Archaeological trash: Geomorphology and early human occupation in Wyoming

Luna B. Leopold\textsuperscript{a}, Claudio Vita-Finzi\textsuperscript{b,\textasteriskcentered}

\textsuperscript{a}Department of Earth and Planetary Science, University of California, Berkeley, CA 94025, United States
\textsuperscript{b}Department of Mineralogy, Natural History Museum, London SW7 5BD, UK

Accepted 14 March 2005

Abstract

The waste products of stone tool making and isolated artifacts found on land surfaces can illuminate aspects of human culture and of landscape evolution even though they lack stratigraphic context. Quartzite artifacts and debris occurring on pediments near Pinedale (Wyoming) include cobbles from which multiple flakes have been removed by percussion. Some of the specimens have been polished and abraded by wind-blown sand. Neither feature is represented in the material excavated at the local Holocene site of Trappers Point. The location of the surface finds in relation to topography and the products of glaciation suggests that occupation in Paleo-Indian or perhaps earlier times was more pervasive in Wyoming than suggested by the few settlement or kill sites on the valley floors. It also shows that relying on sealed sites to date the pattern of human movement across the landscape risks underestimating its antiquity.

© 2005 Elsevier B.V. All rights reserved.

Keywords: Wyoming; Quartzite; Artifacts; Terraces; Cosmogenic

1. Introduction

Middens and other repositories of ancient waste products have long provided archaeology with valuable information about diet, disease, and demography. Flakes and
cores recovered at camp sites are of critical importance in the study of technological progress. On the other hand, the unfinished or discarded stone material that is found on many land surfaces is generally viewed as lacking chronological or cultural value. The field evidence presented here indicates that much can be learnt from such surface material.

In the last half century, field techniques in archaeological excavation have changed in important ways, especially the mapping in three dimensions of the location of nearly all objects unearthed. But even more useful is the ability to date materials within which the artifacts occur, using a variety of radiogenic techniques. These can provide ages over a impressive span of time from millions of years before present to a few years. Yet much more widespread are items which are related to or made by humans but to which these dating techniques are not applicable because the objects are on the ground surface or for other reasons do not exist in a stratigraphic context. They are not in themselves datable or are mixed with other materials of diverse ages. Such objects are generally considered unusable in sequencing and are dismissed as trash or debitage.

Stone chips, flakes, shards, or broken handles are often encountered on Near Eastern tells, the wetlands of Jutland, or the mesas of New Mexico. Some of these scraps tell a story. On a remote cliff overhanging the San Juan River in Utah, there is a tall, stone watch tower around which decorated pot shards show that it was in use for only 50 years, perhaps because their makers were being driven or hunted by alien tribes. R. A. Bagnold, during his extensive early exploration of the Sahara, chose to spend a night in a shallow rock shelter in the uninhabited desert. To find a place to put his wrist watch for the night, he reached up to a narrow ledge above his head and his hand grasped a well-formed stone knife, apparently left by an ancient who slept in that identical spot and who also put his important possession in the ledge above his head. These incidents tell only of a moment in time or a narrow glimpse of time past. The extensive distribution of artifacts on the hills above Pinedale, Wyoming, speaks of a much larger issue and over an unknown period of time but of some paleo-historical importance. Such objects are often considered to be of no importance and thus receive little attention but this perception is misguided.

Some of the artifacts have been cut or pocked by windblown sand, a fact that indicates considerable age. The worked stones are quartzite cores and tools the size of a fist or slightly smaller. The knapping of such quartzite indicated a high degree of specialization and experience in percussion knapping (Dr George Frison, personal communication, July 2002). Many of the artifacts found have as many as 20 flakes removed from the single rock, often bifacially, and show secondary working at the edges. They are all made out of rounded rocks derived from an ancient pediment, and are found at elevations above the glacial outwash plains of Pinedale and latest Bull Lake glaciers. As they are surface finds, none of the known dating techniques can at present be applied to them.

1.1. Geomorphic setting

Pinedale, a small town in Sublette County, is built in a wide flat valley that is the glacial outwash plain derived from the melting of the Pinedale ice sheet in the Wind River Range (Fig. 1). The valley floor is now the flood plain of the New Fork River. Bounding the present valley are terrace levels several meters above the present river which are remnants of extensive flood plains of the New Fork. They were built by deposition of gravel–sand
mixtures carried by the meltwater from mountain glaciers. Nearby hills having various amounts of rounding and channel development are composed of ground moraine or till, or they may be terminal or lateral moraines. But standing well above these terraces are some much higher hills representing earlier levels of the paleoriver.

The geomorphic features provide a reasonable picture of the history of the landscape which we have expressed by conjectural cross-sections representing the recent geologic past. The cross-section in Fig. 2 represents the principal features along a N–S line through
Pinedale. The vertical scale is realistic, but the horizontal scale is foreshortened and schematic. Mount Airy (right) and Cora Butte are two remnants of an extensive pediment, now so dissected that only these two and a few other individual knobs remain; the original form is suggested in Fig. 3a. A pediment by definition is a surface cut on bedrock by flowing water and is characterized by a superficial layer of rock debris transported by the water. Usually a pediment is seen as a surface sloping from the face of a mountain range toward a stream acting as a base level. A pediment differs from an alluvial fan which is usually conical in form whereas a pediment is a bedrock ramp. Most pediments are dissected to some extent.

The profile of the present landscape is shown in dotted lines taken from Fig. 2. The surface was cut on the sedimentary deposits of the Pliocene. The high knobs on the flanks of Cora Hill, Mt Airy, and nearby hills of the same elevation are covered near the crest by a gravel pavement or mosaic of rounded rocks that overlie the Wasatch bedrock. The contact of the gravel and the bedrock is not exposed but the relation identifies a dissected pediment. The rounded rocks of the original pediment surface are the materials from which the artifacts were fashioned. The finer fraction of the original pediment gravel was apparently gradually removed, but, because of the small slope of the hilltop, the forces of erosion have not been sufficient to remove the cobble-size rocks that became more concentrated, forming the local pavement mosaic at various locations and various elevations.

To the west and stretching far to the south is a large plain at 2300-m elevation called the Mesa, a remnant of an extensive surface traceable nearly to Rock Springs 120 km to the south. This was the flood plain of an early stage of the New Fork and the Green River when the river stood at this elevation near Pinedale but sloped to the SSE at about 5 m/km. It was developed after the original pediment had been nearly completely eroded away and probably parallel to it though the earlier pediment was 100 m higher.

In the centre of Fig. 2 is shown the valley flat of the New Fork River, underlain by glacial outwash gravel and sand to the depth of 30–49 m known from wells that draw water from the underlying Wasatch Formation. To the left is the moraine of the last glaciation and against it is a remnant of the former flood plain of the New Fork when it
was flowing on the outwash plain of the Bull Lake glaciation. The cemetery is located on that remnant.

A further major change reflecting a lengthy span of time resulted in dissection of the Mesa. The situation pictured in Fig. 3c prevailed late in the Pleistocene, which experienced at least three major glacial events. The oldest, called Sacajawea, Ridge (not represented in Section C) is dated at more than 272 ka (Phillips et al., 1997). Sacajawea Ridge deposits north and west of Pinedale are rounded hills, with only an occasional large boulder at the surface. Were it not for such rare surface rocks and the occasional roadcuts, one would never suspect that these hills were composed of glacial till.

Section C represents the condition after the Bull Lake glacial period. Using cosmogenic isotopes, Phillips et al. (1997) obtained ages of 130–120 ka for Bull Lake till near Fremont Lake, and Hancock et al. (1999) report ages of 125–118 ka for the corresponding river.
terrace. By this time the valleys of the Green River and the New Fork had been separated by the ridge of Wasatch formation that now connects Cora Butte, Trapper’s Point, Mt Airy, and Stewart Point. The Bull Lake glacier had cut the deep trench of Fremont Lake as well as valleys draining the Wind River Range, and on recession its outwash plain had filled the valleys with a deep deposit of sandy gravel. remnants such as the bench where now is the cemetery, the bench on which the Cora road is constructed, and the flat on which Boulder village stands. The Bull Lake and Pinedale moraines have surfaces littered with large rocks that show little weathering. They are seen in the lateral and terminal moraines bordering Fremont lake just north of Pinedale.

Fig. 4 is a longitudinal profile down the New Fork River from a point near Mount Airy to a place near its junction with the Green River. It shows the relative elevations of the Bull Lake and Pinedale outwash plains now seen as terrace remnants standing respectively 30 m and 20 m above the present river. Cosmogenic dating of Pinedale moraines at Bull Lake gave ages of 23–16 ka (Phillips et al., 1997). Incision over an unknown period left the Mesa isolated as a broad flat between the two river valleys with only a few spurs around the edges of the main range and the Cora–Mt. Airy ridge.

The situation when Cora and Airy had been further reduced in height and volume by erosion is shown in Fig. 3C. The outwash plain of the Bull Lake is eroded. A hypothesis may be developed from consideration of the location and elevation of the sites mentioned above. An approximate age of various surfaces shown in Fig. 3 was estimated using the relation of height of similar surfaces along the Wind River across the mountains to the east. Dates of those surfaces measured by $^{10}$Be and $^{26}$Al techniques were published by Hancock et al. (1999), and yielded mean rates of exhumation of ~13–130 m/Ma.
Correlating dates with height above the river showed a very similar average of about 1 m of surface lowering in 6000 years, or ~170 m/Ma. Using this average applied to the high surfaces, the Mesa standing 100 m above the local river would be dated at 600 ka and the age of the top of Mt. Airy and Cora Butte at 155 m would be in the order of 900 ka.

1.2. The pediment gravel

The gravel seen on the surface of these pediment remnants and on some of the lower hills on the flanks of the peaks is the source material for the artifacts (Plates 1 and 2). These clasts are often so closely spaced and so nearly of the same height that it reminds one of a mosaic. They are highly rounded and vary in color – white, red, black, brown – but all are quartzitic. Among these clasts is green or yellow–green quartzite we have not seen elsewhere.

The ventral side is usually somewhat stained by silt from being buried. A fresh face may be yellowish, pale green, while others are gray or white. An analysis of size distribution of the rounded clasts showed a D50 of 18 mm, D84 of 55 mm, and maximum size of the sample 150 mm. A count of the number of cobbles greater than 30 mm was 50/m². The lithologies less resistant to weathering have disappeared through time and so have the ferromagnesian minerals that weather more easily than quartz. These rocks have no known origin. The gravel described occurs on the tops of hills on slopes that vary from 0 to 7%.

The artifacts found at the surface amid the pediment gravel are mostly the size of a fist or slightly smaller (Plate 3). A few are well formed, large, nearly circular and 15 cm in diameter. All were formed by percussion and the percussion bulb is prominent on many examples The removed flakes were usually 3 to 5 cm in width and 0.5 to 2 cm in thickness. The removed flakes are seldom found. What usually is found is the core or

Plate 1. Characteristic topography in study area 400 m southwest of Cora Butte.
matrix, but many are definite tools. Those might be choppers used to crush bone or other soft objects. Many have as many as 20 flakes removed from a single rock.

The artifacts vary in surface coloration. Some have no apparent discoloration, but others have a difference in color on the dorsal and ventral surfaces. The discolored side was found to be the ventral one in the ground in contact with soil. Some have attained the same discoloration after being flaked as on the original unflaked surface.
Where two flaked surfaces intersect, the ridge between them is usually sharp and minutely jagged, but on what appears to be similar lithology some ridges seem smooth or far less jagged. A number of specimens show both kinds of ridges. Several experienced geologists with knowledge of petrology agree that such specimens were flaked at different times with a long interval between, and have classified our artifact collection into older and younger on the basis of these characteristics. Additionally, on some specimens flake removal appears to have occurred at quite different times, as older surfaces are more weathered than those of later knapping. There are other indications of more than one period of tool making.

The artifacts are found scattered on the surface of nearly all the hilltops that were covered or partly covered by the gravel pavement. They are not embedded in the pavement. On some of the lower hill slopes, gravel is sparse. But where the gravel forms a mosaic pavement, the artifacts are common. For example, the hills north of highway 187 between Trappers Point and Daniel Junction are mostly covered with the pediment gravel. On a promontory we call Jim West Hill No 1 (SW 1/4 Sec 20, T34N R110 W elevation 2237 m), we counted 17 artifacts in 17,000 m² or 1/1000 m². On a hill 400 m to the north (elevation 2285 m), there were 6 artifacts in 15,000 m² or 1/2500 m². The high flat hilltops in Sec 12 and 14 two km to the northwest (elevation 2377 m) have the pediment rocks covering the surface but there were no artifacts. We conjecture that the early people chose locations closer to the river valley. One cannot escape the impression that there were many people involved, or a long period of time was involved in the flaking, or both.

The artifacts discussed here have not been found on any of the glacial outwash plains. That does not mean that they are absent. The flat outwash plains built from glacial meltwaters are now the areas of urban development and irrigated pasture. The surfaces are well vegetated and few exposures of the original surface are available. Where roads have been constructed across the pediment flats that make the geomorphic surfaces such as the Mesa, excavations have exposed many rocks that had been buried to depths of 10 to 40 cm. They are covered with caliche that may attain a thickness of 1 mm, but we have not found any artifacts buried or covered by a thick layer of caliche. All are on the surface of the mosaic pavement.

1.3. Relation to Trappers Point site

Modern or Holocene artifacts are common in the region. They are made of chalcedony or obsidian not from a local source. Well formed pressure-flaked arrowheads and other formal tools, as well as chips from pressure flaking of obsidian and flint, are found on the river terraces and on the hillslopes but not on the mosaic gravel pavement areas. Conversely, the large percussion artifacts, which display no pressure flaking, are found only on the hillslopes covered with the quartzite pediment gravel mosaic.

The present discussion of the worked rocks described must include how these objects relate to a site professionally excavated and well documented, the Trappers Point site (48SU 1006) under the supervision of Dr Mark Miller, State Archeologist of Wyoming (Fig. 1). This was and still is a narrow corridor through which antelope move on the annual migration from the Green River valley to the Red Desert some hundred kilometers to the south. On top of the hill at the site, the lee slope collects some blown sand and in winter a
snow drift. Both of these apparently slowed the animals and permitted their kill. The site is considered a place where seasonal butchering was done for meat and hides. The occupation spanned the Early Archaic, 5000–3000 BP and Late Archaic, 4200–2800 BP. The excavation found several levels of use in which antelope bones were a prominent feature.

Of interest here is whether there is some connection between our pediment surface artifacts and the rock materials excavated at the Trappers Point site. Some statements (Miller et al., 1999) appear to refer to artifacts similar to those discussed here: for example ‘...archaeological landscapes along the Green and its tributaries are littered with tested metaquartzite cobbles on Pleistocene terraces’ (p. 98), and ‘It is possible, but not probable, that some of the smaller artifacts were procured from pebbles on the high Pleistocene terraces flanking the Green River’ (p. 99).

In the discussion of tool types, Miller et al. (1999) draw a distinction between expedient versus formal types ‘based on the degree of overall shaping and modification in the manufacturing process’ (p. 171). They further state that ‘from the study of expedient tools versus formal tools, it was discovered that expedient tools greatly outnumber formal tools in all three strata where taken as a whole’ (p. 171).

Materials considered local in origin (found within 10 km of the site) made up the highest number of tools at Trappers Point. Stratum V (pronghorn bone bed), for example, included 19 cores, 18 utilized flakes, 3 points, 4 hammer stones, and 5 tested cobbles. But most of the quartzite was in the debitage. Out of 57 expedient tools, 18 were made out of quartzite. Most were material from the Laney Formation, chert and porcellanite. ‘Tools and projection points make up less than one percent of the entire lithic assemblage’ (p. 108). In the table separating the items by material type, quartzite made up 12.5 % of the collection (p. 96, Table 7.2). In discussing the size of fragments of the debitage, the greatest number was in the class of 0.25–0.7125 in (0.6–1.7 cm) (pp. 106–107). Thus artifacts of the large size we found were not present in the excavated material.

The archeologists who have looked at our material all concur that they are artifacts, but, in their opinion, not unusually old. Their unstated assumption seems to be that these artifacts are contemporaneous with the Holocene materials of the kind found at Trappers Point. If this were the case, it seems logical that the detailed excavations at Trappers Point would have found at least a few of the types we discuss. None of the size or of percussion flaking were found at the site. Nor did the excavation find any windcut stones of the type to be described subsequently. There is of course often a reluctance to accept any artifacts as older than 11,500 14C years, the age of the oldest Clovis sites.

Study of the report of the excavations led us to conclude that this site did not include the types of artifacts we found, nor did the pediment gravels described here play a part of the Trappers Point culture. Again, Miller et al. (1999) do not mention ventifacted rocks. The small sand deposit on the lee side of the hill does not constitute the condition needed for quartzite stones to be shaped by wind action.

### 1.4. Relative elevations of artifact occurrence

The profile down the valley of the New Fork (Fig. 4) shows the consistent position of the two major terraces. The terrace remnants are not the same in the valleys of the Green or
the East Fork. In the latter there are three prominent terraces and the Green has not been studied in the same detail.

Locations where the Pinedale deposits occur include the remnant just above the home of the Noble ranch and the Noble quarry (Fig. 1). Bull Lake deposits are at the level of the Cora road near the Noble ranch, the cemetery, the museum in Pinedale, the airport, and the broad flat north of Boulder. Percussion-flaked artifacts have not been found in these locations, as noted earlier.

Artifacts are numerous where a gravel mosaic occurs in all the studied locations above these two outwash terraces. Leaving out Trappers Point which has been extensively studied, they occur on the crest and on all the slopes of Cora Butte, Mt. Airy, and Stewart Peak, at Frison hill, at Cactus Garden, and at least one location at the south end of the Mesa.

1.5. Wind action and its age

Our artifacts appear old; they may predate pressure flaking but that is difficult to prove. The facts that argue most strongly for an assignment of substantial age are that several artifacts have been cut, altered or modified by windblown sand. We do not know how much time was required for them to be modified by the wind, but the usual relation to known geologic events is well described.

In the published studies of ventifacts, the most relevant is the work of Sharp (1949) in the Bighorn Mountains of Wyoming. The ventifacts studied by him were found on ‘piedmont surfaces and on bedrock mantled by bouldery stream gravels 5–10 ft thick.’ The surfaces varied in height from 25 to 325 ft (7.2 to 93.6 m) above stream grade. Only the lowest surface was an alluvial terrace. Sharp’s description of the surfaces resembles those discussed here except that the gravel of the latter could not be described as bouldery but rather cobble size or smaller. Also, only the Mesa surface is extensive and the Cora–Airy surface is represented only by a few remnants as described above.

Sharp found ventifacts on four definite levels. The highest level, being the oldest, had fewer windcut stones, more scattered than those on younger and lower surfaces. He discussed possible age of the wind cutting in some detail, and concluded that ‘the age of the ventifacts, with few exceptions, would appear to be the same age as the erosion surface on which they lie’ (Sharp, 1949, p. 190). This is not the case in the situation here discussed. He considered the highest surface to be pre-Wisconsin, the lower ones probably Wisconsin.

Reliable measurements by Sharp showed the ventifaction of all the surfaces was by northwest winds. He concluded from the field evidence that ‘conditions for sandblasting were optimum during episodes of glaciation in the near-by mountains when floods of meltwater inundated parts of the Big Horn piedmont and strong winds prevailed’ (Sharp, 1949, p. 193).

This same view was confidently stated by Bryan and Albritton (1942), who had studied wind abraded rocks in a variety of places. Speaking of the examples they found on the Home moraine of the Cache la Poudre river, Colorado, they stated that ‘The wind-action goes back to middle Wisconsin time. Similar windcut and wind-polished rock fragments occur on the Corral Creek moraine. There is little evidence that they have ever been
protected by a cover of sand. These stones were polished by winds that blew off the ice as it retreated after building the moraine some 25,000 years ago. Therefore, sufficiently resistant rocks in suitable climates will retain a wind polish for many thousands of years’ (Bryan and Albritton, 1942, p.1414).

Some of the artifacts described here are made of rocks that have been pitted, scoured, or polished by windblown sand. On many, but not all areas where the pediment gravels have been studied in this project, wind-polished, cut, or pitted rocks occur. For example, on the hills previously discussed as Jim West Hill No. 1 and 2, rocks polished or pitted were about as frequent as artifacts or 1/ 1500 m². South of the New Fork River between Highway 92 and the Green River, at a location we have called the Cactus Garden (Fig. 1), a small hillock about 2 hectares in size is covered with the pavement mosaic typical of Cora and Airy. On this hillock all the surface rocks appear wind pitted or polished. Another hill in the same vicinity is not covered with pavement, but with sage brush and soil, and is distinguished by the occurrence of a few scattered, well-formed ventifacts 12 to 18 cm in size. The lack of a gravel cover on this latter hill is interpreted as the result of a superficial deposit of windblown silt.

Ventifacts are developed primarily by scouring by winds that pick up sand from the broad flood plain of a streams flowing out of the melting ice as discussed by Sharp (1949) and Bryan and Albritton (1942). There is no indication that the geomorphology of Sublette County was capable of generating windblown sand except during glacial times. At this one locality where wind polish affected nearly every surface rock, most of the artifacts were made of rocks that had been wind-scoured. A few of the specimens of artifacts we collected had definitely been scoured by wind action after their manufacture. Dr Miller examined our collection and of one piece remarked that it had indeed been sharpened on one edge (pers. comm. July 2002). He made no remarks about the wind action but it appears that most professionals have had no experience with wind cut rocks.

On this hill there is clear indication of more than one period of tool making. An example is two rocks found by Dr. Joshua Collins (pers. comm., July 2002) within a hundred meters of one another. One is a round tool about 7 cm in diameter and 2 cm thick at the center rounded and sharpened by percussion with multiple flakes removed. It appears fresh and unweathered. Nearby was a rock about 15 cm in diameter from which several flakes had been removed, but subsequently blasted by wind action so that it is pitted, all sharp edges having been worn away, and scoured on both sides. The two specimens must have been flaked at different times.

It is useful to consider the provenance of the windcut rocks. The Cactus Garden, covered with a dense mosaic of rocks, stands 15 m above the Bull Lake terrace and is the only mosaic-covered hill directly south and near the New Fork river which at that point flows west. The prevailing wind is now from the north, and with the glacier some kilometers to the north and east it can be postulated that the strong north winds coming across the unvegetated outwash plain of the glacier-fed river would blow sand directly over the nearby low hill and blast the surface rocks. This environment would generate ventifacts during the melting of either the Bull Lake or the Pinedale ice. The configuration of the New Fork River at that locality would probably be as described during both of the two glaciations.
Because it took some unknown but significant time to cut the hard rocks, abrasion can be assumed to have been operative during the several thousand years during which the high pressure area over the ice caused a persistent wind. Clovis time was in the order of 13,000 years BP; the wind action must have had its effect earlier as glacial melting was complete about 10,000 to 16,000 years BP. How many years in a waning glacial period were sufficient to do the work is not known.

2. Conclusions

Artifacts formed by percussion flaking are common on hills near Pinedale, Wyoming, where quartzite cobbles derived from the surficial zone of an ancient pediment surface provide a natural source of hard rock materials easily available to early man. Some of these were cut by windblown sand after being used by humans. And there are several indications that the wind action had altered rocks not just once but at least twice over a long period of time. A well-documented excavated site at Trappers Point in the immediate vicinity did not include the type of artifacts discussed. Wind action deposited the sand on Trappers Point in which occupation layers occurred, but no artifacts showed wind scour or pitting.

The indications of considerable age include the facts that (a) percussion objects here discussed did not occur in the Trappers Point site; (b) some artifacts indicate that they were flaked at different times with an interval between to allow some weathering; (c) no pressure flaking occurs on these artifacts; and (d) some of the artifacts have been altered by windblown sand, a process attributed to winds from glaciers.

Whatever its age, the quartzite trash demonstrates two things: technical mastery of an intractable raw material, and like modern highway litter, but more durable, a web of human transit across the landscape.

Acknowledgments

We thank Joshua Collins, Laurel Collins, Garniss Curtis, T. Oberlander, Claude Kazanski, Madelyn Leopold and Barbara Leopold for their help in the field and comments on the draft MS, and Heather Viles and Olav Slaymaker for valuable suggestions.

References