – Class 14 residue.

Under HPILM, a grainy residue with a pink hue (class 14; Figure 6-123F) was observed among residue that was too sparse to confidently identify, but resembled either class 2 or 5 residue (Figure 6-123E). The class 14 residue was similar to class 7, and thus considered to be sediment. Biochemical tests produced weak positives for protein and strong positives for fatty acid. These positive results were attributed to the large amount of residue, although sparsely distributed, that resembled classes 2 or 5 under LPILM. The GC/MS and HPTLM analysis produced no significant results (Table 6-63; Table 6-64). Therefore, the residue was considered animal-derived.

Use-wear analysis showed small flake scars along the working edge (Figure 6-124). Higher magnification showed faint striations parallel to the working edge, which suggested a transverse (cutting) motion (Table 6-63). The edge was slightly worn, but very little rounding.

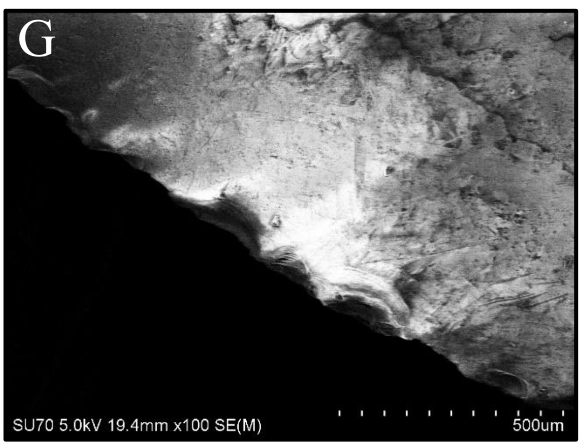
Table 6-63: Residue and use-wear results summary for artefact 56627.

	Residue			Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
14 2 or 5?	Weak	Yes	N/A	Striations Flake scars Edge Damage	Indeterminate	Soft	Transverse Pull/push

In conclusion, artefact 56627 was a tool. Residue analysis indicated an animal-derived residue and use-wear analysis suggested it was a soft material. Use-wear analysis also indicated that the artefact was used in a cutting motion. Therefore, it can be concluded that artefact 56627 was likely used to cut animal meat or raw hide.

Table 6-64: Inquisitive process for artefact 56627 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present across the dorsal surface of the artefact. However, under higher magnification the residue was not densely distributed.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residue was located near the working edge, although much of it was found on the opposite end. The artefact is rather small so the distance is not very far.
4 – Is it Plant or Animal?	Animal. The residue resembled other residue classified as animal and tested positive for fatty acid and weakly positive for protein.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.



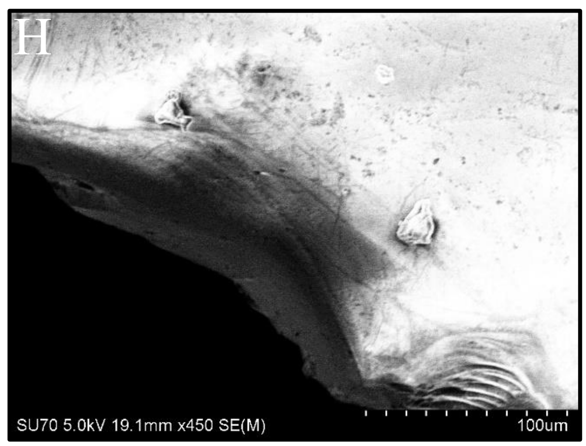


Figure 6-124: Use-wear on artefact 56627.
G – Small flake scars and a slightly rounded edge. H – Faint transverse striations near micro-flakes.

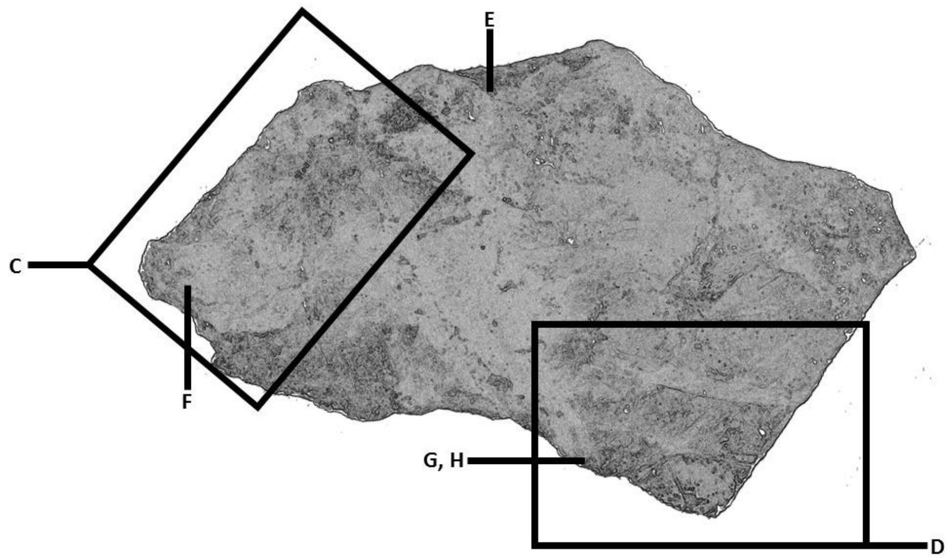


Figure 6-125: Image locations for artefact 56627.

6.2.32 Artefact 57679

Artefact 57679 was a small milky quartz flake and measured 23mm long and 12.5mm wide (Figure 6-126). This artefact was selected for the large amount of dark residue on the dorsal surface. The suspected working area was a protrusion extending out from the edge on the opposite side of where the residue was located. See Figure 6-129 for the location of each micrograph.

The HPILM showed class 1 residue with a few instances of a bright red residue (class 15) (Figure 6-127). This immediately suggested an animal-based residue. Class 15 residue remained a mystery because there was too little to test on its own. Biochemical tests produced positive results for protein, but not for fatty acid. This is interesting because class 1 residue typically correlated to positive results for fatty acid. The GC/MS and HPTLM analysis produced no significant results (Table 6-65; Table 6-66). Therefore, the residue is considered animal-derived.

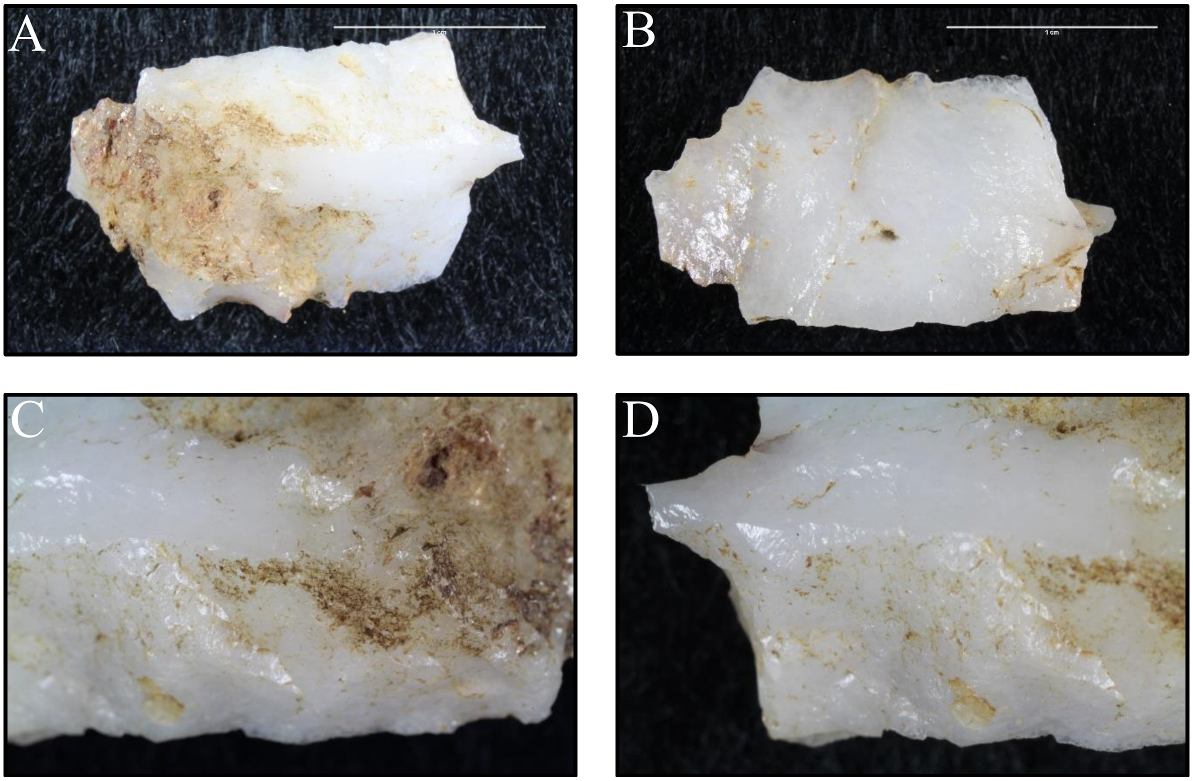


Figure 6-126: Artefact 57679.
A – Dorsal surface. B – Ventral surface. C – Residue on dorsal surface at 20x magnification. D – Broken protrusion at 20x magnification, dorsal surface.

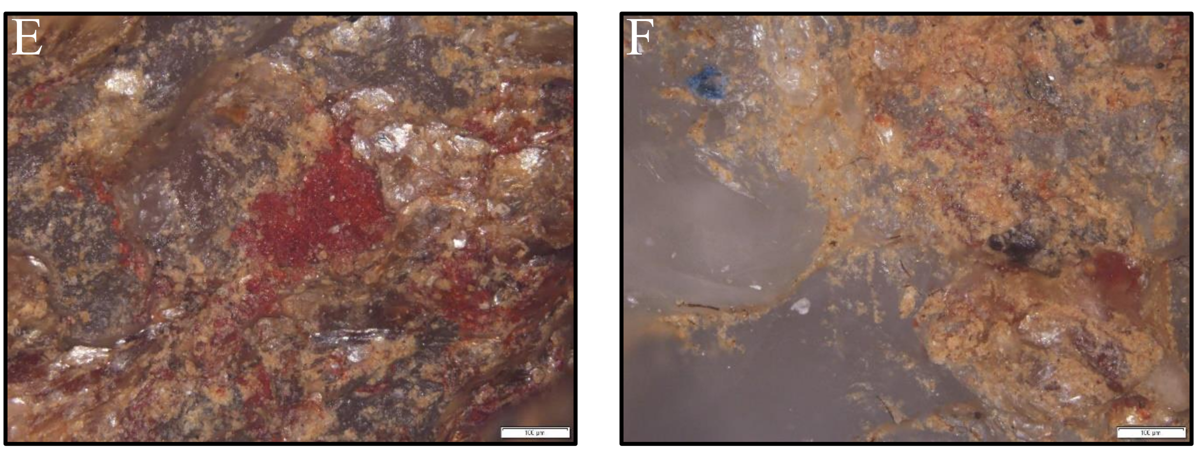


Figure 6-127:Residue on artefact 57679.
E – Class 15 residue. F – Class 1 residue.

Table 6-65: Residue and use-wear results summary for artefact 57679.

	Residue			Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
1, 15	Yes	No	N/A	Flake scars Edge Damage Ridge Wear	Indeterminate	Medium	Puncture Twist?

Use-wear analysis showed a broken tip, but use-wear was still visible (Figure 6-128). A series of flake scars were visible, stacked atop each other in a curved line. These scars suggested a piercing action with a slight twisting motion (Table 6-65). Other flake scars were located along the edge of the protrusion and at the very tip. The ridges around the tip were rounded. Striations were not visible, but the surface was rough, possibly inhibiting them from forming.

Table 6-66: Inquisitive process for artefact 57679 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present on the dorsal surface.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Although most of the residue was located on the proximal end, residue was still situated near the working tip.
4 – Is it Plant or Animal?	Animal. The residue resembled other residue classified as animal and tested positive for protein.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

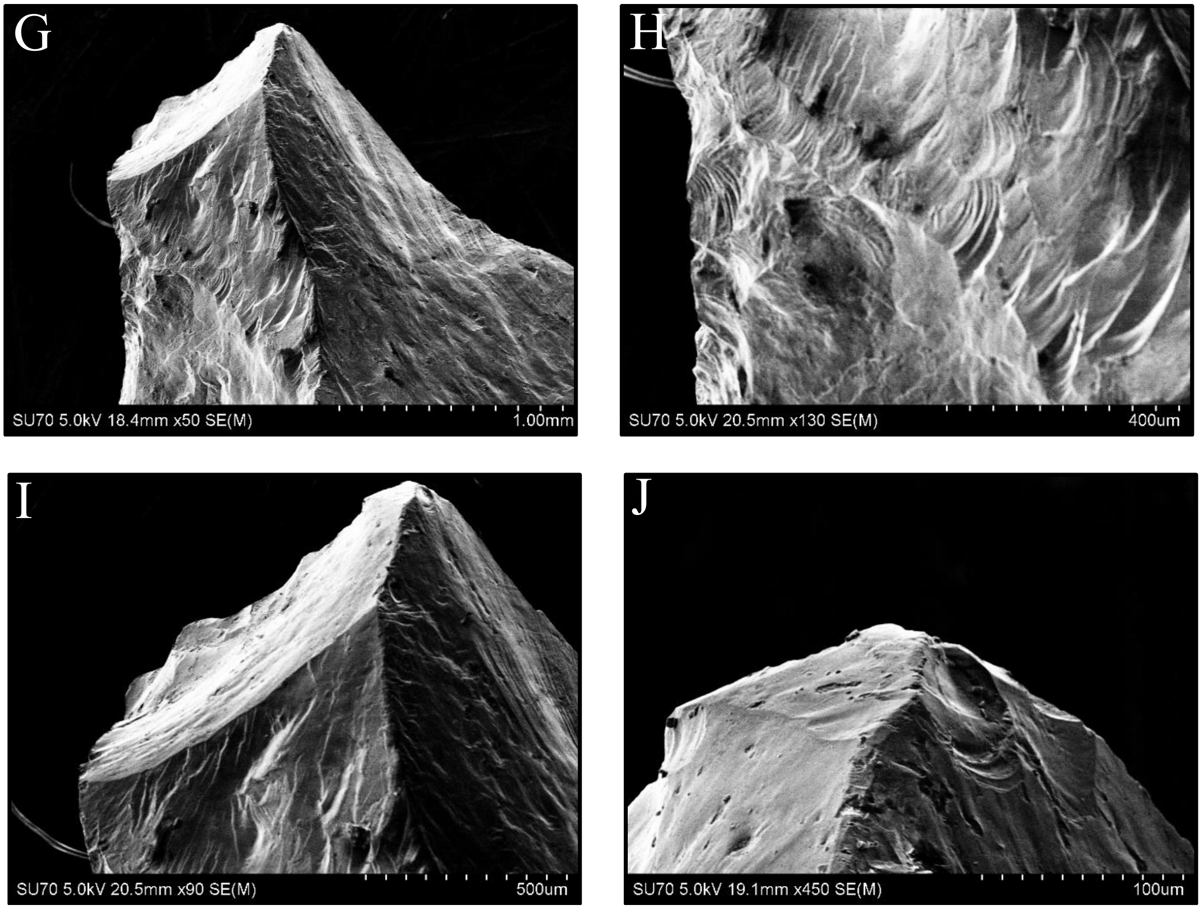


Figure 6-128: Use-wear on artefact 57679.
G – Protrusion with evidence of use. H – Flake scars in curved line and along edge. I – Broken tip. J – Flake scars and rounded ridges at the very tip.

In conclusion, artefact 57679 was a tool. Use-wear analysis clearly indicated that the protrusion was used to puncture a material with a medium hardness. Because residue analysis indicated an animal-based residue, this tool was likely used as an awl or perforator to puncture holes in dry hide.

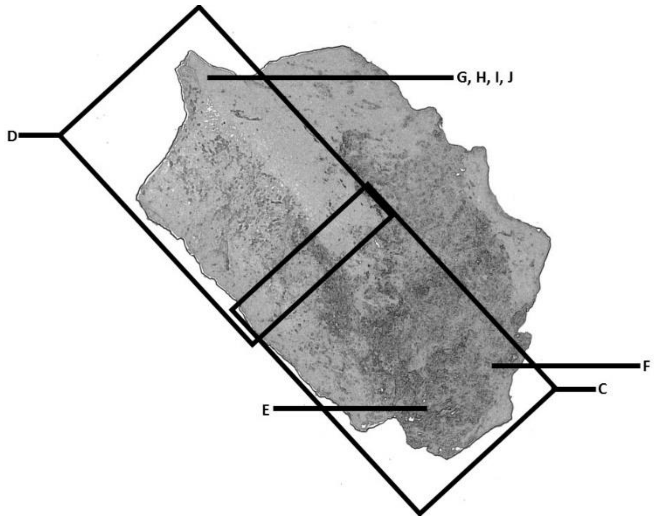


Figure 6-129: Image locations for artefact 57679.

6.2.33 Artefact 57953

Artefact 57953 was a small milky/crystal quartz flake, which measured 21mm long by 15mm wide (Figure 6-130). This artefact was selected for suspected residue located on both the dorsal and ventral surfaces. It also had straight and concave edges that were suitable for use. See Figure 6-133 for the location of each micrograph.

Under HPILM, class 1 residue was observed (Figure 6-131). This residue was interpreted as animal fat residue. Biochemical tests produced positive results for both protein and fatty acid, supporting this interpretation. The GC/MS analysis and HPTLM analysis produced no significant results (Table 6-65; Table 6-66). Therefore, based on the residue classification and biochemical test results, the residue was animal-derived.

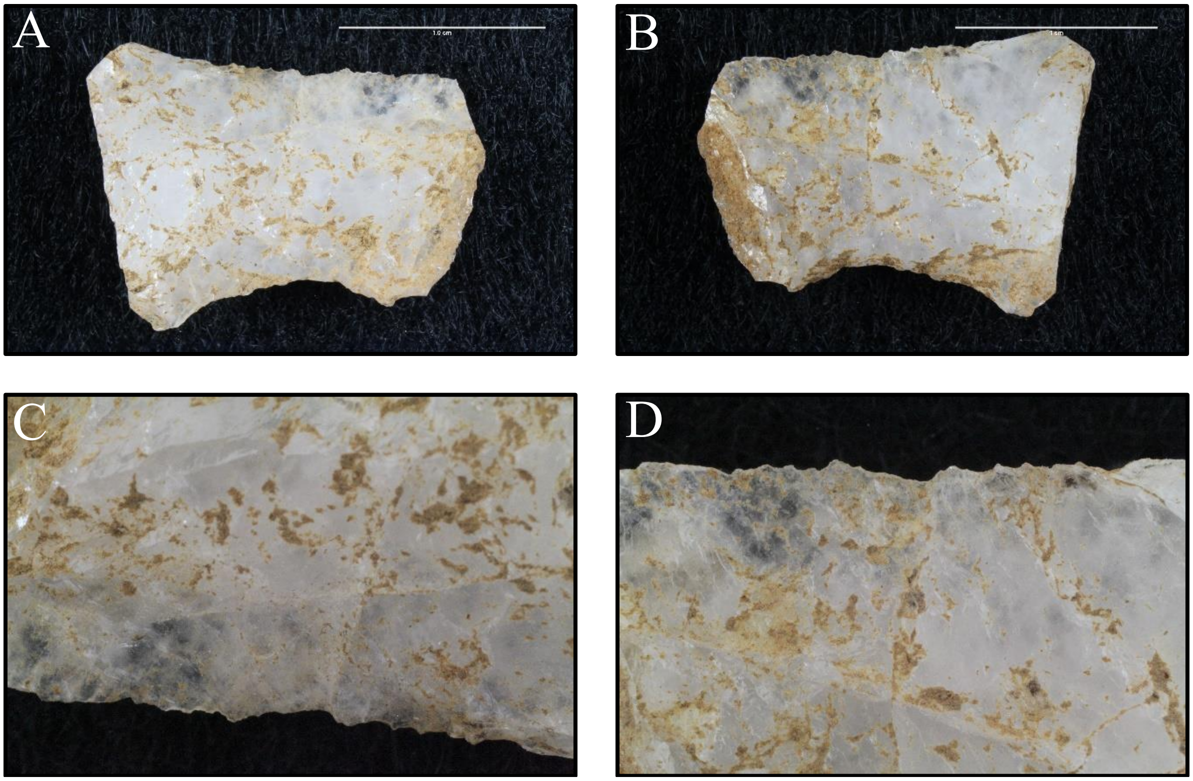


Figure 6-130: Artefact 57953.
A – Dorsal surface. B – Ventral surface. C – Straight edge at 20x magnification, dorsal surface. D – straight edge at 20x magnification, ventral surface.

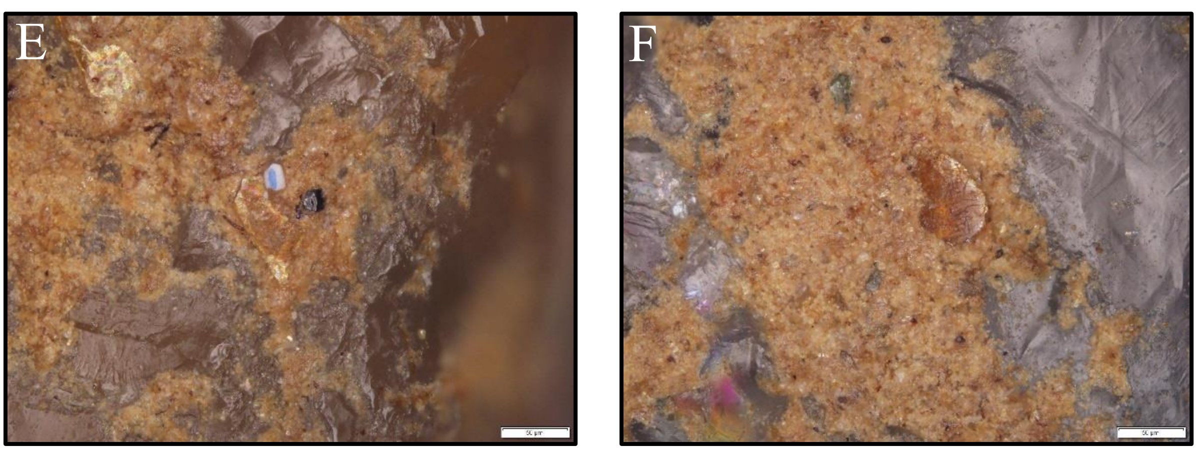


Figure 6-131: Residue on artefact 57953.
E, F – Class 1 residue.

Table 6-67: Residue and use-wear results summary for artefact 57953.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1	Yes	Yes	N/A	Striations Flake scars Edge Damage	Identifiable	Medium/ Soft	Perpendicular/ Parallel Push/Pull

Table 6-68: Inquisitive process for artefact 57953 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present on both the dorsal and ventral surfaces.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residue distribution is hidden by sediment on the artefact, but is present near the working edges. Also, because it can be classified and the artefact was used, the residue is considered anthropogenic.
4 – Is it Plant or Animal?	Animal. The residue resembled other residue classified as animal and tested positive for protein and fatty acid.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

The SEM microscopy showed rounded edges with flake scars caused by use (Figure 6-132). These flake scars were layered, suggesting the artefact was used for a longer period. Parallel and perpendicular striations were present, indicating the artefact was multifunction (Table 6-65). Therefore, use-wear analysis identified cutting and scraping motions on a soft or medium-hardness material.

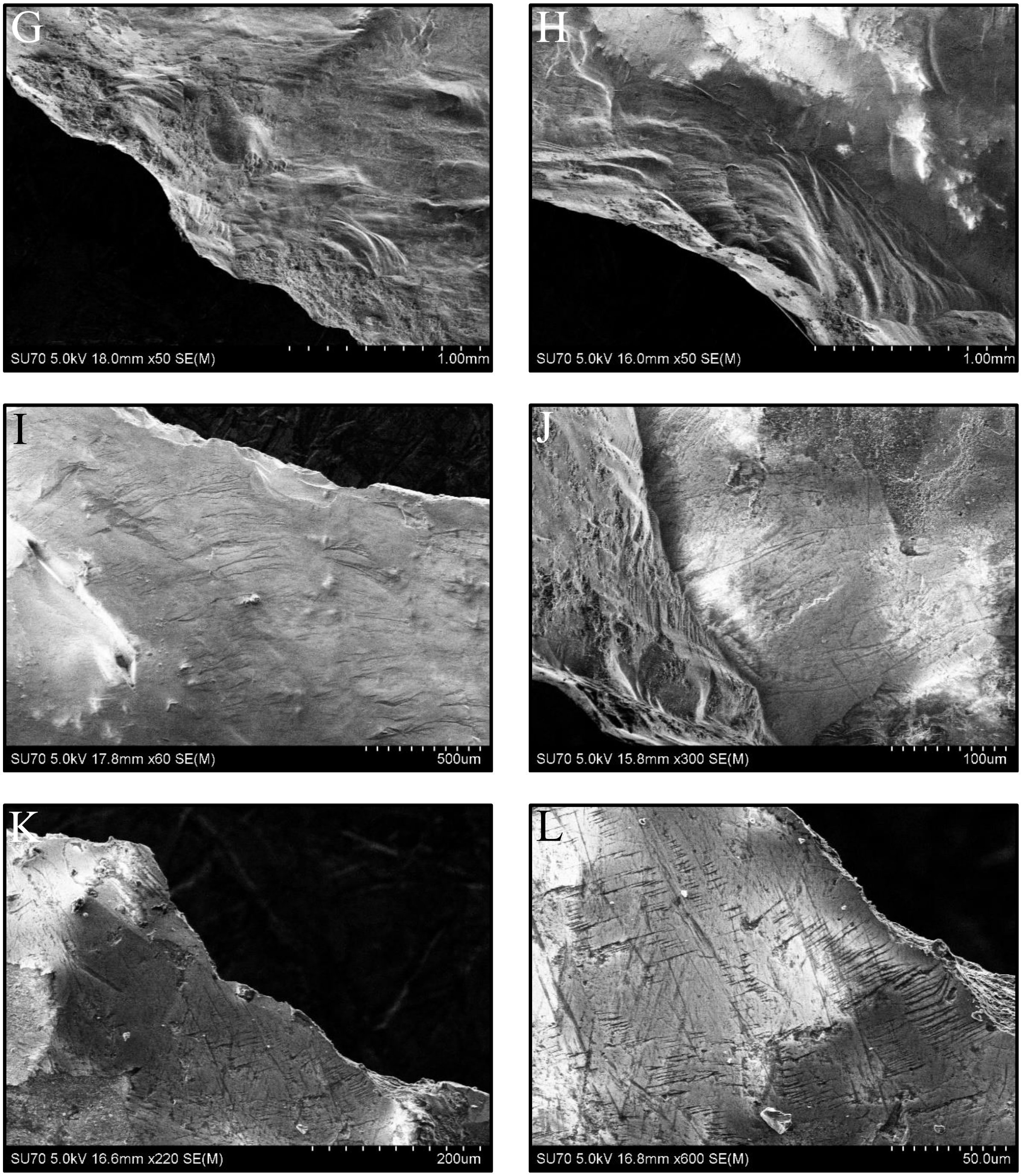


Figure 6-132: Use-wear on artefact 57953.
G, H – Edge rounding and micro-flaking. I – Micro-flaking and lancets. J – Perpendicular striations. K, L – Parallel striations.

In conclusion, artefact 57953 was a tool. Use-wear analysis confirmed its use, indicating that it was used to both cut and scrape a medium-soft material. Residue analysis indicated this material was animal-derived. Therefore, this tool was likely used to butcher an animal by cutting into hide and meat and scraping the hide as well.

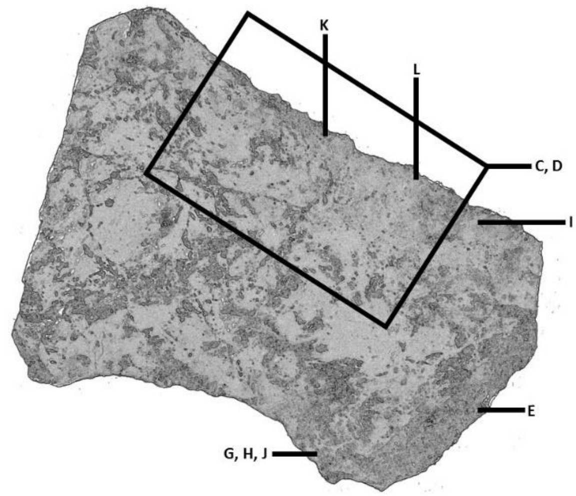


Figure 6-133: Image locations for artefact 57953.

6.2.34 Artefact 63769

Artefact 63769 was a triangular milky/crystal quartz flake, which measured 32mm long and 20mm wide (Figure 6-134). This artefact was selected for its interesting morphology and the presence of dark residue near the tip. The morphology of this tool resembled a small projectile point, but the tip could also function as a drill or graver and the concave base could function as a scraper. See Figure 6-137 for the location of each micrograph.

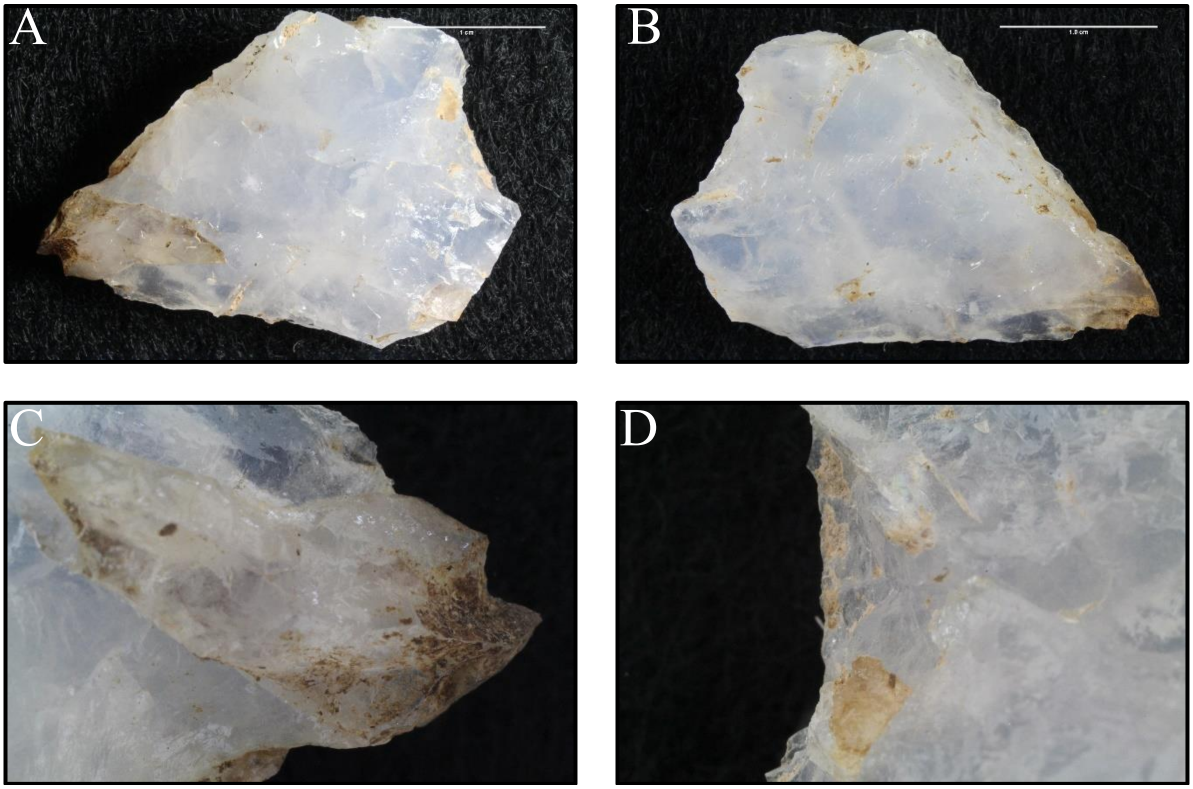


Figure 6-134: Artefact 63769.
A – Dorsal surface. B – Ventral surface. C – Tip with residue and possible DIF at 20x magnification, dorsal surface. D – Concave end (proximal end) at 20x magnification, dorsal surface.

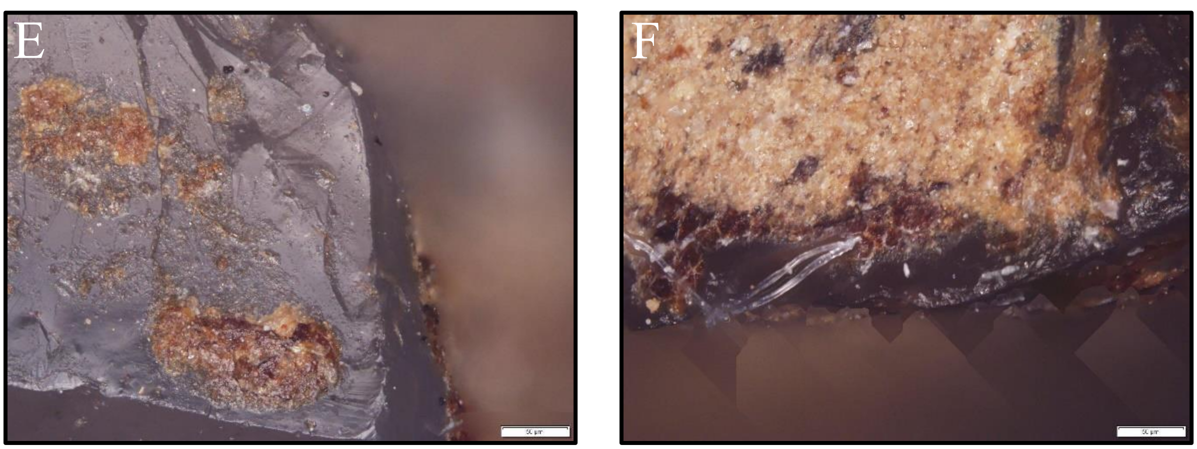


Figure 6-135: Residue on artefact 63769.
E – Class 2 residue. F – Class 12 residue.

Under HPILM, artefact 63769 showed both class 2 and class 12 residues (Figure 6-135). Both residues were considered animal-derived. Biochemical tests produced one weak positive for protein. The GC/MS and HPTLM analysis produced no significant results (Table 6-69; Table 6-70). Therefore, the animal origin of the residue is fully interpreted through the shared visual characteristics with other animal-based residues identified in this study. In addition, the dehydration and desiccation cracking of class 12 residue suggested the residue was blood, which is supported by the Hb-CRTS results (score of 1).

Table 6-69: Residue and use-wear results summary for artefact 63769.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2, 12	Weak	No	N/A	Flake scars Edge Damage	Indeterminate	Medium	Puncture or Push/Pull

Use-wear analysis produced very few results. Under LPILM the tip was clearly damaged. It is suspected that the damage to the tip is a unifacial spin-off fracture, which is a type of diagnostic impact fracture DIF (Fischer, et al., 1984). The tip of the artefact is rounded and damaged. Large flake scars were present near the tip and oriented perpendicular (Figure 6-136). The concave edge appeared natural in some areas, but other locations contain either natural striations, or a large number of perpendicular striations caused by use. Parallel striations are less frequent and hidden amongst the others. In the end, the use-wear remained unclear, but suggested that the artefact was likely multifunctional (Table 6-69).

Table 6-70: Inquisitive process for artefact 63769 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present on both the dorsal and ventral surfaces but at the tip only.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic by SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. The concentration of the residue at the tip suggested it was anthropogenic.
4 – Is it Plant or Animal?	Animal. The residue resembled other residue classified as animal and produced a weak positive for protein residue.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

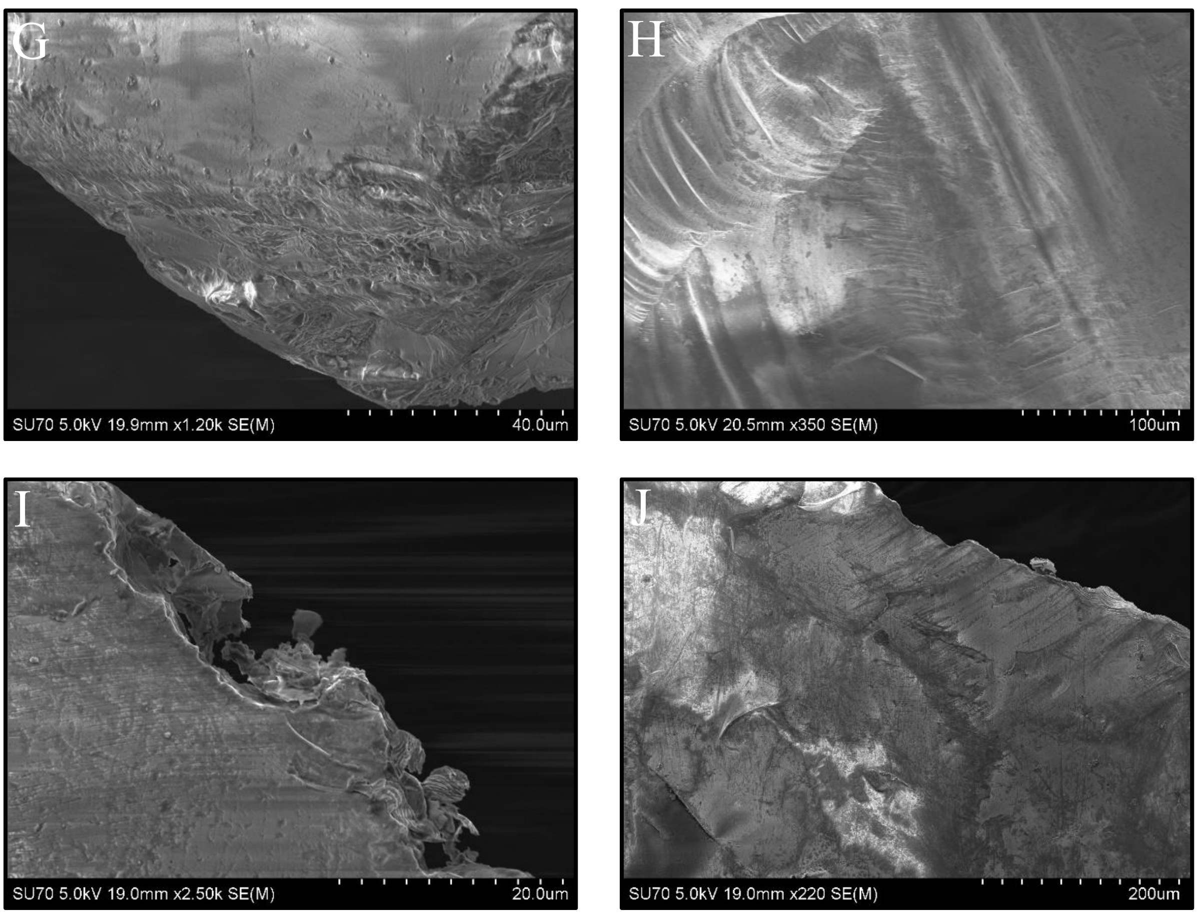


Figure 6-136: Use-wear on artefact 63769.
G – Rounded edge at the tip. H – Perpendicular, long flake scar. I, J – Striations perpendicular to concave edge.

In conclusion, residue analysis indicated an animal-derived residue, which was most likely blood. Use-wear analysis indicated the possibility that this artefact functioned as a projectile point. Further evidence suggested that the proximal end, which was suitable for hafting, was also used as a scraper/spokeshave. However, use-wear does not suggest a hard material, such as bone, but a softer material, such as wood (Knutsson, 1988a). Residue analysis did not indicate plant material. Therefore, the wear on the concave edge is either evidence that the artefact was used as a spokeshave or the scaring is hafting-related. This assumes the striations (straight-sided, Knutsson, 1988a) were use-related and not part of the material (i.e. natural).

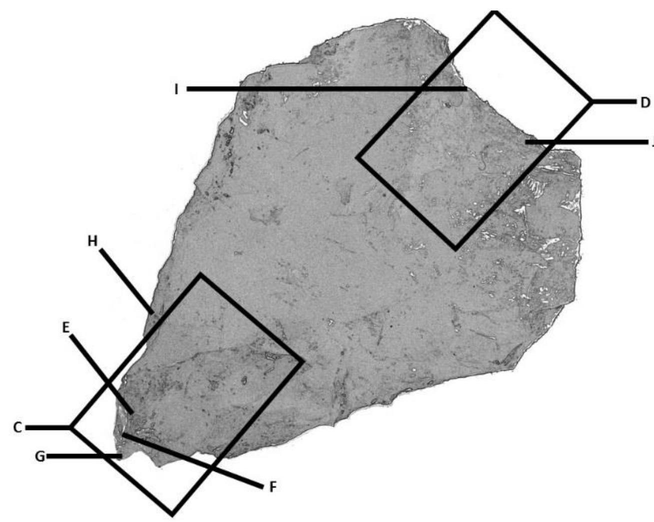


Figure 6-137: Image locations for artefact 63769.

6.2.35 Artefact 69290

Artefact 69290 was a blocky piece of milky quartz, which measured 42mm long and 35mm wide (Figure 6-138). Originally catalogued as a unifacial scraper, this artefact was selected for its possible scraping edge and suspected residue. The residue was sparsely distributed and located around the centre of the dorsal surface, rather than near the suspected working edge. See Figure 6-140 for the location of each micrograph.

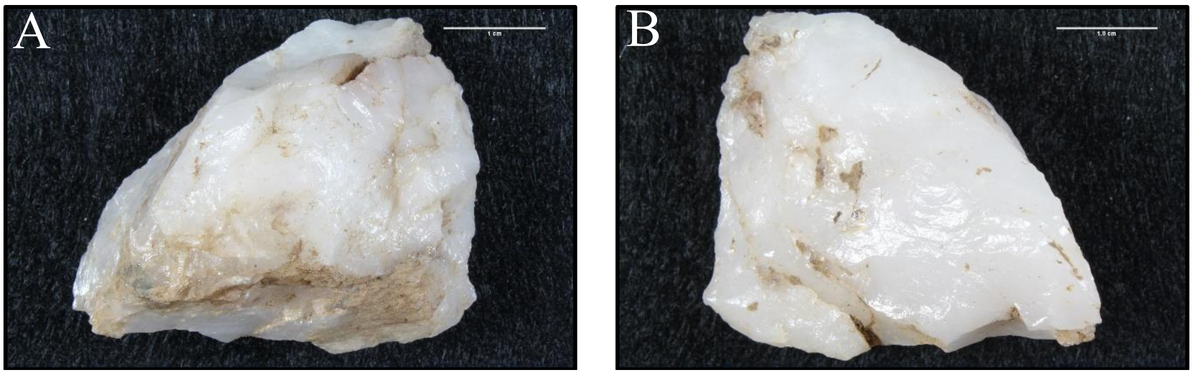


Figure 6-138: Artefact 69290.
A – Dorsal surface. B – Ventral surface.

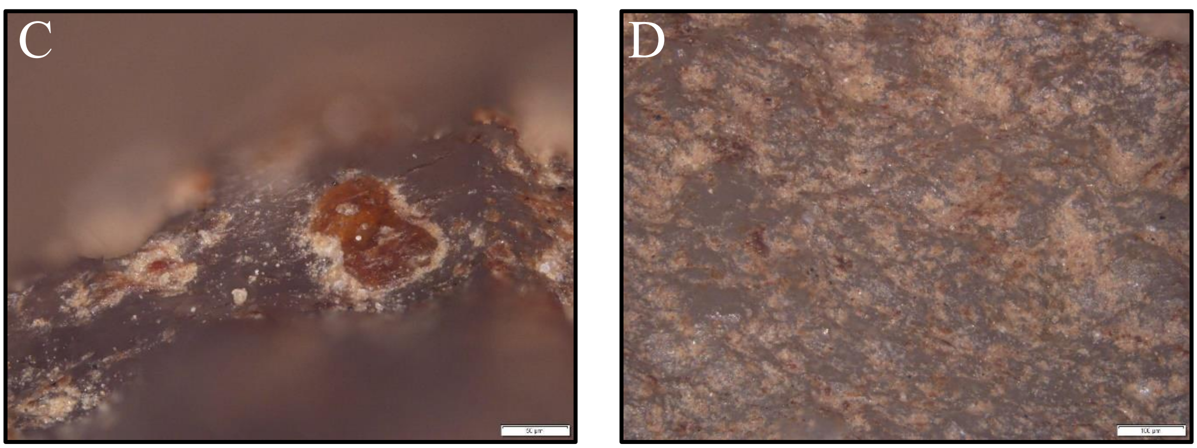


Figure 6-139: Residue on artefact 69290.
C – Unclassified amber coloured residue. D – There was too little residue to properly classify.

Under HPILM, the residue was minimal (Figure 6-139). A small amber feature was noted, but in general there was too little residue to confirm the classification. Biochemical testing and GC/MS produced no significant results (Table 6-71; Table 6-72). Therefore, there were no results to interpret from residue analysis.

Table 6-71: Residue and use-wear results summary for artefact 69290.

Class.	Residue			Use-Wear			
	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
Unclassified	No	No	N/A	N/A	N/A	N/A	N/A

Table 6-72: Inquisitive process for artefact 69290 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present on the dorsal surface.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous.
3 – Is it anthropogenic or environmental?	Environmental. The residue was only found on the dorsal surface and was sparsely distributed.
4 – Is it Plant or Animal?	Unsure. There was too little residue to properly classify and acquire chemical data.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

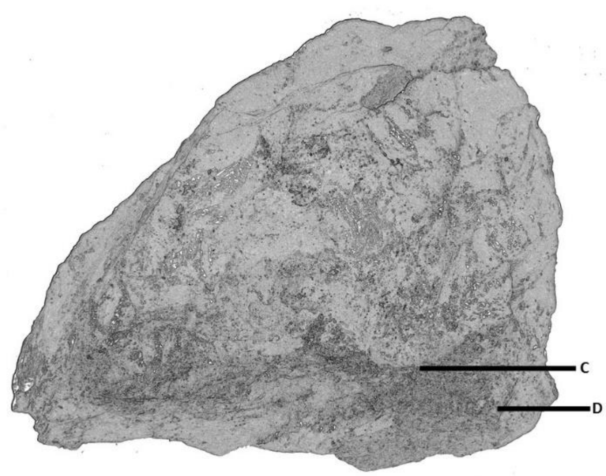
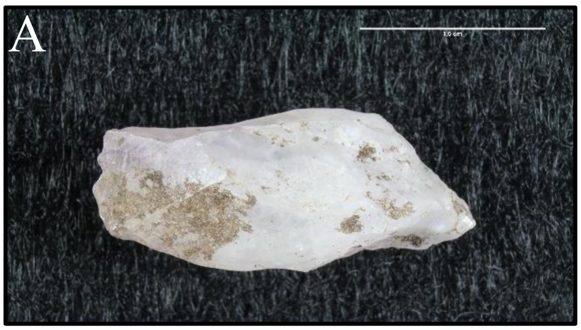


Figure 6-140: Image locations for artefact 69290.

Unfortunately, the artefact was too bulky for the SEM chamber. Therefore, use-wear analysis could not occur. In conclusion, although artefact 69290 could not be properly analyzed, it is not suspected to be a tool.

6.2.36 Artefact 70265



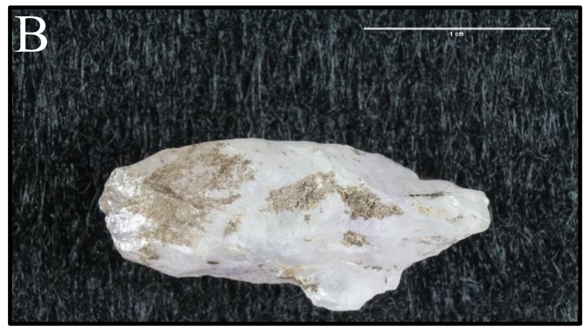


Figure 6-141: Artefact 70265.
A – Dorsal surface. B – Ventral surface.

Artefact 70265 was a small milky quartz fragment with a small amethyst inclusion (Figure 6-141). It measured 22mm long and 9mm wide. This artefact was selected for the presence of a dark brown residue. The distal end comes to a point that could have been used. Residue was mostly concentrated on the proximal end. See Figure 6-144 for the location of each micrograph.

Under HPILM, only class 5 residue was identified (Figure 6-142). Neither biochemical testing, GC/MS, nor HPTLM produced any results (Table 6-73; Table 6-74). Therefore, the association of class 5 residue with animal residue was the only means for interpreting the residue. However, in general this class of residue produced minimal results.

Use-wear analysis showed a rounded, blunt tip with flake scars indicating perpendicular force (Figure 6-143). A few flake scars were also located at the proximal end. Much of the artefact appeared natural and there was not enough evidence of use to confidently identify the artefact's function (Table 6-73).

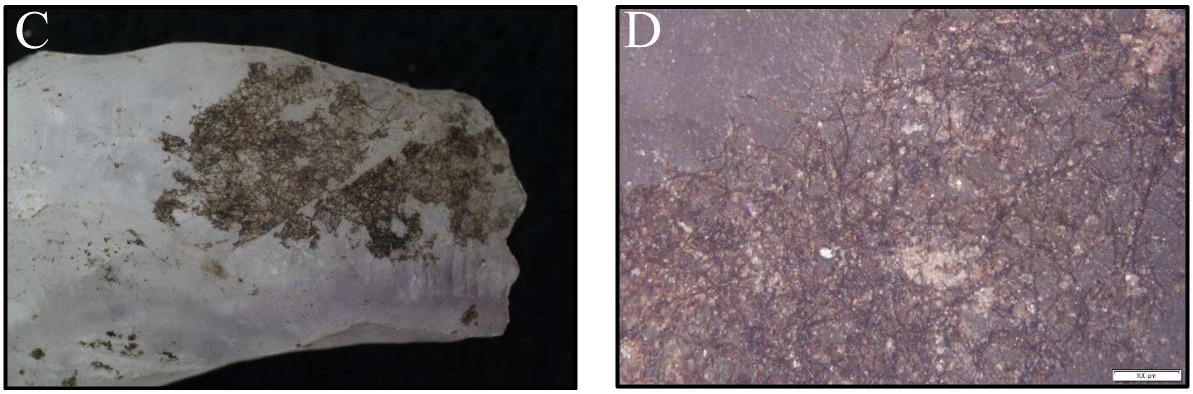


Figure 6-142: Residue on artefact 70265.
C – Residue at 20x magnification. D – Class 5 residue.

Table 6-73: Residue and use-wear results summary for artefact 70265.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
5	No	No	N/A	Flake Scars Edge Damage	Unidentifiable	N/A	N/A

Table 6-74: Inquisitive process for artefact 70265 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present on the dorsal surface.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and belonged to a determined classification.
3 – Is it anthropogenic or environmental?	Anthropogenic. Although most of the residue was located opposite to the working tip, some was located around the tip.
4 – Is it Plant or Animal?	Animal. Based on the residue classification.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

In conclusion, artefact 70265 produced few results. Residue analysis could only classify the residue, but could not identify it. Use-wear analysis only produced a few flake scars and a rounded tip for interpretation. The scars indicate perpendicular force, but were too scarce to confidently interpret use. If an interpretation had to be made, this artefact would likely have been used to puncture hide. However, without additional data this interpretation is speculative.

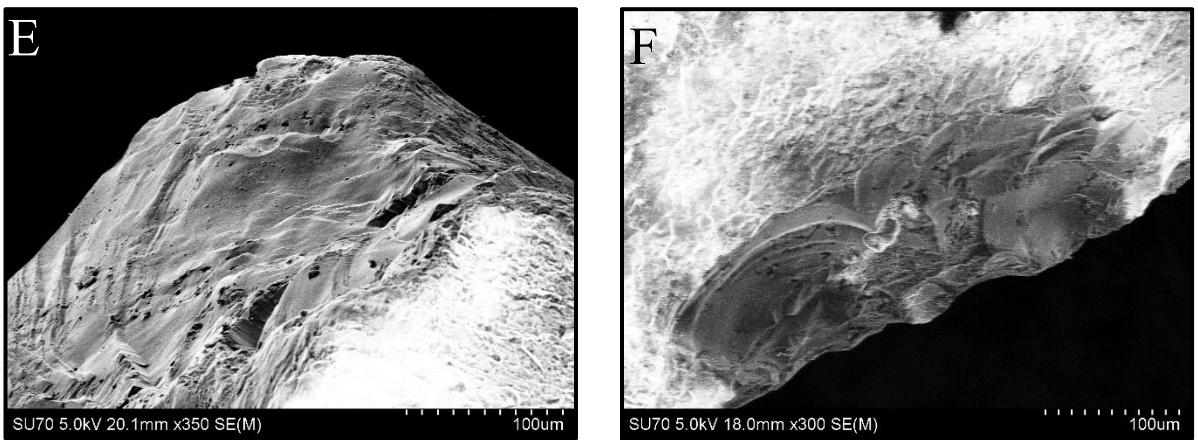


Figure 6-143: Use-wear on artefact 70265.
E – Rounded tip with perpendicular flake scars. F – Flake scars at proximal end.

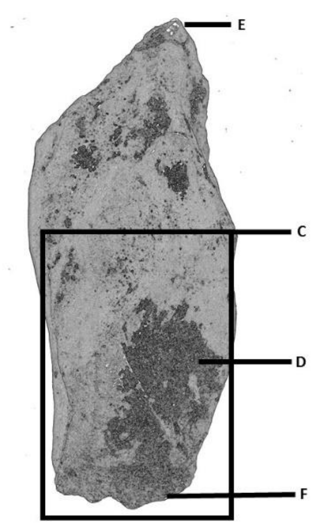


Figure 6-144: Image locations for artefact 70265.

6.2.37 Artefact 70283

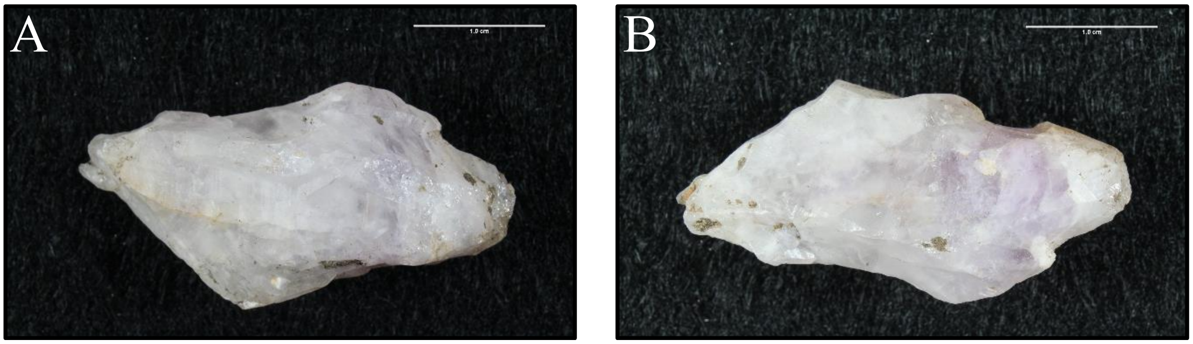


Figure 6-145: Artefact 70283.
A, B – Macro photos. The broader tip is to the right in both.

Artefact 70283 was a small milky quartz with a small amethyst inclusion and measured 35mm long by 16.5mm wide (Figure 6-145). This artefact was selected for the presence of a dark brown residue on both tips. Neither tip appears very suitable for use. See Figure 6-148 for the location of each micrograph.

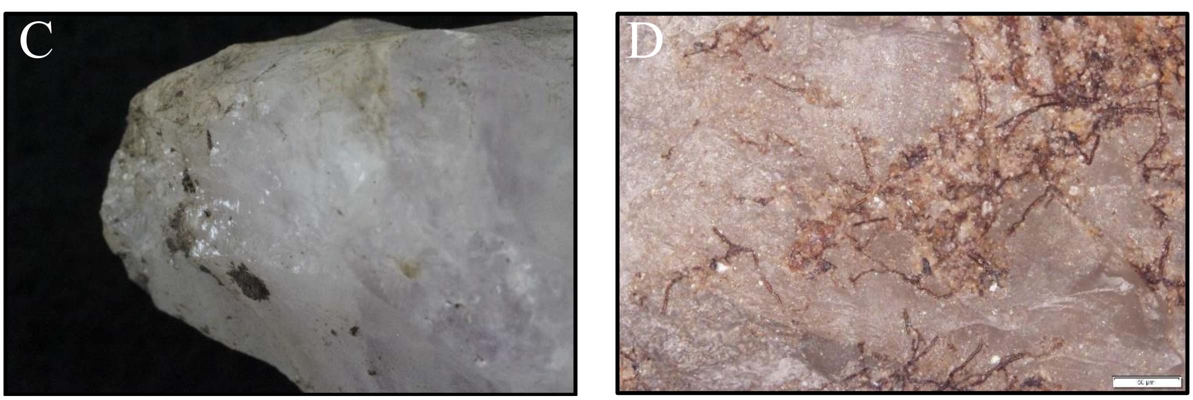


Figure 6-146: Residue on artefact 70283.
C – Residue on broad tip at 20x magnification. D – Class 5 residue.

The HPILM identified the residue as class 5 (Figure 6-146). Biochemical tests produced negative results and protein, but weak positive results for fatty acid. The GC/MS analysis and

HPTLM produced no significant results (Table 6-75; Table 6-76). Based on the classification and presence of fatty acid, the residue was identified as animal. However, this identification is not very confident.

Table 6-75: Residue and use-wear results summary for artefact 70283.

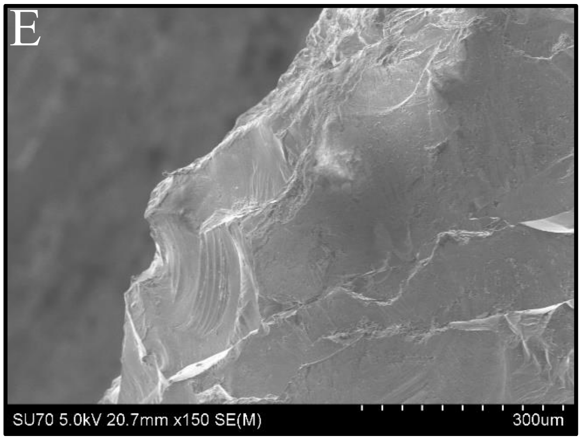
Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
5	No	Weak	N/A	Flake Scars Edge Damage	Unidentifiable	N/A	N/A

Table 6-76: Inquisitive process for artefact 70283 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present on the dorsal surface.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and belonged to a determined classification.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residue was concentrated around possible working tips.
4 – Is it Plant or Animal?	Animal. Based on the residue classification.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis showed edge damage and flake scars at the wider tip (Figure 6-147). No other evidence of use was present. Therefore, although artefact 70283 could have been used, there was not enough data to identify function (Table 6-75).

In conclusion, artefact 70283 produced too few results to identify function. Although residue was visible, the results from analysis were too weak to confidently interpret the residue as animal. In addition, use-wear analysis produced minimal results, which were not diagnostic.



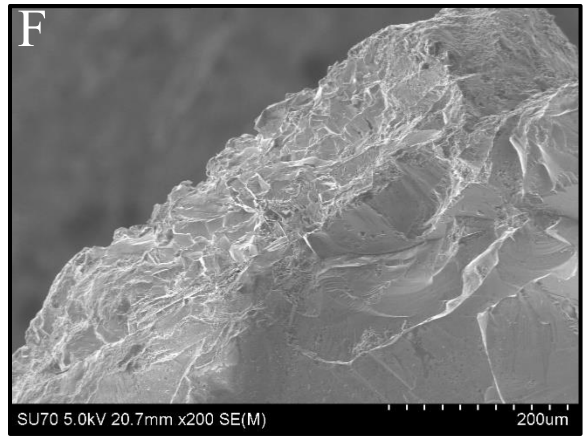


Figure 6-147: Use-wear on artefact 70283.
E – Flake scars on broad tip. F – Edge damage on broad tip.

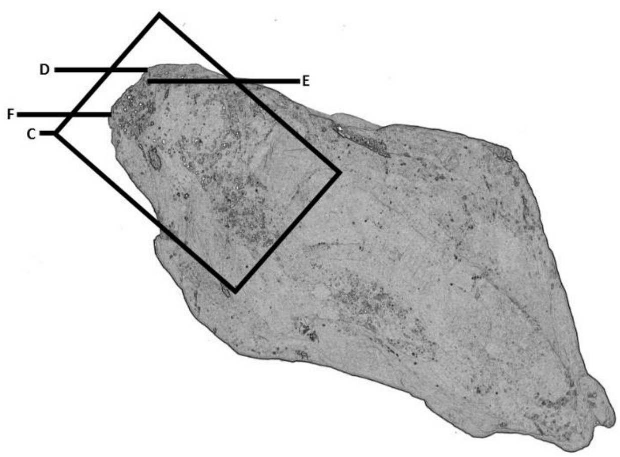


Figure 6-148: Image location for artefact 70283.

6.2.38 Artefact 71653

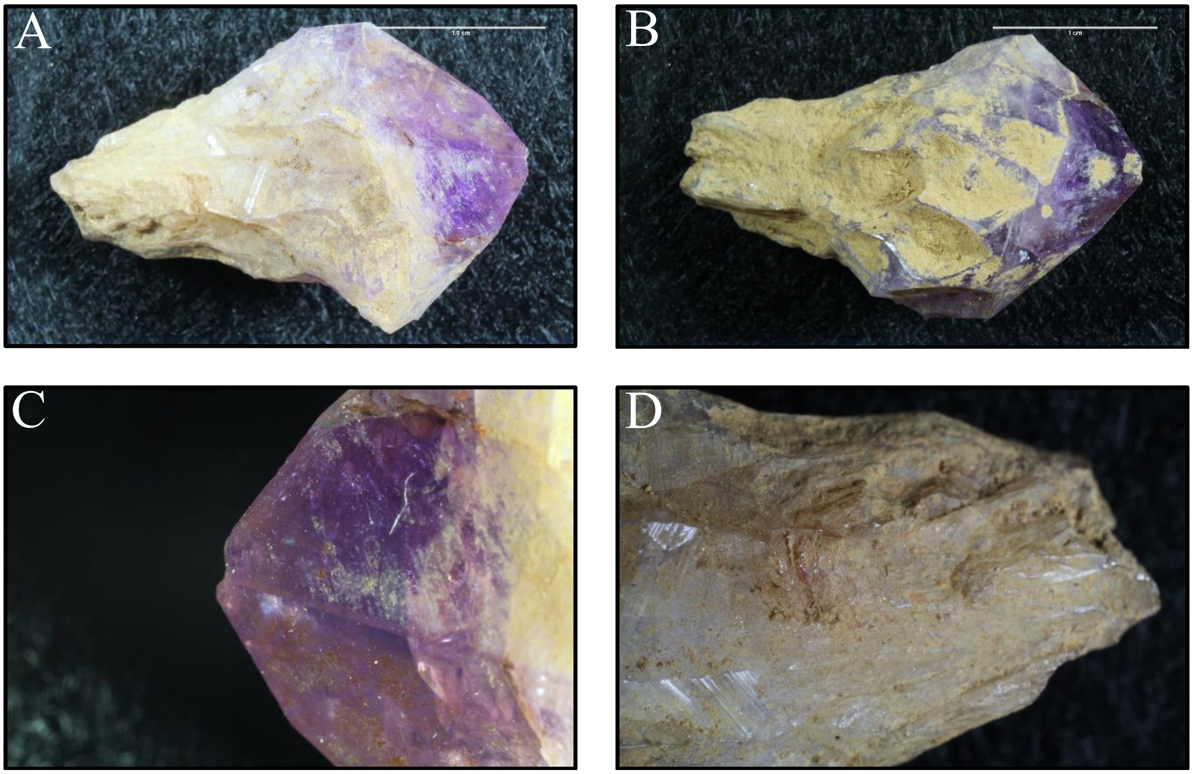


Figure 6-149: Artefact 71653.
A, B – Macro photos. C – Tip at 20x magnification, side A. D – base at 20x magnification, side A.

Artefact 71653 was an amethyst crystal that measured 24mm long and 17mm wide (Figure 6-149). This artefact was selected because of the potential residue adhering to the tip and because it presented another opportunity to determine the function of an amethyst crystal. See Figure 6-152 for the location of each micrograph.

The HPILM identified three residues: classes 1, 2, and 4 (Figure 6-150). All three residues were considered animal-derived. Biochemical tests produced positive results for protein and weak positives for fatty acid, thereby supporting this interpretation. The GC/MS and HPTLM analysis produced no significant results (Table 6-77; Table 6-78). Therefore, the residue was interpreted as animal.

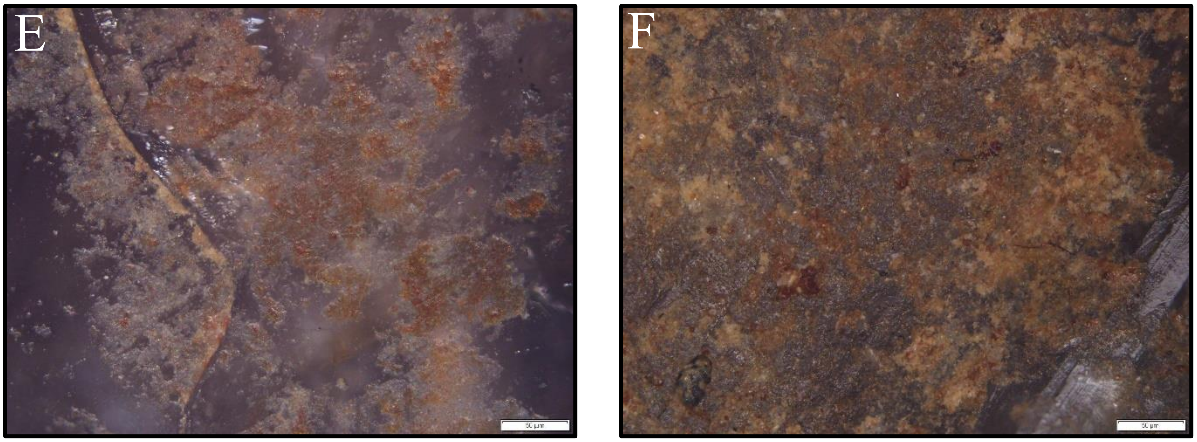


Figure 6-150: Residue on artefact 71653.
E – Class 2 residue. F – Class 1 residue.

Table 6-77: Residue and use-wear results summary for artefact 71653.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1, 2, 4	Yes	Weak	N/A	Flake Scars Edge Damage	Indeterminate	Medium	Puncture

Table 6-78: Inquisitive process for artefact 71653 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the suspected working tip.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residue was located near the tip.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical test results.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

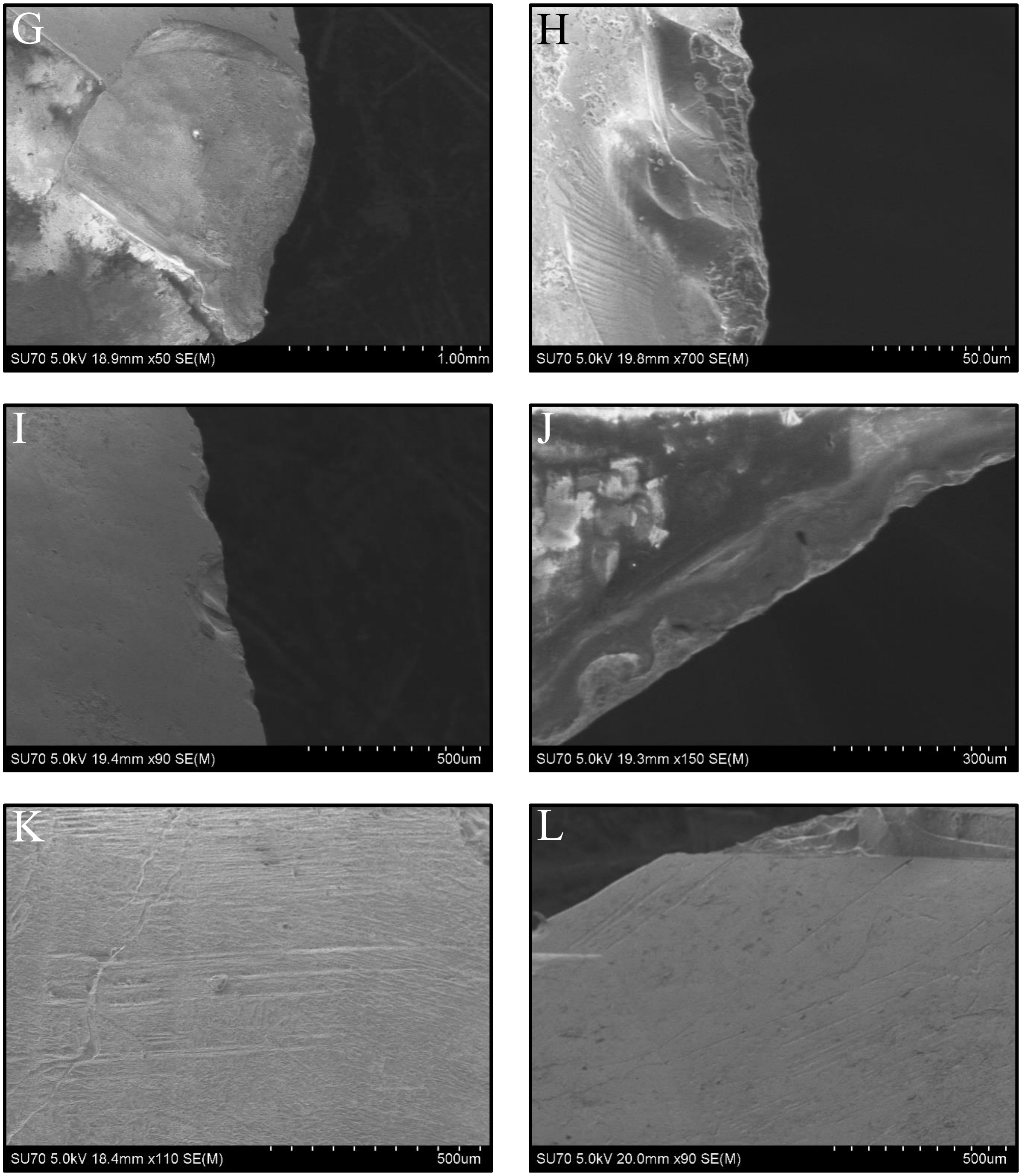


Figure 6-151: Use-wear on artefact 71653.
G – Large flake scar at tip. H – Smaller flake scars within larger flake scar. I, J – Micro-flakes along edges between to crystal faces near the tip. K, L – Striations perpendicular to the working tip.

Use-wear analysis identified flake scars and edge damage at the tip of the artefact (Figure 6-151). Additional flake scars were present along the edge between two crystal faces. Striations were present and oriented perpendicular to the working tip, suggesting a push/pull action that was likely intended to puncture (Table 6-77).

In conclusion, artefact 71653 was considered a tool. Use-wear analysis did not provide very strong results, but damage to the tip and nearby edges in conjunction with perpendicular striations suggested the artefact was used to piece dry hide. The animal residue identified supported this interpretation. However, stronger results were required to increase the confidence of this interpretation.

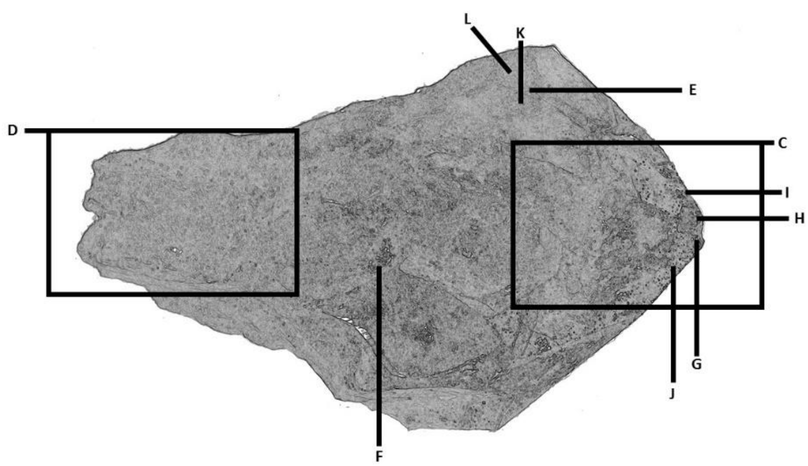


Figure 6-152: Image locations for artefact 71653.

6.2.39 Artefact 71676

Artefact 71676 was an amethyst crystal, which measured 27mm long by 12.5mm wide (Figure 6-153). This artefact was selected because residue was visible under sediment near the tip. In addition, the tip was blunt, possibly caused by use. See Figure 6-156 for the location of each micrograph

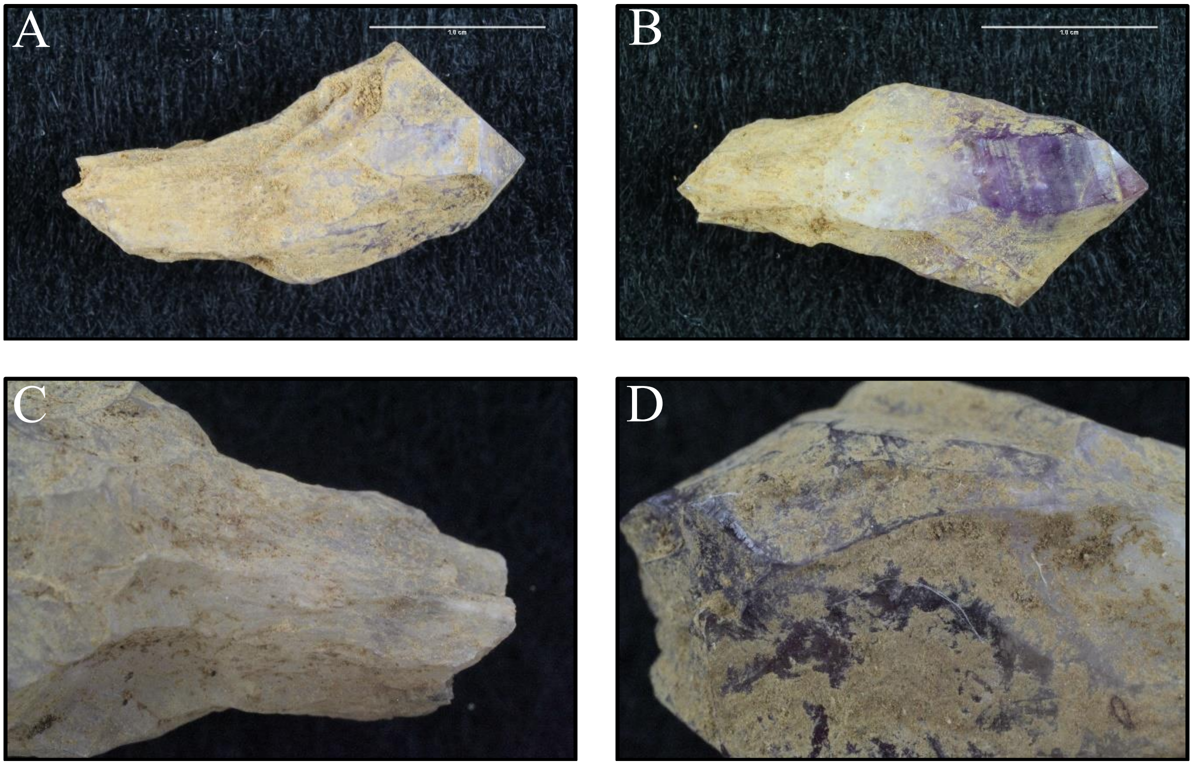


Figure 6-153: Artefact 71676.
A, B – Macro Photos. C – Base at 20x magnification. D – Tip at 20x magnification.

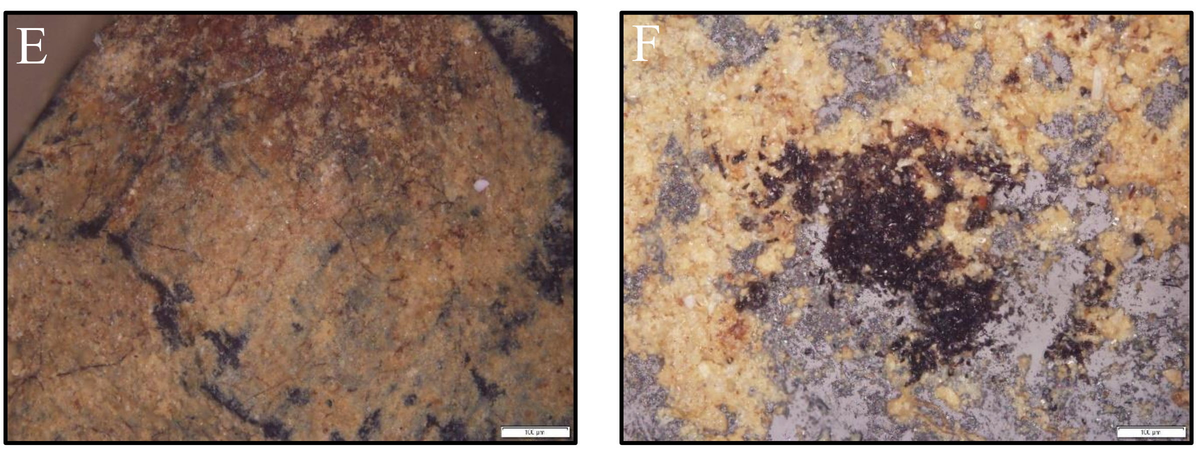


Figure 6-154: Residue on artefact 71676.
E – Class 1 residue. F – Class 16 residue.

The HPILM identified class 1 and class 16 residue (Figure 6-154). Class 1 residue was considered animal-derived. Class 16 residue was a singular occurrence and was a small amount of black residue. There was too little of this residue to individually identify. Biochemical tests produced positive results protein and weak positive results for fatty acid. The GC/MS analysis and HPTLM produced no significant results (Table 6-79; Table 6-80). The residue was interpreted as animal based on the classification and biochemical results.

Table 6-79: Residue and use-wear results summary for artefact 71676.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1, 16	Yes	Weak	N/A	Flake Scars Edge Damage	Unidentifiable	N/A	N/A

Table 6-80: Inquisitive process for artefact 71676 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the suspected working tip.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residue was located near the tip.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical test results.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis showed a battered tip with stress fractures and flake scars, but nothing diagnostic (Figure 6-155). Without striations, a mode of use could not be interpreted. Natural amethyst crystal tips also had flake scars, meaning it was not possible to identify this as a tool (Table 6-79).

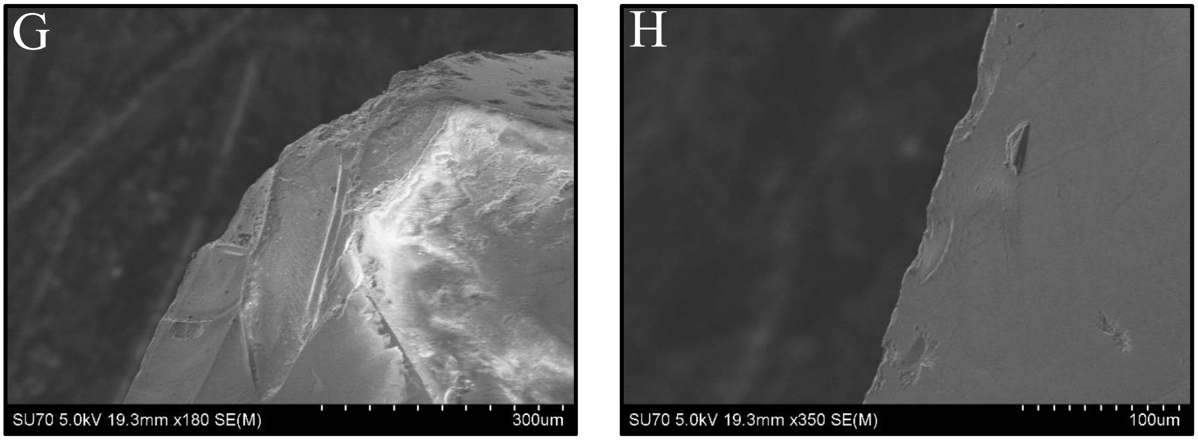


Figure 6-155: Use-wear on Artefact 71676.
G – Flake scars at tip. H – Micro-flaking along edge between crystal faces.

In conclusion, artefact 71676 could not definitively be identified as a tool. Despite the positive results for residue indicated the artefact was used on animal, but the use-wear evidence was not strong enough to confirm the artefact was used extensively. Therefore, artefact 71676 was briefly used as an expedient tool.

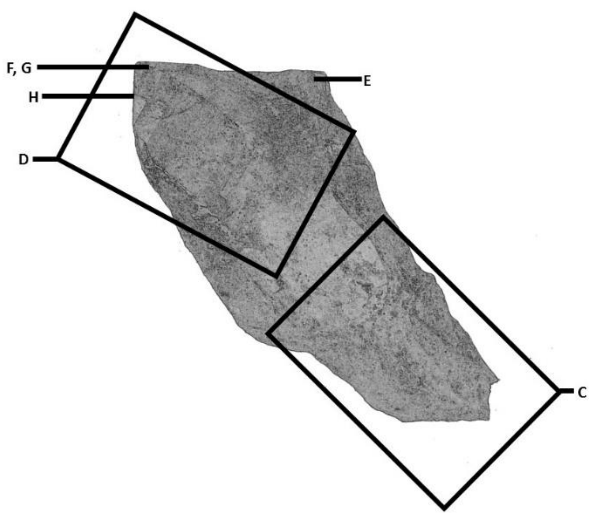


Figure 6-156: Image locations for artefact 71676.

6.2.40 Artefact 72526

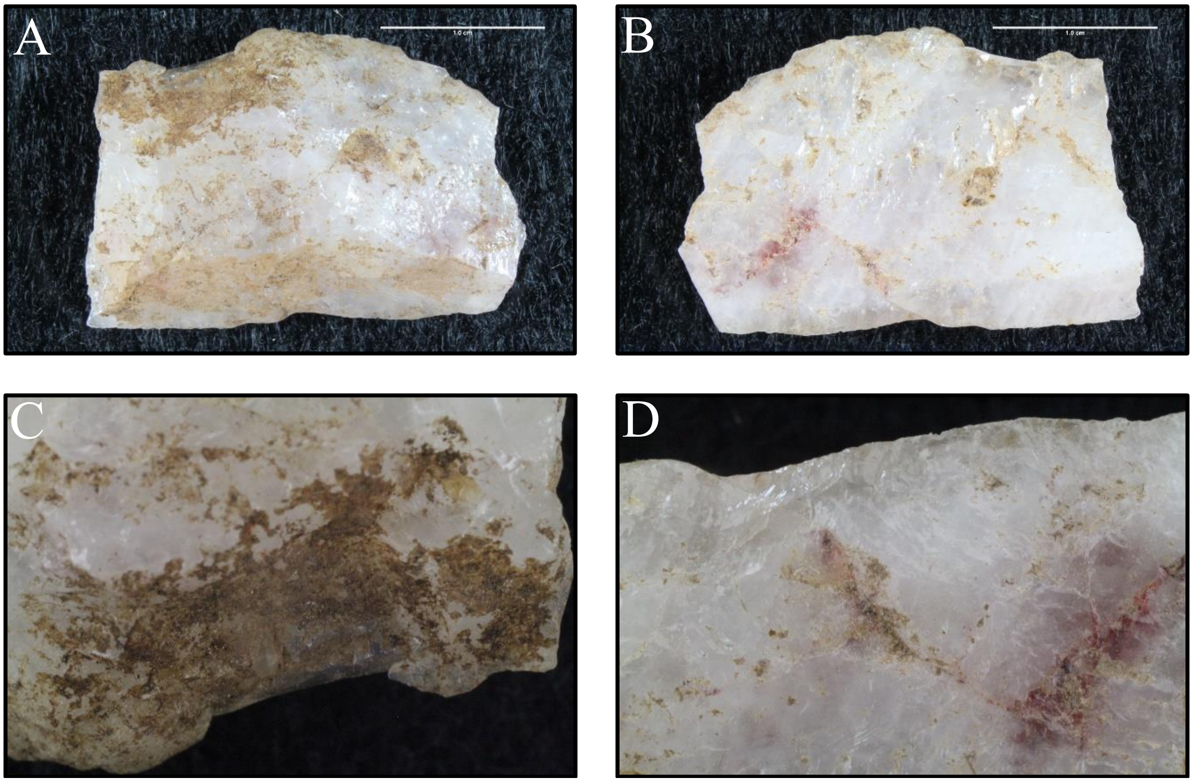


Figure 6-157: Artefact 72526.
A – Dorsal surface. B – Ventral surface. C – Residue on dorsal surface at 20x magnification. D – Straight edge at 20x magnification, ventral surface.

Artefact 72526 was a blocky, milky quartz fragment that measured 29mm long and 18mm wide (Figure 6-157). This artefact was selected for its long straight edge and the large amount of dark brown residue adhering to the dorsal surface of the artefact. The residue was located near the slightly convex and damaged edge. See Figure 6-160 for the location of each micrograph.

The HPILM identified three classes of residue: classes 1, 2, and 5 (Figure 6-158). All of these residues were considered animal in origin. Biochemical tests produced positive results for both protein and fatty acid. The GC/MS analysis and HPTLM produced no significant results (Table 6-81; Table 6-82). The residue was therefore interpreted as animal residue.

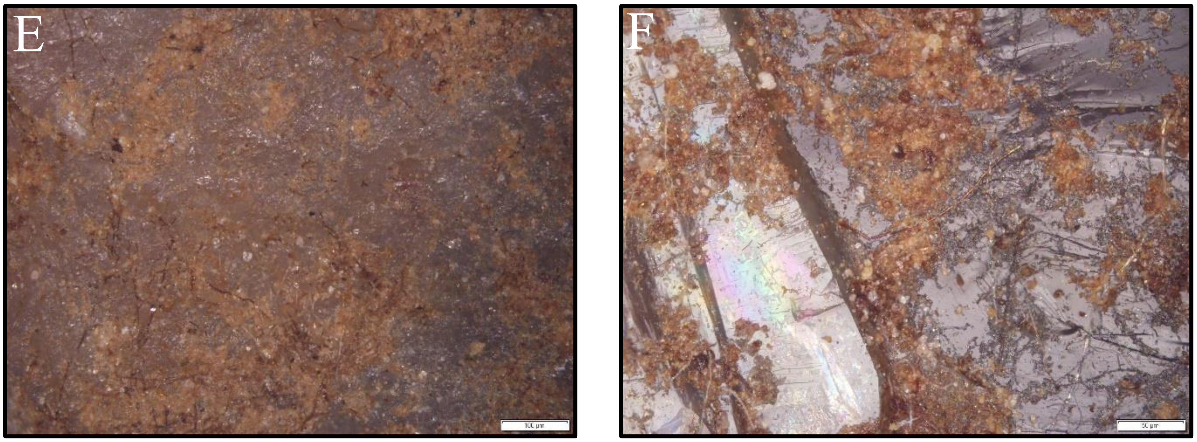


Figure 6-158: Residue on artefact 72526.
E – Class 5 residue. F – Class 2 residue.

Table 6-81: Residue and use-wear results summary for artefact 72526.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
1, 2, 5	Yes	Yes	N/A	Flake Scars Edge Damage	Identifiable	Soft	Push/Pull

Table 6-82: Inquisitive process for artefact 72526 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the suspected working edge.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residues were located near the edge.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical test results.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis showed no signs of wear along the suspected working edge where residue was most densely located. However, use-wear was present along the opposite, straight edge, where class 2 and 5 residues were identified (Figure 6-159). This edge featured multiple flake scars with additional micro-flakes within. Perpendicular striations were located in the middle of the ventral surface, indicating a pulling/pushing motion (Table 6-81).

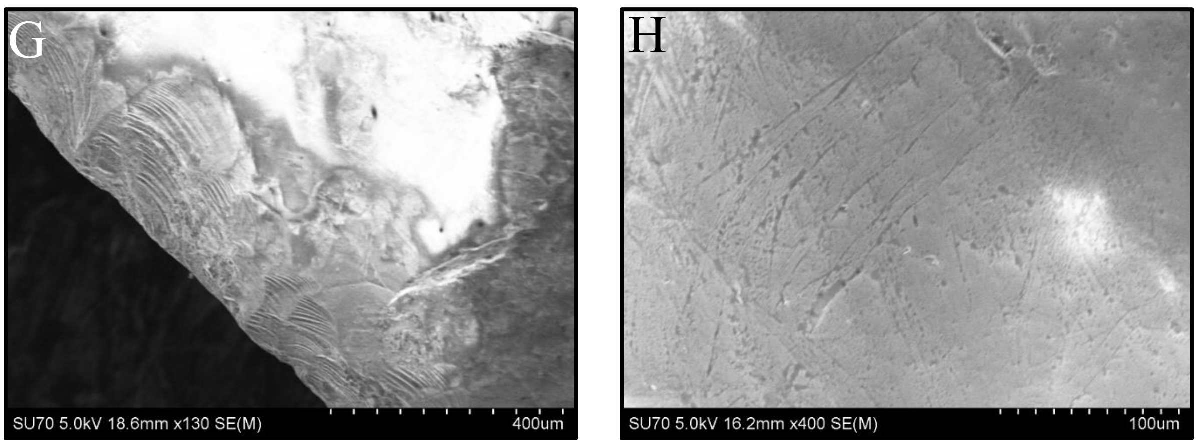


Figure 6-159: Use-wear on artefact 72526.
G – Micro-flaking along straight edge. H – Striations near middle on ventral surface. Oriented perpendicular to the working edge.

In conclusion, artefact 72526 was a tool. Residue analysis identified animal-derived residue on the dorsal surface. Interestingly, this residue was concentrated along the edge opposite to where use-wear was identified. Either a singular task was incredibly messy and residue was distributed across the tool, or the artefact was multifunctional but residue only survives from one activity. Use-wear suggested a pulling motion that was interpreted as scraping. The scars also suggested a softer material because of the smaller size of the flake scars and shallowness of the striations. Therefore, this tool functioned as a scraper to scrape fresh hide.

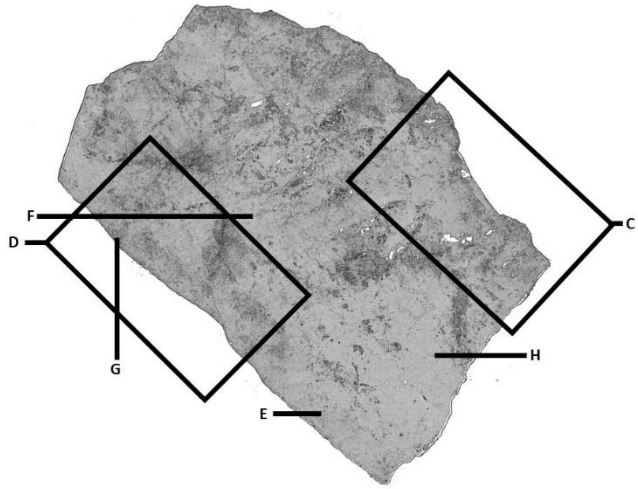


Figure 6-160: Image locations for artefact 72526.

6.2.41 Artefact 76189

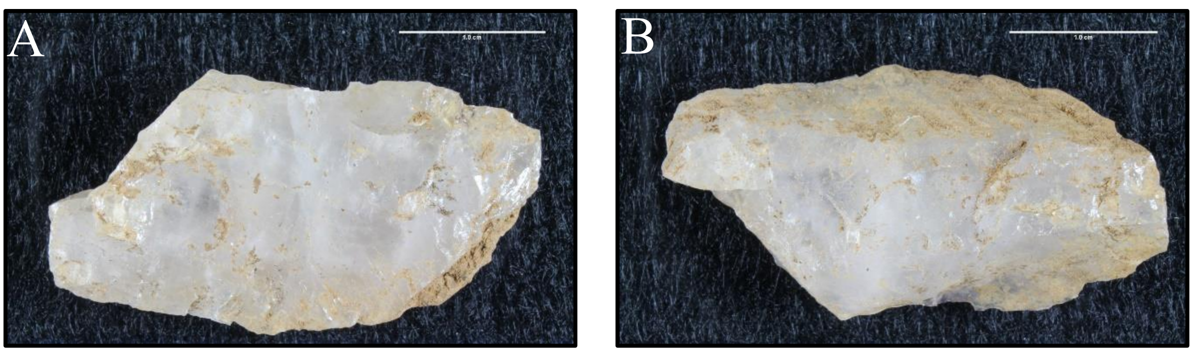


Figure 6-161: Artefact 76189.
A – Ventral surface. B – Dorsal surface.

Artefact 76189 was a milky/crystal quartz flake that measured 35mm long and 18mm wide (Figure 6-161). This artefact was selected for the presence of a dark brown residue with hyphae growth near a rough edge. The morphology was also similar to other artefacts, such as 77023. See Figure 6-164 for the location of each micrograph.

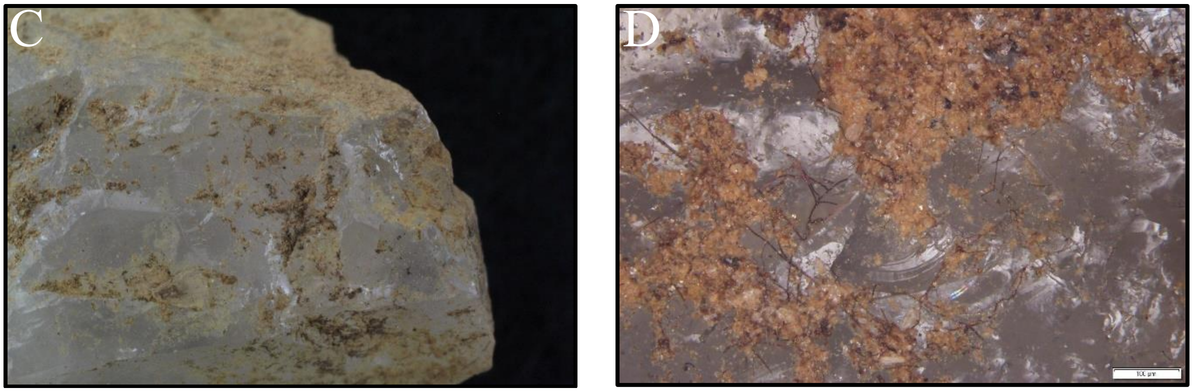


Figure 6-162: Residue on artefact 76189.
C – Residue on dorsal surface at 20x magnification. D – Class 1 residue.

Table 6-83: Residue and use-wear results summary for artefact 76189.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
1,	Yes	Weak	N/A	Edge Damage Ridge Wear	Unidentifiable	N/A	N/A

Table 6-84: Inquisitive process for artefact 76189 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the suspected working edge.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residues were located near the edge.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical test results.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

The HPILM identified class 1 residue, but was almost considered class 7 because of its coarser texture (Figure 6-162). Biochemical tests produced positive results for protein and a weak positive for fatty acid. The GC/MS analysis and HPTLM produced no significant results

(Table 6-83; Table 6-84). Therefore, based on the classification and biochemical test results, the residue was interpreted as animal.

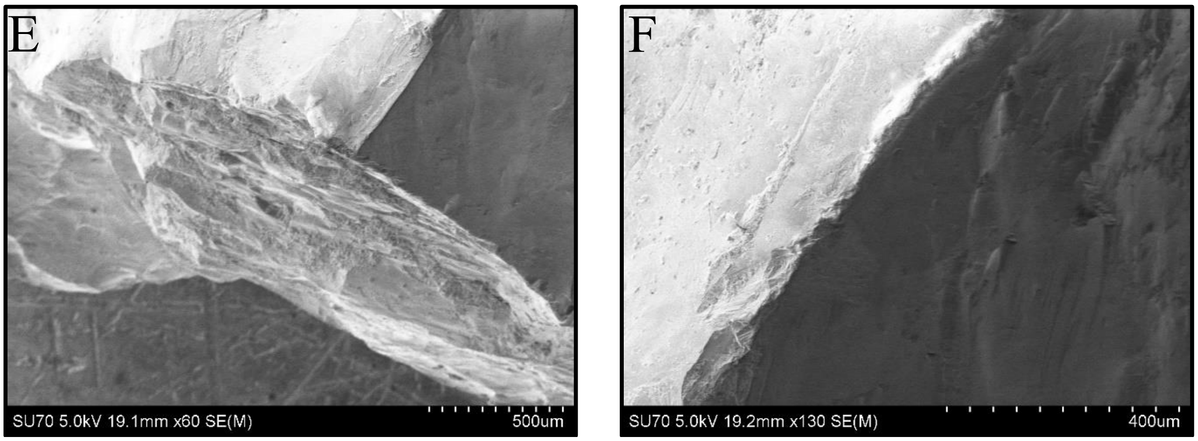


Figure 6-163: Use-wear on artefact 76189.
E – Slight rounding of broken edge. F – Slight rounding of ridge near broken edge.

Use-wear analysis produced few results. Some minor edge rounding was visible along the broken edge where a tip may have existed (Figure 6-163). A ridge in this area was also slightly worn. Unfortunately, no diagnostic wear was present to contextualize the residue results (Table 6-83).

In conclusion, artefact 76189 was used, but its exact function is undetermined. Residue analysis produced positive results for an animal-derived residue, but use-wear analysis was unable to determine the artefact was used. The edge was not particularly sharp and if a tip was present, a large portion had broken off, taking with it any diagnostic indications of use.

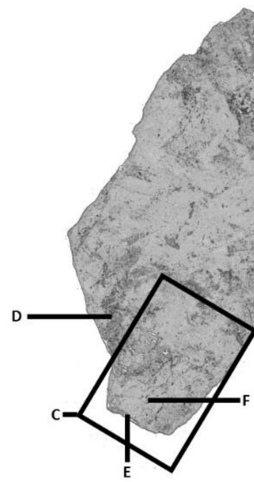


Figure 6-164: Image locations for artefact 76189.

6.2.42 Artefact 77023

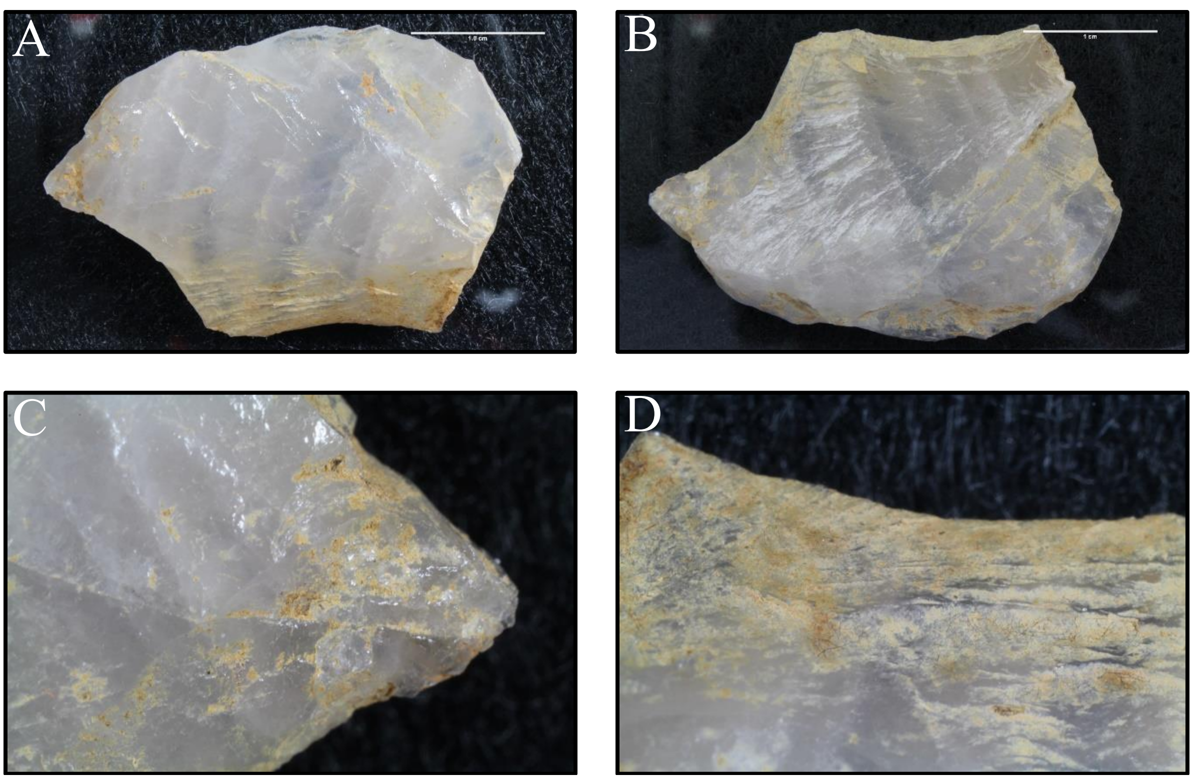


Figure 6-165: Artefact 77023.
A – Dorsal surface. B – Ventral surface. C – Functional tip at 20x magnification, ventral surface. D – Concave edge, Dorsal surface.

Artefact 77023 was clear, but slightly smoky quartz flake, which measured 35mm long and 24mm wide (Figure 6-165). This artefact was selected for the presence of residue near the tip and concave edge. In addition, its morphological shape was similar to a burin and resembled other artefacts identified for analysis. See Figure 6-168 for the location of each micrograph.

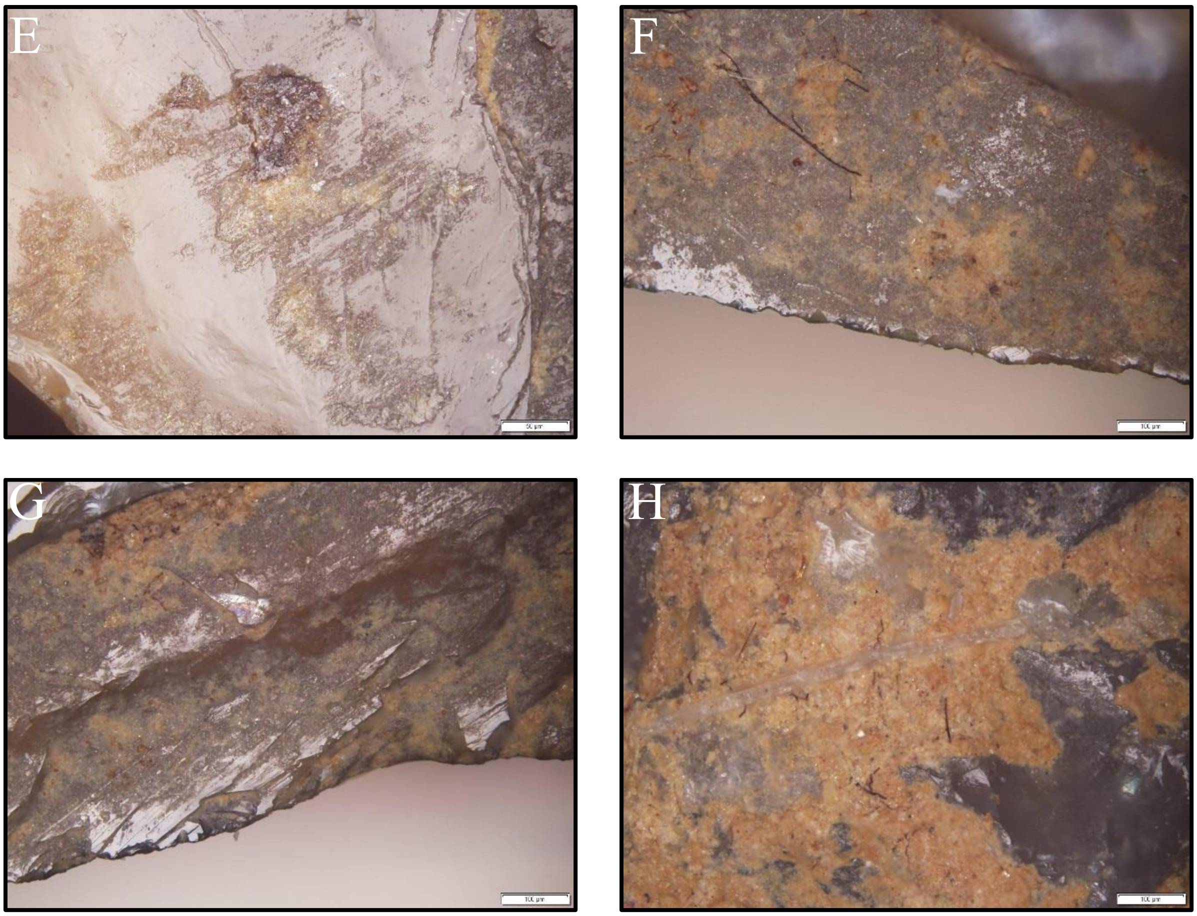


Figure 6-166: Residue on artefact 77023.
E – Class 2 Residue. F, G – Class 4 residue with micro-flaking along edge. H – Class 4 residue.

The HPILM identified class 2 and class 4 residue (Figure 6-166). Both residues were identified as animal-derived. Biochemical tests produced positive results for fatty acid. The HPTLM identified animal fibres. The GC/MS analysis produced no significant results.

Therefore, based on the residue classifications, biochemical tests, and HPTLM the residue was animal (Table 6-85; Table 6-86).

Table 6-85: Residue and use-wear results summary for artefact 77023.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
2, 4	No	Yes	Animal	Striations Flake Scars Edge Damage	Identifiable	Medium/ Soft	Push/Pull

Table 6-86: Inquisitive process for artefact 77023 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the suspected functional areas.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residues were located near functional areas.
4 – Is it Plant or Animal?	Animal. Based on the residue classification, biochemical tests, and HPTLM.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis produced extensive evidence of use (Figure 6-167). The functional tip was rounded and full of flake-scars. The edges of older flake scars were rounded, which suggested the artefact was used repeatedly for a longer duration. Parallel striations were also present near the tip, suggesting a twisting or a cutting motion near the manufactured area around the tip. Striations were also present where the artefact was flatter in the centre of the ventral surface. These could be a result of using the concave edge, where half-moon micro-flakes were observed

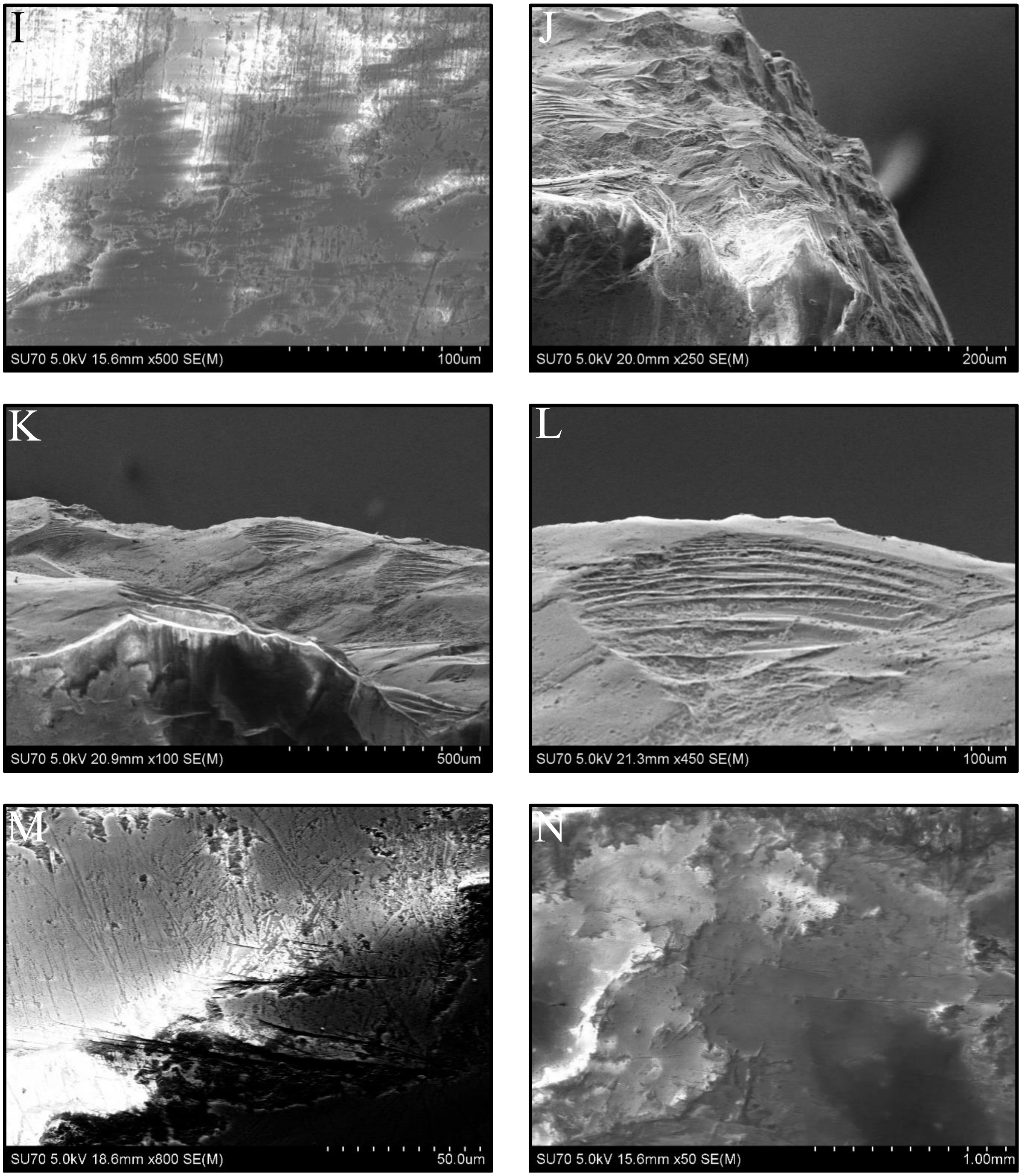


Figure 6-167: Use-wear on artefact 77023.
I – Striations perpendicular to the concave edge. J – Edge damage and flake scars on the functional tip. K, L – Flake scars with rounded edges. M – Striations perpendicular to the manufactured edge adjacent to the tip. N – Striations perpendicular to the tip, but located in middle.

using HPILM. The extensive edge rounding suggested a softer material (Table 6-85). The artefact was likely multifunction, serving as both a burin and scraper.

In conclusion, artefact 77023 was a tool. Use-wear analysis indicated it was multifunctional, while residue analysis identified the residue as animal. The tip area was well worn. Micro-flakes were present, but edges were very rounded, suggesting a softer material was worked. This could indicate either piecing fresh or raw hide. Along the concave edge, micro-flakes were visible and striations located near the centre of the artefact were roughly perpendicular to this edge. Therefore, this artefact was likely used to scrape fresh or dry hide as well.

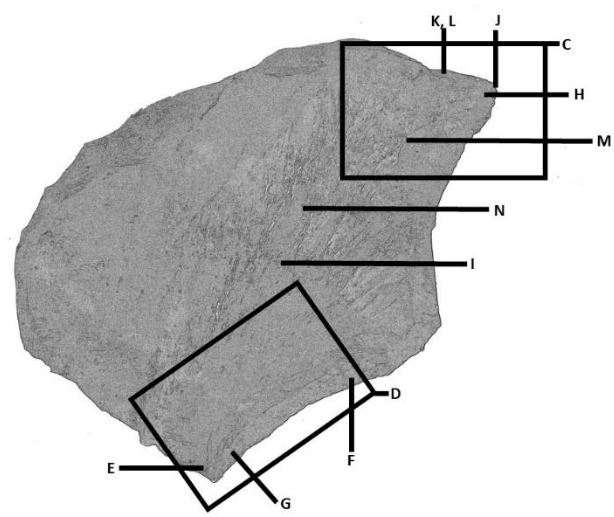


Figure 6-168: Image locations for artefact 77023.

6.2.43 Artefact 77176

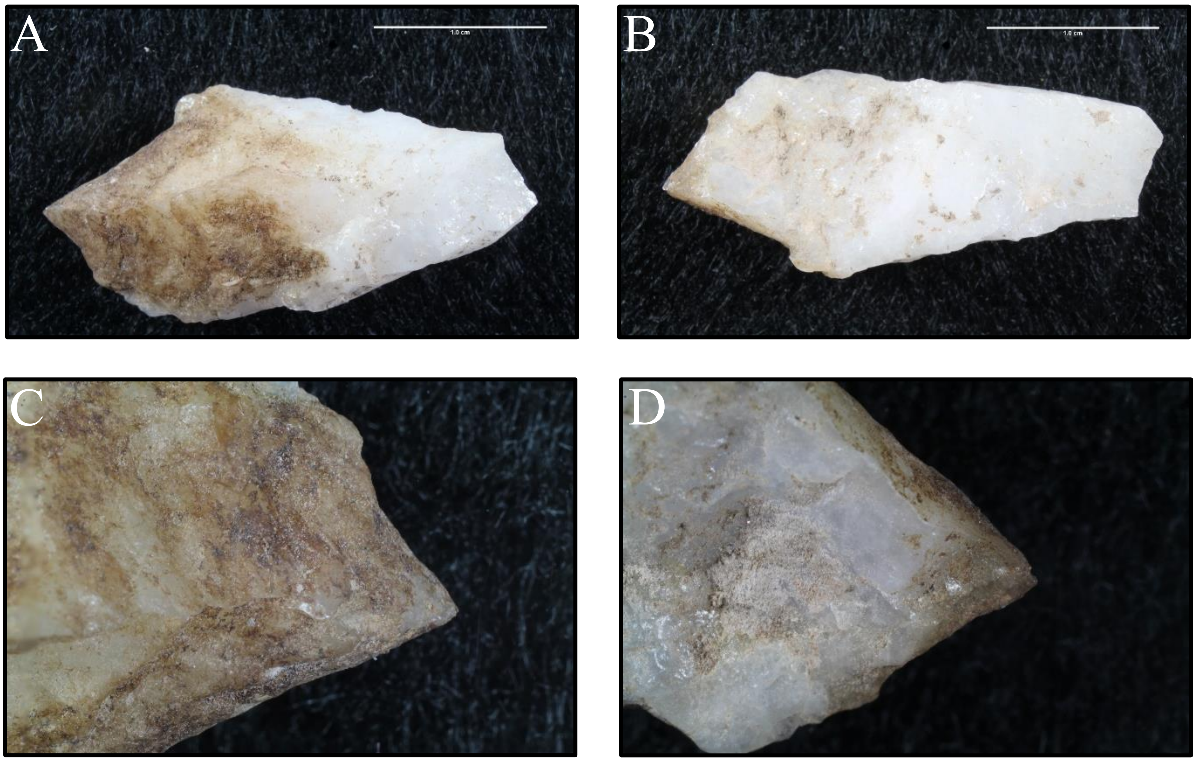


Figure 6-169: Artefact 77176.
A – Dorsal surface. B – Ventral surface. C – Residue at 20x magnification near suspected functional area, dorsal surface. D – Suspected functional area at 20x magnification, ventral surface.

Artefact 77176 was a small milky quartz flake, which measured 29mm long and 14mm wide (Figure 6-169). This artefact was selected the extensive residue accumulated on the dorsal surface of the artefact. In addition, the residue was accumulated near a functional tip. See Figure 6-171 for the location of each micrograph.

The HPILM identified class 6 residue (Figure 6-170), which was present on four other artefacts and considered to be an animal residue. Biochemical tests produced positive results for protein and fatty acid. Interestingly, Hb-CRTS produced a negative result and thus cannot support that the residue contains any blood. This is interesting because artefact 15387, which has class 6 residue, produced the strongest positive result for this test. Both the GC/MS and HPTLM analysis produced no significant results (Table 6-87; Table 6-88). Therefore, based on the HPILM and biochemical tests the residue was interpreted as animal.

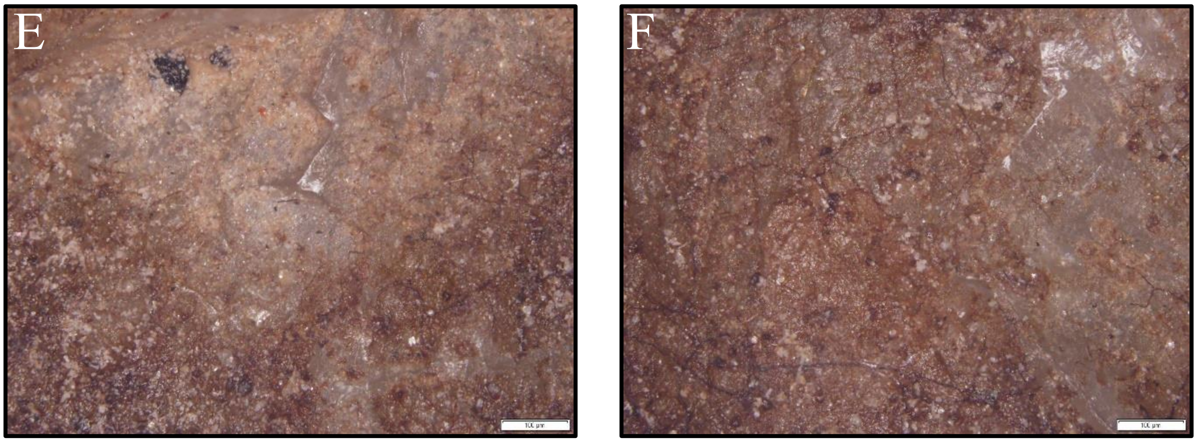


Figure 6-170: Residue on artefact 77176.
E – Class 6 residue, scale bar 100µm. F – Class 6 residue, scale bar 50µm.

Table 6-87: Residue and use-wear results summary for artefact 77176.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
6	Yes	Yes	N/A	N/A	N/A	N/A	N/A

Table 6-88: Inquisitive process for artefact 77176 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the suspected functional area.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residues were located near the functional area.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical tests.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis produced no results (Table 6-87). In general, too much charging obscured any potential use-wear, making interpretations impossible. Therefore, use-wear analysis could not identify this artefact as a tool.

In conclusion, artefact 77176 produced strong residue results, but function could not be confidently determined because use-wear results were insufficient. Its morphology suggested a functional application as either a burin or an awl that was used on animal material, but this interpretation is speculative until further use-wear analysis can be completed.

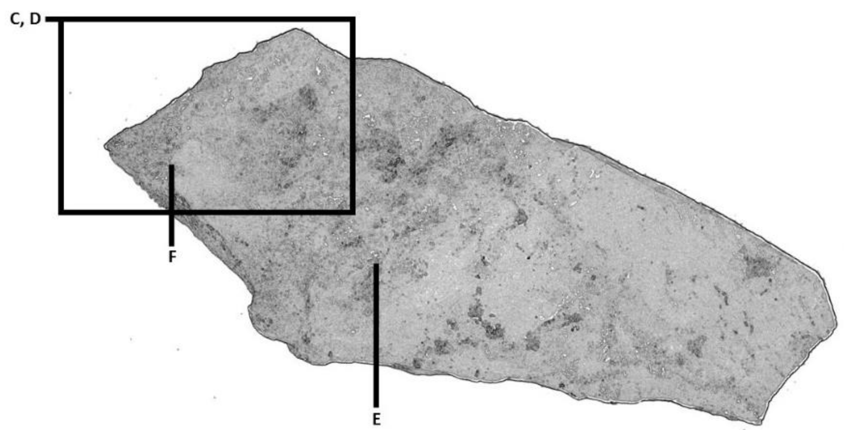


Figure 6-171: Image locations for artefact 77176.

6.2.44 Artefact 86944

Artefact 86944 was a milky/crystal quartz that measured 24mm long 23mm wide (Figure 6-172). This artefact was selected because of the dark residue adhering to the dorsal surface. The suspected functional areas were thin edges on opposite sides of the artefact. Residue was concentrated around the convex edge. See Figure 6-175 for the location of each micrograph.

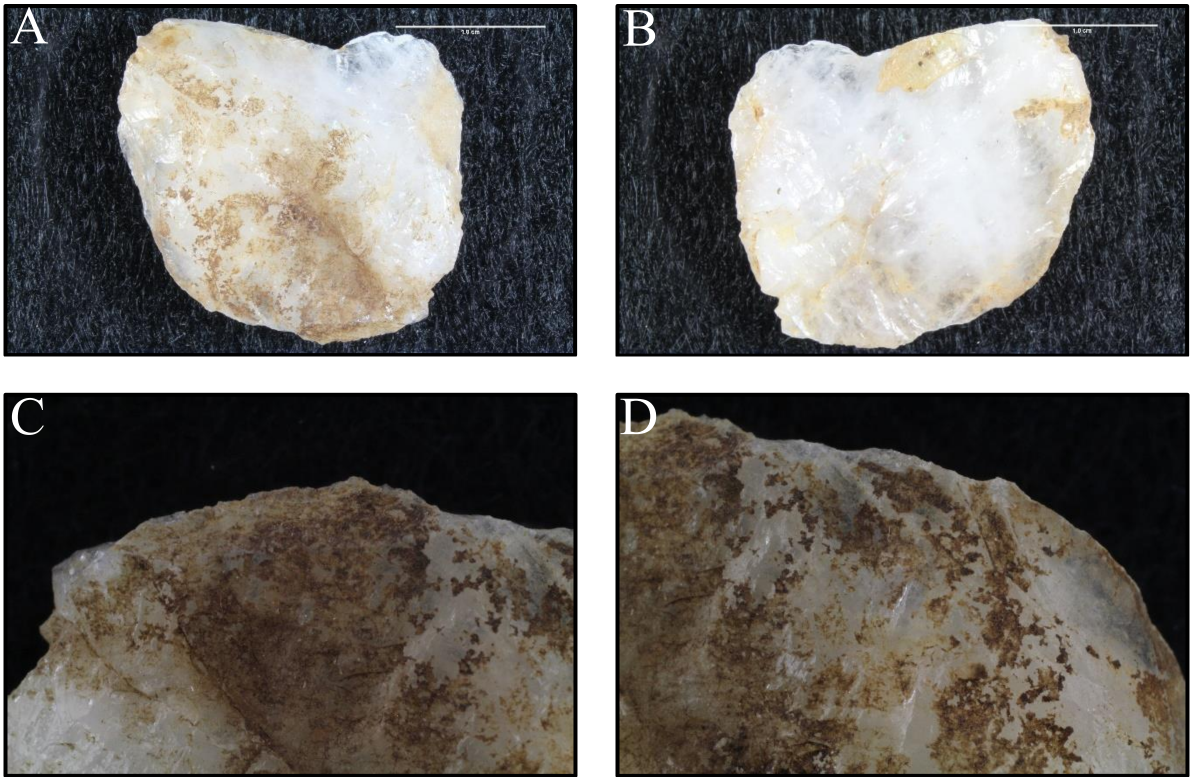


Figure 6-172: Artefact 86944.
A – Dorsal surface. B – Ventral surface. C, D – Residue at 20x magnification, dorsal surface.

The HPILM identified class 4 and class 6 residue (Figure 6-173E, F). Both were interpreted as animal-derived. Biochemical tests produced a weak positive result for protein and a positive result for fatty acid. The GC/MS and HPTLM analysis produced no significant results (Table 6-89; Table 6-90). Therefore, based on the residue classifications and biochemical tests the residue was interpreted as animal. However, SEM analysis showed a large amount of residue adhering to the surface of the artefact with identifiable plant material (Figure 6-173G, H). This material was suspected to be environmental contamination since visually and biochemically the residues resembled residue on other artefacts that did not have such a large amount of plant material.

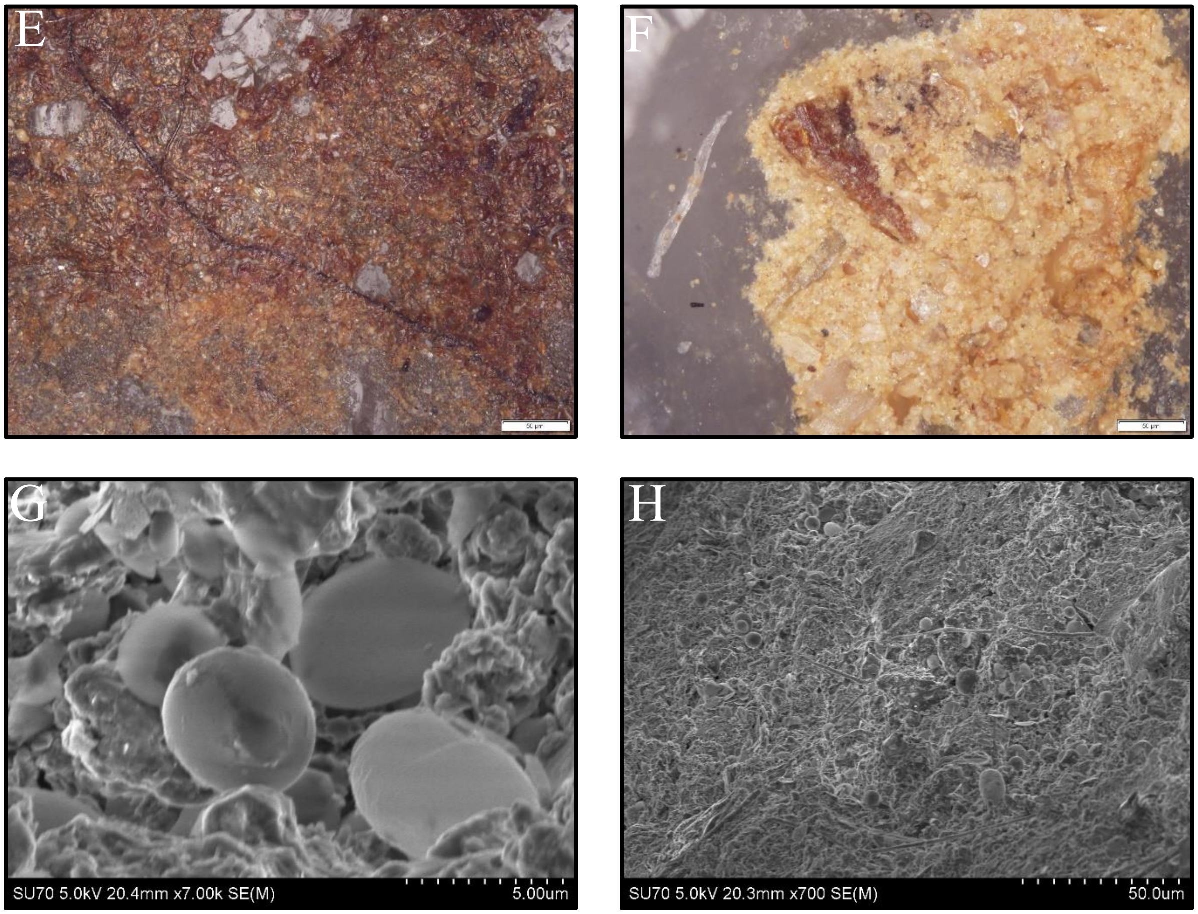


Figure 6-173: Residue on artefact 86944.
E – Class 6 residue, scale bar 50µm. F – Class 4 residue, scale bar 50µm. G, H – Plant material that were likely environmental contamination.

Table 6-89: Residue and use-wear results summary for artefact 86944.

Residue				Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
4, 6	Weak	Yes	N/A	Striations Flake Scars Edge Damage	Indeterminate	Soft	Push/Pull

Use-wear analysis identified striations, flake scars, and edge damage (Figure 6-174). Flake scars and edge damage were located along the shorter curved edge. On two different edges (the edges originally suspected as functional areas) striations were identified and oriented perpendicular to the working edges, suggesting a pulling or pushing motion, such as scraping. The depth and width of these striations suggest a softer material (Table 6-89).

Table 6-90: Inquisitive process for artefact 86944 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near one suspected functional area.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residues were located near one functional area.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical tests.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

In conclusion, artefact 86944 was a tool. Residue analysis interpreted the residue as animal-derived, based on the HPILM classifications and biochemical test results. The SEM analysis identified plant material, but these were suspected to be environmental contamination. Use-wear analysis produced evidence of use, but the frequency of use-wear scars lowered the confidence level of the interpretation. The tool was interpreted as a scraper with three functional edges that were used to scrape fresh or dry hide.

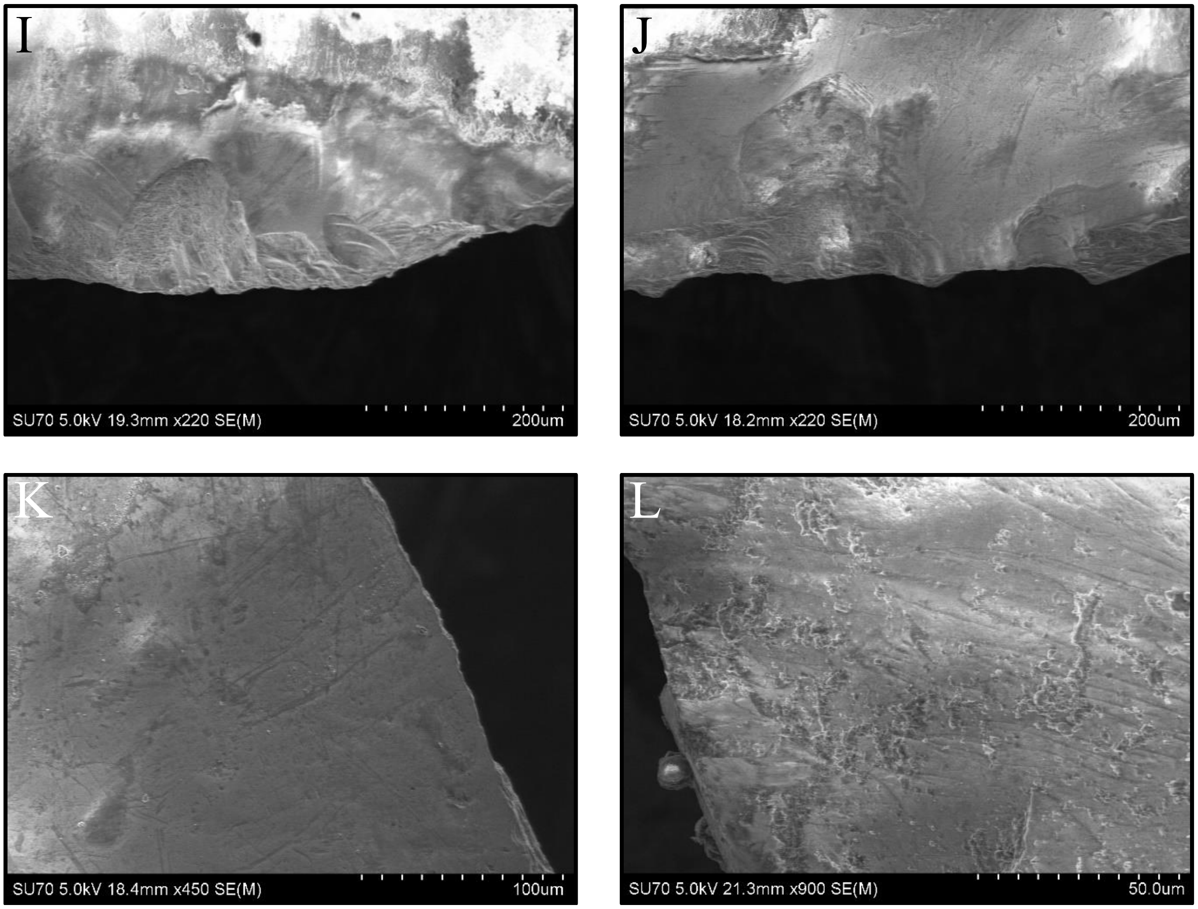


Figure 6-174: Use-wear on artefact 86944.
I, J – Flake scars and edge damage along shorter curved edge. K – Perpendicular striations along straight edge. L – Perpendicular striations along longer curved edge.

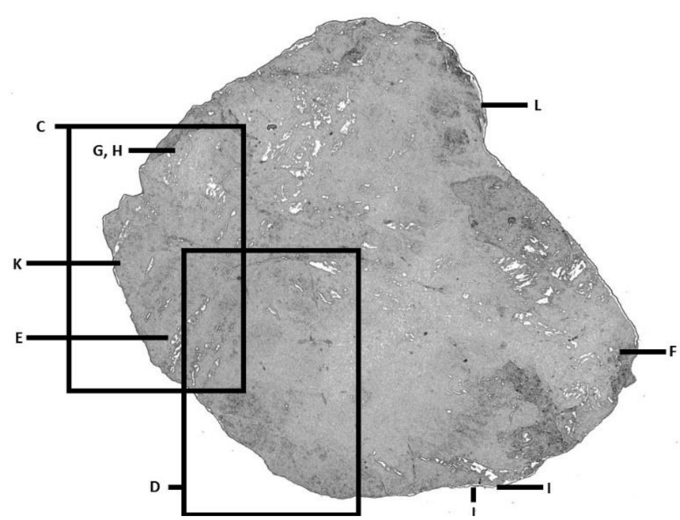


Figure 6-175: Image location for artefact 86944.

6.2.45 Point-1

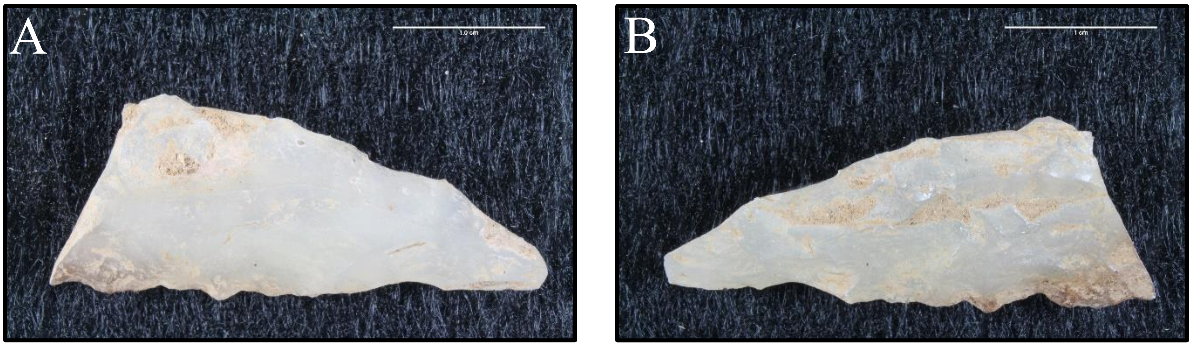


Figure 6-176: Point-1
A, B – Macro images of Point-1. Residue was located on side B.

Point-1 was a small point fragment made of a smoky translucent quartz, measuring 32.5mm long and 13mm long (Figure 6-176). Identified in the CRM catalogue as a projectile point, this artefact was selected for the dark brown residue adhering to its scalloped edge. See Figure 6-178 for the location of each micrograph.

The HPILM identified class 12 residue (Figure 6-177). This residue was interpreted as a blood residue based on the dehydration and desiccation cracking. Biochemical tests produced positive results for protein. One AS reading was particularly high and was likely the result of particulate material contaminating the reading. The GC/MS and HPTLM analysis produced no significant results (Table 6-91; Table 6-92). Therefore, the residue classification and biochemical tests identified the residue as blood.

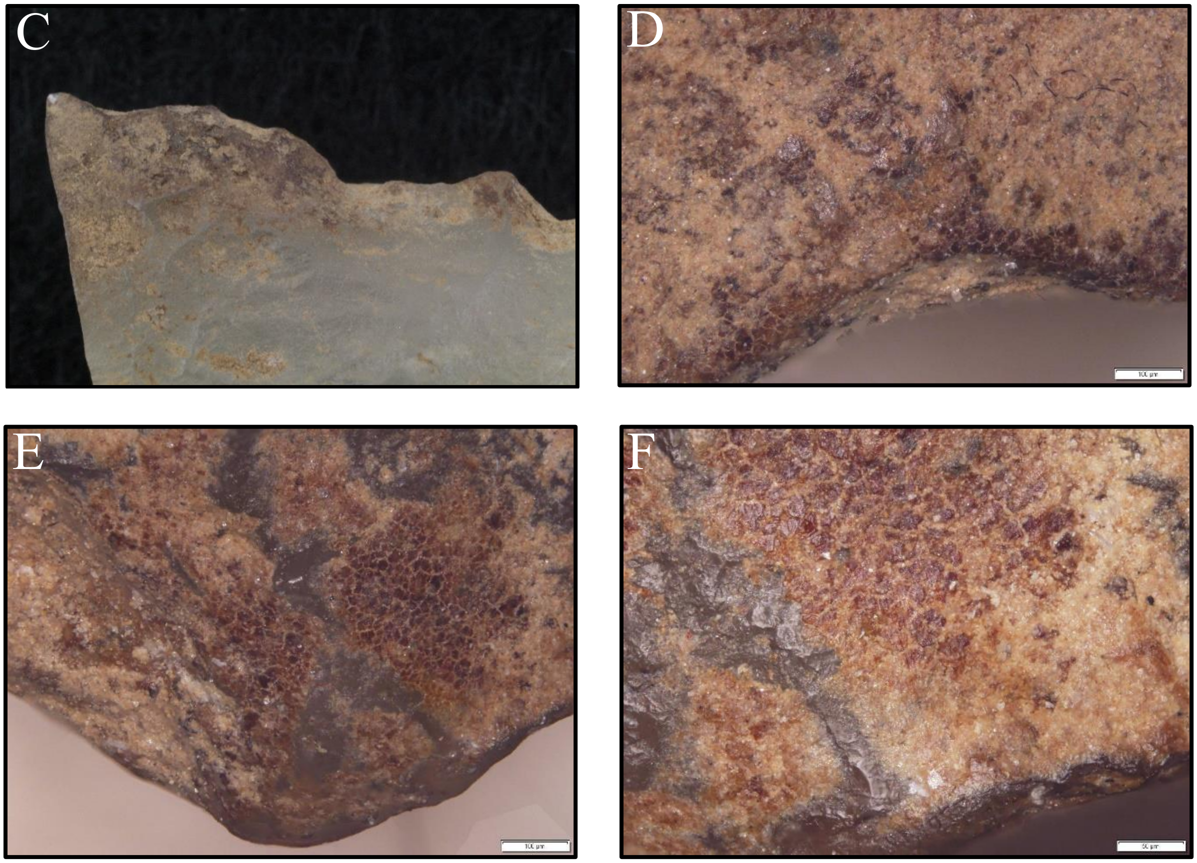


Figure 6-177: Residue on Point-1.
C – Residue at 20x magnification. D, F – Class 12 residue, scale bar 50µm. E – Class 12 residue, scale bar 100µm.

Table 6-91: Residue and use-wear results summary for artefact Point-1.

	Residue			Use-Wear			
Class.	**Protein**	**Fatty Acid**	**Particulate Material**	**Scars**	**Degree**	**Hardness of Source Material**	**Mode of Use**
12	Yes	No	N/A	Edge Damage	Unidentifiable	N/A	N/A

Use-wear analysis produced no results other than a little edge damage (Table 6-91). Projectile points do not always have microwear, particularly if there is only a small fragment left. Although use-wear analysis could not confirm use, this artefact was still a tool because of its CRM catalogue designation.

Table 6-92: Inquisitive process for artefact Point-1 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present along the scalloped edge.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residues were located along the edge.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical tests. Most likely blood residue.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

In conclusion, although Point-1 lacked any use-wear data to indicate it was used, it was still considered a tool. The presence of blood residue suggested the artefact was used for its designated purpose. It was possible the artefact broke from use. Unfortunately, no other pieces were identified in the collection for refit analysis.

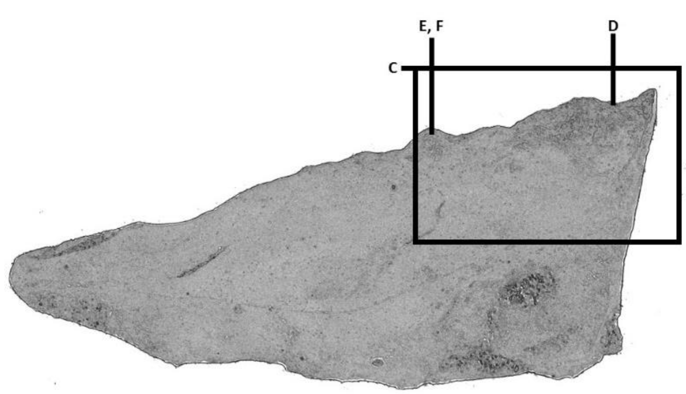


Figure 6-178: Image locations for Point-1.

6.2.46 Point-2

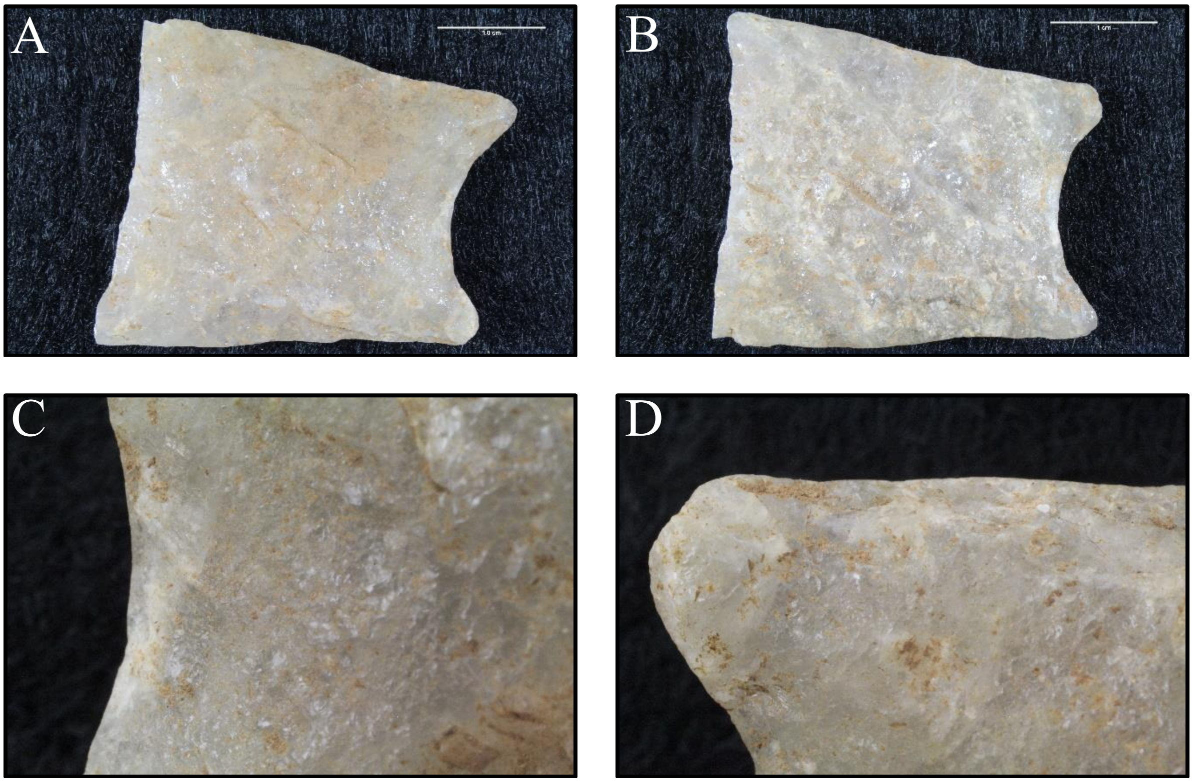


Figure 6-179: Point-2
A, B – Macro images. C – Concave edge at 20x magnification. D – "Ear" at 20x magnification.

Point-2 was the base fragment of quartz point, which measured 36mm long and 31mm wide (Figure 6-179). This artefact was selected for the possibility of hafting residue adhering to the surface. Since only the base was present, use-related residue was not anticipated. See Figure 6-182 for the location of each micrograph.

The HPILM identified class 1 and class 4 residue (Figure 6-180). These were both interpreted as animal and are similar in appearance, suggesting a relationship between these residues. Biochemical testing produced a weak positive result for protein. The GC/MS and HPTLM analysis produced no significant results (Table 6-93; Table 6-94). No evidence for plant or resin material was observed that could have been part of hafting residue.

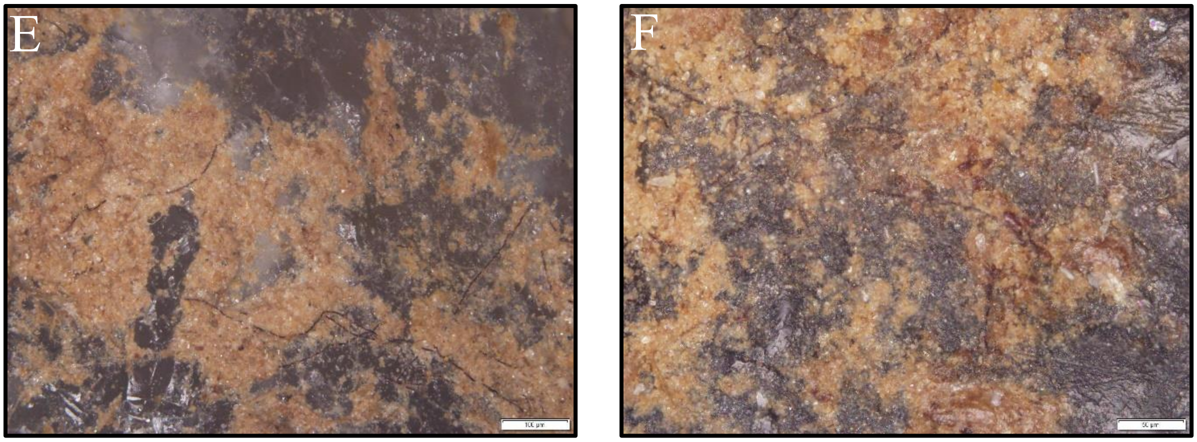


Figure 6-180: Residue on Point-2
E – Class 4 residue, scale bar 100µm. F – Class 1 residue, scale bar 50µm.

Table 6-93: Residue and use-wear results summary for artefact Point-2.

Residue				Use-Wear			
Class.	Protein	Fatty Acid	Particulate Material	Scars	Degree	Hardness of Source Material	Mode of Use
1, 4	Weak	No	N/A	Striations Flake Scars	Indeterminate (For hafting)	N/A	N/A

Table 6-94: Inquisitive process for artefact Point-2 to authenticate and identify residue.

Question	Observation
1 – Is Residue Present?	Yes. Residue was present near the suspected hafting area.
2 – Is it Organic or Inorganic?	Organic. Residues were amorphous and confirmed to be organic using SEM/EDS.
3 – Is it anthropogenic or environmental?	Anthropogenic. Residues were located near the hafting area.
4 – Is it Plant or Animal?	Animal. Based on the residue classification and biochemical tests.
5 – Can a specific tissue be identified?	No.
6 – Can a taxonomic identification be identified?	No.

Use-wear analysis identified one area of hafting related scars (Table 6-93; Figure 6-181G). Near the medial line of the artefact by the concave base a series of short, deep striations were observed. These striations were oriented parallel to the base and perpendicular to the edges. This suggested a small amount of rubbing occurred between the hafting material and the point. Edge grinding was present along the edges near the base (Figure 6-181I, J). Although technically a manufacturing-related wear, this was necessary to dull the sharp edges to avoid unnecessary damage to the hafting fibres.

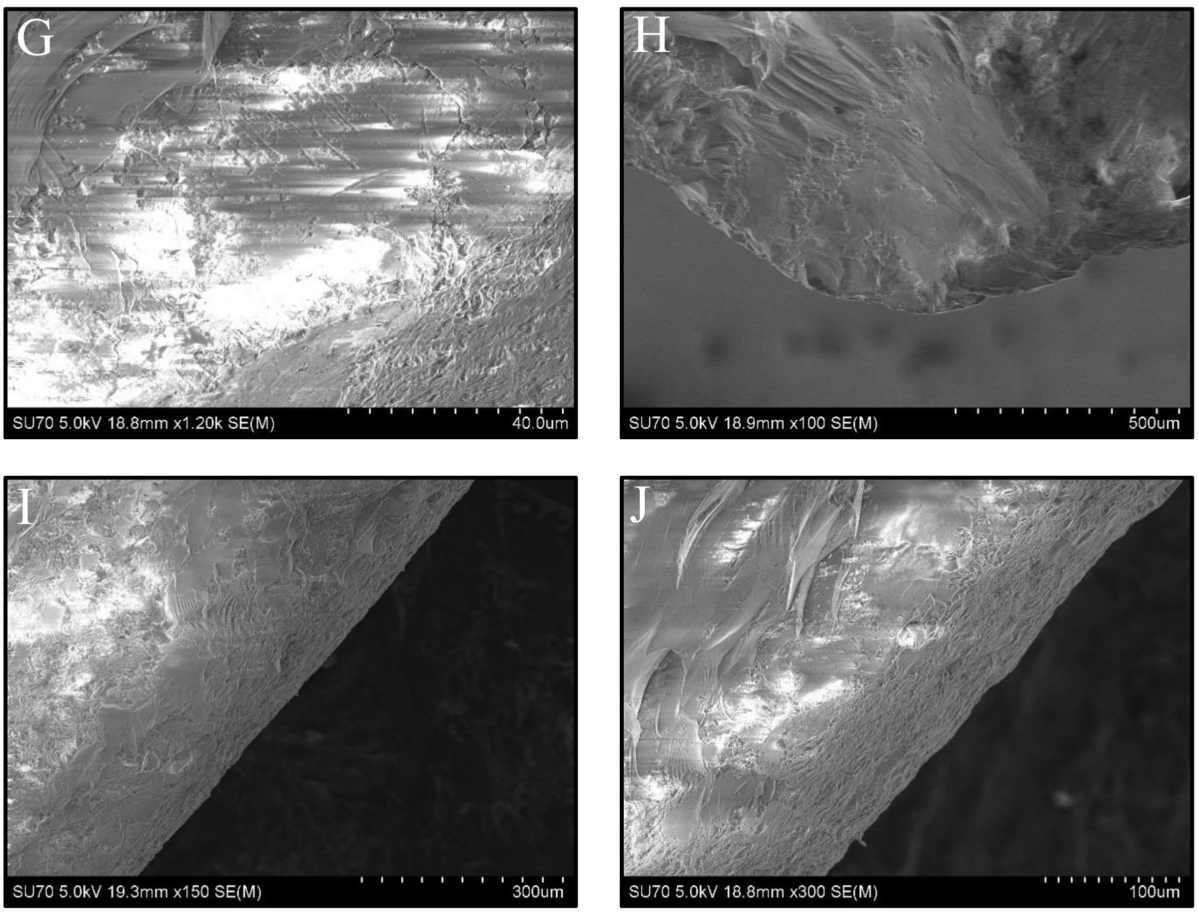


Figure 6-181: Use-wear on Point-2.
G – Striations parallel to concave base and perpendicular to edges. H – Manufacturing scars on one "ear". I, J – Edge grinding to dull edges of point to make the artefact more susceptible to hafting.

In conclusion, there was never any doubt about Point-2 being a tool. It was clearly the base portion of a large point. Residue analysis identified a small amount of animal residue. This either indicated the successful use of the point or that animal material was used as part of the hafting adhesive, if hafting adhesive was used (i.e. sinew alone is sufficient for hafting). The former option was suspected over the latter. In addition, the striations could arguably be interpreted because of use (i.e. force from impact was required to form these striations).

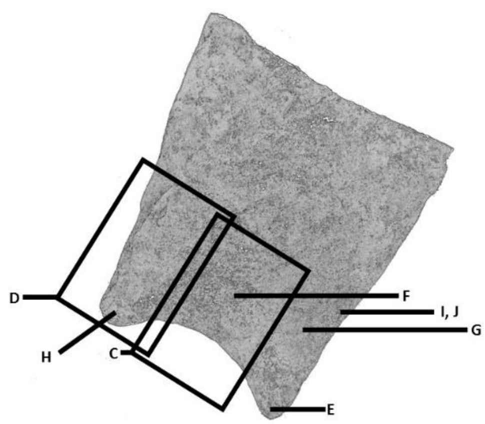


Figure 6-182: Image locations for Point-2.

7 Discussion

The purpose of this study was to determine whether quartz and amethyst were used more frequently as functional implements by the Lakehead Complex than presently understood. The results and interpretations from this research confirm that quartz and amethyst were more frequently used as functional tools. Conventional cataloging methods (e.g. identification of retouch, morphological identification) overlooked many of the artefacts in this study that were identified as tools using a more detailed functional analysis. The intensive and multi-analytical approach of this study has not only identified artefacts from these materials but, in some cases, has also allowed for the interpretation of specific functions. These trends relating to the more specific functions have inferred the purpose behind quartz and amethyst use at the Mackenzie I site, and by extension, within the Lakehead Complex. The implications regarding the site and complex that can be generated from the individual artefact interpretations are discussed below. The multi-analytical methodology employed in this research is also evaluated, including the effectiveness of the methodology for the analysis of quartz and amethyst artefacts. The methodology was designed to interpret the function of each artefact through multiple lines of evidence. Since this is the first approach using these specific techniques on quartz and amethyst, its effectiveness needs to be addressed.

7.1 Evaluation of Methodology

The methodological approach was designed around the identification of residue through various analytical techniques and the support of use-wear analysis to confirm and identify the function (i.e. residue analysis identified the material that has come in contact with the artefact, and use-wear analysis identified how the contact was made). Residue analysis was performed prior to use-wear analysis because the residue adhered to the surface of the artefact, hiding potential use-wear scars on the surface of the tool. Therefore, *in-situ* residue analysis was performed first, followed by residue removal, and then chemical analysis of residue and use-wear analysis. Hodgson (2017) conducted a similar analysis on unifacial taconite artefacts from Woodpecker II. Her approach dictated that the chemical analysis of the residue should be completed after use-wear analysis to eliminate the chance that the residue results would impact the use-wear analysis (i.e. because use-wear can be subjective). The difference in Hodgson's approach and the one presented here largely reflects the difference in the detail of the use-wear analysis due to the experience of the analyst and thus the level of specification that use-wear analysis provides. Hodgson (2017) used residue analysis and use-wear analysis as two separate lines of evidence to evaluate whether they would produce the same interpretation. The approach presented in this study relies more heavily on the strength of each technique to make an interpretation. Residue analysis was relied upon to determine the worked material, while use-wear analysis determined whether the artefact was used, how it was used, and the hardness of the material it was used upon. Use-wear analysis was not used to identify the specific material as in other studies.

7.1.1 Sampling Process

The sampling strategy was by convenience, in that all quartz and amethyst materials recovered and available for analysis were investigated (the quartz assemblage, n ≤ 5,699). Then a selective sampling strategy of this convenience based assemblage was used to separate those with useable edges, producing the 'possible tools collection' (n = 248). Those with residue were analyzed further (the analyzed collection; n = 48). This approach to sampling was successful since more tools were identified from the analyzed collection. Twenty-two of these were previously identified and catalogued as debitage or shatter, but proven here to be functional implements. Three artefacts identified as tools in the catalogue did not have enough residue or use-wear evidence to enable an identifiable function. Unintentionally, certain artefacts selected shared similar morphological traits that may indicate a formal or informal quartz artefact class (to be discussed below). Through the selection and analysis of 48 artefacts only two artefacts were eliminated (Artefacts 8995 and 26700). These two artefacts seemed to exhibit residue under LPILM but did not provide any further evidence even when analyzed under high powered light microscopy. This reflects the inexperience of the analyst at the beginning of the project and may not occur with a more experienced analyst. As the artefacts were analyzed, the researcher became more familiar with the material and use-related features. Therefore, it is likely potential tools were overlooked. This can only be addressed by revisiting the collection.

7.1.2 High Power Incident Light Microscopy for Residue

The HPILM proved to be the most effective and important technique for residue analysis. Examining residue *in situ* identified the colour, gloss, homogeneity, texture, and distribution of residue to generate residue classifications. The residues within the classification categories were compared and in many cases the interpretations based on one artefact in the category could be applied to all of the artefacts in the same category. This was an extremely valuable approach because the chemical analysis in this study produced few positive results, primarily due to quantity. This study is an excellent example of where this approach becomes vital to the interpretations when more specific techniques (e.g. GC/MS) fail to produce results. The disadvantages of this approach included the inherent subjectivity of classifying residue and the low depth of field associated with HPILM. Subjectivity was only overcome by experience and revisiting the classifications until fully satisfied. Low depth of field was addressed by Z-stacking multiple images at different focal points to produce full images of the residues. During analysis, SEM microscopy proved to be an excellent instrument to capture the full depth of field, but was not intended to identify residue in this study. The grey-scale imaging of SEM microscopy hid many important characteristics of residues that are visible using HPILM, such as colour and gloss. Therefore, as other researchers have noted (Borel, et al., 2014; Olle, et al., 2016), incident light microscopy and SEM are complimentary and should be used together when possible.

7.1.3 High Power Incident Light Microscopy for Use-wear

Although HPILM was not intended to identify use-wear, some features were identified during analysis (see artefact 4184). This technique was avoided for use-wear because without the proper microscope components, use-wear scars are difficult to identify on quartz's reflective surface. The SEM was chosen over light microscopy to avoid this issue and view the scars with a full depth of field. In hindsight, this approach should have been used alongside SEM to compensate for limitations of using the SEM (e.g. expensive, extensive use of technician's time, busy instrument with little availability, severe charging obscuring images). Therefore, the combination of these techniques is recommended for use-wear as well.

7.1.4 Ultraviolet Light

Overall UVL needs further research to fully validate this method as a suitable method for screening artefacts for residue or identifying the presence of residue. Its effectiveness was demonstrated prior to analysis, but proved ineffective for this specific study. When it is effective, this technique can indicate the distribution of residue that may otherwise go unnoticed.

7.1.5 Solvent Removal

Solvent removal proved to be rather unsuccessful when considering the GC/MS results. This was attributed to the lack of residue on some artefacts and the short time duration for removals. However, Hodgson (2017) also chose a short sonication time to preserve some residue *in situ* as well and produced interpretive GC/MS data. Therefore, it was more likely the low quantity of residue that proved to be an issue.

Solvent removal also focused on removing residue from a specific location (e.g. hafting end or working end). However, when dealing with such small amounts, a full artefact sonication should increase the chance of acquiring data. Future studies following this approach should sonicate for longer and experiment with other solvents that might better remove residue from quartz (i.e. break the potential ionized bond between the residue and material). Therefore, the technique would ideally remove the residue from the surface of the quartz and then once evaporated the tri-mixture solution would be used to dissolve the residue.

7.1.6 Biochemical Tests

Biochemical testing proved to be more useful than anticipated. These tests were developed to determine what instrument (e.g. GC/MS, LC/MS, etc.) would be most effective for chemical analysis based on the composition of the residue (e.g. protein, fatty acid, carbohydrate) and to evaluate its use as a screening technique.

For this study, GC/MS was always the instrument to be used and biochemical tests were used to compare the results of the two techniques and test which was more sensitive. Since GC/MS failed to produce any positive results, other than contaminants, biochemical tests proved to be more sensitive. Unfortunately, the results could not be compared.

7.1.7 Gas Chromatography-Mass Spectrometry

The GC/MS analysis was disappointing. Data produced was limited to molecules associated with handling (e.g. oils from skin and sunscreen lotion). This was not unexpected since field protocol did not require gloves while handling all artefacts. Requiring this is presently beyond the expectation of CRM excavation and would not have applied to these artefacts in any case. Recommendations for improving the GC/MS results for this project are discussed in section 7.1.5.

7.1.8 High Power Transmitted Light Microscopy

The HPTLM produced a few positive results, but not many. This technique was useful because it identified microfossils and fibres that would not produce results with chemical analysis. It served as an excellent line of evidence to support the classification and biochemical results. Unfortunately, in most cases the visible material was amorphous and unidentifiable, which could not be helped. A detailed HPILM analysis is required to contextualize the material identified using transmitted light.

7.1.9 Scanning Electron Microscopy for Use-wear

The SEM proved to be a very useful instrument. It can produce high resolution images from 80x to over 2000x magnification (higher magnification was not required for this study) with a full depth of field. Grey-scale imaging was not as detrimental to use-wear analysis (only affecting polish) as it was for residue analysis.

The greatest disadvantage of the SEM was the charging effect on the material, which was increased by the presence of organic residue. This charging effect is why some organic objects are often coated with either carbon or gold. Coating also increases resolution. However, this approach is not recommended for archaeological material. Therefore, charging was limited by using a lower energy beam, which unfortunately lowered the resolution. In addition, charging reduced the amount of time an artefact could remain in the instrument. The only way to overcome this issue for future studies is to use a more appropriate SEM, such as an ESEM.

The greatest limitation to the use-wear component of this study was the lack of a reference collection. An experimental component was intended for this project, and a small informal section helped the analyst recognize wear, but including a proper experiment was beyond the scope of the study. Analyzing 46 artefacts in the SEM required many valuable hours from Lakehead's archaeological technician and many hours on an instrument used frequently by other departments and often booked solid for weeks. An experimental component would have required numerous artefacts just to provide one example of the most basic set of tools on the basic variety of material. Therefore, it was determined that using the literature as a reference for use-wear was the only feasible way to use SEM for use-wear analysis. In future, the results presented here can be specifically tested using an experimental program.

7.1.10 Scanning Electron Microscopy for Residue Analysis

Just as HPILM was not intended for use-wear analysis, but used when evidence was present, so too was SEM unintentionally used for residue analysis. The SEM provided a more detailed view of residue distribution, largely because of the extended depth of field. It more easily confirmed the presence of residue (i.e. residue vs inclusions were easily distinguished) and fibres were far easier to examine. However, the lack of colour is a huge disadvantage that can only be addressed through HPILM. In addition, for the SEM in this study, carbon tape was still required to hold the artefact in place, thereby requiring solvent removal to occur prior to SEM analysis to avoid contamination.

7.2 The Analyzed Collection

The artefacts analyzed in this study were those that had a functional edge and residue adhering to their surface. The following section discusses the interpretations from three different perspectives: residue classification, functional interpretations, and morphological groups. The purpose behind this is to identify relationships between residue, form, and function.

7.2.1 The Residue

The residue identified in this analysis was almost exclusively animal residue. All residue classifications that were interpretable were identified as animal based on their resemblance to animal residues identified in the literature (see Lombard's work). Successful biochemical tests identified compounds associated with animal. Although fatty acids are found in plant material, the classifications associated with fatty acid appeared animal related. In addition, the most common residue classifications were found in association with each other on certain tools, which suggested a relationship between the different residues.

Residue preservation was a prevalent issue during this analysis. The acidic soil of Northwestern Ontario quickly decomposes organic material. These artefacts were approximately 9,000 years-old, and thus the survival of residue is questionable. However, three other residue studies in the area, along with this study, support that residue can survive on the surface of tools over thousands of years in the Thunder Bay region (Newman & Julig, 1989; Hodgson, 2017; Cook, 2015). Residues best survive in cracks and crevices within lithic material, but many of the artefacts studied did not have these features. In this study, HPILM proved otherwise and demonstrated that residue could survive on quartz and amethyst materials in a harsh environment, even when adhering to the smooth surface of a crystal face.

A few peculiar characteristics stood out regarding residue preservation. Firstly, most residue was often only found on one surface. Second, most residue was only visible on the dorsal surface. Third, there was a distinct lack of plant residue that could be cultural or a result of taphonomy.

The question of taphonomy raised in the third observation was also relevant to the first observation (i.e. was the preservation of residue on one surface the result of taphonomy?). The presence of residue on one surface presents two scenarios. The first follows the same logic as "the dead bison hypothesis", which suggests that residue contact was accidental (i.e. the artefact was already in deposition and residue came in contact after, thereby adhering to the exposed surface). This scenario does not exclude the residue from being anthropogenic, just from being directly related to the function of the artefact. The second scenario is that residue could only survive in the depositional environment, either the side facing down in the soil and less exposed to the elements, or the side facing up and more likely to be "cooked" onto the surface. In the cases where residue was found on both surfaces, the artefact might have been oriented vertically. Unfortunately, these situations are conjecture and require experimental programs to verify.

The fact that residue was only on the dorsal surface raises questions about the authenticity of the residue. If the residue is only on the dorsal surface, there is no way to guarantee it was a result of use after the flake was detached and therefore related to the identified function. However, it can be argued that more residue will accumulate on the dorsal surface depending on the function of the artefact. Consider a quartz scraper; the ventral surface is flatter and would have been the surface running along the hide. Therefore, the fat being scraped off would accumulate more on the dorsal surface, while the ventral surface remained cleaner.

The final observation (i.e. lack of plant material) was more complicated to answer and presented three possibilities. The first suggested that plant processing was not an activity at the site. This was highly unlikely, particularly since other researchers have identified multiple activity areas at the site (McCulloch, 2015) and it is unreasonable to assume that plant material was unimportant to daily life whether the site was primarily used for hunting/game processing or a camping location. Therefore, it is highly unlikely that no plant processing occurred there.

The second possibility suggested that quartz artefacts were not used in plant processing activities. The informal (pragmatic) or expedient quartz artefacts (discussed below) support this possibility. It is more likely at the Mackenzie I site, particularly because of the large number of projectiles, that the quartz and amethyst material was collected locally to be used in animal processing shortly after they were harvested.

Finally, the question of whether the environment was less favourable to the survival of plant residue can be refuted by Cook's (2015) GC/MS results, which identified plant material on similarly aged ground stone tools associated with the Lakehead Complex or the archaic populations following the Paleoindian period. Hodgson (2017) also identified plant residue on unifacial taconite tools from the nearby Woodpecker II site.

Overall, it should be noted that there is the strong possibility that many of these residues are related and that the difference in appearance, and therefore the difference between the residue classifications, is simply the amount of residue preserved and the ratio of fat to blood. This ratio can be affected by the task being performed (e.g. scraping will produce a residue with more fat while cutting meat will typically produce more blood).

7.2.2 Artefacts by Residue Classification

Artefacts were organized based on their residue classification from Chapter 5 to assess whether a classification can be linked to specific function (i.e. class 1 residue to scrapers). Table 7-1 summarizes the classifications by artefact and associated function. Generally, there are no

Table 7-1: Artefact function by residue classification

Class 1		Class 2	
3885	Drill	4184	Scraper
27868	Not a Tool	15096	Not a Tool
31322	Not a Tool	24842	Drill
39056	Not a Tool	31322_2	Knife
51943	Not a Tool	46551	Not a Tool
57679	Awl/Perforator	49249	Not a Tool
57953	Knife/Scraper	63769	Projectile
71653	Awl/Perforator	71653	Awl/Perforator
71676	Not a Tool	72526	Scraper
72526	Scraper	77023	Scraper/Awl/Perforator
76189	Not a Tool		
P2	Point Base		

Class 1/2		Class 3	
4184	Scraper	14288	Awl/Perforator/Burin/Graver
39056	Not a Tool		

Class 4		Class 5	
14288	Awl/Perforator/Burin/Graver	15096	Not a Tool
15295	Scraper	15387	Spokeshave/Burin/Graver/Awl/Perforator
46541	Scraper	16208	Scraper/Knife?
46551	Not a Tool	16528	Scraper/Burin/Graver
51849	Awl/Perforator	33622	Not a Tool
51943	Not a Tool	42413	Scraper
71653	Awl/Perforator	70265	Not a Tool
77023	Scraper/Awl/Perforator	70283	Not a Tool
86944	Scraper	72526	Scraper
Point 2	Projectile		

Class 6		Class 7	
15387	Spokeshave/Burin/Graver/Awl/Perforator	16208	Scraper/Knife?
24506	Drill	20503	Not a Tool
77176	Not a Tool	52053	Awl/Perforator/Drill
86944	Scraper		

Class 8		Class 9	
24842	Drill	35330	Not a Tool
25073	Scraper	42413	Scraper

Class 10		Class 11	
39056	Not a Tool	42413	Scraper
		51943	Not a Tool

Class 12		Class 13	
44139	Scraper/Knife	51944	Not a Tool
63769	Projectile/Spokeshave		
Point 1	Projectile		

Class 14		Class 15	
56627	Knife	57679	Awl/Perforator

Class 16	
71676	Not a Tool

clear associations between residue type and artefact function, but each artefact class is discussed regardless.

Residue Classes 1, 2, 4, and 5 have the highest artefact frequencies (12, 10, 10 and 9 respectively) and show similar trends. Within these groups, a wide variety of tools are attributed to each residue classification. Therefore, there is no relationship between function and the type of residue for these four classes.

Classes 6, 7, and 12 have fewer artefacts (4, 3 and 3 respectively), which makes it more difficult to confidently determine any trends. Classes 6 and 7 follow the same pattern as the larger classifications (i.e. various functions present within the residue classifications). Class 12, however, has two out of three artefacts with the same possible function (e.g. projectile). Unfortunately, the sample size was not large enough to determine if this trend would continue.

The remaining classifications only have one or two artefacts within each. In the cases where two are present, neither artefact serve the same function. In conclusion, although sample sizes can be small, there is no relationship between residue classification and function. This conclusion is logical because different tools can acquire the same type of residue regardless of task.

7.2.3 Artefacts by Functional Interpretations

Chapter 6 identified an assortment of implements based on their perceived function. Only 7 different types of functional artefacts were identified: scraper, spokeshave, awl/perforator, burin/graver, drill, knife, and projectile (Table 7-2). Most of the identified tools were either scrapers or awls/perforators and nine were identified as multifunctional. This section discusses the different functional categories determined by interpreting the results and discusses the patterns present in each group.

Table 7-2: Artefacts by functional classification

Functional Classification	Number	Artefact		
Scraper	14	4184	25073	57953 (M)
		9942 (M?)	42413	72526
		15295	44139 (M)	77023 (M)
		16208 (M?)	46541	86944
		16528 (M)	56557	
Spokeshave	2	15387 (M)	63769 (M)	
Awl/Perforator	7	14288 (M)	**52053 (M)**	**71653**
		15387 (M)	57679	77023 (M)
		51849		
Burin/Graver	5	**3646**	14288 (M)	16528 (M)
		9942? (M?)	15387 (M)	
Drill	4	**3885**	**24842**	**52053 (M)**
		24506		
Knife	5	16208 (M?)	44139 (M)	57953 (M)
		31322-2	56627	
Projectile	3	63769 (M)	Point-1	Point-2
Function not Identified	17	**15096**	**39056**	70265
		20503	46551	70283
		27868	49249	**71676**
		31322	51943	76189
		33622	51944	77176
		35330	69290	

M identifies artefacts with multiple functions.
? identifies less confident functional interpretations

7.2.3.1 Scraper

Scrapers are the most common and ubiquitous quartz tool identified at sites in all contexts where quartz was used. This is attributed to how the material fragments. Often, quartz fragments have a straight sharp edge and angled surface that are ideal for scraping implements. Therefore, it was unsurprising that quartz scrapers were the highest frequency of identified tools.

Fourteen quartz artefacts analyzed were identified as scrapers (Table 7-2). These artefacts all had straight edges that showed use-wear evidence for motion perpendicular to the edge. Residue analysis in all cases suggested an animal residue, indicating they were used to scrape dry and fresh hides. Two of these were identified as scrapers in the CRM catalogue, and one was identified as a retouched flake.

All scrapers but one were quartz. The single amethyst scraper (artefact 9942) was unique and its classification as a scraper is tenuous. This artefact’s working edge was only 4mm wide. Use-wear analysis indicated a pushing or pulling motion perpendicular to the edge. Therefore, this artefact either functioned as a very precise scraping implement or a burin/graver.

7.2.3.2 Spokeshave

Spokeshaves have a similar mode of use as scrapers, but were used to shave and round objects. Two artefacts (15387 and 63769) were identified as spokeshaves (Table 7-2). Both were made of quartz and had a concave working edge and were multifunctional. Residue analysis identified animal residues for both tools, but in both cases residue was associated with a different working edge. Use-wear analysis for 63769 suggested a softer worked material (e.g. soft wood), but the plant residue did not survive in the depositional environment. Artefact 15387’s wear is indicative of a much harder material (e.g. bone or antler), although spokeshaves are more commonly used on wood.

7.2.3.3 Awl/Perforator

Seven artefacts were identified as either awls or perforators. These tools are used to puncture holes in material, most commonly animal hides. Therefore, it was no surprise that animal residue was found on these artefacts. These artefacts included one amethyst crystal, one fragment with a small amount of amethyst, and five quartz (Table 7-2). Two artefacts were also identified as burins/gravers, which have similar usable features (e.g. sharp point), but do not puncture the material they were used on, which were harder (e.g. bone, antler).

7.2.3.4 Burin/Graver

Burins/gravers are used to create grooves in harder material. Often, spurs protruding from the edge of the artefact are enough to consider an artefact as a burin or graver. Five artefacts were identified as burins/gravers, two amethyst crystals and three quartz flakes (Table 7-2). One amethyst crystal was likely used on plant material (e.g. wood), but residue analysis strongly indicated animal residue for the other five.

7.2.3.5 Drill

Four artefacts functioned as drills, including one amethyst crystal, two amethyst fragments, and one quartz flake (Table 7-2). All artefacts had pointed tips with striations parallel to the working point that indicated a twisting motion, interpreted as drilling by hand. Residue analysis indicated animal residue on all four artefacts. Therefore, they were used to drill into either bone or antler.

7.2.3.6 Knife

Five artefacts were interpreted as knives based on the presence of a straight working edge with parallel striations (Table 7-2). Three of these also functioned as scrapers, and thus it is possible the striations are associated with that task (i.e. if any side to side movement occurred). Animal residue was present on all five, and therefore these tools were used to either to remove the hide from the carcass or to cut the meat from the bone.

7.2.3.7 Projectile

Three artefacts were determined to be projectile points (Table 7-2). Two of these were identified in the CRM catalogue and their interpretation was not refuted in this study. Point 2 was an obvious point base and had evidence of hafting and animal residue, suggesting it was used. Point 1 was a small piece of a lateral edge with possible blood residue, but no use-wear evidence of its use. However, projectile use is easier identified when looking at macrowear rather than microwear. That is how artefact 63769 was identified as a projectile, which had a unifacial spin-off fracture (a diagnostic impact fracture (DIF); Lombard, 2007) at the tip with a large amount of Class 12 residue. Class 12 residue was also present on Point 1, which may indicate the only relationship between artefact function and residue class.

7.2.3.8 Function not Identified

Use-wear analysis could not identify how these artefacts were used, but residue was still present, suggesting anthropogenic contact. In some cases, the artefacts lifespan may have been so brief that wear patterns did not develop. Therefore, some of these artefacts are expedient tools. In other cases, the presence of residue may be through incidental contact. For example, artefacts in the vicinity of animal processing, which is a messy task, may come in contact with animal material. Unfortunately, stronger use-wear interpretations are necessary to accurately interpret the function of these artefacts. In the case of the amethyst crystals, these artefacts may have been ornamental and in some cases hafted.

7.2.4 Artefacts by Morphology

This analysis ignored artefact morphology as a prerequisite for function during the sampling phase other than ensuring that a functional edge was present (i.e. beyond the presence of a usable edge or tip, overall morphology had no impact on an artefacts inclusion in this study). However, after analysis occurred it was important to categorize the artefacts by morphology to identify possible trends between morphology, function, and residue. Artefacts were divided by material type prior to determining morphological classifications (Table 7-3).

The quartz artefacts were subdivided into seven broad morphological categories, and the amethyst artefacts into three. The irregularity of the artefacts makes more specific classifications difficult. The quartz categories include: thin irregular polygon with straight edge, thick irregular polygon with straight edge, blocky with straight edge, irregular with point, burin-style flake, "triangular", and point fragments). The latter three categories represent more standardized morphologies, while the remaining categories are "catch-all" terms for utilized or slightly modified flakes. The amethyst artefacts were divided into: amethyst crystal tip, amethyst crystal tip with long stem, or long, pointed amethyst fragment.

Table 7-3: Artefacts by morphological classification

Morphological Classifications	Artefacts			Residue Classifications	Functions
Thin Irregular Polygon with Straight Edge	4184 15295 16528 20503 25073	31322 31322_2 44139 46541 46551	56557 56627 57679 57953	1, 2, ½, 4, 5, 7, 8, 12, 14, 15	Scraper (6) Scraper/Burin/Graver Scraper/Knife Knife (2) Awl/Perforator Not a Tool (3)
Thick Irregular Polygon with Straight Edge	51943 51944	72526	76189	1, 2, 4, 5, 11, 13	Scraper Not a Tool (3)
Irregular Quartz with Point	24506 27868	49249 51849	77176	1, 2, 4, 6	Drill Awl/Perforator Not a Tool (3)
Blocky with Straight Edge	35330 42413 69290	70265 70283	86944	4, 5, 6, 9, 11	Scraper (2) Not a Tool (4)
Burin-Style Flake	14288 15387	16208 33622	77023	2, 3, 4, 5, 6, 7	Awl/Perforator/Burin/Graver Spokeshave/Awl/Perforator Scraper/Awl/Perforator Scraper(Knife?) Not a Tool
Triangular	62455*	63769		2, 12	Projectile/Spokeshave Not a Tool
Point	Point 1	Point 2		1, 4, 12	Projectile (2)
Amethyst Crystal Tip	3646	71653		1, 2, 4	Burin/Graver Awl/Perforator
Amethyst Crystal Tip with Long Stem	9942 24842	39056	71676	1, 1/2, 2, 8, 10, 16	Burin/Graver (Scraper?) Drill Not a Tool (2)
Long, Pointed Amethyst Fragment	3885	15096	52053	1, 2, 5, 7	Drill Awl/Perforator/Drill Not a Tool

7.2.4.1 Thin Irregular Polygon with a Straight Edge

Thin irregular quartz flakes that had at least one straight edge were the most common type of morphological category included in the analyzed sample (Table 7-3). Eleven of the fourteen artefacts had an identifiable function. Most of these (8) were used as a scraper at one point and three were used as a knife. Two artefacts featured usable points. Both the straight edge and point were used on one artefact, while the straight edge was unused on the other. Residues classifications were numerous, but predominantly animal. Therefore, artefacts within this category were typically (but not exclusively) scrapers that were used on animal material.

7.2.4.2 Thick Irregular Polygon with a Straight Edge

There were four artefacts that were thicker and identified as a separate category (Table 7-3). Only one artefact proved to be used. Two unused artefacts had a convex edge, and neither indicated a functional purpose. Like the thin irregular polygon with a straight edge tools, this functional tool was a scraper used on animal material. Residues classifications were numerous, but all animal-derived. Therefore, it is less likely that the thicker, irregular artefacts were used.

7.2.4.3 Irregular Quartz with Point

Only two of the five artefacts were proven to be tools, one awl/perforator and one drill (Table 7-3). The drill featured wear that indicated a twisting motion. Residues classifications were numerous relative to the number of artefacts, but were all animal-derived.

7.2.4.4 Blocky with Straight Edges

This category consists of six artefacts that were likely unused, but featured residue that warranted further investigation (Table 7-3). Only two were used and functioned as scrapers. These artefacts were similar to the previous category, but were squarer in shape. Multiple residue classifications were present, but all animal-derived.

7.2.4.5 Burin-Style Flake

This was the most interesting morphological category because these artefacts were produced from the same flake fragment. Five artefacts belonged to this category (Table 7-3). Based on experimental observations, the flake is a side fragment (Callahan, et al., 1992; Tallavaara, et al., 2010; Rankama, 2002) originating on the lateral side of a core, the size of which is dictated by the size of the original core. The sizes of these artefacts varied from 23mm to 40mm in length and 11mm to 32mm in width. The degree of modification differed as well, with the most heavily modified artefact being the smallest in size (14288).

Morphologically, one would expect these artefacts to function as burins or gravers, based on the modification of one edge to create a point. However, use-wear analysis produced evidence of five unique artefacts with multiple functions. Artefact 14288 was multi-functional, used as both an awl/perforator to puncture softer material and a burin/graver to demarcate harder materials. Both artefacts 15387 and 77023 were used as an awl/perforator, but also used their straight edge as a spokeshave and scraper respectively. Artefact 16208 only used its straight edge, primarily as a scraper but also as a knife. Only one artefact (33622) from this category was unused.

7.2.4.6 Triangular

There were two artefacts in this category (Table 7-3), but one (62455) was only included as a morphological comparison to artefact 63769 and did not undergo residue analysis because no visible residue was observed. It was only included here to act as a comparison, but unfortunately without evidence for use there was little to compare. Artefact 63769 was interpreted as a projectile and technically belongs to the Point category discussed below. However, morphologically, it is much different than projectiles typical of the Lakehead Complex. Artefact 63769 and Point 1 share the same residue (class 12) that was only identified on one other artefact (44139) which was a scraping implement. Artefact 63769 was also interpreted as a spokeshave, although it was possible the wear patterns were hafting related. Artefact 62455 does not have the same specific morphological traits, but is roughly the same shape. It also bears resemblance to margin-retouched oblique points recovered in Fennoscandia (Manninen & Tallavaara, 2011) and backed pieces from Sibudu Cave, South Africa (Lombard & Phillipson, 2010).

7.2.4.7 Point Fragments

Two quartz point fragments were recovered from the site (Table 7-3). As they are different types of fragments they do not share morphological characteristics, but because of their identification were placed in their own category. Point 1 was lateral edge fragment, while Point 2 was a large base made of vein quartz. Residues differ, but both were animal-derived. A third point fragment (a tip) was discovered after analysis. It appears similar to the base, but was from a different point.

7.2.4.8 Amethyst Crystal Tip

Two amethyst crystals (without a long stem) were suspected of being tools (Table 7-3). Analysis concluded that both served a functional purpose; one as a burin/graver and the other as an awl/perforator. Whether an artefact was used to puncture material or demarcate material likely depended on the task at hand rather than any morphological differences between the two tools. Artefact 3646 was most likely used on plant material, while artefact 71653 was used on animal material.

7.2.4.9 Amethyst Crystal Tip with Long Stem

Four amethyst crystals still had a longer stem on them, which were ideal for hafting (Table 7-3). Only two proved to be used, functional as either a burin/graver or a drill. Whether an artefact was used to demarcate an object or to drill into hard material likely depended on the task at hand rather than any morphological differences between the two tools. Analysis concluded that both artefacts were used on a harder animal material (e.g. bone or antler)

7.2.4.10 Long, Pointed Amethyst Fragment

Two of the three amethyst artefacts that were not crystals, but still had a usable tip, were proven to be used (Table 7-3). Both show evidence of drilling, but artefact 52053 also functioned as an awl/perforator. These artefacts were ideal for drilling because that were longer and able to be used by hand. Residue indicated the artefacts were used on animal material.

7.3 The Role of Quartz and Amethyst at Mackenzie I and within the Lakehead Complex

It is not possible to discuss the quartz artefacts and the site, and the quartz artefacts within the Lakehead Complex separately because there are not enough sites with quartz that have been analyzed this way. However, because the Mackenzie I site contains the highest number of quartz artefacts and is the only Lakehead Complex site to receive this detailed type of analysis regarding quartz material, the discussion of quartz use at the Mackenzie I site and within the Lakehead Complex is one and the same.

Chapter 3 briefly discussed the perceived role of quartz and amethyst at the Mackenzie I site, the Mackenzie sites, and within the Lakehead Complex prior to analysis. Essentially, these materials were a minor lithic material, comprising a small percentage of the collection and a small percentage of tools. The limited use of quartz suggests it served an expedient role. The material is only found at sites where it is easily available in the immediate surroundings. Knapping strategies are quick and efficient and tools, primarily utilized flakes, only show evidence of a singular task. Although quartz can be mislabeled as an expedient tool material, it is an appropriate description for most of the material at the Mackenzie I site.

However, some of the artefacts were informal and required slight modification to produce similarly shaped tools (e.g. burin-style flake). It is important to remember that quartz assemblages are often simplistic because of the materials properties. Simply put, quartz fragments too frequently to undergo persistent modification. That is why cultures in areas devoid of cryptocrystalline material that relied on quartz often have visually unimpressive toolkits. Therefore, the concept of the ‘pragmatic’ tool was presented, which is a type of informal tool, which was inspired by how other quartz researchers’ referred to the application of knapping techniques more conducive to quartz. The pragmatic tool was an implement that was simply and quickly created, but not created for a single use. An example within this dataset was the burin-style artefacts. Although lacking the aesthetic qualities of more heavily knapped chert tools, some of these artefacts (14288 and 77023) were heavily used and served multiple functions.

Thus, the question becomes whether the quartz tools at the Mackenzie I site were expedient, informal/pragmatic, or formal. The answer, as always, was more complicated and the tools fell within multiple categories. For the most part, quartz and amethyst artefacts could only be considered expedient. Many of these artefacts were utilized flakes with little to no modification. Use-wear analysis produced limited results that often indicated a singular task of short duration. In many ways, this was unsurprising and it would be reasonable to hypothesize that many of the taconite artefacts would show similar interpretations (see Hodgson, 2017 for the residue and use-wear analysis of taconite unifacial tools from Woodpecker II). These use-wear patterns, combined with animal residue, support the interpretation of quartz artefacts as expedient.

The location of the Mackenzie I site caused archaeologists to originally surmise that it was a habitation site where toolmaking, hide preparation, and possibly woodworking occurred (Norris, 2012). The presence of over 350 projectile points (see Markham, 2012a for a morphological analysis of these points), suggests hunting occurred nearby and points were replaced/knapped at the site. More recent research supports this multi-use interpretation

(McCulloch, 2015; Bennett, 2014). The evidence presented here strongly supported animal processing, the kind that would occur after a large, successful hunt. The use of expedient tools out of local, less desired material, with only animal residue, suggested an immediate need for more tools to aid in time sensitive animal processing. Taconite was by far the most common lithic material at the site, but the nearest outcrops are 20km away and required forethought and planning to transport the required amount to the Mackenzie I site. The vast amount of material transported indicates the desire to use a specific material and not rely on the locally available quartz and amethyst. Therefore, the use of quartz and amethyst could indicate situations where a higher yield of caribou were harvested than expected and additional tool stone material was required.

At other Lakehead Complex sites, utilized flakes (i.e. expedient tools) were common occurrences (Hodgson, 2017; Newman & Julig, 1989). Newman and Julig (1989) analyzed 36 artefacts from the Cummins site for protein residue. Of these, 21 were identified as utilized flakes and four tested positive for specific animal protein. Therefore, regardless of material, the Lakehead Complex population was familiar with using flakes as expedient tools. Thus, quartz and amethyst artefacts were not unique in this regard.

Hodgson (2017) analyzed unifacial flakes from the Woodpecker II site for evidence of use, using both residue and use-wear analysis. Hodgson observed that expedient/informal tools at Woodpecker II were very task-specific and generally featured only one type of use. In this study, six artefacts were identified as multifunctional, three that may be multifunctional, and twenty single function tools. Therefore, most of the quartz and amethyst artefacts were either expedient or informal tools. Formal artefacts undoubtedly include the two point fragments identified in the CRM catalogue (three including the one identified after analysis was complete). Formal artefacts may also include the burin-style flakes (5 out of 6 identified as tools) because of the consistent morphology. However, function was not consistent and therefore it is difficult to argue a formal classification with such varied function. Therefore, these artefacts were informal tools that worked pragmatically within the constraints of the material (i.e. the tendency for quartz to fragment often requires a manufacturing technique that modifies the artefact as little as possible). Three artefacts within this category stand out as heavily used, multifunctional implements: 14288, 15387, and 77023. These artefacts represent a pragmatic category of informal tools.

These were considered pragmatic for a few reasons. First, they were multifunctional, which suggested they were created for more than a singular task/use. Second, they showed more indications of use, which suggested they were used frequently. Third, they were created from the same flake blank in a similar fashion (i.e. the tipped end was flaked on one side to emphasize the tip and the larger flakes were flaked to produce a concave edge as well). This suggested that a specific tool was envisioned, and although this does not exclude it from an expedient purpose, making it more than a utilized flake. Lastly, the manufacturing technique used little flaking, thus working within the constraints of quartz.

Also discussed in Chapter 3 was the lack of quartz and amethyst artefacts present at other Lakehead Complex sites. This could be a result of field collection strategies, either the Mackenzie I excavations overrepresented the frequency of quartz and amethyst or the easier recognition of taconite artefacts underrepresented the frequency of quartz and amethyst in earlier excavations. However, the identification of quartz artefacts from some of the earliest sites excavated in the area (e.g. the Brohm site), the latter scenario is unlikely. For the former scenario, the cataloguing process removed obvious ecofacts, although distinguishing anthropogenic quartz fragments from natural fragments is still a difficult task and natural pieces undoubtedly and understandingly remain in the collection. In the end, although an overrepresentation may be present in the Mackenzie excavations, the lack of quartz at other sites is likely authentic.

Quartz and amethyst use was focused in areas where the material was readily available (Mackenzie River – Sibley area). The highest number and frequency of quartz was located in areas where it was immediately available (i.e. along the Mackenzie River) and therefore the Mackenzie I and Mackenzie II sites had the largest amount of quartz. Quartz veins were visible in the bedrock and continues to be present in the river. Even moving a few hundred metres away from the river (e.g. Woodpecker sites) drastically reduced the frequency of this material (see Table 3-5).

The fact that quartz and amethyst was more frequent where it was immediately available alone strongly indicates that the material was exploited for expedient use. The use-wear and residue data support this interpretation because many artefacts were limited in use, served one function, and only animal residues were found on the artefacts. The presence of a few more formal or pragmatic tools was likely a reflection that when quality material was encountered, it was exploited. Therefore, specific flake-blanks were often used to create specific tools and if the material was not as prone to fragment, more intricate formal tools (i.e. projectile points) were created.

Amethyst was slightly different but still followed the same pattern. The lack of amethyst on other sites suggested it was not highly sought after, but the presence of used amethyst at the Mackenzie I site indicated the material was used when accessible. The morphological shape of the material restricted the functional possibilities to either a puncturing tool or a graving tool because only useable tips were present. These artefacts required little shaping, making them either pragmatic or expedient. The degree of use and variety of residue maybe the only way to identify the type of tool for classifying each artefact.

In conclusion, this analysis supported the interpretation that quartz and amethyst artefacts were largely expedient. It also indicated that expediency, even when likely, should not be assumed, as specific tools could be more heavily relied upon. The research question addressed whether “the Lakehead Complex used quartz and amethyst as a raw material for functional tools more frequently than is presently understood”. The identification of multiple artefacts as tools that were originally classified as debitage proves that quartz, and particularly amethyst, were indeed used more frequently than previously determined. In addition, the identification of the burin-style artefacts indicates that an entire artefact class was being overlooked.

7.4 Future Directions

The future directions of this project are plentiful and largely address the shortcomings of this thesis. The first project that needs to occur is an experimental program designed to test the interpretations presented here. Thus, the experimental artefacts can be designed to reflect the artefacts analyzed here, their proposed function, and a variety of possible functions to compare the results.

The second direction would be to analyze the taconite artefacts in a similar fashion to identify whether other residues were present. If a wider variety of residues were present, this would support the interpretation that quartz and amethyst artefacts were largely selected for immediate use for animal processing. If the same residues appeared, this would suggest the site was either used only for animal processing or that only the animal residues survived the acidic soils. Analyzing artefacts from other sites can also indicate residue preservation. Hodgson's analysis produced more evidence of plant material, but this can be attributed to successful GC/MS analysis and a more detailed use-wear analysis.

Third, the residue and use-wear analysis of the quartz artefacts from the Mackenzie II site could serve as a comparison to these results, but on a lower scale. In addition, the lower number of artefacts would allow for all the quartz artefacts to receive the same level of analysis. This will provide a larger assortment of used and unused artefacts to identify the frequency that flakes were used.

Lastly, with the growing number of publications on the Mackenzie I site (and the Mackenzie sites in general), the various techniques can be combined to produce more intricate results. Specifically, the combination of residue/use-wear to identify artefact function combined with defined activity areas identified through special analysis (McCulloch, 2015) could provide interesting results. It also presents a smaller scale approach to identifying residue/use-wear on taconite artefacts (i.e. analyzing all the artefacts from a specific activity area following a methodology similar to the one presented here).

8 Conclusion

This study has demonstrated that quartz and amethyst artefacts were more commonly used at the Mackenzie I site than previously indicated. It has also proven that a more detailed and intricate approach to functional analysis is required to properly identify artefact function, rather than rely on morphological traits alone. This is particularly true for quartz because it is more difficult to produce consistent morphologies for specific functions. With that being said, this research identified a specific quartz flank blank commonly used to produce tools, but it is important to note that function varied greatly within this morphological class.

Prior to the excavations of the Mackenzie sites, the presence of quartz at Lakehead Complex sites was minimal. In addition, the presence of quartz at Late Paleoindian sites around Lake Superior (i.e. Lake Minong) was also minimal. Therefore, quartz could be considered predominantly an expedient tool material for this area, but pragmatic tool classes were recovered from the Mackenzie I site and identified during this analysis. In addition, some artefacts were used more heavily than is expected of expedient tools and many of the artefacts were multifunctional, which again suggests a longer lifespan than is typical of expedient artefacts. The results presented here support this interpretation, although informal artefact classes were present as well.

Residue analysis results were nearly exclusively interpreted as animal. This may due to taphonomic circumstances (i.e. plant material typically more water soluble), but only a handful of use-wear results indicate plant processing. Therefore, it can be assumed that residue analysis accurately depicts the importance of animal processing at the site. The Lakehead Complex peoples likely followed caribou herds in the area for a portion of their subsistence. This is reflected in the high number of projectile points at the site. Therefore, animal processing activities would have been common at this site. In addition, dressing the carcasses is time sensitive, and thus it is likely that expedient materials were more likely used for these tasks.

Regarding the methodological approach, as stated it more accurately identifies artefact function than basing interpretations off morphology alone. The multi-analytical approach to this research was critical for its success. Initially, GC/MS was to be relied on heavily, but the method did not produce any interpretable results and either refinement to the method of a different instrument (e.g. LC/MS) is required to produce interpretable data. It required a combination of visual and biochemical analysis to properly interpret the residues.

Residue analysis is becoming more critical for understanding areas where organic material does not often survive. The combination of residue analysis with other types of analysis, whether it be use-wear or spatial analysis, can only strengthen the interpretation of archaeological sites. Further development and execution of residue analysis is necessary to better understand archaeological sites like the Mackenzie I site and the people who once inhabited them.

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10 Appendix A: Residue Classifications

Class 1 Residue

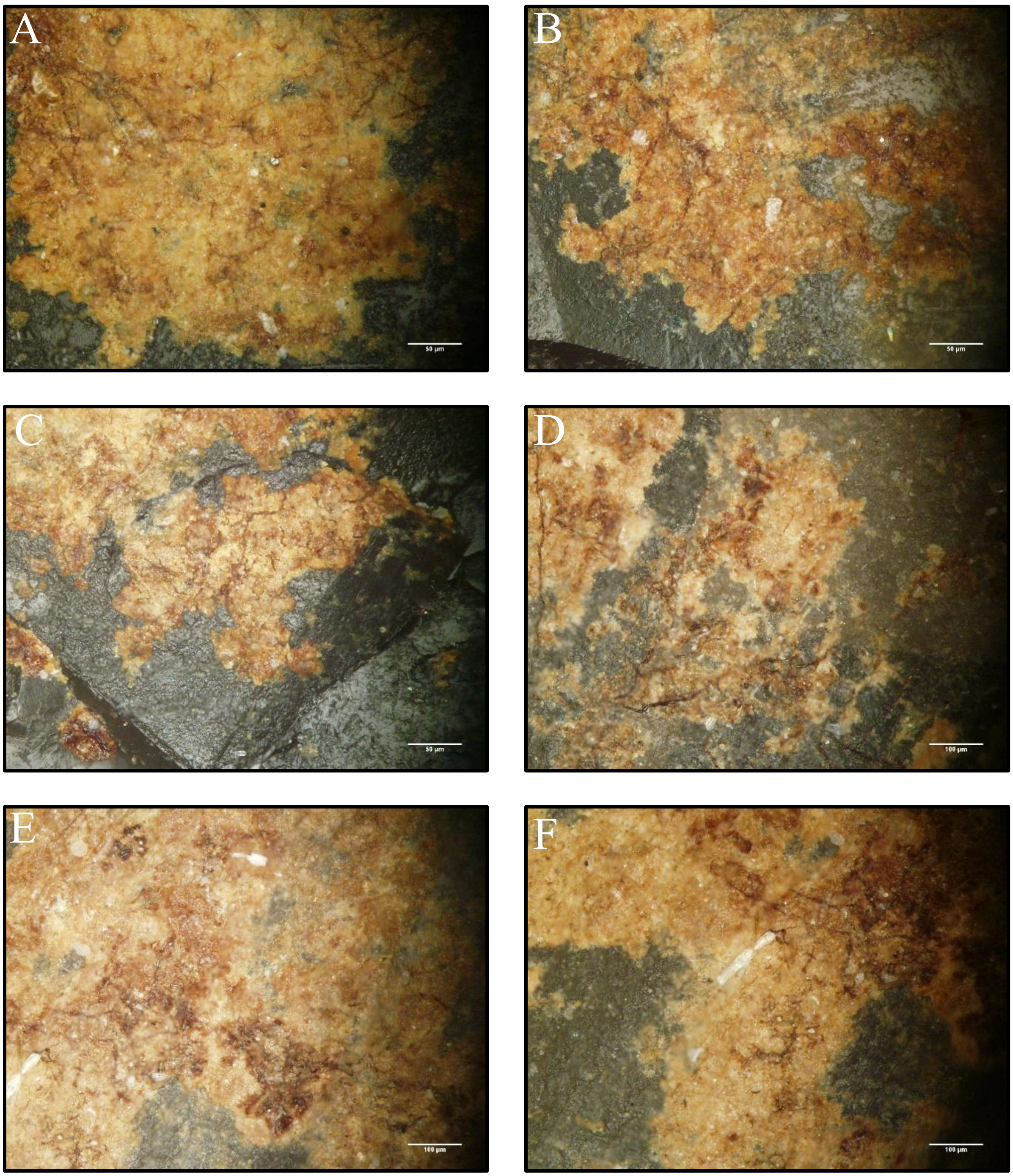

Figure 10-1: Class 1 residue.
A, B, C – Artefact 3885. D, E, F – Artefact 27868.

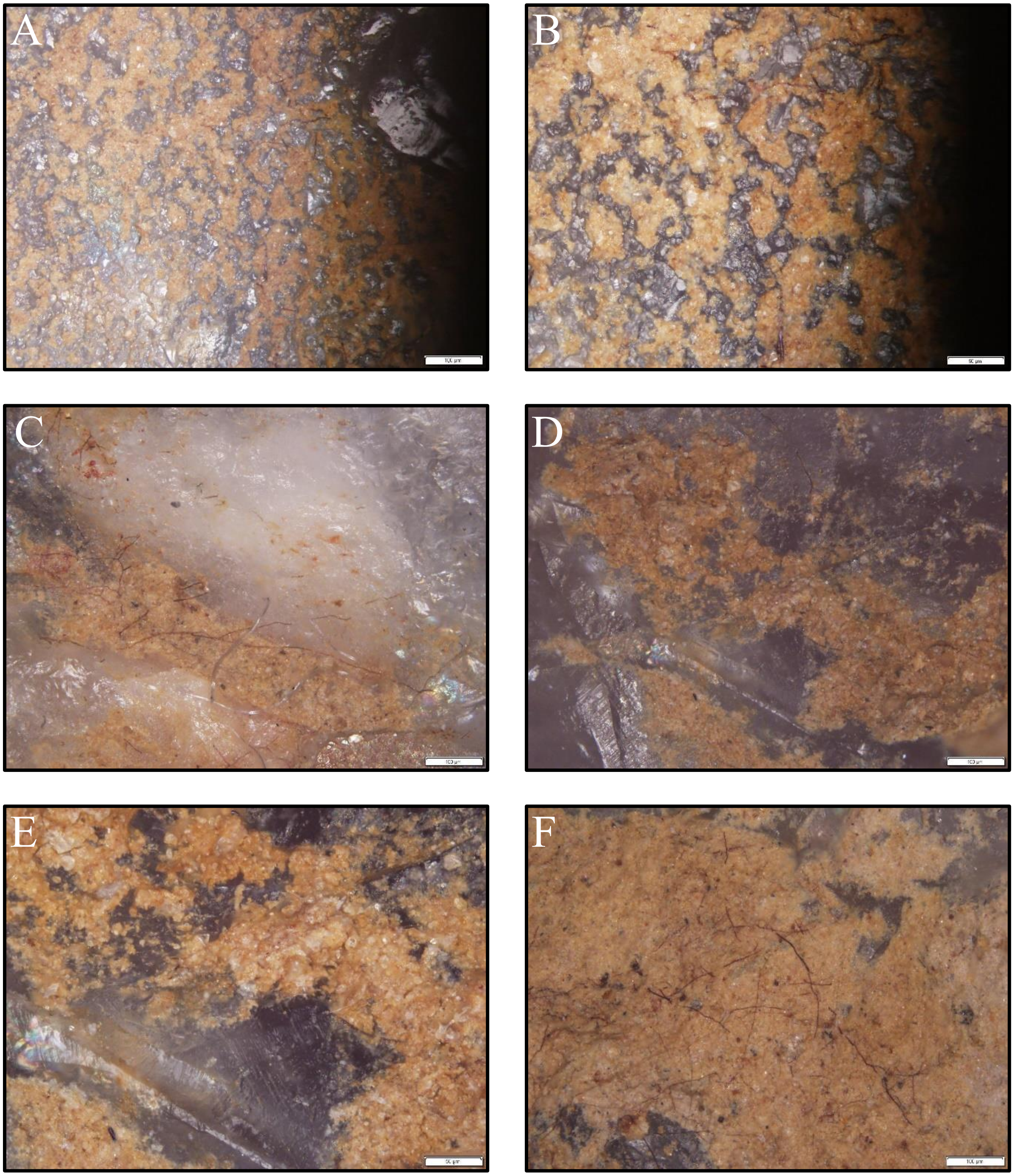

Figure 10-2: Class 1 residue.
A, B – Artefact 31322. C, D, E – Artefact 39056. F – Artefact 51943.

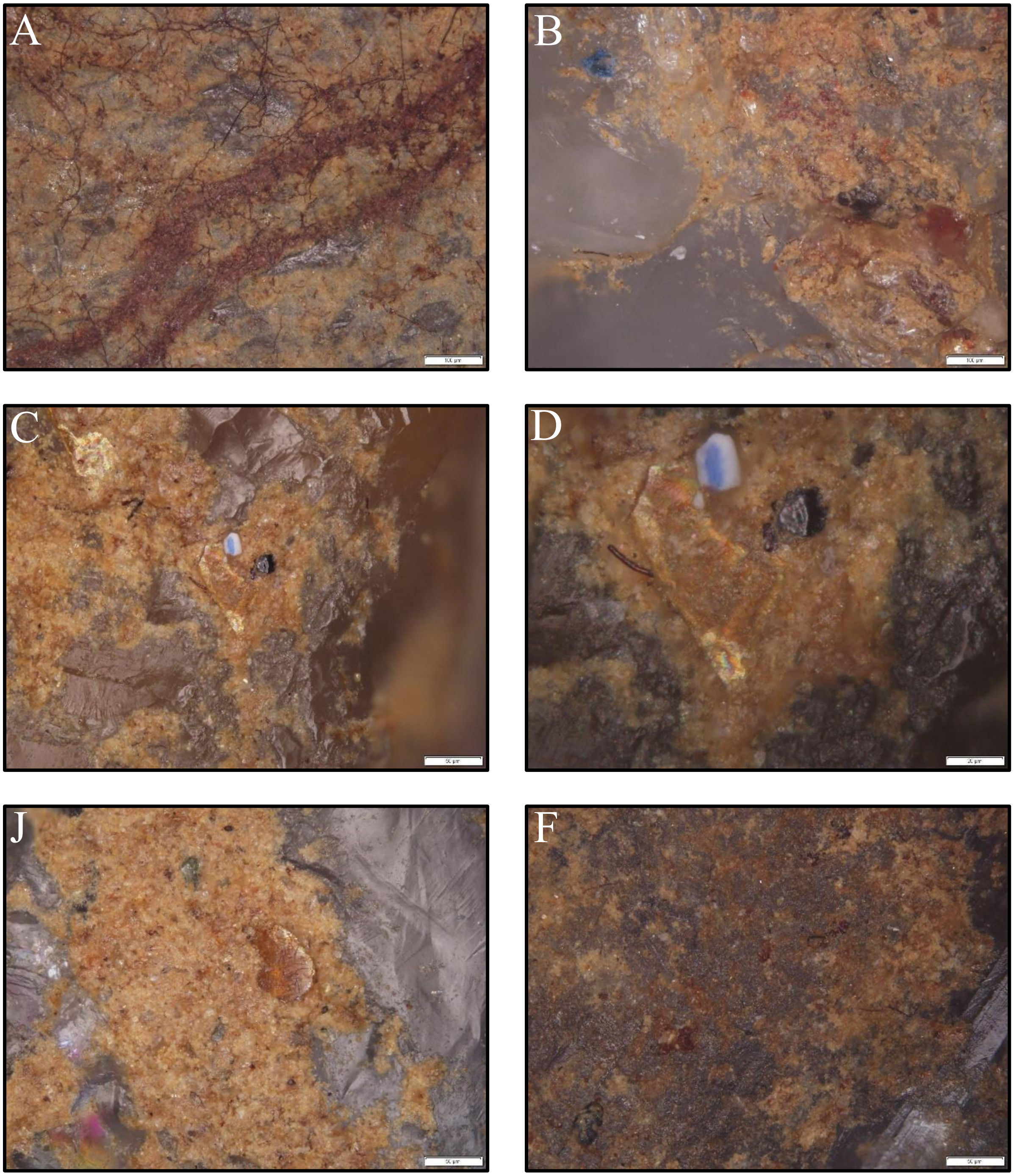

Figure 10-3: Class 1 residue.
A – Artefact 51943. B – Artefact 57679. C, D, E – Artefact 57953. F – Artefact 71653.

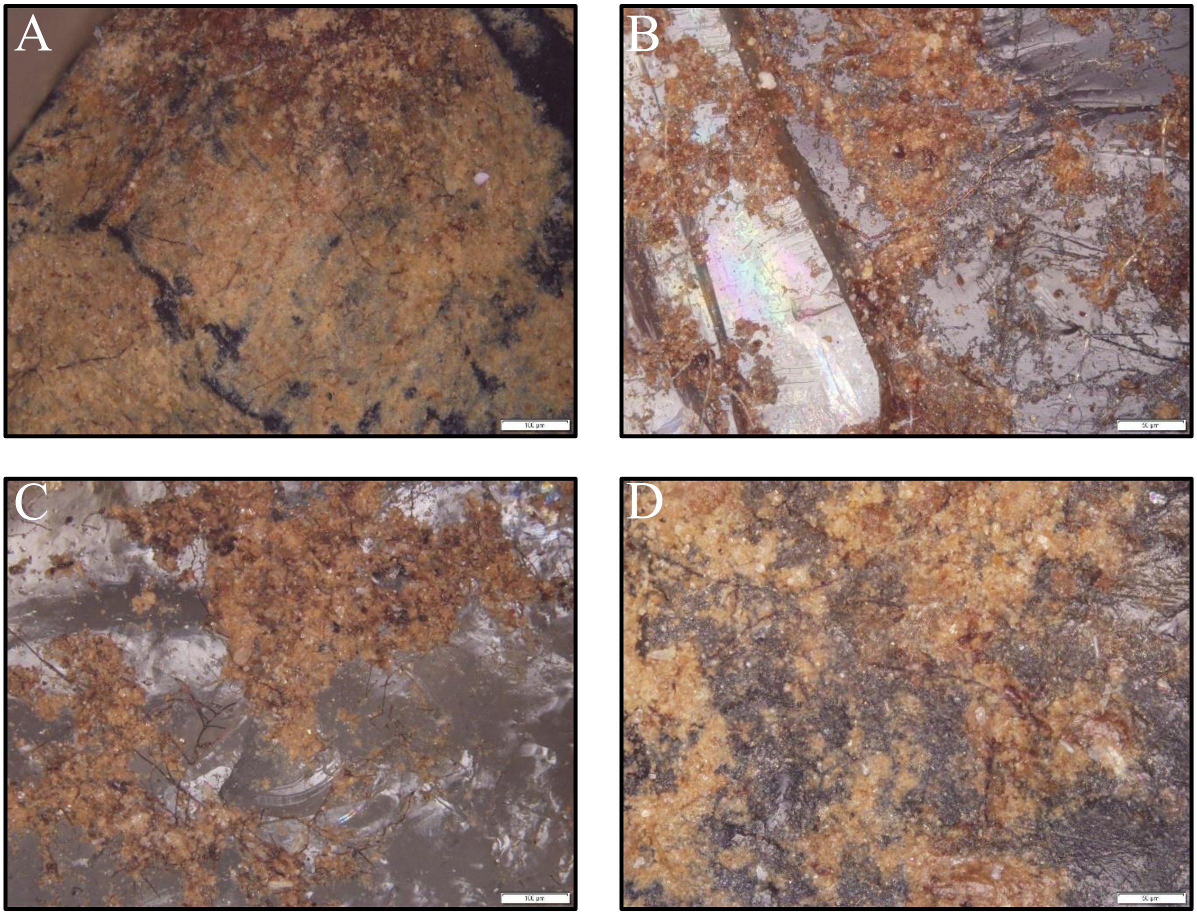

Figure 10-4: Class 1 residue.
A – Artefact 71676. B – Artefact 72526. C – Artefact 76189. D – Point-2.

Class 2 Residue

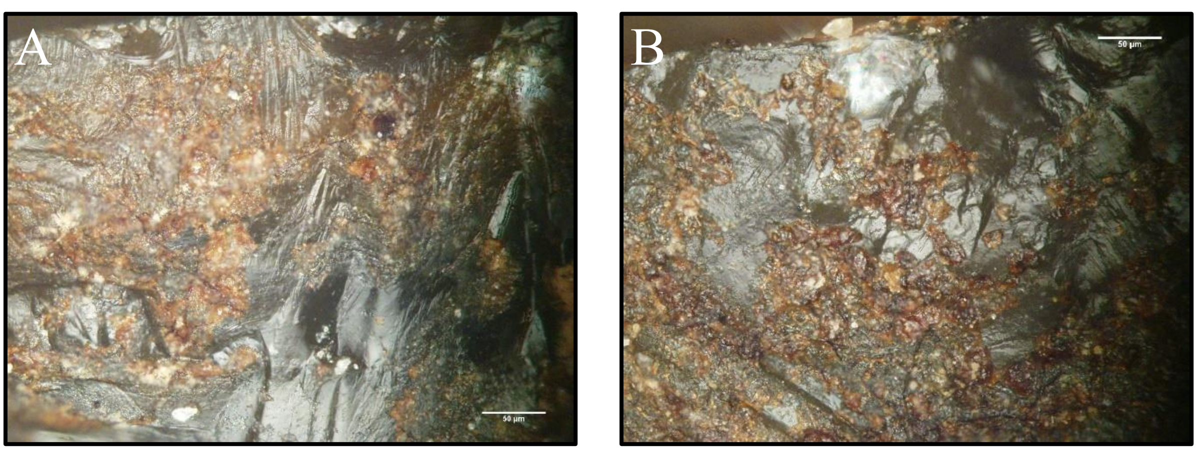

Figure 10-5: Class 2 residue.
A, B – Artefact 4184.

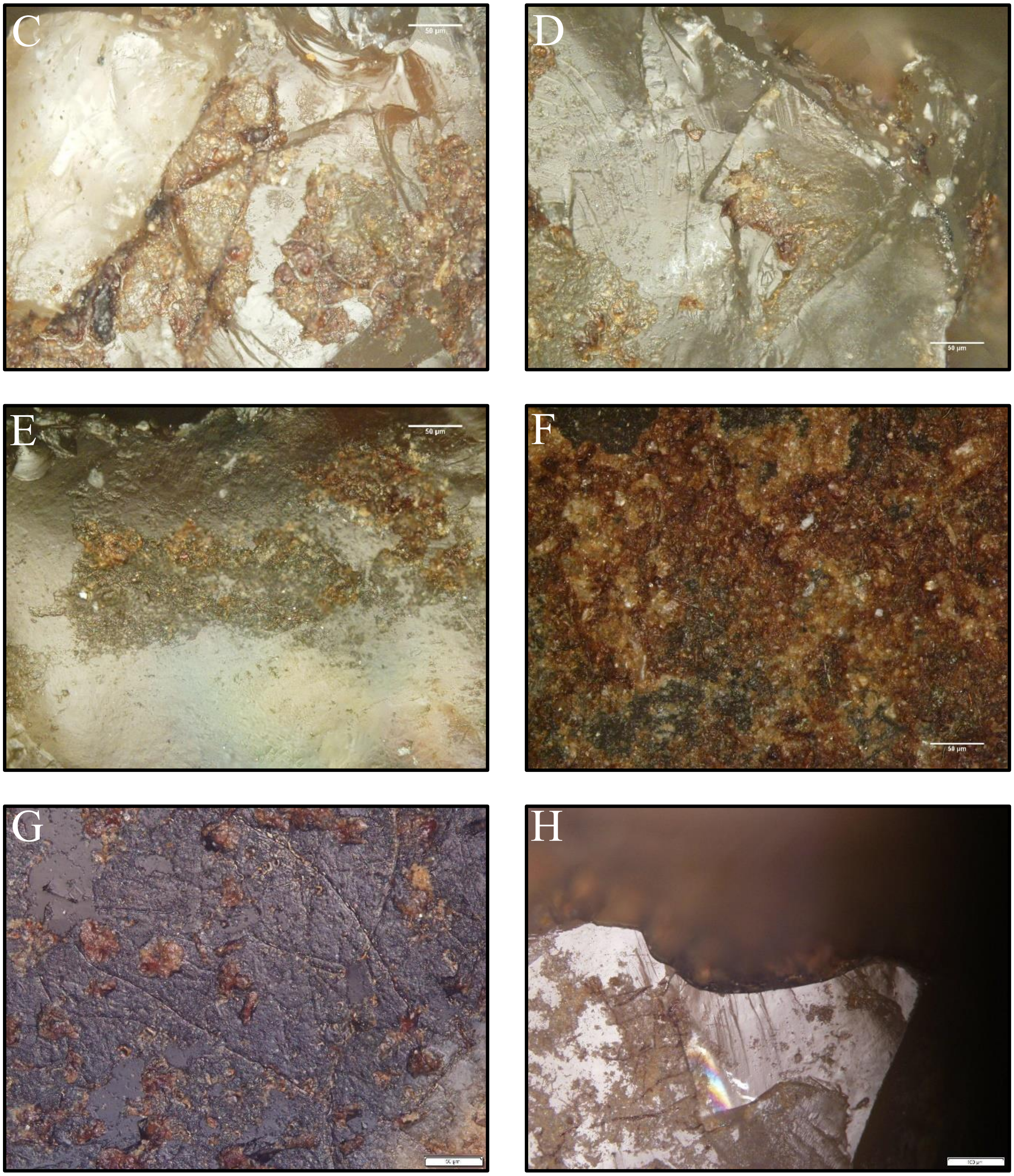

Figure 10-6: Class 2 residue.
A, B, C – Artefact 4184. D – Artefact 15096. E – Artefact 24842. F – Artefact 31322-2.

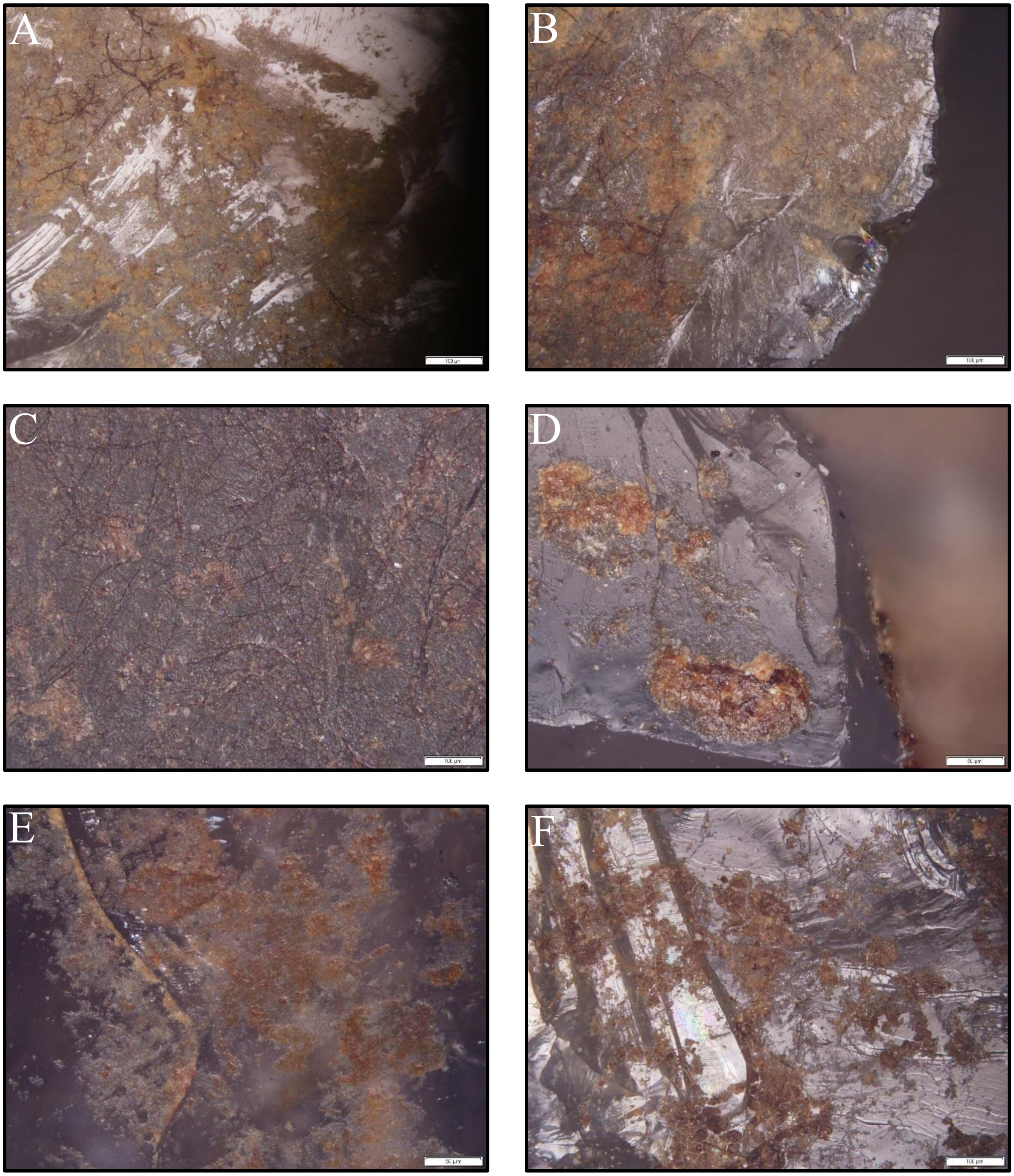

Figure 10-7: Class 2 residue.
A – Artefact 31322-2. B – Artefact 46551. C – Artefact 49249. D – Artefact 63769. E – Artefact 71653. F – Artefact 72526.

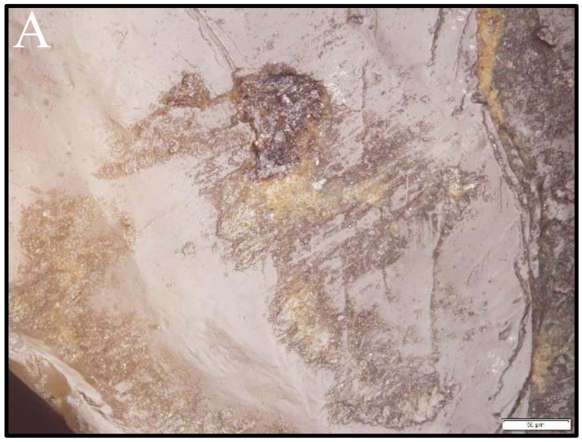

Figure 10-8: Class 2 residue.
A – Artefact 77023.

Class 1/2 Residue

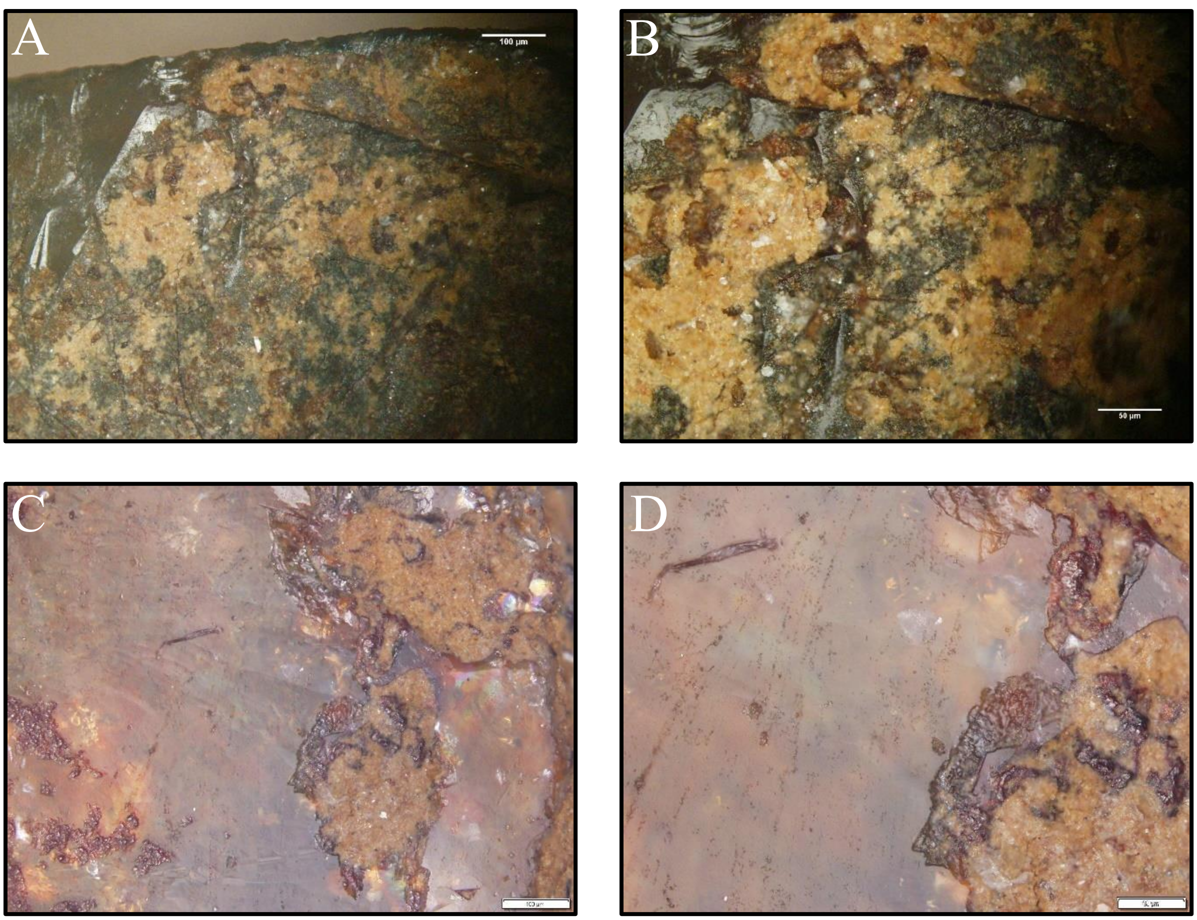

Figure 10-9: Class 1/2 residue.
A, B – Artefact 4184. C, D – Artefact 39056.

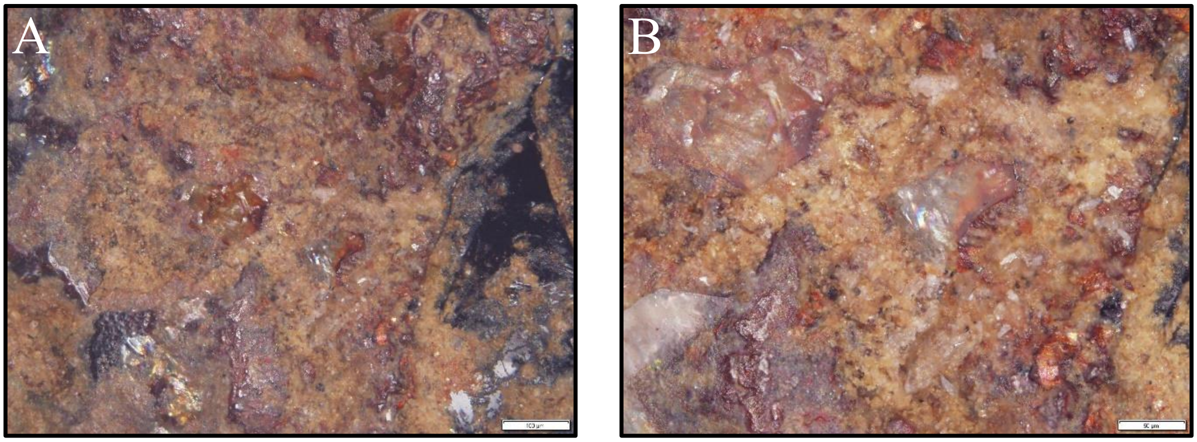

Figure 10-10: Class 1/2 residue.
A, B – Artefact 39056.

Class 3 Residue

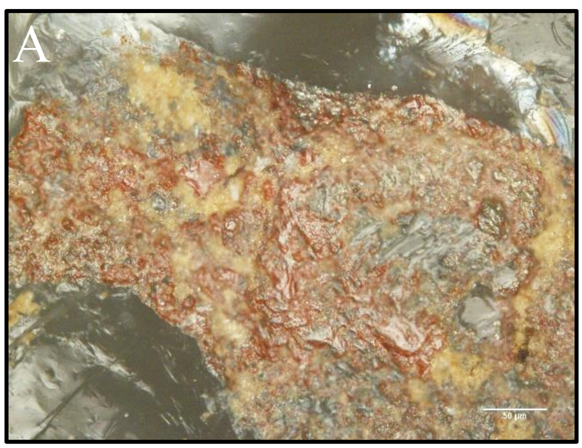

Figure 10-11: Class 3 residue.
A – Artefact 14288.

Class 4 Residue

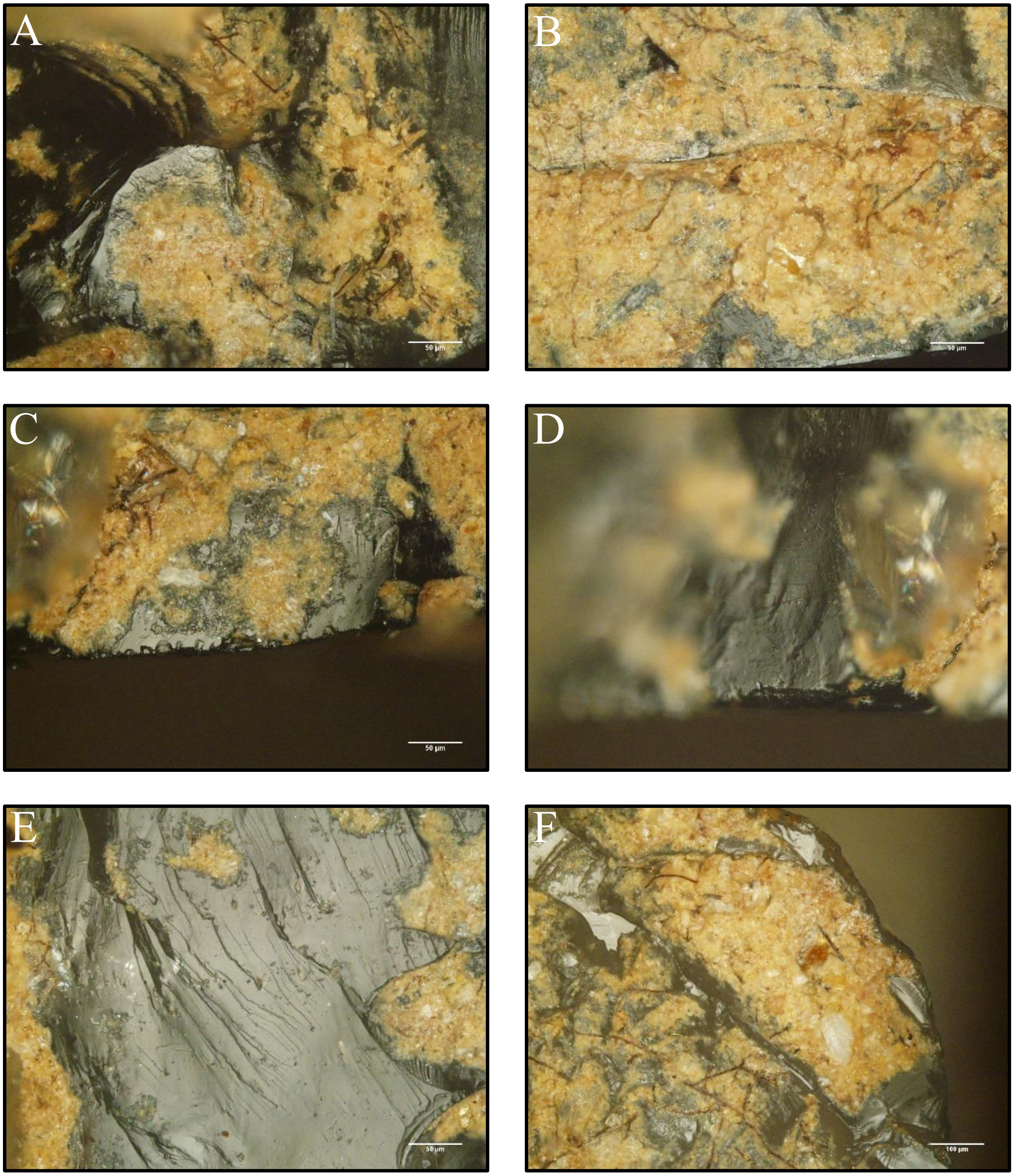

Figure 10-12: Class 4 residue.
A, B, C, D, E, F – Artefact 14288.

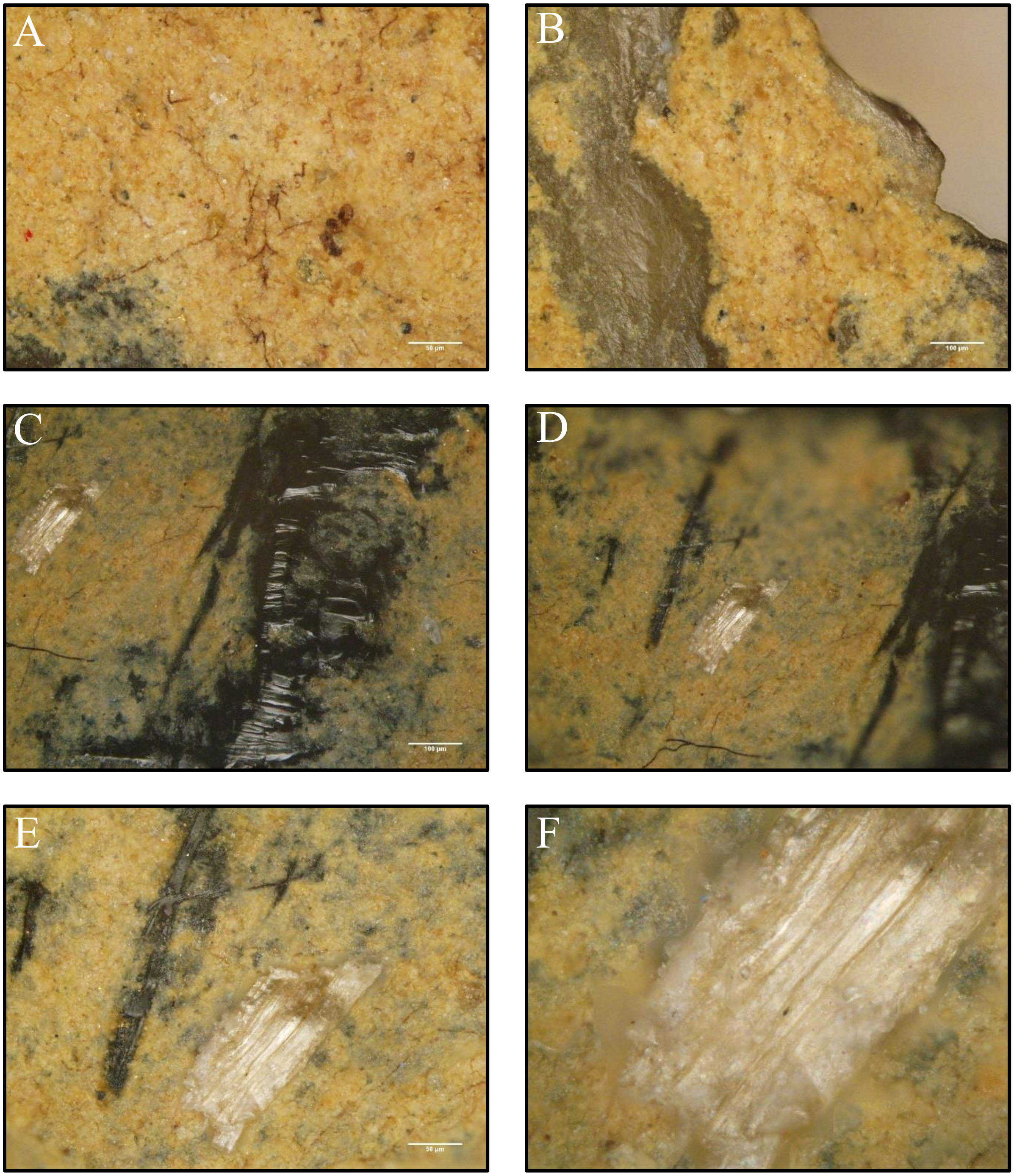

Figure 10-13: Class 4 residue.
A, B, C, D, E, F – Artefact 15295.

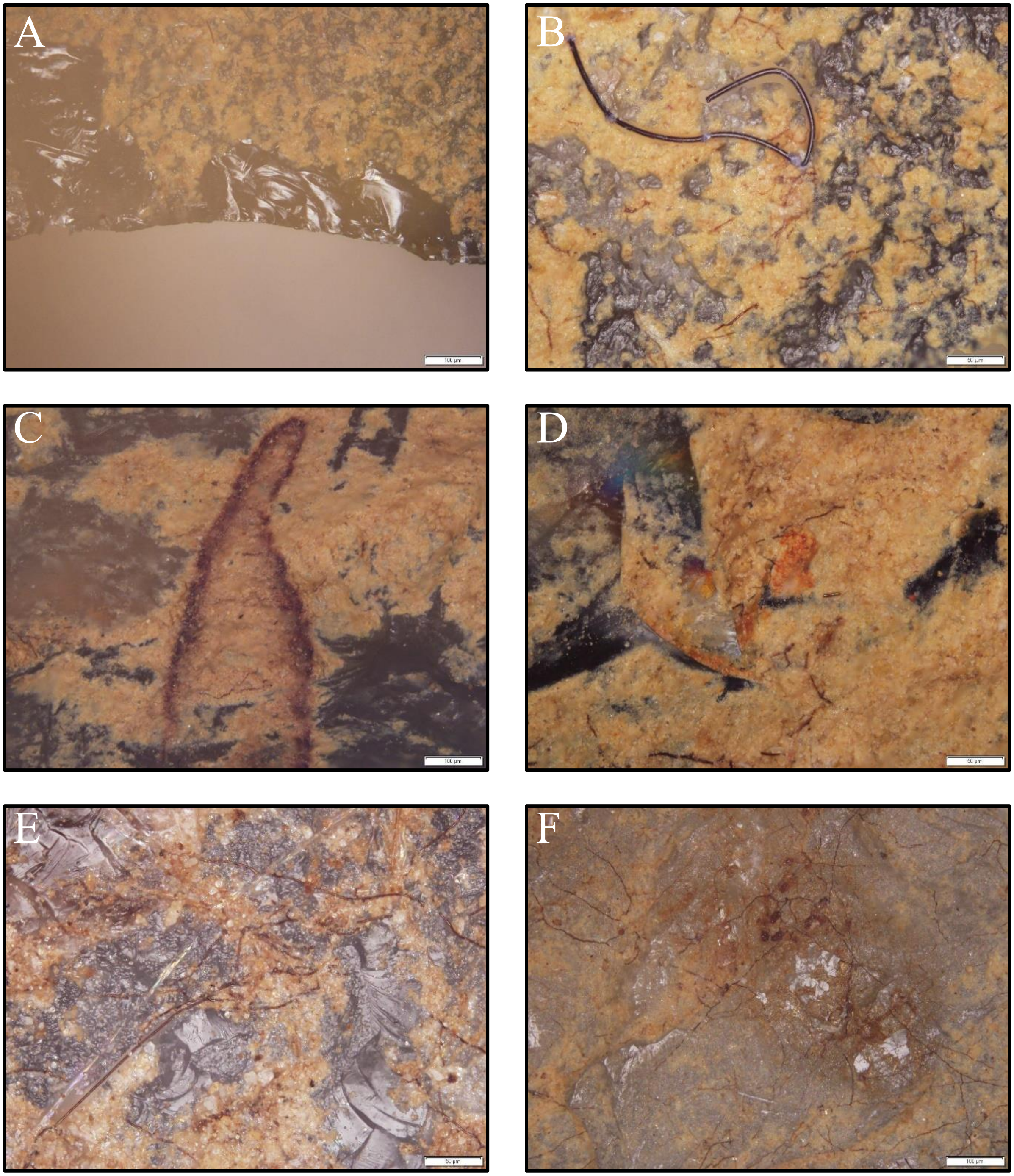

Figure 10-14: Class 4 residue.
A, B – Artefact 46541. C, D – Artefact 46551. E – Artefact 51849. F – Artefact 51943.

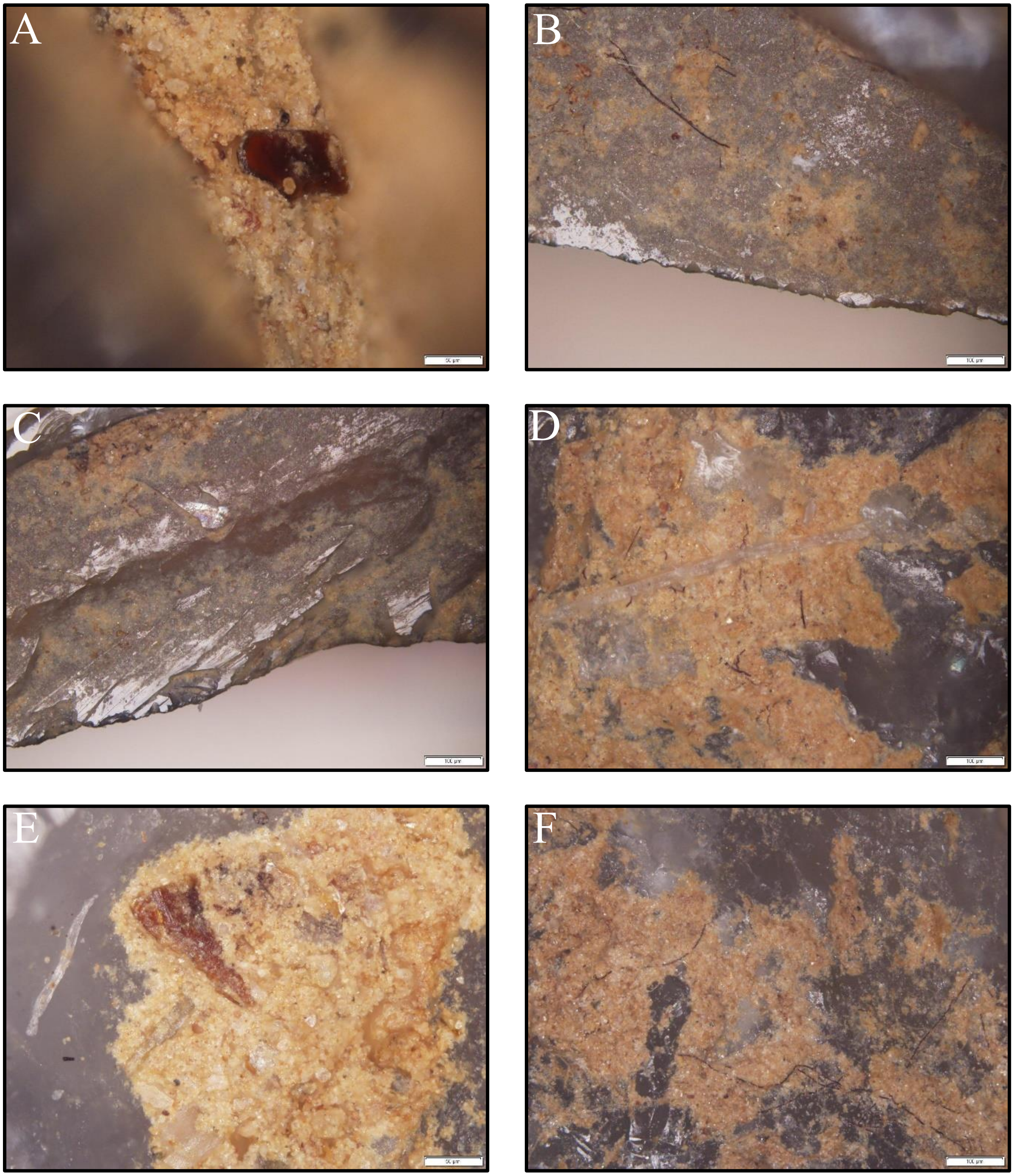

Figure 10-15: Class 4 residue.
A – 71653. B, C, D – Artefact 77023. E – Artefact 86944. F – Point-2.

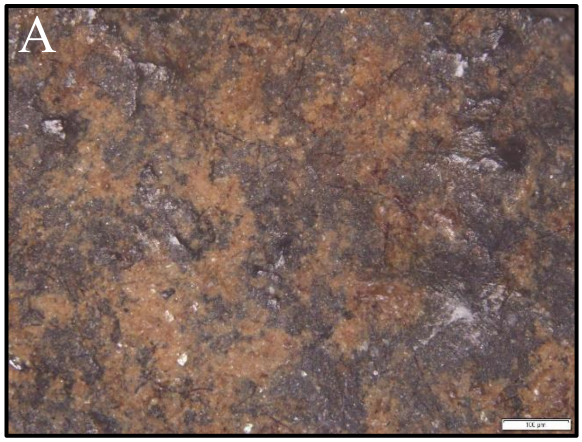

Figure 10-16: Class 4 residue.
A – Point-2.

Class 5 Residue

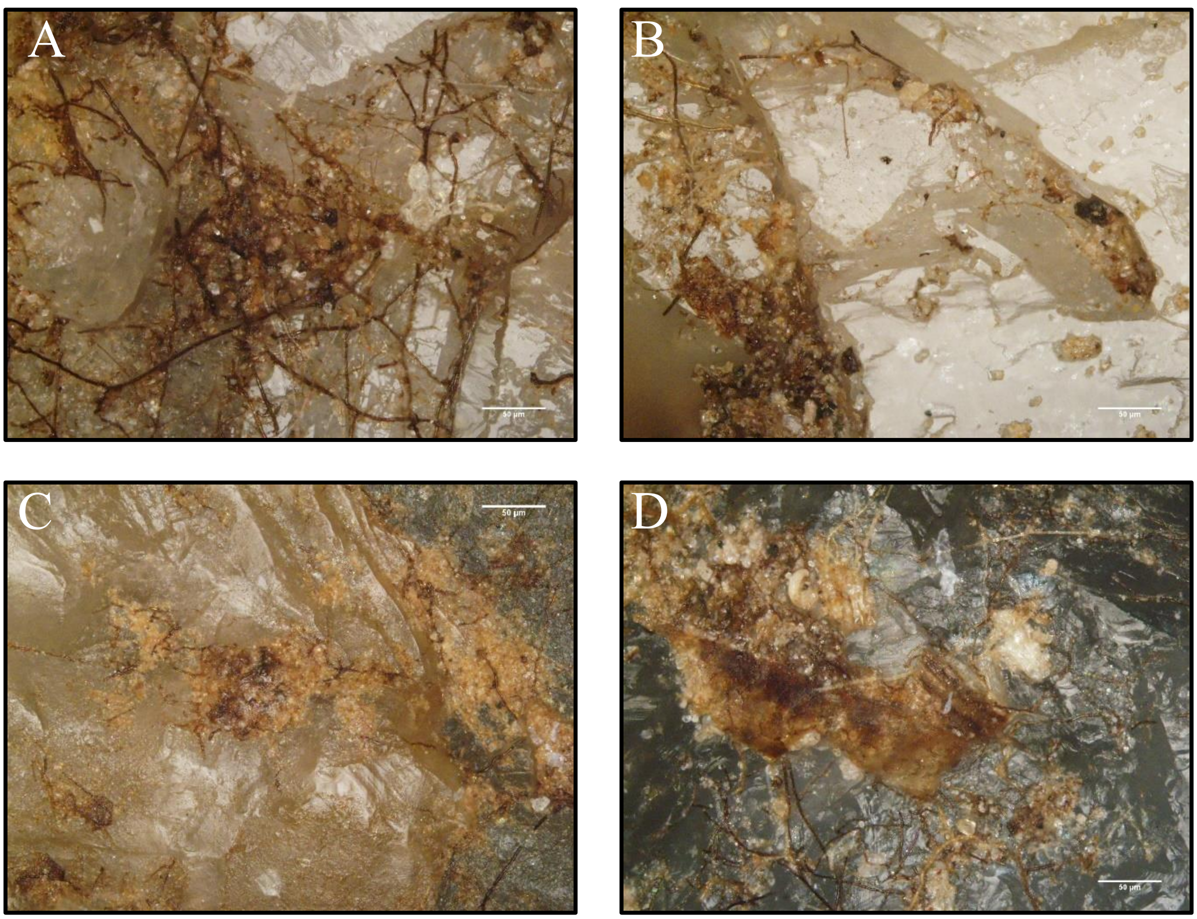

Figure 10-17: Class 5 residue.
A, B – Artefact 15096. C – Artefact 15387. D – Artefact 16208.

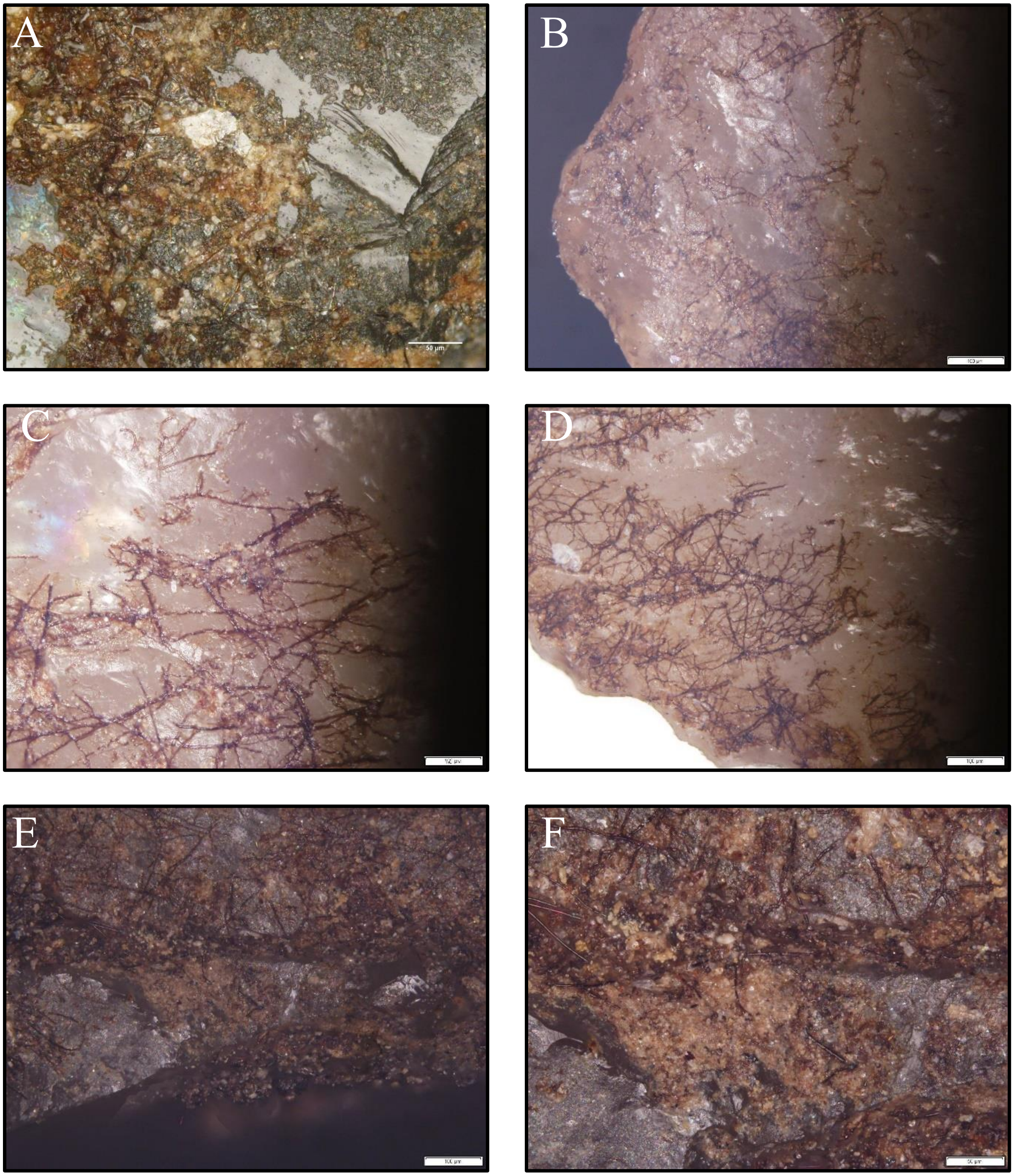

Figure 10-18: Class 5 residue.
A – Artefact 16528. B, C, D – Artefact 33622. E, F – Artefact 42413.

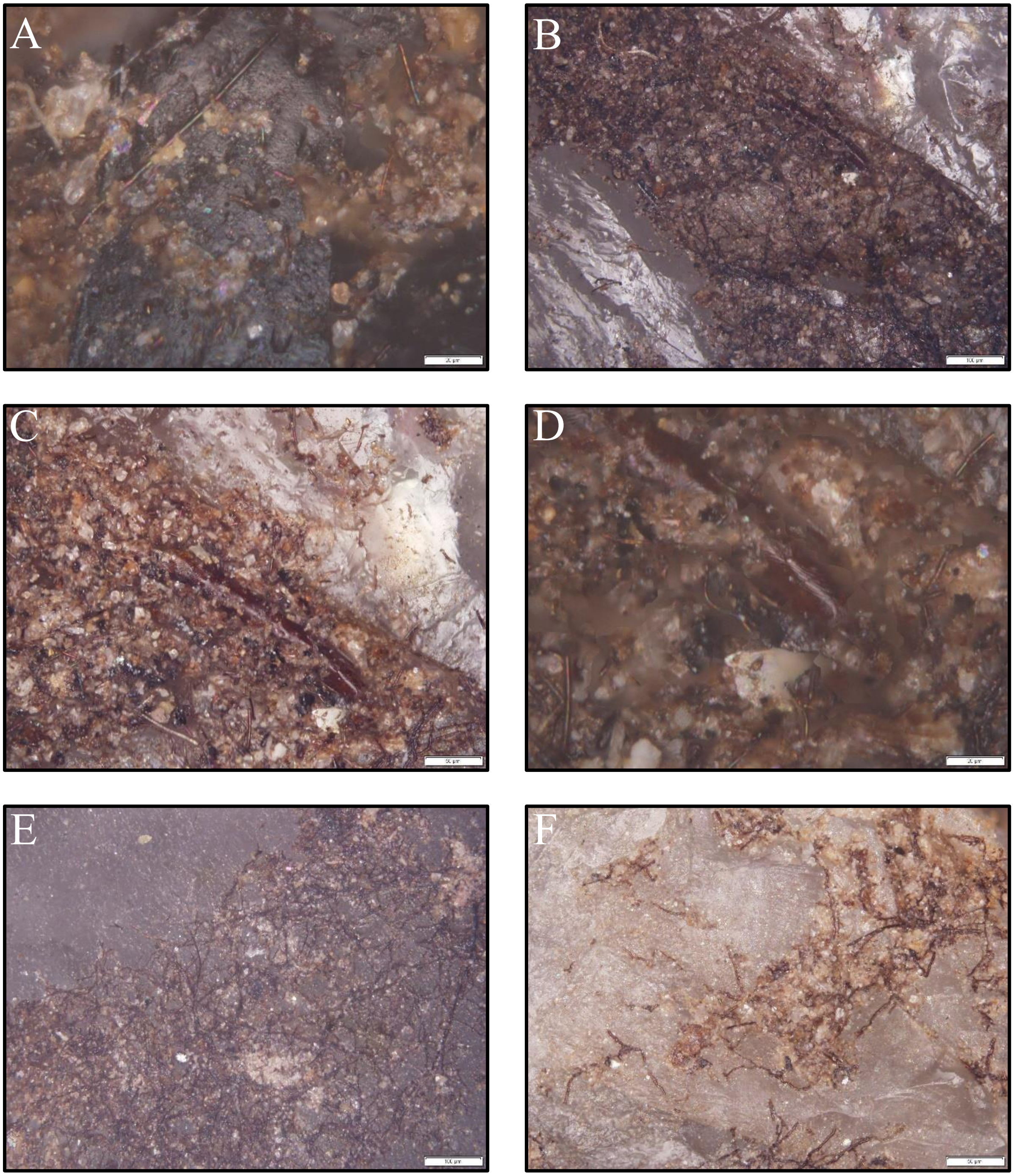

Figure 10-19: Class 5 residue.
A, B, C, D – Artefact 42413. E – Artefact 70265. F – Artefact 70283.

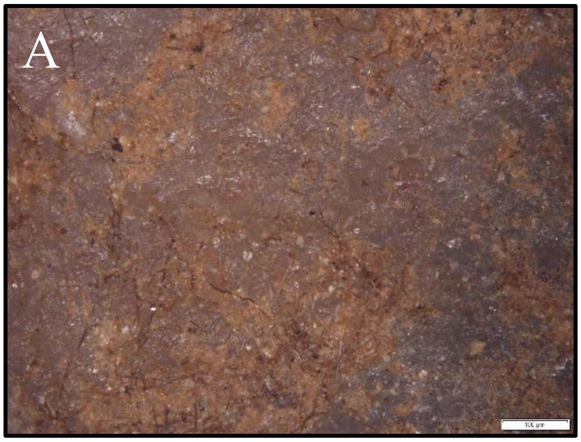

Figure 10-20: Class 5 residue.
A – Artefact 72526.

Class 6 Residue

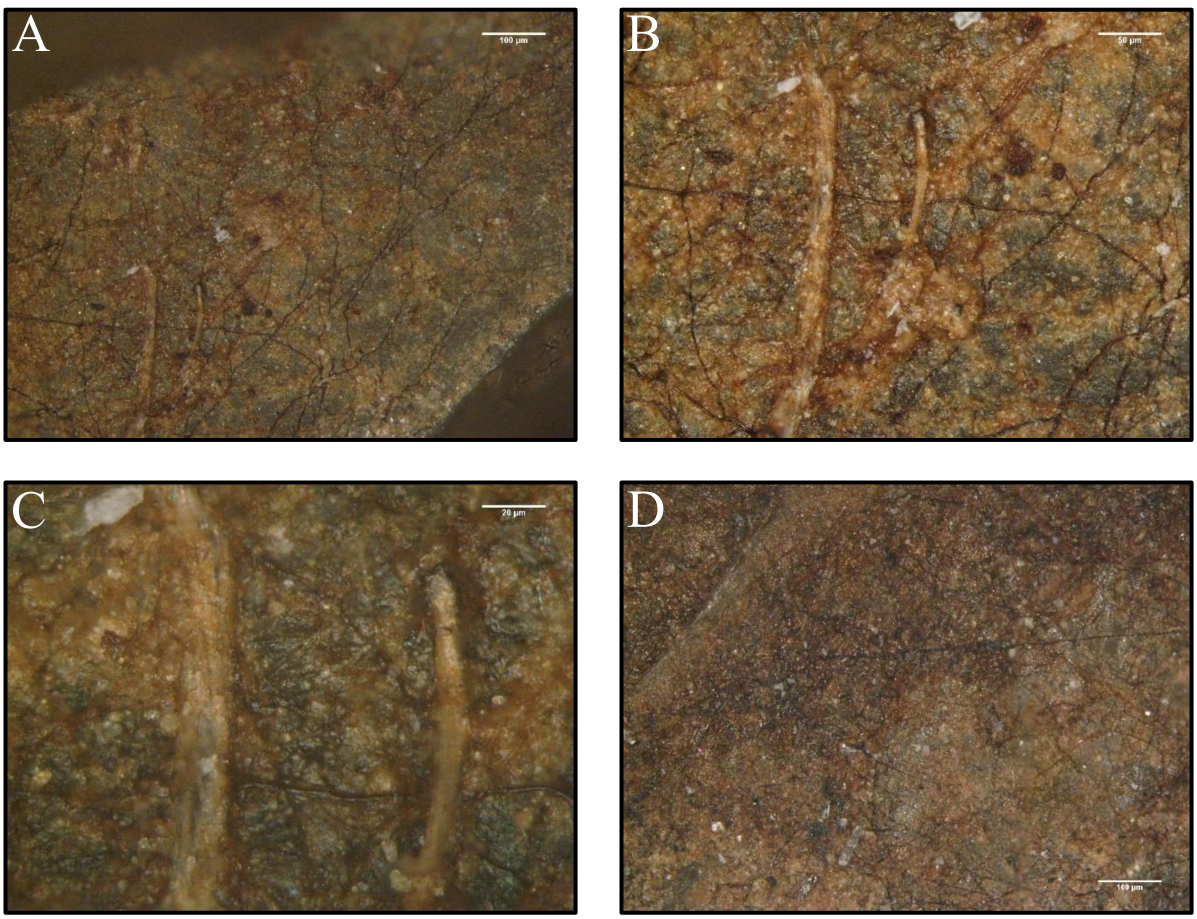

Figure 10-21: Class 6 residue.
A, B, C – Artefact 15387. D – Artefact 24506.

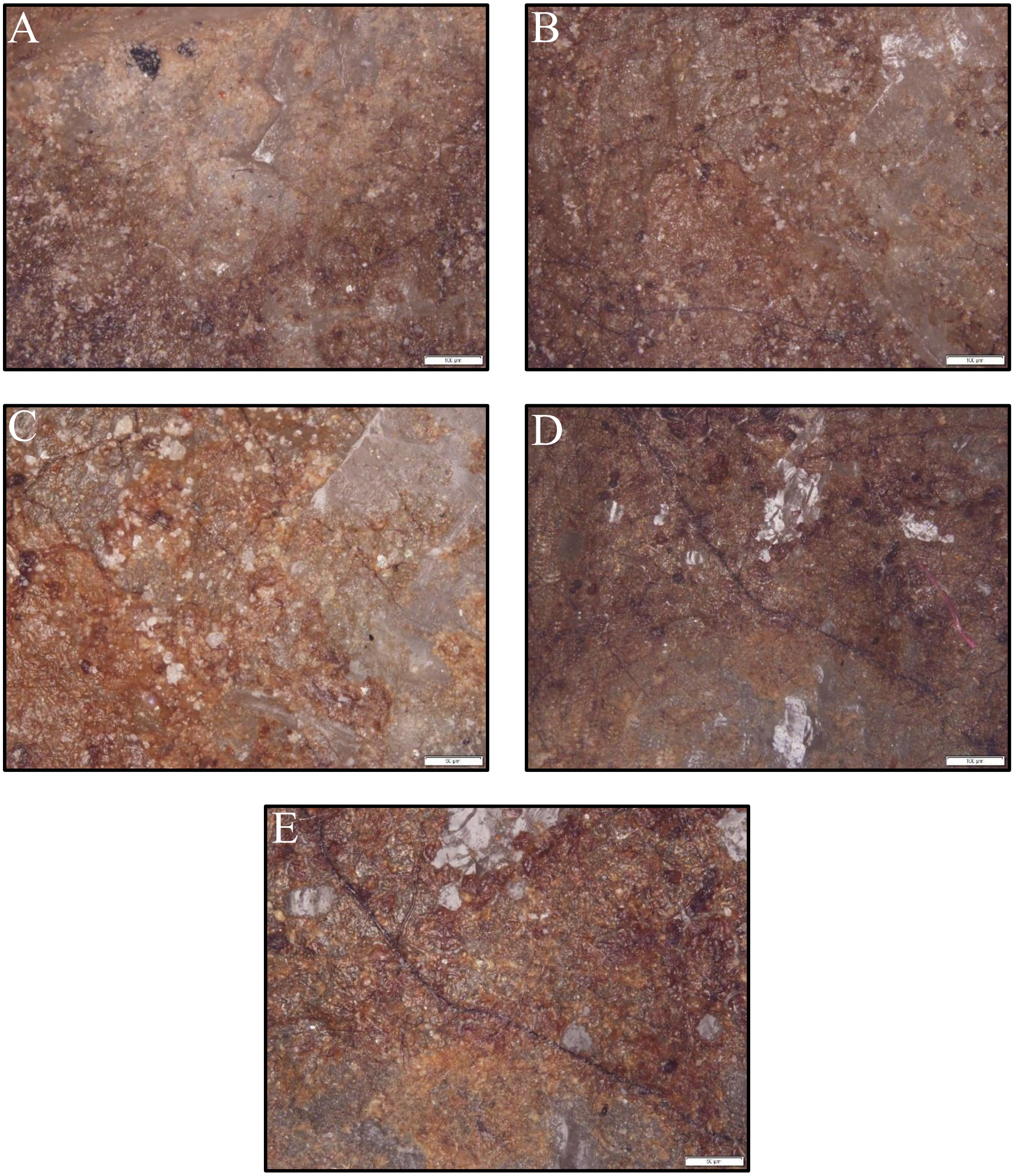

Figure 10-22: Class 6 residue.
A, B, C – Artefact 77176. D, E – Artefact 86944.

Class 7 Residue

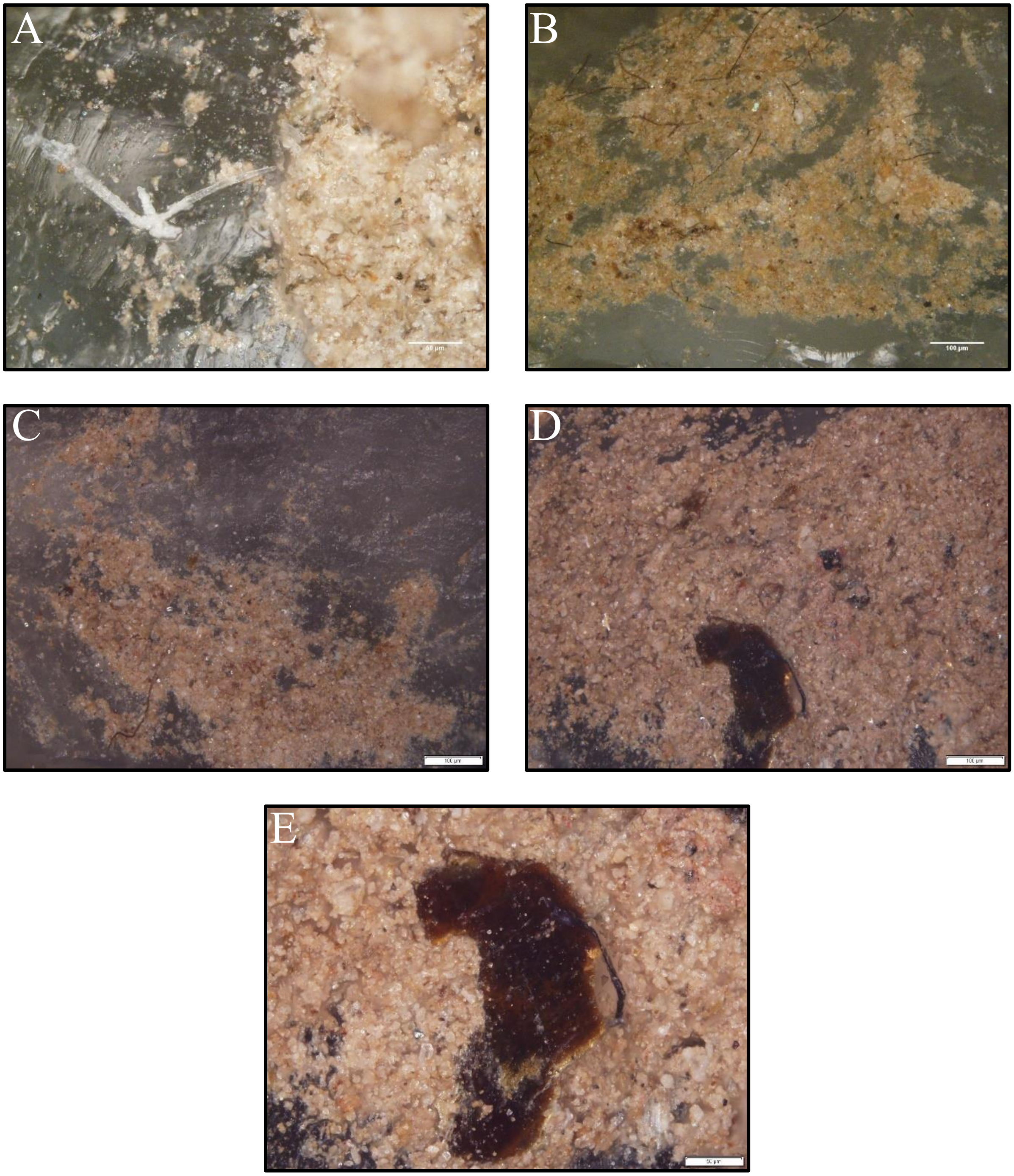

Figure 10-23: Class 7 residue.
A – Artefact 16208. B – Artefact 20503. C, D, E – Artefact 52053.

Class 8 Residue.

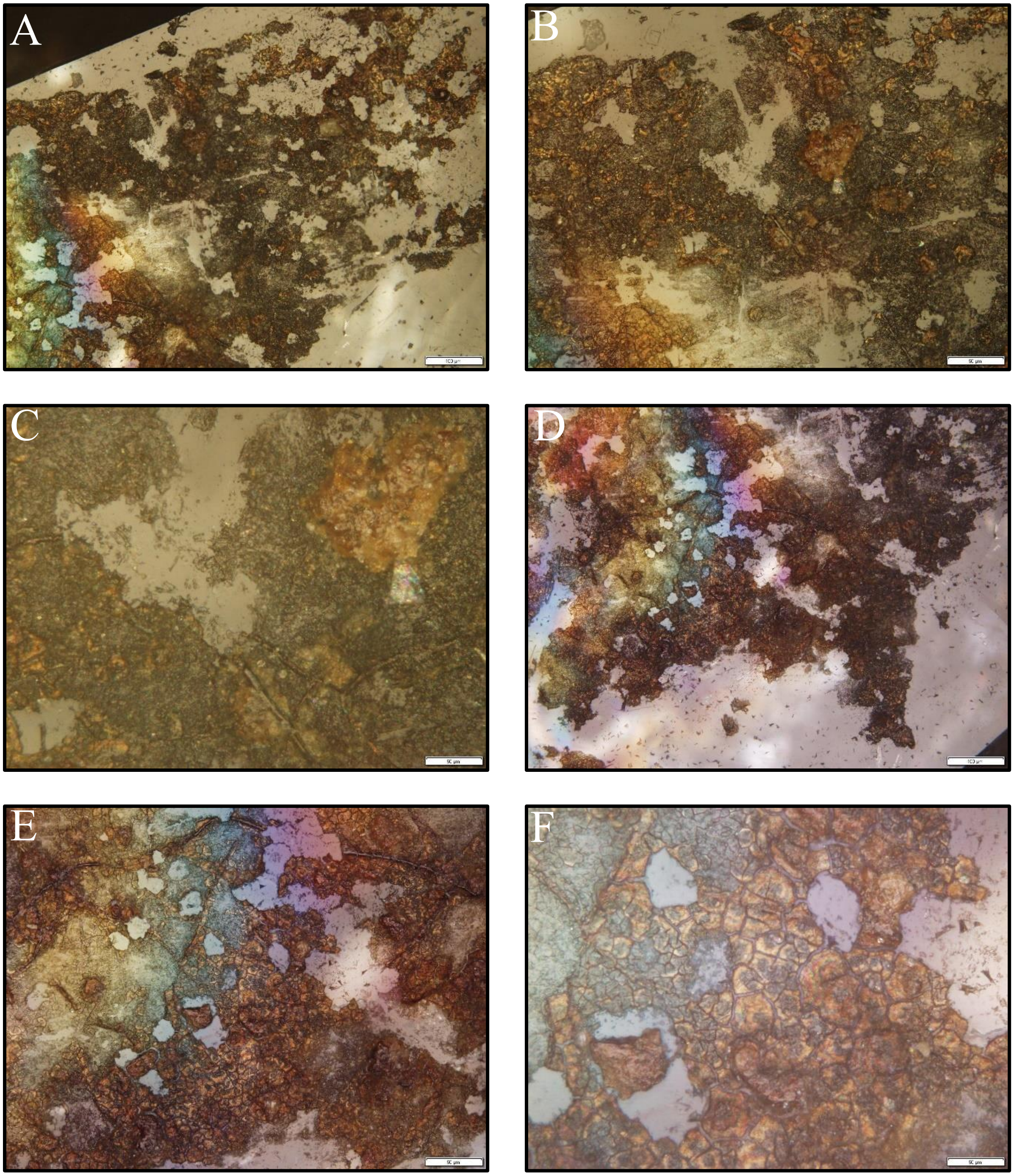

Figure 10-24: Class 8 residue.
A, B, C, D, E, F – Artefact 24842.

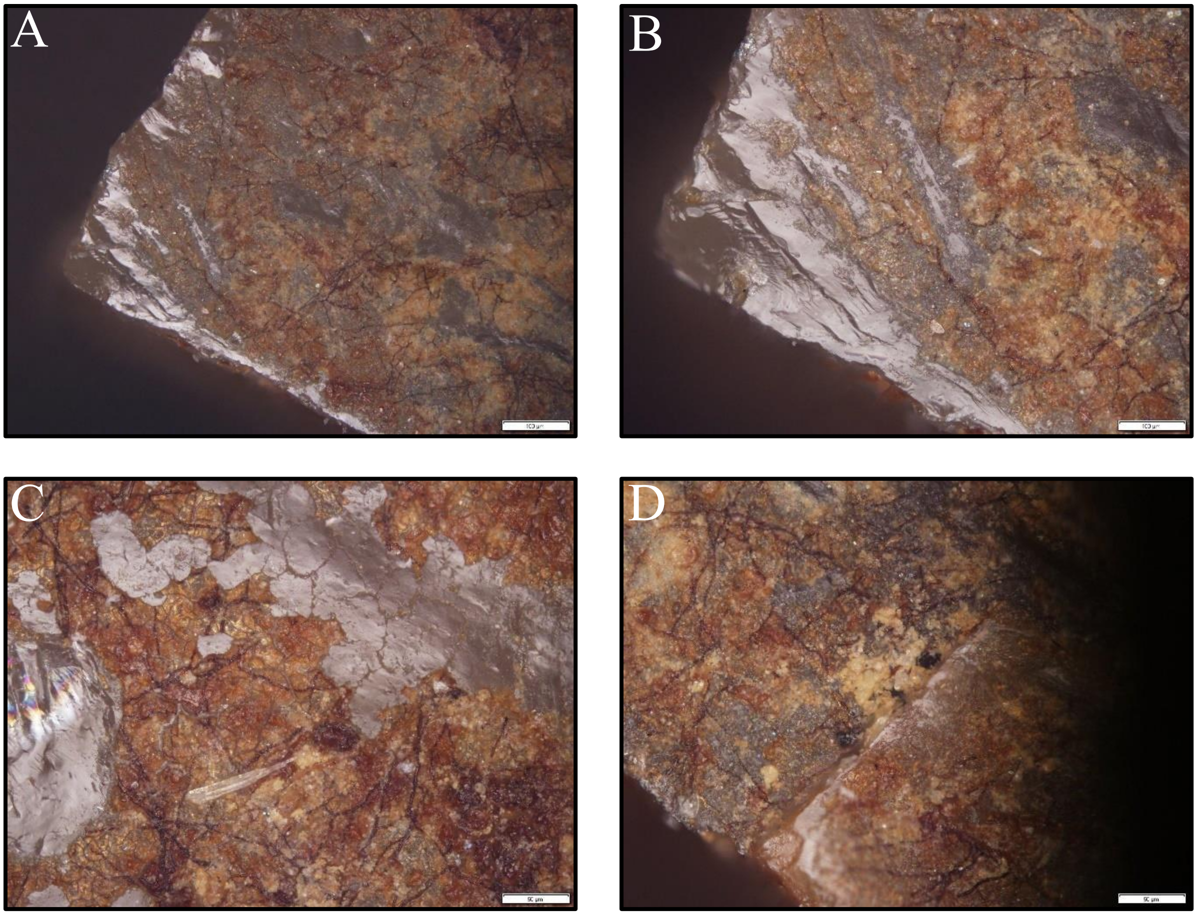

Figure 10-25: Class 8 residue.
A, B, C, D – Artefact 25073.

Class 9 Residue

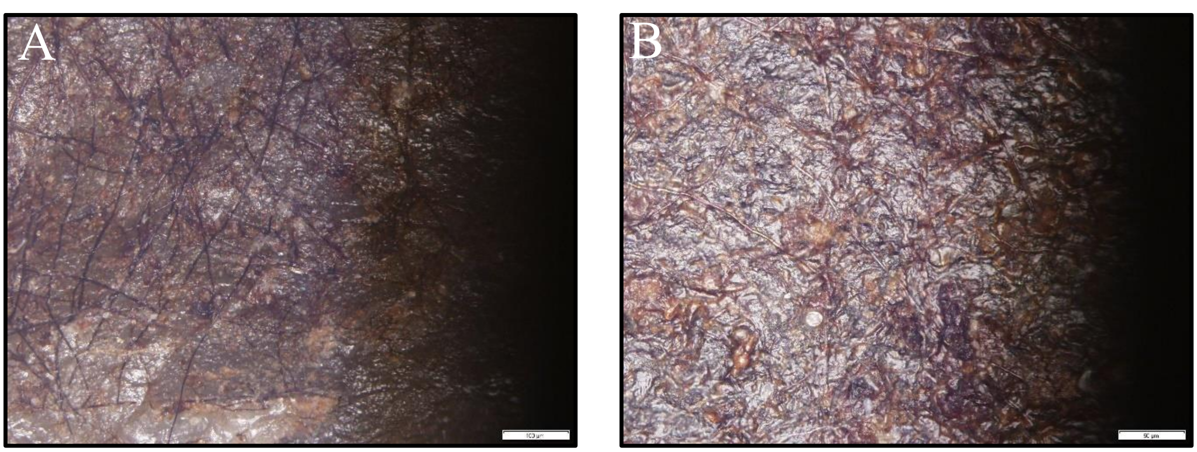

Figure 10-26: Class 9 residue.
A, B – Artefact 35330.

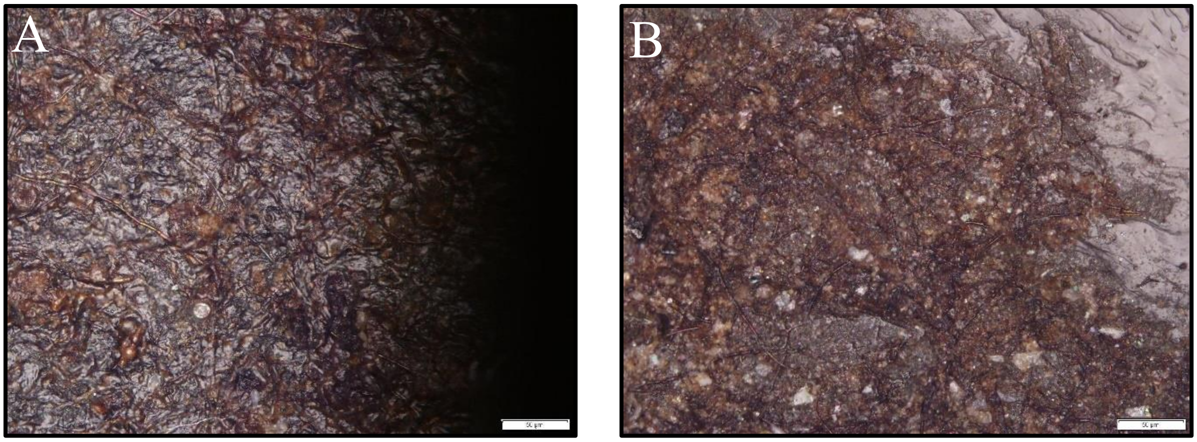

Figure 10-27: Class 9 residue.
A – Artefact 35330. B – Artefact 42413.

Class 10 Residue

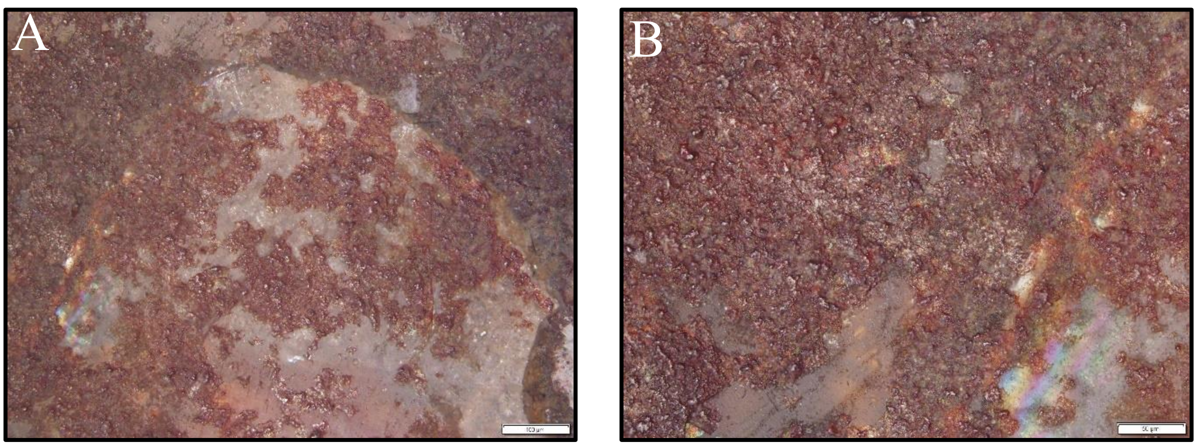

Figure 10-28: Class 10 residue.
A, B – Artefact 39056.

Class 11 Residue

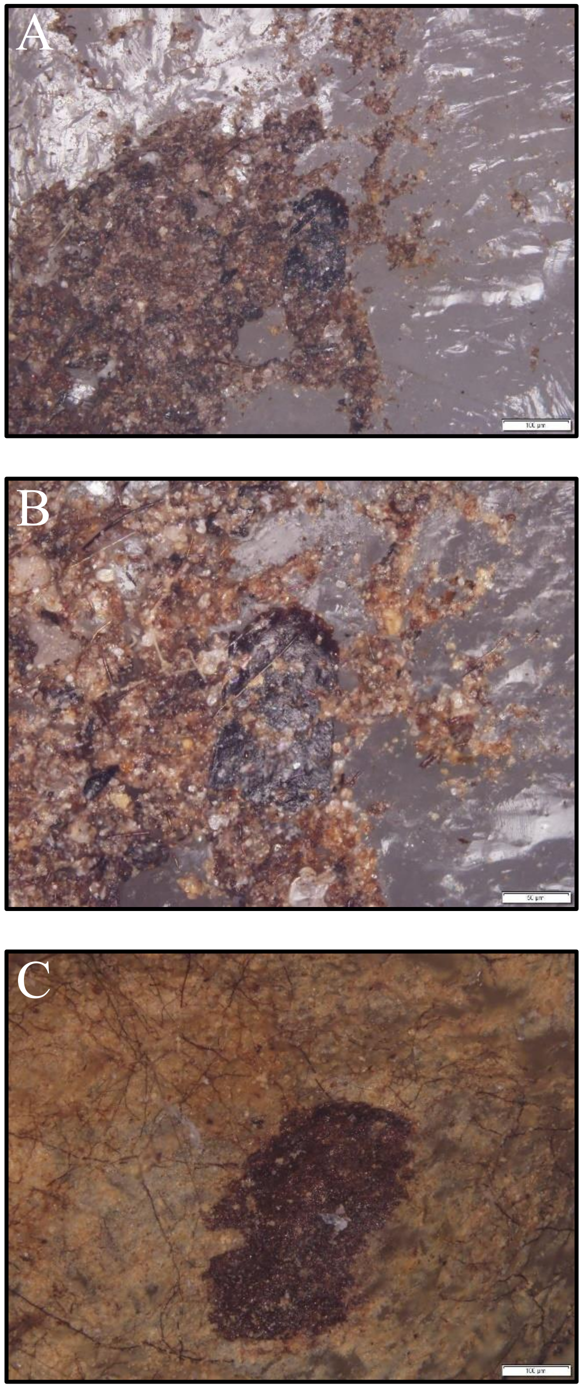

Figure 10-29: Class 11 residue.
A, B – Artefact 42413. C – Artefact 51943.

Class 12 Residue

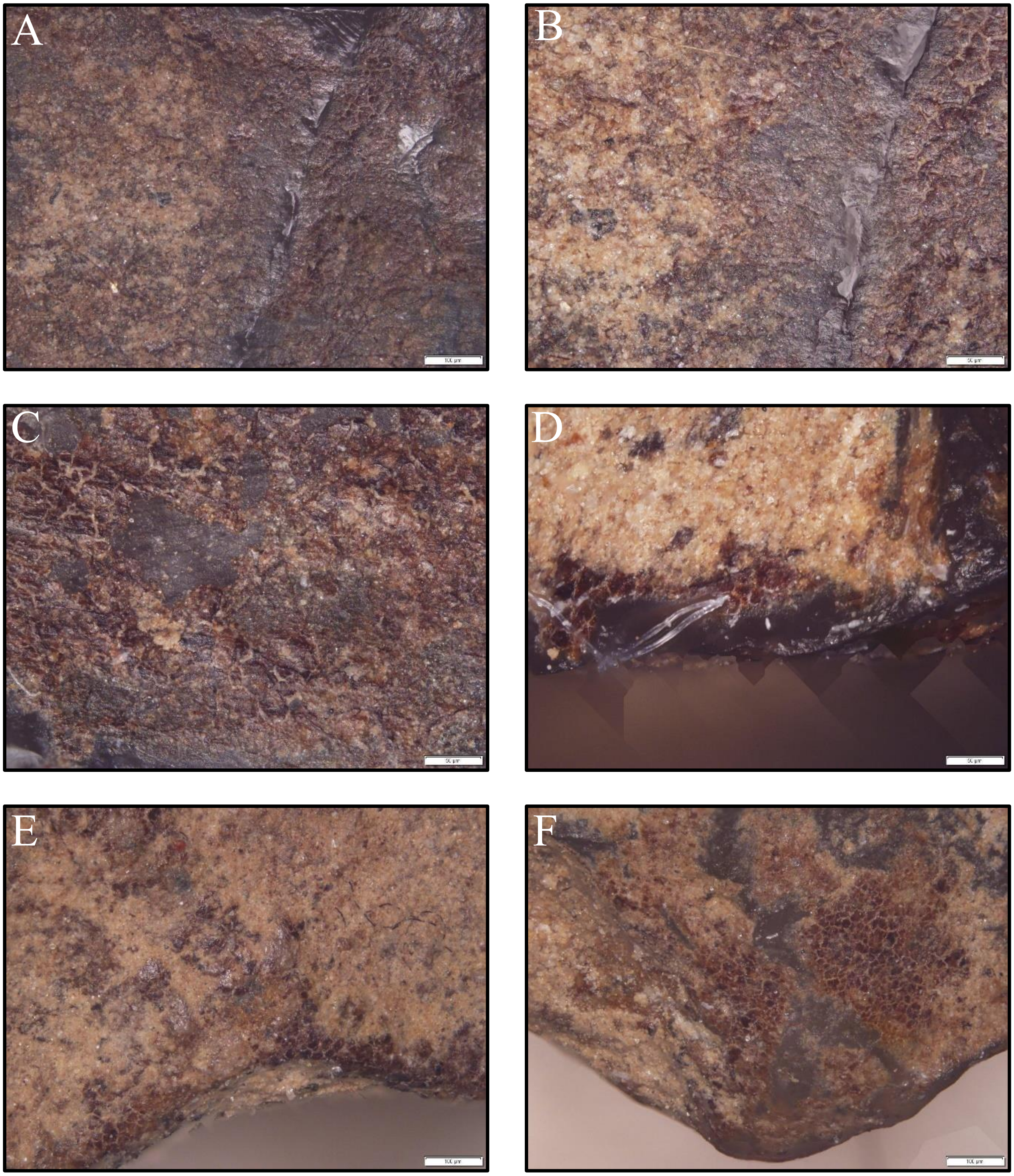

Figure 10-30: Class 12 residue.
A, B, C – Artefact 44139. D – Artefact 63769. E, F – Point 1.

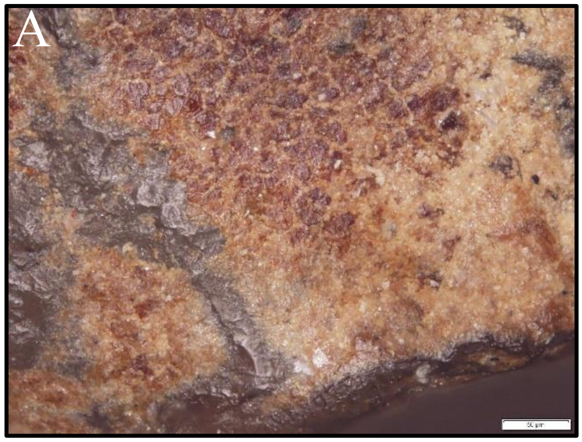

Figure 10-31: Class 12 residue.
A – Point 1.

Class 13 Residue

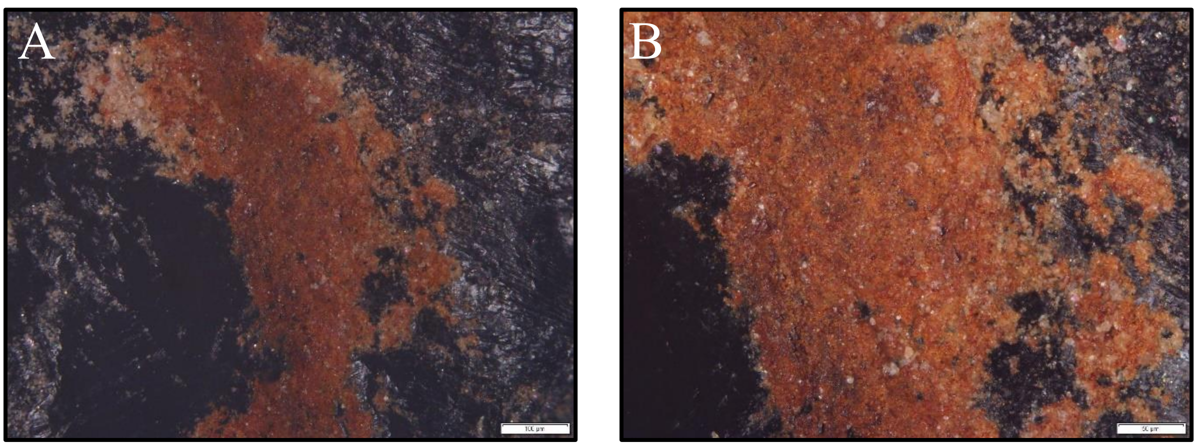

Figure 10-32: Class 13 residue.
A, B – Artefact 51944

Class 14 Residue

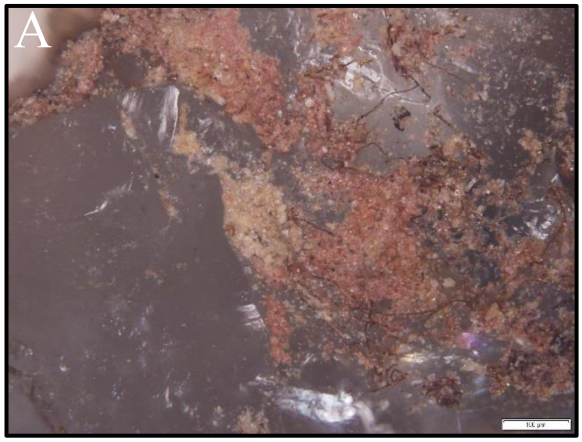

Figure 10-33: Class 14 residue.
A – Artefact 56627.

Class 15 Residue

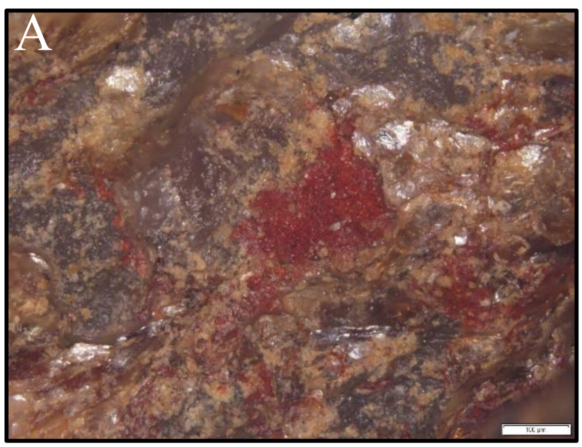

Figure 10-34: Class 15 residue.
A – Artefact 57679.

Class 16 Residue

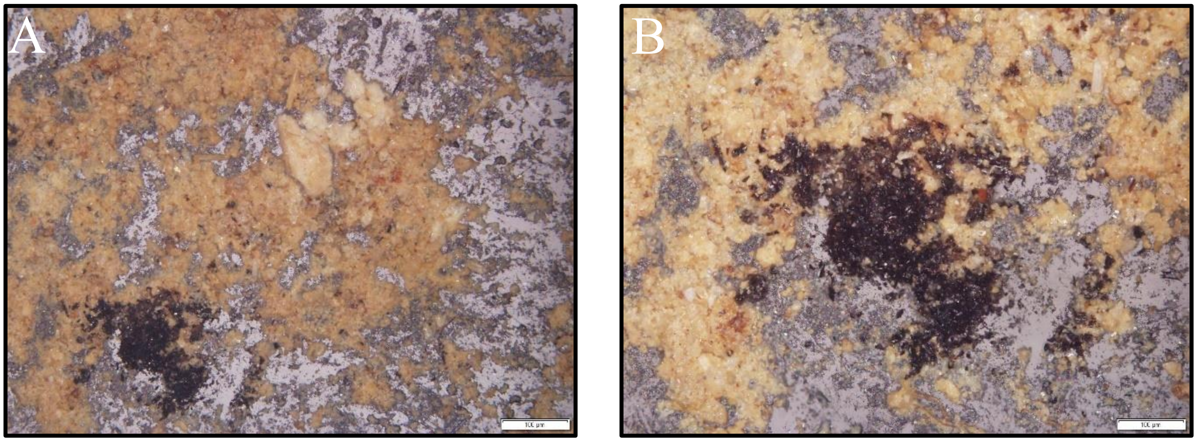

Figure 10-35: Class 16 residue.
A, B – 71676.

Fibres

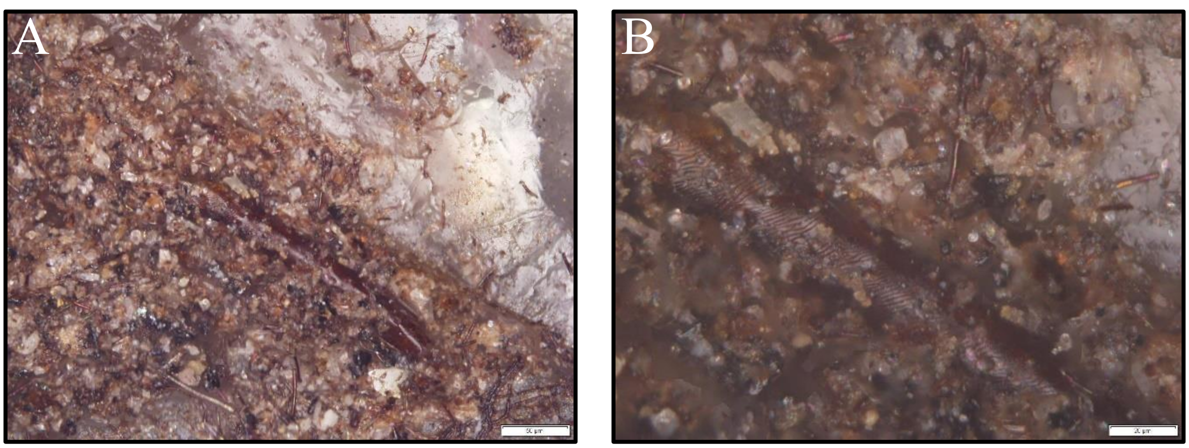

Figure 10-36: Fibres.
A, B – Artefact 42413.

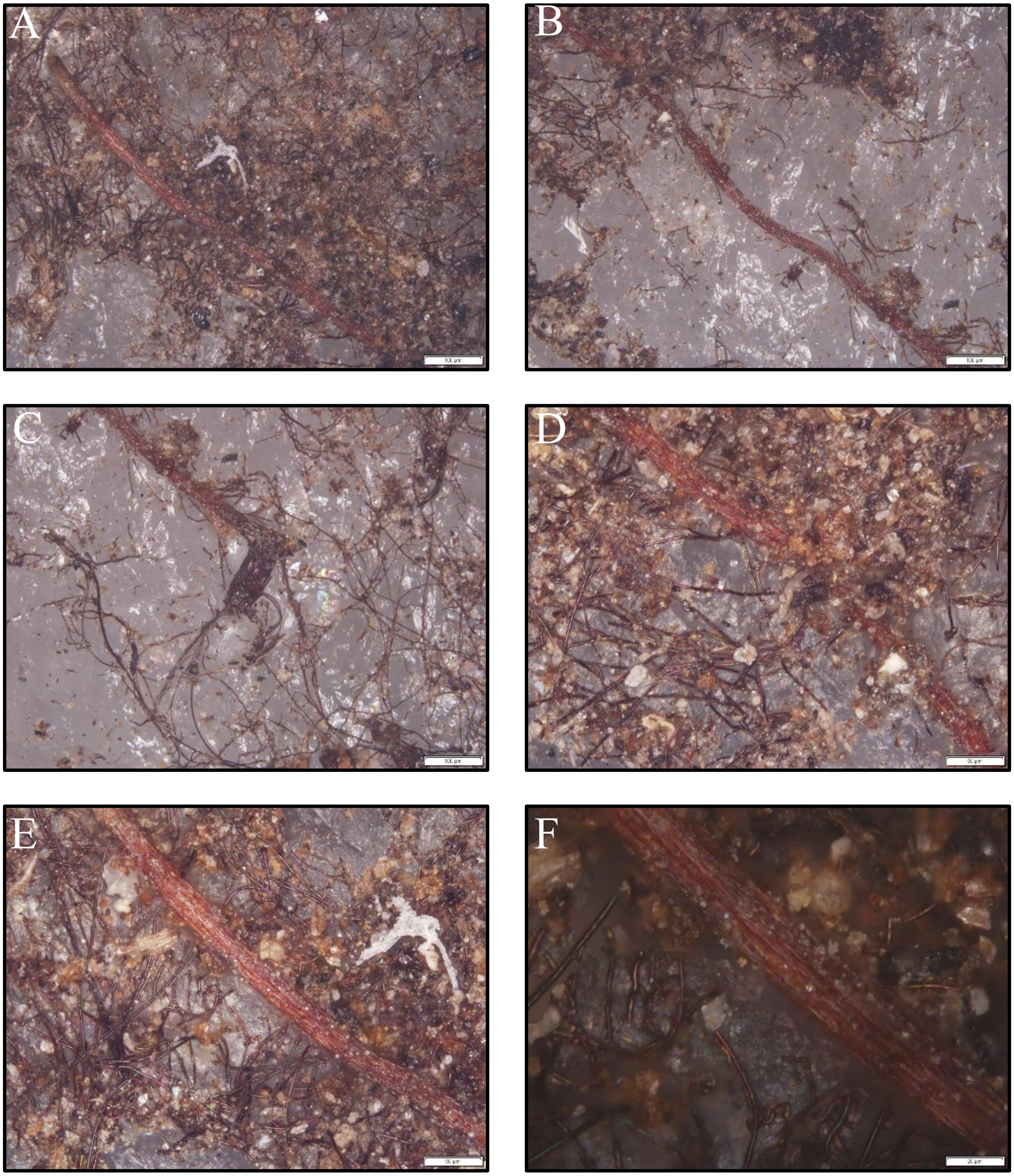

Figure 10-37: Fibres.
A, B, C, D, E, F – Artefact 42413.

Unclassified

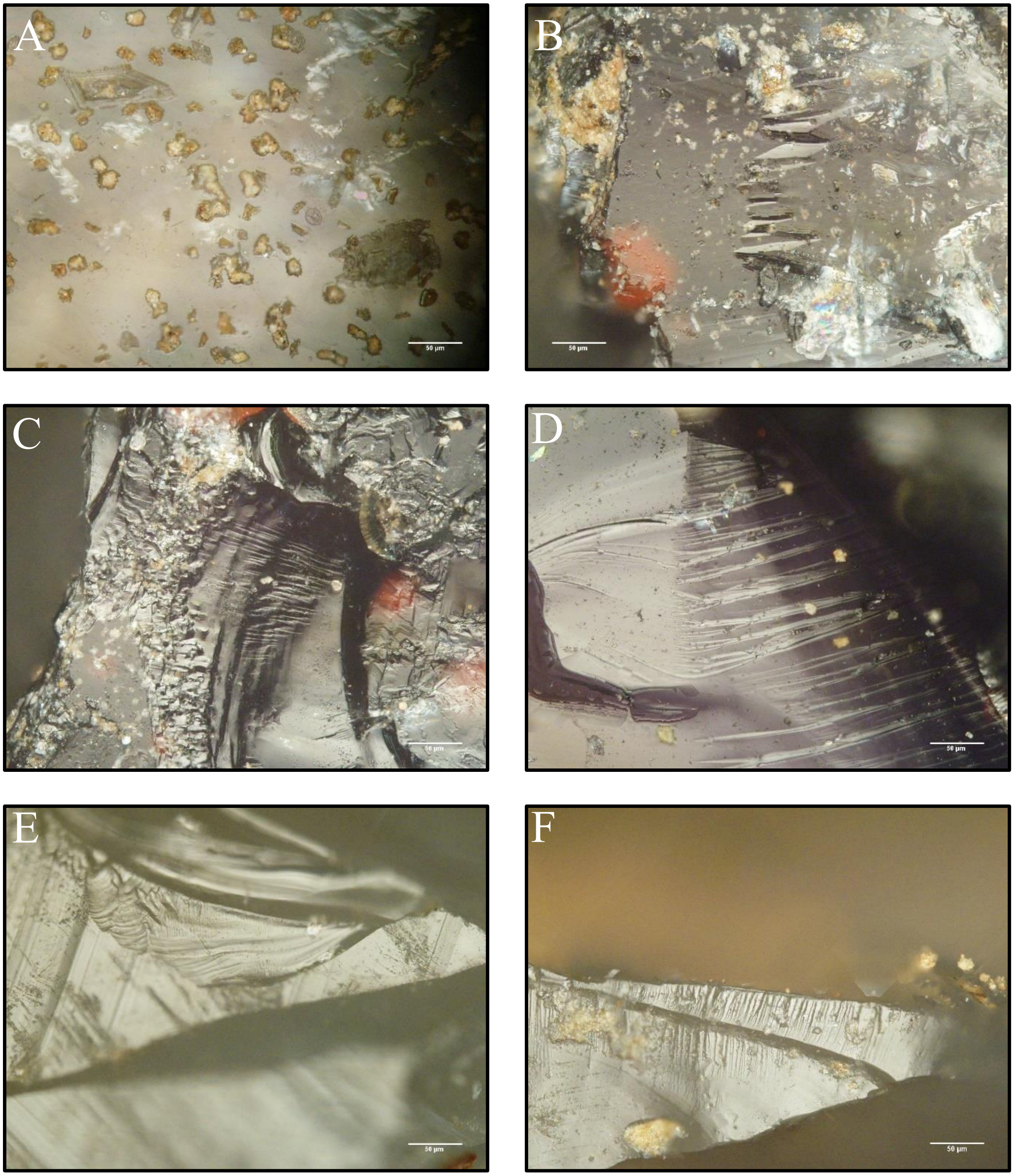

Figure 10-38: Unclassified.
A – Artefact 3464. B, C, D, E – Artefact 9942. F – Artefact 14288

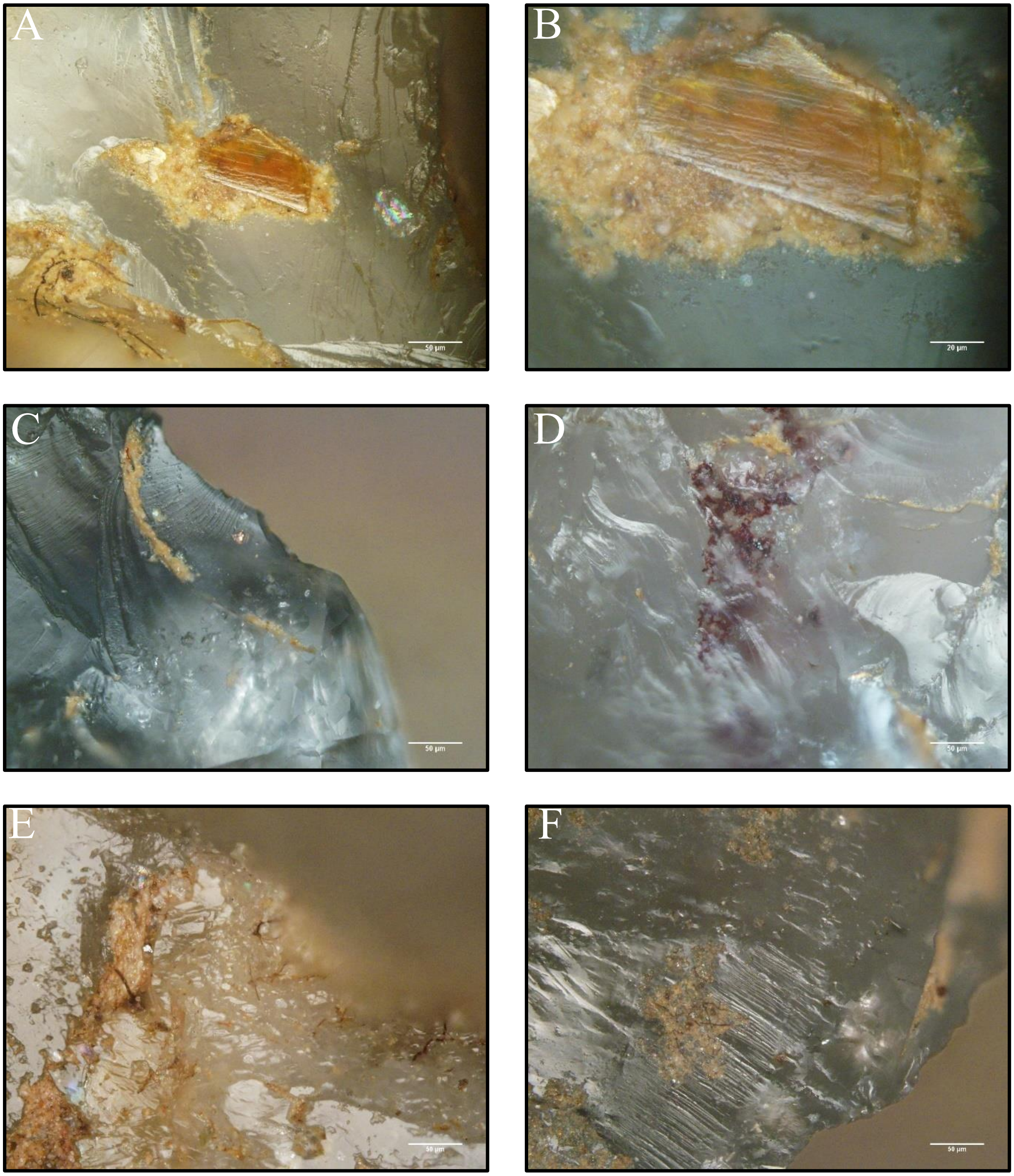

Figure 10-39: Unclassified.
A, B, C, D – Artefact 14288. E – Artefact 15096. F – Artefact 16528

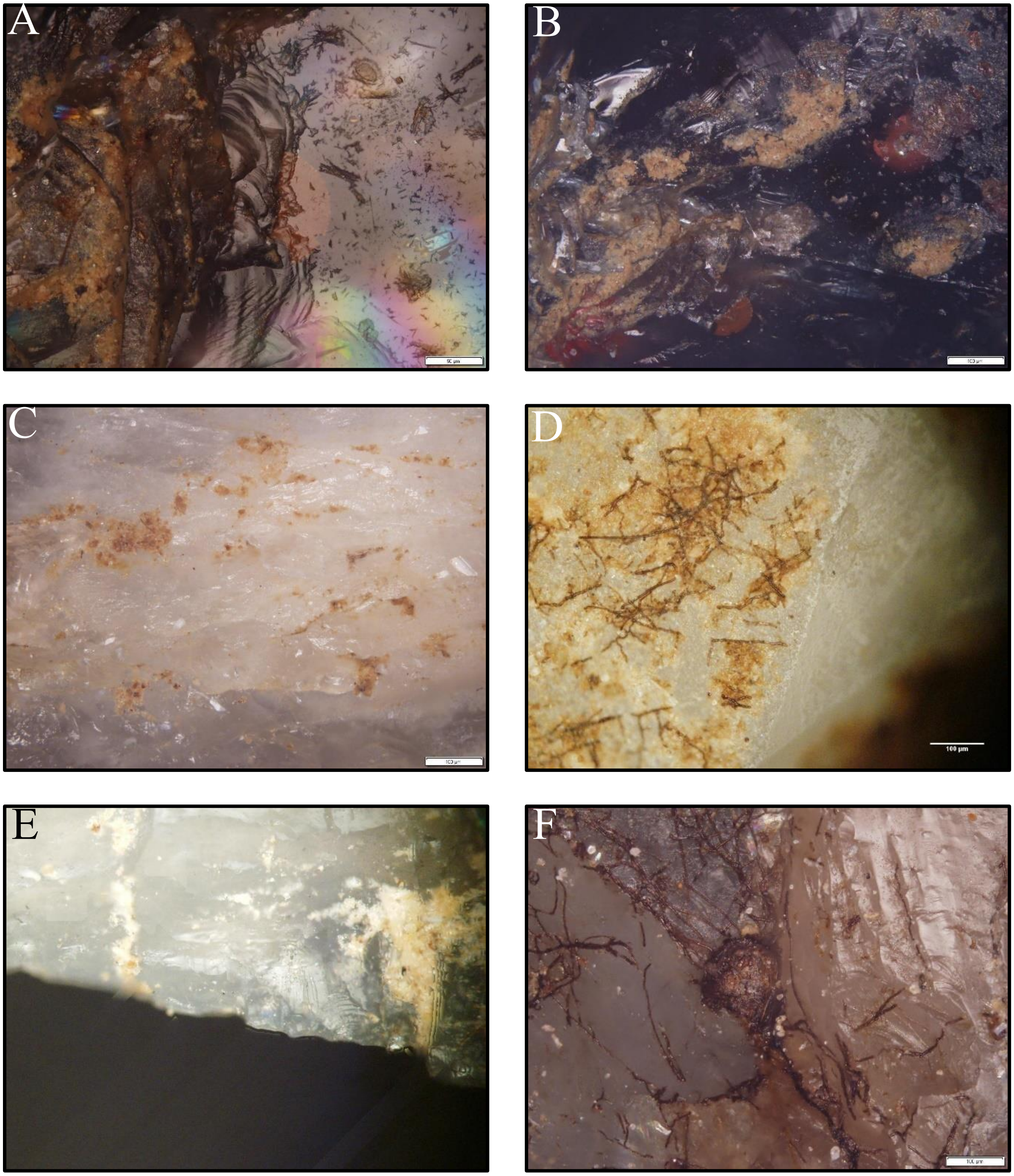

Figure 10-40: Unclassified.
A, B, C – Artefact 24842. D – Artefact 2768. E – Artefact 51849. F – Artefact 56557.

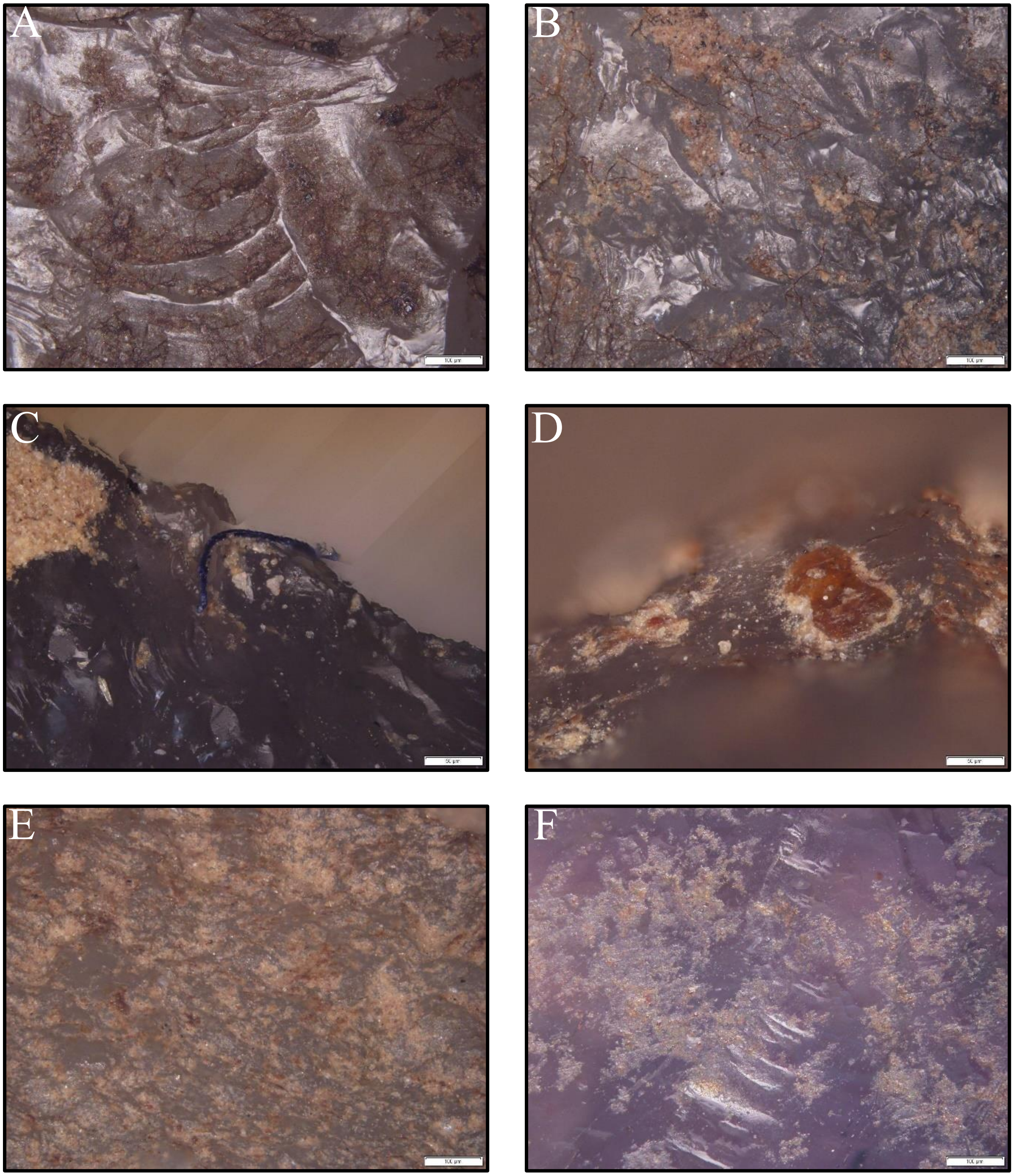

Figure 10-41: Unclassified.
A – Artefact 56557. B – Artefact 56627. C – Artefact 63769. D, E – Artefact 69290. F – Artefact 71653.

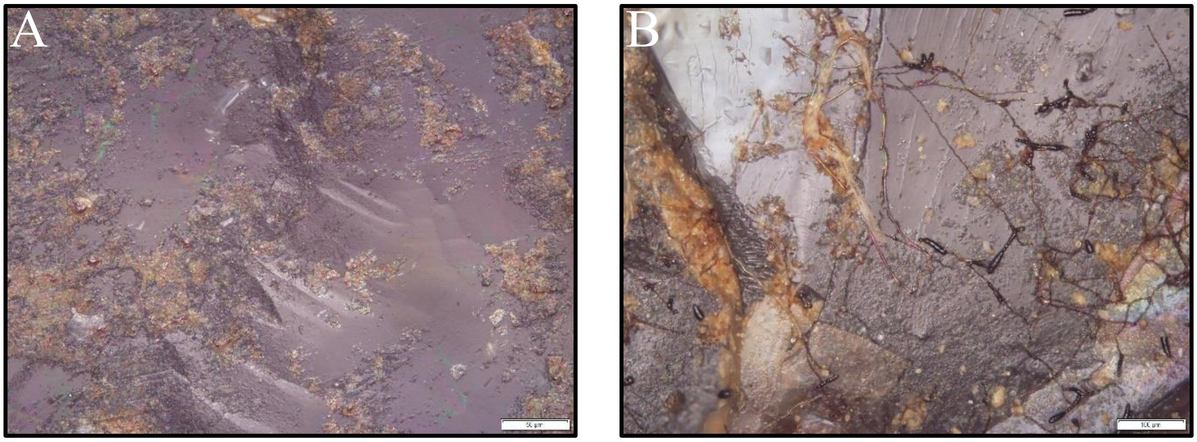

Figure 10-42: Unclassified.
A – Artefact 71653. B – Artefact 76189.