Tools versus Cores
Alternative Approaches to Stone Tool Analysis

Edited by

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CAMBRIDGE SCHOLARS PUBLISHING

Tools versus Cores: Alternative Approaches to Stone Tool Analysis, edited by Shannon P. McPherron

This book first published 2007 by

Cambridge Scholars Publishing

15 Angerton Gardens, Newcastle, NE5 2JA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN 1-84718-117-1

INVESTIGATING THE BEHAVIORAL CAUSES AND ARCHAEOLOGICAL EFFECTS OF LITHIC RECYCLING

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Introduction

Because of the subtractive nature of lithic technology, chipped-stone tools and debris simultaneously serve as potential cores from which useful flake blanks can be produced and other tool forms can be manufactured. In other words, any lithic artifact serves as a potential core or nucleus for further reduction aimed at the production of useable flakes and tools. This inherently fluid characteristic of chipped-stone artifacts complicates the static typological classification required in most archaeological analysis. Consequently, lithic artifact taxonomies are necessarily arbitrary although the reliability of lithic analyses can be greatly enhanced by the use of multiple, nested typologies; several independently measured attributes; and grounding analytical methods with experimental observations (Amick 1999a; Shott 1994).

Rather than approaching the analytical problem of distinguishing stone tools and cores from a typological perspective, the processual approach to dealing with these issues is employed here. A general sequence of lithic reduction (Bousman 1993; Bradley 1975; Collins 1975) provides the foundation for this approach with an analytical focus on defining the variable characteristics and pathways of lithic procurement, manufacture, use, maintenance and discard. Lithic recycling is recognized as the key mechanism for reversing the flow of the lithic reduction process as waste materials can again become usable resources (Hayden et al. 1996). There are various ways this reversal can happen: 1) lateral recycling occurs when an existing (often worn or discarded) tool serves as a core for the production of usable flakes or is reworked to create a different tool form; and 2) secondary recycling occurs when lithic artifacts are scavenged from the archaeological record and reused, reworked or used as cores. Various reduction techniques can be used in lithic recycling, but bipolar compression employing a hammer and anvil is frequently used when the recycled materials are small.

In this paper, I compare various situations of lithic recycling to establish an analytical framework for determining some of its diverse behavioral causes and archaeological consequences. Interesting, Odell (1996a:59) has written that "recycling is a concept that is too difficult to characterize adequately in interpreting the archaeological record" and goes on to say that he has "virtually exhausted the logical ways that recycling can be measured and have failed to find one that works." Although archaeological techniques for the unambiguous identification of lithic recycling are limited, the many ethnographic and archaeological cases described in this paper suggest the door should not yet be closed on this important issue. The behavioral context and archaeological evidence for lithic recycling deserves to be examined more closely because it has been implicated in several current theoretical arguments about economizing behavior (Odell 1996a, 1996b), the concept of tool curation (Bamforth 1986; Binford 1977), and the causes of (Mousterian) assemblage variation (Dibble 1991; Kuhn 1995; Rolland 1981; Rolland and Dibble 1990).

Unfortunately, these studies also reveal considerable disagreement about how to measure and interpret the evidence of lithic recycling. Rolland and Dibble (1990) suggest that the reuse and recycling of artifacts found on previously abandoned sites is a significant cause of intra-site differences in patterns of stone tool consumption and reduction. Furthermore, Rolland (1981) proposes that lithic recycling increases as a function of the duration of occupation. In a recent consideration of the relationship of stone tools and mobility, Kelly (2001:71) reflects agreement with this principle stating, "The longer an encampment is occupied, the greater likelihood that tools will be used extensively, rejuvenated, and scavenged, and that cores will be reduced bipolarly." In contrast, Kuhn (1995:154) states that "it is important to separate the phenomenon of tool 'scavenging' per se from assumptions about the context in which it occurs" and he goes on to argue that lithic recycling increases as a function of increased mobility (and shorter length of occupation).

Despite these disagreements and apparent ambiguities of interpretation, the role of lithic recycling deserves attention from the standpoints of mobility and the energetic analysis of lithic procurement, because, as noted by Kuhn (1995:21), "while the manufacture of stone tools may require comparatively little time or energy, procurement of raw materials has the potential to be a very time-intensive undertaking in some contexts." In a similar vein, Elston (1992) has suggested some hypothetical microeconomic return curves of various lithic procurement strategies in the context of his work at the Tosawihi Quarries in northern Nevada. He suggests that direct quarrying from lithic source areas can provide substantial yields but that procurement costs are often very high because much more time and labor must be spent on the excavation, testing and initial reduction of the raw material (Figure 12-1). Surface procurement of lithic raw material can reduce the time and effort expended in quarry extraction but potential yields tend to be lower because surface exposures of rock are more weathered and easily depleted of the best materials. In contrast, the secondary recycling of stone tools and debris from can provide high returns with relatively low investments of time and energy.

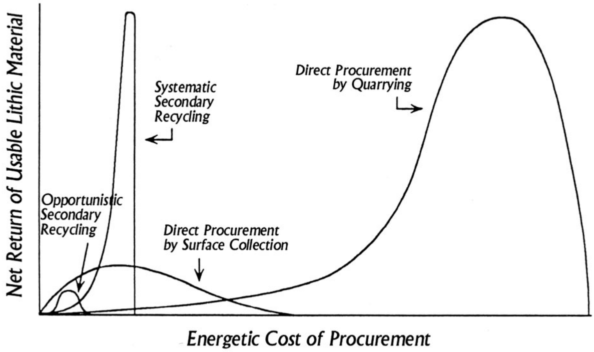

Figure 12-1 Hypothetical return curves for different kinds of lithic procurement strategies (modified from Elston 1992:Figure 14).

Procurement yields are often high when scavenging archaeological sites because the lithic materials have already been artificially concentrated, tested and often manufactured into prepared tool forms. Further benefits of lithic recycling include reducing the costs of travel and search for exotic and desirable raw materials and minimizing the handling costs associated with developing advanced skills (especially in tool blank production and secondary shaping). From the perspective of microeconomic arguments, it is clear that recycling was capable of playing a significant role in the organization of prehistoric stone economies. Examination of the ethnographic record provides additional support for archaeological concerns about the practice of lithic recycling.

Ethnographic Accounts of Lithic Recycling

Numerous ethnographic descriptions of lithic recycling are found among foragers living in arid lands where archaeological sources of lithic materials are easily encountered on exposed surfaces. Horne and Aiston (1924:89) reported that Australian aborigines in the lithic resource poor regions of the Central Desert scavenged archaeological deposits and reworked previously discarded stone tools. Among the Australian aborigines in the Western Desert, Gould (1977:68-69; also see Gould et al. 1971:163) observed "a tendency for these people to pick up ancient stone tools from the surface of sites where they are camped and reuse these implements." He concludes that, "Reutilization of already ancient materials may have been a fairly common behavior among prehistoric peoples in many parts of the world" and cautions that, "It can result in the discovery of early tools in much later levels in an ancient site." In fact, most archaeological concerns about lithic recycling seem to be focused on the potential chronological confusion caused by secondary recycling of artifacts that serve as discrete temporal markers.

Wandsnider (1989:430-436) reviews numerous ethnographic accounts of the reuse of prehistoric arrowpoints by the Paiute, Ute, Yuma, Papago, Seri, Apache, Navajo, Taos Pueblo, and several other historic aboriginal groups in the arid west of North America. For example, Isabel Kelly (1934:141) notes that among the Surprise Valley Paiute, "Arrowpoints found archaeologically were used if in good condition." She also mentions that among the Southern Paiute, "manufactured points found archaeologically also [were] used" (Kelly 1964:75). Smith (1974:11) reports among the Northern Ute, "Old arrow points, discovered when the people were roaming, were picked up, sharpened, and used." Concerning the Jicarilla Apache, Opler (1946:84) states that, "Whenever a group camps near a site formerly occupied by Pueblo Indians or other aliens, the children are sent out to look for flint arrowheads." The Honey Lake Paiute (*Wadatkuht*) often collected obsidian flakes and debris from archaeological sites:

> The *Wadatkuht* got their obsidian from 'Flint Mountain,' *Dakakudak*, a hill near Gerlach, Nevada. Obsidian also was obtained at *Pagushuhad*, a village and archaeological site on the east side of Honey Lake. It also was gotten at one of the hot springs near the lake presumably from an archaeological site. That is to say, the *Wadatkuht picked up chips and nodules left by previous people* as no natural outcrop of obsidian is recorded for that region (Riddell 1960:50, emphasis added).

Similar behavior is reported among the Northern Paiute (Fowler 1992:106-109) and the Western Apache who often scavenged Pueblo sites for flakes and pieces of debris suitable for arrowhead manufacture:

> The old men used to go around to ruins and pick up pieces of white flint there until they had enough to fill a small buckskin sack. Then when they got ready to make arrow points, they laid a blanket down and on this spread out their pieces of white flint. Then they picked whichever one they wanted to work on (Basso et al. 1971:231).

Although ethnographic accounts of lithic artifact scavenging and recycling are common, many archaeologists have failed to appreciate the implications of this behavior for the archaeological record. Furthermore, those few archaeologists who have addressed lithic recycling seem more concerned about its potential to contaminate chronological and functional assessments rather than looking at lithic recycling as meaningful behavioral evidence of prehistoric procurement and technological processes.

Behavioral Significance of Lithic Recycling and Scavenging

Unfortunately, most ethnographic examples of lithic recycling and scavenging have limited utility for theory-building because the situational and organizational context of this behavior is not recorded and poorly understood. However, these ethnographic accounts clearly suggest that archaeologists need to consider recycling as a regular lithic procurement strategy in situations where archaeological sites are commonly exposed on the surface. Acknowledging that surface scatters of lithic artifacts may serve as sources of tools and raw material for later peoples suggests that archaeological recognition of recycling behavior is necessary in the accurate interpretation of lithic assemblages. Obviously, the aboriginal reuse of temporally sensitive tool types (e.g., projectile points in North America) can result in the misinterpretation of chronological assignment. In addition, scavenging of lithic materials from an archaeological site can alter the assemblage composition of the original scatter and may result in an unreliable diagnosis about the activities conducted at the site. Camilli (1988a:159-160) has drawn similar conclusions on the potential impact of prehistoric lithic recycling among archaeological surface scatters found in the desert basins of south-central New Mexico: “the composition of desert basin assemblages may be more indicative of tool recycling than of single episodes of tool importation or manufacture.”

From an economic viewpoint, it is expected that lithic scavenging should focus on the collection of: 1) finished tools that exhibit considerable investment in manufacturing time (e.g., bifaces and projectile points); 2) large artifacts, which contain the potential for further reduction; and 3) pieces of debris that are suitable in shape and form for specific tasks, such as the use of small, flat flakes for arrowhead manufacture in the late prehistoric period of North America. These lithic recycling strategies and others result in several important archaeological implications that have also been recognized by Camilli (1988a:159):

> The complexities introduced into the archaeological record by these technological options include the discard of tools together with the maintenance debris from tools that were originally produced elsewhere; continuous short-distance movement (within and between cultural periods) of recyclable objects in the context of tool and material reuse; and in-place production, use, and discard of tools.

Despite vagueness in the ethnographic record, it is commonly assumed by most archaeologists that lithic recycling increases when toolstone reserves dwindle (e.g., Close 1996:549; Hayden et al. 1996:33). In other words, a key resource is not expected to be conserved until it is in short supply. Although this economic principle may account for many archaeological examples of lithic recycling, it is necessary to compare lithic recycling patterns from diverse archaeological contexts to determine the potential limitations and alternative causes of lithic conservation.

Comparison of Archaeological Examples of Lithic Recycling

An examination of several prehistoric cases from North America is offered to provide a richer context for defining the primary behavioral causes and archaeological effects of lithic recycling (Figure 12-2). These cases include evidence for scavenging and reuse of stone tools by mid-Holocene foragers in central Tennessee; measurement of the tempo and mode of recycling from lithic debris found at prehistoric obsidian quarries and occupational sites in the deserts of southern Nevada; and investigation of the significance of lithic recycling as an organizational strategy for facilitating high mobility in various Paleoindian technologies. These diverse studies also provide various methodological strategies for recognizing and recording lithic recycling patterns.

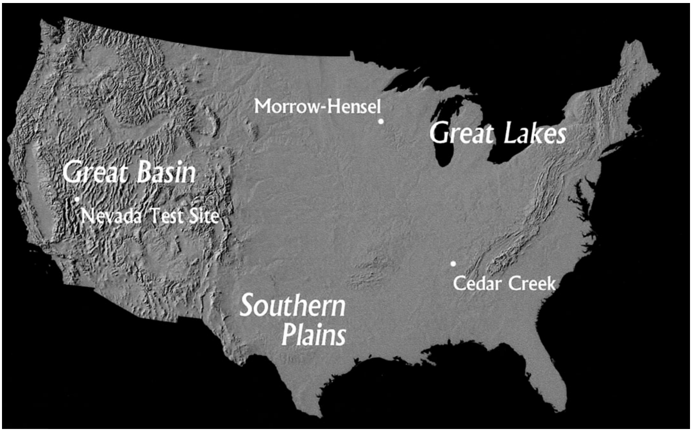

Figure 12-2 Shaded relief map of the USA showing primary geographic regions and site locations discussed in this paper (base map from Thelin and Pike 1991).

These cases show that several interrelated and sometimes contradictory conditions can result in increased recycling including: 1) opportunism; 2) mobility constraints (the extremes of either high or low mobility can limit time and energy available for direct procurement); 3) restricted access to raw material sources; and 4) the organization of technology (recycling can be a regular component of curated or expedient strategies). Because of this demonstrated ambiguity and the equifinality of behavioral evidence and explanatory inference, it is necessary to determine the overall context of recycling behavior to better understand its potential causes.

Opportunistic Secondary Recycling

An archaeological awareness of artifact recycling usually occurs when older artifacts are found in what are determined to be later deposits. Figure 12-3 illustrates three projectile points diagnostic of the Kirk Corner-Notched Cluster excavated from deeply buried alluvial floodplain deposits at the Cedar Creek Site (40Mu432) on the Duck River in Tennessee. Kirk Cluster artifacts are securely dated between 10,000 and 9,000 radiocarbon years BP at several stratified sites throughout the southeastern US (Chapman 1985). However, these Early Holocene diagnostics were co-mingled within an archaeological horizon that also contained several stemmed projectile points classified as members of the Sykes-White Springs Cluster known to date 3,000 radiocarbon years younger (Amick 1985). Initially, this unexpected finding forced questions about security of the radiocarbon age for these two temporal markers as well as possible mixing within the archaeological deposits.

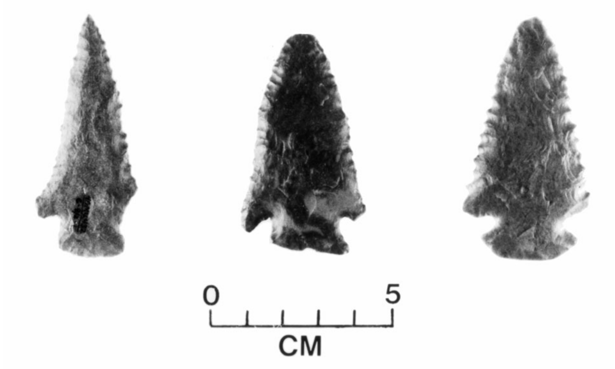

Figure 12-3 Secondary recycled Kirk Corner-Notched projectile points found in much younger mid-Holocene archaeological deposits at Cedar Creek, Tennessee. Note the removal of surface patina by subsequent margin resharpening.

Extensive geomorphological investigations at this site and the surrounding region indicated that the overbank sedimentation was relatively gentle with several periods of surface stability and soil formation during the Holocene (Brakenridge

1984). However, there was no evidence to suggest that regional floodplain surfaces could have lasted for more than several centuries during the Mid-Holocene. Furthermore, alluvial deposits of Early Holocene age that could have contained Kirk occupations were not known in the region. All the dated alluvial sequences in the region begin around 7,000 radiocarbon years BP, although it is possible that earlier deposits are deeper than backhoe testing was capable of exposing (limited to about 250 cm). Comprehensive artifact refitting at a nearby mid-Holocene site within the same alluvial regime has shown that archaeological materials can be vertically dispersed about 30 cm through post-depositional movement but that mixing of discrete occupational surfaces was probably limited to several centuries at most (Hofman 1992).

Radiocarbon dating of charred hickory nuts from the Cedar Creek Site produced an age of 6,375±215 BP (GX-8822), consistent with expectations for the Sykes-White Springs artifacts. How could these Kirk artifacts become incorporated into an archaeological deposit that was three thousand years younger? Fortunately, our initial confusion was easily resolved because these Kirk points had been patinated then retrieved and resharpened by later artifact scavengers revealing younger marginal flaking over the patinated flake scars (often termed "repatination" or what McDonald [1991] called "double patina"). Apparently, mid-Holocene individuals must have collected these finished Kirk tools from exposed and weathered archaeological deposits and reused them.

Using evidence of double patination, flake and flake scar morphology, and flake refitting, Sassaman and Brooks (1990; also see Sassaman 1994:104) have proposed considerable amounts of lithic recycling associated with Early Woodland peoples (c. 2,500-3,000 BP) scavenging lithic debris from Archaic sites (c. 4,500-9,500 BP) in South Carolina. Relatively heavy vegetation covers most ground surfaces of the southeastern US, which probably limited most prehistoric scavenging opportunities. Secondary lithic recycling does not appear to be widespread or easily recognized in densely vegetated, depositional environments, like the eastern US, but it seems to have been encouraged by periods of localized surface erosion and reductions in the residential mobility of prehistoric peoples living in areas with poor lithic resources (Amick 1987; Amick and Carr 1996; Sassaman and Brooks 1990). Procurement of these finished tools probably represented a substantial savings of energy in procurement and manufacture, although this limited evidence suggests that secondary recycling was largely opportunistic in these cases.

Systematic Secondary Recycling

Many stable and eroded surfaces in the Great Basin Desert have provided increasing archaeological evidence that implies secondary recycling was a routine component of lithic procurement strategies during the Late Holocene. Kelly (1988a:52-54, 1988b:726-727, 2001) has argued these increases in lithic recycling are related to reduced mobility and more residential use of valley floor locations in the western Great Basin during the Late Holocene (c. 3,000 BP). In comparison, Lyneis (1982:177) has suggested that Late Holocene occupations in the southern Great Basin are characterized by greater mobility and increased utilization of upland resources.

Evaluation of these contrasting explanations is possible using substantial lithic data accumulated from two decades of archaeological compliance at the Nevada Test Site (NTS) in the southern Great Basin. NTS lithic resources are varied and include obsidian cobbles and pebbles concentrated in the desert pavements and alluvial terraces surrounding Fortymile Wash, a large but intermittent drainage. There is a strong correspondence between the distribution of archaeological materials and obsidian sources on the NTS. This association suggests that a significant amount of prehistoric stone procurement activities were focused at these lowland obsidian sources.

	Raw Material Type		
Point Age	**Obsidian**	**Non-obsidian**	**Total**
Early Holocene	O=152, E=109	O=31, E=74	183
Late Holocene	O=218, E=261	O=219, E=176	437
Total	370	250	620
Chi-square = 58.992, *df* = 1, *p* < .00001			

Table 12-1 Raw material type frequencies and chi-square test of raw material association for a large sample of typable projectile points from the NTS in southern Nevada. Early Holocene types include Clovis, Great Basin Stemmed, Pinto, and Humboldt. Late Holocene types include Large Side-Notched, Gatecliff, Elko, Eastgate, Rose Spring, and Desert Series. Observed values (O) and expected values (E) are listed.

Although alternative materials for the production of stone tools occur in the area, local obsidian sources were often preferred and served as important locations in the context of general prehistoric land use. The reuse of these obsidian scatters over several thousands of years resulted in a complex landscape of debris from overlapping occupations and activities. This palimpsest pattern associated with lithic recycling is not uncommon in North American desert regions (e.g., Bettinger 1989: 331-333; Camilli 1983, 1988a; Camilli and Ebert 1992; Kelly 1988a, 1988b, 2001; Wandsnider 1989) and appears to be particularly intense at the NTS obsidian source areas. Obsidian procurement and reduction produced many redundant byproducts that are ubiquitous throughout these surficial workshop areas.

In the southern Great Basin where stratified lithic components are exceptionally rare, projectile points provide a limited but reliable method of assessing diachronic change in raw material use. Table 12-1 presents raw material frequencies for a sample of projectile points from the NTS classified according to prevailing chronological typologies of the Great Basin (Hester 1973; Holmer 1986; Jennings 1986; Thomas 1981). Although 83% (n=152) of these Early Holocene points are made of obsidian, only 50% (n=218) of the much more numerous Late Holocene points are obsidian. Because most non-obsidian lithic sources are found in upland locations at the NTS, these results would seem to support the proposition that Late Holocene groups in the southern Great Basin focused on upland resources and were more mobile. However, poor regional understanding about prehistoric settlement patterns and the distribution of non-obsidian resources makes it difficult to evaluate this suggestion.

	Obsidian Source		
Point Age	**Local**	**Non-local**	**Total**
Early Holocene	O=41, E=45	O=15, E=11	56
Late Holocene	O=42, E=38	O=5, E=9	47
Total	83	20	103
Chi-square = 4.258, *df* = 1, *p* < .039062			

Table 12-2 Obsidian sourcing results on a sample of projectile points from the NTS in southern Nevada. Nonlocal sources are defined as those greater than 200 km away including: Kane Spring, Brown's Bench, Montezuma Range, Coso Volcanic Field, and Fish Springs. Observed values (O) and expected values (E) are listed.

Limited consideration of obsidian distributions and prehistoric patterns of procurement can provide an alternative means of addressing this issue. Primary obsidian source locations have been identified from regional archaeological surveys and characterized by trace element studies. X-ray fluorescence sourcing of a sample of 103 obsidian points from the NTS demonstrates the degree to which prehistoric inhabitants were relying on local obsidian deposits. Table 12-2 shows that high frequencies of local obsidian use distinguish both the Early Holocene (73%, n=41) and Late Holocene (89%, n=42) tools. However, the proportion of non-local obsidian use is significantly higher during the Early Holocene suggesting a greater scale of mobility.

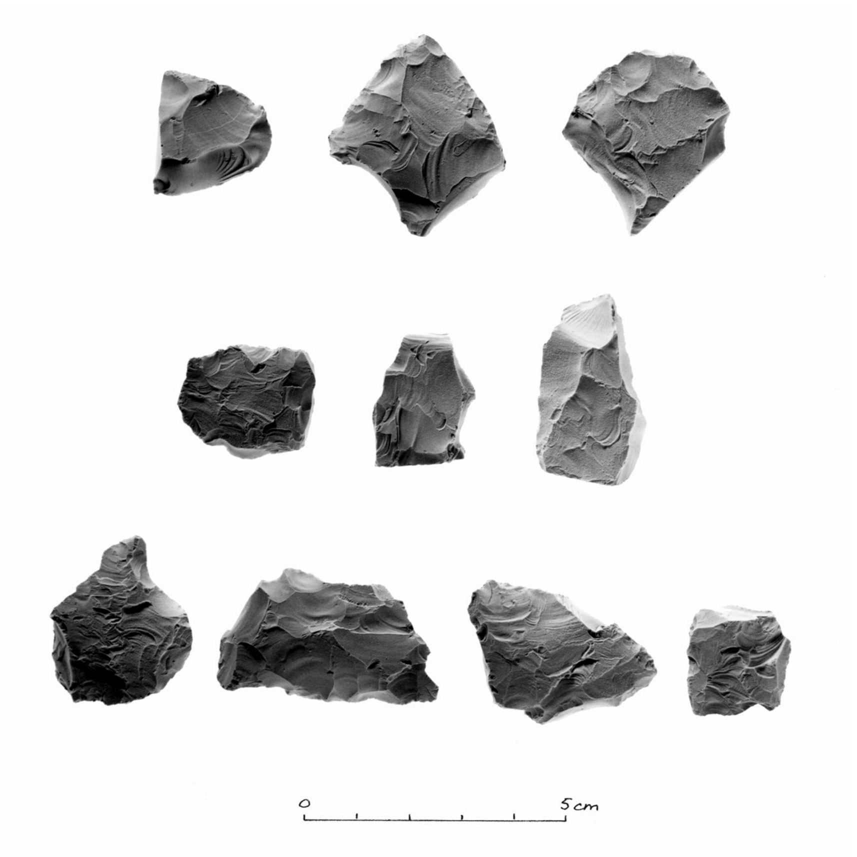

Figure 12-4 Obsidian biface fragments from Dead Horse Flat (26Ny4203) that have been fractured radially (top row) and bipolarly (bottom two rows) during lithic recycling. Smoked with ammonium chloride for photo enhancement.

Despite a general preference for obsidian in this region, it is possible that Late Holocene inhabitants at the NTS showed less frequent use of local obsidian because these resources had been degraded during the Early Holocene. In fact, obsidian source locations associated with the desert pavements along Fortymile Wash contain the densest concentrations of Early Holocene artifacts. Many land surfaces in the southern Great Basin are distinguished by long-term stability for several tens of millennia (Davis 1983), which has three important impacts on the character of the archaeological record. First, these stable surfaces typically produce a palimpsest record of multiple occupations. Second, shallow lithic resources are subject to depletion by prehistoric exploitation because geomorphic processes have not renewed these deposits. Third, the discarded and abandoned lithic debris of previous occupations provides a degraded but accessible source of tool stone for later inhabitants (Ebert 1986:203, 210).

Local preference for obsidian recycling is documented at Dead Horse Flat (Figure 12-4) where 22% (n=45) of the obsidian bifaces showed evidence of recycling through radial fracture and bipolar techniques (Amick 1992). Radial fracture is an effective technique for producing wedge-shaped burin tools (Frison and Bradley 1980:97-99; Root et al. 1999). Bipolar reduction was probably oriented toward the production of usable flakes. Dead Horse Flat is several kilometers from any known obsidian source and this distance may have encouraged recycling of artifacts made from this preferred raw material.

Size Grade	**Unflaked Obsidian**	**Flaked Obsidian**
2.540 cm (1”)	26 (.01)	151 (.03)
1.270 cm (.5”)	466 (.26)	2972 (.58)
0.635 cm (.25”)	1273 (.72)	2018 (.39)
Total	1765	5141
Chi-square = 569.26, *df* = 2, *p* < .00001		

Table 12-3 Size comparison of unmodified obsidian clasts versus archaeological obsidian debitage surface collected at the Buckboard Mesa Site (26Ny4892). Laboratory size grading holds these samples constant by including only pieces larger than 0.635 cm wire mesh. Column percent indicated in parentheses.

Archaeological studies at two large lithic procurement sites on the NTS have provided notable evidence of the depletion of obsidian and chalcedony, two of the locally preferred tool stones. At the Midway Valley chalcedony quarry (26Ny4759), lithic resource depletion is indicated by evidence from lithic refitting, site spatial analysis, and the scarcity of unmodified tool stone (Buck et al. 1994). This surface site served primarily as a procurement station for large chalcedony blocks, but 24 clusters of obsidian flaking debris were also collected from the reduction of small, rounded nodules. Although all unmodified tool stone was collected from the site during archaeological recovery, only two small nodules of obsidian were recorded. This site illustrates severe prehistoric exploitation of a very dispersed scatter of small obsidian nodules. The largest chalcedony also appears to have been depleted because the unmodified chalcedony blocks remaining at the site were usually smaller than the discarded cores.

At Buckboard Mesa (26Ny4892), there was a denser surface scatter of small, subrounded obsidian nodules with several lithic workshops primarily associated with initial through intermediate stages of core reduction (Amick et al. 1991).

Contrary to common archaeological expectations, the discarded waste flakes found at the Buckboard Mesa quarry were generally larger than the unmodified obsidian still remaining on the surface. Table 12-3 compares a size-graded sample of unmodified obsidian clasts with the waste flakes from the site. These data show that 61% of the obsidian waste flakes are larger than 1.27 cm mesh, but only 27% of the unexploited obsidian nodules are that large. This size difference is statistically significant with the remaining obsidian nodules substantially underrepresented in the large size grades. This contradictory pattern suggests that obsidian resources were severely exhausted at Buckboard Mesa.

It has been shown that obsidian exploitation was heaviest at the NTS during the Early Holocene, consequently, these surficial obsidian resources may have been substantially degraded for Late Holocene populations. At Buckboard Mesa, there is additional evidence in the form of recycling older artifacts to support this suggestion. These artifacts commonly contain deep but broad bulbar scars and many flakes possess a large undulation, which often nearly plunges through the core prior to fracture termination. Although Kelly (1988a, 1988b, 2001) recommends bipolar reduction as a measure of lithic recycling, technological analysis of the Buckboard Mesa lithic debris failed to reveal the bipolar technique. Replicative experiments showed that direct freehand, hard hammer percussion rather than bipolar percussion was used to split these small nodules and cores (Amick 1990). This reduction strategy represents an effective means of exploiting small obsidian cores because it minimizes waste and maximizes the production of large flake blanks.

Despite the absence of bipolar flaking, 25 of the 826 obsidian cores and tools examined from Buckboard Mesa exhibited double patinas indicating secondary recycling. Secondary recycling of obsidian artifacts at Buckboard Mesa reflected two primary goals -- flake production from older cores (Figure 12-5) and small biface production (Figure 12-6). Following standard conventions of artifact illustration, the original cortex is represented by stippling and older weathered flake scars are indicated by dashed ripple lines.

Chronological patterning among these recycled artifacts was investigated through obsidian hydration. The potential of obsidian hydration analysis to evaluate artifact recycling has been recognized for some time (Michels 1969; Michels and

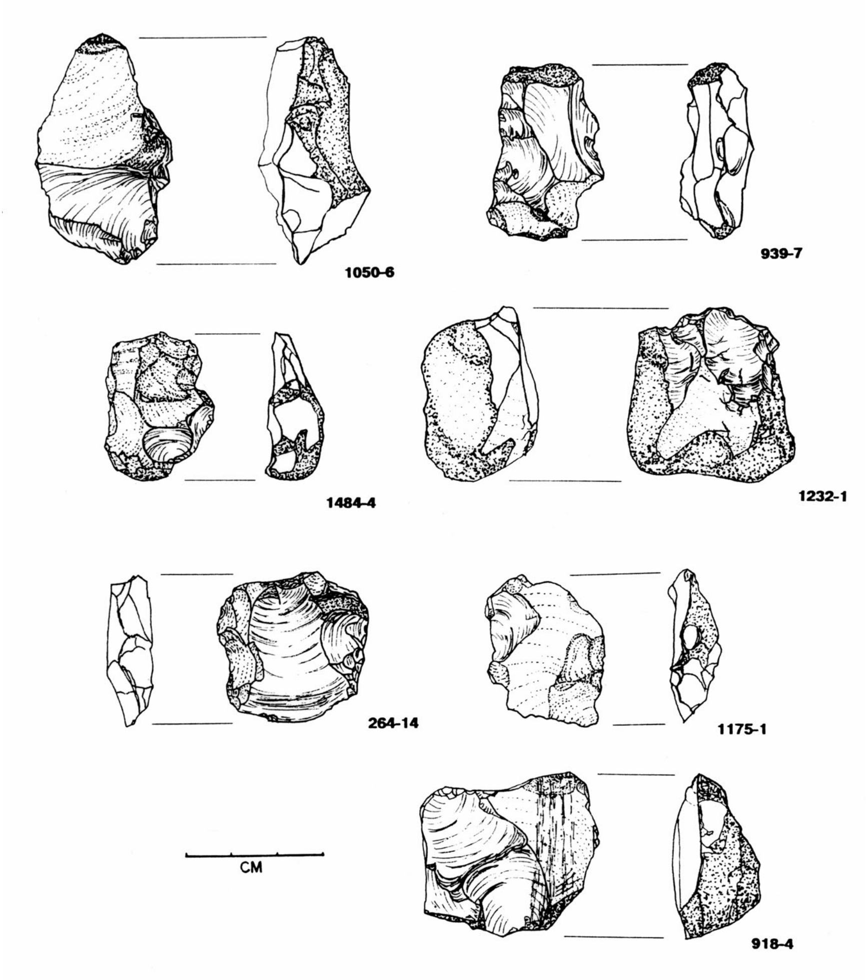

Figure 12-5 Recycled artifacts from Buckboard Mesa (26Ny4892) illustrating later flake production on older discarded cores. Note characteristic scar resulting from splitting technique using direct, freehand hard hammer percussion on Reference #264-14. Drawn by Sue Ann Monteleone.

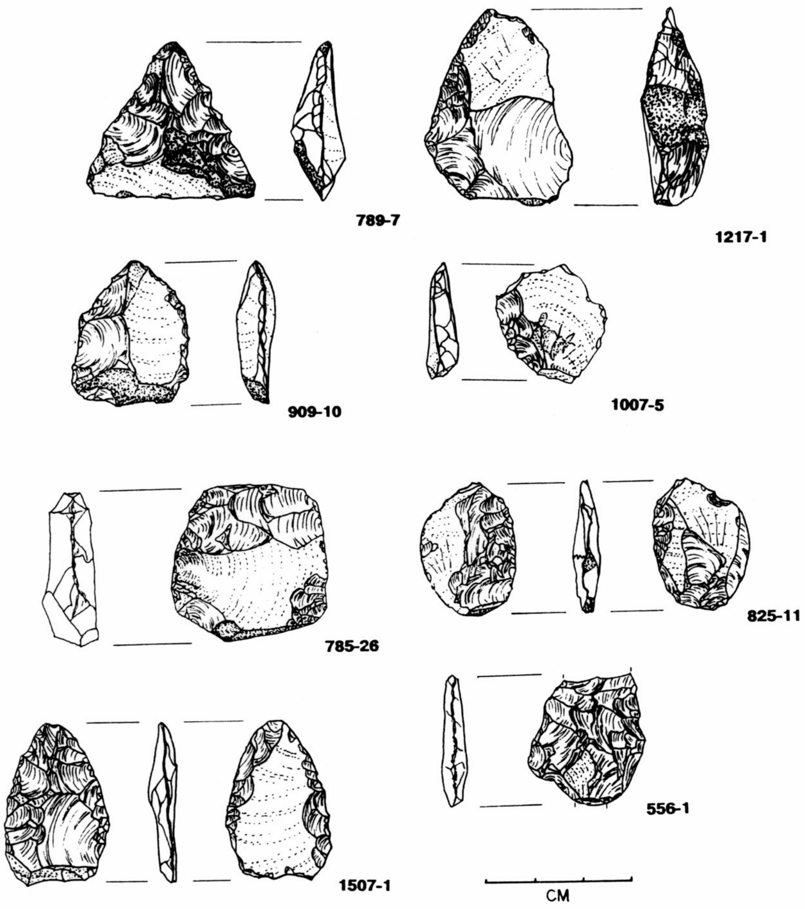

Figure 12-6 Recycled artifacts from Buckboard Mesa (26Ny4892) illustrating older artifacts for small biface production. Reference #556-1 is a broken Late Holocene (Gatecliff) projectile point manufactured on an older weathered artifact. Drawn by Sue Ann Monteleone.

Tsong 1980) and has been used to suggest patterns of artifact recycling at various locations in western North America (Batcho 1984; Earls et al. 1989; Jackson 1985; Kaufmann 1984; Raymond 1985). These efforts have usually focused on the demonstration of chronological anomalies (deposits containing artifacts with a discordant mixture of hydration band thicknesses) or the measurement of two or more hydration bands of different thickness on a single artifact. For example, Earls et al. (1985) found that many projectile point tips tended to produce younger dates than their corresponding stems. That aberration was suggested to result from secondary recycling and tip resharpening of these projectile points although technological analysis was not pursued to support that proposal.

In this study, obsidian hydration analysis is integrated within the framework of technological analysis (Jackson 1984; Rondeau 1990) by measuring hydration bands on the repatinated flake scars of recycled artifacts. This strategy minimizes potential ambiguities caused by measurement errors and differential weathering. Empirical modeling of hydration band measurements on several hundred obsidian projectile points from the NTS has suggested that an hydration thickness development rate of approximately one micron per millennium (Hartwell et al. 1996). Although geochemical content and environmental history can cause variation in hydration rates, this large sample shows NTS hydration measurements are at least capable of distinguishing Early and Late Holocene artifacts. A systematic sample of 60 artifacts from Buckboard Mesa produced hydration band readings between 7.7 and 1.2 microns with an average of 2.5 microns. These data suggest obsidian exploitation begins at the site during the Early Holocene and intensifies in the Late Holocene.

Obsidian hydration measurements on the repatinated artifacts also provided evidence of secondary recycling. Hydration bands were measured on sequential and adjacent flake scars with double patinas when found on a common face (to eliminate the known effects of differential hydration rates occurring on opposing surfaces). Comparison of these paired readings shows a range of 0.1 to 3.9 microns (approximately 100 to 3,900 years) separating each recycling event (Table 12-4). Two artifacts (918-4 and 939-7) fail to show any difference in hydration band thickness, which may reflect measurement error or recycling event separations of less than one hundred years. The identification of recycled artifacts from double patinas probably underestimates the actual amount of recycling that occurred. Many scavenging and successful recycling attempts probably removed items from the site. Furthermore, recycled artifacts that fail to develop double patinas (particularly those with minimal chronological separation) are probably under-recognized archaeologically.

Despite these limitations, this analysis demonstrates that technological preferences for obsidian probably caused Late Holocene groups at the NTS to practice systematic secondary recycling from quarry localities abandoned by Early Holocene groups. Refitting of a broken Great Basin Stemmed point (Early Holocene) at Midway Valley (26Ny4759) illustrates this practice explicitly (Buck et al. 1994). Two pieces of this artifact were found a few meters apart. These pieces refit along an unweathered broken fracture but the original surface of the point is heavily weathered (Figure 12-7). An unweathered scar from platform collapse is present on the stem, indicating that the unweathered fracture is most likely a bending failure caused during the recycling event. This example may represent an unsuccessful percussion attempt to manufacture a small flake blank suitable for the production of a Late Holocene arrowhead from this Early Holocene artifact.

Artifact Reference Number	**Weathered Older Flaking**	**Overlapping Younger Flaking**	**Hydration Band Difference**
264-14	7.7	3.8	3.9
1484-1	4.0	3.2	0.8
1197-1	3.1	3.0	0.1
1232-1	3.1	2.8	0.3
1175-1	5.3	2.7	2.6
1217-1	3.1	2.7	0.4
747-6	3.0	2.4	0.6
918-4	2.4	2.4	0.0
939-7	2.3	2.3	0.0
909-10	2.7	2.2	0.5
785-26	2.3	1.8	0.4
1050-6	2.4	1.8	0.6
789-7	4.5	1.7	2.8
825-11	2.1	1.6	0.5
1507-1	4.5	1.3	3.2
825-11	2.1	1.3	0.8
Average	3.4	2.3	1.1

Table 12-4 Hydration band measurements (in microns) for visibly reworked obsidian artifacts from Buckboard Mesa (26Ny4892). Specimens are ranked by decreasing hydration band thickness (age) of the most recently flaked surface.

Comparison of hydration band measurements from the recycled artifacts with local projectile point hydration chronology suggests obsidian scavenging and reworking is frequently associated with the Late Holocene makers of Rose Spring and Desert Series arrow points. Once bow and arrow technology was adopted, the reduction in projectile point size requirements may have encouraged exploitation of previously discarded debris and increased the potential number of suitable lithic sources. A similar pattern of artifact scavenging and lithic recycling for arrowhead manufacture has been suggested during the Late Holocene in central California (Skinner 1988). In general, the reduction of lithic procurement costs through artifact recycling during the Late Holocene in the Great Basin seems to be linked to complex causes including degraded lithic resources, decreased residential mobility, and adoption of bow and arrow technology.

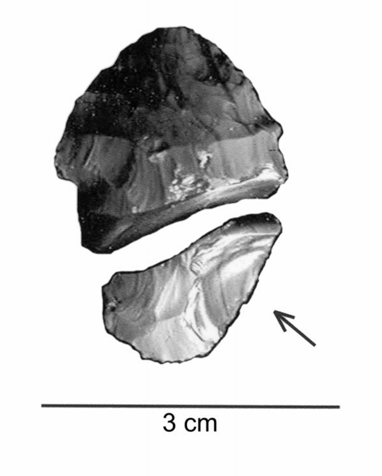

Figure 12-7 Scavenged and recycled Great Basin Stemmed (Early Holocene) projectile point (Reference #1428) from Midway Valley (26Ny4759). Stem exhibits recent flake removed during the recycling effort. Percussion removal of this flake probably caused the artifact to simultaneously break transversely because of bending failure. Proximal and distal fragments can be refit along the surface of this unweathered break.

Systematic Lateral Recycling

Large bifacial cores provide the foundation for many Paleoindian technologies in North America. These bifaces served as tools as well as cores and probably supported high levels of residential mobility because they provided an effective means of reducing transport costs while maximizing the number of usable flake blanks (Kelly 1988b). For example, large bifacial cores and the resulting bifacial flake blanks are commonly associated with Folsom assemblages from the Southern Plains (Amick 1999b). But various other strategies for conserving tool stone are incorporated within Folsom lithic technology including the systematic lateral recycling of exhausted tools (Amick 1996, 1999b). The use of radial fracture (a specific form of bipolar reduction) to produce small useable wedge-shaped tools appears to be an unusually common means of tool recycling in Folsom technology (Frison and Bradley 1980:97-99). Microwear studies of such radial wedges at the

Knife River Flint quarries by Root et al. (1999) indicate at least 20% show contact wear on tips and edges.

On the other hand, there has been considerable debate about the interpretation of bipolar recycling in Clovis assemblages. Some argue that certain bipolar artifacts, sometimes called pièces esquillées, are tools used for slotting and wedging in bone and wood (Lothrop and Gramly 1982; MacDonald 1968). Recently, Bradley and Frison (1996:62-64) identified two pièces esquillées at Mill Iron, a Goshen Complex bison kill in southeastern Montana that is contemporaneous with late Clovis occupations on the High Plains. One is described as a tool with a heavily battered poll that was split during use sustaining interior damage, which they believe resulted because one piece was rubbing against the other while tightly wedged in bone or wood. The second tool has a sharp point formed on one end, while repeated blows to the opposing end produced several flakes (recovered and refitted) during use. The bone bed context for these items is used to support interpretation as tools, presumably during the butchery and processing of the bison carcasses. However, use-wear examinations were not conducted on these purported tools and contemporary replication work suggests that similar patterns of damage can be produced on bipolar cores (Callahan 1987; Flenniken 1981).

Some argue such items in Paleoindian assemblages are simply bipolar cores used as an economizing measure during states of toolkit exhaustion resulting from high rates of residential mobility (Goodyear 1993; Shott 1989, 1999). In his examination of eight eastern Clovis assemblages, Goodyear (1993) proposes that pièces esquillées are best interpreted as bipolar cores because their frequency is inversely related to the frequency of “potential cores.” He argues the lack of “potential cores” indicates depletion of lithic supplies resulting in increased frequencies of recycling through bipolar reduction. Distance from the lithic source can provide an effective alternative for measuring the potential depletion of lithic supplies. Comparison of pièces esquillée frequencies (from original published reports) against distance to primary lithic source from a sample of 35 eastern Clovis assemblages fails to show any clear patterning regarding distances from lithic sources (after Meltzer 1989:Table 2.2). Low sample sizes and variable recovery techniques limit effective comparisons but this generally poor relationship is well illustrated by examining the three eastern Clovis sites with the highest frequencies of pièces esquillées. There are 70+ at Shoop (Cox 1986:125), located 320 km from its primary lithic source; there are 1,046 at Debert (MacDonald 1968:85), located 100 km from its primary lithic source; and there are 567 at Vail (Lothrop and Gramly 1982), located only 25 km from its primary lithic source.

These substantial cases seem to contradict Goodyear’s “toolkit entropy” hypothesis where demand on available raw material should increase with distance from source, resulting in the greater frequency of tool stone economizing measures like bipolar core reduction. In fact, significant numbers of pièces esquillées have been recovered from a wide variety of Paleoindian settlements including lithic quarries and quarry-related sites close to raw material sources (e.g., Arc, n=15; Fisher, n=3; Plenge, n=8; and West Athens Hill, n=5). It may be noteworthy that the majority of Paleoindian assemblages containing pièces esquillées are associated with Gainey Phase sites found around the Great Lakes region and into the Northeast. Gainey is believed to represent the earliest (Clovis) fluted point complex in the Great Lakes region, and based on settlement patterns and faunal remains, is thought to be economically focused on caribou hunting (Jackson 1997; Simons 1997; Stork and Speiss 1994). Gainey assemblages are often dominated by exotic raw material from sources, routinely 100-300 km distant, which suggests an impressive scale of residential mobility with associated demands for "toolkit entropy."

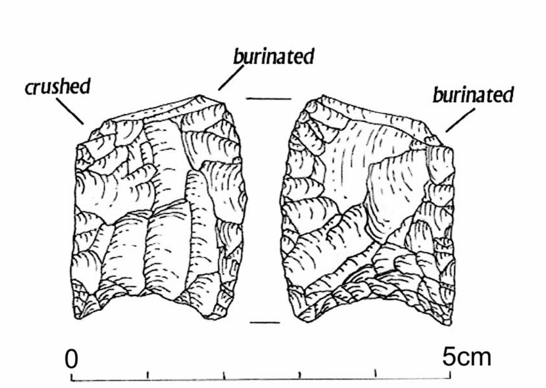

Figure 12-8 Exhausted Clovis (Gainey) projectile point (MH-9) from the Morrow-Hensel site (far western Wisconsin) that shows laterally recycling with transverse burin blows (bipolar) on lateral margins at the bending fracture on distal end. Drawn by Sarah Moore.

Currently, the function of pièces esquillées remains unresolved because of equifinality at the artifact level; wedges and wedge-shaped bipolar cores often look-alike because of similar production and damage patterns (Shott 1999). In fact, these competing functional interpretations need not be mutually exclusive. For example, Morrow-Hensel in far western Wisconsin is a large Gainey Phase lithic assemblage dominated by silicified sandstone from the Hixton source (86%, of the 259 cores and tools; 97% of the 12,422 waste flakes) from 110 km away (Amick et al. 1999). Many of the discarded projectile points at Morrow-Hensel are larger than the manufacturing rejects found at the site suggesting that lithic supplies were dwindling. This assemblage also exhibits bipolar recycling of broken and exhausted tools (Figures 12-8 and 12-9) as well as the bipolar reduction of locally available small chert pebbles for flake blanks (Figure 12-9). Evidence of bipolar reduction presents considerable ambiguity in this case where it seems to represent the "toolkit entropy" of exhausted tools, production of pièces esquillées as wedges, and an effective means of reducing the locally available small chert pebbles. To complicate matters, the lithic assemblage from the Gainey type site in central Michigan is dominated by Upper Mercer cherts from sources 380 km distant, yet this assemblage shows little or no signs of lithic recycling or tool stone conservation (Simons et al. 1984).

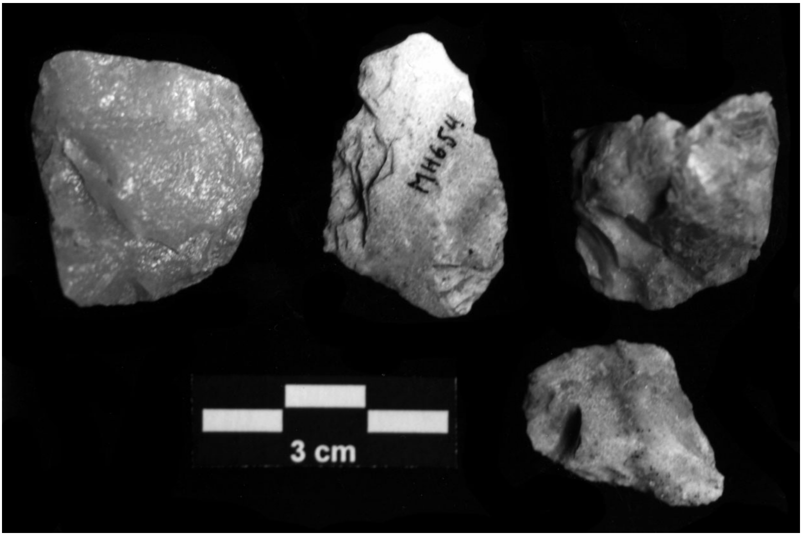

Figure 12-9 Variety of bipolar artifacts from Morrow-Hensel. Top, left to right: Hixton pièces esquillée, Hixton bipolar core made from recycled biface, bipolar core on Prairie du Chien chert pebble. Bottom, right: bipolar flake from Prairie du Chien chert pebble.

In many cases, the high mobility of Early Paleoindian groups placed stress on the amount of available raw material within the toolkit, requiring groups to employ economizing strategies of lithic manufacture like the bipolar reduction of waste and exhausted tools. Conversely, many cases are documented where tool stone availability is not a constraint but bipolar splintered pieces occur (sometimes abundantly) in the toolkit discards. These contradictions may suggest that pièces esquillées served as wedges for splitting bone and wood in some Paleoindian assemblages. The particular association of these artifacts with Gainey occupations of the Great Lakes and Northeast implies a general functional association caribou-hunting lifeways and high mobility.

Conclusions

Several general conclusions can be drawn from this review of lithic recycling. Scavenging and reworking of discarded tools and debris as cores for tool and blank production is very efficient economically although the resulting products may have limited utility because of their small sizes. Generally, there seems to be an inverse relationship between the access to lithic resources and the amount of lithic recycling that occurs. However, there seem to be multiple and contradictory factors that can limit access to lithic resources. Extraordinarily high levels of residential mobility are argued to limit access to lithic resources among the various Paleoindian groups who practiced systematic lateral recycling. Conversely, low levels of residential mobility are argued to limit access to tool stone resources and increase lithic recycling among many Late Holocene groups in the Great Basin (and elsewhere) who settle into lithic-poor locations. Because of this contradiction, it is clear that the identification of lithic recycling alone is not capable of supporting inferences about prehistoric group mobility.

Although these unresolved contradictions exist, residential mobility is generally believed to strongly influence lithic recycling behavior in pre-industrial societies. Alternative archaeological explanations for recycling often emphasize its economic necessity during periods of scarcity, similar to the "waste not, want not" approach of social and historical explanations for recycling behavior in modern American industrial society (e.g., Strasser 1999). However, these assumptions about the behavioral role of recycling remain inadequately supported in prehistoric lithic technologies. Deliberate ethnohistorical and ethnoarchaeological research is sorely needed to investigate the situational and organizational context of recycling behavior in small scale pre-industrial societies and stone age economies (e.g., Kuznar 1995:116).

Additional problems are presented by lithic recycling behavior because of the many different forms it can take. Many archaeologists rely on bipolar cores and debris as the primary means of identifying lithic recycling despite the analytical difficulty in distinguishing the lithic debris from bipolar reduction (Jeske and Lurie 1993). Furthermore, bipolar technology is frequently associated with the reduction of small pebbles and cores and may not necessarily reflect the lithic recycling of discarded waste. At the Morrow-Hensel site, Clovis peoples apparently used bipolar reduction to exploit local chert pebbles as well as for recycling their exhausted tools made of transported tool stone and the manufacture of wedges (typically classified as pièces esquillées). Technological analysis of obsidian exploitation at the NTS shows that direct freehand, hard hammer percussion rather than bipolar percussion was the primary method used in lithic recycling. Opportunistic scavenging and resharpening of projectile points from exposed archaeological sites seems to have been the primary kind of lithic recycling behavior practiced at the Cedar Creek site.

Evidence of scavenging at the NTS obsidian sources is also significant because it contradicts Schiffer's (1987:27-28) suggestion that recycling should be unexpected at quarries: "Scarcely any reuse can be discerned in a lithic quarry-workshop; as a result, the archaeological record contains the bountiful traces of virtually every knapping act that took place." The analysis presented here demonstrates that assumptions about the lack of recycling at lithic quarry-workshop locations are unreliable. In fact, Early Holocene overexploitation of these obsidian resources may have accelerated Late Holocene scavenging behavior at these abandoned quarries.

It is important that archaeologists seek out and attempt to define and explain the kind of observational and interpretive ambiguity demonstrated by lithic recycling. But unless double patina or other unambiguous evidence of sequential flaking (such as differences in obsidian hydration band thicknesses) can be identified, it is often difficult to distinguish lithic recycling with confidence. Consequently, recycled artifacts that do not exhibit these characteristics can be easily overlooked. Because of these analytical obstacles, it likely that prehistoric lithic recycling was much more frequent than most archaeologists recognize.

Identification of lithic recycling is important for rigorous interpretation of archaeological chronology and the formation processes affecting sites and assemblages. In addition, thoughtful recognition and understanding of lithic recycling is important for accurate reconstructions of this prehistoric behavior, which contributes to many current explanatory models of mobility and the organization of technology. Finally, it is important to develop skills and reliable methods to identify material recycling because processual approaches to lithic analysis require a focus on understanding the dynamic life histories of artifacts and assemblages.

Acknowledgments

Thanks to the patient encouragement of Shannon McPherron and John Lindly who invited this paper and supported my prolonged efforts to finish the manuscript. During the past several years, I am very grateful for discussions and comments on these ideas from Peter Ainsworth, Bob Kelly, John Fagan, Ted Hartwell, Jack Hofman, Eric Ingbar, Steve Kuhn, Dave Rhode, Mike Rondeau, Ken Sassaman and Betsy Skinner - each of whom forced me to clarify my thinking on this thorny topic. Many of the archaeological materials reported in this study resulted from data recovery projects supported by the Tennessee Valley Authority and the US Department of Energy. Walter Klippel at the University of Tennessee served as principal investigator for the TVA contracts while Lonnie Pippin and Dave Rhode at the Desert Research Institute (DRI) served as principal investigators on the DOE contracts. Richard Hughes conducted the XRF analysis and source determinations of the obsidian artifacts. Thanks to Sarah Moore and Sue Ann Monteleone for the artifact drawings. Bill Germino produced the photograph of the Dead Horse Flat bifaces. In the end, I remain responsible for these ramblings regardless of all the fine advice and assistance I have had.

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