

The Lord-Collins Site (MAS# 3.12): A Late Pleistocene Human Use of Southeastern Maine, USA?



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The Lord-Collins Site (MAS# 3.12):

A Late Pleistocene Human Use of Southeastern Maine, USA

Abstract

A bifacial, bipointed, flaked stone knife was found during the expansion of a house cellar in the early 20th Century in Sanford, Maine. It was brought to my attention in 2011 by the current owner of the artifact. The geological surface map indicated that the find spot was likely an exposure of late Pleistocene deposits and the form of the artifact resembles some other bipointed knives that may be of Late Glacial Maximum origin. The locality was investigated through test excavations¹ with the geology verified, however, no in-place archaeological deposits were encountered. Dating of the deposits by optical stimulated luminescence (OSL) was also unsuccessful. Never the less there is circumstantial evidence that the knife may have been in late Pleistocene deposits and that it could represent an early use of the area when it was an interface between glacial outwash and the ocean beach. A small stone end scraper, typical of Late Pleistocene/early Holocene cultures, has also been recovered from the locality, but other than its type, there is no indication of its time of origin.

Introduction

As the result of reading a story in a local newspaper in 2011, L. Lord of Sanford, Maine contacted me by email saying that she had in her possession what she thought might be a very old stone knife (Fig 1). It was found during the extension of a house cellar in 1929 in Sanford, Maine. On request, she sent me photographs of the artefact. It does indeed resemble a number of other artifacts that have been recovered from early deposits along the eastern seaboard (Crock et al. 1993; Collins et al. 2013) and is a form that is lacking or at least extremely rare in late Pleistocene/early Holocene contexts in the region (but see Price and Spiess, in press). Also, the surface geology map (Fig. 2) indicates that the find location was the interface between glacial outwash and marine beach deposits, or possible glaciomarine delta formations (Thompson et al. 1989).

For these reasons I concluded that the find could indicate an early archaeological site and was worthy of investigation. On a subsequent trip I visited the find location and examined the stone knife. The property now belongs to a Mr. Collins and he



Figure 1. Stone knife.

¹ The research was sponsored by a grant from the British Academy

indicated he would grant permission for exploratory excavations. He also gave me a small artefact, an end scraper, he had found on the property during landscaping activities. Mrs. Lord loaned me the stone knife for study with the only proviso that it would someday be given to a museum in Maine. A research grant proposal was submitted to the British Academy and test excavations were funded.

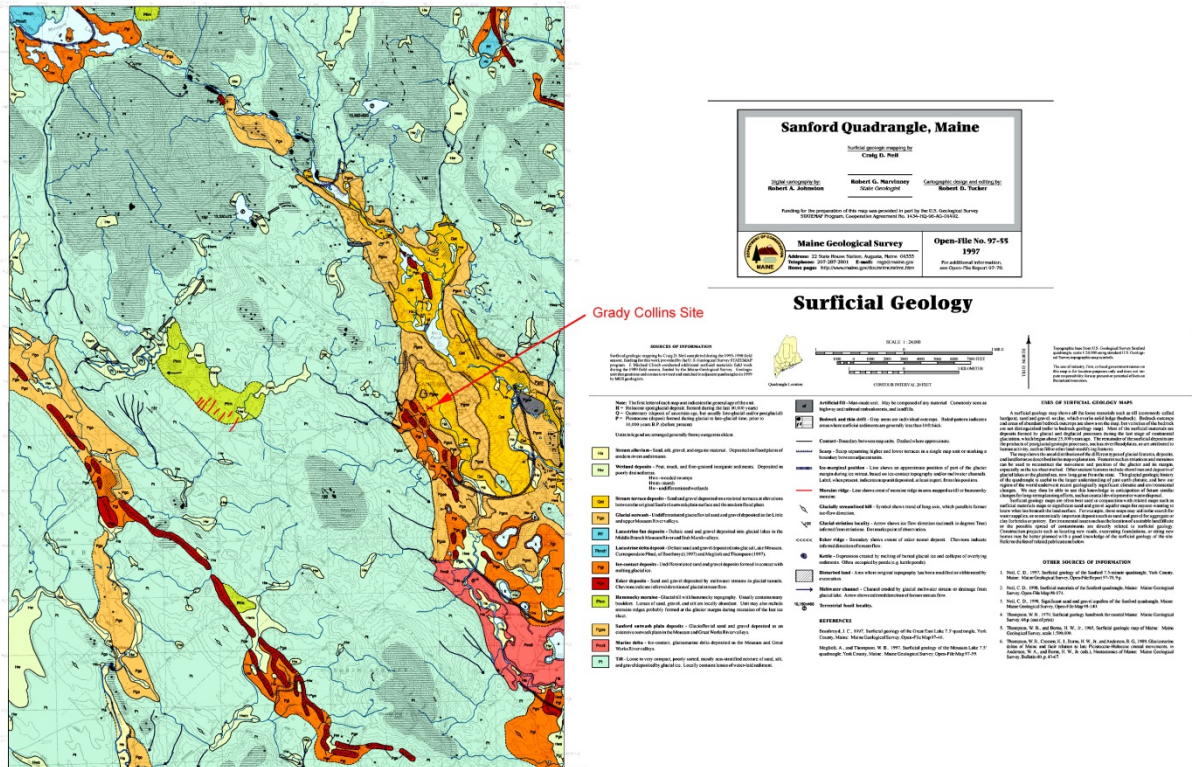


Figure 2. Surface geology map of Sanford, Maine area.

Location

Sanford, Maine is located in the southernmost point of the State close to the border with Massachusetts and 22.5 km northwest of the present Atlantic Ocean shoreline (Fig. 3). It sits on the inland side of the Coastal Lowlands (Toppan 1935:77) along the Mousam River. It is in a typical glacial outwash geological setting and has seen significant post-Pleistocene isostatic uplift and marine transgression (Thompson et al. 1989). The geological situation in the immediate area of the site is very complex and our small stratigraphic sample was not enough to work out details.

The site is now located in an area of 20th century residences (Fig. 4) and other industrial features, such as a sandpit, and exhibits significant land surface disturbance. The stone knife was recovered from the cellar of the current house, built in 1923 (L. Lord, personal communication, when being extended approximately 2 meters southward (Fig. 5). When I visited in 2011 Mr. Collins had been doing some landscaping to the east, uphill, of the house and there was an exposed irregular sand profile (Fig. 6). A preliminary assessment of this indicated that there were in-place deposits that could be investigated.

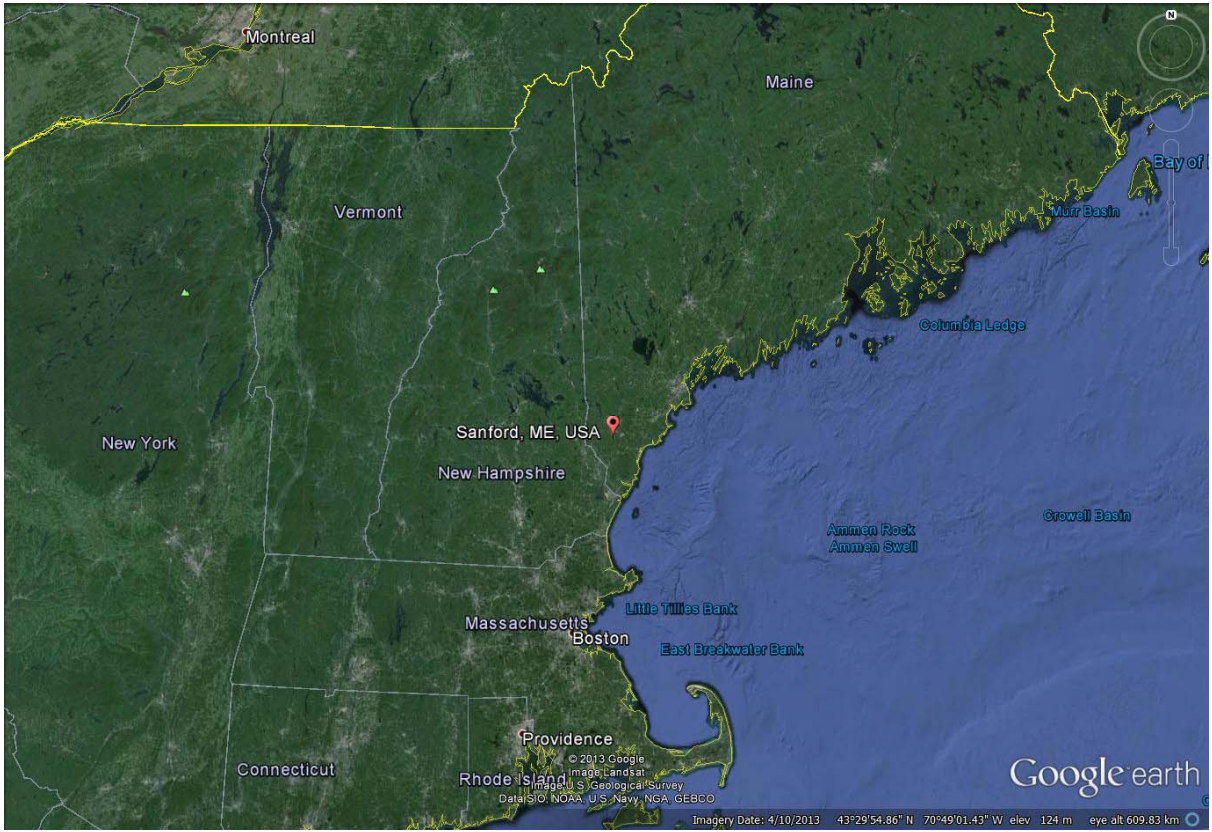


Figure 3. Location of Sanford, Maine.

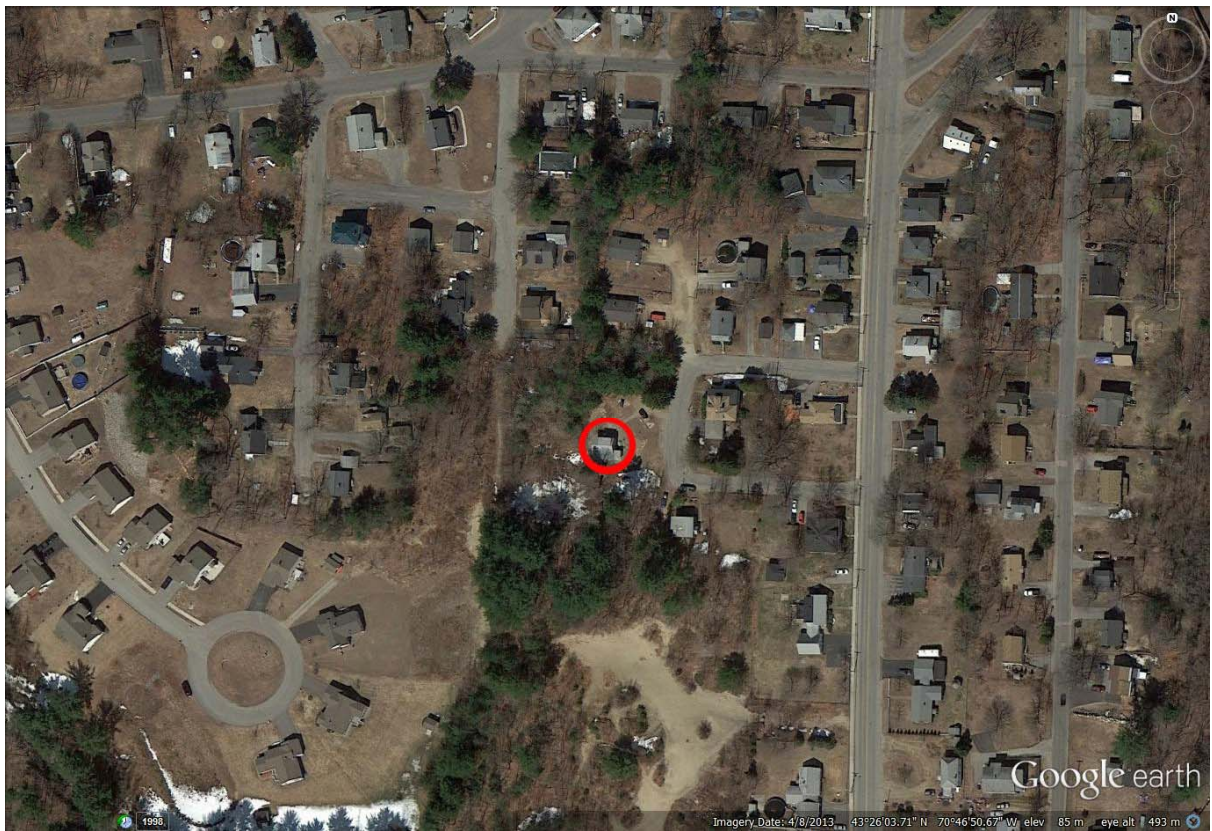


Figure 4. Grady Collins property.

Excavations

Limited test excavations were undertaken to try and find any in-place archaeological features or materials, and if encountered to determine their chronological and cultural origins. They were also done to expose the depositional sequence to reconstruct the geological process and to potentially date them.

The general site area around the house was divided into two intersecting transects, one running east-west downhill along the south edge of the house (and cellar extension where the knife was found) and the other in

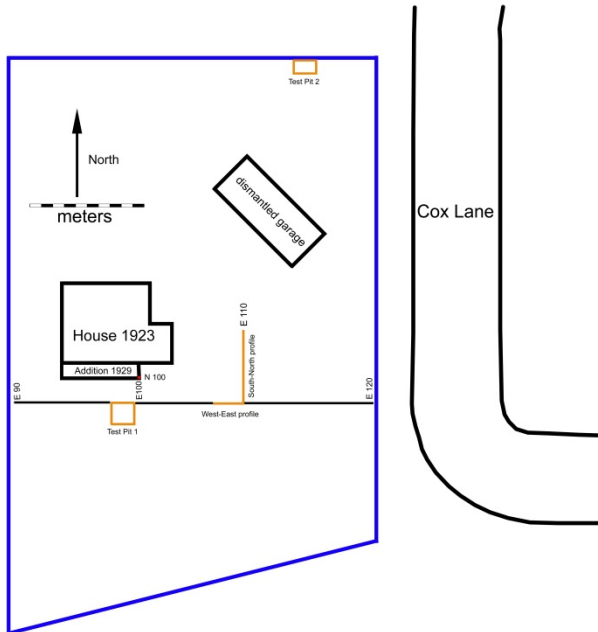


Figure 5. Grady Collins property and excavation plan.

extension where the knife was found) and the other in a north-south direction uphill to the east of the house

(Fig. 5). Initially, investigations were attempted along the east-west line by using a 3 inch diameter auger with two meter spacing (Figs. 6-7). Unfortunately, this was unsuccessful as the auger encountered numerous cobbles. This approach was



Figure 6. Auger testing along east-west profile.



Figure 7. Auger sediments by depth.

abandoned in favour of exposing two profiles and excavating two unconnected test pits (see Fig. 5). The first was 2 X 2 meters just to the south of the house along the east-west transect and the other was sunk near the top of the existing slope in the northeast corner of the property near the road.

Excavations were done with hand tools and in arbitrary horizontal levels in the test pits. Profiles were cut vertically, also by hand. All horizontally excavated and augered sediment was passed through ¼" (6.3mm) mesh screen (Fig. 10) to recover any small artefacts and ecofacts that might be encountered.

Sampling

The two main objectives of the research were to locate any archaeological deposits and to understand the geological setting, including dating of the deposits. Unfortunately, no additional prehistoric artefacts or contexts were found. However, excellent geological sections were exposed that allowed us to obtain sediment samples for dating and geomorphological analyses. Eight OSL samples were recovered (Figs. 8 and 9) and sent to the Luminescence Dating Research Laboratory, Dept. of Earth & Environmental Sciences, University of Illinois of Chicago for dating analysis. Sediment samples were also taken from the same locations for granulometric analysis. An additional sample was taken for soil chemistry analysis. No materials suitable for radiocarbon dating were encountered.

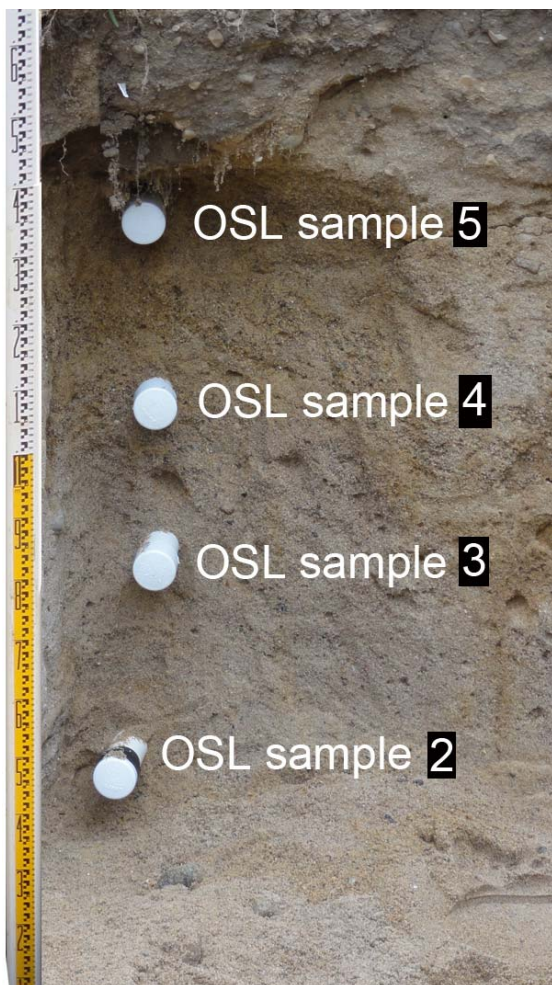


Figure 8. OSL samples north-south profile.



Figure 9. OSL samples Test Pit #2.

Stratigraphy

Sediments encountered in test pit #1 (Fig. 10) were all determined to be of recent origin; deposited when the top of the adjacent ridge was levelled for house and road construction, presumably in the 1920s. As this was the area adjacent to the purported stone knife find, this was unfortunate, but it may also indicate that the knife



Figure 10. Test Pit #1 disturbed deposits.

was recovered from redeposited sediments. This redeposition was very clear in the profile along the east-west exposure (Fig. 11-1 and 11-2) where there is a clear buried soil (A-horizon) that contained early 20th century artefacts (Fig. 11-3), including fragments of a 33 rpm record. Beneath the A-horizon was a well-developed B-horizon with elevated iron oxide content underlain by a C-horizon (Fig. 11-4). This was underlain by a coarse sand C-horizon (Fig. 11-5)

The main north-south profile was topped with a recently deposited mixed organic soil that was brought in for landscaping. This is clearly seen at the north end of the profile. The modern soil was underlain by a C-horizon of interbedded coarse sands with areas of mixed sand and cobbles (Fig. 12). The upper portion of the stratigraphic profile had been clearly removed and replaced by the organic mixed soil in recent times. Because of the length of the north-south profile and its relative shallowness a composite photo was done showing the entire exposed stratigraphy of the cut (Fig.13).

In order to better understand the upper portion of the ridge a test pit (#2) was excavated in the northeast corner of the property at the highest existing elevation near the road. This contained a very different stratigraphy made up of very fine white sand, which contained thin laminated silty-clay layers near its base; similar to varves (Figs. 14-15).

Geoarchaeological Analyses

In order to better understand the depositional conditions of the various sediment units, 8 samples (25 grams each) were analysed for grain size, PH and soil organic



Figure 11. East-west profile stratigraphy: 1) modern landscaping top soil; 2) landscaping redeposition of coarse sand; in-place early 20th century A-horizon soil; 4) in-place well developed B-horizon soil; 5) in-place coarse sand and cobble C-horizon soil.

matter content by Dr. Ben Pears (see Appendix 1). The results indicate that the upper fine-grained sediments in Test Pit #2 were wind deposited and probably loess. The laminations indicate that the deposits were made in a low energy water environment, probably a fresh water pond. The inter-bedded C-horizon coarse sands with cobbles in the north-south and west-east profiles probably represent the

interface between glacial outwash and ocean littoral (beach) sands. A chemical analysis of the lower portion of this coarse sand yielded a relatively high salt concentration (see Appendix 2), supporting the beach interpretation. The well-developed B-horizon also indicates that there was once a well-developed stable A-horizon soil that is now mostly missing.



Figure 12. North-south profile stratigraphy: a) unenhanced 1- modern landscaping top soil, 2- interbedded coarse sand C-horizon; b) same profile with contrast enhanced to better show stratigraphy.



Figure 13. Composite North-south profile.

In addition, soil geochemistry was done on a sample of the coarse sand from the C-horizon by Bartlett Tree Research Laboratories (Appendix 2). The chemistry indicated a near toxically high level of sodium which was interpreted as possibly representing “relict late Pleistocene coastal conditions that were associated with the region immediately after the Laurentide ice sheet retreat” (Lowery, Appendix 2).

Dating

The only organic remains were encountered in the sub A-horizon deposits and were clearly intrusive roots, probably from relatively recent forestation of the area. The eight OSL samples did not yield any credible dates in spite of intensive and even experimental methods being applied. The analyst, Professor Steve Forman, explained:

“We have completed the alternative analytical approach using a multiple aliquot regenerative (MAR) dose procedure on two samples (see attached

table [Appendix 2]) and obtained considerably older ages (72-95 ka) than indicated on the sample submittal forms. Even the SAR ages are too old, though they should be considered minimum estimates because of carry-over signal through the analytical protocols. Something is amiss; either what was sampled, incomplete solar resetting and/or uncompensated sensitivity change in the laboratory”.

Whatever the reason this lack of sediment dating means that the best alternative is sea regression estimates. In this area the best estimate of when it was last a beach, based on submerged deltaic evidence, was between 14,000 and 13,000 years ago (Thompson and Borns 1985a). This was quickly followed by “isostatic uplift [which] caused the sea to recede to the present position of the Maine coast by 11,000 B.P.” (Thompson and Borns 1985b.) This dating places means that if the bipointed knife was in-place, and there are reasons to suggest it was in the coarse sand B-horizon (see below) it likely dates from between 14,000 and 13,000 years ago. This places it firmly in the earliest post glacial occupation of the Maritime provinces (Snow, 1980).

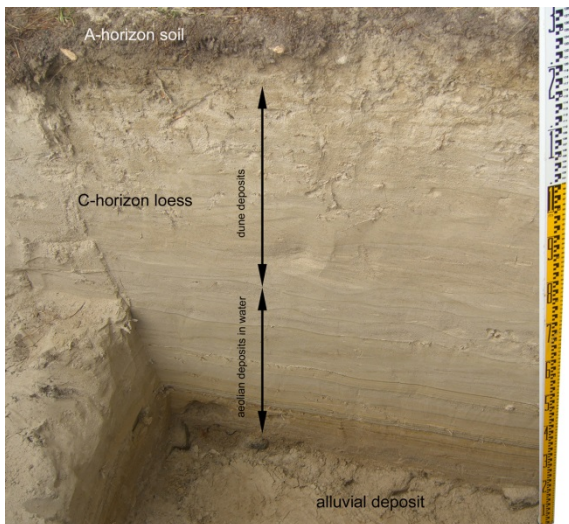


Figure 14. Test Pit #2 stratigraphy.



Figure 15. Test Pit #2 close-up of varve-like deposits.

Artefacts

Two flaked stone artefacts have been found at the locality, neither of which was in a primary depositional context. The stone knife was recovered during the expansion of the house cellar, evidently from deposits that had been pushed off of the top of the hill to the east in the early 20th century. The small end scraper was recently picked up off of the surface and may even have come in with the topsoil used in landscaping the hill slope above the house.

Stone Knife (Linda Lord laurel leaf)

The stone knife (Fig. 16) was flaked of rhyolite from an as yet unidentified source (see Table 1 for dimensions and proportions). There are a number of possible sources in the region such as Kineo in Maine, Mount Jasper and Jefferson in New

Hampshire. The XRF results clearly show that the Linda Lord laurel leaf did not originate at either Mount Jasper or Jefferson (Appendix 3). It is also possible that rhyolite was collected from other sources including glacial till in the immediate vicinity of the Grady Collins location.

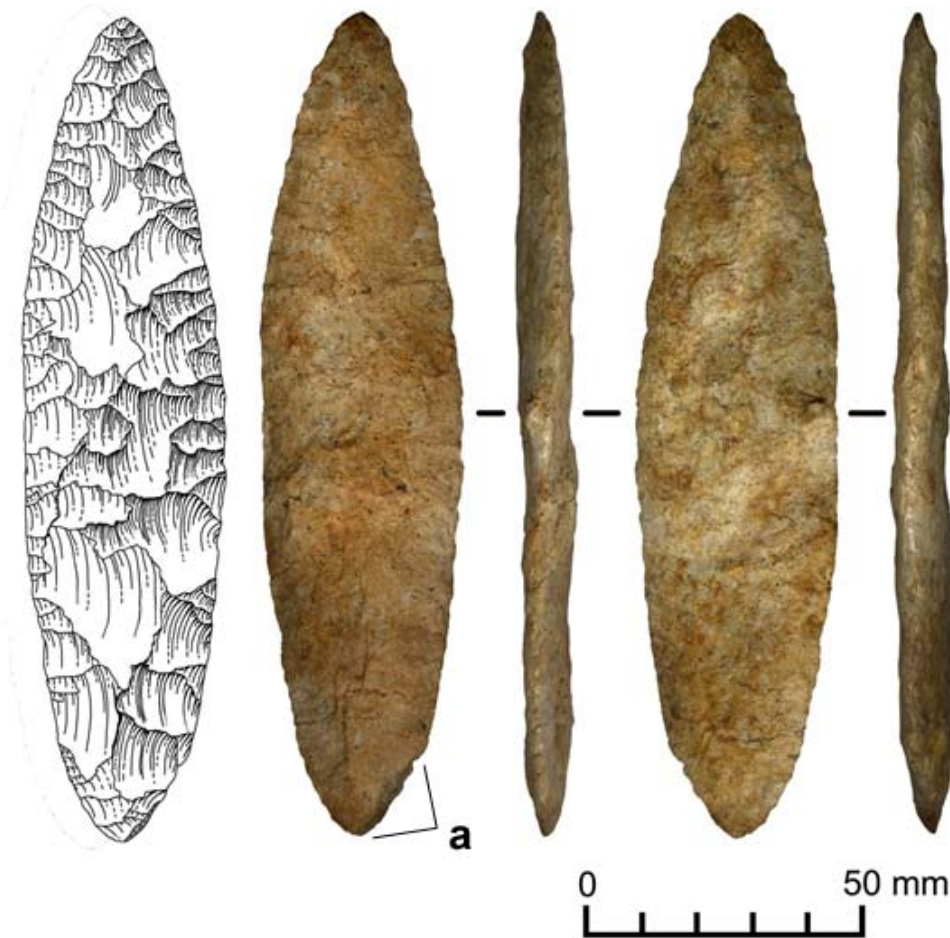


Figure 16. Rhyolite knife. a) area of fresh flaking.

Table 1. Knife dimensions (mm).

Maximum Length	150	Length at maximum width	68-75
Maximum Width	37	Thickness at maximum width	10
Maximum Thickness	10	Minimum thickness	8
Width/thickness	3.7/1	Thickness at ½ length	9
Maximum width/minimum thickness	4.6/1	Width/thickness at ½ length	4.1

Additionally, I noted that the biface has a small area of fresh flaking at the base (figure 16a), probably a result of damage when it was found. This exposed the interior of the piece. There is a clear contrast between this and the weathered surface of the rest of the knife, which exhibits orange-brown staining; probably iron oxide. To test this XRF was done on both the weathered and fresh surfaces clearly showing an elevated iron signature on the weathered areas (Appendix 3, Figure 3).

While it cannot be stated with certainty that this was the result of the artefact being deposited in an iron-rich environment, this is the most likely cause. In the deposits that were encountered in the test excavations the most likely candidate is the B-horizon soil, which is iron enriched. This B-horizon formed below the organic-rich A-horizon in the coarse sand.

The knife is bipointed, relatively narrow, fully bifacially flaked and exhibits a distinct twist in longitudinal section. Original manufacture flaking was percussion with apparently no pressure. Remnant primary flake scars mostly run past the midline but the margins exhibit all around smaller 'retouch' flake scars. There is no indication of patterned flaking. There was a tendency toward alternate edge and facial flaking, which produced the twisting section. This was likely the result of systematic resharpening so that the lowered cutting edge is on the right distal edge at both ends. The stone seems to have been of fairly good flaking quality although there are some crack remnants that caused a few step fractures.

The edges of the implement are still fairly sharp and exhibit only a slight degree of weathering. While the knife was lightly weathered post-depositionally there are no indications that it was transported in alluvial sediments nor that it suffered from sediment abrasion. While its depositional environment could not be directly observed, the relative lack of surface abrasion and increased iron staining may indicate that it was deposited very near to where it was recovered and it may have come from the iron enriched B-horizon.

This implement form is not common in the earliest known archaeological assemblages in the region (Bradley et al. 2008). However, this implement compares reasonably well with a few other bipointed stone knives from submerged contexts (Price and Spiess, in press). There are also now emerging a series of similar artefacts along the Mid-Atlantic coasts of Maryland and Virginia (Stanford and Bradley 2012:100-102; Collins et al. 2013:526). Those that have been found in good dated context are older than the likely date of the Linda Lord laurel leaf, possibly indicating a spread of the form up the coast as the glaciers retreated.

End scraper

The small end scraper (Fig. 17) found by Grady Collins is fairly typical of Paleoamerican forms from all over North America, including New England and the Maritime Provinces. It is incomplete with a recent fracture splitting it longitudinally. It is a dark red stone (Munsungun mudstone) on the surface but the interior is black. The colour differences were caused by the replacement of manganese by iron (Appendix 3, Figures 4 and 5). The old surface is also lightly smoothed all over yet the working edge is still relatively sharp. While this demonstrates weathering, either abrasive or chemical, it does not indicate that the scraper had been in the surf for any length of time nor washed down a river. Its origin and possible relationship to the bipointed biface are unknown.

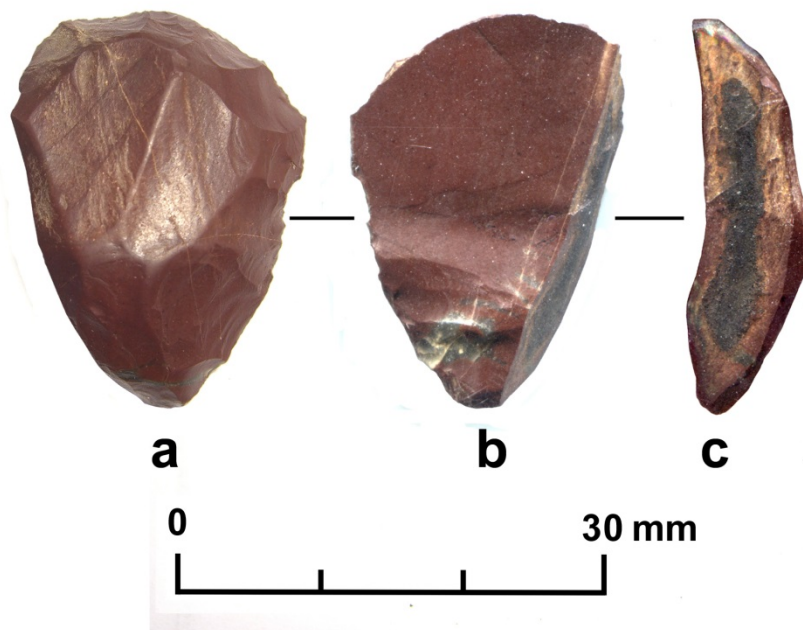


Figure 17. End scraper: a) dorsal; b) ventral; c) side showing differential oxidation.

Conclusions

Based on the find of an unusual bipointed flaked stone artefact and a small stone scraper, archaeological test investigations were undertaken at a location in Sanford, Maine, USA; funded by the British Academy. It was hoped that additional archaeological materials would be encountered in an undisturbed context and that the context could be dated. Unfortunately, no additional archaeological materials were encountered. However, geological deposits at the locality were studied and it is likely that the artefacts did indeed indicate a prehistoric use of the location, probably between 14,000 and 13,000 years ago. This is when the location had recently been exposed by glacial melting but before the ground had time to rebound from the glacial weight. It would have been at the interface between the land, consisting mainly of glacial outwash deposits, and the beach.

The stone knife had not suffered extensive weathering indicating that it had neither been in the ocean surf nor washed down a glacial river. Flaking on the still sharp edges of the knife was fairly abrupt, indicating resharpening. This retouching was done in such a way that it and produced a distinctive twisting of the form. This form of knife is rare in the Maritime provinces, although similar pieces have been recovered from inundated locations in the region. Similar artefacts have also been found, in larger numbers along the mid-Atlantic seaboard of Maryland and Virginia, some in contexts dated between 22,000 and 17,000 years old. The small fragmentary stone scraper is typical of late Pleistocene/ early Holocene tools found in the general area (Spiess personal communication 2013).

Acknowledgements

All of this effort and learning stemmed from a contact with the author by L. Lord, a resident of Sanford, Maine. She generously made me aware of the interesting stone knife and related the story of its find and location. She and husband Malcolm contacted the current owner of the find location and arranged for a visit. They very generously loaned the knife to the author for detailed study with the only proviso that it someday be donated to a museum in Maine. Funding for the excavation and analyses was provided by the British Academy and I was supported by the University of Exeter, UK during the study. I am greatly indebted to G. Collins who allowed us to invade his territory, dig up his lawn and make general nuisances of ourselves for a week. Along with access, he provided us with drinks on hot days and several times fed us. Finally, several colleagues generously volunteered their time to help with the excavations including Dr. Michael Johnson and C.D. Cox from Virginia, Dr. Darrin Lowery from Maryland and Dr. Arthur Spiess, Maine State Archaeologist. All provided more than labour and good humour. Mike brought along equipment and organized the ill-fated auguring. C.D. was our go-to screener and Darrin contributed his knowledge of things geological. Arthur provided equipment, labour, local and regional knowledge and encouragement. Never-the-less whatever may be lacking in this project and report is entirely my responsibility.

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Appendix 1. Particle size analysis from Grady Collins, Sanford, Maine, U.S.A – Pears, B.R.

Abstract

Particle size analysis was conducted upon nine sediment samples taken from Grady Collins, Sanford, Maine, U.S.A in order to determine variations between the horizons and determine potential depositional environments. The samples contained an acidic to moderately acidic pH (5.3 - 6.2) and very low loss of ignition results ranging from 0.40 – 0.79%, although one of the samples (6) did have markedly higher result (3.39%) suggesting the presence of a higher organic content, possibly deriving from the development of more plant species. The particle size analysis was conducted on two fronts using a nest of eight sieves (2mm to 63µm) and a Saturn Digisizer for more detailed analysis on the less than 1mm components. The manual and automated analysis showed a distinctive variation in formation processes including aeolian and more specifically loess (6, 7 and 8) and fluvial sources (1,2,3 and 5). These could derive from loess and glacial meltwaters deposited during a glacial period or possibly in a marine environment where dunes and frequent storms are present.

Introduction

Archaeological investigations at Grady Collins, Sanford, Maine, U.S.A produced a number of sediment samples which require further investigation in order to determine their origins. Geoarchaeological and soil geochemical analysis was therefore conducted on nine sediment samples to compliment the archaeological work and to assist the interpretation of the origin, form, and function of the site and place it within local and regional context. These techniques have successfully been utilised across the world to interpret anthropogenic effects on the landscape and each will complement the other, as well as the archaeological evidence in order to more fully interpret landscape history across the site and the surrounding landscape.

Location and Geology

The site is located in the south west corner of the central Maine basin in Sanford, York county, Maine USA. The solid geology of Maine is highly diverse and encompasses a mixture of lithologies associated with sedimentation, igneous intrusions and orogenic activity. Around Sanford, the site is located upon Silurian to Devonian (c.430-385Ma) marine sandstones with distinctive high level schists and gneisses associated with metamorphic processes formed when a large granite intrusion developed in the Carboniferous (c.290-330Ma) (Osberg *et al.* 1985).

Laboratory Methods

In the laboratory all the samples were dried, sieved (to <2mm) and analysed in the Department of Geography at the University of Exeter. Soil pH (H₂O 1:2.5) was determined following the methods of Avery and Bascomb (1982) and the University of Exeter, Soil organic matter was also determined using percentage loss on ignition (LOI)(550°C) following the University of Exeter methodology. The particle size analysis was determined by wet sieving the 2mm to 63µm size fraction following McManus (1988) and using the program GRADISTAT© (Blott and Pye, 2001), to determine values of mean grain size and sorting using the Udden-Wentworth nomenclature. The samples were also subjected to particle size analysis using the Saturn Digisizer for a comparative set of results and this was conducted upon a 1g sample of sediment and followed the Exeter University methodology.

Results

In total nine sedimentary contexts were selected for further physical and chemical analysis in order to determine formation processes. The contexts selected were dried and subjected to a range of analyses outlined in the methods section and the results are summarised in Table 1 and Figure 1 and discussed further below.

Grady Collins, Sanford, Maine, USA							
Number of Samples - 9		Methods					
Context	Elevation	pH	Loss on Ignition %	Folk & Ward (Φ)	Sand 4mm - 63µm	Silt 63 - 4µm	Clay 4 - 1µm
Sample 1	99.55	5.3	0.52	1.139	91.65%	8.27%	0.09%
Sample 2	99.88	6.0	0.74	0.706	88.04%	11.92%	0.04%
Sample 3	100.16	6.1	0.56	0.919	90.29%	9.70%	0.01%
Sample 4	100.36	6.1	0.40	-0.327	77.59%	22.30%	0.11%
Sample 5	99.52	6.1	0.79	0.819	81.91%	17.88%	0.21%
Sample 6	99.52	6.2	3.39	0.858	47.98%	50.01%	2.02%
Sample 7	101.24	6.0	0.54	3.464	60.56%	39.44%	0.00%
Sample 8	100.96	5.8	0.46	3.314	85.46%	14.54%	0.00%
Sample 9	99.55	6.1	0.45	1.568	93.97%	5.99%	0.04%
Replicates							
Sample 1 (Replicate)	99.55	5.4					
Sample 3 (Replicate)	100.16	6.1					
Sample 6 (Replicant)	99.52		3.39		47.00%	50.86%	2.15%

Table 1, Summary of results from Grady Collins, Sanford, Maine

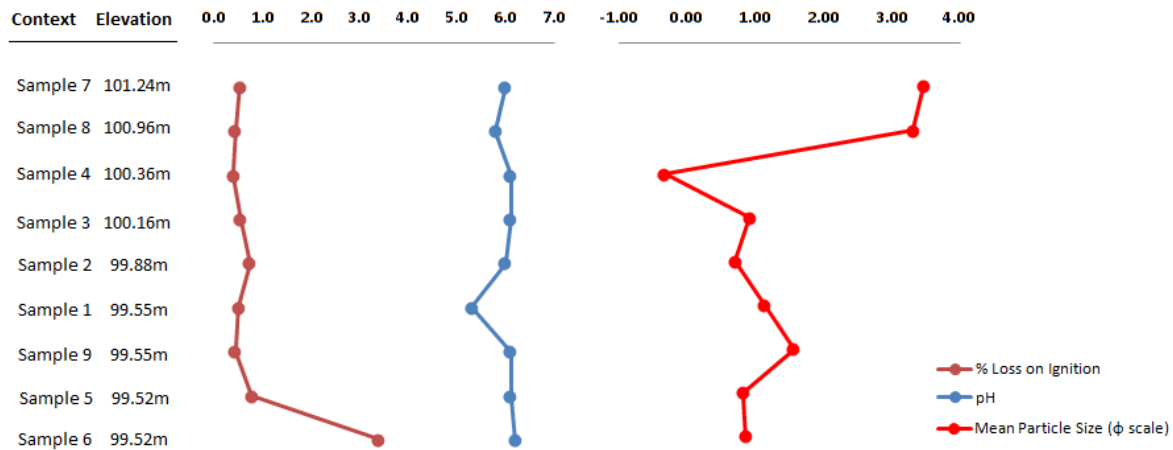


Figure 1, Graphical summary of pH, % Loss on Ignition and mean particle size (ϕ) results with depth from Grady Collins, Sanford, Maine, USA.

Discussion of the results

The pH of the samples ranged from 5.3 to 6.2 which equates to an acidic to moderately acidic sediment which is typical of many free draining sandy sites. Figure 1 illustrates the results decreasing with depth and whilst there are clear variations in results e.g. 5.3 at sample 1 (99.55m) the overall down profile picture is one of stability and not one of increased acidity with depth, typical of post burial leaching. The percentage loss on ignition results also demonstrate clear homogeneity in the level of organic material present. The results range from 0.40 to 0.79% which illustrates the presence of little to no organic material, not an unusual response from C horizon sediments. In contrast though sample 6, the B horizon sediment had considerably higher loss on ignition results (3.39%) and this is likely to be due to the presence of more organic components in the form of degraded plant, roots and possibly micro charcoal fragments deriving from surface vegetation and an air borne source.

Manual Particle Size Results

An analysis of the particle size results illustrate some key variations between the samples. The overall mean particle size illustrated in figure 1 shows that samples 7 and 8 at the highest elevations (101.24m and 100.96m) have mean particle sizes of 3.31ϕ and 3.46ϕ typical of very fine sands with coarse skewedness and a high lepto- and platy- kurtosis. Figure 2 shows more clearly that both samples contain a high percentage of $63\mu\text{m}$ particles (44.4-49.0%), however sample 7 also contains a high percentage of $<63\mu\text{m}$ (37.1%), whereas the majority of the rest of sample 8 is coarser, with 41.9% in the $125\mu\text{m}$ fraction. Both these sediments appear therefore to consist of fine grained inclusions which might derive from aeolian or fluvial transportation, however, the extra high

percentage of $<63\mu\text{m}$ sediment in sample 7 might also indicate possible deposition from a loess source, which typically has a grain size of between $20\text{-}50\mu\text{m}$ (Donahue *et al.* 1977).

In contrast to samples 7 and 8, sample 4 has a mean particle size of -0.32ϕ which equates to a poorly sorted, very coarse sand with a fine skewness and platykurtosis. Figure 2 shows, in more detail, that just under 50% of the sample is composed of the 2mm fraction and the rest of the sample between $250\mu\text{m}$ and 1mm. The coarser nature of this sample suggests that the depositional processes are less likely to be aeolian and point more towards a fluvial depositional environment.

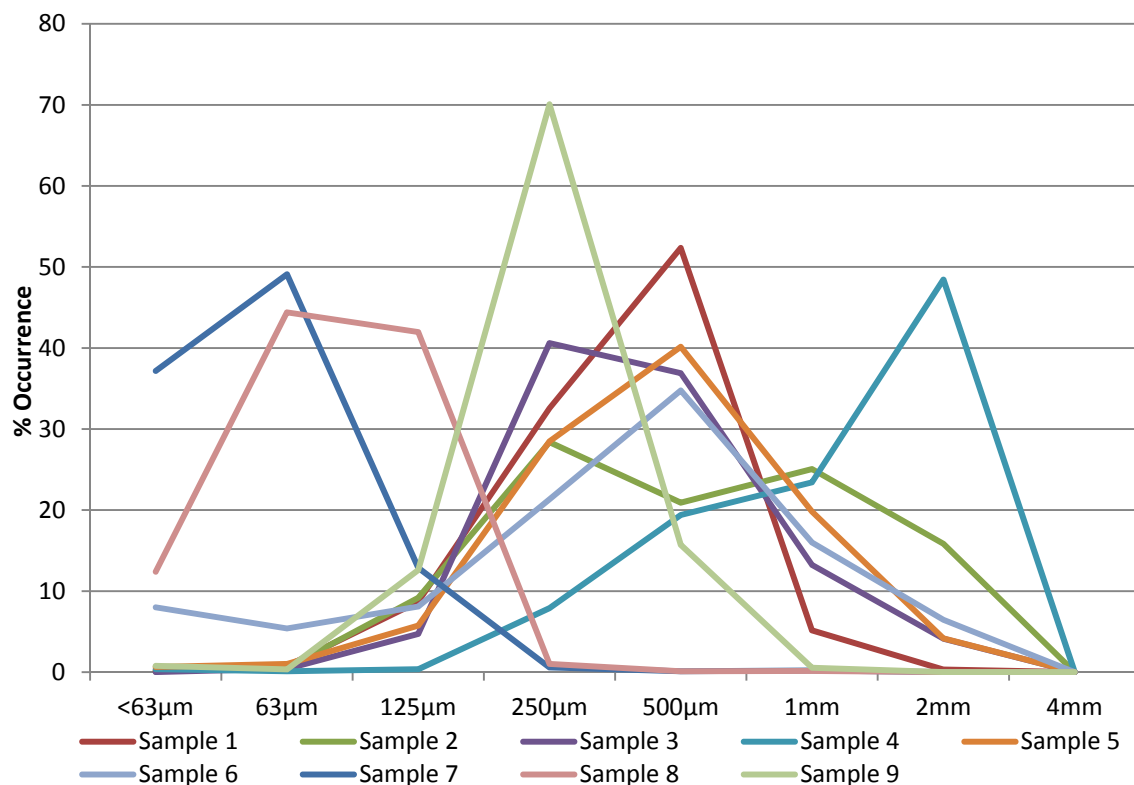


Figure 2, Detailed graphical summary of the manual particle size results from Grady Collins, Sanford, Maine, USA.

Sample 2 contains the second coarsest inclusions with 15.8% at 2mm but also a steady percentage of results between $250\mu\text{m}$ and 1mm (74.3% in total). This can be classified as a poorly sorted coarse sand under the Folk and Ward method, and contains a symmetrical skewness and platykurtosis. These results also suggest fluvial deposition but perhaps with more energy and a more variable flow range, perhaps through seasonal flooding. In contrast samples 1, 3, 5 and 6 contained very similar results especially in the $500\mu\text{m}$ and $250\mu\text{m}$ fractions. The results range from 34.7% to 52.3% in the $500\mu\text{m}$ and 21.3% to 40.6% in the $250\mu\text{m}$. These samples range from medium to coarse sands and are moderately to poorly sorted with a largely symmetrical skewness and mesokurtic kurtosis. In each of

these cases water deposition is likely to be the fundamental method of deposition but with highly changeable energy values possibly through flash flooding. The most uniform sample analysed was number 9, which contained 70.0% within the 250µm fraction and another 28.3% split between the 125µm and 500µm fractions. This very uniform distribution however is interpreted by Folk and Ward as a moderately well sorted medium sand with coarse skewness and very leptokurtic. Overall this suggests a relatively stable depositional environment possibly in gently flowing water.

Digisizer Particle Size Results

Alongside the manual sieving of the samples from Grady Collins, Sanford, Maine, U.S.A a program of electronic, computerised particle size was also conducted in order to look more closely at the finer fraction present in each of the samples and also as a guide to the quality of results provided by each. As mentioned in the methodology section, the analysis was conducted using the loss on ignition residue, as this removed any organic material, and analysed the fractions between 500µm and 1µm. Crucially, though this included the 63µm to 16µm which might assist with an aeolian source.

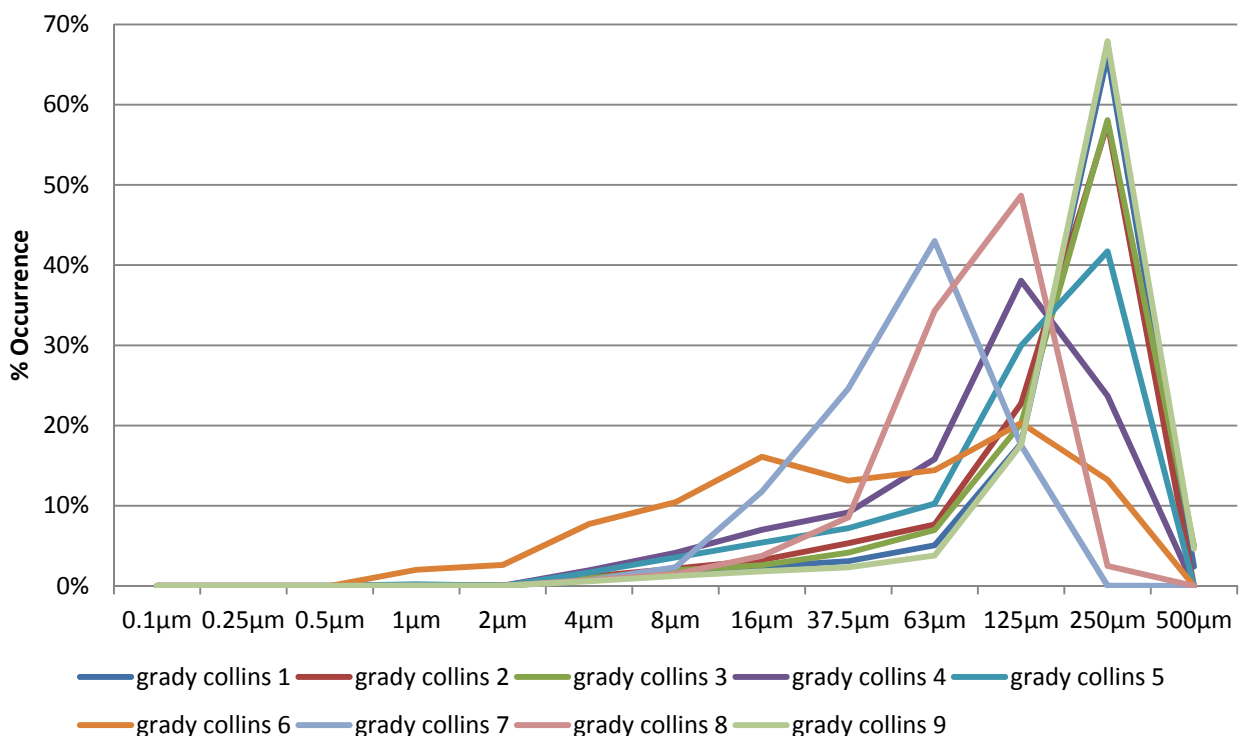


Figure 3, Detailed graphical summary of the particle size results from the Digisizer analysis from Grady Collins, Sanford, Maine, USA.

Overall the results, shown in figure 3, exhibit a number of samples (1, 2, 3, 5 and 9) with remarkably uniform particle size, especially in the 250µm fraction (between 40-70%). This supports the initial

sieving analysis; the sediments can be classified as medium sands, probably deposited by fluvial sources. The clear difference with samples 7 and 8 can also be determined from the computerised particle size analysis with the markedly finer grained constituents present in higher percentages. However, with the more detailed work on the 16 μ m to 63 μ m fractions a more in depth analysis can be made. Sample 8 is slightly coarser than sample 7 with more sediment in the 125 μ m to 63 μ m fractions and less than 10% in the 37.5 μ m to 16 μ m size range. In contrast sample 7 has a peak of c.41% at 63 μ m and considerably more overall percentage in the 16 μ m to 37.5 μ m fractions. This suggests that sample 7 has more of the accepted silty particles found in loess but that is not to say that sample 8 does not have an influence from an aeolian source.

The utilisation of both manual and automated particle size has revealed some key issues which have suggested that this methodology should be utilised again in the future. Figure 4 illustrates the results of the nine individual samples against each other in order to determine the accuracy and precision of the results from both. In most the results are consistent, especially sample 9, as this was composed of a sample which both analytical systems could detect. However, many cases because the manual sieving was able to detect to a coarser fraction (4mm) some samples were shown to contain sediment pertaining to a higher energy source. Sample 4 is an excellent example of this which contained several large rounded stones which could only relate to higher energy fluvial action. The reverse situation is demonstrated with sample 6. Here the manual sieve suggests only 8% of the sample was <63 μ m, compared to between 52-53% in the digisizer results. Of this percentage 28.6% to 29.2% was in the 16 μ m to 37.5 μ m fractions, less than samples 7 and 8, but again aeolian influences in deposition must have been occurring, possibly in a vegetated plain, due to the distinctive organic results. The comparative work conducted here on these samples has therefore illustrated that both methodological systems should be conducted to enable more detailed interpretations of formation processes.

Figure 4, Refer to additional document in attachment

Conclusions

The results of the sediment analysis of the nine samples from Grady Collins, Sanford, Maine, USA illustrate a degree of similarity in pH (5.3 to 6.2) and loss on ignition results (0.40% to 0.79%) suggesting fairly acidic deposits with little to no organic material, typical of free draining C horizons located across the globe. In contrast, however, sample 6 did contain evidence of a higher loss on ignition (3.39%) illustrating a higher organic content, but similarly typical of a B horizon which has more plant, root and micro charcoal fragments as soil forming processes have taken place over time. Distinctive variation in formation processes were determined from the particle size analysis conducted and this suggested a formation process including largely fine grained aeolian sediments (6, 7 and 8).

Of these, the presence of considerable 16 μ m to 37.5 μ m particles suggests that they could be loess deposits. In contrast, sample 4 was considerably coarser and relates to a period of high energy fluvial deposition, possibly flooding. Samples 1, 2, 3 and 5 are also probably the result of fluvial action but the lack of coarse inclusions suggests a lower energy source and possibly waning flood conditions or a less intense deluge of water. Gentle water flow is also illustrated in the unimodal results from sample 9 (70.0% in the 250 μ m fraction) which might be the result of the slow flow of water after a flood event. What is conjectural, however, is whether this supposed flooding was occurring during an interglacial or glacial period as both are likely; but if the fine grain samples are loess then the water borne deposition could be the result of glacial meltwater flooding events. Alternatively, they could also be the result of a perimarine environment with aeolian activity forming dunes and occasional marine storms causing seasonal flooding, followed by slow water recede. This scenario might also explain the high Na results as both marine winds and flooding would increase the sodium levels in the sediments as seen in many lowland shallow coastal areas.

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Appendix 2. SOIL GEOCHEMISTRY "GRADY COLLINS SITE" SANFORD, MAINE.

SOIL GEOCHEMISTRY "GRADY COLLINS SITE" SANFORD, MAINE

Soil Analysis Report - Technician Copy

Bartlett Tree Research Laboratories

Darrin Lowery

Bartlett Arborist: Norm Brady

Plant Species: Other

Location/ELM ID: front of hse

Fertilization Goal: Maintain Vitality

, 21601

Sample ID: 176671

Date: 14-Aug-12

A&L: 12-226-0570

Results

Soil pH 6.0 Acceptable

Nitrogen (ENR) 78.0 * Medium

Phosphorous (P) 62.0 High

Potassium (K) 40.0 * Very Low

Magnesium (Mg) 34.0 * Very Low

Calcium (Ca) 468.0 * Very Low

Sodium (Na) 384.0 High

Ideal pH range for Other: 5.5 to 6.5

Iron (Fe) 116.0 Medium

Manganese (Mn) 4.0 * Very Low

Copper (Cu) 2.0 Medium

Zinc (Zn) 1.2 * Low

Boron (B) 0.8 Medium

Soil Organic Matter (OM) 2.7 * Low

Nutrient Retention Capacity 6.4 Medium

Comments:

[Near toxic level of sodium.](#)

NOTE: The near toxic level of sodium observed in the soil at the site may represent relict late Pleistocene coastal conditions that were associated with the region immediately after the Laurentide ice sheet retreat.



Appendix 3. **Chemical Analysis of two artefacts
from the Grady Collins site, Maine, using
portable X-ray fluorescence spectrometry**

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August 2013

Introduction

At the request of Professor Bruce Bradley of the University of Exeter, UK, the Gault School of Archaeology Research undertook a study to geochemically profile two artefacts excavated from the Grady Collins site, Maine using a portable X-ray fluorescence spectrometer (pXRF). The primary objective was to analyse the rhyolite bi-pointed biface (fig. 1A) to determine if iron (Fe) concentrations were higher in the weathered surface than the less weathered surface; a small ‘freshly flaked’ area on the edge of the bi-pointed biface (fig. 2). A small flake scraper made on Munsungun chert (fig. 1B) was also sent for chemical analysis. The primary objective was to determine if there were any significant changes in the chemical signature of the flake from the interior (black surface) and the exterior red surface of the material.

Analysis using pXRF has become a valuable tool for archaeologists investigating material culture, incorporating chemical-based studies with traditional methods as a means of examining material procurement, mobility patterns, social and group interactions and trade and exchange. Soils, ceramics, metals, rock art and, silicate rocks are the most common materials studied using pXRF and numerous research projects have been conducted into its validity (Čechák et al. 2007; Zhu et al. 2011; Wilson et al. 2008; Musílek et al. 2012; Frahm et al. 2013; Frahm 2013; Glascock & Ferguson 2012; Koenig et al. 2013). The non-destructive nature of pXRF spectrometry means that archaeologists and museum curators are more disposed to this technique over traditional lab-based destructive techniques.

Rhyolite is a felsic extrusive rock with a silica (SiO_2) content of ~ 69% - 77%. The mineral content of rhyolite typically contains quartz and plagioclase, along with smaller amounts of amphibole, biotite orthoclase, pyroxene (hornblende), and glass. Due to the volcanic nature of rhyolite, certain elements, including Rb, Sr, Y and, Zr, will be present in the chemical composition and allow for source determination based on these concentrations similar to the process used in obsidian provenance studies (Glascock & Ferguson 2012; Frahm et al. 2013; Frahm 2013; Forster & Grave 2012).

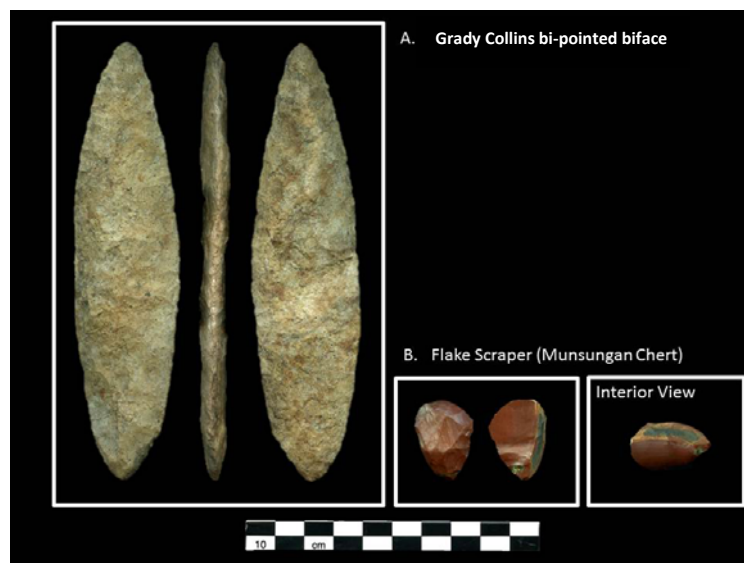


Figure 1: Artefacts from the Grady Collins Site

Instrumentation and Methodology

Chemical analysis of the rhyolite bi-pointed biface and Munsungun scraper were conducted in the laboratory. A total of 24 spot readings were taken from the rhyolite bi-pointed biface, 10 from each side of the bi-pointed biface with a further 4 from the less weathered area. Five spot readings were taken from the Munsungun flake scraper, 3 readings from the exterior (red), and 2 from the interior (black) surface.

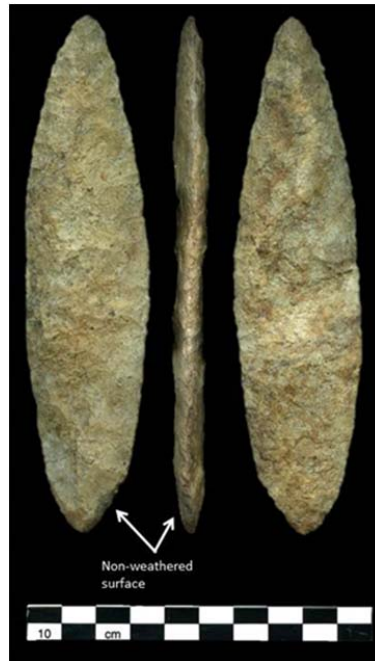


Figure 2: Rhyolite bi-pointed biface showing "freshly" flaked surface

Analyses were conducted using a Bruker Tracer III-SD handheld (pXRF) energy-dispersive X-ray fluorescence spectrometer equipped with a rhodium target X-ray tube and a silicon drift detector with a resolution of ca. 145 eV FWHM for 5.9keV X-rays at 200,000 cps over an area of 10 mm². Data was collected using a suite of Bruker pXRF software (X-ray Ops ver. 1.2.21, and S1PXRF ver. 3.8.30) and processed using Microsoft Excel® running Bruker's empirical calibration software add-on. Monthly quality assurance checks are conducted on the spectrometer to confirm operating parameters and calibration using a Bruker standard alloy sample (40Duplex2205CK) and four USGS samples (BCR-2, DNC-1a, QLO-1, & SBC-1).

The rhyolite bi-pointed biface was measured at 40keV, 36.20μA, using a 0.3 mm aluminium/0.02 titanium filter in the X-ray path, and a 60 seconds live-count time. Peak intensities for K α & L α peaks were calculated as ratios to the Compton peak of Rhodium and converted to parts-per-millions (ppm) using Bruker's factory calibration for obsidian, compiled by the Archaeometry Laboratory at the University of Missouri Research Reactor (MURR) (Glascock & Ferguson 2012) and evaluated by Robert Speakman of the Center for Applied Isotope Studies at the University of Georgia (Speakman 2012).

The Munsungun flake scraper was measured at 40keV, 55µA, using a 0.3 mm aluminium/0.02 titanium filter in the X-ray path, and a 60 seconds live-count time. Peak intensities for Kα & Lα peaks were calculated as ratios to the Compton peak of Rhodium and converted to parts-per-millions (ppm) using a chert calibration developed by the Gault School of Archaeological Research in collaboration with Charles A. Speer of the University of Texas at San Antonio and the Chicago Field Museum Elemental Analysis Laboratory.

A preliminary statistical analysis was conducted using multivariate analysis to determine if the rhyolite bi-pointed biface matched to any previously sample rhyolite sources in New England. Prior to this analysis, data was transformed using a base-10 logarithm to remove magnitude differences. Linear discriminant analysis and canonical discriminant analysis were used for the verification and subsequent source assignment of archaeological artefacts.

Results

The results of the iron concentrations for each spot reading taken from the rhyolite bi-pointed biface are shown in figure 3. Readings GCK-1 to GCK-10 are from face 1, GCK-11 to GCK-20 are from face 2 and readings GCK-FF 1 to 4 are from the non-weathered surface of the bi-pointed biface .

Iron concentrations range from 15335 to 5034 ppm with a mean average of 9720 ppm. Whilst it is clear that the concentration of iron fluctuates across the surface of the bi-pointed biface (see fig. 3), the mean average reading for face 1 is 10187 ppm (range = 6188 ppm) compared to a mean of 10132 ppm (range = 10300 ppm) for side 2. This would suggest a fairly stable level of iron enrichment in the rhyolite as a whole across both faces (although some area's yield higher individual concentrations). The less weathered surface has a mean average iron content of 7523 ppm, with a range of 1740 ppm suggesting a more stable iron concentration across that area than is seen on face 1 and 2. This data would suggest the levels of iron in the bi-pointed biface have increased by approximately 35% due to surface weathering.

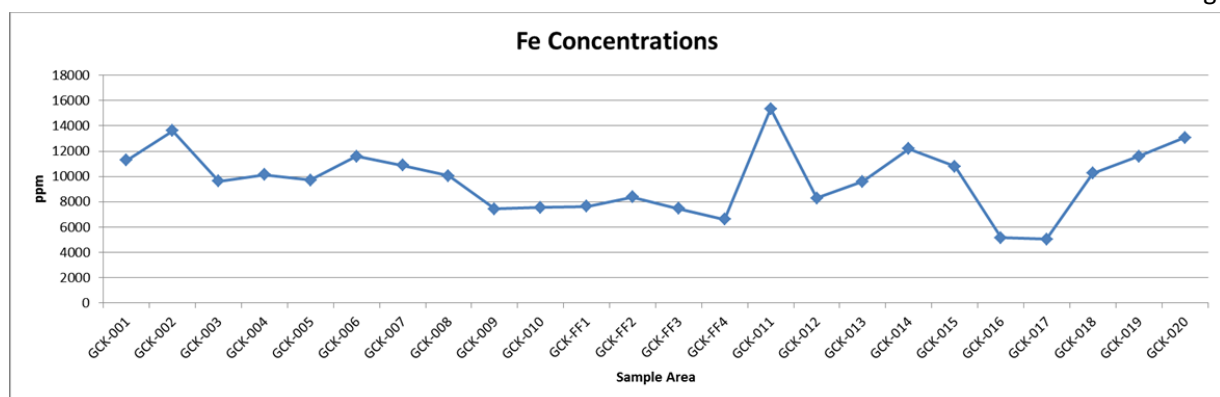


Figure 3: Iron levels in rhyolite bi-pointed biface

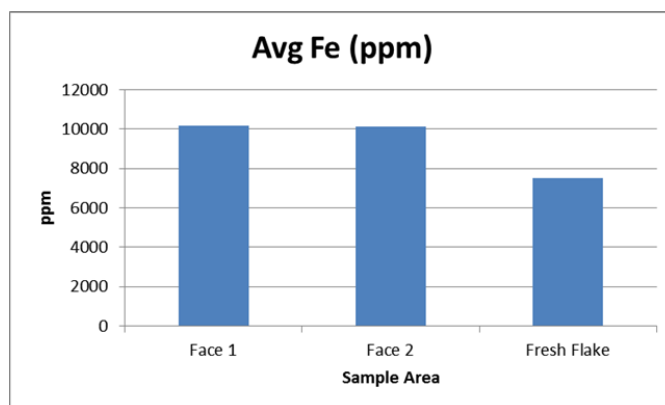


Figure 4: Mean average of Iron by sample area

The results from the analysis of the Munsungun flake scraper show significant variation in the levels of manganese present in the exterior and interior of the flake. The mean average concentration of manganese (Mn) present in the interior surface is 33760 ppm, whilst the exterior of the flake has an 89% decrease in Mn to a mean average of 3435 ppm (see fig. 6). This decrease occurs via the replacement of the element Mn with Fe, which has an average concentration of 45357 ppm on the exterior surface of the flake.

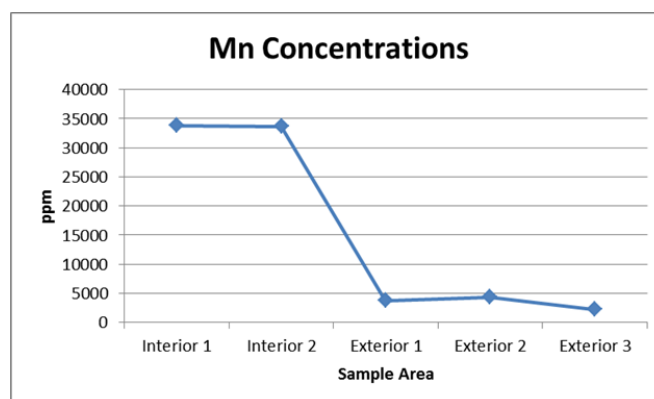


Figure 5: Manganese concentrations in flake scraper

Provenance

The final stage of the analysis was to compare the geochemical signature of the rhyolite bi-pointed biface to two sources of rhyolite identified in New Hampshire. These two sources have been previously identified as the source of rhyolite artefacts recovered from various Paleoindian, Archaic and Woodland archaeological sites in New Hampshire (Pollock et al. 2008). These sources are ~ 17miles apart; the first is a dike consisting of distinctive red and green color spherulitic flow-banded rhyolites located on Mount Jasper to the northwest of Berlin, New Hampshire (Boisvert & Pollock 2009). The second source, located near Jefferson, New Hampshire, is located in bouldery till, esker, alluvial, and glacial lacustrine deposits that “drape the hillsides in the area” (Pollock et al. 2008). A total of 125 readings were taken directly

from the outcrop for the Mount Jasper source. Due to the nature of the Jefferson source, only two readings were taken *in-situ* (a total of 40 readings) with a further 100 readings taken from nodules which had been removed and curated from the Jefferson location during field excavations. The results are presented in figure 4, which shows the canonical discriminant plot of the Mount Jasper source (in blue) and the Jefferson source (in red). Source assignment is made when an artefact plots within one of the 95% confidence ellipses, figure 4 shows that the Grady Collins bi-pointed biface does not match either of the two sources that were sampled.

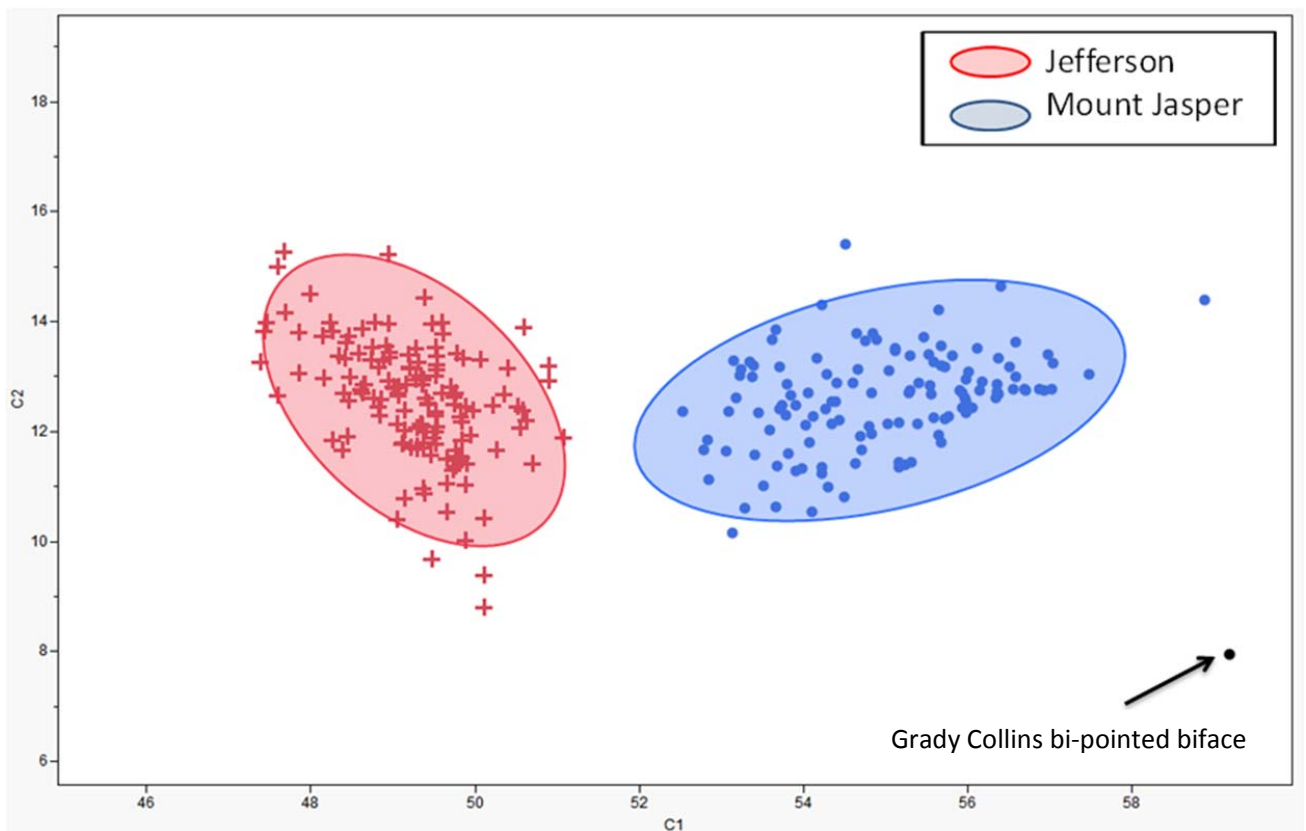


Figure 6: Canonical discriminant analysis of two geologic sources and the Grady Collins bi-pointed biface with 95% confidence ellipses.

Conclusions

Without further analysis on the taphonomic sequence and depositional environment of these two artefacts, it is difficult to put forward any definitive explanations as to their chemical signatures. Based on the data available, it is clear that both artefacts have undergone chemical alteration during deposition. With the increase of iron in the weathered surface of the bi-pointed biface, and the replacement of manganese with iron in the scraper, it is possible that these artefacts were at some point exposed to iron rich sediment, where the enrichment/depletion of these two elements may have occurred, however, as explained above, it would be difficult to assess the mechanics by which this

process took place. In terms of a provenance for the bi-pointed biface, analysis has so far ruled out a connection to two sampled sources in New Hampshire.

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Appendix 1 – Raw data

Table 1: Bi-pointed biface elemental concentrations (ppm)

	Mn	Fe	Zn	Ga	Th	Rb	Sr	Y	Zr	Nb
GCK-001	28.30	12859.18	94.11	122.20	89.85	230.59	107.04	93.21	257.39	78.81
GCK-002	86.42	16180.99	102.90	124.53	91.26	230.40	108.62	97.11	244.59	76.82
GCK-003	0.00	10646.71	80.78	121.62	90.13	225.66	105.50	100.91	255.26	78.93
GCK-004	43.34	11825.01	99.67	121.96	91.88	222.34	108.62	95.89	300.59	79.91
GCK-005	0.00	10872.87	90.07	121.22	90.67	211.86	102.77	88.12	255.62	77.62
GCK-006	15.09	12819.40	93.29	121.11	85.53	215.66	99.46	89.34	258.36	74.05
GCK-007	2.40	12368.67	79.85	119.74	91.21	217.29	105.90	96.08	274.20	78.72
GCK-008	0.00	11007.06	88.57	120.05	89.40	226.98	99.93	95.15	285.75	77.86
GCK-009	0.00	7518.60	82.86	119.96	86.67	230.47	100.41	95.32	228.83	77.05
GCK-010	0.00	7820.33	90.62	116.21	92.87	221.25	98.11	89.29	223.36	77.58
GCK-011	159.15	18376.71	117.28	129.18	90.16	232.98	109.28	108.34	219.44	77.13
GCK-012	71.90	8867.40	84.25	121.58	90.09	234.85	105.93	91.44	260.37	76.50
GCK-013	89.83	10827.31	106.82	118.15	86.25	213.08	108.28	97.05	291.28	78.30
GCK-014	111.77	14054.69	155.97	123.11	89.26	241.97	103.86	90.60	227.87	77.74
GCK-015	121.94	12414.29	190.29	121.41	90.56	221.22	104.21	91.52	212.51	78.09
GCK-016	0.00	4888.71	94.47	113.88	89.70	224.37	103.18	87.59	240.64	77.01
GCK-017	0.00	4596.72	92.47	113.86	88.79	234.44	106.03	84.66	250.11	76.53
GCK-018	0.00	11006.88	94.89	119.72	89.24	221.66	100.12	88.15	240.43	76.18
GCK-019	0.00	13482.74	114.79	122.54	92.01	227.77	110.29	107.94	294.37	79.92
GCK-020	0.00	14794.13	95.38	122.14	88.06	231.25	98.39	84.38	227.65	75.68
GCK-FF	0.00	8121.84	79.91	123.02	91.59	240.05	107.50	103.89	250.10	81.13
GCK-FF2	0.00	9435.91	100.70	121.38	95.57	240.65	108.84	101.50	273.94	82.19
GCK-FF3	0.00	7982.31	84.14	123.12	93.04	236.16	111.30	106.68	281.36	81.72
GCK-FF4	0.00	6893.72	81.72	122.01	89.67	231.64	111.96	102.30	315.95	81.01

Table 2: Munsungun Flake Scraper elemental concentrations (ppm)

	Ca	Ba	Ti	Cr	Mn	Fe	Co	Ni	Cu	Zn
Scraper (blk)-001	6836.91	1033.36	0.00	119.49	33814.53	0.00	0.00	27.15	100.68	83.73
Scraper (blk)-002	6745.64	1274.51	0.00	160.02	33704.56	0.00	0.00	25.06	94.61	65.81
Scraper (red)-001	5495.08	0.00	1019.65	80.03	3772.78	38730.35	38.19	20.81	81.43	44.92
Scraper (red)-002	5574.54	145.34	901.38	74.56	4319.22	43777.51	40.60	19.21	91.74	52.35
Scraper (red)-003	5378.37	0.00	1313.26	73.79	2212.81	53563.47	45.99	13.00	89.16	25.93