Identification of macrofossils within stone tools

A possibility for tracing the source of artifacts?

by Timothy E. Allan and Matthew Bolton

This paper discusses the application of malacological identification of macrofossils in stone tools. A macroscopically distinct toolstone utilized by prehistoric peoples, reported widely in archaeological consulting literature across central and southern Alberta (Meyer *et al.* 2007; de Mille 2009; Bohach 2010; Porter 2014), features fossilized root traces and occasional large fossil shells. These fossils can be identified, and correlated with temporal and geologic formations indicative of the environments within which the taxa occurred. Artifacts with fossils morphologically coherent with *Hydrobia*, *Lioplacodes*, and *Viviparus* spp. are identified in stone artifacts analyzed in this paper. These taxa are consistent with depositional environments of Paleocene period Paskapoo Formation sedimentary rocks, particularly, as identified at the Blindman-Red Deer River confluence and Joffre roadcut paleontological localities (Hoffman and Stockey 2011). In this paper we explore how the identification of these fossils offer clues to the procurement areas which were sought out by prehistoric toolmakers. We do not suggest that all Red Deer Mudstone is from these localities, though the fossil molluscs presented so far do not refute this conclusion, but we do suggest that identifying large fossil shells can be a critical diagnostic tool for identifying the geologic origin of artifacts.

Recent decades have seen a surge in papers published on "archaeological sourcing," or the linking of archaeological materials to their geologic origin to draw inferences on mobility and procurement. These studies are often valuable in identifying systems of long distance trade and mobility patterns by identifying sources of rock made to construct stone tools and debris. Shackley (2008) reports nearly 35 papers published in *Archaeometry* on archaeometric analysis of lithic materials between 2000 and 2007 alone. Systematic and conclusive analysis of stone tool materials and their suspected sources has great potential to reveal information about prehistoric mobility and resource selection. However, sourcing studies often rely upon intensive, expensive, and destructive methodology in order to provide conclusive results. Methods such as petrographic analysis (Fenton and Ives 1984; Kristensen *et al.* 2016a, 2016b), inductively coupled plasma mass spectrometry (ICP-MS) (ten Bruggencate *et al.* 2016; MacKay *et al.* 2013), and instrumental neutron activation analysis (INAA) (Kendall and Macdonald 2015) require the destruction or alteration of artifacts. In amorphous cryptocrystalline silicates, such as chert or flint, research has been conducted into microfossils within the matrix of the artifacts to distinguish chert varieties (Biittner and Jamieson 2008). However, this analysis also required the invasive alteration of material culture, such as destroying artifacts for geochemical analysis or thin sectioning. In most cases, archaeologists and curators look for non-destructive methods of

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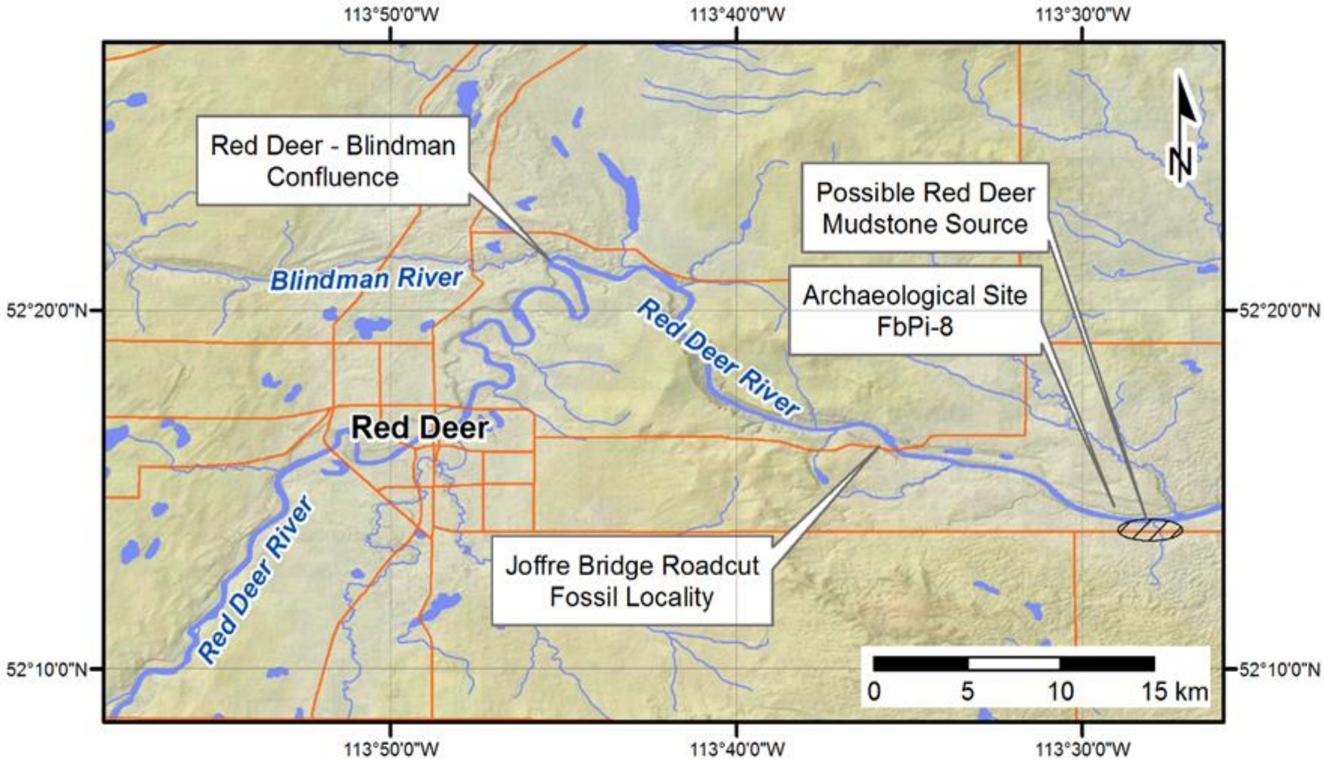


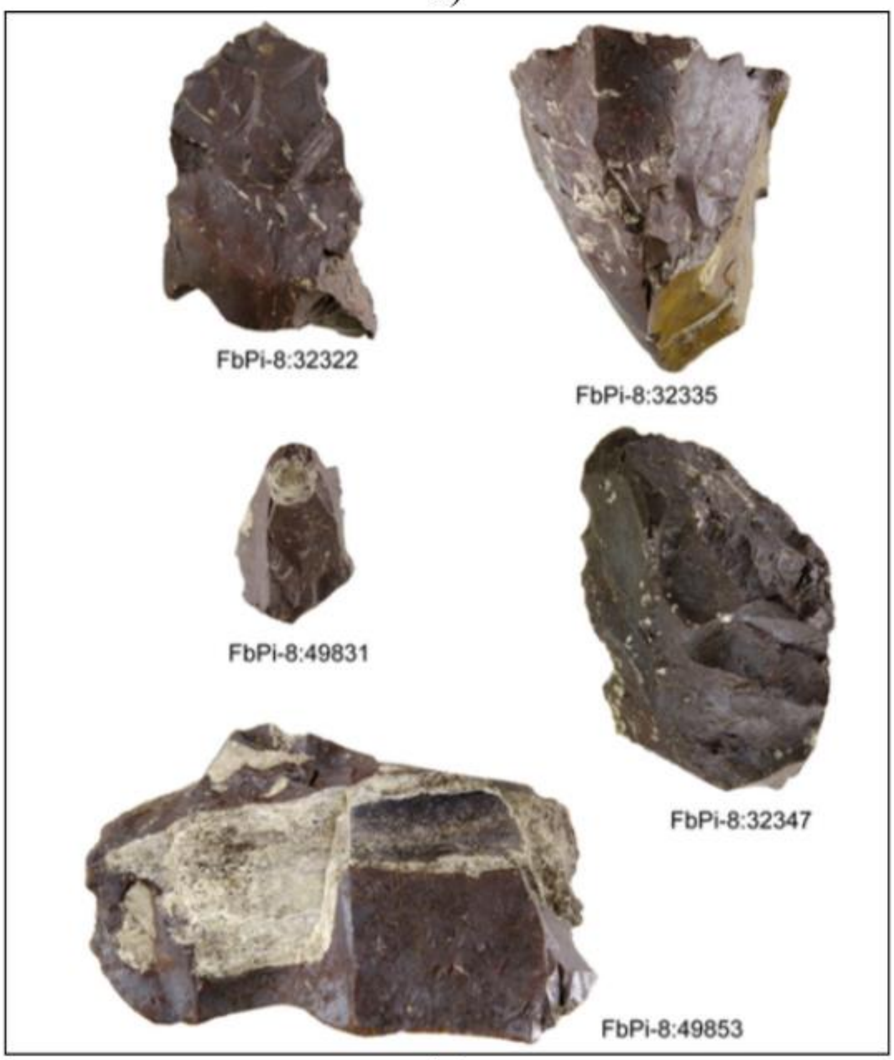
Figure 1. Map of Red Deer, Alberta and surrounding area; locales described in this paper are highlighted. Note: site locations have been generalized.

archaeological sourcing to preserve the integrity of artifacts for posterity or cultural significance, and maintain potential for museum display. Macrofossils, such as mollusc shells or plant remains, are not uncommon in archaeological hand samples. When macrofossils are visible, they can often be identified when viewed with a hand lens or low-powered microscope. This paper will present a case for the presence of macrofossils within stone tools from Central Alberta, and discuss the potential for their origin in that region's Paskapoo Formation sedimentary rocks. Although only a few examples are presented, this article is intended to show the potential of fossil identification in establishing the provenance of fossiliferous stone tools. At present, the authors know of no published works that have provenanced archaeological material using the identification of large fossils within artifacts.

Paskapoo 'Chert' or Red Deer Mudstone?

Consultants (Bohach 2010; de Mille 2009; Meyer *et al.* 2007; Porter 2014) have described a fine grained, dark red to tan mudstone, commonly with black patina and white macrofossil inclusions or 'bog material' as 'Paskapoo Chert' and 'Red Deer Mudstone' across central Alberta. We have reviewed these descriptions, both in the literature and of artifacts discussed in this paper. Based on our observations of museum specimens, this material is a fine to medium grained siltstone, rather than an amorphous cryptocrystalline silica such as chert. We suggest that the term "Red Deer Mudstone" is a better representation of the material described in this paper over "Paskapoo Chert", since the latter does not caption its true mineralogical properties so far observed.

a)



b)

Figure 2a. Discarded heat treated cobble from FbPi-8, arrows pointing to fossil vertebrates.
Figure 2b. Prepared cores from FbPi08. Adapted from Porter (2014).

Fossil Content, Geological Origins and Heat Treatment

This material has been commonly identified in reports by Meyer *et al.* (2007), de Mille (2009), Bohach (2010), and Porter (2014), as having fossil inclusions of plants and gastropods visible in hand samples. Porter (2014) and Bohach (2010) suspect this material was procured and heat treated at the archaeological site FbPi-8 (fig. 1), on a high fluvial terrace of the Red Deer River. Heat treatment probably improved the working characteristics of the material, turned it a dark red to tan colour, and turned the plant fossils white. Evidence of heat treatment is presented as discarded cobbles with red discoloration suggestive of intentional burning (fig. 2a). FbPi-8 yielded several cobbles that contained fossil plants, shells, and vertebrate fishes. These cobbles were possibly discarded following insufficient heat treatment or because the exceptionally high fossil density proved too difficult to work into useable tools. Several prepared cores were also present, having much more 'knappable' proportions of fossils (fig. 2b). The prepared cores also had a more lustrous quality than the discarded samples and appeared almost waxy, perhaps a product of heat treatment. FbPi-8 contained several buried hearth features and primary reduction debitage indicative of a lithic workshop (Porter 2014). Macroscopic qualities of the materials found at FbPi-8 match those of projectile points donated to the museum by private collectors. These donated specimens are the artifacts of interest in this paper. Our preliminary investigation into Red Deer Mudstone tools has uncovered projectile points with identifiable fossils at FfPh-15, FfPi-13, FfPi-15, FfPm-1, and FgPh-1, and sites designated from private collector's surface finds in the greater Red Deer, Central Alberta region. For the protection of these sites' integrity, and for the privacy of landowners, we chose not to reveal the precise location of these sites in this article, but more generalized locations are shown later.

FbPi-8 (Red Deer Mudstone Workshop) is situated near two paleontological research localities that have yielded a diverse array of plant and animal life from the Late Paleocene; these sites are located at a roadcut near the Joffre Bridge, and at the confluence of the Red Deer and the Blindman River (fig. 1) (Fox 1990; Hoffman and Stockey 2011; Taylor and Stockey 1984; Wighton and Wilson 1986). Both localities include lithology and fossil assemblages that are typical of the Paskapoo Formation (G. Hoffman, personal communication 2017). The Joffre roadcut locality features seven beds or units interpreted as fluvial, swamp, lacustrine and floodplain deposits (Hoffman and Stockey 2011). The rock types present include claystone, mudstone, calcareous mudstone, coaly mudstone, siltstone, medium-grained sandstone, and a thin coal bed. Most include scattered mollusc shells and/or plant remains; rarely, some include remains of vertebrate fish and reptiles, or insects (Hoffman and Stockey 2011). The main exposures at the Blindman River locality are a bed of grey calcareous mudstone that is interpreted as a lacustrine deposit, and a medium-grained sandstone that is interpreted as a fluvial channel deposit. Both contain plant and mollusc fossils and, rarely, insect and vertebrate remains (Fox 1990; Taylor and Stockey 1984).

Fossiliferous Projectile Points

The stone tools discussed in detail in this article (FfPh-15a; FfPi-13:16) are currently housed in the Royal Alberta Museum (RAM) Archaeological Collections, and were all surface finds donated by private collector, Stanley Reynolds. These artifacts lack any stratigraphic context; however, they offer a wealth of raw

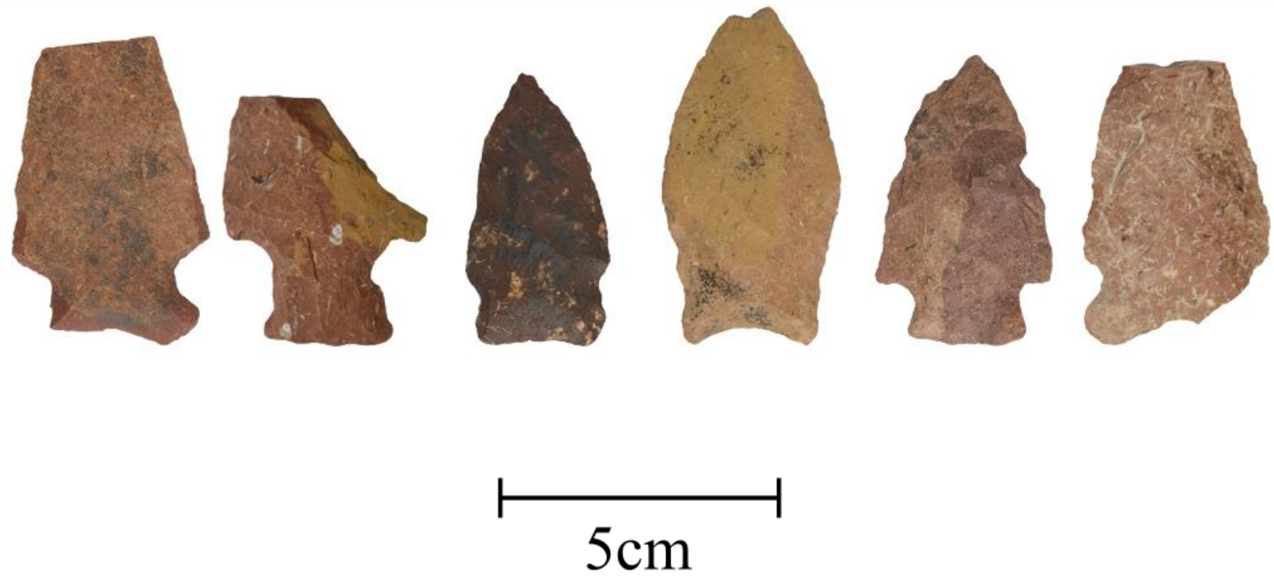


Figure 3. A selection of projectile points from the Reynolds Collection with fossils. Photo by Author.

material and geographic information, which in turn can reveal patterns in the distribution of artifacts from distinctive rock types. In aggregate, the material donated from Reynolds will be henceforth referred to as the Reynolds Collection. All artifacts were photographed with permission from the RAM Curator of Archaeology, Jack Brink. Artifacts conform to the macroscopic characteristics of Red Deer Mudstone, described earlier. Of the ten projectile points photographed from the Reynolds Collection that matched the descriptions (three of which are shown in Figure 3), eight contained root traces indicative of the Red Deer Mudstone, and two contained possibly identifiable fossil molluscs (fig. 4, 5).

FfPh-15:a is a projectile point from the RAM's Reynolds Collection (fig. 4). It is a large, stemmed, atlatl or spear point that is broken across the blade; the base of the point is flat, flares slightly, and is approximately 2.5 cm at its widest (fig. 4). Based on these morphological characteristics, this projectile point fits closely with the classification of Burmis Points, like those found at EgPn-700 near Calgary (Vivian *et al.* 2011). Points of this morphology have been found in association with archaeological material dated to between 7000-7800 years BP (Peck 2011).The point is reddish brown, with spots of tan patina matrix towards the center right of the blade. Two large (*ca.* 4-5 mm) conispiral molluscs are visible externally in this artifact. These shells were inspected and photographed using a dissecting (10 to 40 times magnification) microscope under plain light. Although identification of the fossil gastropods from the points is tentative at best considering the minor cross-sectional views, the fossils are apparently dextrally coiling turbinate shells. The shells could belong to several aquatic gastropod taxa, although they appear morphologically coherent with *Hydrobia*, *Lioplacodes*, and *Viviparus* spp. Other apparent fossil mollusc remains visible in FfPh-15:a are large and rather flatly convex, perhaps indicating clams (Pelecypoda) (e.g., *Unio* or *Sphaerium* spp., among the most common fossils in the Paskapoo Formation (Hamblin 2004) or other Gastropoda.

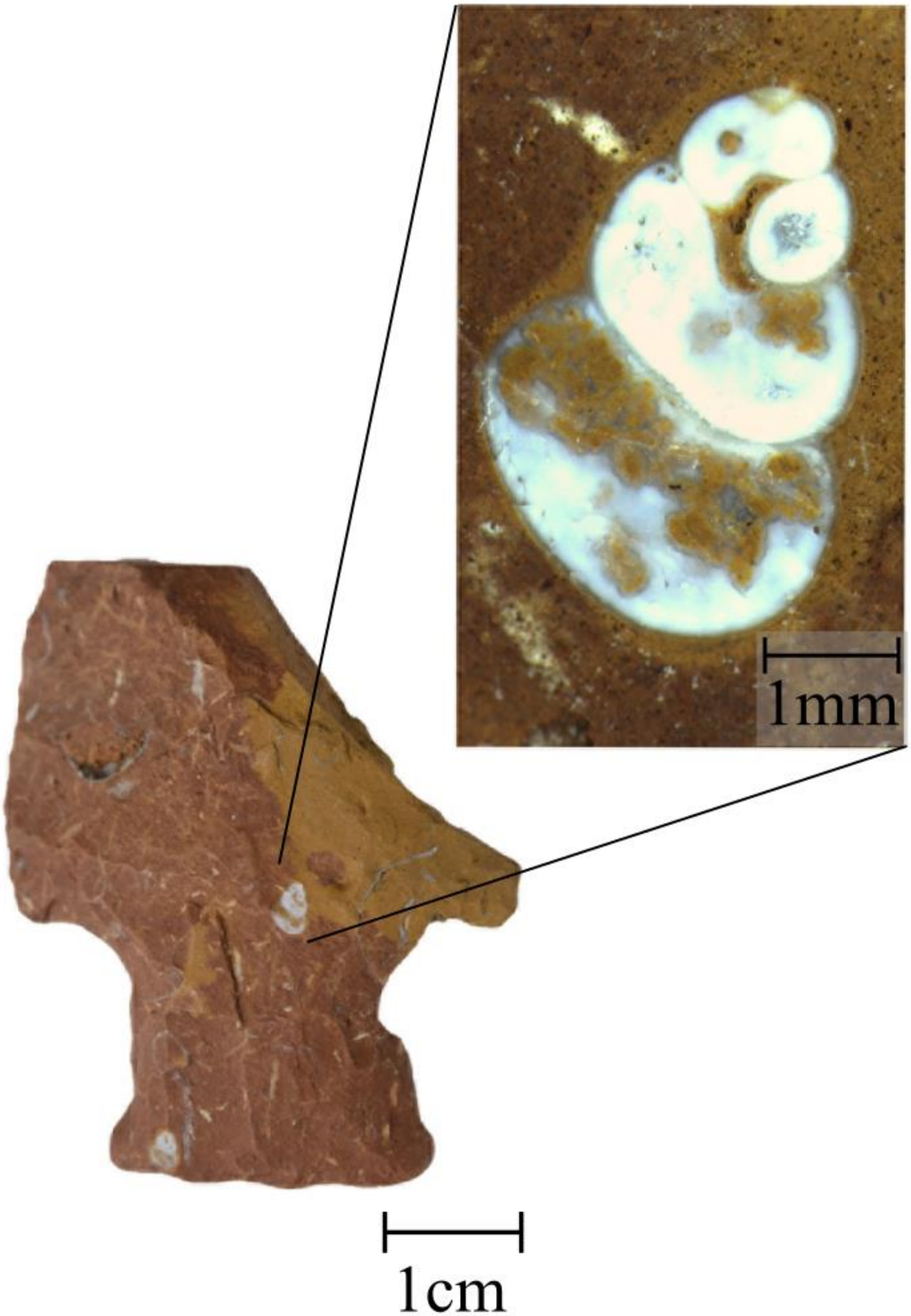


Figure 4. Stemmed projectile point (FfPh-15:a) with a mollusc fossil enlarged. Photos by Author.

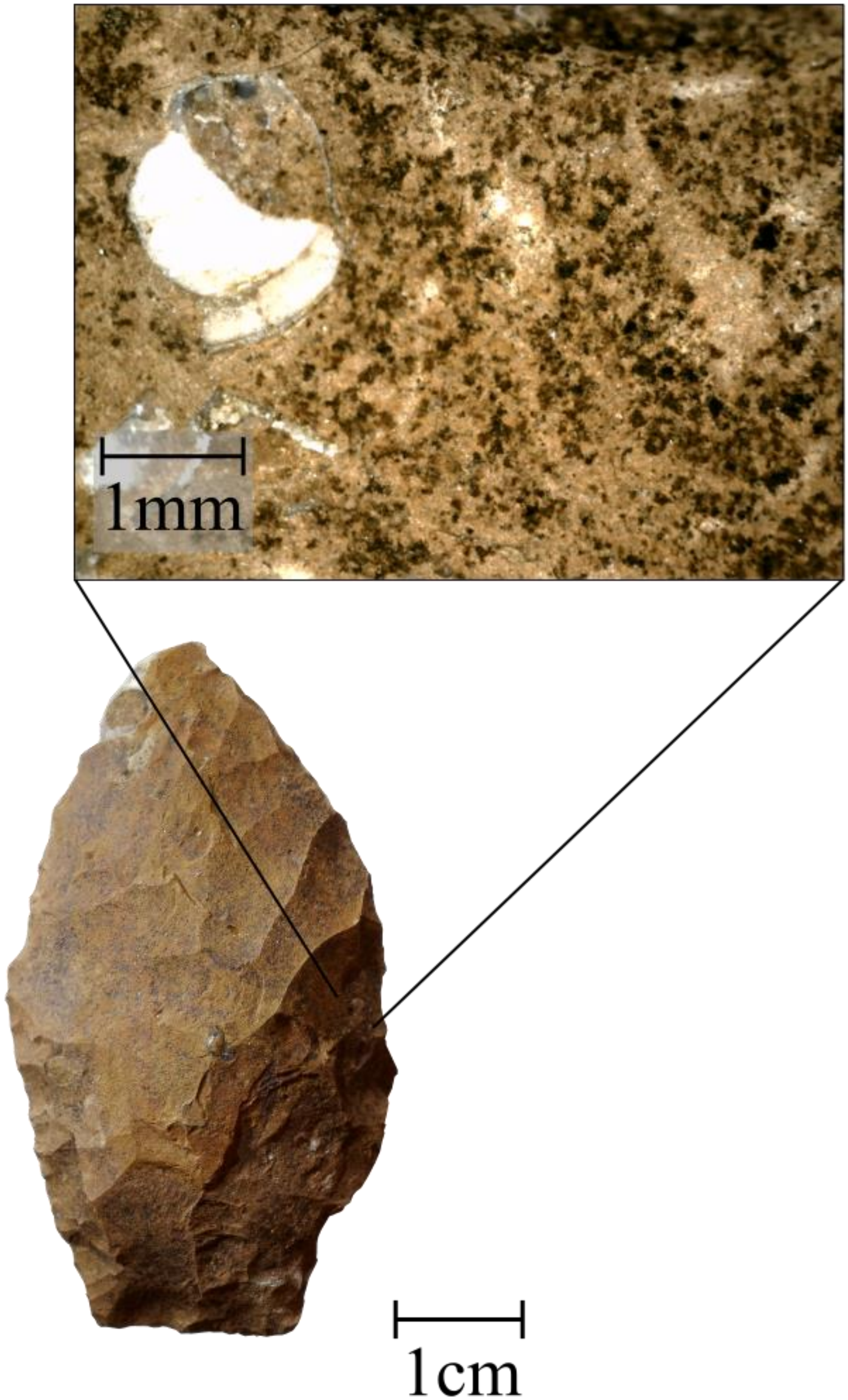


Figure 5. Leaf-shaped projectile point (FfPi-13:16) with a mollusc fossil.
Photo courtesy of Todd Kristensen.

FfPi-13:16 is another projectile point from the RAM's Reynolds Collection (fig. 5). The artifact is an unfinished, complete, leaf-shaped point with a flat, tapered base; the artifact is approximately 6 cm long, 3.5 cm wide, and has a 1.8 cm wide base. Leaf-shaped projectiles are an ambiguous morphology; as such we have not assigned this artifact with a temporal distinction. This point also contains several turbinate fossil shells. One of these shells is visible in cross-section, wherein the posterior of the body whorl is cut through, exposing its interior. Though it at first appears sinistrally coiled, the general morphology of the snail appears inconsistent with sinistral snails (e.g., Physids); it is visibly reversed from the normal apertural view, seen enlarged in Figure 5 inset. The visible section of the shell indicates an elongate (i.e., taller than wide) body whorl that is not greatly expanded, however, the cross-cutting view of the shell has likely obscured some diagnostic features. As such, this attribute may exclude some *Vivaparus* and *Liplacodes*, although dependable differentiation for these specimens is unrealistic. Other small molluscs are also apparent in the point; one (a larger dextral turbinate or fusiform shell) is located very near the point's apex. This shell appears to have an intact external surface and a clear view of the body whorl or aperture; following further investigation it may be identifiable to the species level.

The identification of fossilized macroremains, as with the shells preserved in the artifacts described above, requires clear representation of multiple features, often from a variety of angles. As such, even where preservation is very good, the certainty of taxonomic identification is often inherently lacking (e.g., Hartman *et al.* 1989). Further close inspection of these fossiliferous artifacts is required to provide a clearer perception of the chronological origin of the materials, and will be useful for narrowing the geographic uncertainty of the stone sourcing.

Paleontological Discussion

Hydrobia is known from a variety of environments, such as brackish or highly saline waters, however deposition from a lacustrine environment is likely. This genus is consistent with the imbedded fossils described in artifacts FfPi-13:16 and FfPh-15:a. Paleoenvironmental work from the Paskapoo and neighboring Porcupine Hills Formations provide evidence for early Paleocene aridity (Hamblin 2004); this interpretation is echoed by Jerzykiewicz and Sweet's (1988) findings from other rocks in the Albertan Foothills. However, the inclusion of coal, and increased plant fossils indicate a shift to moister conditions throughout the Paleocene. This is supported by McIver's (1989) interpretation of climate from the Ravenscrag Formation of southwestern Saskatchewan.

Fossil *Viviparus* and *Lioplacodes* potentially present in FfPi-13:16 and FfPh-15:a, are both known globally from freshwater lacustrine environments or slow-moving streams (e.g., Chin, Hartman, and Roth 2009; Radley and Barker 2000; Szymanek, Kryzyaztof, and Niychoruk 2016). Likewise, extant *Sphaerium* clams (as may have been visible in FfPh-15:a) live in either lentic or lotic fresh water (Clarke 1981), and as such, probably indicate a similar local depositional environment. If the larger shell remains in FfPh-15:a represent *Unio*, they probably represent the fauna of a riverine environment, though this genus exists in some lakes as well (Dillon 2000; Ostrovsky, Gophen, and Kilikhamen 1993). Considering this, the general ecological signal derived from the malacological fauna of these artifacts (regardless of the precise taxon or taxa the molluscs belong to) represents a fluvial-lacustrine environment,

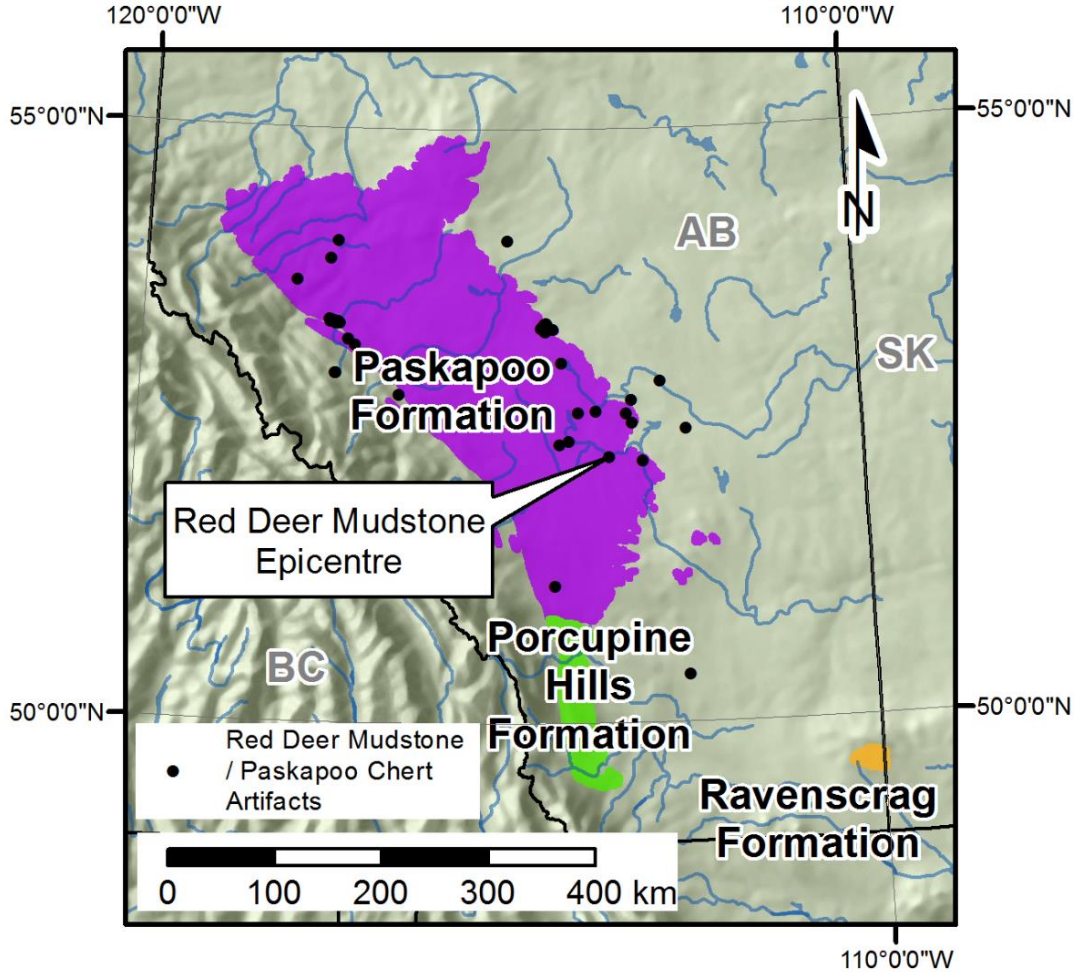


Figure 6. Map highlighting Albertan extent of select fossiliferous Paleogene-aged rocks, the epicenter of Red Deer Mudstone artifact finds, and the distribution of reported Red Deer Mudston / Paskapoo Chert artifacts found by consultants. Bedrock mapping from Prior *et al.* (2013).

much like that identified in the Blindman-Red Deer and Joffre roadcut localities.

The presence of three prospective genera (i.e., *Hydrobia*, *Lioplacodes*, and *Viviparus*) are known from the Paskapoo Formation and similar regionally proximate Paleocene rocks, associating these artifacts to a general region of procurement (Tozer 1956). Given the malacological evidence and the proximity to Paskapoo Formation exposures, it is likely that fossiliferous rocks from the Paskapoo Formation, deposited in the Paleocene, were procured and modified to construct the artifacts described in this paper. However, the taxa remarked upon in this paper are also known from other rock formations, so the Red Deer River region discussed here may not be the sole source of Red Deer Mudstone. We hypothesize that following further investigation it will be revealed that the toolstone material we call Red Deer Mudstone in this paper is actually a mosaic of materials of similar appearance from multiple sources. Red Deer Mudstone/Paskapoo Chert artifacts have been reported by consultants at 68 archaeological sites, covering a wide swath of the Paskapoo Formation across the province (Todd Kristensen, personal communication 2017) (fig. 6). Alternative potential sources include other Paskapoo Formation exposures in western central and southern Alberta (Tozer 1956), the nearby Porcupine Hills Formation (Henderson 1935), or perhaps as far away as the Ravenscrag Formation (Cypress Hills Alberta/Saskatchewan) or Montana (Yen 1948). The extent of these formations in Alberta are shown in Figure 6. Macrofossil identification may be a means of linking artifacts to specific source locations with future research. Clearly there is a need to further explore the nature of the Red Deer Mudstone tools, such as through petrographic or mineralogical analysis of artifacts and likely parent rocks.

Conclusion, Future Directions

This paper has revealed that mollusc macrofossils can be used to support claims of stone tool provenance. Here, some large fossils that have been described as a diagnostic feature of Red Deer Mudstone were investigated to support the material's possible origin within Paskapoo Formation sedimentary rocks. Given this promising start, the utility of macrofossil identification for provenance purposes must be explored. Once a baseline of data has been established, such as petrographic study of both artifacts and parent rock from suspected sources, fossils could potentially become a convenient indicator of this material. Large fossil molluscs are clearly visible in some artifacts described as Red Deer Mudstone from private collections in central Alberta. They can be quickly and reasonably accurately identified (probably up to genus or species), all without the use of expensive or destructive analytical methods. This leaves us to consider why this material, with clearly visible and distinct fossils within, was selected for in prehistoric times. In future research, we would like to consider possible social factors surrounding this material's procurement and modification (particularly heat treatment). In an area where quartzite (a harder and more knappable rock) is locally available, Red Deer Mudstone was sought out and intentionally modified to improve its tool making quality. Perhaps the bold white fossils visible in this material gave Red Deer Mudstone value beyond the utilitarian, and sources were actively sought because of this quality over arguable more pragmatic rock types.

The non-destructive malacological methods described in this paper can provide further clues as to the depositional environment of the parent rock, and may potentially be used to infer the geologic formation that the artifact was procured from. Paskapoo Formation rocks are distributed throughout central and southern Alberta (Prior *et al.* 2013; also see Figure 6). However, the distribution of specific (i.e., indicator) Paleocene fossils may narrow the prehistoric procurement areas of this material considerably. Although only a preliminary summary, the results of this paper indicate that some fossils within Red Deer Mudstone artifacts are identifiable, at least to morphotype, and possibly to genus or finer resolution, and represent distinct depositional contexts. I plan to expand on the potential of this research, and continue to develop a method related to fossil representation within artifacts and its application in archaeology.

Acknowledgements

The authors would like to recognize that these artifacts were constructed by the ancestors of modern indigenous peoples, now living in Treaty 6 and Treaty 7 territory. The authors would like to thank Todd Kristensen, Historic Resources Management Branch, and Georgia Hoffman, University of Alberta, for sharing information and supporting this project. We would also like to thank Jack Brink, RAM Curator of Archaeology, for providing access to the collections and for granting permission to publish the artifact photographs. We would also like to recognize the relationship the RAM and the Archaeological Survey of Alberta have with the private collectors and land owners of Alberta. Without all these people and groups, this project would not have been possible.

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