REJUVENATION SIGNATURE ANALYSIS: MEASURING REJUVENATION IN EASTERN GREAT BASIN ARCHAIC DART POINT ASSEMBLAGES

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ABSTRACT

Rejuvenation Signature Analysis: Measuring Rejuvenation in Eastern Great Basin Archaic Dart Point Assemblages

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This thesis explores rejuvenation of eastern Great Basin Archaic period atlatl dart points within the contexts of artifact curation, variability, use-life, and type. By analysis of past rejuvenation experiments, a contemporary rejuvenation experiment, and dart point assemblages from Archaic period strata of four major eastern Great Basin caves, a system that quantifies rejuvenation signatures on atlatl dart points was developed. This system is proposed as Rejuvenation Signature Analysis (RSA). It is advanced that RSA can quantify the extent and kinds of rejuvenation that occur in a population of atlatl projectile points. If levels of rejuvenation can be quantified in atlatl dart point populations, then conclusions can be advanced concerning curation and the integrity of morphologically derived types from within these populations. Using morphology alone to determine projectile point types as temporal markers should be reconsidered. Using RSA analysis in practical applications to quantify rejuvenation in other dart point assemblages from both inside and outside the eastern Great Basin is also discussed.

ACKNOWLEGEMENTS

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The University of Utah opened its anthropology collections and labs to my research. Without access to these collections, this study would not have been possible. The Arkansas Game and Fish Commission allowed me the necessary permits for the carcass experiment.

I would finally like to thank my mother, Betty Spencer, who sacrificed much time, treasure and opportunities throughout her life for me. She expected me to complete this project.

I dedicate this thesis to my wife, Leesa, who supported me in all ways possible.

I take full responsibility for the contents of this paper. Any errors or bias in this paper are entirely my own.

ACS

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CHAPTER 1

DEFINITION OF THE RESEARCH PROBLEM AND GOALS

INTRODUCTION: RESEARCH PROBLEM

The cause of formal artifact variability in the archaeological record, specifically in stone tools, remains unknown. This is not to say that the archaeological record is silent or that the issue has been ignored. Quite the opposite is true. Starting almost 40 years ago, this issue was hotly debated by archaeological communities on both sides of the Atlantic (Binford and Binford 1966, 1969; Freeman 1966; Bordes and de Sonneville-Bordes 1970; Mellars 1970; Renfrew 1970; Sackett 1966, 1986; Kuhn 1990, 1991, 1992, 1994, 1995; Dibble 1984, 1987, 1991a, 1991b, 1995a, 1995b; Holdaway et al. 1996; Dibble and McPherron 2006; and many others). Looking back to the 1970's, it was widely known as the "Bordes-Binford" debate (Rolland and Dibble 1990:480). It would be simplistic to reduce the argument to stylists vs. the functionalists. The debate centered at the very core of how archaeologists begin to arrange all of the stuff they analyze, especially lithic artifacts. At the heart of the question is, "Should lithic artifact morphological attributes determine type or should lithic artifact use-life and function form the basis for analysis?" It is a fundamental question that still begs answering.

In the last four decades, other archaeologists have proposed answers or alternatives to this question. For example, Rolland and Dibble (1990) proposed that because both Bordes and Binford base their arguments on “natural, discrete categories” of artifacts or assemblages (Rolland and Dibble 1990: 483) then neither Bordes nor Binford’s arguments are tenable. They use other possible processes, such as availability of raw materials, “tool-reduction intensity”, attrition and reuse, environmental factors, subsistence niche, and regional variations to account for the majority of lithic variability in the examples they cite. Kuhn, on the other hand, would build on Dibble’s resharpening views and relate variability to economies of scale in raw material procurement (core and blank size), extent of “cave-use”, or activities niche (Kuhn 1991). All of these analyses depended heavily upon statistical analysis of lithic assemblages as well as correlations to other artifactual and non-artifactual factors to demonstrate their variability hypotheses.

American proponents of processual explanations for variability in lithic artifacts in prehistoric North American cultures seem to have focused on narrowly defined influences on variability such as curation, lithic artifact use-life, consumption, raw material procurement, and rejuvenation. Rejuvenation in atlatl dart projectile points (e.g. Flenniken 1984; Flenniken and Raymond 1986; Flenniken and Wilke 1989; Frison 1968, Goodyear 1974; Miller 1980; Shott 1995; Titmus and Woods 1986) focused the rejuvenation argument on a particular class of lithic tools. Common American approaches often focused on experimental flintknapping replication studies to make inferences concerning possible prehistoric artifact use-life models. In all of these studies, both European and American, both statistical and experimental, none of the protagonists have developed a compelling and objective analytical technique to recognize and quantify rejuvenation of lithic artifacts. This is an obvious research gap. Until this gap is quantified, there can be no resolution to this argument and therefore, this portion of the debate continues.

RESEARCH GOALS

My first research goal is to develop an analytical tool to fill this gap in lithic artifact use-life analysis. I will examine the artifact use-life of eastern Great Basin atlatl dart points and focus on the processes of rejuvenation.

Rejuvenation is different than resharpening. The definition of rejuvenation as it is applied here is to convert a broken, non-functional tool into a similar functioning tool that is returned to the use-life stream. Resharpening is essentially retouching a non-broken dulled tool edge to produce an edge of similar sharpness as one first obtained from the initial manufacturing step (Hayden 1989). Lateral recycling occurs when a broken tool has been remanufactured into a form whose function is now different than originally intended (Schiffer 1972).

The analytical framework of the rejuvenation process to be examined will be to first determine if unique and identifiable signatures occur when a particular “type” of eastern Great Basin dart point is rejuvenated. This will be accomplished by physical examination of previous rejuvenation experiments (Flenniken and Raymond 1986; Towner and Warburton 1990), a projectile point fracture experiment (Titmus and Woods 1986), and conducting a highly structured rejuvenation experiment of my own. By comparative examination of projectile point interim rejuvenation strategies/trajectories in these experimental collections, I will determine the inherent rejuvenation patterns. These patterns are observable and represent rejuvenation signatures. The process of examining these lithic tools for patterns of rejuvenation signatures will be called Rejuvenation Signature Analysis (RSA).

RSA will be applied to Archaic atlatl dart point collections from four well known and deeply stratified eastern Great Basin archaeological sites; Danger Cave, Hogup Cave, Cowboy Cave, and Sudden Shelter . These sites were chosen because they represent the most important Archaic sites in the eastern Great Basin (and perhaps western North America). These sites were used in original projectile point - type naming schemes by many other researchers (e.g. Jennings, Aikens, Holmer, Thomas, O’Connell, Layton, et al.). Additionally, the availability of the collections, excellent stratigraphic controls, ^{14}C dating, and high populations of Archaic atlatl dart points made these research collections a logical choice. This analysis will include both extant dart points and dart point fragments. Three major accomplishments are desired. First, this will be a proof-of-test for this new experimental technique. Second, it will make available an empirically proved model of rejuvenation, curation and use-life and subsequently illustrate this facet of lithic artifact variability. Third, and probably most critical, it may put to rest a late 20th century argument: the validity of using Great Basin projectile points as reliable cultural markers (Bettinger, O'Connell, and Thomas 1991; Wilke and Flenniken 1991).

THESIS STRUCTURE

This thesis is divided into ten chapters and five appendices. Chapters one through nine are self contained. Chapter ten uses the previous chapters for summary, discussions, inferences and conclusions. The appendices are supplemental materials linked to the research and arguments of the thesis. A brief description is as follows:

Chapter 1 is introductory. It introduces the research problem and goals as well as notes on terminology to be used throughout the discussion.

Chapter 2 discusses the physical and cultural research area.

Chapter 3 is a discussion of projectile point typology research within the Great Basin cultural area.

Chapter 4 discusses previous rejuvenation theory and models in the Lower and Middle Paleolithic, North America (generally), and the Great Basin (specifically).

Chapter 5 is a review of the Flenniken-Raymond experiment, Warburton-Towner experiment, the Titmus-Woods breakage experiment, and the Spencer experiment. These experiments will be known as the control collection.

Chapter 6 records the formulation of rejuvenation signatures and constructs Rejuvenation Signature Analysis (RSA).

Chapter 7 applies and measures RSA in the control collections.

Chapter 8 applies and measures RSA in the archaeological (test) collections from Danger Cave, Hogup Cave, Cowboy Cave, and Sudden Shelter and formulates internal conclusions pertinent to this chapter.

Chapter 9 is a limited morphometric investigation of RSA in both in the control and test collections.

Chapter 10 summarizes and discusses all findings, lists inferences and conclusions, implications for researchers and field archaeologists, and makes possible recommendations for additional RSA applications.

Appendix I is a glossary and explanation of abbreviations pertinent to this thesis.

Appendix II is an updated summary of projectile point and rejuvenation experiments to date.

Appendix III is the data spreadsheets from all collections and experiments.

Appendix IV is the hyperlinked photographic images of the test collections.

Appendix V is a copy of the Scientific Take Permit from the State of Arkansas.

Within reference to the thesis structure, it is necessary to note that terminology will be defined within the discussion context (where practicable) and a glossary (Appendix I). In this way, readers familiar with the terminology will have clarification of definition at this important part of the discussion. Readers not familiar with the techniques or terminology can further be directed to an expanded definition within the glossary. It was observed throughout the review of extant literature, however, that several very specific terms have been used interchangably or the meaning of the terms changed throughout time. A few of the commonly accepted terms may be used slightly differently in this discussion. If confusion and uncertainty of terms used in this discussion occurs to the reader after reviewing the terms in context and in the glossary, terms and terminology discussed in Appendix I, Glossary, will be the final referee.

CHAPTER 2

PHYSIOGRAPHIC AND CULTURAL OVERVIEW OF THE RESEARCH AREA

INTRODUCTION

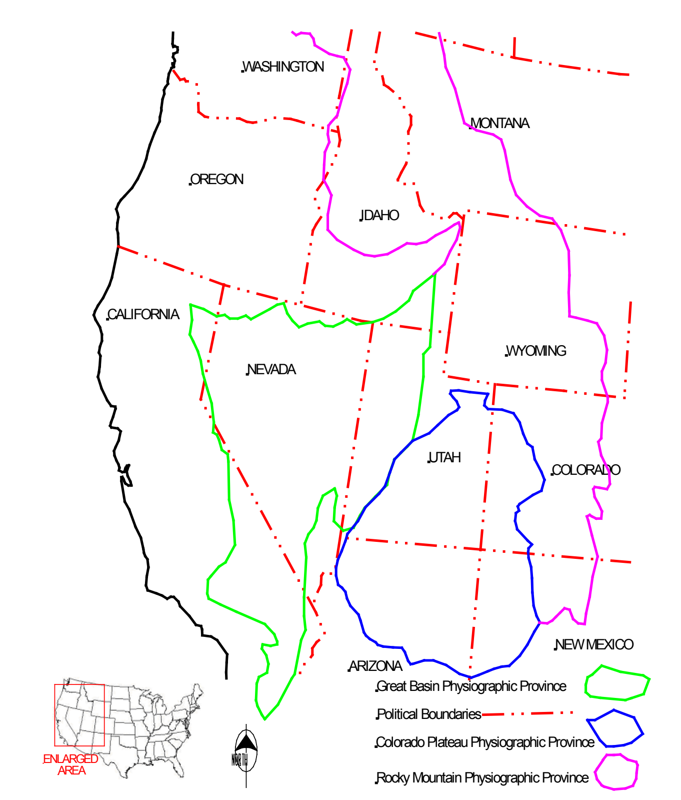


Figure 2.1 Great Basin and surrounding physiographic provinces.

Located in much of the western United States, the Great Basin physiographic province covers over 400,000 square miles (D'Azevedo 1986:1; see Figure 2.1). The prehistoric culture area is even larger (Jennings 1986:114; see Figure 2.2). This cultural area is further subdivided into five sub-areas and has been used nearly continuously by hunter-gatherer groups for almost 13,000 years, and perhaps even longer. This thesis is particularly concerned with the prehistoric cultural eastern Great Basin sub-area and usually when "eastern Great Basin" is referred to here, it is directed to mean this cultural sub-area rather than the physiographic province, hydrologic division, or floristic component, all which incidentally intertwine and overlap.

EASTERN GREAT BASIN PREHISTORIC CULTURAL SUB-AREA

The prehistoric eastern Great Basin cultural sub-area (EGB) follows roughly the political boundaries of the modern state of Utah, with slight overlap into Nevada along the Bonneville Basin on the west; the Raft River Mountains of southern Idaho on the north; the Flaming Gorge area in the most southwest part of Wyoming; and the far western part of the Colorado Plateau along the Colorado state line. Although having great physiographic differences, the greater access to water resources (as opposed to most of the western sub-area), similar biotic communities, and similar prehistoric material cultures are overriding criteria for the designation of this sub-area's cultural boundary.

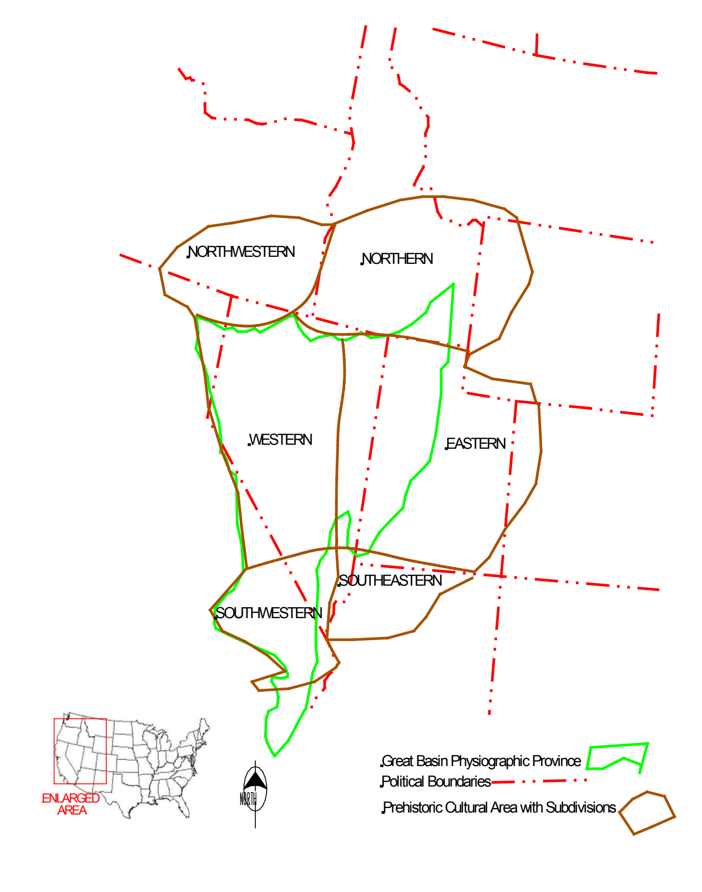


Figure 2.2 Prehistoric cultural sub-areas of the Great Basin.

EGB contains portions of the Basin and Range Province, Rocky Mountain Province, and Colorado Plateau Province (Stokes 1977). These major physiographic divisions are roughly shown in Figure 2.1. Hunt (1967) characterized the Basin and Range Province as north-south trending mountain ranges and broad high desert valleys (4000+ feet above mean sea level; amsl) by its block fault geology. Cronquist et al. (1972) and later Grayson (1993) tended to make definitions more on unique biotic communities that changed with elevations (the lowest elevation at Beaverdam Wash at 2000 feet amsl to the highest at Kings Peak at 13, 528 feet amsl) within the EGB. There were many varied ecotones where prehistoric people could make a living.

Overview of the Prehistoric Cultures of the EGB

Understanding the physiographic landforms and the individual biomes within these areas is the key to unlocking the adaptive strategies and resultant material cultures of these prehistoric peoples. This ecological approach proposed by Madsen and O'Connell (1982) is the context in which the following prehistoric EGB cultures will be discussed.

Bonneville Period (9000-7500 B.C.)

The Bonneville Period (see Figure 2.3) takes its name from the late Pleistocene Lake Bonneville and the now desiccated shorelines and mudflats associated from this once massive freshwater pluvial relic. It represents the earliest human occupation in the EGB. As with most

Paleoindian evidence in North America, solid contextual cultural materials are quite hard to come by. So far, unambiguous stratified "Classic" or Clovis Paleoindian cultural material (fluted projectile points, specialized scrapers, etc.) has yet to be found. What isolated fluted points have been found in the EGB are usually on badly deflated surface contexts such as paleodunes, relic river deltas, springs and playa margins (see Copeland and Fike 1988; Tripp 1966; Gunnerson 1956). Instead of a more "Clovis-like" culture, the earliest cultural evidence from three caves (Danger Cave, Smith Creek Cave, and Hogup Cave; see Figure 2.4) resembles the stemmed projectile points

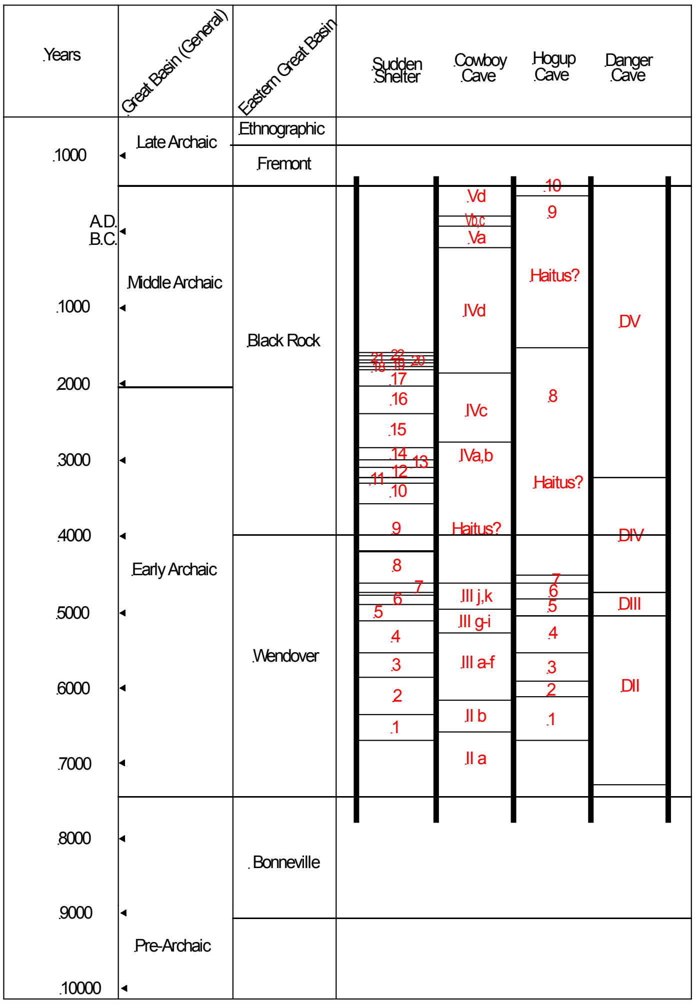
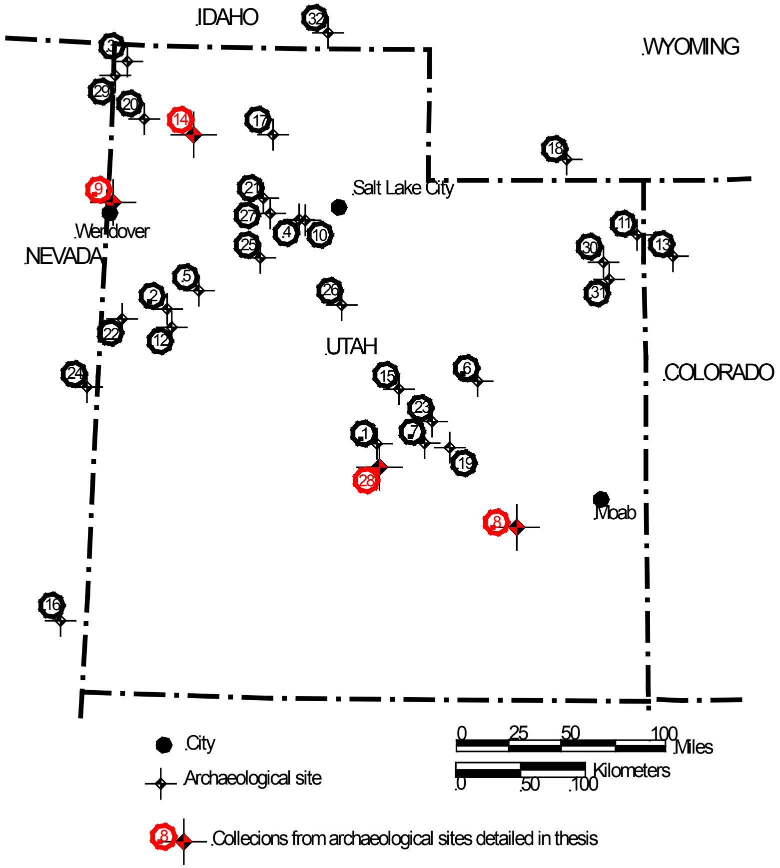


Figure 2.3 Chronology and cultural periods correlated with strata from Sudden Shelter, Cowboy Cave, Hogup, and Danger Caves. Stratigraphy after Holmer (1978).



	Site Name	References
1	Acord Lake	Tripp (1966)
2	Barn Owl / Crab Cave	Madsen (1982)
3	Beatty Springs	Dalley (1976)
4	Black Rock Cave	Steward (1937); Madsen (1983)
5	Camel's Back Cave	Schmitt and Madsen (2005)
6	Cedar Siding Shelter	Martin et al. (1983)
7	Clydes Cavern	Winter and Wylie (1974)
8	Cowboy Cave	Jennings et al. (1980)
9	Danger Cave	Jennings (1957)
10	Deadman Cave	Smith (1941)
11	Deluge Shelter	Leach (1970, 1970a)
12	Fish Springs Cave	Madsen (1982)
13	Hell's Midden	Lister (1951)
14	Hogup Cave	Aikens (1970)
15	Joes Valley Alcove	Barlow and Metcalfe (1993)
16	O'Malley Shelter	Fowler, Madsen, and Hattori (1973)
17	Promontory Caves	Steward (1937)
18	Pine Springs	Sharrock (1966); Kelly et al. (2006)
19	Pint-Size Shelter	Lindsay and Lund (1976)
20	Remnant Cave	Dalley (1976)
21	Sandwich Shelter	Marwitt, Fry, and Adovasio (1971)
22	Scribble Shelter	Lindsay and Sargent (1979)
23	Silverhorn Wash	Gunnerson (1956)
24	Smith Creek Caves, Amy's Shelter Kachina Cave	Gruhn (1979); Bryan (1979); Tuohy (1979)
25	Sparrow Hawk	Janetski (1983)
26	Spotten Cave	Mock (1971)
27	Stansbury Cave	Jameson (1958)
28	Sudden Shelter	Jennings, Schroedl, and Holmer (1980)
29	Swallow Shelter	Dalley (1976)
30	Swelter Shelter	Leach (1970, 1970a)
31	Thorne Cave	Day (1964)
32	Weston Canyon Rockshelter	Delisio (1971)

Figure 2.4 Archaic sites of the eastern Great Basin.

from the Western Pluvial Lake Tradition of the western Great Basin (see projectile point Figures 2.5a and 2.5b). Atlatl use in the Bonneville period with these large stemmed points as atlatl dart points is speculated, however, the very dearth of other perishable material cultural remains (atlatl spearthrower parts, mainshafts, foreshafts, etc.) and cultural remains in general make confirmation of atlatl use difficult. These points could be spear points; however, Flenniken (1985) indicated that these projectile points could still be dart points in a spear armature (Odell and Cowan 1986).

Initial strata at Smith Creek Cave (Bryan 1979) yielded the earliest date of 11,200 B.P.; followed by Danger Cave (10,270 B.P.) and Hogup Cave (9500 B.P.). With little subsistence evidence to rely on, it has been conjectured that these "highly mobile" early people used both lake-side and upland subsistence strategies through this Pleistocene-Holocene transitionary period (Aikens and Madsen 1986).

Wendover Period (7500 – 4000 B.C.)

The Wendover Period correlates to the Early Archaic as defined elsewhere in the Great Basin (see Figure 2.3). It has also been referred to as the "Desert Culture" or "Desert Archaic". Archaeological stratum representative of this period can be found in Hogup Cave, Danger Cave, Deadman Cave, Black Rock Cave, Sandwich Shelter, Sudden Shelter, Cowboy Cave, and Weston Canyon Rockshelter (see

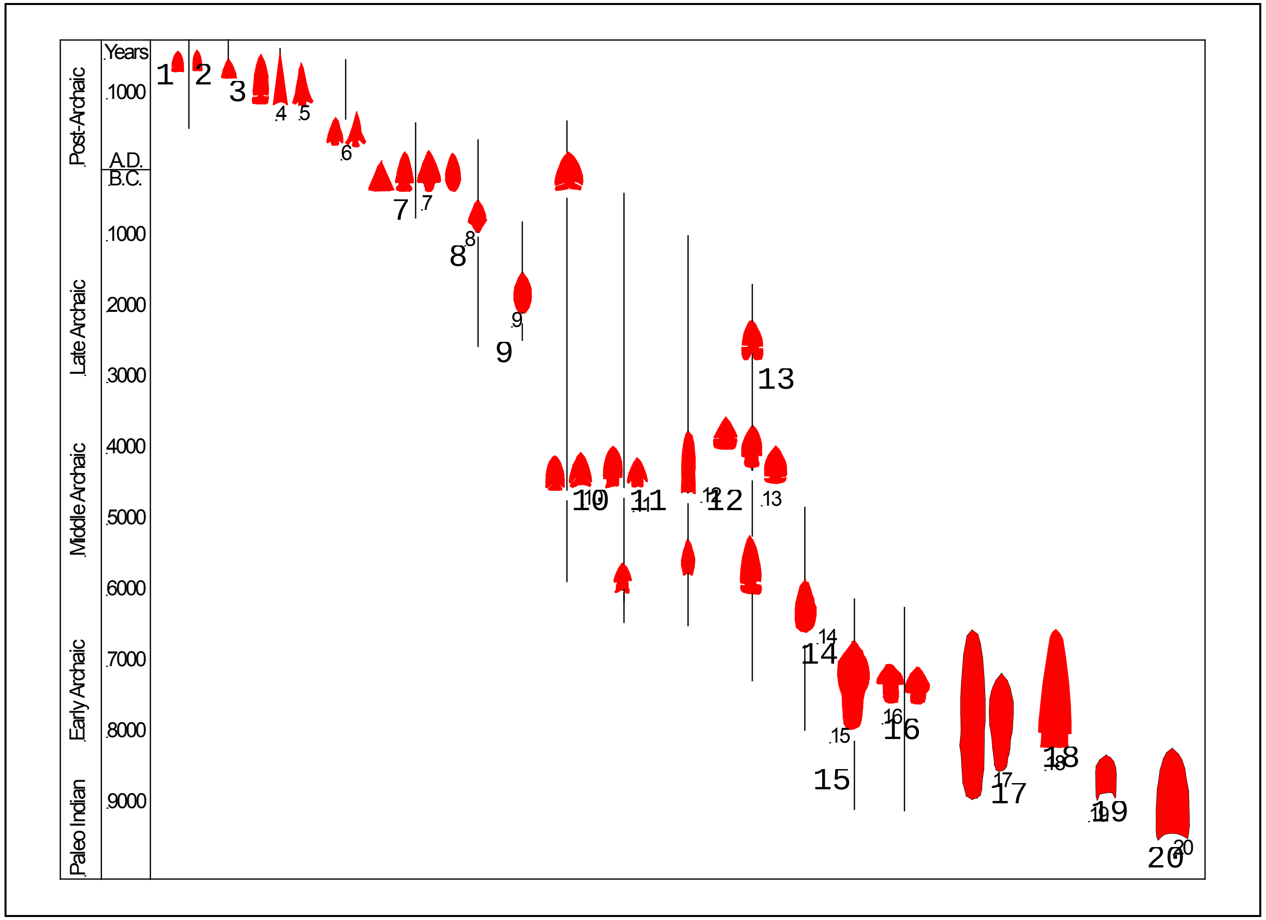


Figure 2.5a Accepted Great Basin projectile points and chronology. After Jennings (1986:117).

Figure 2.5a Accepted Great Basin projectile point types and chronology. After Jennings (1986:117).

Type Names and Alternative Names

1 Desert Side-notched Series
  - Desert Side-notched
  - Uinta Side-notched
  - Bear River Side-notched

2 Cottonwood Triangular

3 Bull Creek Concave-base

4 Parowan Basal-notched

5 Nawthis Side-notched

6 Rose Spring – Eastgate Series
  - Rose Spring Corner-notched
  - Eastgate Expanding-stem
  - Eastgate Split-stem

7 Martis Series
  - Martis Tiangular
  - Martis Corner-notched
  - Martis Stemmed-leaf

8 Gypsum

9 McKean Lanceolate

10 Elko Series
  - Elko Corner-notched
  - Elko Eared
  - Elko Side-notched
  - Elko Contracting-stem

11 Pinto Series (Gatecliff, Little Lake & Bear Creek Series)
  - Pinto Square-shouldered
  - Pinto Sloping-shouldered
  - Pinto Shoulderless
  - Pinto Willowleaf

12 Humboldt Series (Great Basin Concave-base Series)
  - Humboldt Concave-base A
  - Humboldt Concave-base B
  - Humboldt Basal-notched
  - Triple-T Concave-base

13 Large Side-notched
  - Northern Side-notched (Bitterroot Side-notched)
  - Hawken Side-notched
  - Rocker Side-notched
  - Sudden-Side-notched
  - San Raphael Side-notched

14 Cascade

15 Large unnamed stemmed

16 Large stemmed (Great Basin Stemmed Series)
  - Lake Mohave
  - Silver Lake
  - Parman Series
  - Windust

17 Haskett 1 and 2

18 Scottsbluff

19 Folsom

20 Clovis

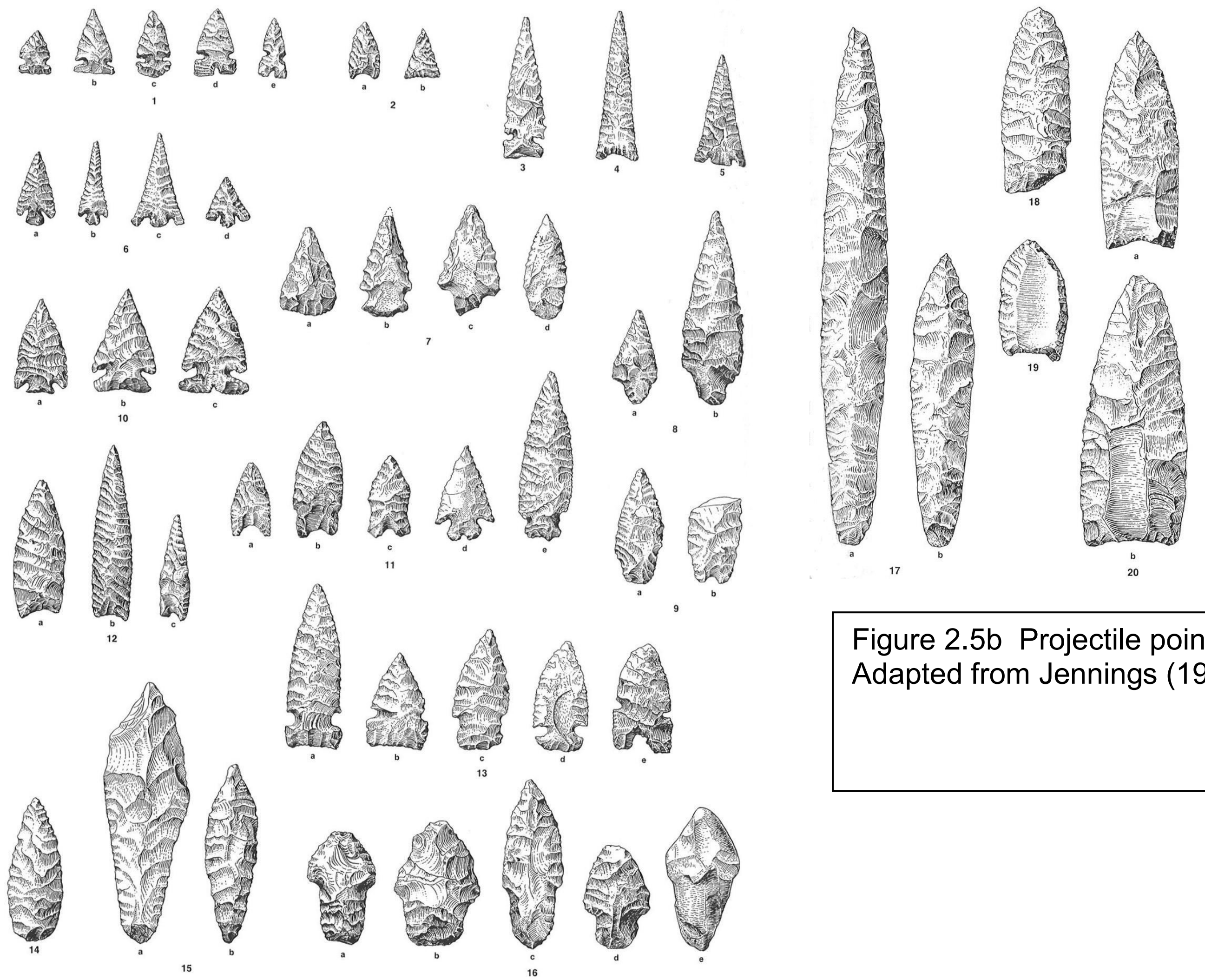


Figure 2.5b Projectile points of the Great Basin. Adapted from Jennings (1986:118-119; Figure 4).

Figures 2.3 and 2.4). In addition to these sites, many other sites dating to this period can be found within the EGB (see Figure 2.4).

Aikens and Madsen (1986) attribute this to the wide variety of environmental niches (lakeside, upland, high altitude, etc.) used by these “highly mobile” hunter-gatherers. Although lacking in some of the open sites, many of the cave and rockshelter sites contain an excellent preservation of perishable cultural materials, subsistence residues (chaff, seeds, plants, bone, coprolites, etc.), environmental indicators (macrofossils, pollen, etc.), as well as intact cultural features (hearths, cache pits, etc.). What emerges from this evidence is a long persistent culture of seasonal hunting in upland sites and plant procurement/seed processing along lowland lake and wetland margins. Indeed, some of the wetland/lakeside cave sites (i.e. Danger Cave) have Wendover Period stratums containing several feet of compressed winnowed chaff from processing the small seeds from pickleweed (*Allenrolfea occidentalis).* Rhode, Madsen, and Jones (2006) have proposed that this is the earliest evidence of small seed use in western North America. Plant processing tools and implements (basketry, milling stones, etc.) also show increased frequency in the material culture record.

The archaeological record also contains evidence of hunting both large game (mountain sheep, bison, antelope, and mule deer) and small game (hares, rabbits, rodents, birds) with small game being the dominant species found in subsistence residues. Prevalence and use of small game species varied from site to site, however. For example, Hogup Cave showed a preference for lagomorphs (rabbits) and avian species with a resulting observation of nets, snares, and throwing sticks (mostly used to drive and capture rabbits) and the use of decoys and bunts to capture and hunt waterfowl. Other contemporary lake-side cave sites showed a lack of use of avian species altogether (Schroedl and Coulam 1989). The subsistence hunting weapon of choice at all Wendover Period sites, however, was the atlatl and atlatl dart point.

Use of the atlatl is not unique in the prehistoric record. Raymond (1986) indicates that prehistoric hunters and gatherers have used the atlatl on all continents except Africa and Antarctica. Some Upper Paleolithic (Magdalenian) atlatl spearthrowers are 13,000 years old (Garrod 1955). Atlatl use was speculated during the Bonneville period but clearly confirmed here with the findings of atlatl spearthrowers, mainshafts, foreshafts, and hafted and unhafted dart points within Wendover Period contexts. Atlatls from the EGB (from both the Wendover and following Black Rock Periods) have been shown in Aikens (1970:284) as being from Hogup Cave and Gunnerson (1969: 100) from Rasumssen Cave near Nine Mile Canyon. Atlatls from other parts of the Great Basin and of similar antiquity are shown in Elston (1986: 140), Loud and Harrington (1929), Cressman and Krieger (1940: 16-49), Cressman (1944:169-179), Dalley and Peterson (1970:283-285), and Tuohy (1982:85).

Holmer (1978) describes Wendover Period EGB dart points as the following types (see Figures 2.5a and 2.5b):

Pinto Shouldered	Rocker Side-notched
Humboldt Concave-base	Hawken Side-notch
Elko Corner-notched	McKean Lanceolate
Elko Eared	San Rafael Side-notched
Elko Side-notched	Gypsum
Northern Side-notched	

Examination of these Archaic EGB projectile points from four specific sites for rejuvenation signatures will be the focus of this thesis.

Black Rock Period (4000 B.C. to 500 A.D.)

The Black Rock Period represents a transition from the Middle to Early Archaic as characterized elsewhere in the Great Basin. The material culture for the most of the period remains practically unchanged from the Wendover Period, with the exception of more use of Elko Series and Gypsum points and later, towards the end of the period (ca. 200 B.C. to 500 A.D.), the bow-and-arrow is introduced and atlatl dart points all but disappear from the material record.

Upland sites seem to be even more intensely used with some whole or partial abandonment of the previous playa-side cave sites (such as Hogup and Danger Caves). This has been attributed to more arid conditions (Mehringer 1977; Madsen and O'Connell 1982) and diminished playa margins, wetlands, and lowland riparian resources.

Sevier - Fremont Period (500 A.D. to 1350 A.D.)

After a 9000 year hunter-gatherer subsistence pattern based on mobile foraging, at (or near) 500 A.D. the EGB shows an influx of new peoples and/or new ideas with the adoption of maize, beans, and squash horticulture, ceramics (vessels and figurines), subterranean and masonry structures, complete use of the bow-and-arrow to the exclusion of the atlatl, and radical changes in rockart. A more dramatic change in EGB material culture would not occur until Euro-American contact in the late 18th and early 19th centuries. By that time, the Sevier-Fremont peoples would have been gone from the EGB for almost 500 years.

The "Fremont" culture was named by Morss (1931) as descriptive of a diffused northern variant of traditional Southwest cultures (Anasazi, Mogollon, Hohokam, etc.) that were being initially studied at this time; "Fremont" coming from the Fremont River in south central Utah where initial investigations were conducted. "Fremont" is the generalist term; it can also mean the manifestation of this tradition on the Colorado Plateau and the term "Sevier" would be reserved for the tradition along the eastern Great Basin physiological boundary (Madsen and Lindsay 1977). A few researchers see Athabascan origins via the Plains in migration/influences (Aikens 1966). Some, like Morss see more Southwest migrations/influences (Gunnerson 1969, Berry 1980, and many others). Exact origins and cultural relationships are unknown.

Habitation sites are often in the form of small pithouse hamlets and villages. Dry laid masonry for granaries and room blocks were common where pit structures were impractical. Limited activity sites where no structures are identified are found through-out the study area. Finally, regional variations based on ceramics, structures, and rock art have been recorded in the EGB.

By 1350 A.D. the Sevier- Fremont can no longer be identified as a cultural tradition. They may have migrated due to a shift in climatic conditions making horticulture impossible (drier, arid climates desiccating lakesides or wetland margins), migrated or merged with an influx of Numic speaking people into the area, or reverted back to earlier hunter-gatherer foragers for the above reasons or reasons yet unknown.   Modern DNA studies could help resolve the origins and demise of the Sevier-Fremont Tradition and clarify its relationship to the Archaic Cultures of the past and the modern peoples of the ethnohistoric present.

Late Prehistoric Period (1350 A.D. – Euro-American Contact)

In the EGB, this period is probably the least studied and understood. It is postulated that Numic-speaking people, the antecedents of the ethnographic peoples, entered the EGB at this time. Subsistence life styles were much the same as the Wendover and Black Rock Period peoples, with a few subtle changes in the material culture.   First, atlatls are thought to have been completely replaced with the bow-and-arrow with small Desert Series (see Figures 2.5a and 2.5b) side-notched projectile points dominating the material culture. Second, ceramics were still used in limited circumstances. These were thick, coarsely tempered vessels, and “crude” when compared to the earlier Sevier-Fremont ceramics. Finally, few “habitation” structures have been discovered. This may be due to the high mobility of the people and the ephemeral structures they created or a general lack of archaeological research into the seasonal foraging settlements of the Late Prehistoric Period peoples.

Euro-American contact with these ethnological peoples (Ute, Paiute, Shoshone, and Goshute) occurred at different times throughout the EGB. It is recorded as early as 1776 A.D. with the Dominguez- Escalante Expedition (Bolton 1950) and as late as the early 19th century with trappers and fur traders. By the mid 19th century the contact with a trickle of government explorers and trappers would soon give way to a flood of colonists seeking refuge from religious persecution, miners, ranchers and cattlemen, military expeditions (to both suppress the indigenous people and keep an eye on the oppressed religious colonists), and all of the other trappings of a growing nation pushing West. The Late Prehistoric Period ends with defeat, collapse, subjugation, relocation, and limited recovery of these ethnographic people as seen today.

CHAPTER 3

HOW EGB ARCHAIC DART POINTS BECAME TYPES

INTRODUCTION

At the beginning of the 20^{th} century, many North American archaeologists were attempting to make sense of flaked stone tools with observation of stone tool manufacture (Cushing 1895; Holmes 1919; Pope 1913) and incipient classification systems (e.g. Wilson 1899). By the mid-20^{th} century the emphasis of these classification systems had changed from simple cataloging and sorting to fairly elaborate stone tool taxonomic systems aimed at building cultural chronologies, such as the Midwestern Taxonomic Model (e.g. McKern 1939). Willey and Sabloff in "History of American Archaeology " describe this period as the "Classificatory-Historical Period (1940-60) with American archaeologists beginning to be " . . . concerned with context and function and hinted at process. They did not replace their prevailing preoccupation of . . . chronological ordering" (Willey and Sabloff 1974:131). This is evident in the work of many American archaeologists. During this time they ascribed systematic morphological attributes into what they would contend were indicative of temporal markers or "types" (Ford 1954; Krieger 1944; Rouse 1960; Spaulding 1953).

1912 - 1950

It was against this backdrop of blossoming early-20^{th} century American archaeological method and theory that large scale excavations in the Great

Basin were started. Prior to this, little regard was given to projectile point typology. Most early Great Basin excavations, such as Loud's excavation of Lovelock Cave, central Nevada (Loud and Harrington 1929) were more concerned with gathering artifacts for display (see Heizer and Napton 1970) rather than creating analytical frameworks of types. Although Harrington (1933) was one of the first to name Great Basin projectile point types after a place or locality, a tradition that had been started in the Midwest and Plains and carried out in amazing complexity (e.g. Morrow 1984), the notion of artifact type was not used with consistency. The same is true of Stewart's excavations at the Promontory Caves (Stewart 1937). Perhaps the earliest attempt at classification and typology of projectile points came with Cressman (Cressman 1942) and Krieger (Cressman, Williams, and Krieger et al. 1940). A.D. Krieger was an early advocate of the concept of type and its applications to archaeological assemblages (Krieger 1944). When these concepts were applied to the projectile points of the Roaring Springs Rockshelter, southern Oregon, 28 morphological types were established. These types were then sub-divided onto nine "temporal" subtypes correlated to stratigraphic units. This was advanced thinking for the day.

1950 - 1970

The carefully controlled stratigraphic excavation of Danger Cave starting as early as 1949 would prove to be one of the most important studies in the cultural chronology of the Great Basin. Although Jennings (1957) had an exhaustive sample of projectile points from these excavations, he was hesitant to construct elaborate type variety schemes. He would eventually employ a series of 87 binomial designators (e.g. W1, W2, etc.) for the entire chipped stone assemblage (Jennings 1957: 100-101). Jennings would say of the chipped stone tool types he created as ". . . not as synonymous with cultural truth, but like most other types, as an invention of the analyst for his own convenience" (Jennings 1957:99). Jennings also believed that his simplistic system would be re-examined and would invite future and more locally sensitive analyses. It would be reexamined and resorted extensively in the coming years (Aikens, Riddle, Thomas, Holmer, O'Connell, Layton, etc). Even Jennings (1986), however, would eventually bow to the efforts of those archaeologists, who were determined to establish a regional chronology of named projectile point types (*e.g.* Heizer and Baumhoff 1961, Clewlow 1967, O'Connell 1967; Aikens 1970; Layton 1970; Adovasio and Fry 1972; Holmer 1978; Thomas 1970, 1981, 1983).

On the western side of the Great Basin, the University of California Berkeley (and later led by Heizer) had been surveying, excavating, and analyzing Great Basin archaeological sites since the late 1930's. By the 1960's this "Berkeley" group was well invested in projectile point classification systems that were sensitive to chronologies as well as spatial boundaries.

By the late 1960's Thomas was working in central Nevada with the Reese River field inventories (Thomas 1969). Projectile point classifications relied heavily upon Heizer and the Berkeley group typological methods. Thomas (1970) would improve on this Berkeley classification and propose the "Reese

River Key I" as a dichotomous method to "impose structure" on newly observed Great Basin projectile point assemblages.

1970 - 1980

By the 1970's creating named projectile point type classifications was a growth industry that was occurring repeatedly across the Great Basin (Aikens [1970]. Layton [1970], Holmer [1978], Thomas [1981]). Great Basin projectile points were now being divided into classes and subclasses, types and varieties in an attempt to build cultural chronologies. Some archaeologists felt that these named projectile point types also ". . . connote certain geographical and temporal associations that have historical relevance" (Clewlow 1967:143; Layton 1970:216). Others believed that projectile point types tied to chronologies would impose "temporal order" (Thomas 1981:9). Whatever the case, by the 1970's there were many varieties and classifications that had common type names which defined chronologies in the EGB but that had a completely different definition in the western Great Basin. As Thomas (1981: 10) would summarize, "By the mid-1970's, it became clear that all was not well with Great Basin projectile point typologies". For example, the work of Layton (1970) in the High Rock Desert of northern Nevada would establish a chronology for the northwest Great Basin by proposing six new cultural phases. As "key fossils" to these phases, Layton morphologically defined 17 new projectile point types in a context of 26 types total. When these types were correlated against the types Aikens was formulating for Hogup Cave in the EGB (Aikens 1970), the chronologies and projectile point types did not

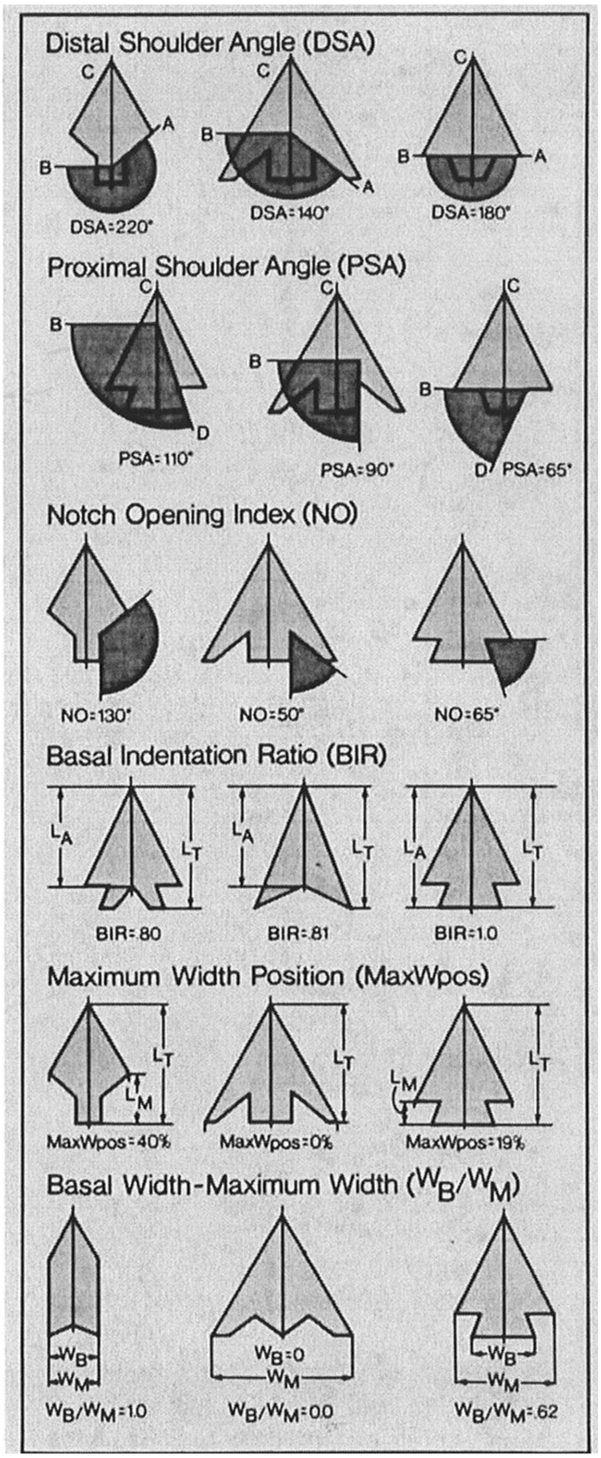


Figure 3.1 Thomas' attribute definitions (after Thomas 1981:14; Figure 3).

mean the same thing. O'Connell would do much the same at Surprise Valley (O'Connell 1967, 1971). Some late 1970's typologies had substantial analytical distance from either technological or cultural processes (Holmer 1978, 1980[a], 1980[b], 1986; Holmer and Weder 1980). For example, Holmer (1978) constructed a typological system based entirely on discriminant analysis to standardize and validate EGB Early to Late Archaic Period projectile point types. It involved a process that required several minutes with a shadowbox / grid and recording of seven different discriminant points. This analytical method would not work unless the projectile point was bilaterally symmetrical. It also assumed that breakage occurred only at the projectile point tip and not the base. The mathematical distances between projectile point attributes were the analytical engine that drove this morphological typology. Subsequently, the technologies that originally produced and maintained the projectile points were completely ignored.

THOMAS AND THE MONITOR VALLEY

By the early 1980's Thomas endeavored to correct the many disparities of the 1970's by creating a standard for Great Basin morphologically based typologies. Thomas' (1981) "How to Classify Projectile Points from Monitor Valley, Nevada" would use 400 "typable" (artifacts that possessed the attributes he would measure) projectile points from a deeply stratified rockshelter (Gatecliff Shelter, 26Ny301) and projectile points from other excavated and surface sites in the Monitor Valley to form a collection of roughly one thousand points. If the projectile points did not fit his schema, they were "undiagnostic". Thomas then used attribute protocols developed in his previous Reese River studies (Thomas 1970; Thomas and Bettinger 1976). As described in Thomas (1981:11) these attributes are:

> *Distal Shoulder Angle---DSA*. The Distal Shoulder Angle is that angle formed between the line (A) defined by the shoulder at the distal point of juncture and line (B) drawn perpendicular to the longitudinal axis (C) at the intersection of A and C. *DSA* ranges between 90 degrees and 270 degrees. If points are asymmetrical, the smaller value of DSA is measured. *DSA* is recorded to the nearest 5 degrees.
>
> *Proximate Shoulder Angle---PSA*. The Proximate Shoulder Angle is that angle formed between the line (D) defined by the proximal point of juncture and the line (B) plotted perpendicular to the longitudinal axis at the intersection of C and D. *PSA* ranges between 0 degrees and 270 degrees. If points are

asymmetrical, the smaller value of PSA is measured. *PSA* is recorded to the nearest 5 degrees.

Shouldered. A point is termed shouldered is DSA and PSA can be measured. If these two angles do not apply, the point is termed unshouldered.

Basal Indention Ration---BIR. Basal Indention Ratio is the ration of the length of the longitudinal axis (L_A) to the total length (L_T) parallel to C, i.e. BIR=L_A / L_T. Basal Indention Ratio Ranges between .0 and about 0.90.

Length-Width Ratio---L/W. The Length-Width Ratio is the ratio of the total length (L_T) parallel to the longitudinal axis to the maximum width (W_M) perpendicular to E, i.e., Length-Width Ratio =(L_T) / (W_M).

The *Maximum Width position* is the percentage of the total length between the proximal end and the position of maximum width (100 L_M/L_T). Range is generally between 0 and about 90%.

Basal Width-Maximum Width --- W_B/W_M. The Basal Width-Maximum Width Ratio is the ratio of the width at the widest portion of the base (WB) to the maximum width (WM) Range is from 0 to about 0.90.

Thomas's standardized attributes are shown in Figure 3.2.

CONCLUSIONS

Presently, Thomas (1981) is the most widely accepted schema. It uses a binomial descriptive system describing the place name, type (e.g. Elko) and the variety (e.g. corner-notched). This type-variety-series naming system was a fairly obvious cross-over from the ceramicists (Smith, Willey, and Gifford 1960; Sabloff and Smith 1969). There are currently 79 "known" and 19 "unknown" projectile point types with many permutations of varieties (IMACS 2001: Sec. 320 part B pp. 4-5) commonly used in the Great Basin (also see Figure 2.5a and 2.5b). Holmer (1978), Layton (1970), Thomas (1981), and Aikens (1970), however, shared one common trait: all of these typologies had little reference to how projectile points were made, their use-life, and "rejuvenation" (Flenniken 1985:266).

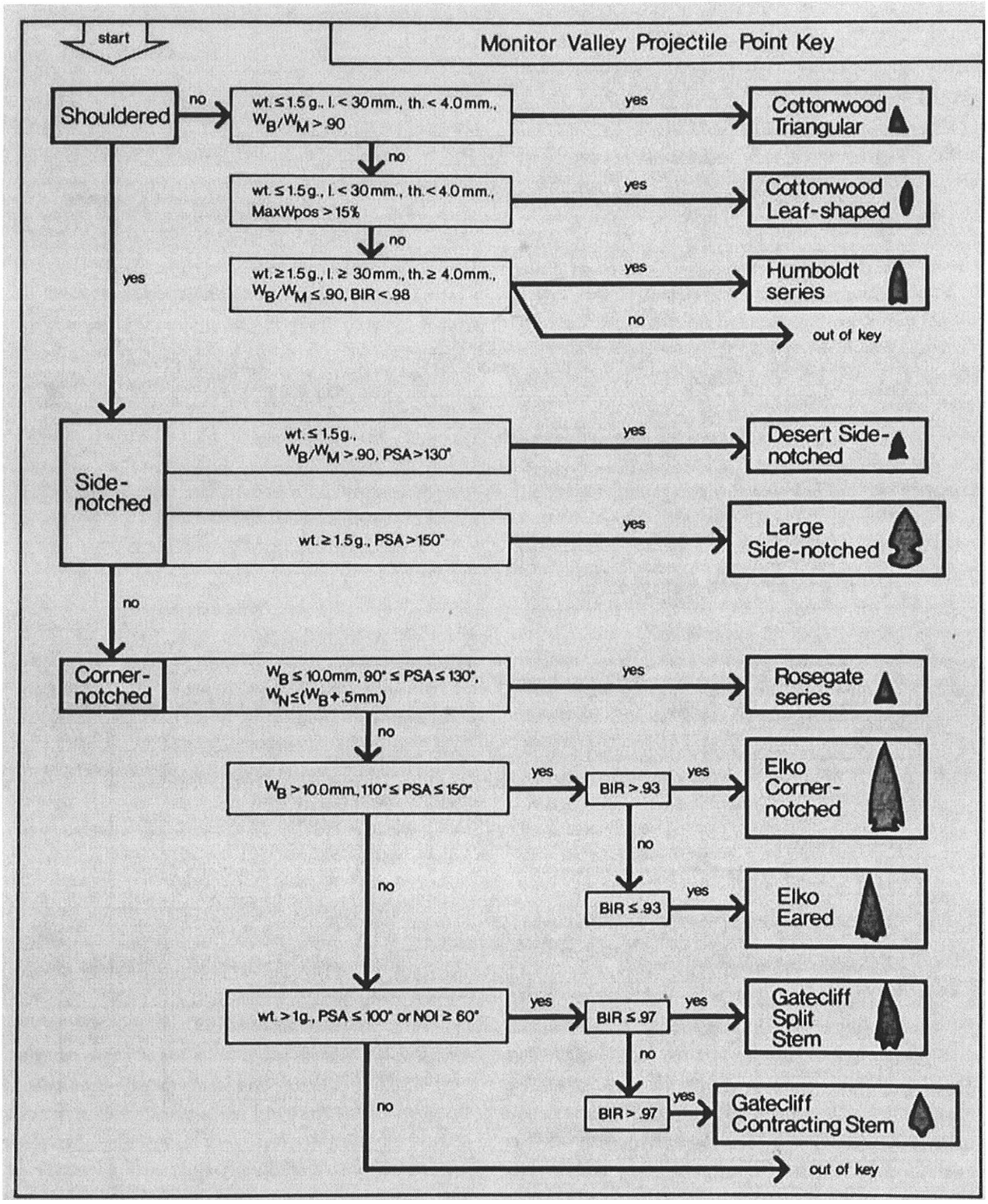


Figure 3.2 Monitor Valley dichotomous key. Adapted from Thomas (1981:25; Figure 11).

CHAPTER 4

OVERVIEW OF REJUVENATION THEORY AND RETOUCH MODELS

INTRODUCTION

Beginning almost 40 years ago, retouch or rejuvenation theory would have its roots in the embrace of processual archaeological thought and the abandonment of the normative-empiricist paradigm (Dibble 1995a: 302). At its very core is the notion of the “Frison Effect”.

THE FRISON EFFECT

Frison (1968) was probably the first to discuss how lithic assemblages and types could dramatically change as a result of rejuvenation within artifact use-life. This was first demonstrated in archaeological investigations at the Piney Creek Site, a Paleoindian site from northern Wyoming (Frison 1968). Here, Frison was able to show by refitting and conjoining broken tools that numerous resharpening events had taken place during the tool use-life. Eight years later Frison et al. (1976) would show how rejuvenating projectile points could radically change projectile point morphology and especially change “types”. In “Fossil Bison and Artifacts from an Early Altithermal Period Arroyo Trap in Wyoming”, Frison, Wilson, and Wilson (1976) excavated the Hawken site, a natural bison trap dating back around 4500 B.C. Here, perhaps a hundred or so *Bison bison occidentalis* were killed, butchered, and select food parts harvested. This site was able to give information on what time of year the bison were trapped and slaughtered, the herd

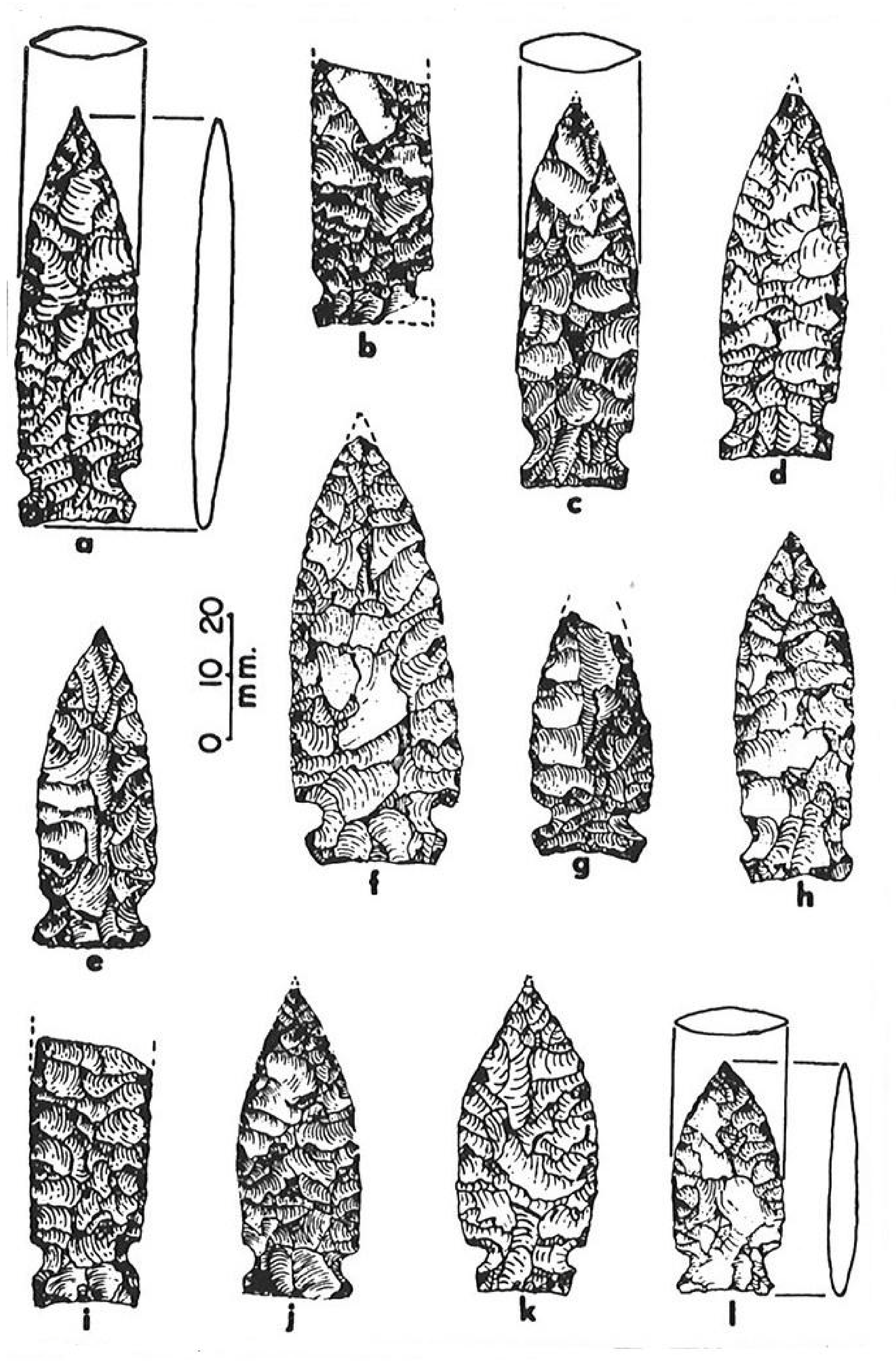


Figure 4.1 Unmodified projectile points from the Hawken site, after Frison et al. (1976:43; Figure 11).

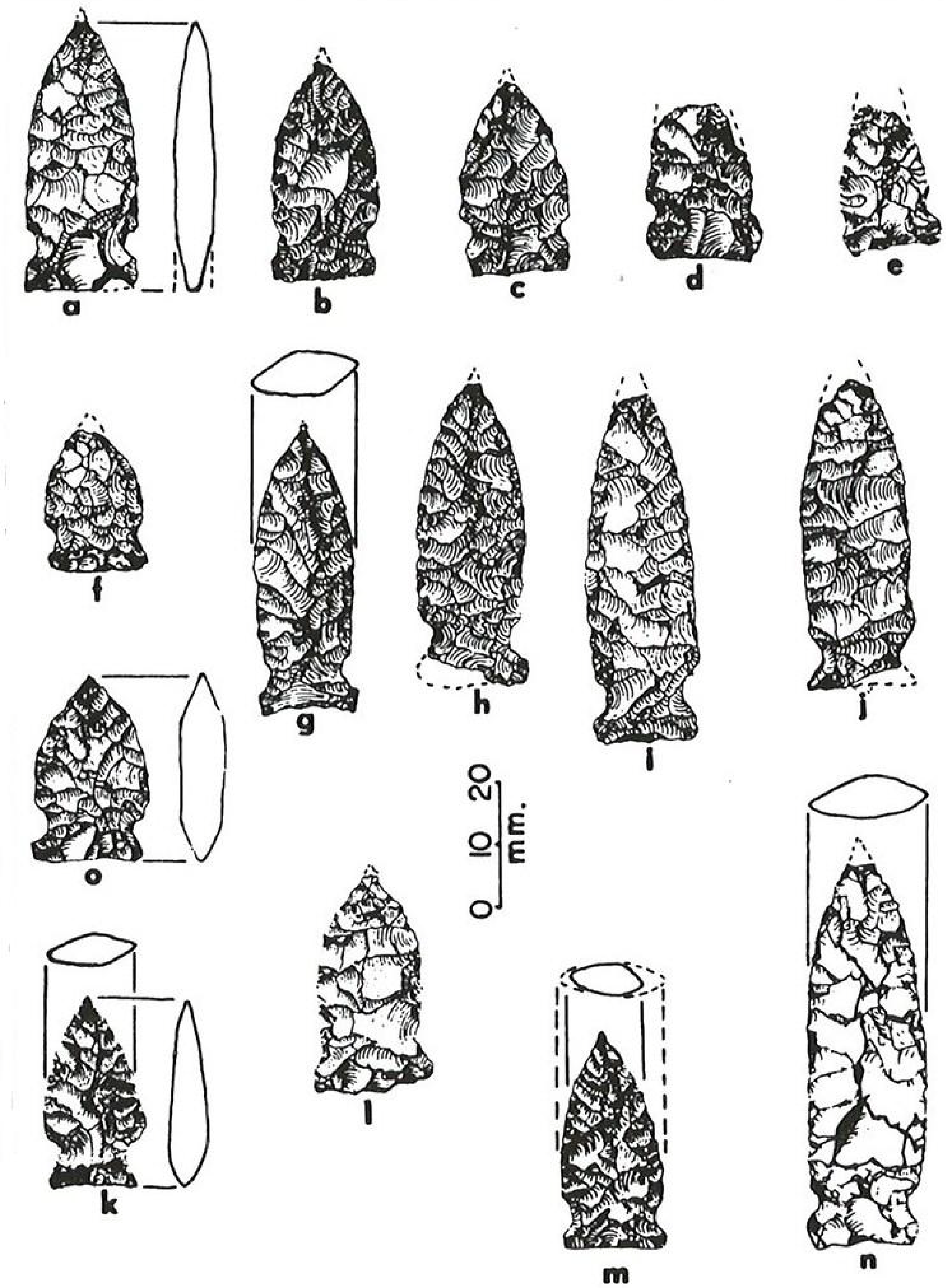


Figure 4.2 Projectile points from the Hawken site modified after breakage. After Frison et al. (1976:44; Figure 12).

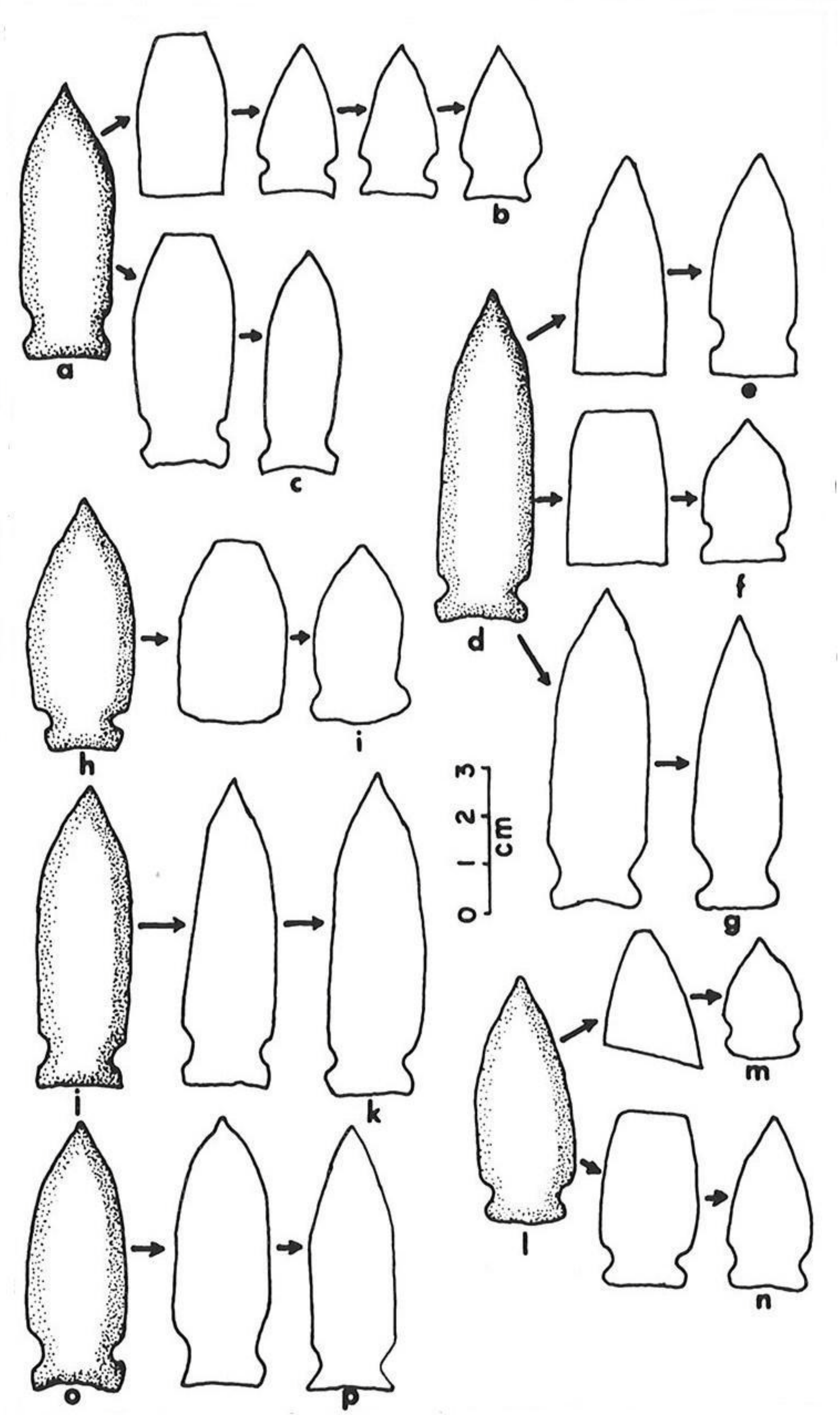


Figure 4.3 Archetypal forms and hypothetical breakage followed by reworking to regain functional utility of the broken specimens. After Frison et al. (1976:45; Figure 13).

composition, as well as osteological data. Of particular concern was the analysis of the atlatl dart point collection, called “Hawken” points. Frison noted:

> “Most projectile points broke during use and since many of these were reworked into functional projectile points, the total range of variation is quite large. However, it can be demonstrated that the original points clustered around a single style with minor variations: elongate with concave to slightly convex base. Most of the variation in the Hawken collection is in the blade edges.”(Frison et al. 1976:42-43).

These “reworking” strategies, (here called rejuvenation signatures), are quite apparent in Frison’s projectile point figures (see Figures 4.1, 4.2, 4.3). Frison reasoned that with Hawken projectile points, cyclic breakage and repair would result in similar type projectile points; albeit smaller and with great variation in edge and blade attributes. Jelinek (1976: 19) would latter name this maintence cycle of lithic use, brakeage, and repair the “Frison Effect”.

RETOUCH MODELS AND MIDDLE PALEOLITHIC SCRAPERS

Dibble (1984) would further apply the “Frison Effect” in “Interpreting Typological Variation of Middle Paleolithic Scrapers: Function, Style, or Sequence of Reduction”. Dibble would compare three types of scrapers (single, double, and convergent) from Middle Paleolithic assemblages excavated in Bisitun, Iran, and conclude that instead of being three distinct types based on morphology and implied function (Bordes 1961) the scrapers were essentially the same “type” expressed as products of retouch in a reduction continuum. He would go on to state that even though a certain amount of variability must be assigned to such underlying attributes of quality of raw materials, knapper skill, or “errors”, greater weight and caution must be given when types are defined by morphology, design, and or function. Finally, he would conclude that perhaps as much of one-fourth of Bordes’s 63 discrete Middle Paleolithic flake tool assemblage types (Bordes 1961) could be explained by his reduction retouch model (Dibble 1984: 435).

Dibble (1987) would continue to refine his retouch model with analysis of four different classes of scrapers (*racloirs*) from three different Middle Paleolithic sites in Iran and France (Bistiun, La Quina, and Combe Grenal). The analysis strongly supported a bifurcating model of intensive retouch leading to modification of more edge loci (see Figure 4.4).

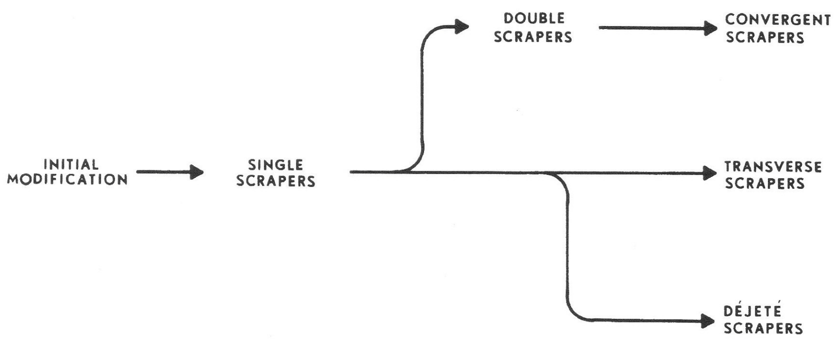


Figure 4.4. Flowchart suggesting typological consequences of reduction. Movement from left to right reflects increased reduction of the edge(s), while branching reflects retouching of additional edges. Adapted from Dibble (1987:115; Figure 4).

Rolland and Dibble (1990) would further refine the retouch model by factoring in raw material constraints (including blank size, tool stone quality, availability) and intensity of reduction (including flintknapper skill sets, local variations, settlement types, climatic change, and food species selection). They would refer to this amended model as a "new synthesis" of Middle Paleolithic variability (Rolland and Dibble 1990: 480).

Not all researchers accepted the original retouch model or the new synthesis as the explanation for variability in Lower and Middle Paleolithic scraper assemblages (Baumler and Speth 1993; Pettitt 1992; Mellars 1995; and many more). Some like Kuhn (1990, 1991, and 1992) would try to build on Dibble's model with indices that would attempt to quantify retouch intensiveness and equate it to invasiveness (*e.g*. Kuhn's Reduction Index). Several researchers tried to replicate Dibble's models with experiments and studies of their own (*e.g.* Close 1991; Barton 1988; Gordon 1993) often, with limited success. Finally, other researchers would take a portion of the retouch model and apply it to other Middle Paleolithic tool types, such as notched tool reuse and maintenance in relationship to tool stone availability (Holdaway, McPherron, and Roth 1996).

Dibble (1991a:264) would agree that his retouch model did cause and would cause considerable controversy. In 1995, Dibble would attempt to reconcile his retouch model with questions posed but not immediately addressed by some of these other researchers in, "Middle Paleolithic Scraper Reduction: Background, Clarification, and Review of the Evidence to Date", (Dibble 1995a). Questions still remained.

Experimentation and testing of the Dibble's retouch model (in reference with Kuhn's Reduction and invasiveness index) would continue into the 21th century. Hiscock and Clarkson (2005) would conduct their own experimentation on Kuhn's geometric index of reduction and later (2007) they would, like so many other researchers before them, turn to archaeological materials from Combe Grenal to test these models with notched flake types.

REJUVENATION IN PREHISTORIC NORTH AMERICAN ARTIFACT ASSEMBLAGES

Rejuvenation was recognized as a concern in typologies (Goodyear 1974; Miller 1980) and artifact variability in general by North American archaeologists during the same time period as Dibble was hypothesizing on the effect of retouch on Lower and Middle Paleolithic scraper assemblages. A good example is Goodyear's resharpening experimentation of "Dalton" assemblages from the Brand site in Missouri. Goodyear demonstrates how during the use-life of one particular hafted tool ("Dalton" type projectile points), its morphology, and inferred function, can change dramatically before expention (Goodyear 1974:28-32). A similar illustration of rejuvenation of hafted bifaces is the progression from "Perkiomen" projectile points to endscrapers and then into drills (Kinsey 1972; Kraft 1970; Andrefsky 1984). Schiffer (1972) would refer to this as “lateral recycling”. Shott (1995) would later demonstrate how similar use-life resharpening of hafted endscrapers in Paleoindian scraper assemblages could ultimately produce spurred endscrapers, a “diagnostic” trait of Clovis artifact assemblages. The most controversial application of rejuvenation theory in North American archaeology, however, would be those experiments conducted, co-authored, or influenced by Flenniken.

FLENNIKEN-THOMAS DEBATE

In the same year that Dibble would start his Middle Paleolithic scraper retouch hypothesis (Dibble 1984) Flenniken would complete his first rejuvenation experiment (Flenniken 1985). Flenniken’s initial rejuvenation experiment consisted of the replication of 24 composite spear points, 11 of which were used by five hunters in simulated hunting scenarios of two live feral goats (Flenniken 1985). The composite spear points were recovered and repaired. Nine of the 11 rejuvenated projectile points changed morphological type after this single hunting scenario. This first experiment demonstrated two conclusions and three observations. His first conclusion was that the “reduction continuums” were stable “signatures” but the morphological types were not (Flenniken 1985:272-273). The second conclusion was that non-rejuvenated projectile fragments that were discarded because of un-recoverable damage cannot be used in “archaeological illustrations” as dotted line figures (Flenniken 1985:273). This is due to the fact that ". . . diagnostic portions of the original projectile points are missing" (Flenniken 1985:273). His observations were somewhat straight forward if not intuitive. First, thicker projectile points can withstand greater damage during hunting. Second, that most of the projectile point breakage occurs at or near the hafting element due to bending fractures (Flenniken 1985:273). Finally, that prehistoric "spear- based" hunters probably used similar composite spears. There were, however, several problems with this first experiment. First, public outcry at using live animals in simulated hunting experiments reached to the highest levels of Washington State University (Flenniken, personal communication). Replication of the experiment using live animals in today's more conscientious and public aware environment would be impossible. Second, controls over the original large projectile point types were fairly relaxed. Finally, the goals of the experiment were not implicit to the impact of rejuvenation on use-life, but to advance the concept of the validity in reduction continuums and reduction systems analysis.

Towner and Warburton (1985) would continue the debate by giving a technological basis for Flenniken's arguments for projectile point rejuvenation at the 50^{th} annual session of the Society for American Archaeology in Denver, Colorado. Warburton and Towner would refine their technological approach and publish their results five years later (Towner and Warburton 1990). This experiment is discussed at length in Chapter 5.

Warburton and Towner's 1985 experiment may have been the impetus for the second Flenniken experiment. In this experiment, Flenniken and Raymond (1986) used replicated atlatl darts to fully flesh out their rejuvenation hypothesis. Stricter controls were exerted over the experimental collection; more care was given to adherence to a particular "type" (Elko corner-notched; ECN). Thirty-six projectile points were replicated, of which 6 were rejected because of "manufacturing" errors. The thirty remaining points were then hafted in foreshafts using materials and methods consistent with archaeological examples recovered in Great Basin sites. It is significant to note that even at this technological stage, 73.3% of the projectile points underwent morphological changes necessary for hafting. This in turn produced changes in variety (Flenniken and Raymond 1986:606). The points were then used in simulated hunting scenarios without involving live animals. The points were used until notable damage occurred. The broken points were ultimately recovered and returned to the laboratory for analysis and rejuvenation.

Significant observations were made. First, Flenniken and Raymond (1986:607) recorded that most of the breakage occurred at the hafting element (ca. 70%) rather than the tip (43.3%), thus reinforcing their original experiment. Again, this observation runs counter intuitive to many of the "resharpening" arguments that assume that most of the breakage of projectile points would be at the tip (Holmer 1978, Thomas

1981, Frison 1976; Odell and Cowan 1986). Next, out of the 24 atlatl points capable of rejuvenation, 8 of the 24 rejuvenations resulted in a morphological change in type (33.3%; Flenniken and Raymond 1986: 608). Their major conclusion was that:

> "The process of typing projectile points and fragments recovered from surface lithic scatters, single component sites, or non-stratified, multi-component sites on the basis of morphology is dangerous" (Flenniken and Raymond 1986:610)

The rebuttal to follow in the same issue of *American Antiquity* by Thomas (1986) attacked Flenniken and Raymond (1986) on several fronts using a wide variety of arguments to support Thomas' use of projectile points as time markers. Thomas was especially vigorous in defending the dichotomous key that he had earlier devised in morphological typing of Great Basin projectile points (Thomas 1970, 1981, 1983; see Figure 3.2). By example and argument, Thomas accused Flenniken and Raymond of "(a) misunderstanding of contemporary archaeological inquiry "(Thomas 1986:620). He went on to use his own dichotomous key to show that 5 of the 24 rejuvenated points were misclassified because of such variables as "proximal shoulder angle" (Thomas 1986:621). Thomas goes even further in manipulating the data in one of Flenniken and Raymond's tables to show that only 25% became "older" while 8.3% became "younger". This dilution of the total percentage changed (33.3%) by parsing is somewhat suspect.

Thomas also attacked the notions of flintknapping and replication. In general, he was highly critical that replicative research experiments could explain past human behavior. These criticisms are typical of the normative-empiricist paradigm (Dibble 1995a:302).

In the same year, another supportive study of Flenniken and Raymond (1986) was conducted by Titmus and Woods (1986) on atlatl dart point breakage. This was an important study, because many of the Great Basin projectile point typologies by the morphology proponents and anti-rejuvenation advocates were based on the analysis of complete projectile points and generally excluded fragmentary points. By providing insight into how projectile points break during their use-life, Titmus and Woods demonstrated that manufacturing and use breakage signatures are discernable and diagnostic. Unlike Flenniken's earlier experiments, the set of 34 atlatl points subjected to use-life breakage were not rejuvenated. They did, however, conclude that the majority of use-life breakage occurred on the proximal end (near the base and notches) of the projectile point. This is the loci that is most sensitive to changes of type through rejuvenation (Flenniken 1986:609-610) and which Thomas (1981:14-15) claimed would be least likely to change. A more complete summary of this experiment is discussed in Chapter 5.

The last exchange of academic broadsides in the Flenniken-Thomas rejuvenation hypothesis debate occurred three years later in 1989. Flenniken and Wilke (1989) synthesized their arguments into 12 basic assumptions made by Great Basin archaeologists that relied on using morphologically typed dart points as temporal markers. They further invalidated each assumption and concluded a rejuvenation use-life cycle for ECN and Northern Side-notched projectile points that could include changes into the Gypsum types, Little Lake types, and Humboldt types (Flenniken and Wilke 1989:134-135; see also Figure Figure 2.5a and 2.5b). This was similar to morphological changes suggested in Hawken points by Frison (1976).

The anti-rejuvenation protagonists for dart points as temporal markers regrouped and two years later, gave their rebuttal. Bettinger, O'Connell, and Thomas (1991), three archaeologists largely responsible for naming and refining the vast majority of Great Basin projectile point types (see Figures 2.5a and 2.5b), used the protocols that they knew best: selective measured attributes and statistical inference. Their main contention is that if ECN and Northern Side-notched (NSN) are the "archetypes" (Bettinger, O'Connell, and Thomas 1991: 167), then the rejuvenated products (Gypsum, Little Lake, and Humboldt types) should be smaller (less overall length in the collection means) and weigh less. Thomas completed the study of over 6000 extant museum specimens from 31 different sites to test this hypothesis. This collection is referred to as the "Great Basin Database", a collection that has been either drawn or Xeroxed with measured and weighed projectile point attributes. Their conclusions:

> "The purported archetypes are the heaviest in only three of the 31 collections documented… In the other 28, the heaviest points are those alleged to have been rejuvenated (Table 2). Moreover, in the 11 cases in which a statistically significant difference exists between the mean weight of the largest archetype and that of the largest rejuvenated form, it is the rejuvenated form that is heavier --- all 11 times" (Bettinger, O'Connell, and Thomas 1991:171)

Wilke and Flenniken's (1991) terse rebuttal makes two additional points. First, Bettinger, O'Connell and Thomas chose not to argue with Flenniken and Wilke on their presentation of the 12 assumptions of Great Basin "projectile points as time markers" protagonists, but rather the use-life rejuvenation hypothesis of ECN and NSN to subsequent smaller types. Second, Wilke and Flenniken went further to show that comparing extant ECN points and NSN points to extant Humboldt, Gypsum, and Little Lake points was illogical, due to the fact that all might be rejuvenation products and the original points (the one that would make the difference in comparisons) were removed from the reduction sequence and subsequently, no longer exist.

As a final rebuttal to Flenniken and Raymond (1986) and Wilke and Flenniken (1991), Beck (1998) resurrected much of Thomas' Gatecliff data (Thomas 1983) in support of using Great Basin projectile points as temporal markers. Beck's approach was empirical, statistical, and non-replicative.

Additional use of replication and carcass experimentation is in Hutchings, where beef ribs targets and replicated Clovis points were used to determine lithic fracture propagation velocity in Clovis points (Hutchings 1997) and Clovis channel flakes (Hutchings 1999). These carcass experiments were replicative, however, the goal of the experiment was to determine lithic fracture propagation velocities in channel flakes, rather than investigation of retouch or resharpening.

More recently, Andrefsky (2006) would attempt to meld the retouch and rejuvenation models of Dibble, Flenniken, and Kuhn by creating an index of retouch for hafted bifaces (Hafted Biface Retouch Index; HRI). It has at its core the arguments proposed by Blades (2003), Clarkson (2002), Kuhn (1991-1994), Shott 1989 and Weedman (2002) of retouch being indicative of curation. It especially draws on Kelly (1988) and the notion of hafted dart points used as dart points as well as cutting, sawing, and scraping tools and in some cases, cores for raw materials (alternative use-life). In this experiment, seven hafted bifaces manufactured from Glass Buttes, Oregon obsidian of differing morphology (side-notched, corner, notched, stemmed, etc.) were used to saw through 3 cm dried twigs and then cut deer hide leather. After becoming too dull to cut leather, they were resharpened on the armature through five rejuvenation cycles. An index of 16 quadrants were established on the biface bilaterally from tip to ligature line; dorsal and ventral sides; eight quadrants on a side. A measure of flake invasiveness indicative of retouch to each quadrant was measured and recorded after each of the five resharpening episodes. Indices from the experiment collection were compared to a random sample of 28 obsidian projectile points excavated from the Birch Creek Site (35ML181) in southeastern Oregon. The projectile points were analyzed by XRF to determine the location of their obsidian source. A basic conclusion was that those bifaces with a higher HRI (indicative of higher retouch) were also those bifaces manufactured from a more distance obsidian source. Bifaces with closer obsidian sources had a lower HRI. It appears, however, the HRI has a few drawbacks: A) it is only most useful on thinner, less diamond shaped profile bifaces (Andrefsky 2006:753). B) There is no experimental data on using some of the bifaces for their apparent intended purpose, i.e. projectile points. Only resharpening or blade retouch was accomplished. No discussion was given to impact fractures and repair after breakage.

CONCLUSIONS

Over the last 40 years, the larger functionalist vs. stylist issue seems to have coalesced into smaller, idiosyncratic arguments (i.e. the Dibble retouch model, Kuhn Retouch Index, Clarkson Index, the Flenniken - Thomas debate, etc.). Many of the original protagonists have passed on. With the passing of Louis Binford in April, 2011, it is interesting that a concise, compelling, and definitive lithics variation model has yet to be given.

CHAPTER 5

THE CONTROL COLLECTION: OVERVIEW OF THE EXPERIMENTS

INTRODUCTION

Andrefsky (1998:6-8) traces the origins and evolution of lithic replicative research and flintknapping in *Lithics: Macroscopic Approaches to Analysis* from early 1850's English artifact counterfeiters such as Edward Simpson (Blacking 1953; Andrefsky 1998:7) to the scientific approaches of researchers like Flenniken and Raymond (1986); Frison (1968,1989), and Titmus and Woods (1986). Amick and Mauldin (1989) also give an excellent treatment of replicative approaches in *Experiments in Lithic Technology.* As an advocate for the cognitive approach, Flenniken would be the outspoken voice for these types of experimental studies. Over 25 years ago, Flenniken outlined what he believed to be the future of lithic replicative studies and flintknapping in a processual and cognitive context (Flenniken 1985). Specifically:

> "Cognitive archaeology must have participants with in-depth skills and information that can only be manifested, in terms of flintknapping, in the discipline by replication. Replication of flaked stone tool reduction technologies within strict scientific and experimental guidelines will be the *only* demonstrable method of understanding prehistoric behavior reflected by flintknapping. This process, according to Crabtree (1975: 105) 'represents 99.5 percent of the history of mankind.'" (Flenniken 1985:200)

This current experimental replicative approach incorporates a methodology to examine four breakage/rejuvenation experiments, compare them, and ascertain common rejuvenation signatures. These signatures will then be used to analyze extant and broken projectile point collections from four significant EGB archaeological sites. By the integration of experimental rejuvenation experiments with analysis from assemblages from archaeological contexts, the rejuvenation signature hypothesis will be tested for validity and applicability in research.

TITMUS AND WOODS FRACTURE PATTERN EXPERIMENT (TW)

The research goal of the Titmus and Woods (1986) study was to determine atlatl dart point fracture patterns and differentiate between those factures caused during manufacture and those fractures caused during use. Unlike contemporaneous experiments of Flenniken-Raymond and Warburton-Towner, rejuvenation of projectile points after breakage was not included in the research set.

The Elko Corner-notched atlatl dart point type (ECN) was used during this experiment because of previous investigations (Flenniken 1985; Flenniken and Raymond 1985; Tower and Warburton 1985) and with previous experience with manufacture of the ECN type. One of the major goals of the experiment was to record manufacture induced fracture patterns.   Titmus and Woods also selected this type because of its propensity to break during manufacture, especially around the notches and barbs. This is probably due to the narrow notch-width or notch opening index (Thomas 1981:14; see Figure 3.1). Narrow notch widths limit the space in which the notching tool can be operated, whether notching is accomplished using the palm-vise method (used by most flintknappers) or the finger-vise method (perfected by Titmus---see Titmus 1985:254-255).

Thirty-nine ECN projectile points were manufactured from three different obsidian sources (Glass Buttes, Oregon; Browns Bench, Idaho; and Centennial Mountain, Idaho). For illustrations, see Figure 5.1. Nine (23%) of the projectile points were broken during manufacture, at which point the manufacture trajectory for these projectile points was terminated. The remaining 30 projectile points were used in the use-breakage experiment.

The 30 projectile points were hafted similar to Flenniken-Raymond, Warburton-Towner, and Spencer. Hardwood dowel foreshafts, elk-leg sinew binding, and pine/charcoal mastic were all used. The primary dart shafts were also hardwood dowel (after Raymond 1986). The atlatl replica was fashioned after the Winnemucca Lake atlatl (Harrington 1959; Hester 1974:29-34), a typical “Great Basin” style atlatl. All 30 dart points were thrown at various materials, both “hard” and “soft” targets, until use-breakage was achieved (Figure 5.2).
Two different data sets were collected: projectile points broken during manufacture and points broken during use. Significant breakage signatures were observed for each data set. Manufacturing breakage

signatures are mostly confined to barbs. This was either the result of crushing the barb when attempting to apply pressure to the notch platform, lateral breakage from the notch platform to opposing notch platform, or longitudinal fracture from the notching platform that removes the same side blade margin (Figure 5.3). The conclusions for fractures occurring in manufacture are that fractures are usually limited to the barbs. This is a very recognizable fracture signature.

Fractures occurring during use-life can occur on any part of the projectile point blade, ligature line, or hafting element. Use break fractures were one of three types: bending, shearing, or crushing. When all breaks are considered, including a combination of breaks or "compound" breaks, most of the breaks occurred at or near the proximal end. This is in opposition to Thomas' assertion that most damage occurred at the distal end (Thomas 1981:14), leaving mostly bases un-fractured. Odell and Cowan (1986:204) were the only other experimenters that noted similar damage to tips only; however, they attributed this to the mastic used (Elmer's Glue®) and using cherts and flints rather than brittle obsidians. Generally then, bases are the typological "money-spot", most likely to be reworked (especially for obsidian projectile points). Flenniken and Raymond's rejuvenation hypothesis of the majority of rejuvenation occurring at the proximal (basal) location was substantiated.

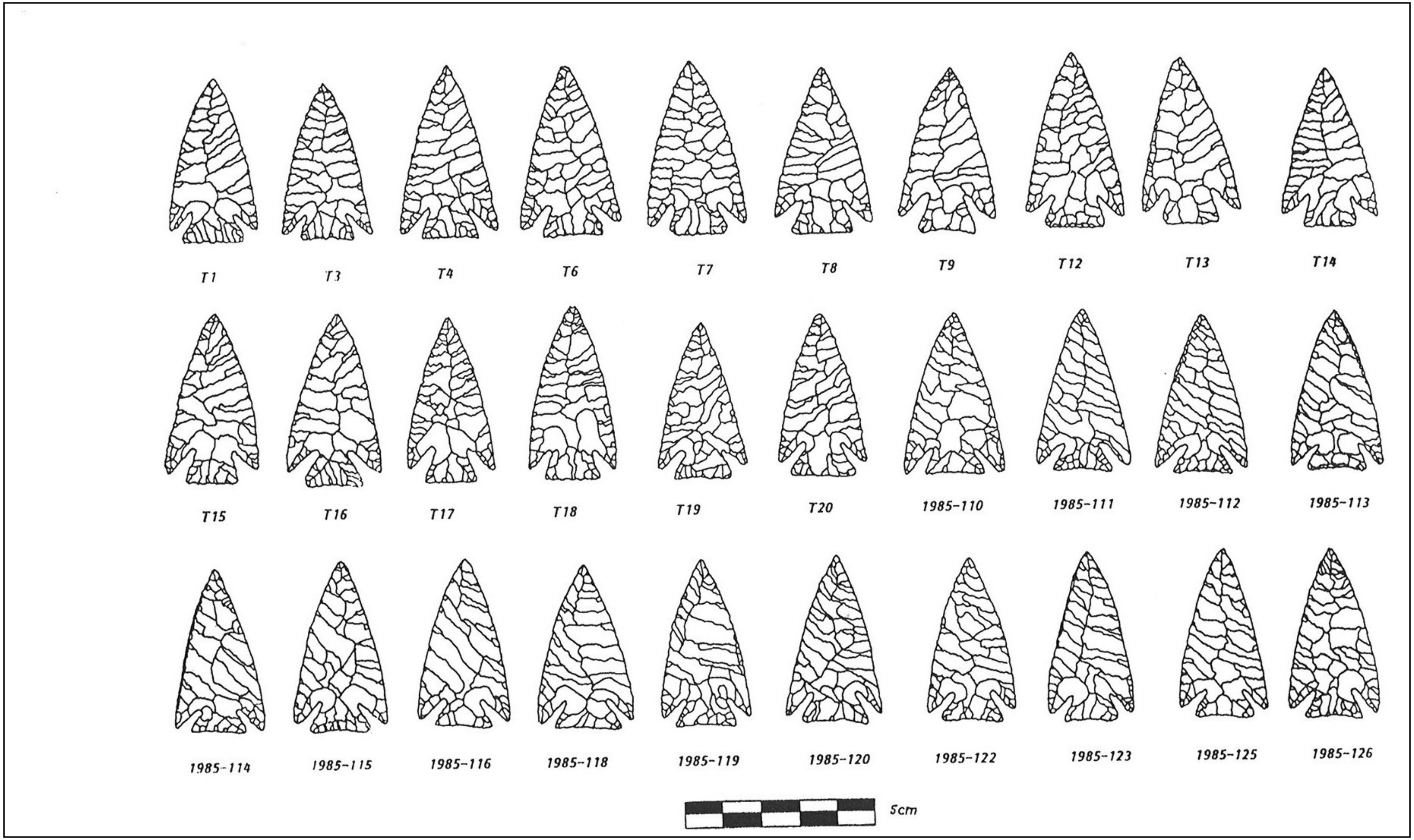


Figure 5.1 TW experiment projectile points prior to use breakage. After Titmus and Woods (1986:39; Figure 1).

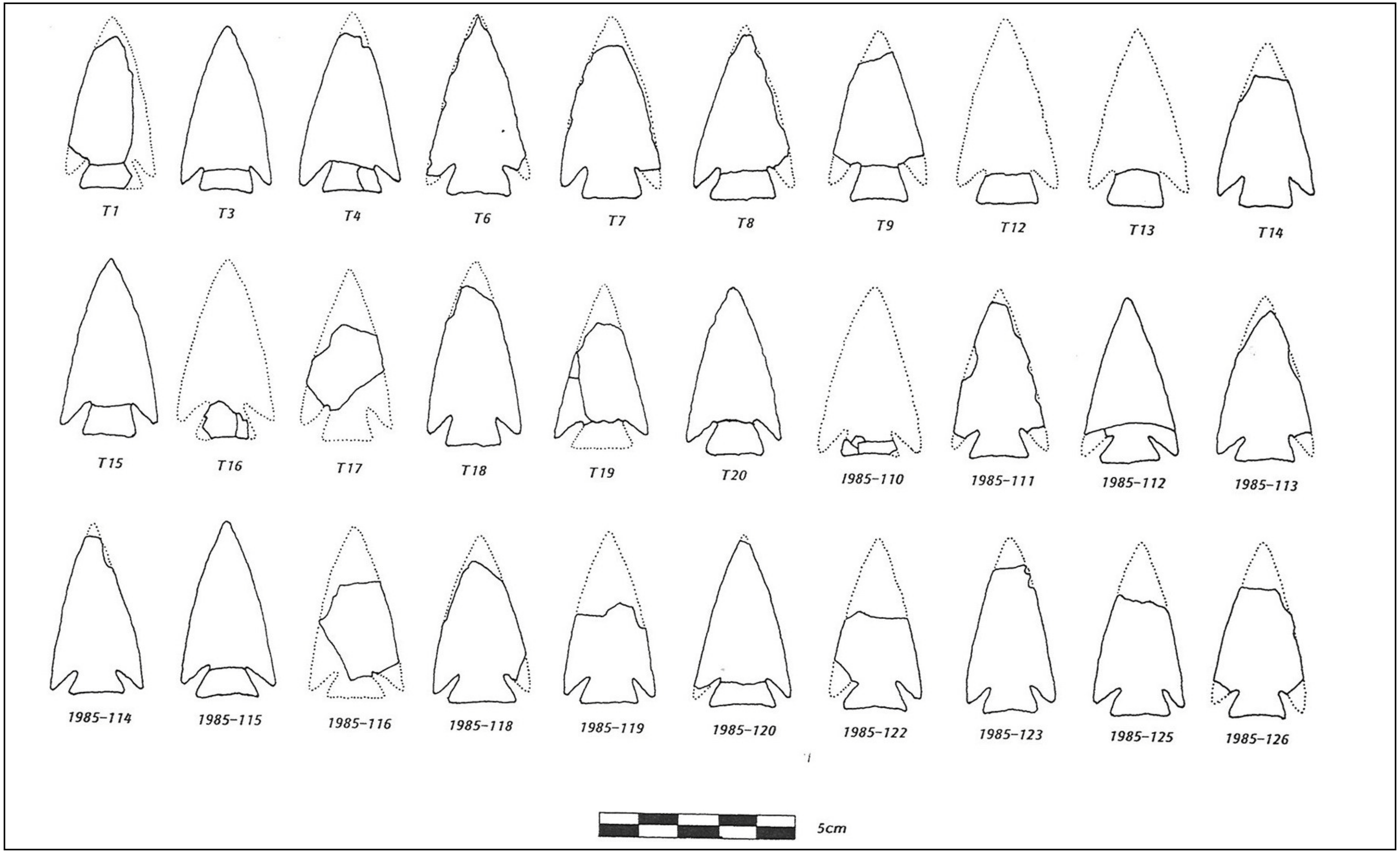


Figure 5.2 TW collection after use breakage. See Titmus and Woods (1986:44; Figure 4).

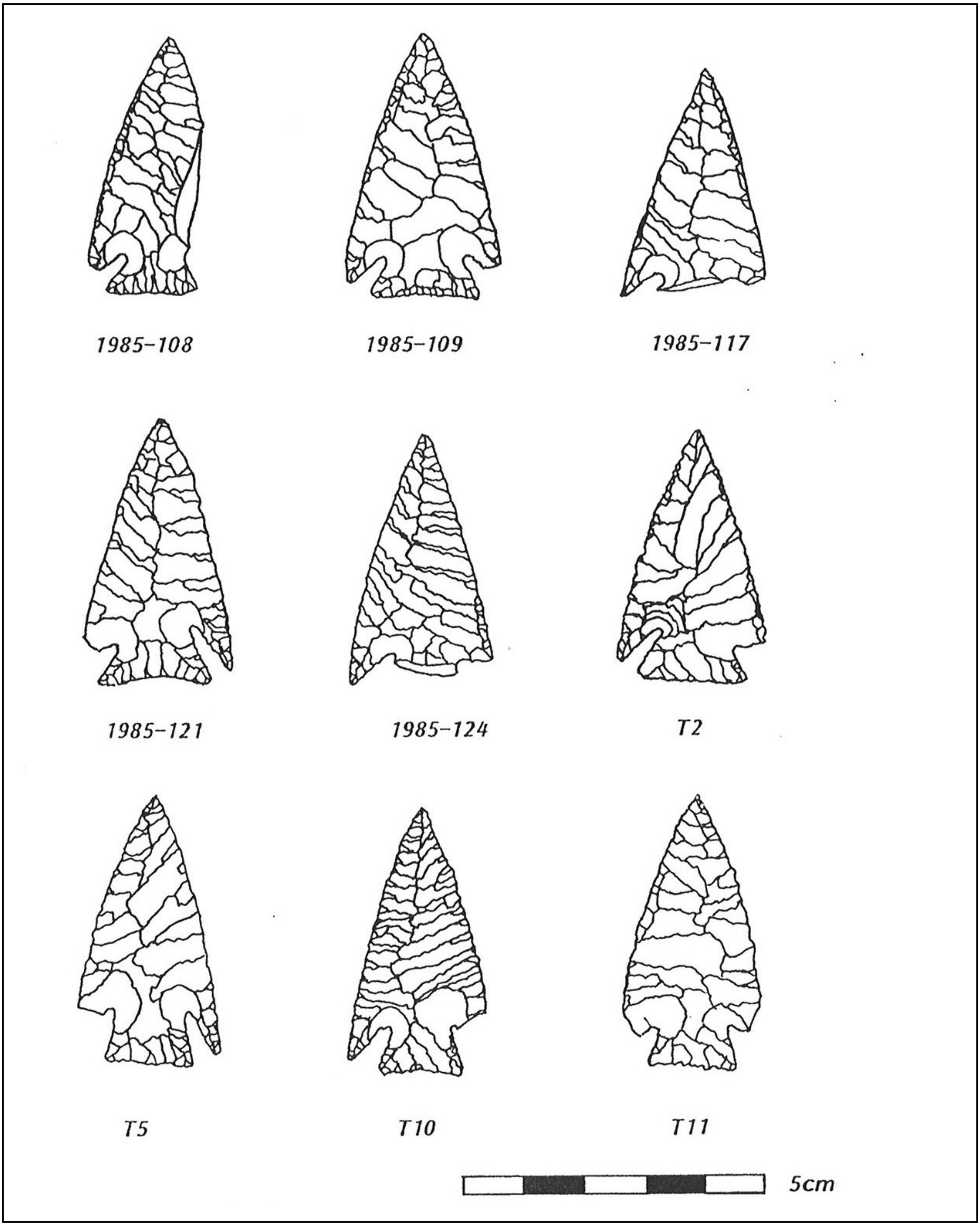


Figure 5.3 Breakage during manufacture. After Titmus and Woods (1986:42).

Maintaining consistent point morphology, especially size, was the most challenging variable during ECN replication. Thomas (1981:14-15) was supported in the Titmus and Woods study in the rejection of length, width, and thickness as morphological type variables.

Titmus and Woods successfully maintained that breakage pattern analysis can be applied to projectile point fragments. Currently, these fragments are usually only used in type frequency charts and tables. With application of Titmus and Woods study, new information might be obtained from these fragments.

WARBURTON AND TOWNER EXPERIMENT (WT)

Towner and Warburton (1990) (referred as the Warburton and Towner [WT] experiment in order to avoid confusion with the Titmus -Woods [TW] experiment) viewed rejuvenation as a vital part of curation. Curation of stone tools by prehistoric peoples may have originated in the Lower Paleolithic. Ethnoarchaeological research in Australia (Binford and O'Connell 1984; Gould and Saggers 1985), Alaska (Binford 1979, 1980), and Africa (Gallagher 1977) has observed that modern hunters-gatherers curate stone tools. Curation as a part of artifact variability in archaeological assemblages was part of the Binford-Bordes debate.

WT used curation as defined by Binford (1979) as the spatial and/or temporal separation of tool manufacturing loci and tool use/discard loci.

Rejuvenation in stone tools, then, is often that active process between manufacture and discard. Although there are several ethnographic accounts of projectile point manufacture (Pope 1913; Holmes 1919; Cushing 1895), accounts of actual rejuvenation of stone tools is exceptionally rare.

Other authors have put forth the notion of conservation of energy in reworking or rejuvenation of projectile points (Hayden 1974; Keeley 1982; Odell and Cowan 1986). WT assert that high initial energy costs during manufacture would seem to reinforce curation oriented resharpening and/or rejuvenation.

Three aspects of rejuvenation were covered. Projectile point morphology, manufacturing debitage vs. rejuvenation debitage, and predictive modeling for projectile point shapes.

The first portion of the experiment used Oregon obsidians to produce 30 Elko Corner-notched (ECN) projectile points (Figure 5.4). Preforms (point blanks) were produced by percussion then reduced and finished with pressure flaking.

One projectile point was broken during manufacture (longitudinal fracture from the notching platform that removed the same side blade margin ---see Titmus and Woods 1986:43). This point was excluded from the additional phases of the experiment. Two points were also damaged during manufacturing (barb failures). They were rejuvenated and hafted; however, they did not meet type requirements as described by Thomas (1981) for ECN. ECN was described by Thomas (1981: 20-21) as having a Proximal Shoulder Angle (PSA) of 110° -150°; a base > 1.0 cm wide; a Basal Indentation Ration (BIR) of >.93. Length, width, and thickness, however, are not definitive type attributes. It is evident from the narration and drawings that the experimenters had the same problems as Titmus and Woods, Spencer, and to some degree, Flenniken and Raymond with maintaining ECN (according to Thomas 1981) replicated morphological types.

Foreshafts were willow (*Salix* sp.), binding was Elk leg-sinew (*Cervus canadensis*), and pitch mastic was ponderosa pine (*Pinus ponderosa*). Atlatl mainshafts were cane (*Phragmites* sp.). All 29 points were thrown with a replica atlatl at a dead ponderosa pine tree until damage to the projectile points could be discerned. Two projectile points were lost during the process. One projectile point sustained compound breakage and could not be rejuvenated. The projectile point that was broken during manufacture was removed from the study, therefore, only 26 projectile points were rejuvenated (Figure 5.5).

Fracture damage during use was very similar to damage observed in the Titmus and Woods experiment. Forty-one percent (11 points) received basal damage, ten points (37%) received tip damage, and 22% (6 points) received both tip and basal damage. This also agrees with the Flenniken - Raymond experiment and the Spencer experiment in that similar method, materials, and protocols were used. It also somewhat agrees with Bergman and Newcomer (1983), although in Odell and Cowan (1986:204) reported less basal damage. Materials

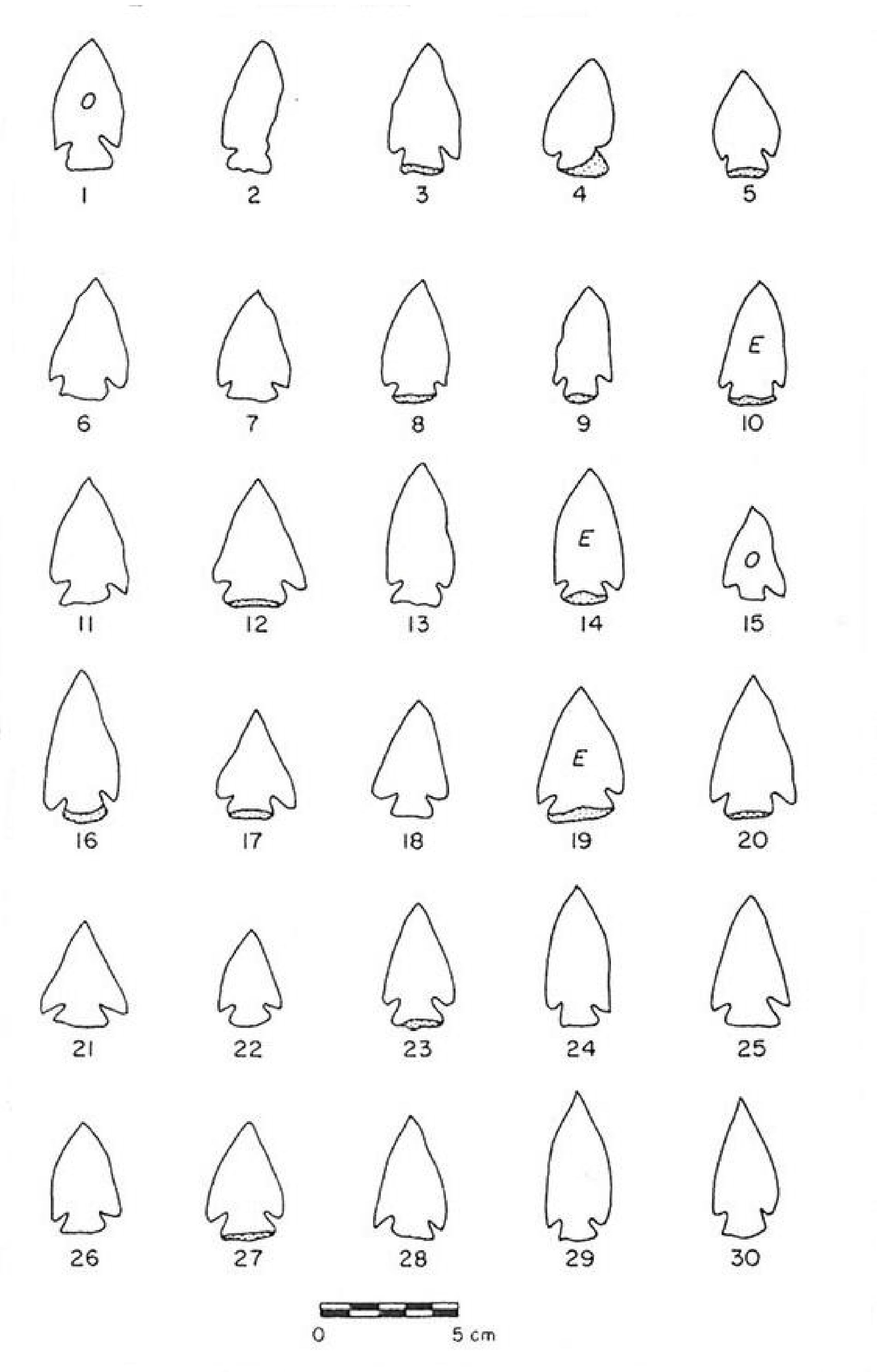


Figure 5.4 The original WT experimental set prior to rejuvenation. After Towner and Warburton (1990:312; Figure 1).

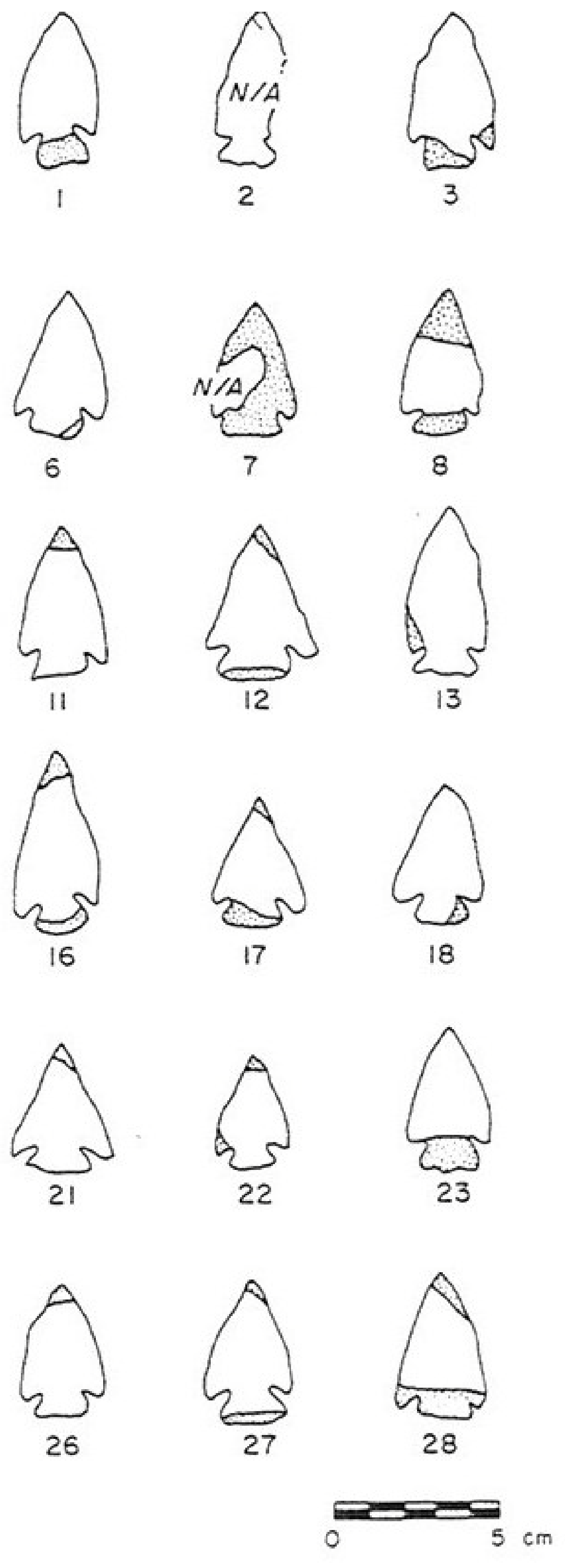


Figure 5.5 WT projectile points after use breakage. After Towner and Warburton (1990:313; Figure 2).

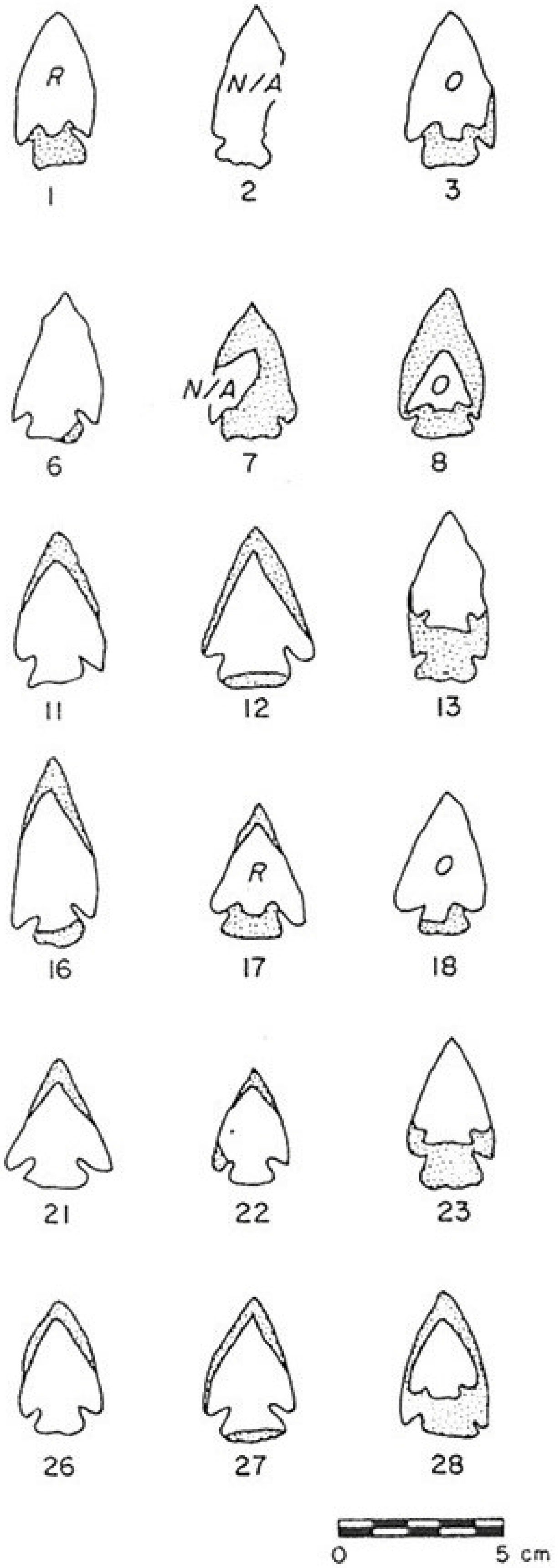


Figure 5.6 WT Projectile points after rejuvenation. After Towner and Warburton (1990:315; Figure 3).

(obsidian vs. flint), mastics (Elmer's Glue® vs. natural resins), delivery systems, and targets may play a role in these differences.

The 26 points were then rejuvenated (see Figure 5.6) by Towner with the same constraints expressed by Flenniken and Raymond as well as Spencer: 1) conservation of mass, energy, and materials, 2) attempt to maintain ECN morphology. The result was that 8 points changed type (31%) and 18 points (69%) retained ECN type. This differed somewhat from Flenniken and Raymond and Spencer where 33.3% (FR) changed type and 50% (SP) of projectile points changed type.

The second part of the experiment was to determine if pressure flake signatures (debitage) could be differentiated between production and rejuvenation. Essentially after preform blanks were produced by percussion (and percussion flakes removed and segregated) only pressure sequence flakes were studied. Pressure production debitage was characterized by three types of flakes: platform preparation flakes, pressure or tertiary flakes, and notching flakes. Rejuvenation debitage was characterized by what Towner and Warburton (1990:318) called rejuvenation pressure flakes, rejuvenation notching flakes, and rejuvenation alternative flakes. All debitage was segregated during manufacture and rejuvenation, counted, weighed, and sorted with 1/4, 1/8, and 1/16 inch mesh nested screens. Results of which are noted in Table 5.1.

Flake type	Screen size ¼"	⅛"	1/16"	Total
Production pressure	57(2.7%)	630(29.9%)	1421(67.4%)	2108(100%
Production notching	1(0%)	179(23.4%)	584(76.4%)	764(99.8%
Production platform preparation	0(0%)	18(4.1%)	417(95.9%)	435(100%
Rejuvenation pressure	2(.2%)	46(6.7%)	634(93.1%)	682(100%
Rejuvenation notching	1(1%)	14(14.7%)	80(84.2%)	95(99.9%
Rejuvenation alternate	0(0%)	16(11.7%)	121(88.3%)	137(100%
Total	61(1.4%)	903(21.4%)	3257(77.2%)	4221(100%

Table 5.1 Flake types and screen recovery of WT. After Towner and Warburton (1990:318)

Production platform preparation flakes are produced by a downward shearing motion designed to remove a small lip created by the previous pressure flake removal. These flakes have a "steep" platform to ventral surface angle, absence of platform faceting or ground (abraded) edge, and are small in size. In cross section, they exhibit a pronounced curvature (see Figure 5.7).

Production pressure flakes are produced to shape and thin the preform. They exhibit a distinct bulb of percussion and faceted/abraded edges. Pressure flakes are usually longer than they are wide and will have the remnants of previous flaking episodes on their dorsal surfaces (see Figure 5.7).

Production notching flakes are the most distinctive of flake types. They are small, lunate flakes with a distinctive "v" shaped platform. Due to their size and fragility, they are also often broken or crushed during the notching process (see Figure 5.7).

Rejuvenation pressure flakes and notching flakes are virtually the same as production counterparts except that rejuvenation products tended to be smaller. They would be indistinguishable in an archaeological context.

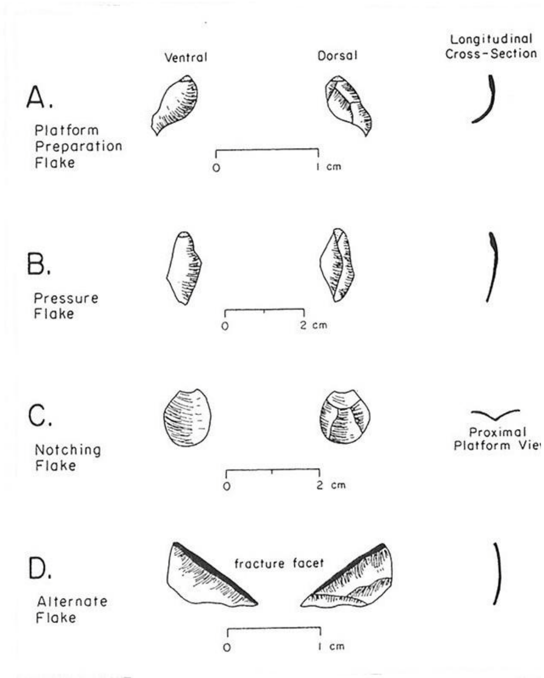


Figure 5.7 WT flake types produced during experiment. After from Tower and Warburton (1990:316; Figure 4).

Warburton and Towner claimed that “alternate” pressure flakes were unique to the rejuvenation process. Alternate flakes are produced by platform preparation. Instead of shearing, as is the case in platform preparation flakes during production sequence, here a pressure flake is removed from one side, the biface then turned over, and the next flake is produced using the flake scar from the alternate side as a platform. This preparation is very useful in rejuvenation of a “square” edge that was produced during a bending fracture.

Finally, the production artifact assemblages and rejuvenation assemblages were compared. Production assemblages contained only pressure debitage. Rejuvenation assemblages contained smaller pressure debitage, alternate flakes, and fragments of tangs, barbs, point tips, point bases, ears, etc.

Warburton and Towner suggested a number of implications. Relying on supporting data from Bamforth (1986), Binford (1979), Gramly (1980), and Kelly (1988), they believe this experiment may substantiate that prehistoric hunters did curate materials and bring such materials back to camp to be rejuvenated or “retooled”. They stated that empirical evidence (as suggested by Kelly 1988) might be found in temporary hunting camps where it is assumed that retooling and rejuvenation of the tool kit would occur. To obtain this data, however, they recommended that archaeological methodologies would need to be adapted to recover the very small rejuvenation assemblages that would be produced.

FLENNIKEN AND RAYMOND EXPERIMENT (FR)

Much of this experiment was discussed in Chapter 4. Access and permission was obtained to analyze the original rejuvenated projectile points of this experiment from Flenniken at the laboratory of Lithic Analysts, Hot Springs, Arkansas. The Flenniken and Raymond (FR) collection consists of willow foreshafts and 36 replicated projectile points. Six of the points were originally rejected because of typological discrepancies between replication idealization and typological classification (Flenniken and Raymond 1986:604). The remaining 30 were used in simulated hunting (see Figures 5.8 and 5.9) and 24 were successfully rejuvenated (see Figures 5.10 and 5.11). These materials were photographed, weighed, and

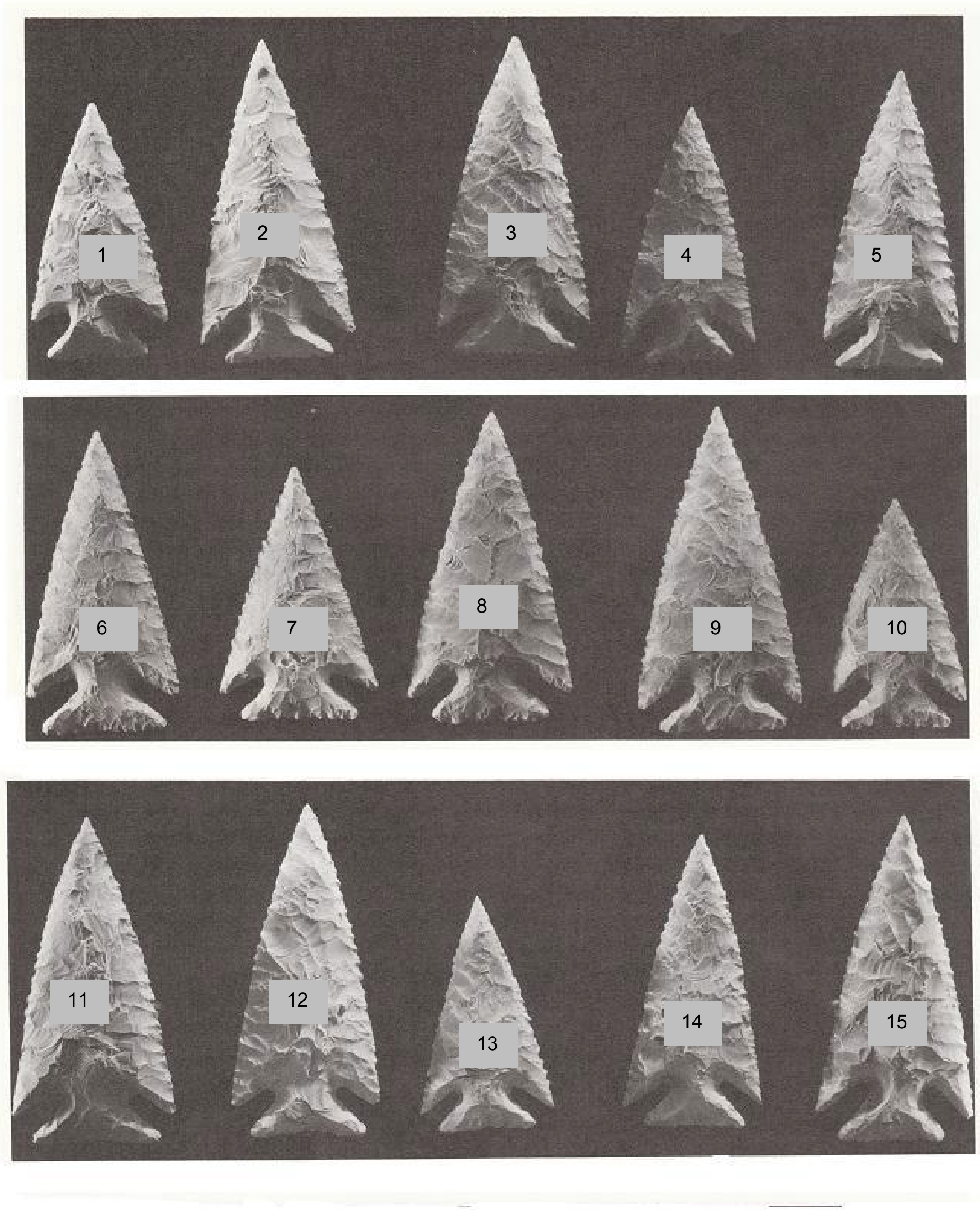


Figure 5.8 From Flenniken and Raymond (1986:605) adapted from Figure 1. Original projectile points prior to use and rejuvenation, population A. Numbering of projectile points corrected from original. Projectile points actual size.

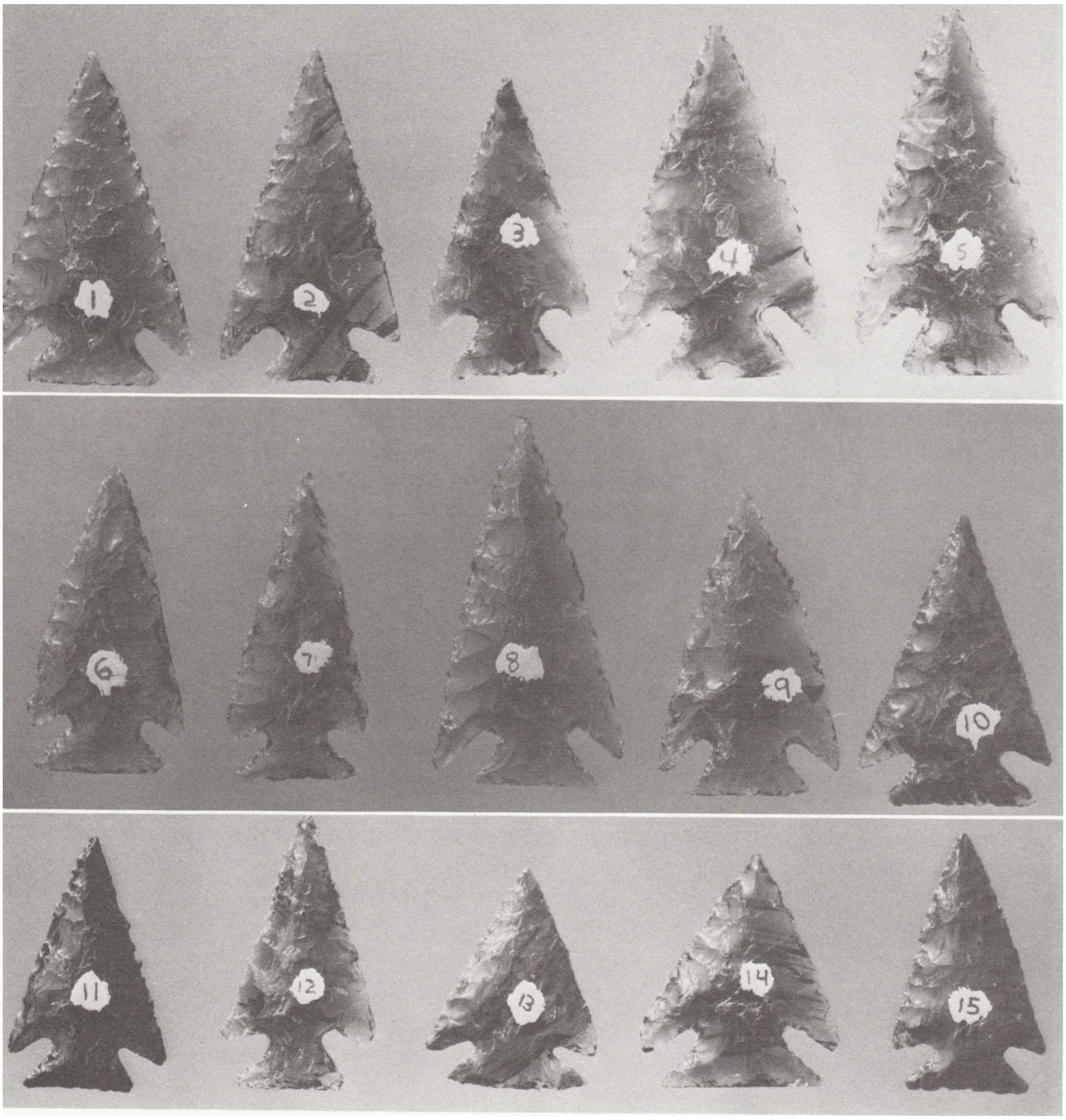


Figure 5.9. From Flenniken and Raymond 1986:606 Figure 2. Original projectile points in population B. Projectile points are actual size.

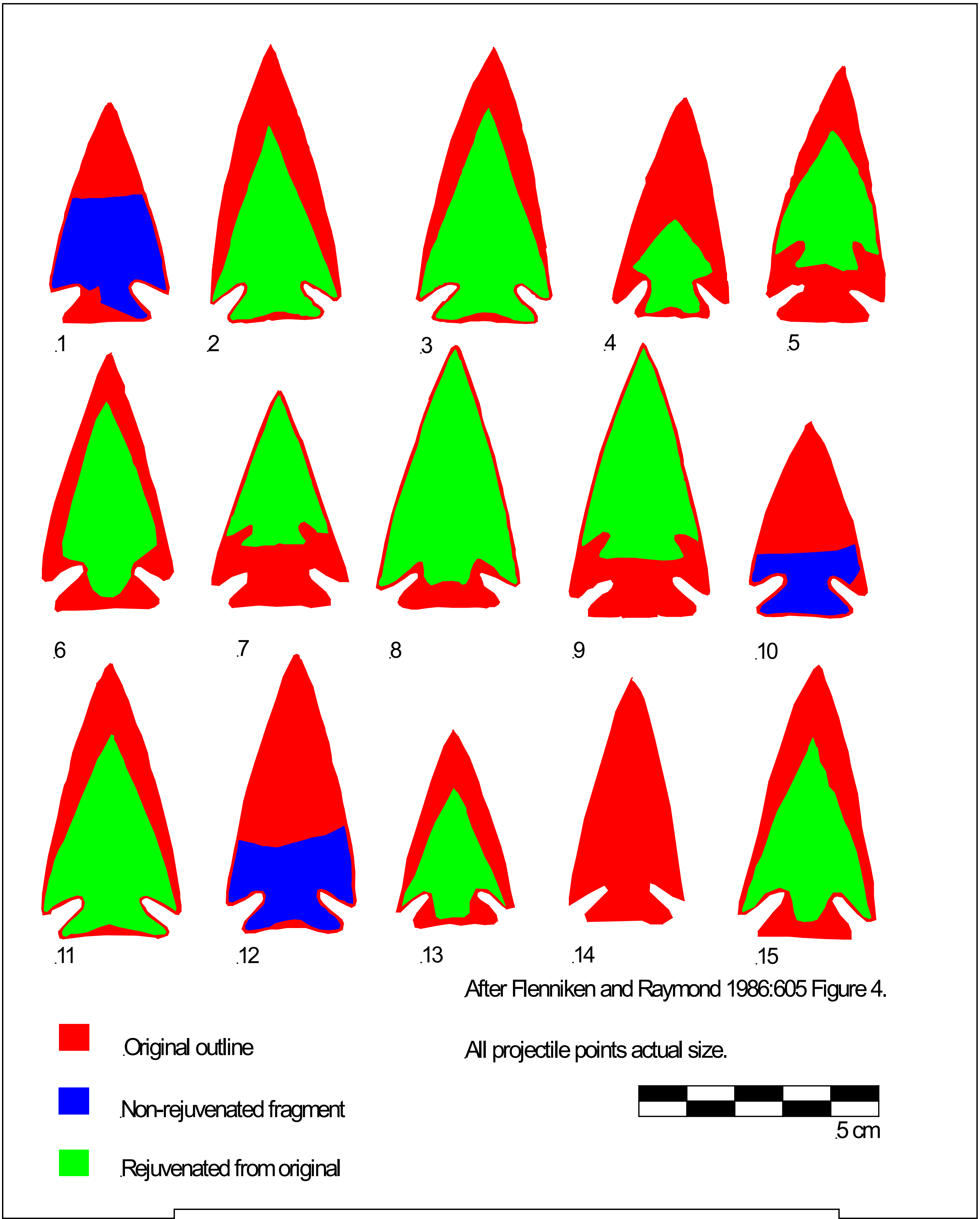


Figure 5.10 FR rejuvenated composite phases: original, fragments, and rejuvenated Population A.

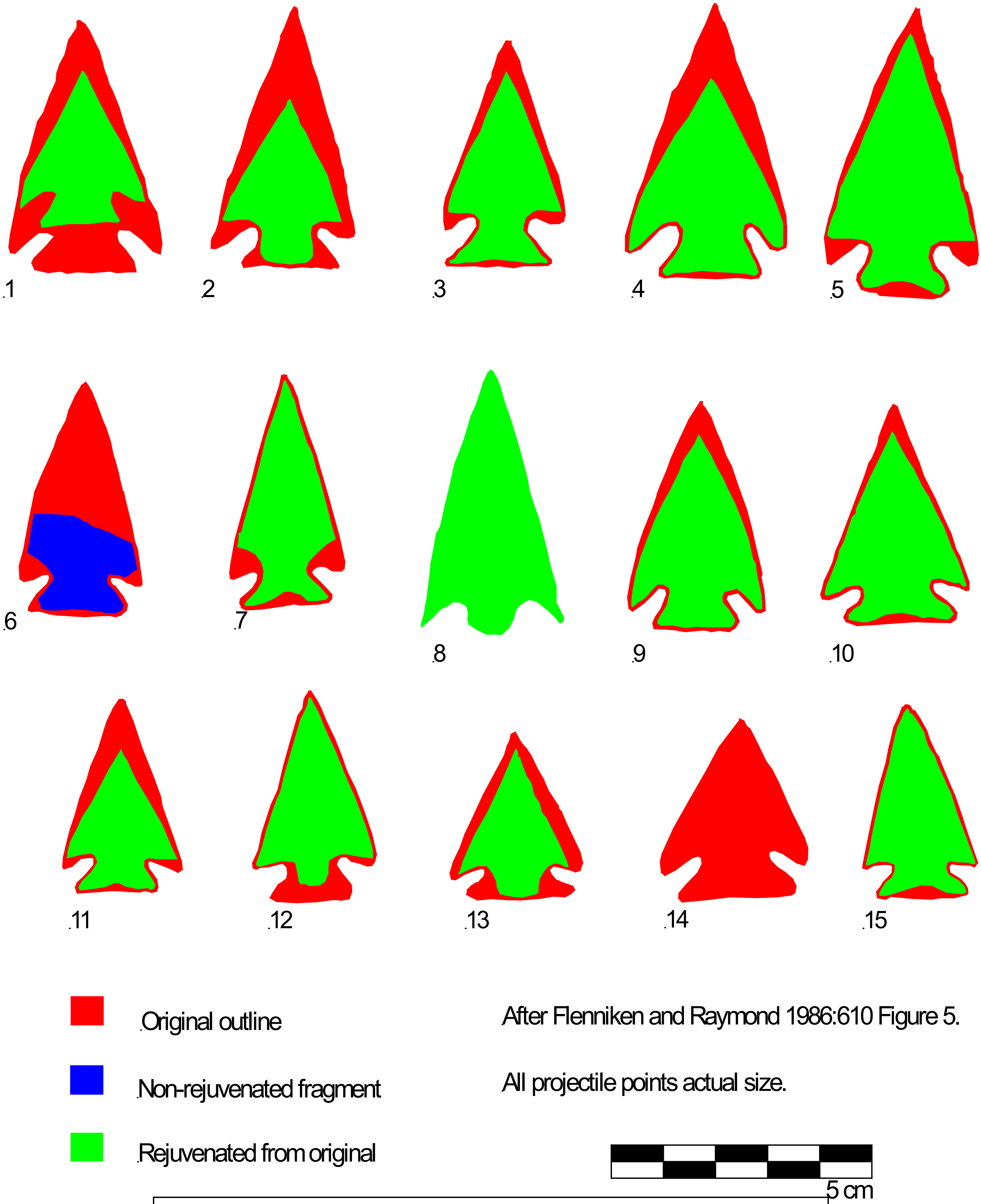


Figure 5.11 FR rejuvenated composite phases; original, fragments, and rejuvenation Population B.

measured with uniform data points corresponding to all collections to be studied. Each of the authors made 15 projectile points for this experiment. Flenniken produced population A (Figure 5.8) and Raymond population B (Figure 5.9). Population A was manufactured from flake blanks derived from a single nodule of Glass Butte, Oregon, obsidian. Population B, was manufactured from flake blanks derived from seven different nodules of Glass Butte, Oregon, obsidian. Reduction methods consisted of soft hammer percussion for nodule reduction to flake blanks, percussion thinning of flake blanks with soft hammerstone or antler baton, and pressure thinning and shaping with copper-tipped flakers and notching tools. Different skill levels can be discerned between the authors. As with Warburton and Towner, some difficulties were encountered insuring that Thomas' (1981) ECN attributes were strictly replicated.   Slight variations in morphology between the populations of ECN resulted from different skill levels or intra-quarry lithic material variation. Manufacturing errors did occur and usually resulted in the production of functional projectile points that varied greatly in shape. These points might be assigned by archaeologists to different morphological types representing different temporal types. As stated previously, these attempts were rejected from the experiment populations (6 out of 36 attempts, 16.6%).

As a summary from Chapter 4, significant observations were made. First, Flenniken and Raymond recorded that most of the breakage occurred at the hafting element (ca. 70%) rather than the tip (43.3%).

This observation runs counter intuitive to many of the “resharpening” arguments that assume that most of the breakage of projectile points would be at the tip (Holmer 1978, Thomas 1981, Frison et al.1976). Next, out of the 24 atlatl points capable of rejuvenation, 8 of the 24 rejuvenations resulted in a morphological change in type (33.3%; Flenniken and Raymond 1986: 608). Changes in sub-type resulted when five (16.6%) of the projectile points were fitted to the hafting element. The implications of these changes will be further discussed in Chapter 10.

SPENCER EXPERIMENT (SP)

The first phase in the Spencer experimental replication analysis was the complete study of earlier materials from Flenniken and Raymond (1986), Towner and Warburton (1990), and Titmus and Woods (1986). Review of these earlier materials was helpful in setting up the parameters of the proposed experiment, correlating methods and materials, and filling in research gaps. This experiment did many things the others did not. For example, using elapsed time as a factor in measuring conservation of energy, segregation of all flaking sequences, and notation of residual residues were all original techniques. It also gave the experimenter a firsthand understanding of previous research questions as well as perhaps insights into the larger question of a rejuvenation continuum.

Methods and Preparations

As stated earlier, I was granted direct access to the Flenniken Raymond experiment. I traveled to the University of Utah Museum of Natural History and was granted access to the Danger Cave, Hogup Cave, Cowboy Cave, and Sudden Shelter collections. Photographs and measurements of the atlatl point assemblages were conducted on-site and within a prescribed research time limit. Photographs throughout the entire methodology for all collections were taken with a Cannon EOS Rebel © digital camera with a calibrated target and camera stand. This procedure was used with all of the photographs, overcoming many of the distortion and parallax problems discussed by McPherron and Dibble (1999:38-52). Two high density format digital images per projectile point (dorsal and ventral sides) were taken. A control photograph with provenience information was also taken of each artifact. Each artifact was photographed with a 5 cm scale.

All projectile point weights were taken with an Ohaus © Portable digital scale and recorded manually to a MS EXCEL© spreadsheet. Although scale precision is within .01 gram, weights were rounded to the nearest .1 gram.

All measurements of projectile points were taken with calipers. A steel metric measuring tape was used to measure the few objects larger than 150 mm (6 inches) in the experiment, such as the mainshafts of the atlatls.

Both original and replicated projectile point morphometric information was taken from tables and figures included in Towner and Warburton (1990) and Flenniken and Raymond (1986) and adapted to standardized data points entered on EXCEL spreadsheets (see Appendix III). Corrections were made in some of the projectile point figures and descriptions for the new spreadsheets. For example, the original photographs published in *American Antiquity* (Flenniken and Raymond 1986:605, Figure 1) had been mislabeled and misrepresented in scale. Corrected scale and labeling are shown in Figure 5.8.

A base set of ECN were replicated from obsidian from the Massacre Lake source in north central Nevada, Glass Buttes source in central Oregon, and Mineral Mountain source in central Utah. All debitage was segregated by reduction stage for each point replicated and saved for future examination. The usual reduction sequence was as follows:

A) Detachment of a flake blank from a nodule-type core of obsidian with a soft hammerstone of wielded tuff (Kellogg, Idaho source).

B) Percussion flake blank preform shaping and thinning with soft hammerstone or deer antler baton.

C) Removal of original flake blade striking platform with antler baton or large diameter (4 gauge copper wire bit) pressure flaking tool. Often, larger alternate pressure flakes were removed to further thin proximal preform area (bulb of percussion).

D) Large diameter pressure flaking tool used to set platforms and initiate mid-stage preform thinning.

E) Medium diameter pressure flaking tool (6 gauge copper wire bit) used to shape projectile point and late stage thinning. Platforms were maintained in the similar manner as the previous step.

F) With projectile blank complete, two large pre-notch flakes were removed with the medium diameter pressure flaking tool from each corner intended for notching. Similar flakes were removed from the opposite side.

G) Palm-vise method was used to notch projectile point with a flattened-tipped copper notching tool. Notching flakes were immediately segregated.

The 30 atlatl projectile points in the experimental control were photographed (see Figures 5.12 and 5.13) weighed and measured using the protocols established in analyzing the FR collection. It was first planned to digitally render each projectile point with Photo Modeler® software for stereolithography analysis. Unfortunately, the time constraints to do this (8-10 hours processing time per projectile point) and costs ($200 to $300 per artifact at time of writing) were neither practical nor contributive to the goals of the research. These

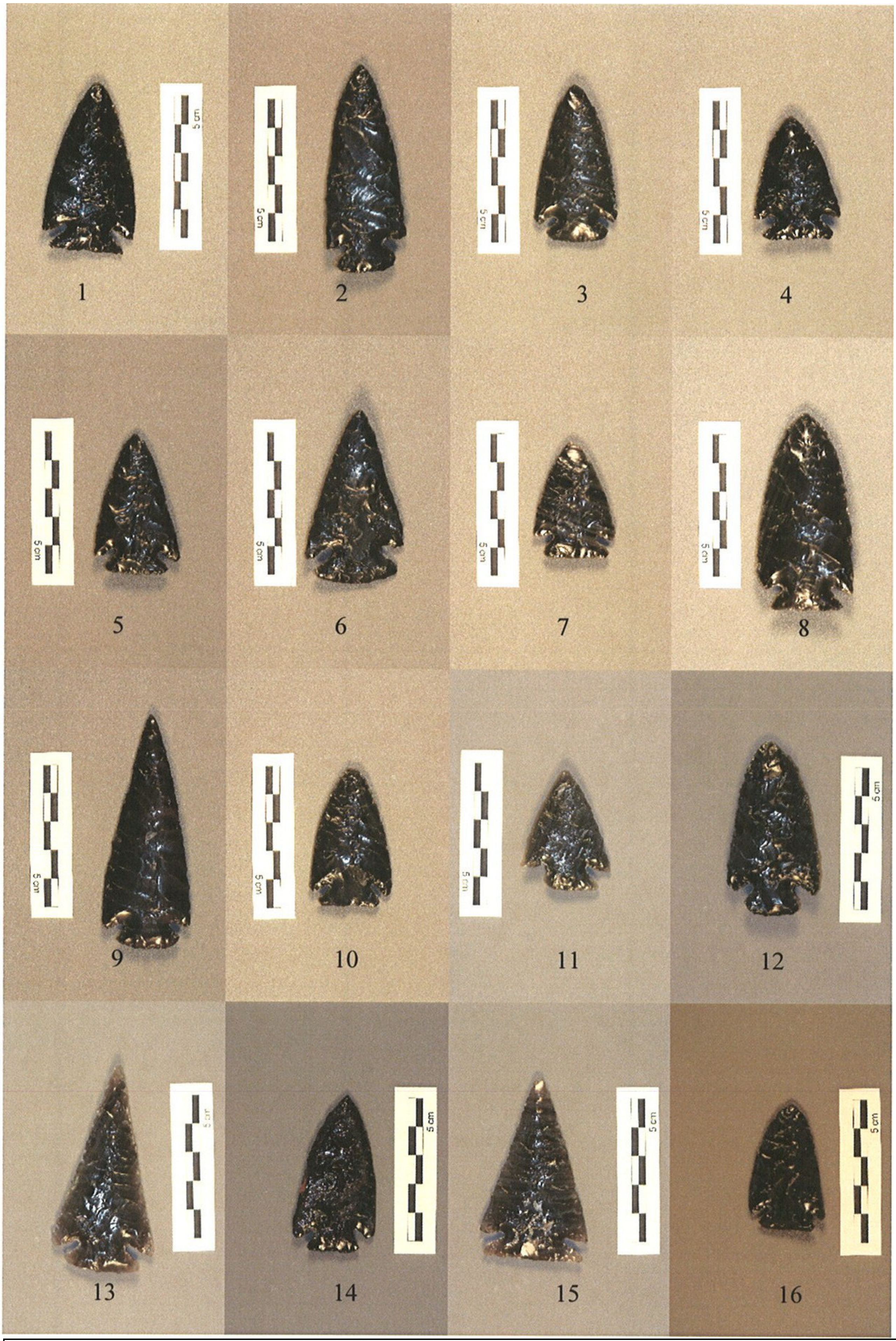


Figure 5.12 SP projectile point set 1-16. Scale: 50% actual size. (Photo credit A. Spencer).

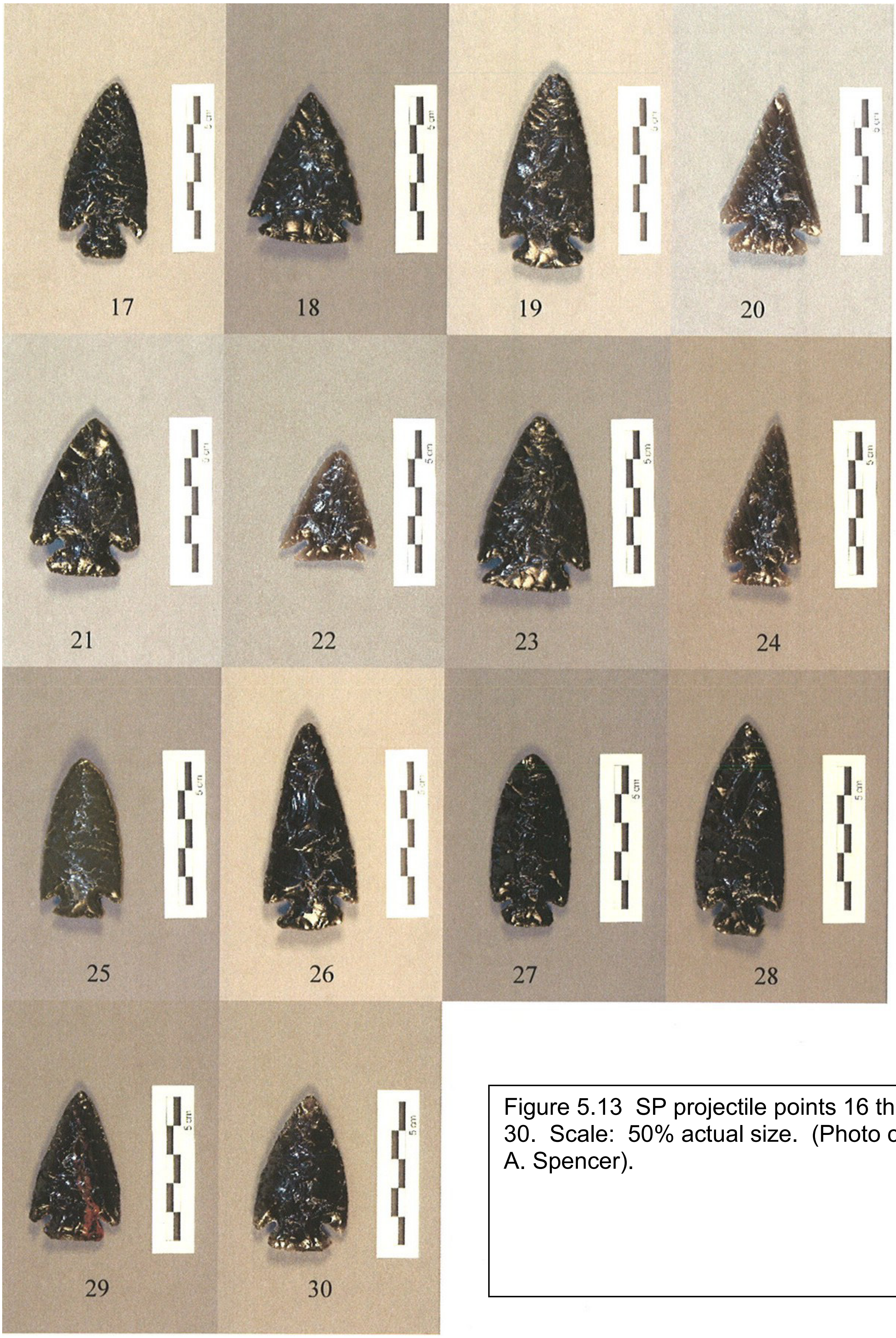


Figure 5.13 SP projectile points 16 through 30. Scale: 50% actual size. (Photo credit: A. Spencer).

photographs would be later hyperlinked to the attribute spreadsheet for analysis (Appendix III).

Next, each projectile point outline was drawn with QuickCad ©, a computer assisted drawing (CAD) program by AutoDesk ©. This produced a digital image that could be effectively analyzed for individual replicated projectile point attributes.

Prior to hafting, the projectile points in the SP were verified as Elko Corner-notched types using the IMACS guide (IMACS 2001) and Thomas' (1981) dichotomous key as a basis for typing (Figure 3.2).

In the final methodological procedure before hafting, each projectile point was assigned a unique number that was painted onto the projectile point surface (Figure 5.14). The foreshaft armature was correspondingly painted with a matching number (the identification number of the projectile point).

Figure 5.14. Detail of dart point on foreshaft with pitch mastic. (Photo credit: A. Spencer).

Prepared projectile points were then hafted on to 20 - 25 cm long by 1 – 2 cm diameter willow (*Salix* sp.) foreshaft armatures. These foreshafts were similar to specimens found at Danger Cave (Jennings 1957:190), Hogup Cave (Aikens 1970:59, 162,163), Falcon Hill (Hattori 1982:113-118), and NC Cave (Tuohy 1982:85). The points were fitted into sawn foreshaft armatures and held in place with a piñon pitch (*Pinus edulis*)/ charcoal mastic (Gibby 1993: 75). The willow foreshafts were only slightly larger in diameter than the foreshafts used in the TW and FR experiments.

The points were further secured to the armature by a ligature of chewed deer leg-sinew (*Odocoileus* sp.), let dry, and then sinew binding waterproofed with an additional coating of piñon pine pitch / charcoal mastic from pre-prepared pitch sticks (Figure 5.14).

Hafted darts were fitted into one of five 1.5 m fletched mainshafts. The mainshafts were birch doweling fletched with goose feather. A socket held the dart armature in place to the mainshaft. This allowed for quick change of foreshafts.

Considerable care was taken in determining the material for the mainshafts. Complete mainshafts in the archaeological record are very rare. Limited examples can be seen in recovered materials from Danger Cave (Jennings 1957), Gypsum Cave (Harrington 1933), Hogup Cave (Aikens 1970:161), and Newberry Cave (Davis 1981). Modern experimental examples are often bamboo, hardwood doweling, or cane (*Phragmites* sp.). Flenniken and Raymond (1986:607) and

Towner and Warburton (1986: 313) used cane. Raymond (1986), Titmus and Woods (1986:40), and Couch et al. (1999:30) all used birch hardwood doweling. Odell and Cowan (1986:199) used a “handcarved wooden shaft” of unknown type. For continuity in comparing contemporary experiments, birch hardwood doweling was used.

Simulated Hunting

A generic replication of a western North American atlatl (Figures 5.15, 5.16) similar to prehistoric specimens described by Harrington (1933), Aikens (1970:154-160), Dalley and Peterson (1970:283-285), Cosgrove (1947), and Guernsey (1931:71-72) was used to throw the darts approximately 10 meters into a white-tail deer carcass (*Odocoileus virginianus*) simulating a hunting scenario (see Figure 5.16).

Figure 5.15 Author with atlatl (spear thrower), fletched mainshaft, and foreshaft with dart point. (Photo credit: L. Spencer).

There were many facets of a hunting scenario that were not addressed. “Positioning strategy”, stalking, ambush, trailing, etc. were several of full range of hunting related behaviors that could not be replicated. This was not the goal of the experiment. The goal was to produce a data set of broken and ultimately rejuvenated projectile points.

Figure 5.16 Author throwing fletched atlatl mainshaft at carcass target. (Photo credit: L. Spencer).

As in all hunting situations, there were both strikes and misses, according to the distance of the target and skill of the hunter. The procedure recorded if the atlatl projectile point struck the target (approximately 35%), struck the backstop of 5/8” OSB (approximately 55%) or in the soil or woods in front or behind the target (ca. 10%). The experiment best attempted to replicate breakage from a thrown atlatl dart at velocities consistent with a hand-held “spear thrower”. Other experiments have used compound bows, crossbows or other machines to quantify the power behind the throwing of an atlatl and sophisticated ballistic measuring devices to measure speed of the atlatl as it approached or impacted the target (see Appendix II). I was confident that I could achieve my desired results (broken atlatl projectile points) within a hunting scenario without these extraordinary measures.

All of the projectile points used in the experiment typically fractured in one of five ways as described by other analysts (Bergman and Newcomer 1983; Barton and Bergman 1982; Frison 1978; Shea 1988; Titmus and Woods 1986; Woods 1988; Odell and Cowan 1986). Titmus and Woods (1986) suggest two slight additional variations on the five principal ways, listed below. Basically, the impact fractures are described as:

1. Burin fractures. The force of the impact of the projectile point on the intended or unintended target would produce a burin-like fracture usually occurring at the tip or shoulder of the projectile point and terminating short of the ligature line (Figure 5.17 Photo B). This type of fracture rarely occurs during manufacture (Titmus and Woods 1986: 3). Often this type of fracture would lead to multiple fractures and often a complete shattering of the projectile point.

2. Spall or flute-like fracture. This fracture appears like an attempt to remove a channel or flute-like flake from the tip of the projectile point (see Figure 5.17 Photo A). Frison et al. (1976) also observed this type of fracture in the Hawken site projectile points. It also tends to stop at the ligature line or can terminate in a bending fracture. This type of fracture is most likely to occur when striking stone, bone, or other high density "hard" targets. Odell and Cowan (1986:204) referred to this as a "snap and step" fracture. In the experimental sets, it rarely occurred

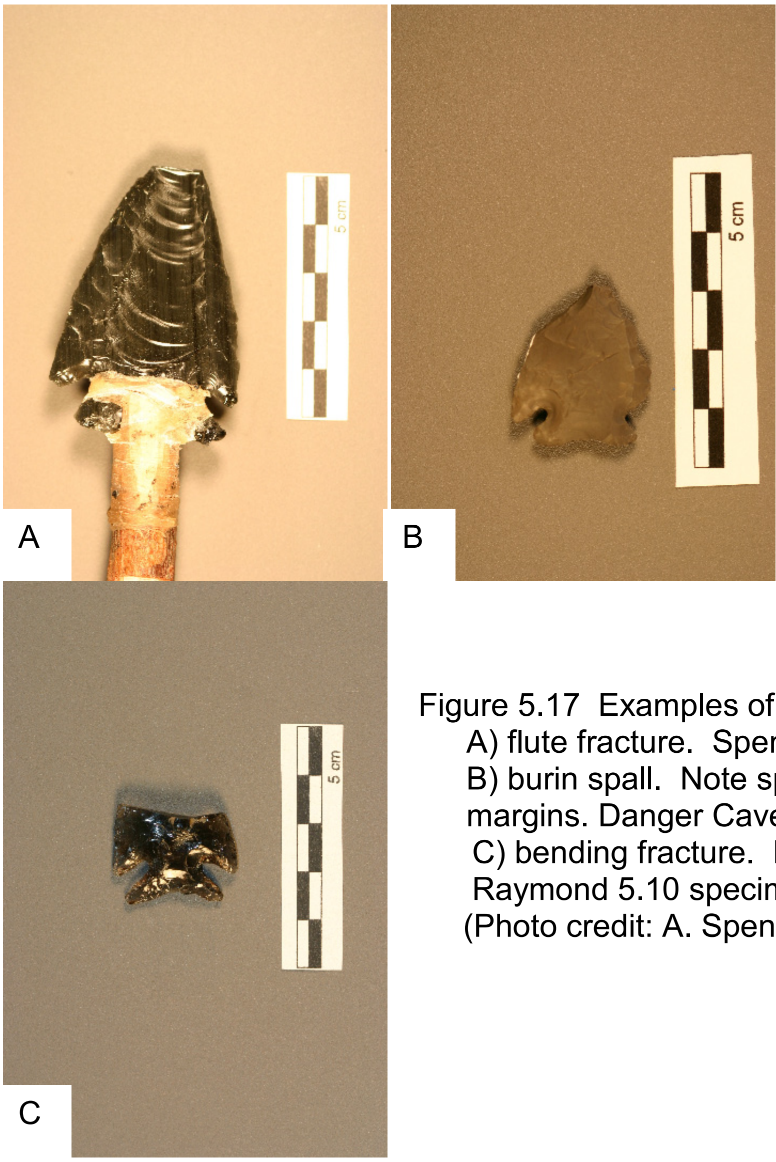


Figure 5.17 Examples of breakage.
A) flute fracture. Spencer 23.)
B) burin spall. Note spall on both margins. Danger Cave SEQ# 363
C) bending fracture. Flenniken – Raymond 5.10 specimen 10A.
(Photo credit: A. Spencer).

when striking soft woods, soils, etc. and was not observed during manufacturing unless intentional removal of a basal thinning flute-like flake (*e.g.* “Clovis” or “Folsom”).

3. Bending fracture. Flenniken (1984) recorded that this was the most common use-life fracture. This was also the most common type of fracture in the other experimental sets (Spencer, Warburton and Towner, Titmus and Woods --- see Figure 5.17 Photo C). It often occurred on the tip, above the ligature line, base, or any of all three locations. It is literally a “bending” or a “snapping” of the projectile

point where impact forces at the tip travel through the projectile point and express themselves laterally distant from the original point of impact. This is very similar to "hinge fractures" that sometime occur during percussion production of a biface or projectile point. It rarely occurred during the pressure flaking stage of manufacture.

4. Shearing fracture. For Titmus and Woods (1986:43) a shearing fracture was very similar to a burin fracture. It occurs during use due to the forces originating in-line with the long axis of the blade. Titmus and Woods (1986:45) described it as follows:

> "These fractures can result from the splitting of the cone of force and leave a flake scar that forms a right angle edge on both faces (Crabtree 1972:48). The majority of barbs broken as a result of impact reveal shearing break features. These differ from bending breaks in that the force is initiated at the margin, as opposed to the base. Shear breaks seldom reveal a bulb of force or a hinged or lopped termination".

5. Crushing fracture. Titmus and Woods (1986:43) also observed this type of fracture produced by a hard, solid surface. Crushing fractures result at the distal end and margins. A crushing fracture can produce a flute-like flake or " . . . terminate on the tool face or leave deep step fractures at the point of impact" (Titmus and Woods 1986:43).

Ideally, it would have been best to use live animals during the actual hunting scenario. This was attempted by Flenniken (1985:269-270) on feral goats. Here he discovered that:

> "Animal movement fractured several of the projectile points, and these point fragments traveled considerable distances within the animal's body." (Flenniken 1985:270)

Flenniken insisted that projectile points fracture differently in live, thrashing bodies as opposed to carcasses. The ethical, moral, and practical aspects of using live animals in this experimentation outweigh any of the potential data benefits. The closest match to approximate actual hunting was to use carcass data. Carcass data has been previously used (Appendix II) in lithic research with everything from elephant, deer, moose, goat, dog, donkey, cow, horse and gazelle as targets. Use of such carcass data was questioned (Titmus and Woods 1986:43). But alternatively, the use of live animals was not acceptable to the research committee at the University of Leicester. The Umatilla Nation, Pendleton, Oregon offered a live bison to be used if some of their members would be allowed to participate in a simulated hunt. They even offered to provide a sedated bison for just this purpose. Although very tempting, the offer was respectfully refused based on the ethical, moral, and safety issues discussed.

Artificial carcass targets have also been previously used in research. Everything from beef ribs (Hutchings 1997, 1999), bone and hide bundles (Knecht 1994), to carpet covered straw bales (Van Buren 1974) have been used. For this experiment, a white-tailed deer carcass was obtained with a special scientific use permit from the

Arkansas Division of Game and Fish. The deer carcass was obtained from "kill salvage" (road kill) specifically for use as a target. Aside from the fracture of the two rear legs, only minimal collateral damage from the vehicle strike were observed in this specimen. The carcass was obtained in January. Care was taken to keep the carcass "cold" but not frozen, out of reach of dogs, coyotes and curious neighbors, and insuring the permit was posted at all times to discourage subsequent visits by game enforcement officers (see Appendix V).

Provisions were made at the carcass and vicinity to ensure maximum recovery of the broken atlatl points (Figure 5.16). Flenniken and Raymond, Titmus and Woods, and Warburton and Towner lost projectile points during the breakage part of the experiment. This experiment employed a tarp below the carcass and a backstop of oriented strand board (OSB). Still, two projectile points (mostly fragments) were lost in the surrounding forest litter. Flenniken's observations of modern Australian atlatl hunters noted a significant decrease in lost projectile points (Flenniken, personal communication) as opposed to simulated hunting.

Simulated hunting was conducted until critical damage was done to all 30 points, foreshaft damage was irrecoverable, or dart was not immediately recoverable in the carcass. In one example the foreshaft was so deeply imbedded in the carcass that it was impossible to retrieve until the end of the experiment. This point was not rejuvenated. All of the broken projectile points and fragments were collected and returned to the laboratory for photographs, measurements, weights and further analysis. Even with measures in place to avoid loss, two projectile points were lost during the experiment.

Penetration of the carcass was also recorded. In the 35% of the times that the projectile points struck the carcass, 50% of the time the atlatl dart point completely passed through the carcass, impacting on the OSB backstop (Figure 5.16). This often made it difficult to determine if the projectile point was fractured during carcass contact/penetration or as a result of striking the backstop. It was also difficult when the projectile point fractured within the carcass to recover all of the fragments. Even though the carcass did not produce the same twisting movements as a living creature, some separation of fragments along the tract of penetration was also observed.

After the simulated hunting portion of the experiment was completed, the carcass was skinned and dressed using stone tools. Sinew, bone, and hide materials from the carcass were all harvested for future use. The stone tool suite from this process was saved for microwear,

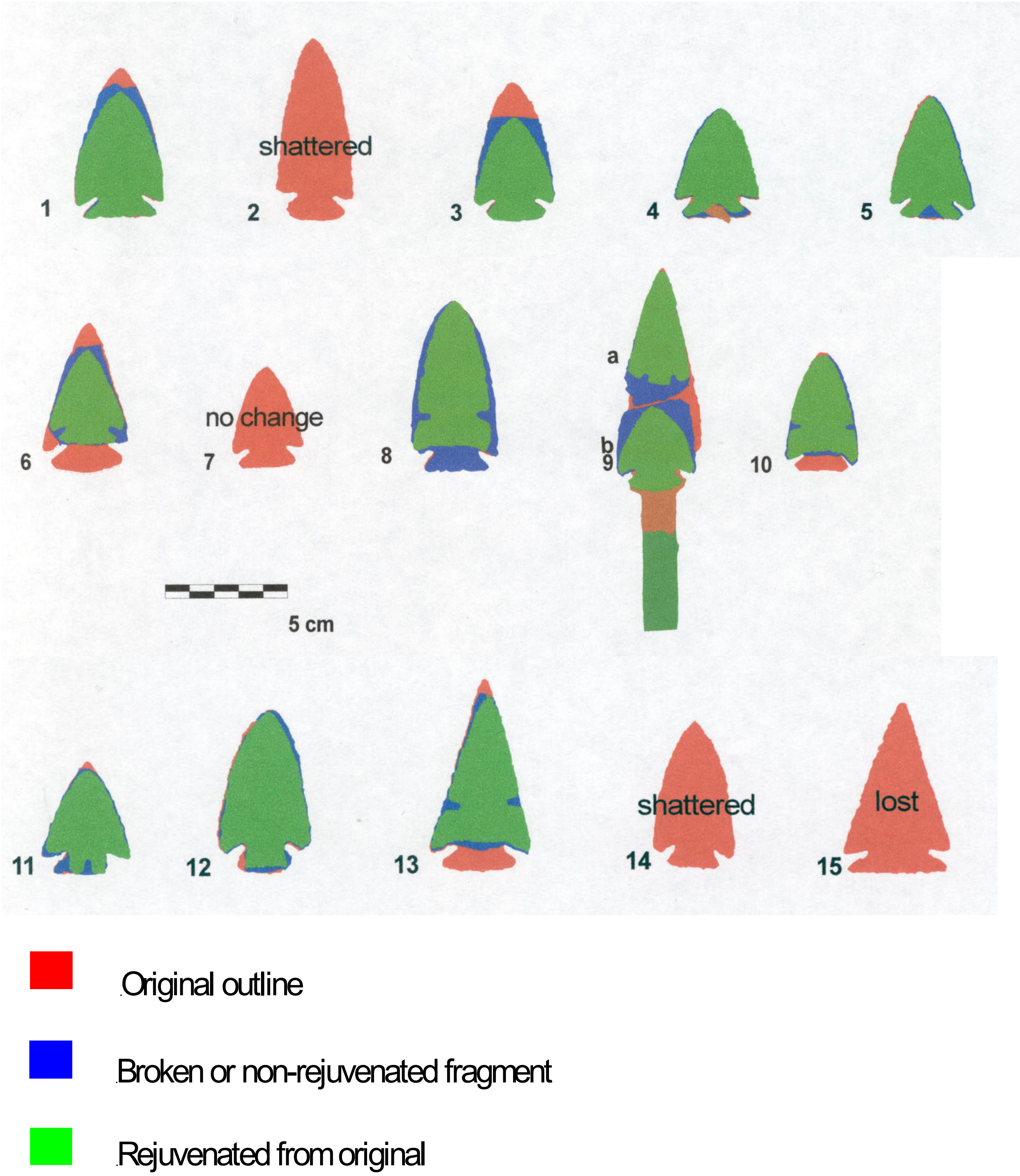


Figure 5.18 Projectile point phases of Spencer collection 1-15. All projectile points are shown ½ actual size.

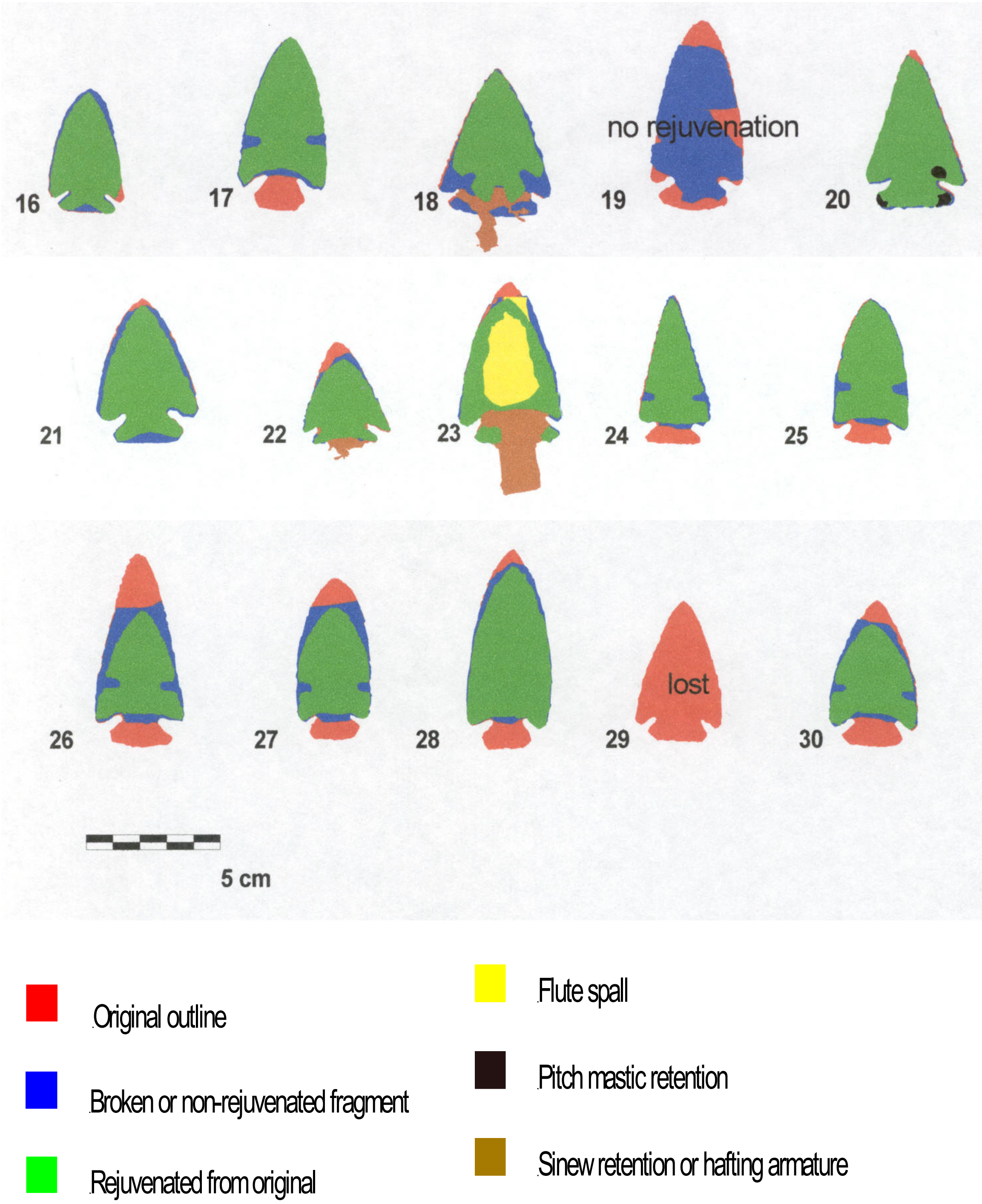


Figure 5.19 Projectile point phases of Spencer collection 16-30. All projectile points are shown at ½ actual size.

residue, and macrowear analysis. This will be the subject of another paper.

Rejuvenation

Twenty-six projectile point fragments broken in the simulated hunting portion of the experiment were recovered and rejuvenated (see Figures 5.18 and 5.19) under similar procedures outlined by Flenniken and Raymond (1986:608) and Towner and Warburton (1986:313). Great care was taken to record how the projectile point was fractured, during use or during rejuvenation, or as an unintended fracture during manufacture.

Care was taken to determine if fragments to be rejuvenated would have sufficient mass after rejuvenation to fall within the parameters of dart points (> 6 grams). Without sufficient mass, rejuvenation could occur but would invariably produce projectile points in the weight threshold of arrowheads.

The protocol for rejuvenation was as followed:

a. The damaged projectile point, fragments, and armature from the simulated hunting target were collected after every successful throw at the carcass. If projectile point and armature were deeply imbedded in the carcass, the entry location was marked and the projectile point and armature were removed with flake blades after all of the projectile points had been thrown, broken, and collected.

b. After recovery of the broken projectile point and fragments, a rejuvenation decision was made on areas of the point or fragment to be refurbished. In one example (Figure 5.18 #9), sufficient mass remained in both the distal fragment and the hafted fragment to rejuvenate both into projectiles that could be returned to use-life.
c. A #6 copper bitted pressure flaker was used to recover breakage, reform margins, and remanufacture hafting elements. Platforms were set with a flat bladed notching tool (used as a rasp) and a fine, small grained abrading stone.
d. Notches were made with the flat bladed notching tool.
e. Where armatures had been damaged or fractured, armatures were repaired or replaced. If projectile points required additional modifications for new hafting to armature (basal thinning, etc) this was accomplished at this time.

Rejuvenation to smaller ECN morphological types was given first priority, however, if alternative basal or margin (side) notching would return the projectile point into a use-life trajectory with the least expenditure of time, effort, and mass, the projectile was rejuvenated accordingly. Likewise, rejuvenation was based on the most economical use of the fragment in terms of re-use of the hafting armature (foreshaft). As Keeley (1982:800) would point out, there are economic pressures to re-use the armature. These pressures are measured in time (i.e. a few minutes needed to produce the flintknapped projectile point vs. several hours needed to produce an armature), cost (like stone, armature materials are found in specific locations that may not be always at hand), and effort of manufacture.

WT noted that rejuvenation of the projectile point while still on the armature was preferred, noting conservation of energy and materials. It was not observed if FR made the same provisions and observations. In the SP experiment, the majority of the projectile point fragments had either broken at the hafting element, broken on the blade and loosened the hafting element to the extent that hafting element repairs were warranted, or fractured the armature making it irreparable. For example, eight (27%) of the atlatl foreshafts were damaged as a result of the experiment to the extent that a new hafting armature was needed. Fracture of the armature was not noted in the Titmus-Woods experiment, Warburton-Towner Experiment, or Flenniken-Raymond experiment. Raymond (1986:163) would, however, comment that considerable attrition did occur to atlatl foreshafts during the Flenniken-Raymond (1984) experiment.

In 90% of the rejuvenation samples, it was not possible to rejuvenate the remaining fragment in the armature because of loosened hafting materials, broken hafting element, fractured armature, or insufficient fragment mass remained hafted to the armature. In the three samples where this would have been possible, insufficient purchase and manipulation of the hafted projectile point within the palm-vise made this type of rejuvenation strategy awkward and ineffective. In most cases, salvageable armatures were “de-sinewed”, sinew set aside where possible for re-use, and the remaining un-recoverable hafting element where the projectile had snapped at the ligature line was discarded into the rejuvenation debitage. In the majority of cases, the piñon-charcoal mastic which secured the projectile point within the armature and waterproofed the sinew, was extremely brittle and would shatter when the projectile point would experience use-life fractures. The brittleness of the mastic may also contribute to the overall fracture potential of the dart point; a concept that requires further investigation. Many discarded fragments, however, still retained filaments of sinew and residues of mastic (see Figure 5.18 specimens 4, 18, and 22 for sinew, Figures 5.19 specimen 20 for mastic). Mastic residues were also observed in the rejuvenation debitage.

All rejuvenated projectile points were photographed, measured, and weighed similar to recording in the FR collection, TW collection, and WT collection. Flenniken, however, had coated his original, pre-breakage points with aluminum chlorohydrate to give contrast to flaking scars and to reduce the translucency of especially transparent types of obsidians (see Figure 5.8). For consistency in study of all of the different collections, as well as the logistics in coating the hundreds of projectile points examined, no other projectile points were coated. Also, concern was noted that coating may obscure or affect the residues that the projectile points may have retained (pitch, sinew, serum, etc.).

Sample #	Pressure	Alternate	Notch	Total #	#5	#10	#35	Weight (grams)
1	140	0	0	140	4	53	83	0.8
2				0				
3	436	0	0	436	9	72	355	1.8
4	63	0	0	63	5	6	52	0.2
5	140	0	0	140	2	17	121	0.4
6	324	0	4	328	5	66	257	1.8
7	No rejuv			0				
8	325	0	4	330	42	53	235	8.3
9b	91	0	5	96	0	24	72	0.4
9a	274	0	0	274	6	58	210	1.8
10	177	0	6	183	4	21	158	0.5
11	170	0	3	173	1	15	157	0.3
12	274	0	0	274	9	40	225	1.5
13	259		4	263	8	25	230	0.8
14	Shattered			0				
15	Lost			0				
16	224	0	0	244	0	24	220	0.4
17	199	0	4	203	10	30	163	1
18	230	0	4	234	18	87	129	3.5
19	Shattered			0				
20	Shattered			0				
21	343	0	0	343	13	94	236	2.6
22	92	0	0	92	0	24	68	0.4
23	65	0	0	65	1	23	41	0.3
24	162	0	0	162	7	26	129	0.9
25	252	0	5	257	16	46	195	1.9
26	490	0	3	493	29	105	359	5.5
27	485	0	3	488	25	87	376	3.3
28	178		0	180	12	35	133	1.9
29	Lost			0				
30	247	0	2	249	14	57	178	2.1
TOTALS								
	5640	0	47	5710	240	1088	4382	42.4

Table 5.2 Distribution of rejuvenation debitage in SP experiment.

Debitage

All debitage from both manufacture and rejuvenation was segregated by reduction stage and collected and treated much in the same way as in the Warburton and Towner experiment. Notching flakes were also segregated and collected before they were combined with the other debitage. Debitage was also weighed and graded with #5, #10, and #35 Hubbard Scientific mesh screens (grade # is number of squares per inch). The #5, #10, and #35 mesh screens roughly corresponds with 1/4, 1/8 and 1/16" nested screens used in the Warburton and Towner experiment. Debitage smaller than #35 grade were fragments considered pressure flake shatter and of dubious relevance.
Non-flaking residues such as copper flaker fragments, pitch, sinew, hammerstone/abrader dust, and chaff from the leather palm pad were effectively captured with the #35 mesh gauge. The #10 gauge mesh seemed to capture the majority of relevant rejuvenation debitage and is recommended for this phase of analysis.

Manufacturing time vs. rejuvenation time

Differing from the other researchers, the Spencer manufacturing and rejuvenation stages were timed. The relevance and perception of time by prehistoric and ethnographic peoples is a separate discussion. These observations for this experiment were in minutes in order to give a relative measure of economy and costs during manufacturing as opposed to rejuvenation.

Manufacturing times and rejuvenation times were recorded for all specimens. Table 5.3 graphically correlates the two values. Where values are “0”, either the projectile point was shattered, lost, or not rejuvenated. The mean time to manfacture a projectile point was 50.2 minutes as opposed to a mean time of 12.1 minutes for rejuvenation.

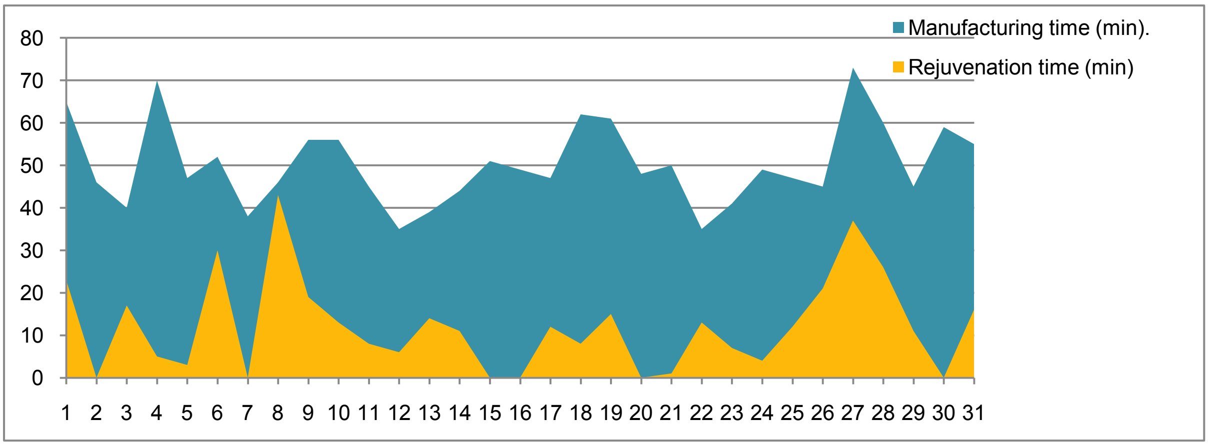


Table 5.3 Manufacturing time vs. rejuvenation time in SP collection.

Many cost factors are not accounted for in this estimation. For example, acquisitions of materials costs (for both stone and non-stone parts of the weapon system) were not accounted for. Expenditures of energy for quality of materials vs. expedient materials may also be accounted for differently. Certainly, the skill set of the flintknapper has a great deal to do with the expenditure of time as well as the measure of success. The basic conclusion is that it is more advantageous to rejuvenate a projectile point with less energy costs (as expressed in time) than to begin the manufacturing process anew.

SP Observations

The results of the SP rejuvenation experiment validated many but not all of the results of both the WT and the FR experiments. Probably the most important validation was the change of type during rejuvenation. Of the 26 fragments in the SP collection rejuvenated, 13 (50%) changed type. Adding to the rejuvenated fragments count were two fragments from projectile point SP 9. Fragment 9a, the most distal fragment with a flute–type spall running the length of the body of the blade, was rejuvenated in to “Rose Spring” series point. The bottom or most proximal fragment, 9b was still retained in the armature and was able to be rejuvenated into another ECN (see Figure 5.18 specimens 9 A and 9B).

In total, 13 (50%) were rejuvenated back to the ECN with qualifications. These qualifications were that six projectile points (20%) of the 13 ECN had changed into a sub-type (Elko Eared) either due to basal modifications to accommodate initial hafting or to accommodate hafting to a new armature because of armature failure during the simulated hunting experiment. The Spencer experiment concurs with the observations of Flenniken-Raymond in recommending that the Elko series sub-types are totally the result of basal modification to accommodate hafting and should not be classed as sub-types.
Most of the projectile points (8 or 30%) that changed type were rejuvenated to a side-notched type, similar to Northern Side-Notched. This side-notched morphological form allowed for the most

conservation in blade length, width across the hafting element, and required little time to effect a recovery. One rejuvenated "type" was a "Pinto" series (Figure 5.18 #11), one was "Martis" series (Figure 5.18 #12), one "Clovis" type Figure 5.19 #28) and one un-named side-notched rocker base type (Figure 5.19 #24) that would have been "out of key" (Thomas 1981).

Some of the hypotheses advanced by the other experiments were not validated. For example, the Spencer experiment did not validate the Washburn-Towner experiment in the observation of alternate flakes in the rejuvenation debitage (see Table 5.1). This may be due to different rejuvenation decisions employed, recovery rejuvenation methods, or bias in identification. The majority of alternate flakes produced in the Warburton- Towner experiment were the recovery of mid-blade bending fractures. The majority of bending fractures in the Spencer experiment occurred on the ligature line, hafting element, or tip.

Also contrary to Warburton and Towner methodology was use of the 1/16" mesh screen. At 1/16" screen size, the debitage borders on microscopic and is mostly composed of ground edge fragments and flake shatter. With a #35 grade mesh screen, it was extremely difficult to sort meaningful debitage.

The debitage analysis did observe other organics in the debitage that could possibly be dated with AMS sampling procedures. Pitch, sinew, and leather palm pad fragments were all observed in the finer meshed (#10 grade or 1/8 inch mesh). This is a possible way to directly date rejuvenation debitage as well as to identify segregated reduction loci.

The ideas advanced by Warburton and Towner as well as many other authors on the notion of conservation of energy in reworking or rejuvenation of projectile points (Hayden 1974; Keeley 1982; Odell and Cowan 1986) were reinforced and substantiated by the Spencer experiment. Rejuvenation as opposed to remanufacture was expressed in an average time savings of over 400% increased efficiency.

CONCLUSIONS

All four experiments replicated ECN obsidian atlatl dart points. These were thrown at different types of targets until the projectile points fractured, or for other reasons, were removed from use-life. Similar fracture patterns (like fracture types located on topologically similar projectile point locations) were observed in each of the experiments, regardless of the type of target used. In all of the experiments, change of type was noted when projectile points were prepared for hafting. These were mostly sub-type changes during hafting preparations. In the control experiments, where rejuvenation was conducted after breakage, a significant amount of projectile points changed type. Although one experiment attempted to define rejuvenation signatures through debitage, results were problematic and offered no practical way with current excavation conventions to substantiate debitage based rejuvenation signatures.

CHAPTER 6

FORMULATION OF REJUVENATION SIGNATURES

INTRODUCTION

As previously stated, rejuvenation of atlatl dart points is a flintnapping manufacturing/remanufacturing technique to recover from unintended breakage of projectile points during initial manufacture, recover from fractures produced from use and to place the projectile point back into the use-life stream, or to make a decision to discard a broken or "less confident" projectile point and remove it from the use-life stream. The goal of Rejuvenation Signature Analysis is to identify the signatures that would indicate what flintknapping strategies were used to either return a projectile point into the use-life continuum or to discard it. Lateral rejuvenation occurs when a projectile point is refurbished into a tool no longer intended as a projectile point (Schiffer 1972). Although lateral rejuvenation is recognized, it is only minimally discussed here. It is also recognized that hafted projectile points originally intended for projectile points could be used for expedient knives or other cutting, sawing, carving, fleshing, scraping, or "sharp edged" tools (Ahler 1971; Andrefsky 1997; Kelly 1988; Nance 1971; Truncer 1990; Andrefski 2006). Such alternative use-life analysis would require extensive microwear examination that is beyond the scope of this thesis.

The methods to determine RSA signatures were those of basic scientific method: 1) form a hypothesis 2) create a "known" control 3) test the known control against an unknown data set 4) determine the validity of method and hypothesis. The basic hypothesis is that signatures characteristic of rejuvenation would be recognizable by individuals familiar with the strategies, trajectories, and products of lithic tool reduction. These signatures would be discernable, discrete, and quantifiable. The “known” or control experiments are detailed as far as original projectile point morphology, how the fragments fractured, morphology of broken fragments, pressure flaking strategies to rejuvenate the fragmentary projectile points, and morphology of finished rejuvenated products. The methods of rejuvenation in the Flenniken-Raymond experiment and Warburton and Towner experiment were noted and compared to the methods of rejuvenation in the Spencer experimental set. These three experimental sets formed the control. These rejuvenation observations were placed into broad rejuvenation signature categories. It was quickly observed that these broad categories could be greatly expanded through subdivisions or combinations of one, two, or more processes of rejuvenation methods. Although many variations on a repetitive theme could be given, three main divisions of rejuvenation signatures emerged: rejuvenation of the blade from blade tip to ligature line, rejuvenation of the ligature line and/or hafting element (base), and total refurbishment of the projectile point.

FORMULATION OF RSA FROM ALL EXPERIMENTS

Rejuvenation During Manufacture

Rejuvenation during manufacture seems to be a term internally at odds with itself. The definition of rejuvenation as it is applied here is to convert a broken, non-functional tool into a similar functioning tool that is returned to the use stream. When breakage occurs during manufacture, technically the artifact has not originally entered the use stream and therefore, is not rejuvenated but recovered. With recovery, the manufacturing can then continue. The late manufacturing stage and usual placement of this most common breakage/fracture on the projectile point during manufacture make this type of recovery almost "pre-rejuvenation". For simplification, the definition of rejuvenation is slightly expanded to overlap late manufacturing stage fractures and recovery.

Manufacturing breakage signatures are mostly confined to barbs and notch platforms. This was either the result of crushing the barb when attempting to apply pressure to the notch platform, lateral breakage from the notch platform to opposing notch platform, or longitudinal fracture from the notching platform that removed the same side blade margin (Figure 5.3). These manufacturing breakage signatures were experienced by all experimenters and observed in all collections although the percentage of these fractures as opposed to all other fracture signatures was quite low. The more skillful of the flintknapppers in the control collections tended to experience less barb crushing/notching related fractures than the less skillful. Much has to do with the correct placement of the notching tool as it is pressed and twisted on the notch platform (Titmus and Woods 1986:43). It also seems that the technique of notching (palm vise vs. finger vise) and the more range of stability and control that the flintknapper has over the projectile point placement within the hand and fingers contributes to the number and percentage of notching related fractures. Both proper and consistent placement of the notching tool against the notch platform and palm vise vs. finger vise techniques are skill related abilities. Titmus and Woods (1986:47) reported that :

> "About 25% of our attempted replications resulted in manufacturing breaks. However, this frequency will vary depending on the skill of the knapper. Other knappers have produced as many as 47 similar corner-notched points without a single instance of manufacturing damage . . . "

In the study collections, determining if the fractures originated during manufacture or were the result of use impacts was largely determined by examination of the notch platforms. In both use-life fractures and manufacture fractures, rejuvenation was often attempted to repair, recover, or reform notch platforms. This often resulted in loss of symmetry, increase in the notch opening angle, increase of notch depth, alternative notches, additional notches, diminished barbs (one side), and loss or modification of spur. When occurring in manufacture, partial recovery of the notch and/or barb was often attempted. This is somewhat distinctive and is represented both in control and study collections. When occurring during use-life breakage, it often required a full remanufacture of the notch platform and/or hafting element.

Debitage Signatures

No debitage was collected during the Flenniken-Raymond experiment. In the Warburton-Towner experiment, projectile point blanks were thinned and formed by percussion. This debitage was not collected. All post percussion debitage (pressure flaking) in the WT experiment was segregated and reserved. In the Spencer experiment, all debitage was segregated by reduction stage, collected, and reserved. The research goal of segregation and study of manufacturing and rejuvenation debitage was to determine what debitage signatures were produced during each stage and if these signatures were recognizable and discrete.

The WT experiment concluded that pressure flake signatures could be differentiated between production and rejuvenation. Pressure debitage produced during manufacture was characterized by three types of flakes: platform preparation flakes, pressure or tertiary flakes, and notching flakes. Rejuvenation debitage was characterized by what Towner and Warburton (1986:318) called rejuvenation pressure flakes, rejuvenation notching flakes, and rejuvenation alternative flakes. These manufacturing and rejuvenation flakes have been described in Chapter 5 under the Warburton and Towner experiment sub-chapter.

The Spencer experiment substantiated the manufacturing debitage signatures and use debitage signatures discussed in WT with some variation in recording their "alternate" flake designation. This was partly due to the reduction sequence for each projectile point manufactured. Often, in the SP experiment, large alternating pressure flakes were used to thin the original striking platform/ bulb of percussion on the flake blank. These alternating pressure flakes, however, were larger and more robust than the smaller alternating pressure flakes used to rejuvenate a bending fracture on a broken projectile point. The Spencer experiment recognized alternate flakes in the production debitage, however, they were conspicuously absent in the rejuvenation debitage for reasons previously discussed.

Finally, the production artifact assemblages and rejuvenation assemblages were compared. Manufacturing assemblages contained only pressure debitage in the WT experiment because percussion debitage was not retained. In the Spencer experiment, all reduction stage debitage (primary, secondary, tertiary) was observed in the manufacturing flakes. Rejuvenation assemblages contained smaller pressure debitage and fragments of tangs, barbs, point tips, point bases, ears, shattered points, etc. Non-flaking residues (mastic, sinew, hammerstone fragments, leather chaff, copper fragments) were also observed. Again, manufacturing debitage could be discerned from rejuvenation debitage by the rejuvenation products containing smaller sized pressure flakes, notch flakes, and formed projectile point fragments. Actual application in archaeological excavations, however, would require precise control of screen size (1/8 or #10 gauge screen), volumetric sampling, and extensive processing time to recover and analyze the smaller fragments. Unless the archaeological excavation is designed to recover the smallest debitage in a specific location where manufacturing/rejuvenation activities took place (see Binford 1969, 1979, 1980; Binford and O'Connell 1984; Kelly 1988) then rejuvenation signatures from debitage in archaeological sites will remain problematic.

Flake Scar Signatures

Frison et al. (1976) indicated that the trajectory of flake scar patterns changed from parallel to random flaking on the distal portions of the Hawken points he believed to have been rejuvenated after breakage (see Figure 4.3). This observation was true for the projectile points that were rejuvenated on the distal portions of the blade and margins, however, it was not observed in cases where rejuvenation occurred on the proximal (basal) portions of the projectile point, at the ligature line or below (hafting element and base). In most flintknapping, flaking/thinning trajectories of projectile points, basal thinning, pre-notching flaking, and notching usually over-scar the flaking strategy employed on the margins and blades. For example, basal thinning of the projectile point preform usually directs flakes from the base longitudinally to the center of the projectile point. This interrupts the often parallel flaking patterns that were employed on the margins and blade. This is a part of the usual manufacturing procedure. This interruption is the reason that basal thinning is reserved as a final biface thinning strategy.

In the FR and SP collections, “before” and “after” rejuvenation photographs of flake scars were available. Flake scar signatures on the WT collection were not available in any of the illustrations, line drawings, etc. (only outlines of the points before and after). On the “test” collections, only “after” flake scar patterns were available for study. Four general observations of the “control” collections were made:

A. Where projectile points were rejuvenated from bending fractures occurring above mid-blade, and where the hafting elements had remained largely intact, differences in flake scar patterns could be detected. This was especially true in the SP collection.

B. In instances where margins were repaired, rejuvenation flaking strategies almost completely obliterated the original flake scars. This was especially true in the FR collection.

C. Those projectile points where basal/hafting element rejuvenation occurred, new flaking scar signatures almost completely obliterated the original flaking scars and appeared the same as basal/hafting element manufacture flake scars.

D. Where new notching platforms were created in rejuvenated projectile points and notching flakes removed, no noticeable new signatures could be discerned unless notching strategies changed between original manufacture and rejuvenation, (e.g. corner notching to side notching strategy).

The basic assumption in examining archaeological materials, however, is that one flaking strategy (parallel flaking) was employed in manufacture and another strategy (random, parallel oblique, etc.) flaking was used in rejuvenation. In the control collections, it appears that the flintknapper chooses the flaking strategy they are most accustomed to using whether it be in manufacture or rejuvenation. Flenniken used oblique parallel flaking both in manufacture and margin repair, remanufacturing blades, or remanufacture of the entire projectile point.

Refitting debitage from manufacture or rejuvenation back to flake scars is rarely possible even under extremely favorable conditions (Cahen et al. 1979; Frison 1968; Spencer 2001) and it is hardly practicable. The information gained would not be worth the price in time spent.

In summary, rejuvenation flake scar analysis is only creditable where bending fractures were recovered from a blade tip or mid blade rejuvenation strategy. This, however, could be an inference that in these cases, only this type of rejuvenation occurred on the projectile point. It is reasoned that if only basal/hafting element rejuvenation was employed, the blade would probably reflect the majority of original flake scar patterns with only slight margin retouch. If both basal/hafting element rejuvenation and margin/blade rejuvenation occurs (essentially remanufacture of the complete projectile point), flake scars will appear as a newly manufactured archetype.

Use-life Rejuvenation Signatures

The location of the fractures on the projectile point and what types of fractures occurred seems to dictate the rejuvenation trajectory or strategy employed. The following scenarios describe use-life rejuvenation signatures in terms of fracture type and fracture location.

Rejuvenation of the Blade

Bending Fractures

Bending fractures on the blade from ligature line to the tip (see Figure 6.1) were a common type of occurrence. The majority of fractures occurred at the ligature line as opposed to the tip, opposite to conventional wisdom. In those cases where the fracture was closest to the tip, recovery was often "resharpening" where blade margins were constricted at the point of the fracture and a new tip remanufactured. Flenniken (personal communication) described this process similar to "sharpening a pencil". It still remains a No. 2 pencil (it does not change into a pen)

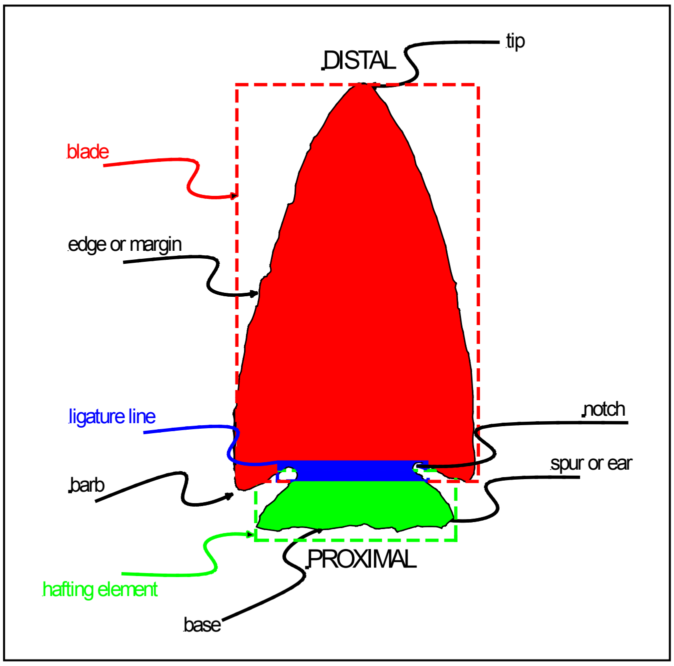


Figure 6.1 Projectile point attribute locations.

but the pencil grows shorter. Often, if the tip is “mocronate” or “nipple/needle like” a new expedient nipple-like tip will be rejuvenated on a projectile point with constricted and slightly asymmetrical margins.

Bending fractures that occurred mid-blade often presented the most challenges for rejuvenation. In the Flenniken- Raymond assemblage, this was a threshold to make a “non rejuvenation” decision and discard (see Figures 5.10 #1, #10, #12 and #6). Spencer only encountered four bending type fractures at mid-blade and three were compound fractures (fractures at several locations) that produced “shattering” of the projectile points (see Figure 5.18 #2, #14, and #19). These multiple fractures rendered them non-recoverable. In only one SP example, Figure 5.18 #9) was there sufficient mass above and below the mid-blade fracture for rejuvenation. Warburton and Towner recorded three such fractures (see Figure 5.6) Titmus and Woods recorded several bending fractures on the blade, but only one mid-blade (Figure 5.2 #1985-119). Several of the other Titmus-Woods fractures that were near mid-blade were compound fractures that would have made the point non-repairable. Except for small and narrow projectile points (Figures 5.6 #8, #19, #28, Figure 5.10 #4), there is usually not enough mass forward or behind the ligature line for rejuvenation of projectile points fractured at mid blade. Rejuvenated point types that are attempted are usually a great morphological distance from the original.

Spall Fractures

Spall fractures on the blade create the same recovery challenges as bending fractures with many of the same recovery strategies employed. If the spall fracture originates at the tip (as in Figures 5.18 #9A, Figure 5.19 #23), often the spall fracture is remnant on the flake scars of the rejuvenated projectile point. In the instances where spall fractures were observed in the Spencer collection, rejuvenation strategies consisted of basal notching on the blade (creating a new hafting element , Figure 4.18 #9A) and resharpening the tip and margin reset (Figure 5.19 #23). Although Titmus and Woods recorded spall fractures, they did not rejuvenate any of their experimental collection.

Burination Fractures

Burin or burination fractures of the blade were treated much the same way as bending fractures, however, many of the burin fractures would laterally remove an entire margin to the ligature line. Even in burin fractures that only extended a few millimeters, it would be necessary to "resharpen" the tip and reset the margins. Burin type fractures on the blade were observed in all collections.

Rejuvenation of the ligature line and hafting element

Bending fractures

Bending fractures at the ligature line or hafting element often result in sufficient blade mass for remanufacture of notching, base, or both. Bending fractures at the ligature line were the most common breakage pattern observed. Although the original ligature line and/or hafting element is usually discarded when the armature is recovered, if the blade has sufficient mass it can give the opportunity for a similar notching or hafting element as the original or new notching on the margins (side notching) to conserve mass. Subsequent recovery of bending fractures on the ligature line and hafting element, however, increase the likelihood of type or sub-type change.

Spall and Burin Fracture

Because the mechanics of the impacts that produce spall and burin fractures, i.e. impacts to the distal portion of the projectile point, no spall or burin fractures to the ligature line or hafting element were observed. If a spall or burin fracture occurred, it usually originated at the projectile point distal portion and continued laterally to the ligature line or hafting element, usually removing a margin and barb.

Crushing and Shearing

These were “sub” breakage types mentioned by Titmus and Woods (1981). Crushing and shearing fractures to the ligature line and hafting element usually are in the form of a crushed barb (produced in late stage manufacture) or a sheared barb or ear (produced in use-life). A sheared barb was usually in conjunction with a bending fracture on the distal portion of the projectile point. Rejuvenation strategies would include construction or partial construction of a new barb by expanding a notch (with barb and notch not completely mirroring the opposite), remanufacture of a new margin and barb, removal of the ears and widening of the notch to make a stemmed hafting element, or remanufacture of tip, margins, ligature line, and hafting element to essentially create a new archetype.

DEFINING REJUVENATION SIGNATURE NOMENCLATURE

After all rejuvenation strategies of the control collections were examined, a descriptive classification method was developed. Because debitage and flake scar signatures although valid, show little practical application to extant collections, only late stage manufacturing signatures and use-life signatures formed the basis for the cladistic divisions. The resulting classification method synthesizes where the rejuvenation occurs on the projectile point and which strategy was employed. Nomenclature follows the following format:

"RSA" : This denotes Rejuvenation Signature Analysis.

"1,2,3": This numeral marks the location for where the rejuvenation occurs.

> "1" denotes rejuvenation occurring on the blade somewhere between tip and ligature line (see Figure 5.3).
>
> "2" is at the ligature line or hafting element.
>
> "3" is for locations of both the blade, ligature line and/or hafting element.

"A, B, C, D, N, H": These letters describe the actual rejuvenation strategy employed.

> "A" is essentially resharpening to form a new tip.

"B" is recovery from a bending fracture on mid-blade to form a "blunt" or bunt. It is also argued that "B" type rejuvenation strategies laterally recycle a hafted projectile point into a hafted scraper or similar defleshing tool.

"C" is recovery of blade margins.

"D" is the remanufacture of a "monconate" or expedient, fragile tip.

"N" is the partial or expedient recovery of the ligature line, notching platforms, notch, or barbs.

"H" is the complete recovery of the hafting element by remanufacture.

The classification "RSA1C" would then be interpreted Rejuvenation Signature Analysis, blade location, recovery of blade margins. RSA classifications are more fully discussed in the proceeding pages.

RSA1

This is rejuvenation of the projectile point blade above the ligature line (see Figure 6.1). This was the most common type of rejuvenation in the experimental collections and perhaps the easiest to determine by direct observation and /or blade angle measurement. RSA1 rejuvenation occurs on the blade and in current classification systems is least likely to affect "type". RSA 1 is further refined into four sub classifications:

RSA1A

This is the resharpening of the blade anywhere from tip to ligature line resulting in a blade that rapidly becomes disproportionally smaller when compared to the base or hafting element. Goodyear demonstrated this type of resharpening through replication experimentation of “Dalton” assemblages from the Brand site in Missouri (Goodyear 1974: 28-32). Frison et al. (1976) hypothesized that this was the major rejuvenation process in Hawken projectile points. This resharpening blade edge angle was described by Hoffman (Hoffman 1985). In the control collections, the blade edge angle measurement of the resharpened projectile point becomes more acute (see Figure 6.2 #A-F) or shows contracting margins and tip. Other signatures observed in the control collections were:

a) Reduction in ratio of the blade size to hafting element. This ratio of blade size to hafting element is apparent in those samples in the control collections. The hafting element appears to be relatively larger than the now diminished blade.
b) The blade showed a change in the blade shoulder angle that appears like a “constriction” at or near the terminus or tip.
c) The projectile point appears smaller than the collection mean length.
d) The projectile point is lighter in weight than the mean weight of the collection.

e) If substantial time has elapsed between original manufacture and new rejuvenation, or if the projectile point has experienced weathering, heat (in some cryptocrystalline silicates) or other hydration or patination accretion process, a change in patination may be evident (see Figure 6.2 #D). McDonald (1991) demonstrated the this rejuvenation signature when lithic materials are reworked by later cultures resulting in a change in patination.

RSA1B

This is recovery of a impact fracture, usually but not limited to a bending fracture, on the body of the blade by making a re-flintknapped convex edge, essentially a "blunt" (see Figure 6.3). This strategy is similar to rejuvenation seen by Goodyear (1974) and Kinsey (1972) where projectile points were laterally recycled into hafted scrapers. It was determined that the majority of projectile points rejuvenated by this method in the control and test collections are not being laterally recycled into a non-projectile point use-life (e.g. hafted scrapers) because of the thin bifacial edge constructed on the bunt edge. In the

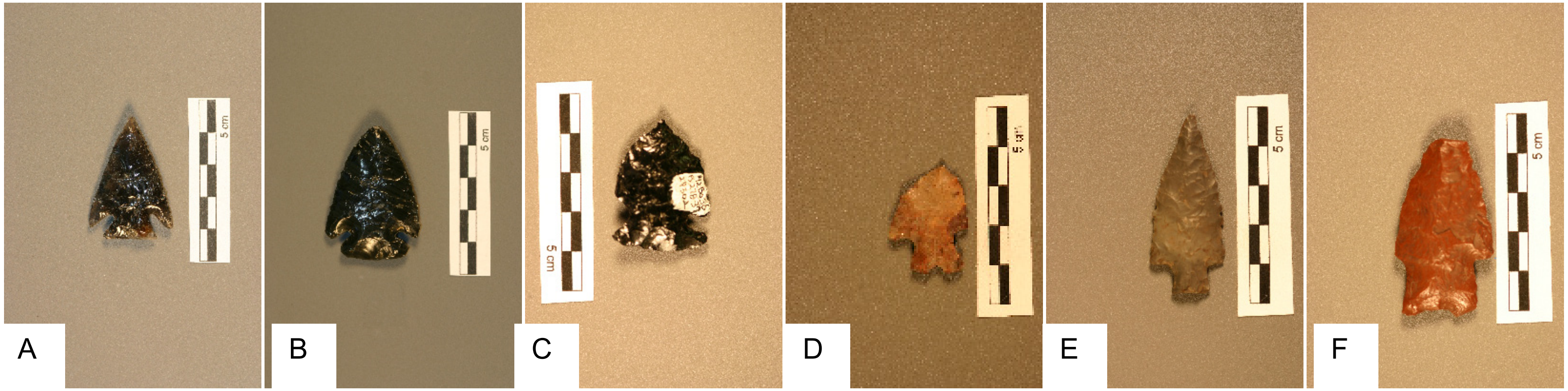


Figure 6.2 Examples of RSA1A found in all collections. A) Flenniken –Raymond 9B. Blade only rejuvenation, smaller blade B) Spencer 3. Blade length reduced. C) Hogup Cave FS278-37. Change of angle symmetry and fragile tip. D) Sudden Shelter 452.500. Change of blade symmetry. Note change of patination suggesting time interval between rejuvenation. E) Cowboy Cave 239-4. Contracting margins at tip.

F) Danger Cave SEQ # 379. Note ratio between blade and hafting element. (Photo credit: A. Spencer).

SP collection, it was fully intended to rejuvenate the broken projectile into a functioning dart point.

RSA1C

This signature is recovery of damage to the blade with an edge or margin modification. Recognizable signatures on the blade are:

a) Remnants of platform preparation. This is also known as "edge or margin retouch".
b) Narrow or diminished blade width.
c) Repair to recover edge symmetry to diminished edge sinuosity created by burin fracture.
d) Hafting element is not rejuvenated. Frequently used in conjunction with RSA1A, however, also commonly used with all other rejuvenation strategies.
e) Edge serration is often used as an edge recovery method.

In summary, RSA1C is obvious in blade symmetry, edge and margin set-up for reworking, and flaking platform repair. Often, this strategy of repair is used in combination with resharpening (1A), repair of tangs or notches (2A), repointing or serration of an edge (see Figure 6.4).

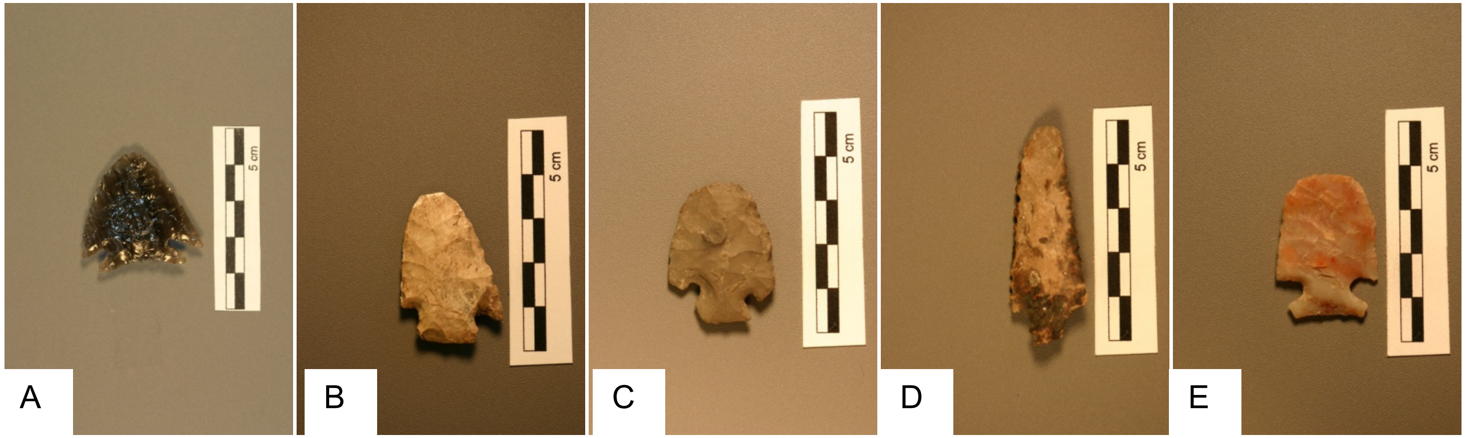


Figure 6.3 Examples of RSA1B found in all collections (except Flenniken-Raymond). A) Spencer 22. B) Danger Cave SEQ# 132. C) Hogup Cave FS266-4. D) Cowboy Cave FS411-3. Note change of patination on tip suggesting time interval between rejuvenation. E) Sudden Shelter FS417-300. (Photo credit: A. Spencer).

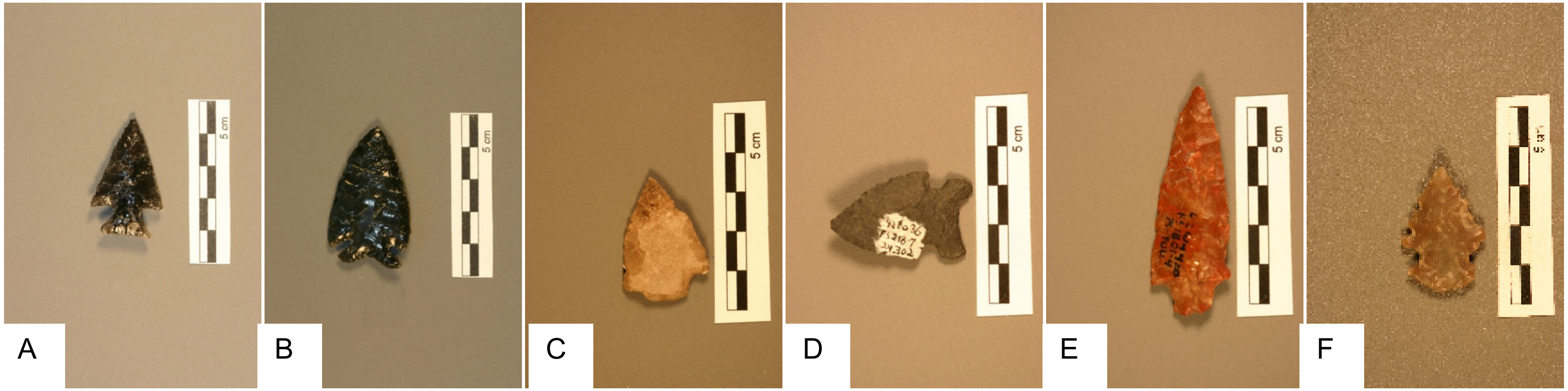


Figure 6.4 Examples of RSA1C found in all collections. A) Flenniken –Raymond 3B. B) Spencer 16. C) Danger Cave SEQ# 62 Note change of patination. D) Hogup Cave FS218.7. D) Cowboy Cave FS1801.4. E) Sudden Shelter FS1557.200. Note partial refurbishment of edge with serrations. (Photo credit: A. Spencer).

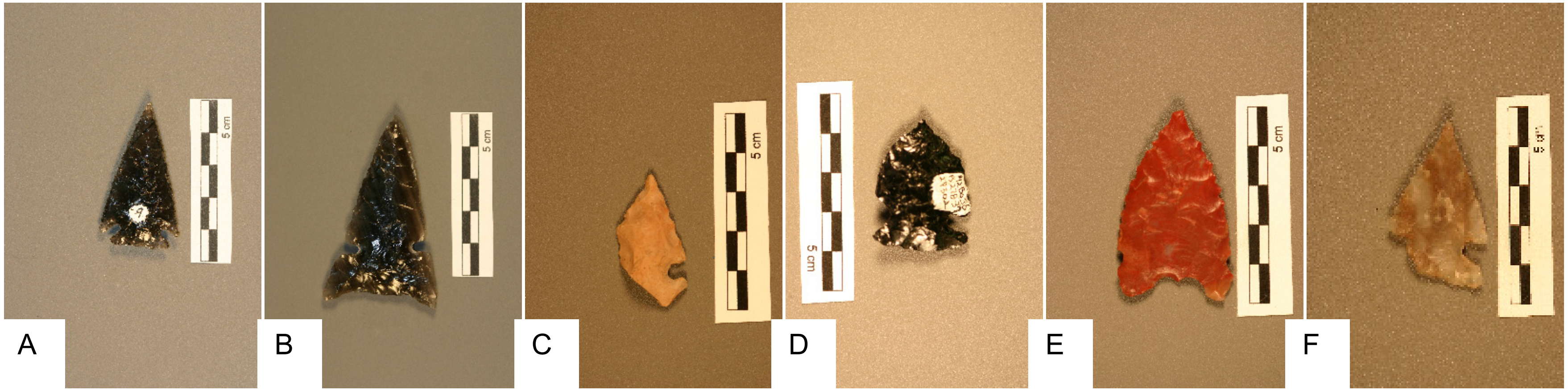


Figure 6.5 Examples of RSA1D found in all collections. A) Flenniken –Raymond 9A. B) Spencer 13. C) Danger Cave SEQ# 36 D) Hogup Cave FS278.37. D)   Cowboy Cave FS1897.5. E) Sudden Shelter FS1047.77. (Photo credit: A. Spencer).

RSA1D

This is repair to the blade with an expedient, fragile tip. It is sometimes referred to as a moncronate or nipple like tip. This is where a minor broken tip (usually 1-2 mm) is expediently repaired to a sharper point. Signatures on blade are:

a) Only the tip is reworked without incorporating changed margins along blade edges.
b) The expedient tip is often not in line with lateral axis of blade.

The resulting tip is usually asymmetrical, often pointing away from the lateral line of the projectile point. This type of repair was observed in all collections. Frison (1978) recorded this type of tip in several of the Hawken type points he observed. This is perhaps the easiest of rejuvenations or repairs (see Figure 6.5).

RSA2

This is rejuvenation below the projectile blade and ligature line, commonly known as repair to the hafting element. Presently, the hafting element is the most common attribute for differentiating "type" (Thomas 1981). Any rejuvenation on this part of the projectile point could produce profound changes to type, much more than changes that will occur in RSA1. It can be commonly seen in both the Flenniken-Raymond experiment and the experimental set, however, without the complete suite of resulting debitage, any new location of notching, or a new stem or base is extremely difficult to determine. As such, this element currently has two subdivisions, RSA2N and RSA2H.

RSA2N

This is direct but not total modification of the hafting element. This includes recovery of notching, tangs, spurs, and simple modifications to the existing base, usually expedient basal changes for fit on foreshaft during hafting. See Figure 6.6. One of the most common recoveries is barb repair. Barbs are often damaged in the manufacturing process when an opposing notch is being created. Barbs are also routinely damaged incidental to fractures on the tip or midsection of the blade. Spurs or “ears” are also broken in the manufacturing process and partially recovered. In summary, signatures observed were:

a) Expedient basal thinning or notching to accommodate the armature.
b) Recovery of notching, tangs, spurs, or ears.
c) Simple modifications of the hafting element
d) Extra notches at ligature line or on base.

RSA2H

This is complete modification of hafting element (new location of notching, new stem or base). This could produce a smaller, analogous version of the original projectile point or a completely new hafting strategy resulting in a change in type. It was a common strategy in the experimental collections, however, demonstrating this signature in the archaeological collections by visual examination was challenging.
For examples, see Figure 6.7.

RSA3

RSA3 is the complete refurbishment of the projectile point. Blade, ligature line, and hafting element are completely reworked to form a new projectile point (see Figure 6.8). This strategy was easily noted in the control collections, however, like the RSA2H signature, this signature appears as a new, mostly unmodified archetype in the study collections. It makes the basic assumption that all of the assemblage examined has completed at least one rejuvenation cycle. Unless projectile points found with this signature occur in a non-use-life context (i.e. offering, cache, grave goods, etc.) they were analyzed as a completely refurbished projectile point. The point is sometimes smaller in length and width than the mean lengths and widths in the collection. Complete rejuvenation can effectively erase previous reduction strategies and flake scar patters.

MULTIPLE RSA SIGNATURES

It was common for rejuvenated projectile points to have multiple rejuvenation signatures. Often, if a projectile point was completely rejuvenated (blade, ligature line, and hafting element) it would show RSA1A, RSA2N, and RSA2H signatures. These accumulative signatures would be reflected in an RSA3 signature. In Chapters 7 and 8, RSA signatures were applied to both the control and study collections. In these chapters, the implications of the kinds of RSA signatures as well as implications of multiple RSA signatures on the projectile point will be discussed.

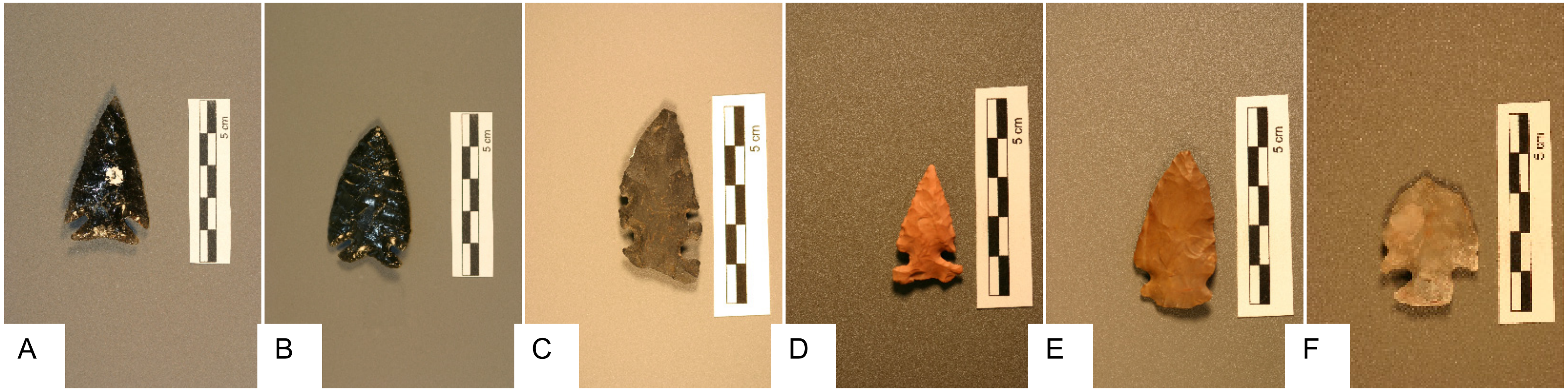


Figure 6.6 Examples of RSA2N from all collections. A) Flenniken-Raymond 3A. Concave base to accommodate hafting. B) Spencer 16. Concave base to accommodate hafting. C) Danger Cave SEQ 188. Multiple notches. D) Hogup Cave FS639.109 One side corner notch, other is side notch. E) Cowboy Cave FS1396.11 Recovery of tang, extra notch in base. F) Sudden Shelter FS311.29. Recovery of spur. Also note RSA1A on blade. (Photo Credit: A. Spencer).

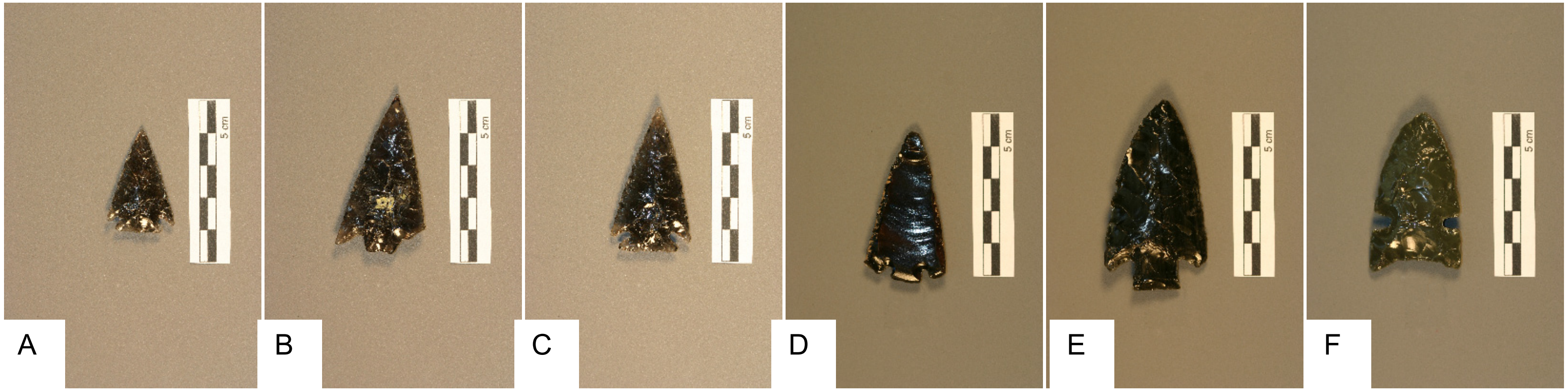


Figure 6.7 Examples of RSA2H from control collections. A) Flenniken-Raymond 7A. B) Flenniken-Raymond 8A. C) Flenniken Raymond 9A. D) Spencer 9b. Note large flute-like flake scar from impact fracture. E) Spencer 12. F) Spencer 25. (Photo credit: A. Spencer).

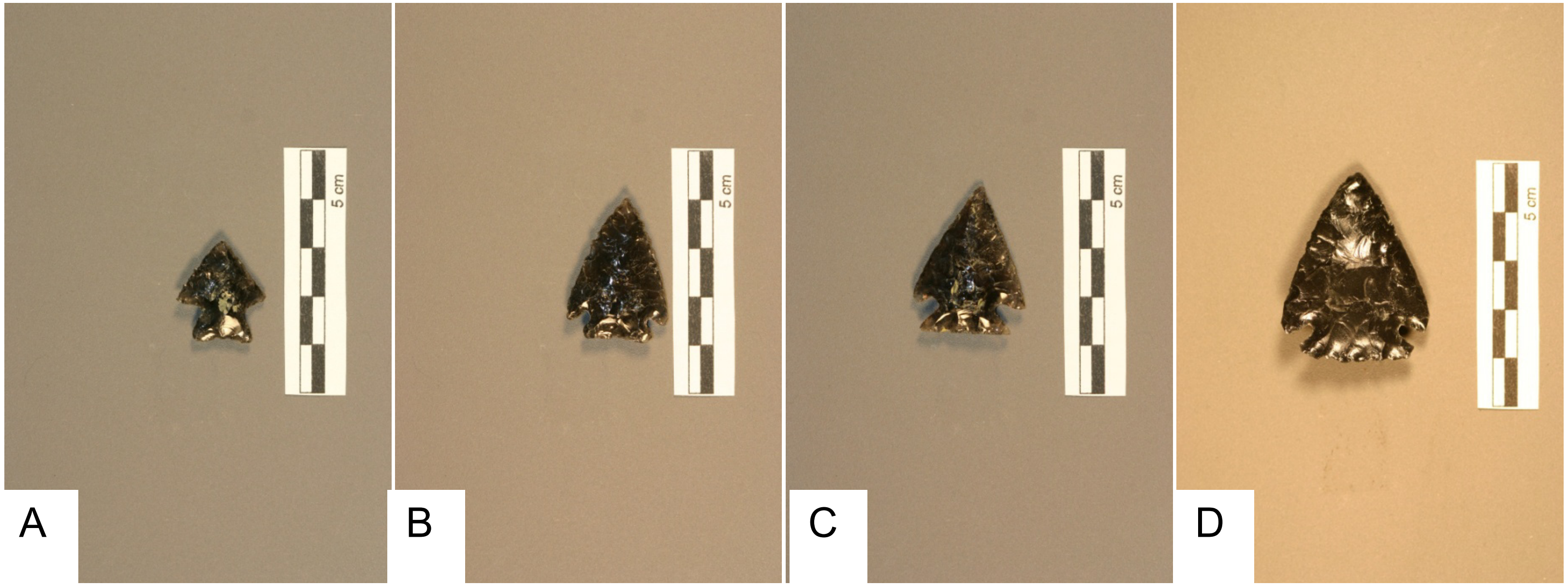


Figure 6.8 Examples of RSA3 from control collections. A) Flenniken-Raymon A4. B) Flenniken-Raymond A5. C) Flenniken- Raymond B1. D) Spencer 6. (Photo Credit: A. Spencer).

Table 6.1 RSA signature attributes derived from control collections.

RSA	Type	Signatures Observed	FR	SP	WT
RSA1A	resharpening of blade	diminished blade; small blade to hafting ratio; constriction of blade at shoulder	2a,3a,11a	1,3,21	11,12,15
		smaller than collection mean in length; less than collection mean in weight	4b,9b,10b	23	20,21,24,25
		change of blade symmetry "terminus" angle; change in patination on blade			26,27
RSA1B	bending fracture	blade rounded near tip or mid blade without "tip"; diminished blade		22,27	
	recovered by rounded	hafting element not rejuvenated; rounded blade smaller than hafting element			
	edge or "bunt"	smaller than mean in length; smaller mean in weight			
		lacking blade symmetry "terminus" angle; change in patination on blade where			
		rounded			
RSA1C	recovery of edges or	remnants of platform preparation; narrow or diminished blade width	9b,10b,15b	16,20	16
	margins from shearing	serration as a strategy to recover edge or edges			
	or bruin spall fractures	reworking to recover edge symmetry and diminish edge sinuosity due to fracture			
		hafting element not rejuvenated; blade width smaller than hafting element width			
		often used with RSA1A but common with all other rejuvenation strategies			

Table 6.1 (continued)

RSA1D	expedient, fragile tip	only tip reworked without incorporating changed margins along blade edges			
		blade tip not in line with lateral axis of blade			
RSA2N	direct but not total	expedient basal thinning or notching to accommodate the armature	2a, 3a, 11a, 12b	4,5,11,16,21	22
	modification of the hafting	recovery of notching, tangs, spurs, or ears	3b, 4b, 5b, 7b		
	element. Could occur	simple modifications of the hafting element	10b, 11b, 15b		
	to accommodate hafting	extra notches at ligature line or on base			
RSA2H	complete modification	smaller than the mean lengths in the collection	4a,6a,7a,8a,13a	6,8,9b,10,11	1,2,5,9,13,14
	of the ligature line	less than the mean weights in the collection	15a,2b,8b,13b	12,13,17,18	17,18,23,29
	and hafting element	notching flakes present in the rejuvenation debitage		24,25,26,27,28	30
		hafting element remnants in rejuvenation debitage		30	
RSA3		all of the above signatures could be present			
		notching flakes present in the rejuvenation debitage	4a,5a,6a,1b,2b	6,8	8,19,28
		hafting element remnants in rejuvenation debitage			

OBSERVATIONS AND CONCLUSIONS

A series of rejuvenation signatures was successfully developed from direct observation of rejuvenation within three test collections. These signatures describe where the rejuvenation occurred on the projectile point (tip, blade, ligature line, or hafting element), the most likely use-fracture necessitating the rejuvenation signature, and the strategy or trajectory employed in the rejuvenation.

Rejuvenation signatures from flake scars and debitage were also examined. It was concluded that most rejuvenation strategies “over write” or erase existing flake scars and only in very special circumstances would the rejuvenation flake scars be recognizable and measurable. Rejuvenation signatures from debitage are likewise a task that cannot be discerned under usual excavation techniques and accepted screen recovery sizes. Refitting of debitage is possible but neither practical nor time effective. Debitage analysis of the very small organics (sinew, pitch mastic, leather) mixed with segregated recovered debitage, however, may give insight into material procurement and possible ^{14}C dating of a rejuvenation event.

In exploring the various scenarios of rejuvenation strategies, I concluded that RSA is the most effective technique of measuring rejuvenation in dart point collections.

CHAPTER 7

MEASUREMENT OF RSA IN THE CONTROL COLLECTIONS

INTRODUCTION

Projectile point reproduction, simulated hunting, and rejuvenation were the three main experiments that formed the control collections. These three processes produced a known number of projectile points (n=96) that had completed at least one cycle within a rejuvenation continuum. How much, what kinds and the circumstances in which rejuvenation took place are still questions to be reckoned with. This chapter addresses these questions.

RSA ANALYSIS OF THE FLENNIKEN-RAYMOND COLLECTION (n=30)

Of the 36 projectile points replicated during the experiment, six (16.6%) were discarded because of morphological discrepancies to the ECN type defined by Thomas (1981). Of the remaining 30 projectile points, one was lost during simulated hunting, and five retained insufficient mass for rejuvenation. Therefore, 24 of the 30 projectile points (80%) were rejuvenated to some degree. Table 7.1 shows RSA signatures and the number of signatures for each projectile point.

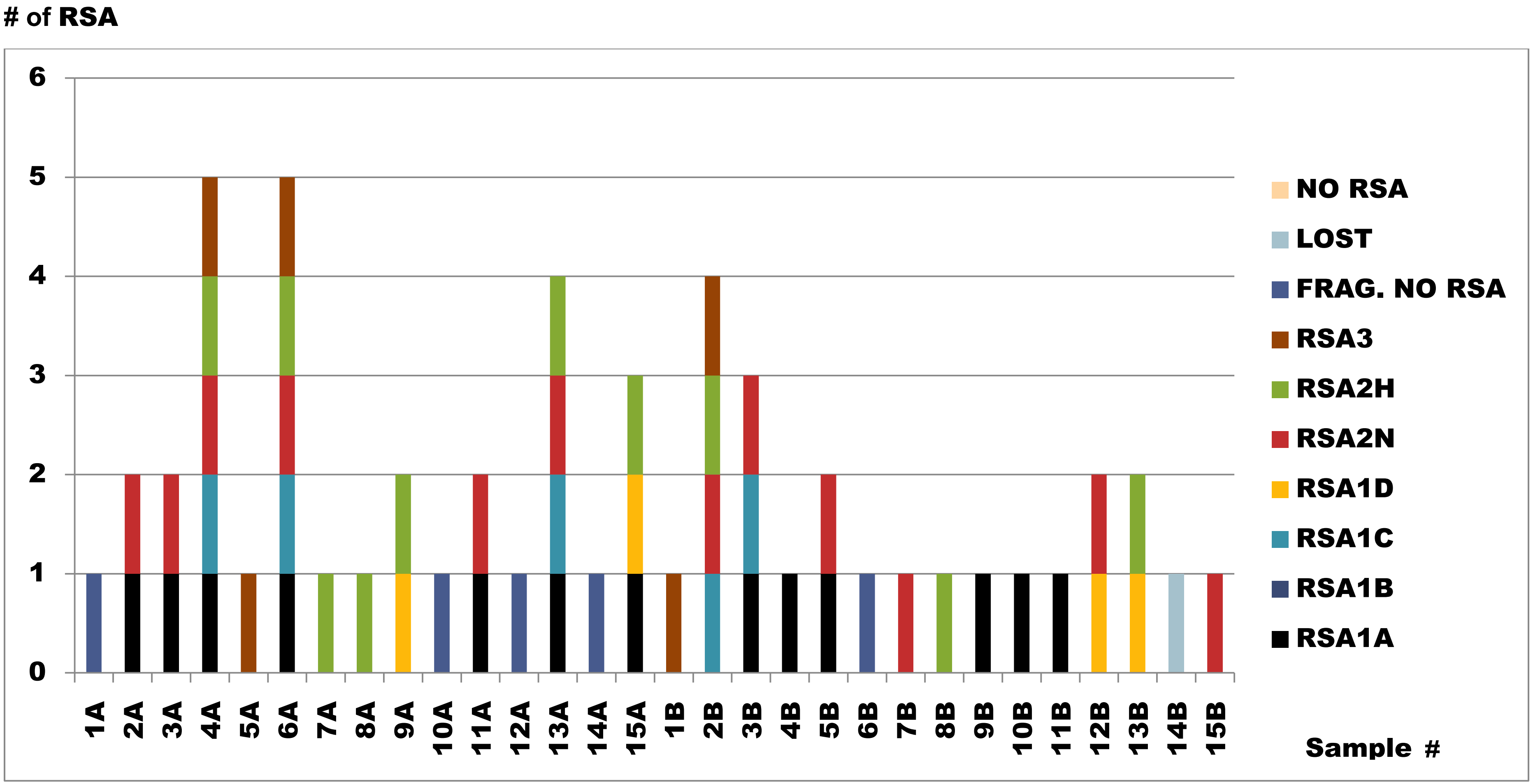


Table 7.1 Numbers and types of RSA signatures in the Flenniken-Raymond collection.

RSA blade signatures (18) and ligature line/hafting element signatures (22) were almost equally present. Total rejuvenation (RSA3) was only present in three specimens.

For RSA blade signatures, RSA1A was the most common rejuvenation signature observed (13 or 43%). Flenniken-Raymond produced no “bunts” (RSA1B). Margin or edge repair was observed in five (17%) of the specimens. Expedient tips or RSA1D were observed in four (13.3%) of the specimens.

Ligature line signature RSA2N was observed in 12 examples (40%). Complete haft rejuvenation or RSA2H was observed in 10 (33.3%). RSA3 occurred in five (16.7%) of the population. This was the same number of fragments where rejuvenation was not possible (5 or 16.7%).

The Flenniken-Raymond collection had 13 specimens with multiple RSA signatures. For this collection, two had five signatures, two had four signatures, two had three signatures, seven had two signatures, and 10 had only one signature. Five fragments were observed where no rejuvenation was possible. One projectile point was lost. The combination RSA1A and RSA2N occurred in four (13.3%) of the specimens, RSA1D and RSA2H occurred in two (6.7%) of the specimens, RSA1D and RSA2N occurred in one (3.3%) of the specimens, RSA1A, RSA1D, and RSA2H occurred in one specimen

(3.3%), RSA1A, RSA1C, and RSA2N occurred in one specimen (3.3%), RSA1A,RSA1C, RSA2N, RSA2H occurred in one specimen RSA1C, RSA2N, RSA2H, and RSA3 occurred in one specimen, and RSA1A, RSA1C, RSA2n, RSA2H, and RSA3 occurred in two specimens. Multiple RSA signatures in the control collections demonstrated a sequenced rejuvenation with the combination of multiple signatures indicative of a specific task. Multiple RSA signatures in the control collection specimens seemed to correlate and/or indicate a higher likelihood of change of type.

Out of the 24 atlatl points capable of rejuvenation, eight of the 24 rejuvenations resulted in a morphological change in type (33.3%; Flenniken and Raymond 1986: 608). Changes in sub-type resulted when five (16.6%) of the projectile points were fitted to the hafting element.

Mastic residues (pitch) were observed on four (13.3%) of the specimens. Mastic was in sufficient quantities for AMS dating.

RSA ANALYSIS OF THE WARBURTON - TOWNER COLLECTION (n=30)

Thirty (30) projectile points were replicated in the Warburton - Towner experiment. Of these, two points did not meet the morphological requirements described by Thomas (1981) for the Elko Corner-notch (ECN) type and were defined as “others”. One projectile point (Figure

5.5 #2) was broken during manufacture (typical as described in the Titmus- Woods experiment as a manufacturing break) and removed from the experiment. Both the ECN points and the “others” (29) were used in the simulated hunting portion of the experiment. Of these, two were lost and one fragment did not retain sufficient mass to be rejuvenated. Eight (31%) of the points changed type or subtype and 18 (69%) remained within the ECN category. Therefore, 26 (89.6%) of the broken projectile points were rejuvenated. Table 7.2 shows RSA signatures and the number of signatures for each projectile point.

RSA blade signatures (26) and ligature line/hafting element signatures (17) differed significantly from the Flenniken-Raymond experiment (18 blade and 22 hafting element) and the Spencer experiment (24 blade, 22 hafting element). Total rejuvenation (RSA3) was only present in 3 specimens. RSA3 in FR also was observed in three specimens. It was observed in two specimens in the Spencer experiment.

For RSA blade signatures, RSA1A was the most common rejuvenation signature observed (13 or 43%). Both Warburton and Towner and Flenniken-Raymond produced no “bunts” (RSA1B). Margin or edge repair (RSA1C) was observed in eight (26.6%) of the samples. Expedient tips or RSA1D were observed in five (16.6%) of the samples.

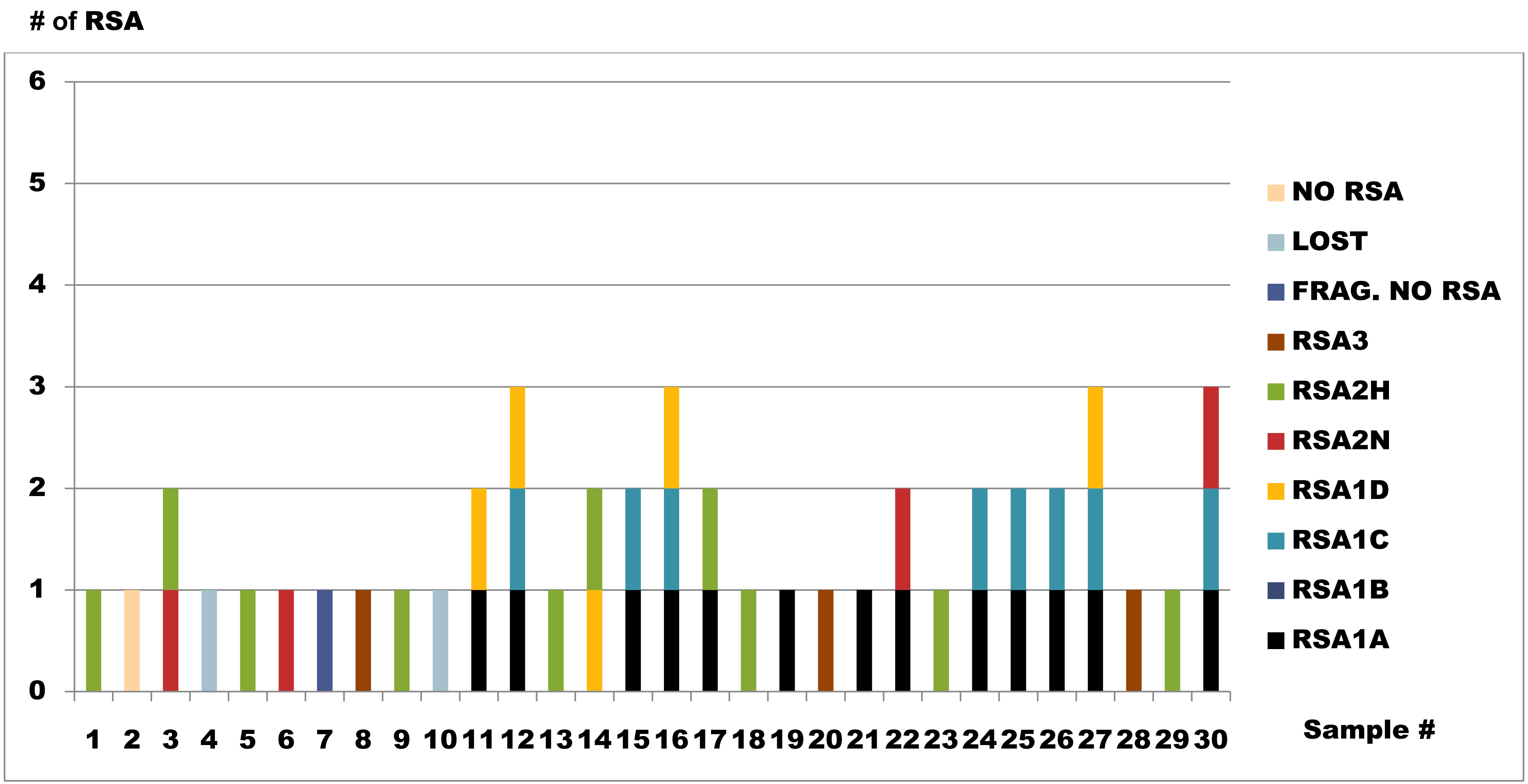


Table 7.2 Numbers and types of RSA signatures in Towner - Warburton collection.

RSA ligature line / hafting element signatures were observed in 17 (56.6%) of the samples with signature RSA2N observed in four examples (13.3%) and complete haft rejuvenation or RSA2H observed in 10 (33.3%). As previously stated, RSA3 or complete rejuvenation to a new archetype occurred in five (16.7%) of this study.

The Warburton - Towner collection had 12 specimens with multiple rejuvenation signatures. For this collection, four had three signatures, eight had two signatures, and 13 had only one signature. The combination RSA1A and RSA1C occurred in four (13.3%) of the specimens, RSA1A and RSA1D occurred in one (3.3%) of the specimens, RSA1A and RSA2N occurred in one (3.3%) of the specimens, RSA1D and RSA2H occurred in one (3.3%) of the specimens, RSA2N and RSA2N occurred in one of the specimens (3.3%), RSA1A, RSA1C, and RSA1D occurred in one specimen (3.3%), RSA1A, RSA1D, and RSA2N occurred in one specimen (3.3%). Multiple RSA signatures in the control collections demonstrated a sequenced rejuvenation with the combination of multiple signatures indicative of a specific task or rejuvenation trajectory. Often, two or more rejuvenation signatures were necessary to repair the tip (both RSA1A and RSA1D involve tip repair) and reset the margins (RSA1C). Other RSA signature combinations may be necessary to repair the notches, ears, and hafting elements (RSA2N, RSA2). Often, most of the RSA signatures are involved in RSA3.

Mastic residues were not recorded in the Towner- Warburton collection.

RSA ANALYSIS OF THE SPENCER COLLECTION (n=30)

Thirty (30) projectile points were replicated in the Spencer experiment. All of these projectile points were used in the simulated hunting portion of the experiment. Of these, two were lost and one dart point could not be recovered until the experiment was over and the carcass dismembered. Three fragments did not retain sufficient mass to be rejuvenated. Unlike the other experiments, however, one projectile point produced two "rejuvenatable" fragments (see Figure 5.19 specimens 9 a & b). Seventeen (56.7%) of the points changed type or subtype and 14 (46.7%) remained within the ECN category. Therefore, 24 (80%) of the broken projectile points were successfully rejuvenated and returned to the use-life stream. Table 7.3 shows RSA signatures and the number/frequency of signatures for each projectile point.

RSA blade signatures (24) and ligature line/hafting element signatures (22) differed slightly from the Flenniken-Raymond experiment (18 blade and 22 hafting element) and the Warburton-Towner experiment (26 blade and 17 ligature line/hafting element). Total rejuvenation (RSA3) was present in 2 specimens in the Spencer experiment.

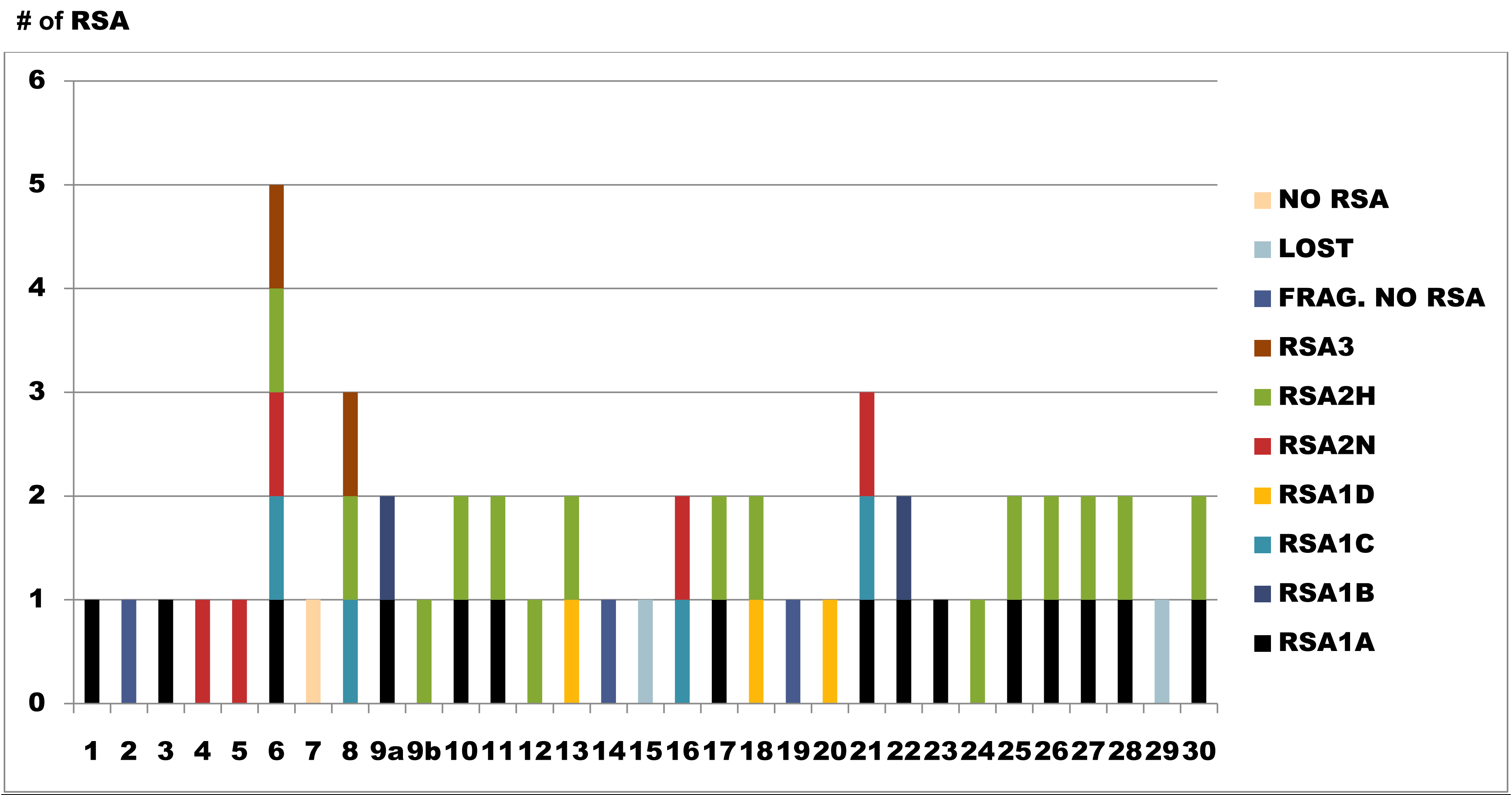


Table 7.3 Numbers and types of RSA signatures in the Spencer collection.

For RSA blade signatures, RSA1A was the most common rejuvenation signature observed (15 or 50%). The Spencer experiment was the only one of the three control collections to record a "bunt" (RSA1B). Margin or edge repair (RSA1C) was observed in four (13%) of the sample. Expedient tips or RSA1D were observed in three (10%) of the sample.

For RSA ligature line / hafting element signatures, complete haft rejuvenation or RSA2H occurred in 15 (50%) of the samples with signature RSA2N observed in five specimens (16.7%). As previously stated, RSA3 or complete rejuvenation to a new archetype occurred in two (6.7%) of the population.

As in all of the control collections, multiple rejuvenation signatures were observed on some of the Spencer specimens. For the Spencer collection, 16 specimens had multiple RSA signatures. Basically, one specimen had five rejuvenation signatures, two had three signatures, 13 had two signatures, and nine had only one signature. The combination of RSA1A and RSA2H occurred in eight (26.7%) of the specimens, RSA1A and RSA1B occurred in two (6.7%) of the specimens, RSA1A and RSA1D occurred in two (6.7%) of the specimens, RSA1D and RSA2H occurred in two (6.7%) of the specimens, RSA1D and RSA2N occurred in one specimen (3.3%), RSA1C, RSA2H, and RSA3 occurred in one specimen (3.3%), RSA1A, RSA1C, and RSA2N occurred in one specimen (3.3%), and RSA1A, RSA1C, RSA2N, RSA2H, and RSA3 occurred in one specimen (3.3%). As stated previously, multiple RSA signatures suggest a sequenced rejuvenation. This could be minor rejuvenation of resharpening the tip and adjusting the margins (RSA1A and RSA1C). Or it could be complete rejuvenation of resharpening the tip, adjusting the margins, creating new notches, and creating a new base which results in a "new" projectile point (RSA1A, RSA1C, RSA2N, RSA2H, RSA3).

The hypothesis that the higher number of multiple rejuvenation signatures the more likely that type changes occurred in the collection was substantiated by the Spencer collection. The Spencer collection saw the highest number of multiple rejuvenation signatures (16) and the greatest number of projectile points that changed type or sub-type (17).

Mastic was retained on one specimen (see Figure 5.19 specimen 20). Sinew retention was also observed on four specimens (see Figures 5.18 specimens 4 and 9b and Figure 5.19 specimens18 and 22). Both mastic and sinew were retained in amounts necessary for AMS dating.

OBSERVATIONS AND CONCLUSIONS

Within the three control collections, a total of 96 projectile points were replicated. Of these, 89 were used in simulated hunting scenarios. A total of 74 were rejuvenated. Ten projectile points were not rejuvenated; five projectile points were lost (displayed graphically in

Figure 7.1). This information was used to construct the following frequency chart (Figure 7.2) and model of use-life and rejuvenation continuums (Figure 7.3).

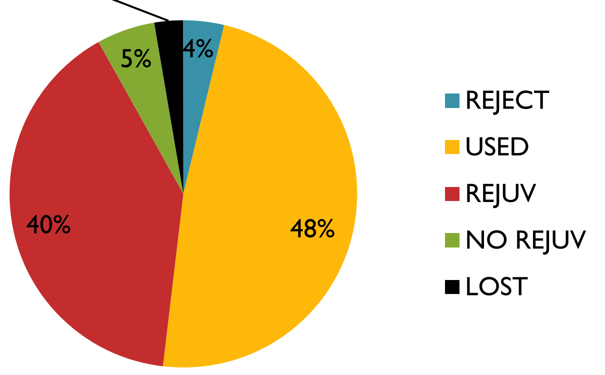


Figure 7.1 FR, TW, SP Percentages in Use-Life and Rejuvenation Continuums

n=96
Used in Experiments = 89
Rejuvenated = 74
Lost = 5
Rejected=7
No Rejuvenation = 10

In Figure 7.1, it is interesting to note that the numbers of “rejected”, “no rejuvenation”, and “lost” are very low. These totals also only reflect one rejuvenation cycle. In a use-life continuum that is receiving constant inputs from new manufacturing, new rejuvenation, curation, and even finding previously “lost” projectile points, these percentages would be expected to be much higher. In a use-life and rejuvenation continuum model, many of these input products would cycle until: discard, curation, lost, lateral recycling, ritual offering, or burial internment.

In Figure 7.2, the three most used rejuvenation trajectories were RSA1A (resharpening), RSA2H (rejuvenation of the base) and RSA1A and RSA2H (both resharpening the blade and remanufacture of the base). The next order of rejuvenation trajectories were modifications of the ligature line (RSA2N) recovery of the tip and ligature line (RSA1A and RSA2N), repair of the tip and hafting element (RSA1D and RSA2H) and remanufacture of the projectile point (RSA3). Tip and margin repair (RSA1A and RSA1C), tip, margin, and expedient tip repair (RSA1A, RSA1C, and RSA1D), tip margin, and notch repair (RSA1A, RSA1C, and RSA2N), and tip, margin, notch, hafting element, and remanufacture (RCA1A, RSA1C, RSA2N, RSA2H, RSA3) were the next important rejuvenation trajectory. Each of the other rejuvenation trajectories were used only once (See Figure 7.2).

RSA1B was the least used rejuvenation trajectory. This could be explained by many factors. First, the goal of the experimenters was to return the projectile point into use-life with the most efficient and “high confidence” “type” of projectile point. A “bunt” has limited penetration power for most game and hence, low confidence, however, it is a preferred style where hunting waterfowl is concerned. A bunt will cause more trauma and bone breakage in waterfowl than a sharp tip point. It could have been “preference” by the experimenters or skill level. It is interesting to note that I have the lowest flintknapping skills of all the experimenters and made the only “blunts” observed in the control collections. Bunts or “blunts” are also a lateral recycling technique where a projectile point with an intact hafting element is remanufactured into a scraping or defleshing tool. The hafting element is often changed to a heavier armature so that downward pressure can be exerted while drawing the implement across the working surface. RSA1B could be a rejuvenation signature associated with this type of lateral recycling.

Blade recovery rejuvenation trajectories accounted for only six of the 20 (30%) rejuvenation trajectories observed in the control collections. Fourteen of 20 (70%) involved ligature line and hafting element repair most often used with some aspect of blade repair. These ligature line and hafting element strategies were the trajectories most likely to change projectile point morphology and hence "type". Of the 96 projectile points replicated for the experiments, 33 or 34.3% changed type. A total of 48 or 50% did not change type. This 50% figure is mostly due to the constraint protocol of experimenters rejuvenating projectile points to the archetype, ECN, wherever possible.

Figure 7.3 is the hypothetical use-life model for the control collections with the "weight" (size) of each activity drawn relative to its observed occurrence within the control collections. For example, "lost" points occurred only in 5 specimens, hence a small circle. The main and central driving force is the use-life continuum. This is where projectile points constantly enter as newly manufactured, rejuvenated, curated, or rarely "found" projectile points. In the central use continuum, the

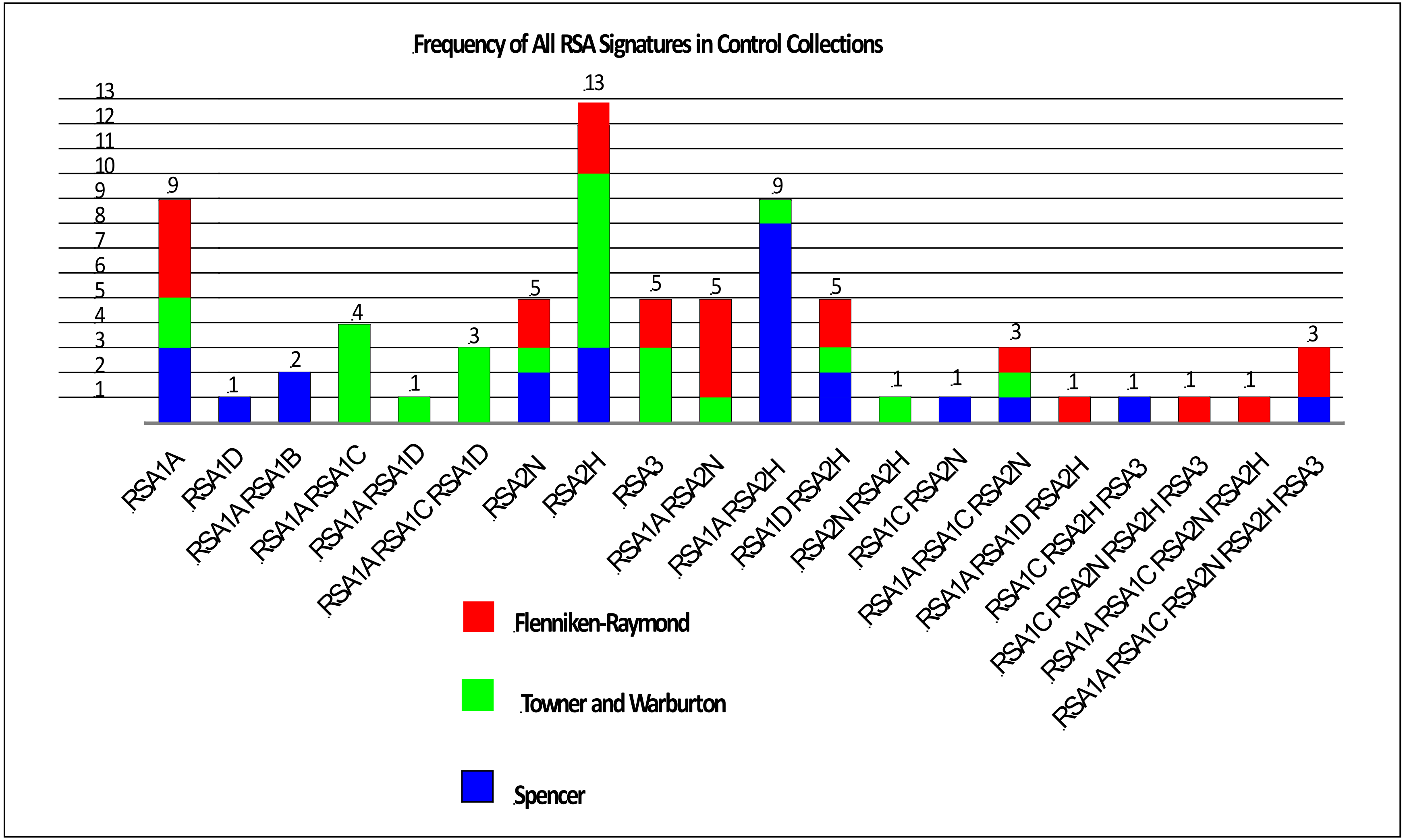


Figure 7.2 Frequencies of RSA signatures in control collections.

projectile points are used for projectile points, i.e. hunting, warfare, gaming, etc. It is recognized that other researchers have observed hafted projectile points originally intended for projectile points could be used for expedient knives or other cutting, sawing, carving, fleshing, scraping, or "sharp edged" tools (Ahler 1971; Andrefsky 1997; Kelly 1988; Nance 1971; Truncer 1990). The underlying assumption in this use-life continuum is that although it is possible that these other activities can be used for hafted projectile points, the ultimate and non-expedient use is the intended use as a projectile point.

The next major driving force, the rejuvenation continuum, involves rejuvenation in the form of resharpening, repair, and remanufacture. This is illustrated in the sub-processes or rejuvenation signatures that occurred in the control collection (see Figure 7.2).

All of the experimenters lost projectile points, even though special precautions were often taken to recover the most projectile points and fragments as possible (see tarp in Figure 5.16). No actual "lost" projectile points from the control collections were returned into the use-life continuum. In Figure 7.3, a dotted line was drawn from "lost" to "found" as this is a purely conjectural activity and not readily observed in the control collections.

The other conjecture of the model was removing projectile points from the use-life continuum through ritual offerings or burial internment.

This was also not observed in the control collections, hence the "dotted" line and very small dotted circle.

The lateral recycling of projectile points to non-projectile use is probably characterized by rejuvenation signature RSA1B. Usually this occurs when the projectile point has a lateral mid-blade bending fracture and is not recoverable as a projectile point because of insufficient remnant blade mass. The hafting element and ligature line are intact and capable of re-hafting.

The discard portion of the model is mostly due to a projectile point shattering with multiple use-life impact fractures, insufficient remnant mass, or a conscientious decision to remove a functioning projectile point from use-life due to a lack of confidence. Flenniken-Raymond decided to remove 6 of their replicated projectile points from use-life because the projectile points did not meet the morphological criteria established by Thomas (1981) for ECN "type". Warburton and Towner also observed that two of their projectile points did not meet these morphological criteria, however, these projectile points remained in use as "other" designates. This concern to successfully replicate to a specific, narrowly defined type was noted by all experimenters, however, it was largely an artificial constraint established during

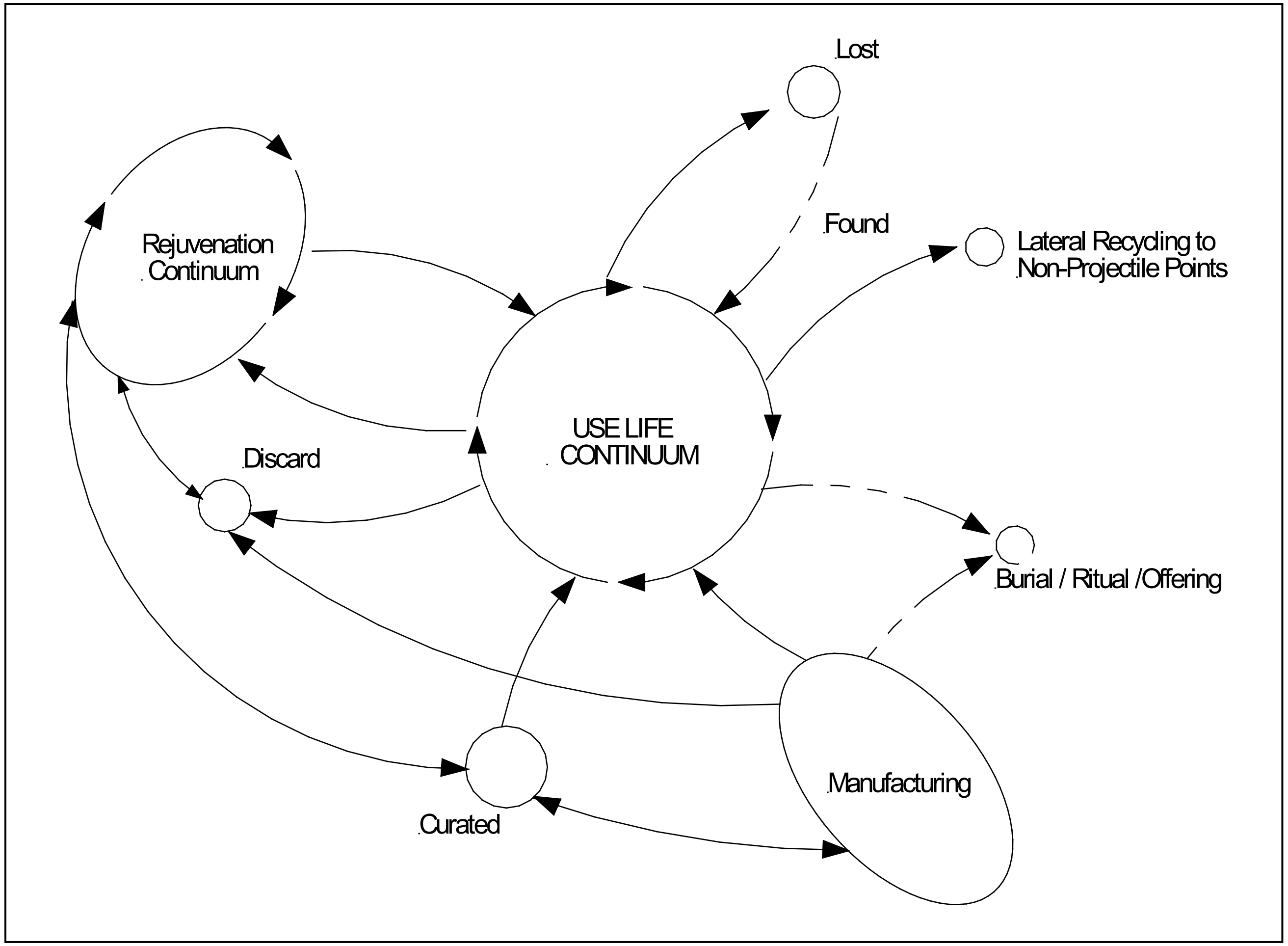


Figure 7.3 Model of Use - Life and Rejuvenation Continuums in Control Collections

replication and rejuvenation protocols. Warburton-Towner also discarded one projectile point that was irrecoverably broken during manufacture.

Each of the experimenters temporarily curated projectile points and foreshafts until that time that the simulated hunting scenario could be completed. They also saved preforms (as in the case of Warburton and Towner) for further reduction. All experimenters temporarily curated materials until they could be analyzed and rejuvenated. Flenniken-Raymond and Spencer both curated the rejuvenated projectile points from their experiments for future studies. The curated sub-process therefore includes completed, ready-to-use weapon sub-systems, recoverable projectile point and sub-weapon system fragments (foreshafts, etc.), and late stage manufactured preforms.

Mastic residues were examined in all of the control collections. Two of the three collections (Flenniken - Raymond and Spencer) contained rejuvenated projectile points with retained mastic and/or sinew in sufficient quantities for ^{14}C AMS dating. It is assumed that the Warburton- Towner collection also had specimens that retained pitch mastic; however, physical examination of the projectile points was not possible. Retained mastic and sinew (as well as any other retained organic residues) suggest two conclusions: a) the projectile point in question has undergone at least one use-life and rejuvenation cycle and b) the retained mastic and sinew could more accurately date the projectile point than inferences by “type”. This aspect of residue analysis could be important in accurately placing projectile points in a chronological sequence, independent of “type”.

In conclusion, analysis of rejuvenation trajectories within the three control collections shows that rejuvenation can be measured by strategies of rejuvenation, frequency of rejuvenation signatures, location of signatures on the projectile point (blade, ligature line, or hafting element), and by those strategies that are most likely to cause a morphological change of “type”. Rejuvenation can further be described as a functionality or complementary process of a use-life continuum model.

Other examinations of the control collections suggest that analysis of retained mastic and sinew may be a viable alternative in ^{14}C dating of the projectile point *per se*, independent of morphological analysis of “type”.

CHAPTER 8

MEASURING RSA IN THE TEST COLLECTIONS

INTRODUCTION

Atlatl dart point collections from four deeply stratified caves located in the EGB were chosen as a test bed for measuring RSA in extant assemblages (see Figure 2.4). Collections from Danger Cave, Hogup Cave, Cowboy Cave, and Sudden Shelter have been extensively used by other researchers (*e.g.* Jennings, Aikens, Holmer, Thomas, O'Connell, Layton, Madsen, Adovasio, Clewlow, Fowler, Schroedl, and a great host of others) for chronology building, environmental (climate) and ecological reconstructions, material culture analysis (especially perishable items such as nets, cordage, basketry, and footware), and lithic studies (especially projectile point type constructions). Because of their careful excavation, ^{14}C dates, and use as type sites for projectile points, these archaeological sites were logical candidates.

Located in the state of Utah in the physiographic provinces of the Great Basin (Basin and Range) and Colorado Plateau and Rocky Mountains, these sites are located within 150 miles of each other (see Figure 2.4) in four markedly different environmental zones and ecotones. As discussed in Chapter 2, these sites are all well within the EGB. The stratigraphic sequences between these archaeological sites have been correlated by corrected ^{14}C dating, pollen, soil genesis, and other environmental indicators (see Figure 2.3). Materials for all collections are currently located at the University of Utah, Utah Museum of Natural History Anthropology Collections, Salt Lake City, Utah. I received special permission to conduct non-destructive analysis of these collections. I was able to weigh, measure, photograph, and analyze the projectile points from these collections over the course of two weeks in April, 2005.

During this analysis, methods as described in Chapter 5 were used. Three additional categories of analysis were added to the “test” or cave projectile point assemblages: Fracture, Potential Rejuvenation, and Material. If the fragment retained a fracture signature (FRACT) this was noted (burin, flute like, bending, or combinations of these three). Potential Rejuvenation (POT.R) indicated that sufficient mass remained for dart point rejuvenation even though it was fractured. Materials (MAT.) were coded as: (1) cryptocrystalline silicate (ccs), (2) obsidian, (3) ignimbrite, (4) basalt and glassy basalt, (5) siltstone, (6) quartzite, and (7) rhyolite. This was to determine if there was a correlation between rejuvenation signatures, rejuvenation strategies, “types” and materials. At the time of analysis, material sourcing had not been conducted. Page (2008) sourced many fine grained volcanic tool stone sources for the Bonneville Basin and eastern Nevada, specifically fine grained volcanic tool stone sources for Danger Cave. This was fortuitous and will be further discussed in applied RSA studies in Chapter 10.

Projectile point assemblages were analyzed as they were brought to me. Analyses were entered into an EXCEL spreadsheet with hyperlinked photographs. Because of previous analyses, publication, and display purposes, some of the trays had all extant or nearly extant projectile points. Some trays had large percentages of projectile point fragments. I made no effort during the analysis period to make priorities or conduct initial pre-sorting. The projectile points in the charts and figures are denoted by their acquisition number usually at the bottom axis of the figure. In later notes, however, I did attempt to arrange the artifacts from a particular feature or context from information obtained from the publication or monograph.

DANGER CAVE ASSEMBLAGE (n=225)

Danger Cave is located in a middle latitude desert (annual precipitation of less than 5 inches) approximately 1.5 miles northeast of present day Wendover, Utah (see Figure 2.4). At an elevation of 4325 feet, the cave overlooks the Bonneville Salt Flats to the east and is part of a small cove formed by the remnants of Pleistocene Lake Stansbury. Danger Cave was reported in the 1930's and first excavated by E.R. Smith of the University of Utah. First known as Lamus Cave and Hands and Knees Cave by the locals (the only way to obtain entrance to the rear chamber), Danger Cave was so named in 1941 when a large roof spall detached and came within feet of crushing some of the members of the excavation party, hence "danger" cave. Work was suspended near the start World War II and would not resume for another eight years under the supervision of Jesse D. Jennings. With major help from the University of Utah 1949-53 field schools, excavation was completed. Careful stratigraphic controls, collections, and notes (for the time) were taken throughout the course of these later investigations. With cultural deposits more than 11 feet deep, it is one of the important archaeological sites in North America. Projectile points from strata DII through DV of Danger Cave (7800 B.C to 1000 BC; Jennings 1978: 35; see also Figure 2.3) were examined for RSA signatures. These strata are complex with huge quantities of fibrous plant materials, plant chaff, ash, charcoal, animal dung (mostly rats and mountain goat), twigs, and leaves. Some of the strata had been intentionally or unintentionally burned *in situ* in prehistoric times, converting the organic components into a fine white ash. Preservation of the organics within the strata differed from the exposed rock overhang and apron (no organics) to the deposits of the rear grotto (almost all organics preserved). Compounding the interpretation problem, many of the early excavation notes, photographs, and some of the earliest artifacts were lost when work was temporarily suspended during World War II. Subsequent excavations of the apron and rear grotto by Jennings, however, compensated for some of the loss of this earlier information. These recovered materials were substantial in preservation quality, quantity, and diversity of artifact types.

I examined all of the projectile points from strata DII to DV. The projectile points from these strata were analyzed within the procedures, contexts, and constraints previous detailed. All types of atlatl dart points, not just ECN, were examined for rejuvenation signatures. The results of this analysis form the information presented in Tables 8.1 through 8.8. These are the RSA signature(s) for each of the projectile points. Table 8.9 is a composite of all Danger Cave RSA signatures.

Analysis of Danger Cave RSA Signatures

Danger Cave was the largest of the four cave assemblages' analyzed (225 specimens). As such, it had the most variation in RSA signatures observed. Most surprising was that all 225 specimens had a rejuvenation signature. Some were fragments (15) usually with mid-blade bending fractures or composite (multiple) fractures with nil potential of rejuvenation into another dart point. These fragments, however, still retained evidence of past rejuvenations. A few were fragments with past rejuvenation signatures and with rejuvenation potential (14). Five had rejuvenation potential but were neither functional projectile points nor fragments. The others fell within the spectrum of simple resharpening (RSA1A) to complex or complete remanufacture (RSA3) with many multiple RSA signature permutations in between.

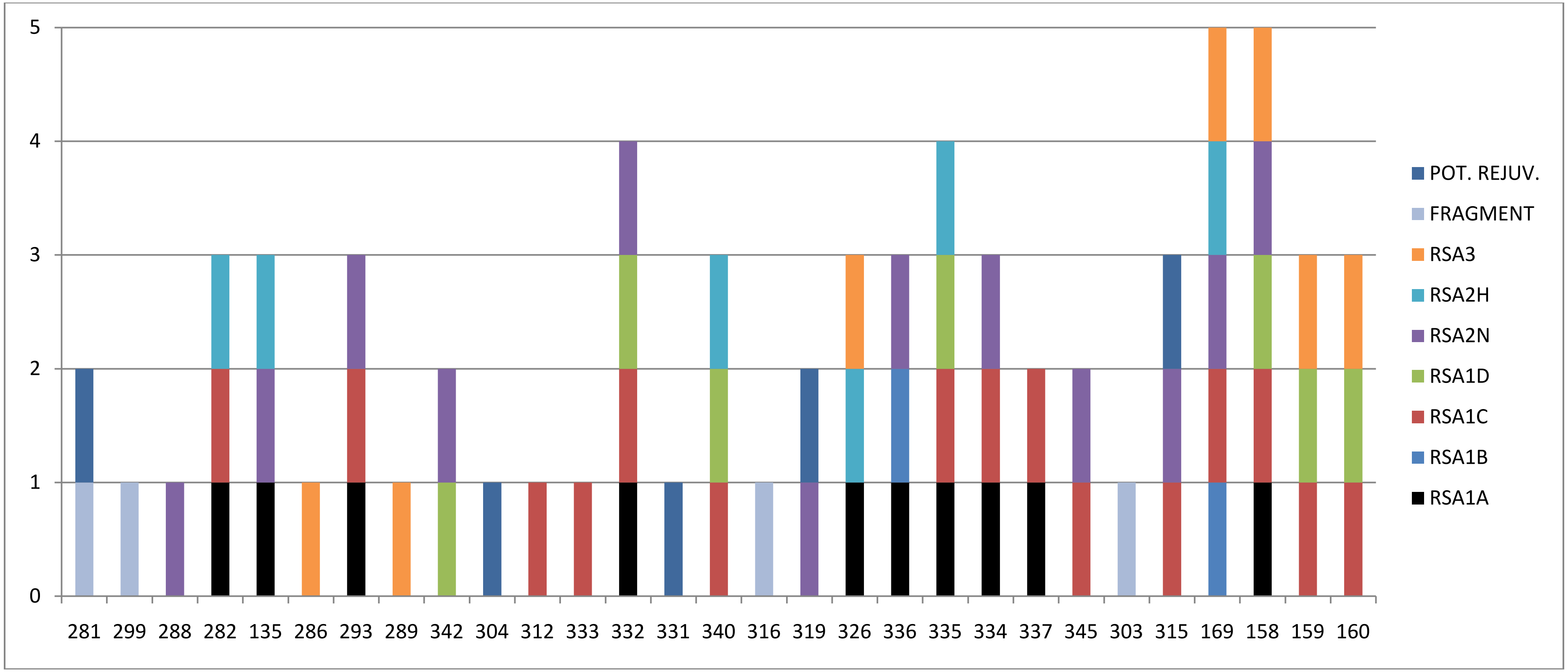


Table 8.1 Frequency of Danger Cave projectile point RSA signatures 1-29. Specimen acquisition number bottom axis.

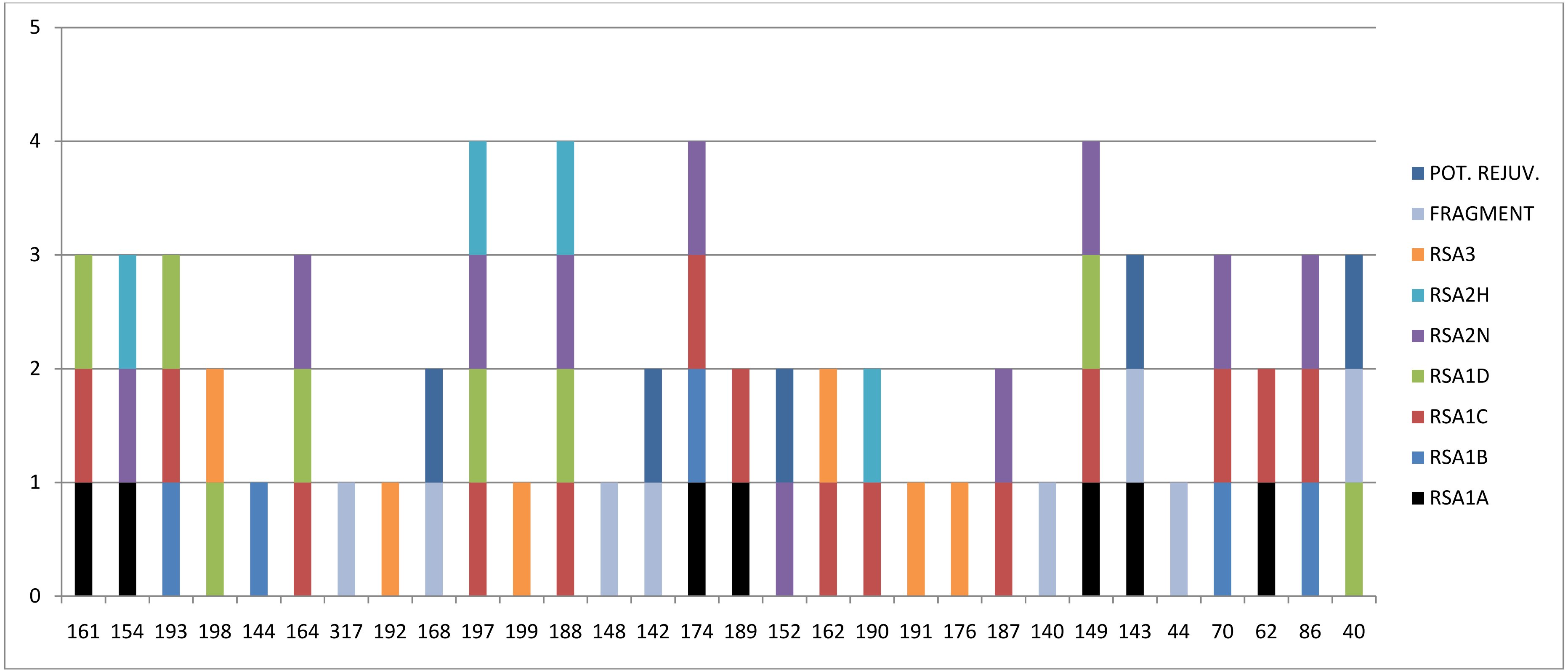


Table 8.2 Frequency of Danger Cave projectile point RSA signatures 30-59. Specimen acquisition number bottom axis.

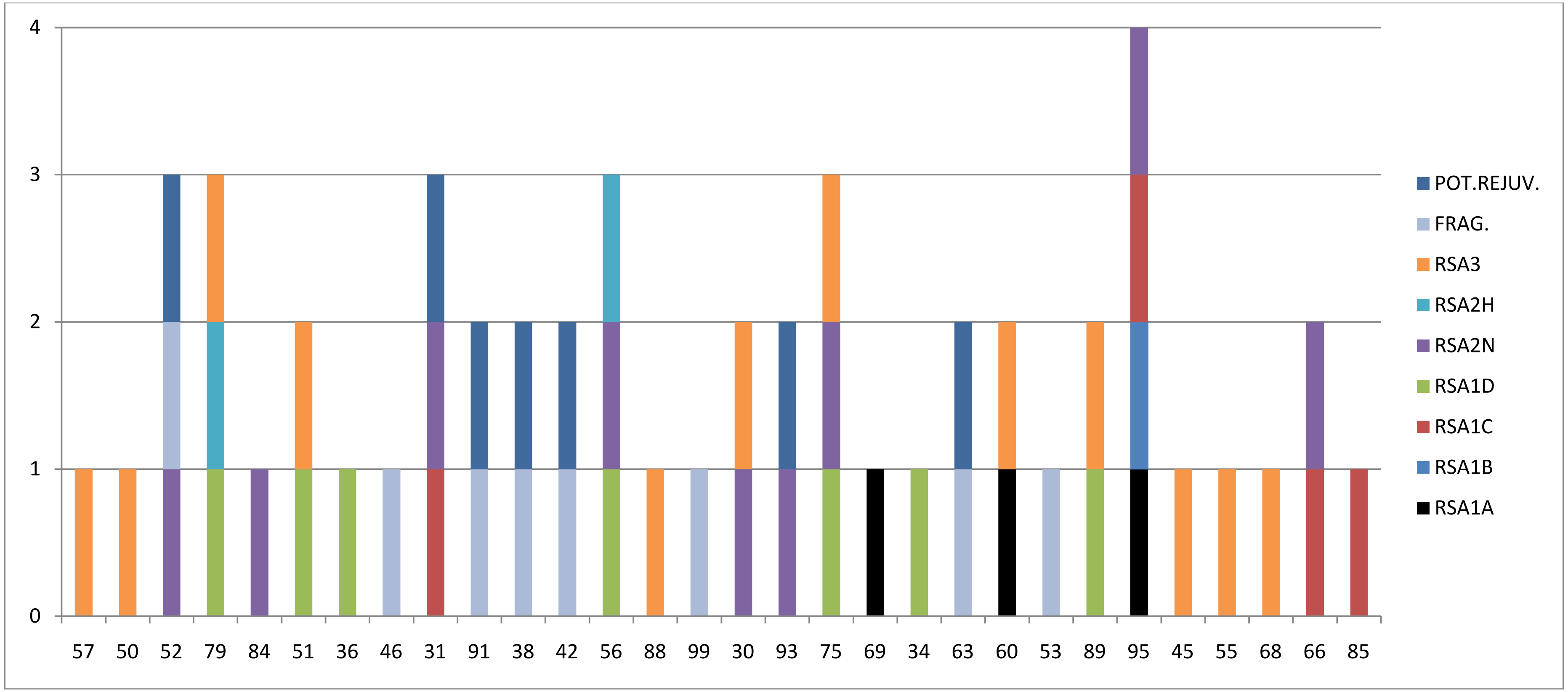
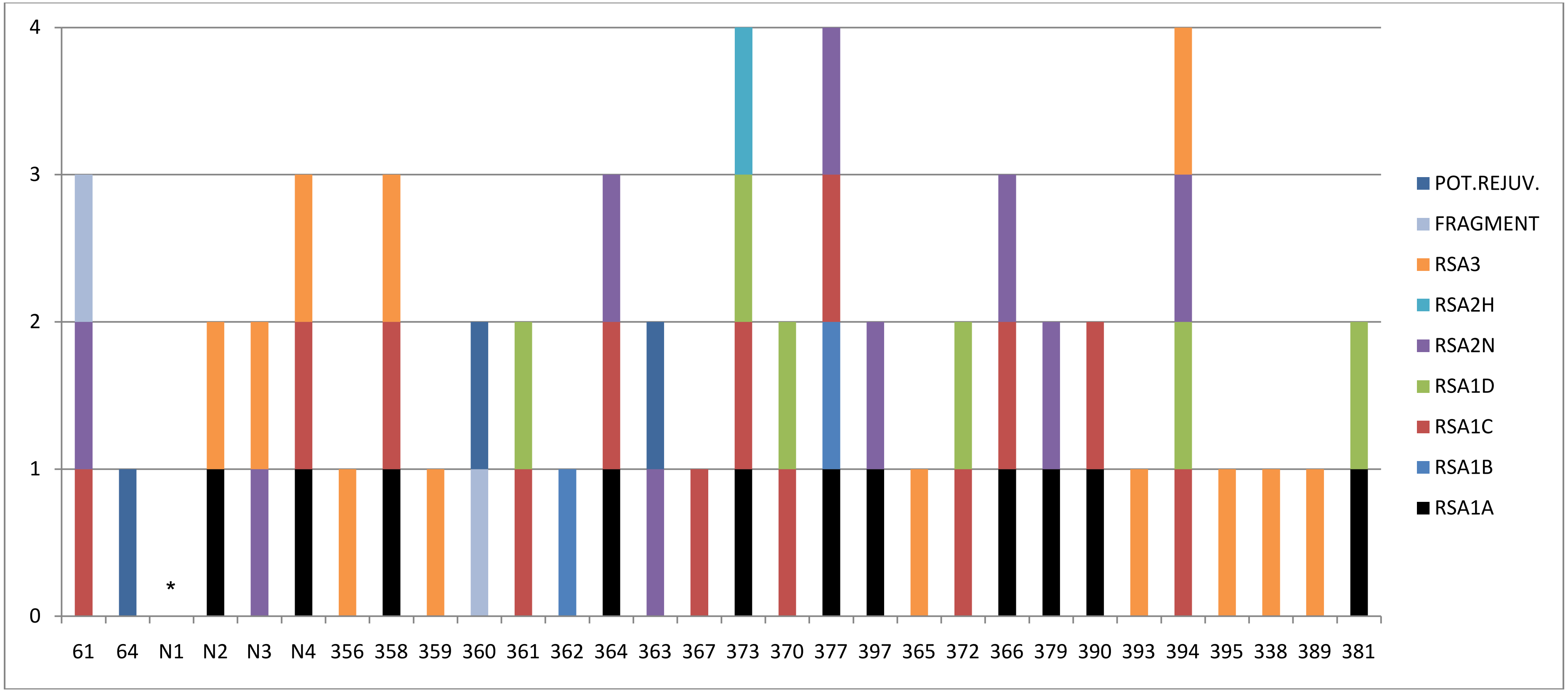


Table 8.3 Frequency of Danger Cave projectile point RSA signatures 60-89. Specimen acquisition number bottom axis.



*N1 artifact was missing.

Table 8.4 Frequency of Danger Cave projectile point RSA signatures 90-119. Specimen acquisition number bottom axis.

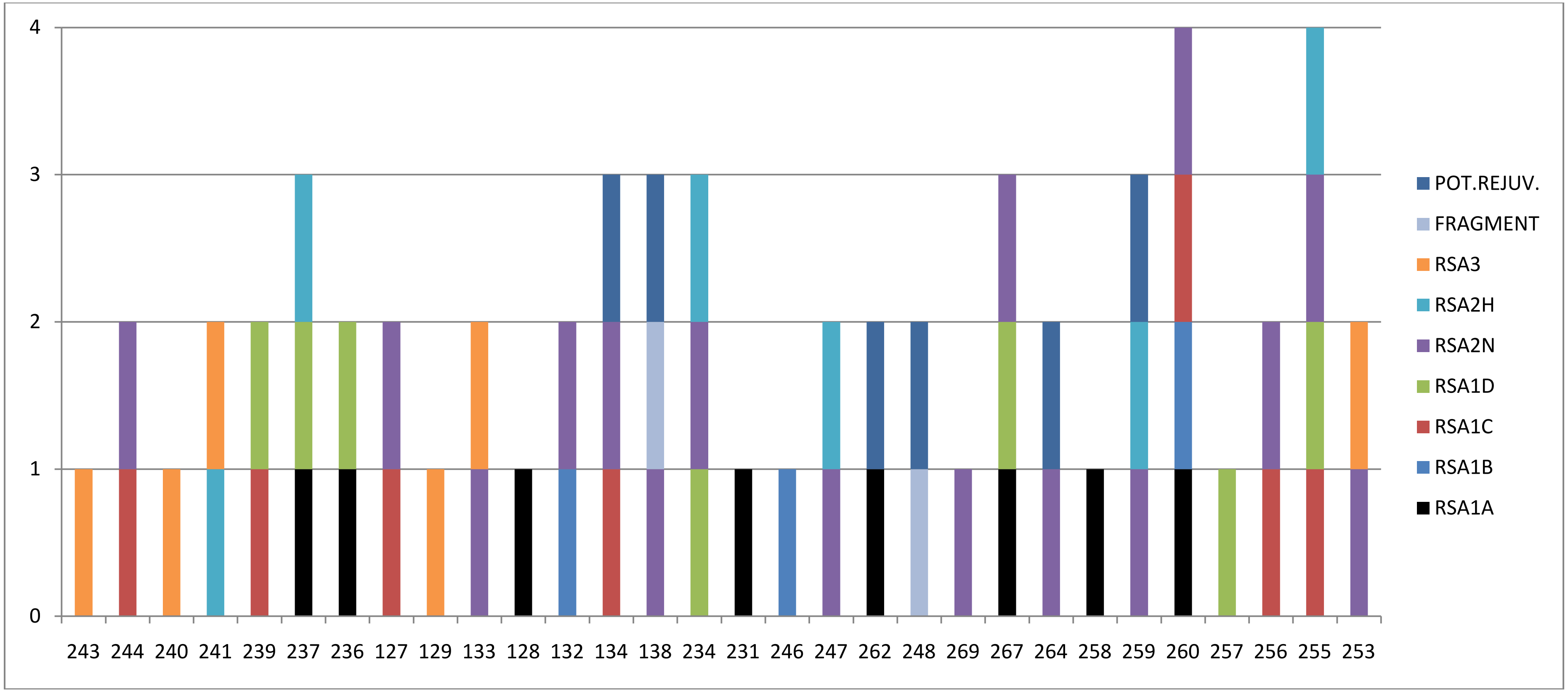


Table 8.5 Frequency of Danger Cave projectile point RSA signatures 120-149. Specimen acquisition number bottom axis.

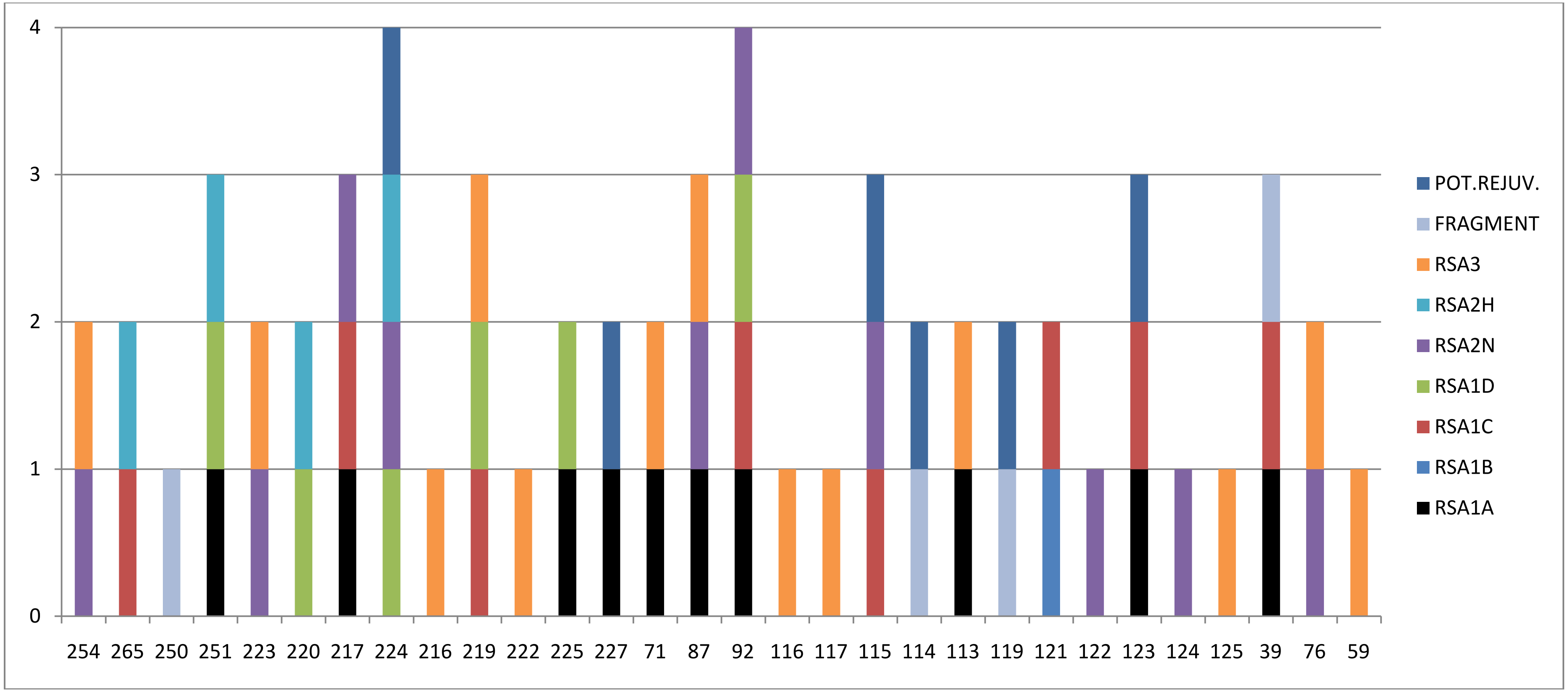


Table 8.6 Frequency of Danger Cave projectile point RSA signatures 150-179. Specimen acquisition number bottom axis.

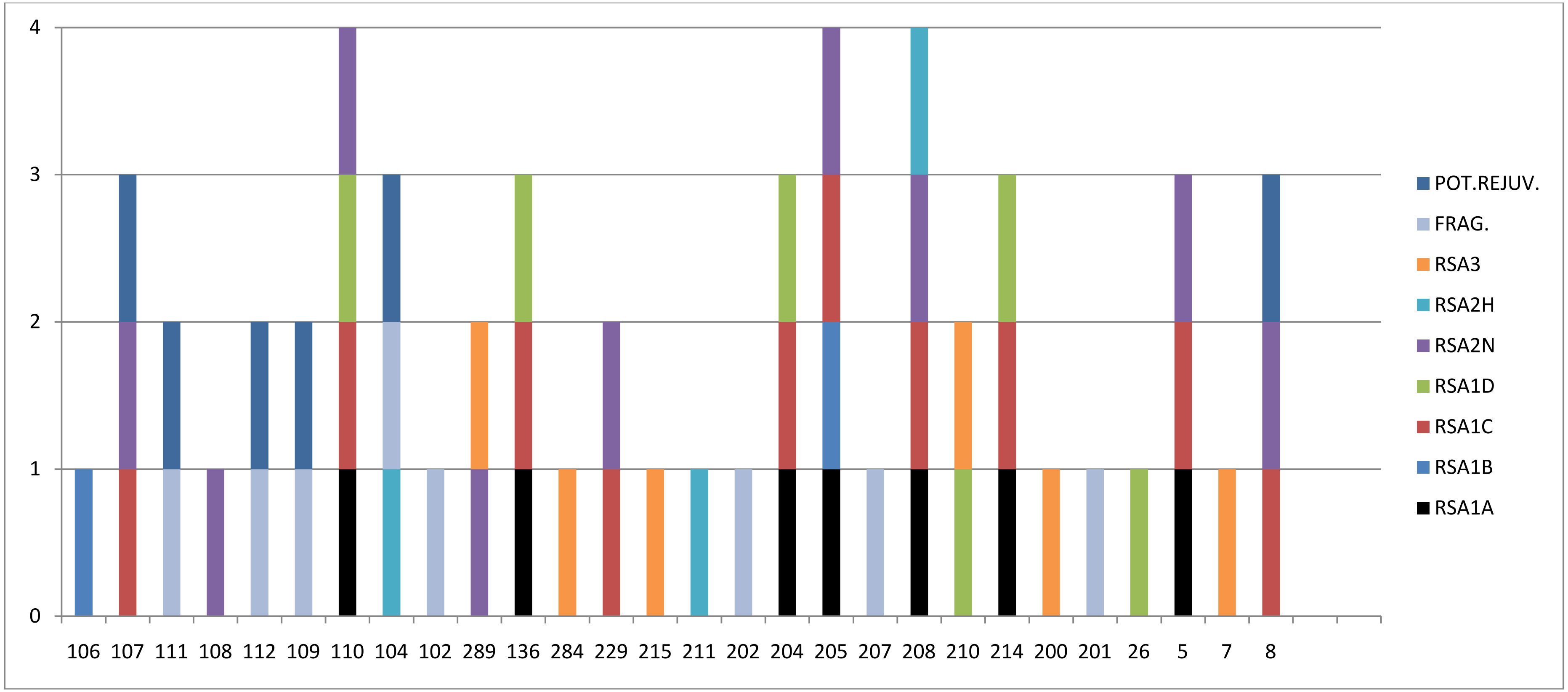


Table 8.7 Frequency of Danger Cave projectile point RSA signatures 180-207. Specimen acquisition number bottom axis.

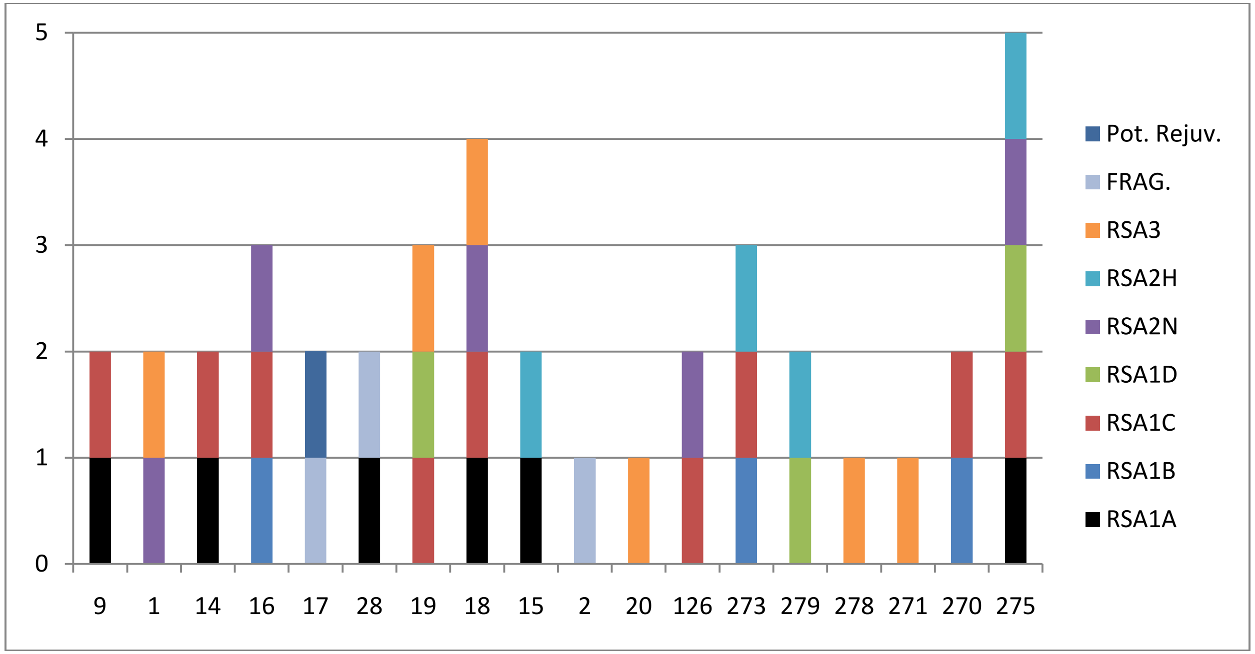
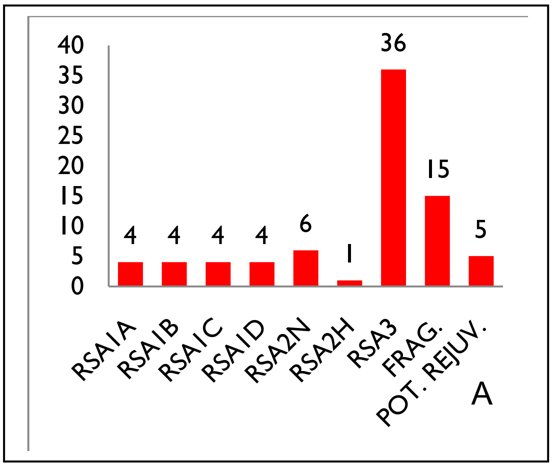
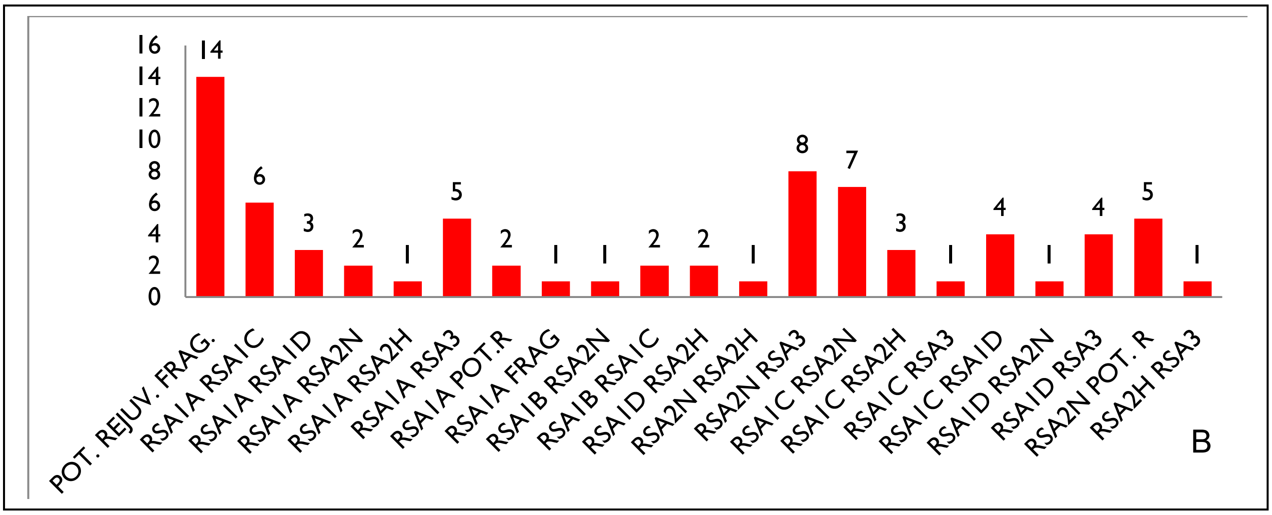


Table 8.8 Frequency of Danger Cave projectile point RSA signatures 208-225. Specimen acquisition number bottom axis.

Table 8.9 Frequency of all RSA signatures for Danger Cave. “A” is single signatures, “B” is two signatures, “C” is three signatures, “D” is four and five signatures (continued on next page).





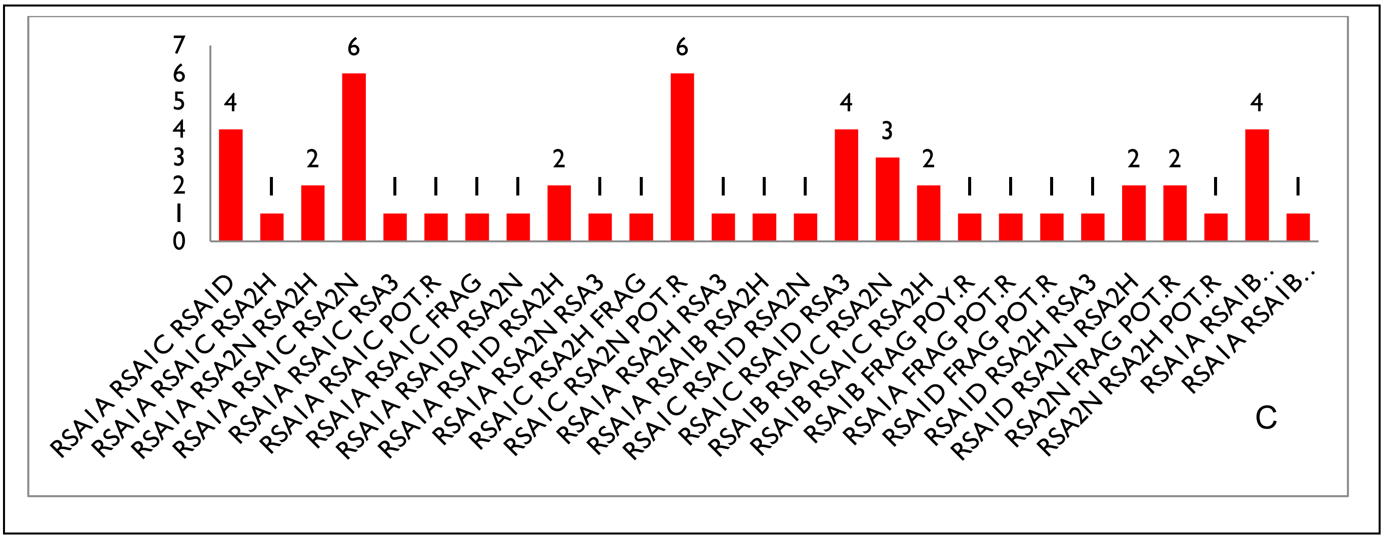
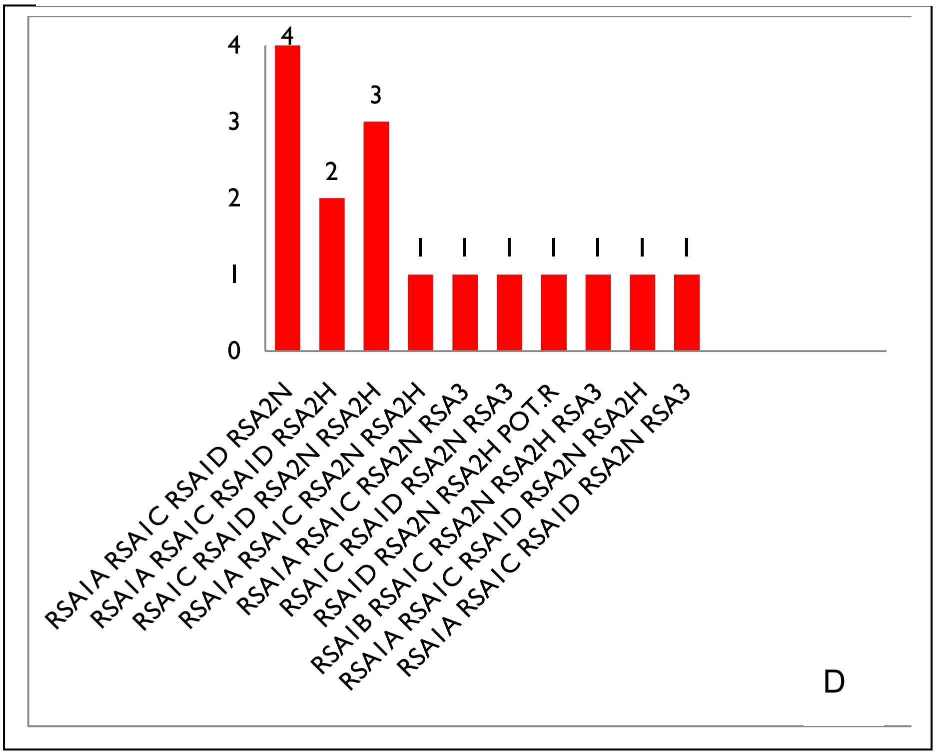


Table 8.9 continued from previous page.



The RSA signatures can perhaps best be broken down by numbers of signatures observed on the projectile points (see Table 8.9 A, B, C, D):

Single Rejuvenation Signatures

Single rejuvenation signatures were 79 or 34.8% of the total assemblage. These single rejuvenation signatures were divided between 9 categories. Single signatures should not be discounted as a rejuvenation strategy. A single RSA signature can have a profound effect upon the morphology of the projectile point. For example, the recorded projectile point (SEQ# 9; see Figure 8.1) is an extreme example of RSA1A. Sixteen of these signatures were associated with rejuvenation of the blade, seven were rejuvenation of the ligature line/hafting element, and 36 were the total refurbishment of the projectile point. It is significant to note that within this group RSA3 represents the highest single or multiple RSA signature of the assemblage.

Figure 8.1 RSA1A from Danger Cave (SEQ#9). (Photo credit: A. Spencer).

Two Rejuvenation Signatures

Seventy-four or 32.6 % of the signatures were double signatures. Seven of the double signatures were blade, 9 were ligature line/hafting element, and 5 had RSA3 as a part of the signature. Again, those RSA trajectories that have refurbishment of the ligature line/hafting element or total refurbishment (RSA3) have the greatest potential for change of type. A significant portion of two rejuvenation signatures categories were those in which fragments could be potentially rejuvenated (14). High percentages of fragments, and fragments that could be potentially rejuvenated, strongly suggests active curation.

Three Rejuvenation Signatures

Forty-nine of the three signatures were signatures divided between 26 categories. A total of six signature categories were associated with blade rejuvenation, 15 were associated with ligature line/hafting element refurbishment, and five were associated with the total refurbishment of the projectile point. As rejuvenation signature trajectories increase, the more likely that these rejuvenation signatures refurbish the ligature line or hafting element.

Four and Five Rejuvenation Signatures

Sixteen showed four and five rejuvenation signatures divided between 10 categories. At this level of signature complexity, none were exclusively blade refurbishment, most had components that refurbished the ligature line/ hafting element (12), or total projectile point rejuvenation (4). These categories have the increased potential of changing type through refurbishment. These as well as any combination of RSA signatures should be regarded as ordered strategies of rejuvenation trajectories.

Other Observations Affecting Rejuvenation

In the control collections, all of the projectile points had undergone only one rejuvenation/use-life cycle. It was observed in the Danger Cave assemblage that several of the projectile points appear to have been rejuvenated during several (at least two) cycles (SEQ# 293, 319, 345, 315, 143, 397,134, 227,114,108, and126; see Figure 8.2 following page). Many of the projectile points in the Danger Cave assemblage may have undergone multiple rejuvenation cycles, however, these specimens were the most obvious under the current analytical controls.

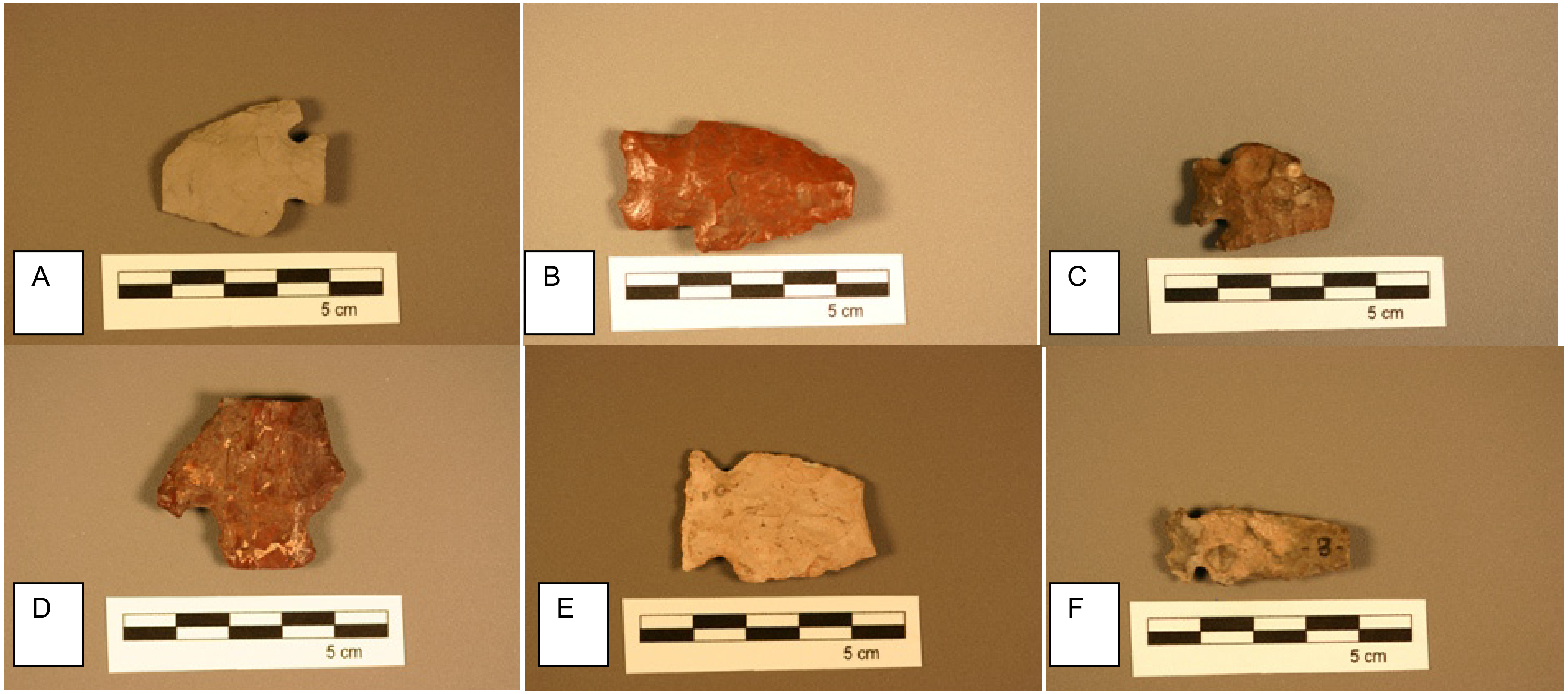


Figure 8.2 Examples of multi-rejuvenation cycle projectile points from Danger Cave. A. SEQ# 319. B SEQ# 397. C. SEQ# 126. D. SEQ# 293 E. SEQ# 315 F. SEQ# 134. Note refurbishments before bending fracture to blade. (Photo credit: A. Spencer).

Two of the projectile points in the Danger Cave assemblage retained sinew (SEQ# 390) and pitch (SEQ# 338) in quantities sufficient for AMS dating (see Figure 8.3). Current UMNH collection protocols, however, prohibit destructive analysis.

Figure 8.3 Retained sinew (SEQ# 390) and pitch (SEQ# 338) projectile points. (Photo credit: A. Spencer).

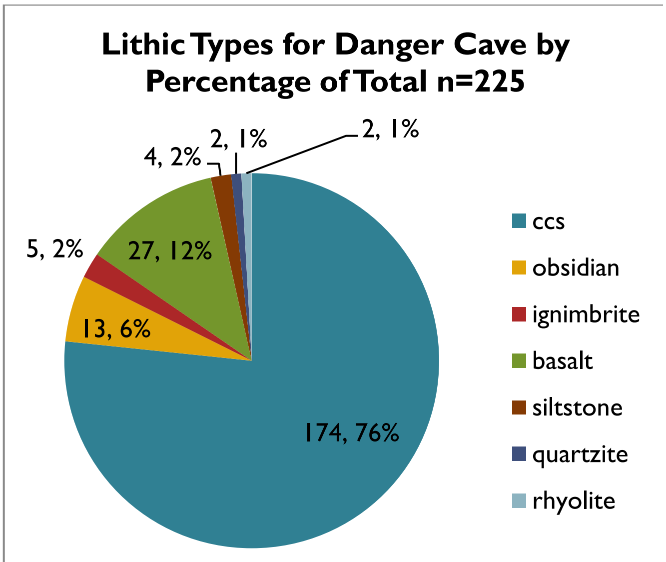


Figure 8.4 Lithic tool stone as observed in Danger Cave projectile points.

All lithic types associated with the projectile points were recorded during analysis. These analyses were based on visual inspection only (see Figure 8.4). Of the 225 specimens examined, most were cryptocrystalline silicates (174), followed by basalts and glassy basalts (27), obsidian (13), ignimbrite (5), siltstone, quartzite (2), and rhyolite (2).

Finally, many of the projectile points exhibited non-use-life fractures. This was typically thermal spalling (pot lid fractures), probably from the *in situ* conflagrations shown mostly in stratum DII. In other contexts, these pot lid fractures would be interpreted as intentional and final discard (throwing discard into a fire or firepit) and not a facet of curation. Because these thermal fractures occurred *in situ,* curation intended for future use and/or rejuvenation cannot be ruled out.

HOGUP CAVE ASSEMBLAGE (n=102)

Hogup Cave is similar in location and setting to Danger Cave. Hogup Cave is located in the Hogup Mountains approximately 75 miles northwest of Salt Lake City and 50 miles north northeast of Danger Cave (see Figure 2.4) at an elevation of 4700 feet above mean sea level (amsl). Ten miles east of the cave is the Great Salt Lake. Directly west of the cave are the salt flat remnants of Pleistocene Lake Bonneville. The cave is in the middle latitude desert. Rainfall is typically less than five inches a year. The nearest water source is approximately one mile west of Hogup Cave. This is a deep perennial seep that covers approximately .5 acres with typical seep vegetative mats and other hydrophitic plants. It is postulated that this was the same water supply used by the early inhabitants of Hogup Cave.

Excavated in 1967-68 under the supervision of C. Melvin Aikens, it too was deeply stratified, with over 13 feet of cultural debris observed. Much like Danger Cave it has an external outer chamber and an inner grotto that was sealed off in late prehistoric times. Because Aikens' stratigraphic, collection, and excavation controls were rigorously maintained, an excellent monograph was produced.

The strategraphy of Hogup Cave is characterized by huge deposits (many tons) of vegetable matter (seed harvest chaff, woody shrubs and leaves, sedges, and grasses) cordage, and hundreds of pounds of animal bones, hair (mostly antelope), hide, as well as considerable amounts of remarkably preserved animal and human fecal matter. As with Danger Cave, some of these deposits were regularly burned *in situ* producing a fine white ash. Notwithstanding these conflagration episodes, the preservation of organic materials behind the cave mouth drip line is still quite remarkable.

Projectile points examined in this present study come from strata 1-12 (6850 B.C. to 420 A.D.) with special emphasis on projectile points found in strata 1-10 (6850 B.C. to 650 B.C.; Aikens 1970:29, see Figure 2.3). Strata 12-16 were postulated as associated with later Sevier-Fremont and Numic cultures, both of which had bow-and-arrow technology. This is further demonstrated by the presence of atlatl fragments, mainshafts, and foreshafts in strata 1-12 with wooden artifacts associated with arrow technologies found in strata 12-16 (Aikens 1970:155, Figure 113).

The only preliminary sorting of the collection materials were between arrowpoints and atlatl dart points. Aikens (1970: 33) recorded 325 projectile points from all strata and sources. I selected 102 specimens as being atlatl dart points or dart point fragments.

Tables 8.10 through 8.13 are an RSA analysis of these 102 specimens by kind and distribution of RSA signatures. Table 8.14 is a frequency of all RSA signatures observed in the Hogup Cave assemblage.

Analysis of Hogup Cave RSA Signatures

Hogup Cave and Danger Cave assemblages are similar in kinds of signatures observed. For example, of particular significance are the numbers of RSA3 rejuvenations (8), fragments (11), and potentially rejuvenated fragments (9) (see circled area in Table 8.14 “A”). Danger Cave had similar frequencies in these kinds of signatures (RSA3=36; FRAG.=15; potentially rejuvenated=5; and potentially rejuvenated fragments=14). Danger Cave understandably has more kinds and distribution of signatures, given double the specimen numbers of Hogup Cave.

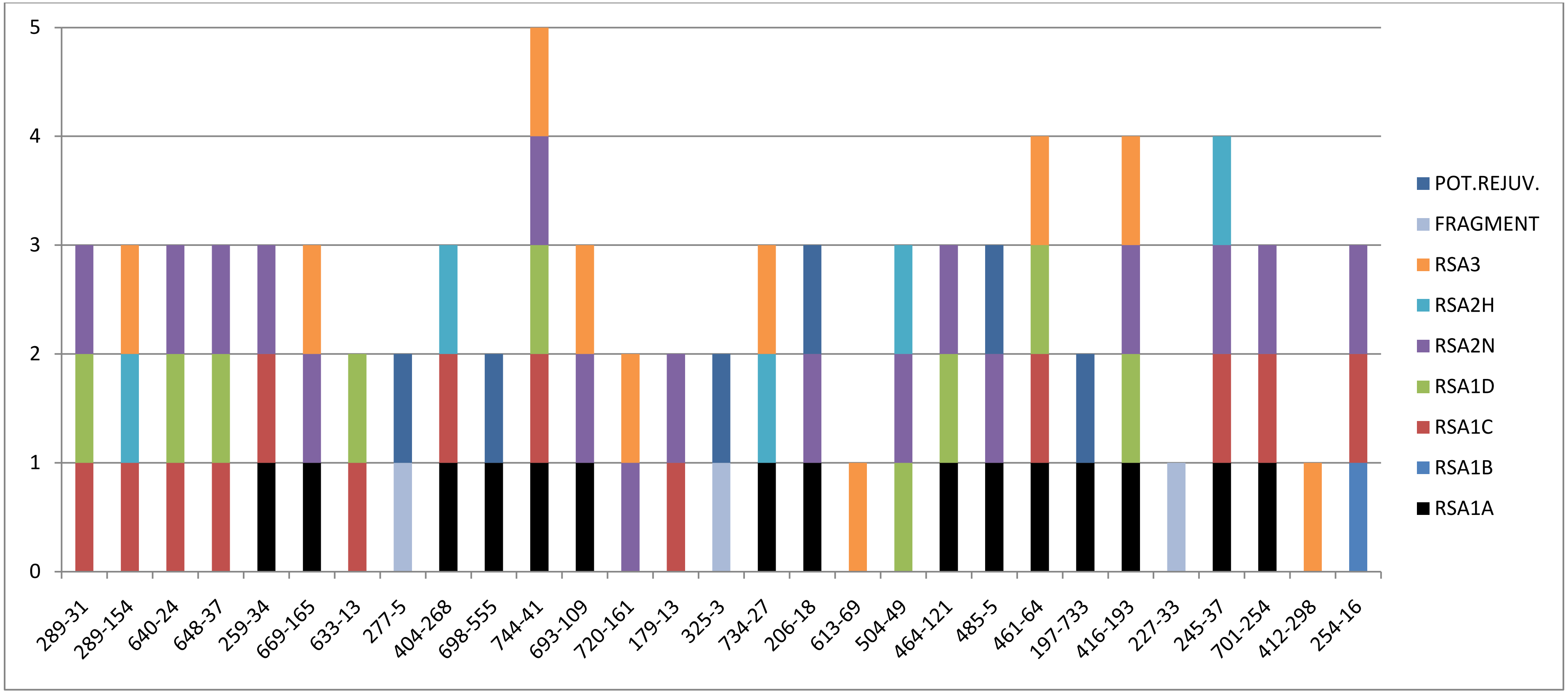


Table 8.10 Frequency of Hogup Cave projectile point RSA signatures 1-29. Specimen acquisition number bottom axis.

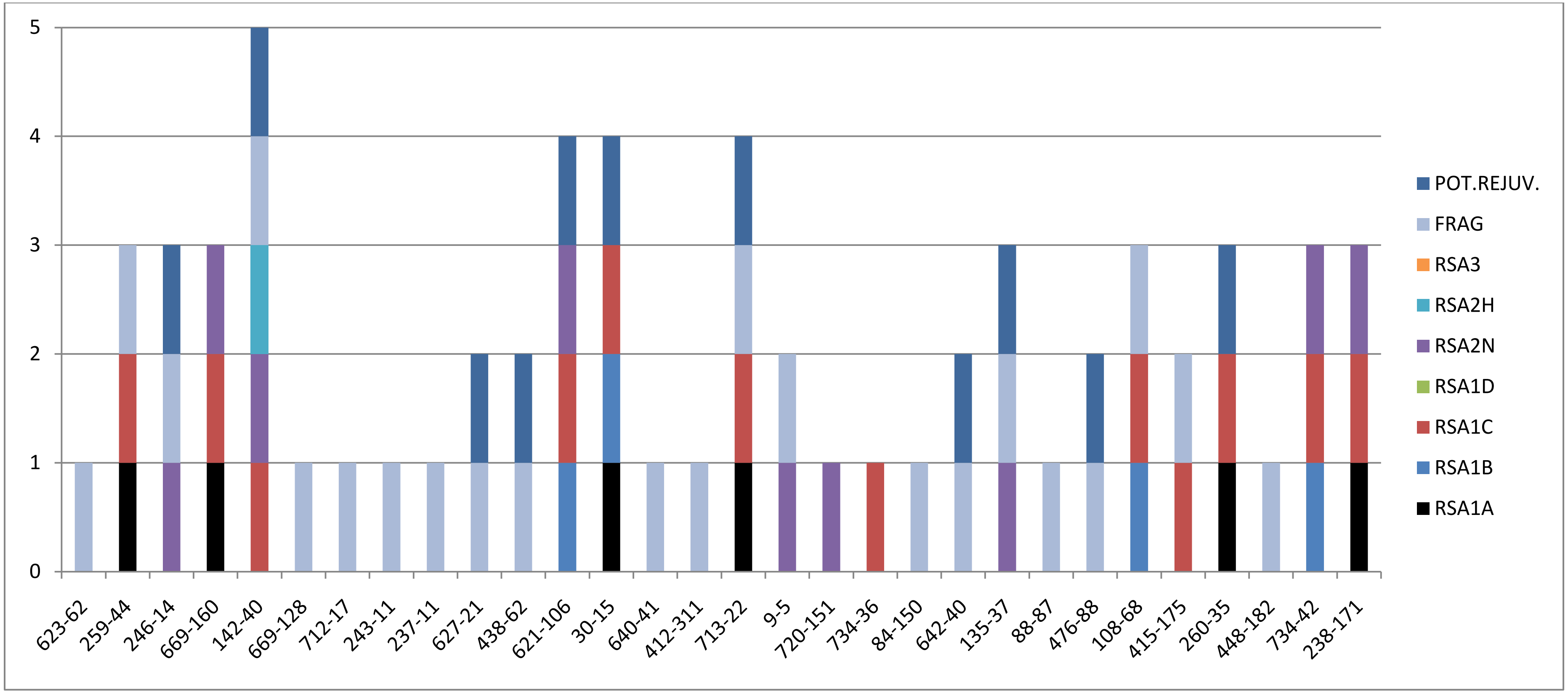


Table 8.11 Frequency of Hogup Cave projectile point RSA signatures 30-59. Specimen acquisition number bottom axis.

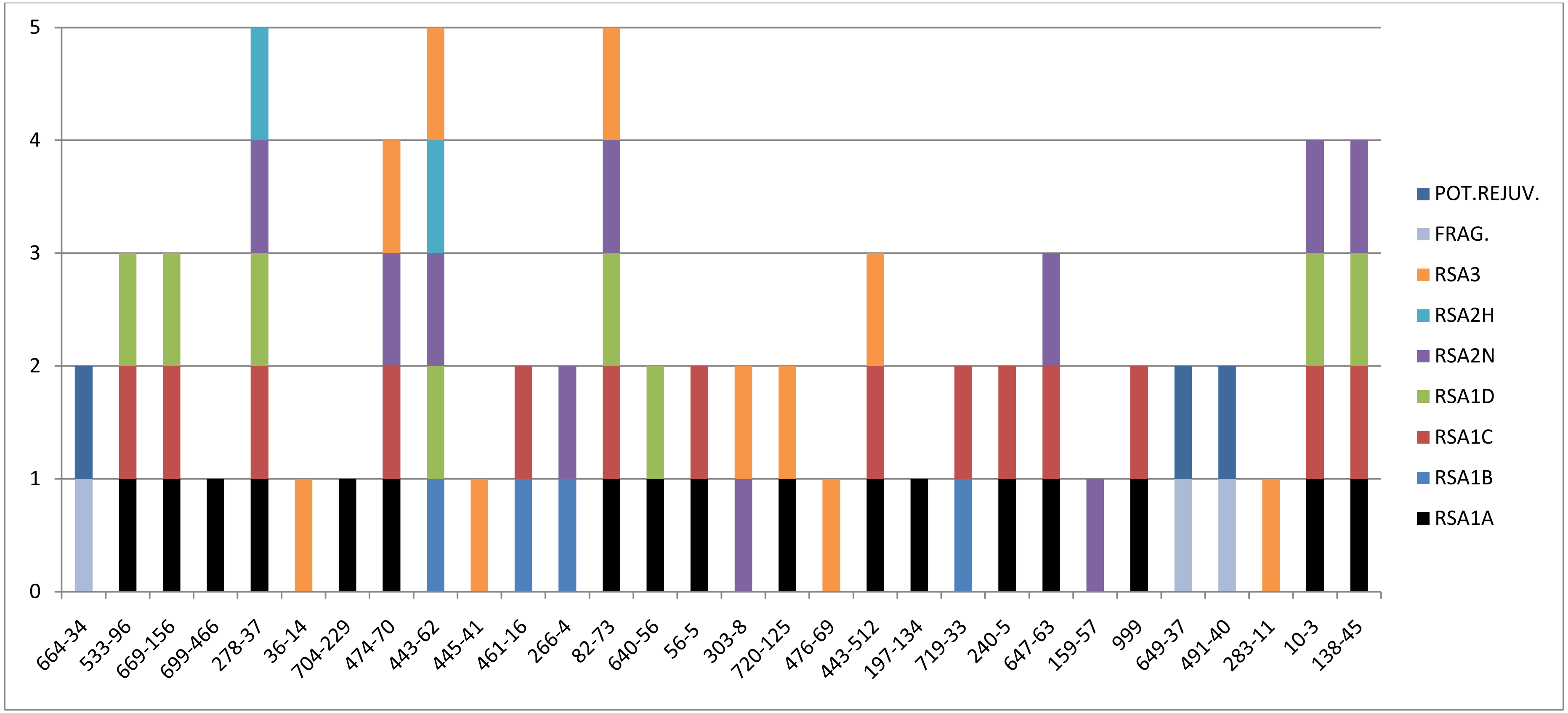


Table 8.12 Frequency of Hogup Cave projectile point RSA signatures 60-89. Specimen acquisition number bottom axis.

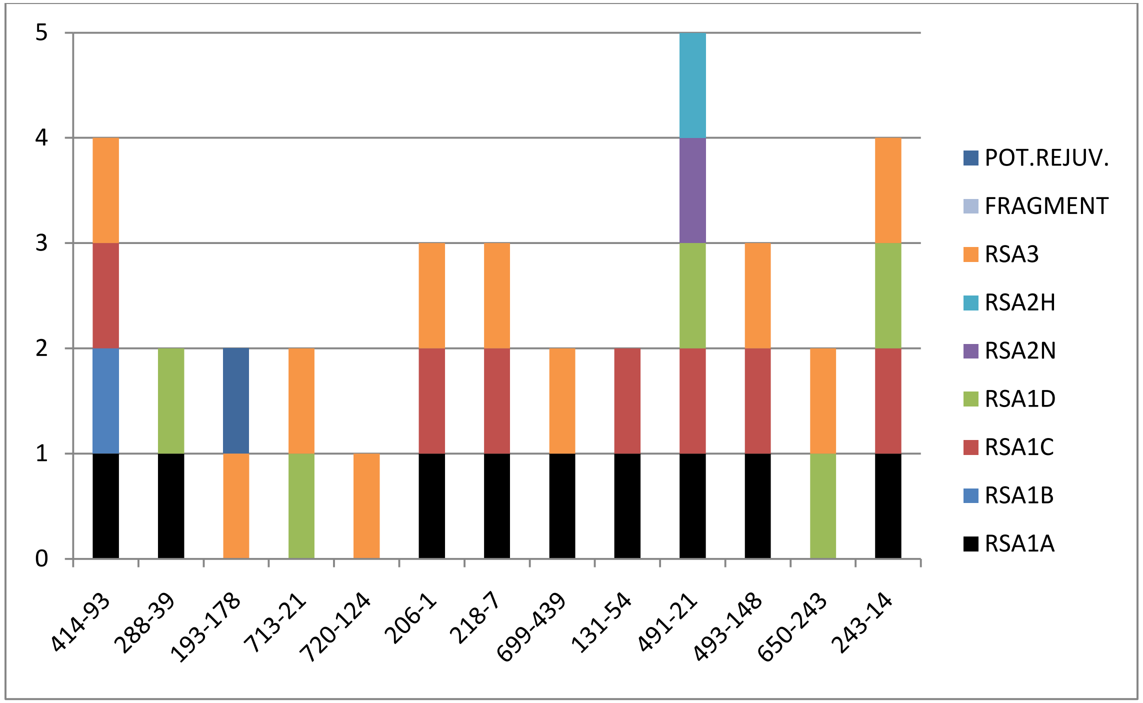


Table 8.13 Frequency of Hogup Cave projectile point RSA signatures 90-102. Specimen acquisition number bottom axis.

The RSA signatures can perhaps best be discussed by numbers of signatures observed on the Hogup Cave assemblage projectile points (see Table 8.14 A, B, and C).

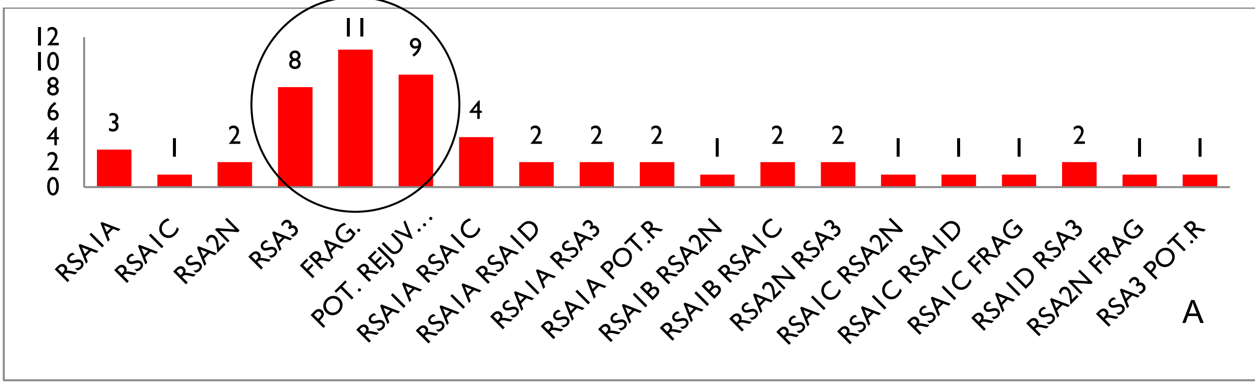
Single Rejuvenation Signatures

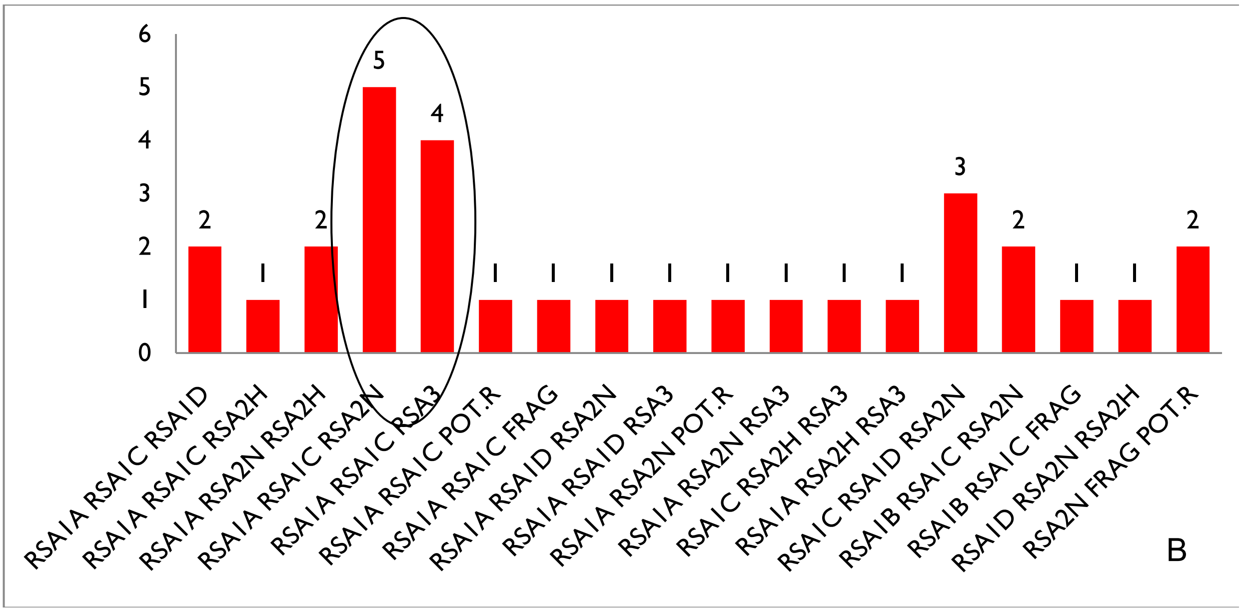
Single rejuvenation signatures were 25 or 24.5% of the total assemblage (see Table 8.14 A). These single rejuvenation signatures were divided between 5 categories. Four were signatures associated with blade refurbishment, two were ligature line signatures, and eight were with total refurbishment of the projectile point (RSA3). The largest single rejuvenation category was fragments (11), followed by completely refurbished (8).

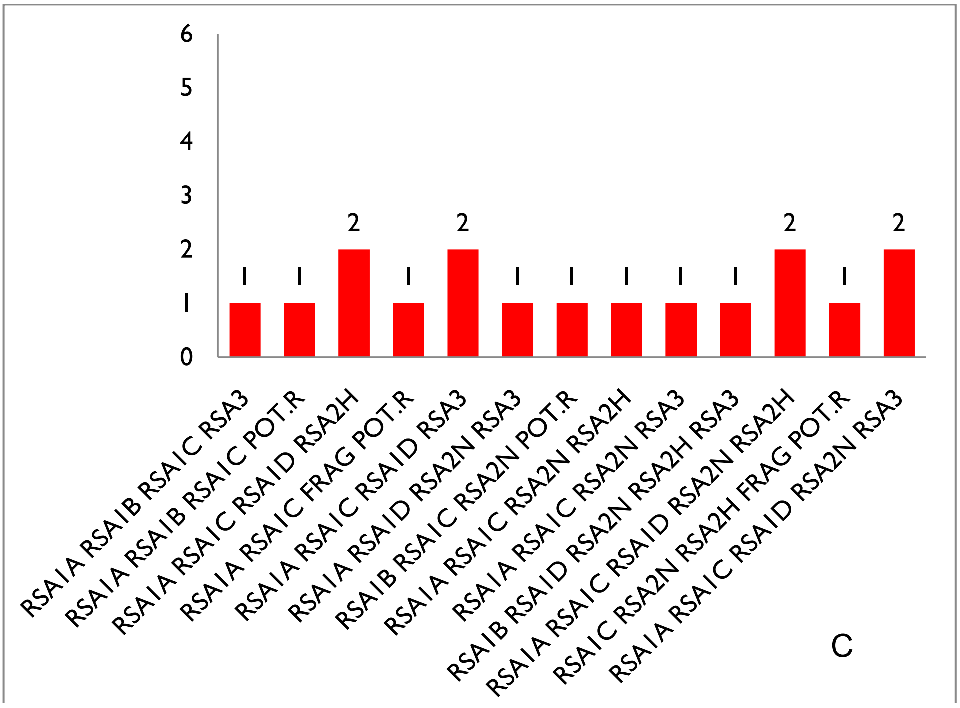
Two Rejuvenation Signatures

Double rejuvenation signatures were 22 or 21.5% of the assemblage. These signatures were divided between 14 categories. Potentially rejuvenated fragments were the largest of the double signature categories (9). Twelve signatures were blade rejuvenation signatures, 3 were ligature line/hafting element signatures, and 5 were total refurbishment.

Table 8.14 Frequency of all RSA Signatures for Hogup Cave. “A” single and double signatures, “B” is three signatures, “C”is four and five







Three Rejuvenation Signatures

Triple rejuvenation signatures were 31 or 30.4% of the assemblage total. These signatures are divided among 18 categories (see Table 8.14 B). Of interest are two reduction signature trajectories (circled in Table 8.14 B). These are trajectories RSA1A RSA1C RSA2N (resharpening, margin repair, and ligature line modification) and RSA1A RSA1C RSA3 (resharpening, margin repair, and total refurbishment). This demonstrates RSA signature analysis as a method to determine rejuvenation trajectories. Four categories were blade repair (five specimens), 10 categories were ligature line / hafting element repair (18 specimens) and four categories with RSA3 as a terminating signature (four specimens). Again, as signatures increase in number and complexity, the probability that type changing rejuvenation trajectories were used also increases.

Four and Five Rejuvenation Signatures

In the Hogup Cave assemblage, there are nine categories of four signatures and four categories of five signatures. These 17 signatures form 16.7 % of the total. Between the thirteen categories, there are only two reduction strategies (each having one specimen) that deal with blade rejuvenation. The other ten categories mostly terminate in RSA3 (nine specimens) or ligature line or haft repair (seven specimens) both of which have a high probability of changing type.

Other Observations Affecting Rejuvenation

Multiple rejuvenation cycles were also observed in the Hogup Cave assemblages (see Figure 8.5). These were specifically observed in projectile points SEQ# 639-109, 206-108, 623-62, 412-31, 640-56, and 10-3. This multiple rejuvenation cycle is inferred when the projectile point has undergone one rejuvenation cycle to return it to the use-life continuum and then a subsequent, often terminal, damage is received

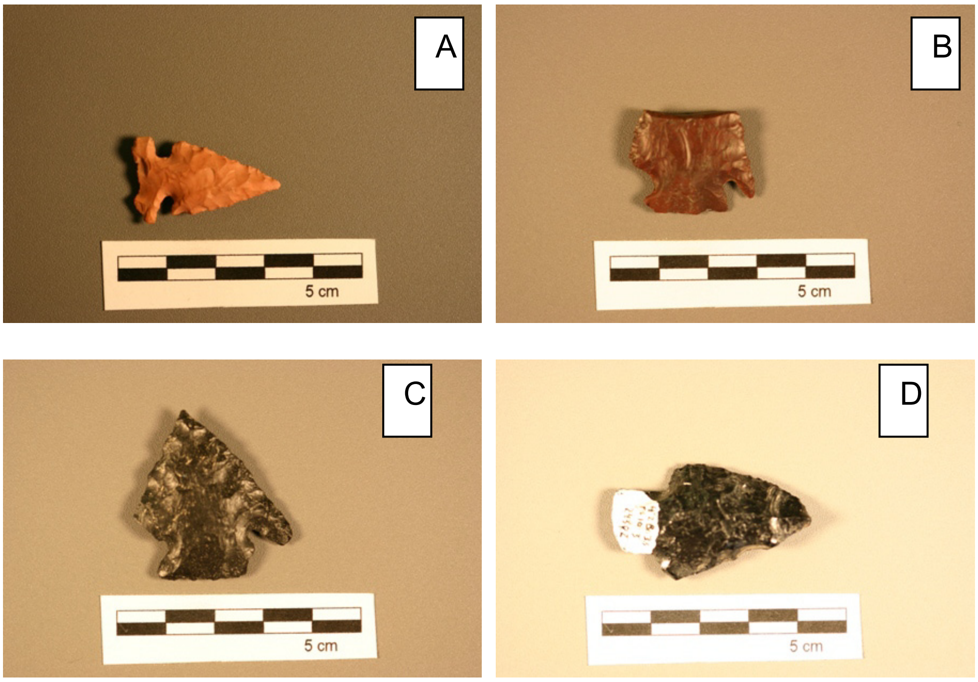


Figure 8.5 Multiple rejuvenation- cycle projectile points from Hogup Cave. A. SEQ 639-109. Note one side notch and one corner notch. B. SEQ# 412-311. Repair of barb then mid-blade bending fracture. C. SEQ # 640-56. RSA1A and RSA1D then break of barb and tang. D. SEQ# 10-3. Repair of flute spall at tip then break of barb. (Photo credit: A. Spencer)

causing it to cycle out of use-life. Again, as mentioned in the Danger Cave analysis, it is assumed that the majority of the projectile points in the test assemblages had received at least one rejuvenation /use-life cycle. Often the challenge was not to determine if the projectile point has been rejuvenated, but the number of rejuvenation/use-life cycles it had completed. One particularly interesting projectile point was observed in the Hogup Cave assemblage (Figure 8.6). It had been discovered as two fitting fragments, glued back together to make one specimen, been labeled as SEQ# 491-40 and classified as a "one notch projectile point". It has the undeniable manufacturing fracture signature described by Titmus and Woods (1986:40-45) associated with notching. Just as the first notch was nearing completion, pressure from the notching tool to the notch platform produced a lateral bending fracture to the opposite margin. Both fragments were discarded as having insufficient mass for rejuvenation. Again, this classic classification error occurs when morphological descriptions ignore manufacturing processes. Its' implications for rejuvenation analysis are twofold. First, this projectile point has not undergone a use-life rejuvenation cycle because of extremely late stage manufacturing breakage. Second, this projectile point more closely fits an "archetype" than projectile points that may have previously undergone rejuvenation cycles. This archetype has bilateral

Figure 8.6 Corner notched point broken during manufacture. (Photo credit: A. Spencer).

symmetry. The margins are regular and equal. Except for the unfortunate breakage that occurred before the second notch could be formed, it fits Thomas (1981) archetype of an Elko corner-notch without equal.

Traces of mastic (pitch) and sinew were also looked for in the Hogup Cave Assemblage. No sinew or pitch residues were noted on the projectile points examined in this assemblage.

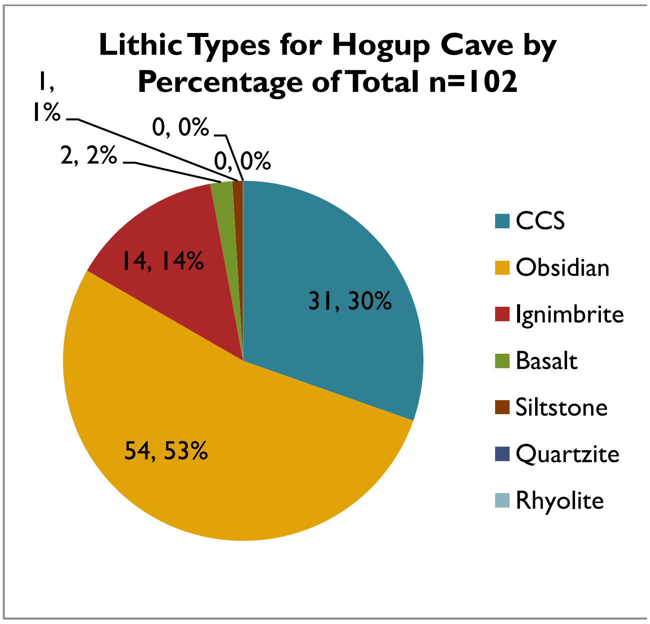


Figure 8.7 Lithic types for Hogup Cave by Percentage of Total (n=102).

Projectile point lithic materials were noted during the analysis (see Figure 8.7). Obsidian and ignimbrite were found in higher percentages in Hogup Cave than Danger Cave. This is possibly due to Hogup Cave's closer proximity to Brown's Bench obsidian and ignimbrite sources (near Jackpot, Nevada) or sources in southern Idaho (near Malad). Rejuvenation strategies and availability of materials will be discussed in Chapter 10.

COWBOY CAVE ASSEMBLAGES (n=44)

Cowboy Cave is located on the absolute margin of the eastern Great Basin cultural area in the canyonlands area of Wayne County, Utah. This western projection of the Colorado Plateau physiographic province (see Figure 2.1; 2.4) is characterized by steeply cut sandstone canyons, lack of permanent water sources, and piñon-juniper ecotones. This naturally formed sandstone grotto is at an elevation of 5800 feet above mean sea level. The area around Cowboy Cave receives about eight inches of precipitation a year. Cowboy Cave is currently only accessible by hiking or horseback, hence the appellation "cowboy".

Excavated under Jesse D. Jennings as part of the 1975 University of Utah Anthropology Field school, the archaeological assemblage is probably best known for its excellent preservation of perishables such as fiber, basketry, wooden tools and tool fragments, plant remains, and a dung layer from extinct Pleistocene mega-fauna. Very few projectile points and other lithic industries were recovered (Jennings 1978:93). I analyzed the projectile points from Archaic strata, Units II – IV (6640 B.C. to 1380 B.C.; see Jennings 1978:93; also see Figure 2.3). Unit I is a dung layer associated with now extinct herbivores (bison, elephant, camel, horse, and sloth (ca. 9860 B.C.) without evidence of human interaction. Unit V (60 A.D. to 455 A.D.; see Jennings 1978:93) is inferred to be more associated with late prehistoric bow-and-arrow use.

Analysis of Cowboy Cave RSA Signatures

A total of 44 specimens were determined to be atlatl dart points or fragments. These were segregated from the total collection of worked stone and analyzed according to protocols described in Chapter 6. Tables 8.15 and 8.16 are the recordation of the RSA signatures found on the projectile points. Table 8.17 is the frequency of all RSA signatures observed.

As with the previous assemblages analyzed, probably the best method of description is by the groupings of RSA signatures.

Single Rejuvenation Signatures

Only three categories of single RSA signatures were recorded. These 17 signatures, however made up 38.6% of the collection. RSA3 signatures were the largest (10) followed by fragments (6), and RSA1A (1) (see circled portion of Table 8.17). Only one signature pertained to blade refurbishment. Ten signatures were total refurbishment. Based on the information that very little bone materials were recovered and the total assemblages of lithic industries were small, it can be inferred that hunting and weapon system production were minor activities during the time span in which Cowboy Cave was occupied. This would put only minor rejuvenation pressures on the use-life and rejuvenation continuums. It was also noted (Jennings et al. 1980:7) that high quality cryptocrystaline silicate (ccs) tool stone in large quantities was available no more than 15 to 20 km to the east of the site. This would

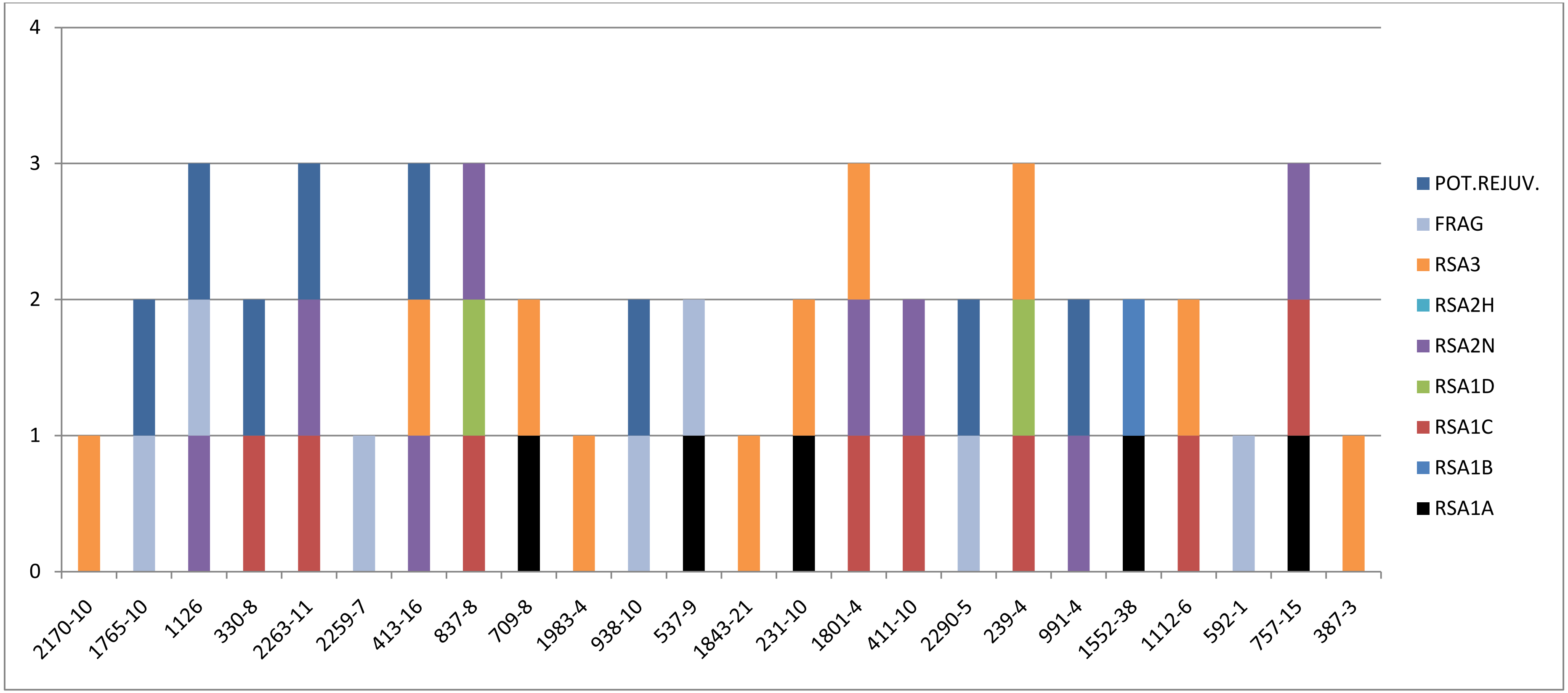


Table 8.15 Frequency of Cowboy Cave projectile point RSA signatures 1-24. Specimen acquisition number bottom axis.

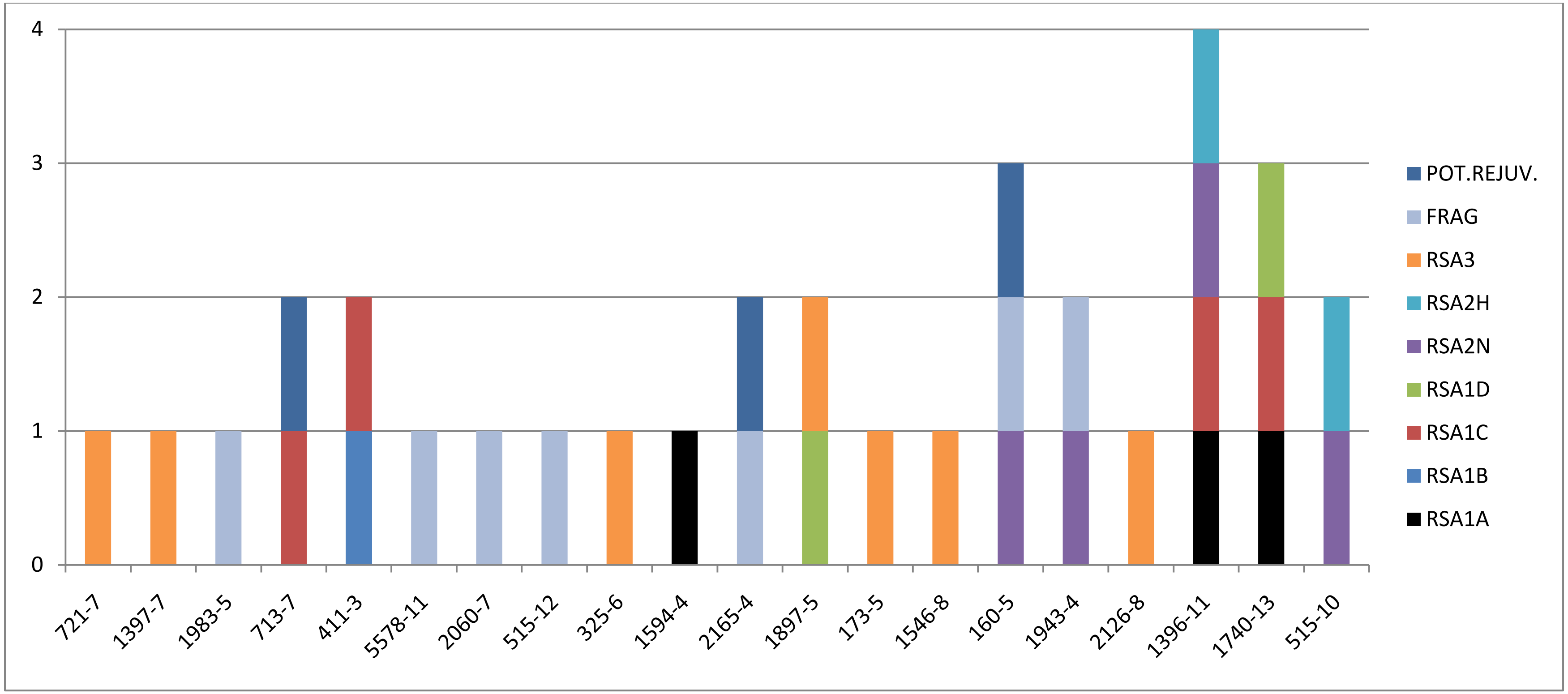


Table 8.16 Frequency of Cowboy Cave projectile point RSA signatures 25-44. Specimen acquisition number bottom axis.

allow for the large amount of RSA3 signatures (whole functioning projectile points) and fragments (as well as potentially rejuvenated fragments [6]) to be observed in the assemblage as part of curation/discard.

Two Rejuvenation Signatures

Two RSA signatures made up 11 categories with 17 specimens (38.6%). The largest category was potentially rejuvenated fragments (6) followed by “resharpend and totally rejuvenated” (2). The other double rejuvenated categories either involve a fragment or potentially rejuvenated fragment signature in combination with both blade and ligature line/hafting element signatures.

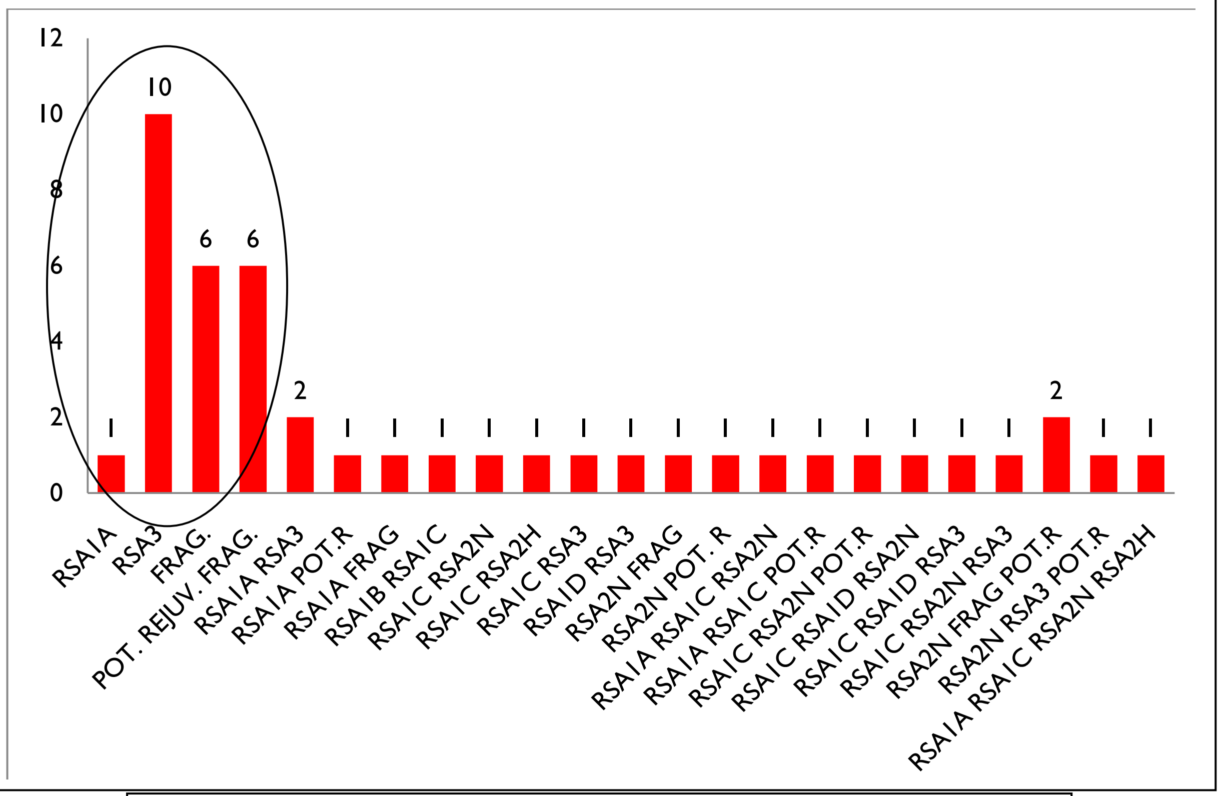


Table 8.17 Frequency of all RSA signatures for Cowboy Cave.

There were many fragments, potentially rejuvenated fragments, and RSA3 combination signatures that were only seen in the Cowboy Cave and Sudden Shelter asssemblages. Nine signatures were blade rejuvenation, four were ligature line/hafting element, and four were combinations of RSA3.

Three, Four, and Rejuvenation RSA Signatures

Eight three RSA signature categories with nine specimens, zero four RSA categories, and one five RSA signature categories were observed. If the three and five specimen categories were combined, this would account for nine categoreis with 10 specimens (22.7%). All of these categories either involved fragments with additional RSA signatures, potentially rejuvenated fragments with other RSA signatures, or RSA3 with additional signatures. Again, there were many RSA signature combinations involving fragments, potentially rejuvenated fragments, and RSA3 that were only observed in Cowboy Cave and Sudden Shelter. Of the RSA signatures observed only one was blade refurbishment, six were ligature line/hafting element, and three were RSA3.

Other Observations Affecting Rejuvenation

Unlike Hogup or Danger Cave, there were no projectile points that suggested multiple rejuvenation cycles. This also supports the inference that rejuvenation and use-life continuum pressures were very slight. One projectile point (SEQ# 721-7; see Figure 8.8) was observed to retain pitch mastic in sufficient quantities for AMS dating.

Figure 8.8 Pitch retentive stemmed projectile point, Cowboy Cave SEQ# 721-7. (Photo credit: A. Spencer).

All of the tool stone materials were high quality ccs. No other tool stone types were observed. With high quality tool stone readily available, rejuvenation pressures associated with economy and scarcity would be virtually eliminated.

SUDDEN SHELTER ASSEMBLAGE (n=102)

This large rock overhang is located east of Salina, Utah at 7,200 feet AMSL in the piñon-juniper-sagebrush ecozone near Ivie Creek, a permanent stream (see Figure 2.4). Due to Sudden Shelter's higher elevation, it has adequate rainfall (ca. 15 inches per year) and an extensive variety and quantity of plant materials that were important food sources to prehistoric peoples. It was first discovered in the 1950's and largely forgotten until a proposed highway improvement project again sparked interest in the site. In response to these proposed highway improvements, Sudden Shelter was excavated in 1974 as an archaeological field school project that developed into a highway salvage contract by the University of Utah, Department of Anthropology. Sudden Shelter contained deeply stratified colluvial deposits incorporating cultural materials that suggest late-summer seasonal use to gather and process abundant plant, seed, and animal resources. Unlike the other cave sites analyzed in this study, Sudden Shelter contained no perishable materials other than carbonized plant remains. Calibrated ^{14}C samples from occupational components place use of Sudden Shelter to at least 8,000 years B.P.(Jennings et al. 1980). Projectile points from dated components I-III (see Figure 2.3) were analyzed for RSA signatures. These analyses are recorded in Tables 8.18, 8.19, 8.20, and 8.21. Synthesis and frequency of RSA signatures was recorded in Table 8.22.

Analysis of Sudden Shelter Rejuvenation Signatures

A total of 102 specimens determined to be atlatl dart points or fragments were analyzed for RSA signatures. The following is a synthesis of this analysis by group.

Single RSA Signatures

Six categories of single RSA elements were observed, the largest category being fragments (16), followed by RSA3 (5 specimens; see circled area on Figure 8.22). Single RSA signatures comprised 28 specimens, or 27.4% of the population. It is interesting to note that the majority of signatures for Sudden Shelter were fragments, potentially rejuvenated fragments, combinations of RSA signatures and fragments and potentially rejuvenated fragments, RSA3, or combination of other RSA signatures and RSA3. This is very much like the patterning of RSA signatures from Cowboy Cave. Of these single signatures, three categories (5 specimens) were blade repair signatures, and two categories (7 specimens) were ligature line rejuvenation and RSA3 (2 specimens).

Two Rejuvenation Signatures

Ten two RSA categories were observed with a total of 39 signatures. This is 38.2% of the assemblage. Much like the single RSA signature grouping, potentially rejuvenated fragments form the greatest two signature category (22). This is also the greatest number of specimens in any Sudden Shelter assemblage category.

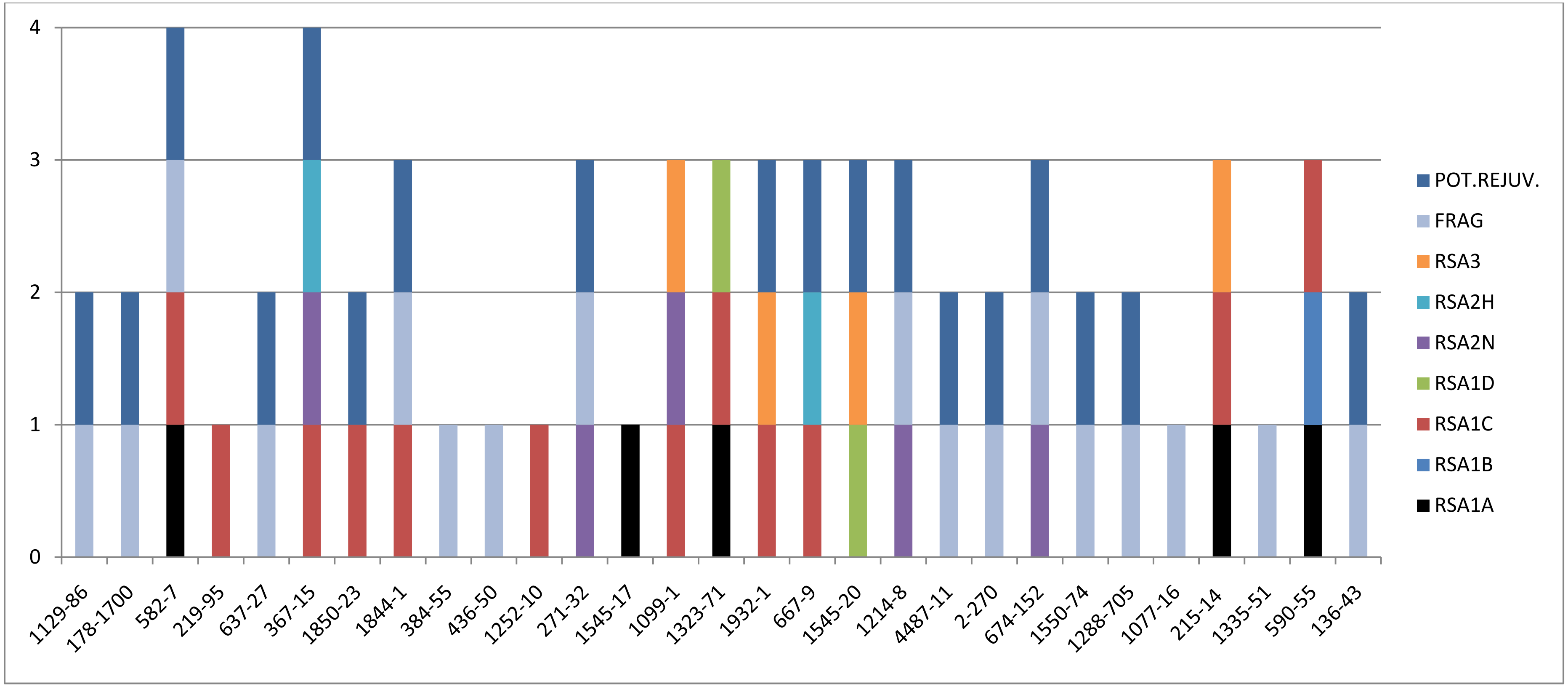


Table 8.18 Frequency of Sudden Shelter projectile point RSA signatures 1-29. Specimen acquisition number bottom axis.

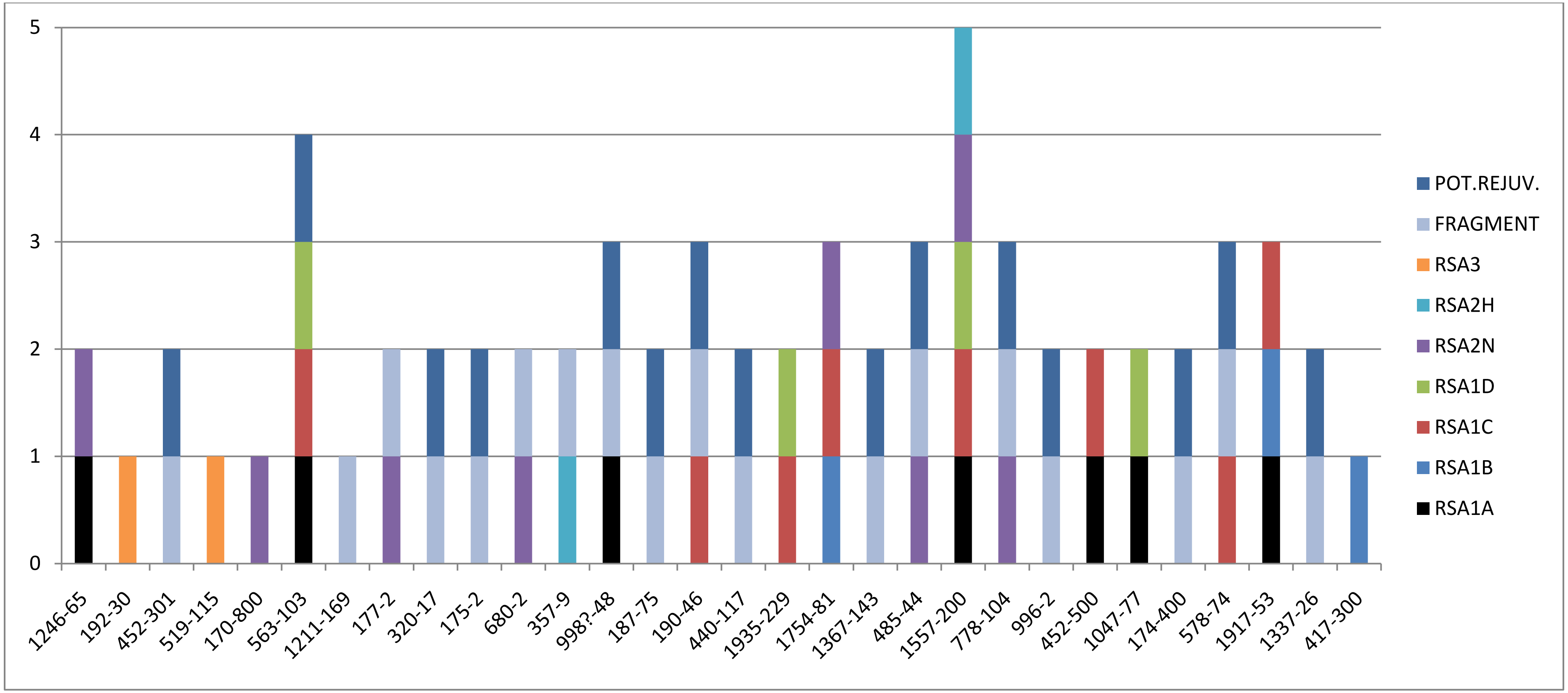


Table 8.19 Frequency of Sudden Shelter projectile point RSA signatures 30-59. Specimen acquisition number bottom axis.

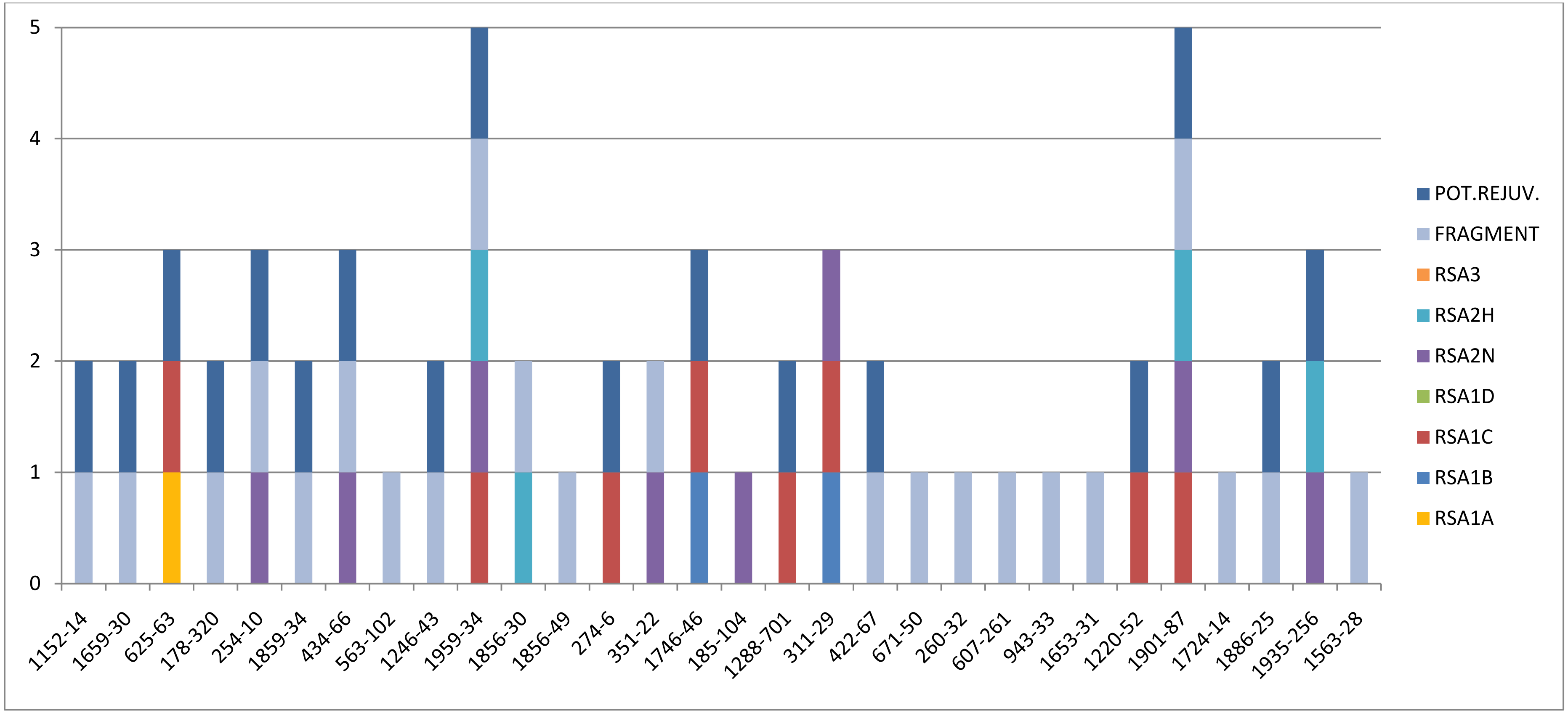


Table 8.20 Frequency of Sudden Shelter projectile point RSA signatures 60-89. Specimen acquisition number bottom axis.

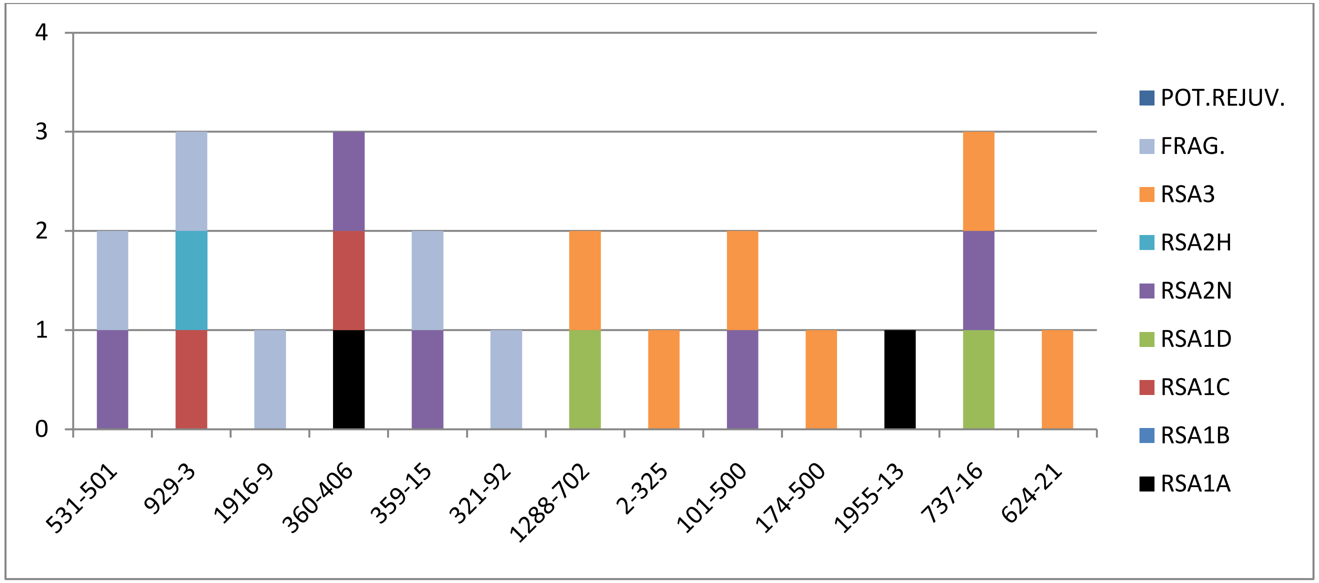


Table 8.21 Frequency of Sudden Shelter projectile point RSA signatures 90-102. Specimen acquisition number bottom axis.

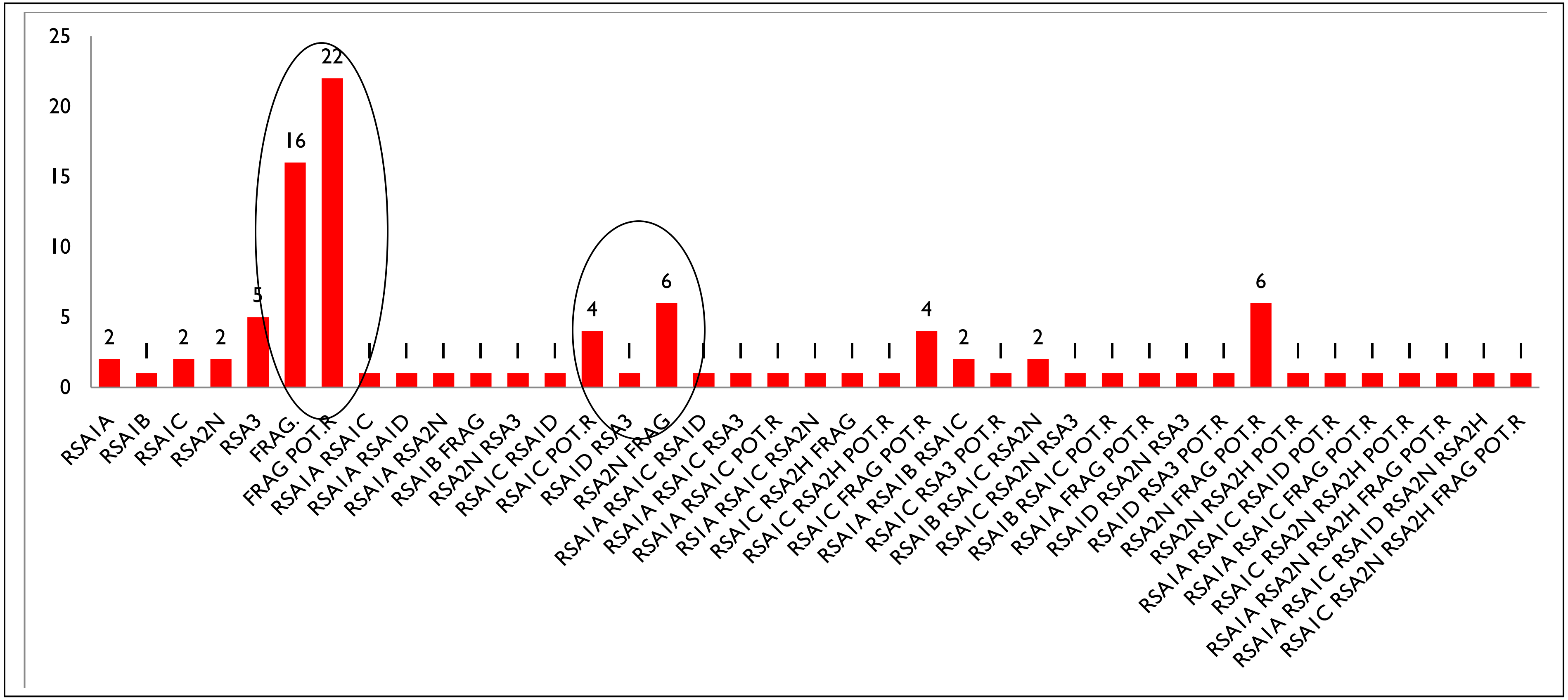


Table 8.22 Frequency of all RSA signatures from Sudden Shelter.

Five categories were blade rejuvenation with five specimens. Three were ligature line rejuvenation with eight specimens. One was a combination with a RSA3 signature. In this series, blade and ligature line/complete rejuvenation signatures are nearly equal.

Three Rejuvenation Signatures

Seventeen categories contained three RSA signatures (27 specimens). This is 26.4 % of the total assemblage. Like almost all of the RSA signatures at Sudden Shelter, most of the three composite signatures are combination signatures ending with “fracture”, “potentially rejuvenated”, or RSA3. Five combination signatures pertain to blade rejuvenation (6 specimens), six “three” combination signatures are ligature line/hafting element (6 specimens), and four combinations contained RSA3.

Four and Five Rejuvenation Signature Combinations

Four and five combination signatures (three categories each) contained six specimens. This accounted for 5.88% of the assemblages. Five of these combination signatures end in “potentially rejuvenated”. Two signatures pertain to blade repair. The remaining four are ligature line/hafting element repairs.

Other Observations Affecting Rejuvenation

As with Cowboy Cave, no multiple rejuvenation cycle specimens were observed. No pitch or sinew retentive projectile points were observed.

Three of the 102 specimens were obsidian, the remainder were ccs. It was recommended by Hogan in Jennings et al. (1980:105) and Weder that the ccs materials were readily obtainable from relatively close by cobble colluviums and the obsidians were visually recognizable types from the Mineral Mountain sources in Millard County, Utah.

The most compelling observations were the numbers of fragments, fragments that were potentially rejuvenated, RSA3, and combinations thereof. Forty-two or 41% of the assemblage was fragmented or potentially rejuvenated fragments. Similar to the rejuvenation continuums observed at Cowboy Cave, occupants at Sudden Shelter felt little or limited rejuvenation pressures and cycled these remnants through discard/curation. Jennings et al. (1980) infers from the number of plant taxa, animal remains, and firepits (over 300), that Sudden Shelter was seasonally used between April and October. Seasonal use for plant processing (seed gathering) was also suggested for Cowboy Cave.

INFERENCES AND CONCLUSIONS

Rejuvenation Signature Analysis was applied to a combined 477 atlatl dart points from Danger Cave, Hogup Cave, Cowboy Cave and Sudden Shelter. As a test bed for RSA analysis, these analyses determined the numbers and types of rejuvenation within these projectile point assemblages, what other process occurred at these sites that affected rejuvenation, the differences in rejuvenation patterns between these sites, the different rejuvenation trajectories that may affect type, such as blade vs. type sensitive RSA signatures, and how RSA can illuminate other intra site analyses in modeling use-life and rejuvenation continuums.

Numbers and Types of Rejuvenation

A total of 471 rejuvenation signatures were recorded in 101 rejuvenation signature categories. Each rejuvenation signature category is essentially a rejuvenation trajectory. For example resharpening, margin refurbishment, notch replacement, and hafting element repair trajectory would be expressed as RSA1A, RSA1C, RSA2N, RSA2H category. Danger Cave and Hogup Cave shared many of the same rejuvenation trajectories, whereas Cowboy Cave and Sudden Shelter shared many of the same trajectories only seen in these two archaeological sites (mostly dealing with fragments and potentially rejuvenated fragments). Rejuvenation trajectories might be linked to the type of subsistence strategies/activities occurring at each site. This was most likely how the cave sites were used (seasonally as opposed to long term), access to subsistence resources and lithic materials for tool kit refurbishment, and general rejuvenation pressures while these locations were in use.

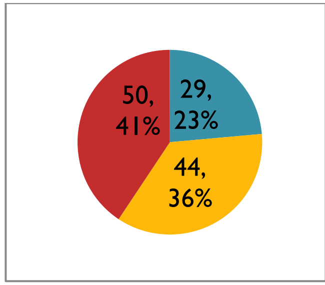
For example, rejuvenation pressures at Hogup and Danger Caves were fairly high and well marked as opposed to Sudden Shelter and Cowboy Caves. Hogup and Danger Cave exhibited specimens that showed one or more rejuvenation cycles within the rejuvenation continuum, whereas Cowboy Cave and Sudden Shelter did not. Essentially, RSA analysis has documented and measured the effects of artifact variability in these assemblages with inferences to cause.

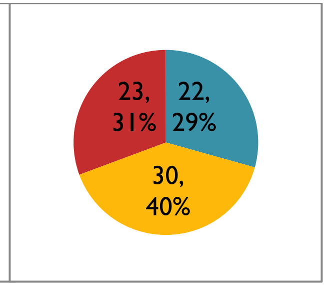
Blade RSA vs. Type Sensitive RSA

Throughout the analysis of the test assemblages, signatures that indicated blade refurbishment, ligature line/hafting element, and the total refurbishment of the projectile point were observed and recorded. These are shown graphically in Table 8.23. As shown in this table, RSA signatures that are sensitive to type occurred between 62% and 76% in the assemblage populations. These figures suggest that type changes did occur in these populations during the rejuvenation continuum and that these type changes were significant. It must be observed that basing any morphological typological schema on criteria that ignore the rejuvenation processes in these test collections should strongly be reconsidered.

Cave	Signature combination	Blade	Ligature Line / Hafting Element	RSA3
Danger Cave	1	16	7	36
	2	7	9	5
	3	6	15	5
	4&5	0	13	4
Hogup Cave	1	4	2	8
	2	12	3	2
	3	4	18	4
	4&5	2	7	9
Cowboy Cave	1	1	0	10
	2	9	4	3
	3&4&5	1	6	3
Sudden Shelter	1	5	7	2
	2	8	8	1
	3	5	6	4
	4&5	2	4	0
	TOTALS	82	109	96

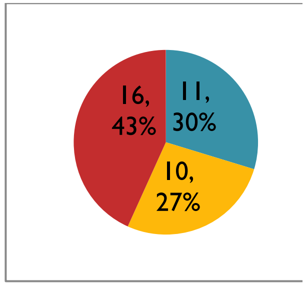
Table 8.23 Non type sensitive (blade) vs. type sensitive (ligature/hafting element and RSA3) RSA signatures shown tabular and in pie-charts.

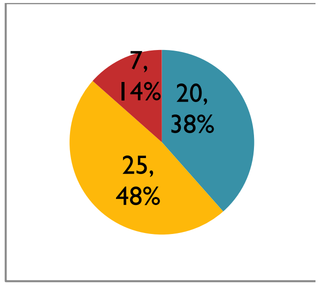




Danger Cave
23% Blade
76% Type Sensitive

Hogup Cave
29% Blade
71% Type Sensitive





Cowboy Cave
30% Blade
70% Type Sensitive

Sudden Shelter
38% Blade
62% Type Sensitive

Blade RSA (non type sensitive)

Ligature Line/Hafting Element RSA (type sensitive)

RSA 3 (type sensitive)

The percentages of blade, ligature line/hafting element, and complete refurbishment of the projectile point RSAs also dispel the notion that the majority of breakage and repair of these projectile points occurred on the tip and upper blade (Thomas 1981; Holmer 1978:1) in the locations where modifications had little or no affect on type change. Over 60% of RSA in all of the test collections involved refurbishment of the ligature line and hafting elements. Again, these are the locations that are most sensitive to type change.

Use-life and Rejuvenation Continuum Models for Test Assemblages

Figure 8.9 illustrates use-life and rejuvenation continuums for Hogup and Danger Caves, Cowboy and Sudden Shelter. The use-life model for the control collections is added for comparison only (Figure 8.9 “A”).

Figure 8.9 “B” is a use-life model for Danger Cave/Hogup Cave. They were grouped as such because of the similarity and frequencies of the RSA types observed. The rejuvenation continuum shows multiple rejuvenation cycles were observed on some of the specimens from Hogup and Danger Caves. The relative “size” of the rejuvenation continuum indicates that rejuvenation pressures are still relatively high at Danger and Hogup Caves. Likewise, pressures for lithic material procurement are relatively high. For example, Page (2008) and Page and Skinner (2008) reported the overwhelming majority of obsidian and ignimbrite sources for Danger Cave as coming from 130 +km to the northwest from the Browns Bench area near Jackpot, Nevada. Fine grain tool stone (mostly basalts) were sourced from 70 to 80 km to the south and southwest (Page 2008:127). For Hogup Cave where obsidians and ignimbrites comprised 67% of the projectile point materials (and basalts only 2%), distance to the Browns Bench sources was still 60 to 70 km to the west. For both caves, quartzite and ccs sources remain largely unknown, but are assumed to be at least 30 to 60 +km from the cave sites because of their geographic locations in reference to salt flats and other sedimentary rock outcroppings. In all, the geographic distance from these sources indicate increased rejuvenation signatures, hence rejuvenation pressure, as demonstrated by the analysis.

Sudden Shelter and Cowboy Caves, however, had adequate to excellent ccs sources on site (as colluviums) or at short distance (15 to 20 km) as was the case for Cowboy Cave. Rejuvenation pressures were low as shown by smaller activity signatures in "rejuvenation" and "material". Inverse to "rejuvenation" and "material" activity signatures, curation/discard activity signatures were a higher order in Cowboy Cave and Sudden Shelter (Figure 8.9 "C"). These signatures are shown as overlapping activities. Basically, unless these projectile points and fragments are inaccessible (buried by sediments, forgotten caches, etc.) they still must be accounted for as curated/discard if they are available on the cave floor or apron. In Hogup and Danger Caves, materials regarded as "discarded" because of thermal fractures, (thought to be thrown into the fire), must be still considered curated because of the massive *in situ* conflagrations involving organics in some of the strata.

Models for both Danger/Hogup and Cowboy/Sudden assume that some of the projectile points would be "lost". Numbers of these "lost " projectile points cannot be determined, however, with the control collections showing five lost projectile points over a simulated hunting cycle of approximately 90 atlatl throws, this may be a significant number (as calculated over 9000 years of occupation). The contextual locations of these lost projectile points, however, are unlikely to be on the cave floor or apron.

Finally, the models account for projectile points exiting the use-life cycle by ritual offerings and burial/interments. These special contexts were examined in the literature for all of the test assemblage sites. Currently, this part of the model is still conjecture.

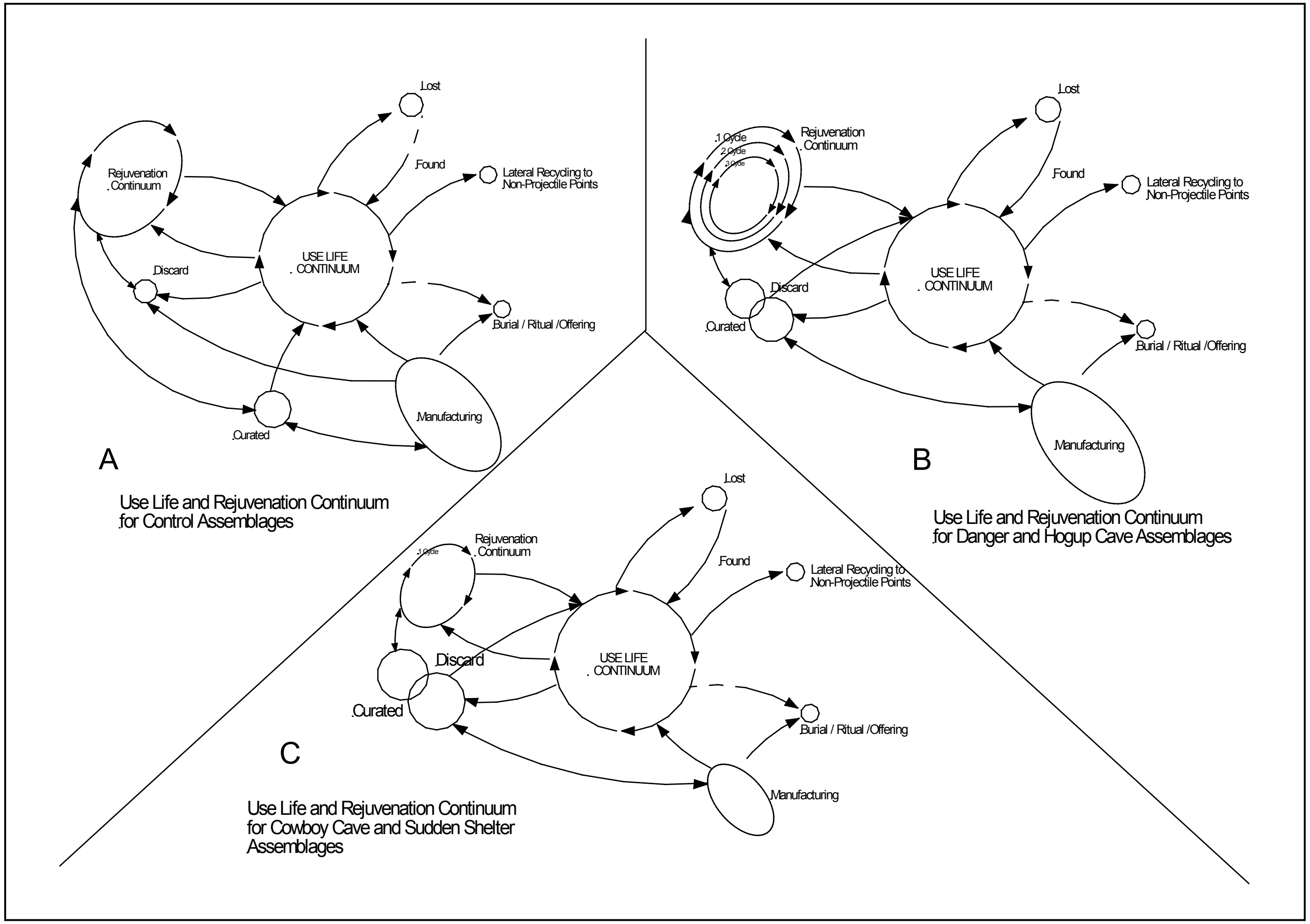


Figure 8.9 Use-life and Rejuvenation Continuum Models for A) control collections; B) Danger and Hogup Caves; C) Cowboy Cave and Sudden Shelter.

In summary, the data from Rejuvenation Signature Analysis suggests that rejuvenation pressures for Danger Cave/ Hogup Cave were high and rejuvenation pressures for Cowboy Cave and Sudden Shelter were extremely low. Whether this is due to high quality tool stone materials near at hand (as in the case at Cowboy Cave), resource procurement strategies that rely on harvesting and processing of plants rather than animals, or strategies that rely on only the most expedient repairs, it is apparent that different resource access and exploitation was occurring at the EGB desert/salt flat caves as opposed to the caves and rock shelters of this extreme margin of the EGB (western portion of the Colorado Plateau physiographic province). Intra- site activities such as informal caching and curation of complete or nearly complete atlatl points and fragments, retaining or curating broken atlatl projectile points that could be potentially rejuvenated at a later time and/or place, and a general lack of other lithic industries at Cowboy Cave (and to some extent Sudden Shelter) all infer the importance of other limited subsistence activities (such as gathering and processing of seed resources) conducted at these locations during their seasonal use.

CHAPTER 9

LIMITED MORPHOMETRIC ANALYSIS OF CONTROL AND TEST COLLECTIONS

INTRODUCTION

Dibble (1995a) in his attempt to rectify some of the compelling questions in his scraper reduction models completed several morphological tests and indices. He would summarize as saying:

> "The importance of these studies in the present context is that they extend even further many of the implications inherent to the notion of the Frison Effect in general and to scraper reduction in particular. This goes back again to the whole notion of how these models can be tested. With a higher number and diversity of independent test implications derived from a single, unified explanation, the less probable that supporting data are a result of either some alternative explanation(s) or chance alone." Dibble (1995a:355).

The problem with both processual archaeological thought (especially lithic replication studies) and the normative-empiricist approach is that the same data sets, models, and statistical analysis can be interchangeably used as proof of concept (and often different opposing concepts) by either camp. "Alternative explanations" still abound. The purpose of this chapter is to apply simple morphometric indices to control and test data to determine any similarities, if any.

MORPHOLOGICAL ANALYSIS OF THE CONTROL COLLECTIONS

Control Assemblage Comparisons

The control collection is the Flenniken-Raymond Experiment, Warburton-Towner Experiment, Titmus-Wood Experiment, and

Spencer Experiment. These experiments were excellent for forming breakage pattern models, rejuvenation signatures, and RSA analysis. Unfortunately, Titmus and Woods replicated a data set of projectile points that were intended only for the breakage pattern model and were not further rejuvenated. Access to the data of the Warburton-Towner experiment was limited to length and width measurements before and after rejuvenation (excluding weight measurement and thickness). Only the Flenniken-Raymond and Spencer Experiments are comparable for length, width, thickness, and weight. Morphological analysis of the control collection is therefore fairly limited by completeness of data sets for only two of the experiments. Table 9.1 lists maximum, minimum, mean, and standard deviation for these variables in the original sample sets. Table 9.2 lists the same measurements for the variables after the first cycle of rejuvenation.

In analysis of Table 9.1, the first apparent observation is that the FR and SP collections which form the control have some significant intra-collection differences. Replicated projectile points from the Spencer experiment tended to be longer, thicker, and consequently, heavier. With lengths variable but widths similar, thickness appreciably corresponds to weight; i.e. the thicker the projectile point the more mass increases, therefore the more the projectile point weighs. This is further expressed in the weight/thickness ratio. In comparing the length and thickness means and the length and thickness standard deviations, the two collections show appreciable variability. This is probably due to differences in flintknapper skill set. Although the

Table 9.1 Flenniken-Raymond (FR) and Spencer (SP) Limited Morphometrics of Original Projectile Point Experimental Sets forming the Control.

FR

	Length	Width	L/W Ratio	Thickness	Weight	W/T Ratio
max	59	37	2.269	6.5	7.5	1.4
min	31	20	1.135	4	3	0.6
mean	47.1	26.4	1.797	5.1	4.8	0.9423
sd	7.5537	3.3795	0.2800	0.5632	1.3486	0.2311

SP

	Length	Width	L/W Ratio	Thickness	Weight	W/T Ratio
max	82	39	2.733	10	24.8	2.983
min	38	25	1.152	4	5.4	1.05
mean	57.2	31.3	1.849	6.5	11.8	1.82175
sd	10.6460	3.6571	0.3911	1.3830	4.3621	0.507603

Control Sample Means and Standard Deviation

		sd
Length	52.15	9.0999
Width	28.8	3.5183
L/W Ratio	1.823	0.3355
Thickness	5.8	0.9731
Weight	8.3	2.8554
W/T Ratio	1.4	0.3693

Flenniken-Raymond collection is balanced by the combination of one of the most accomplished North American flintknappers (Flenniken) with one of his less accomplished students (Raymond), the extra level of expertise still shows though in the sample means. Materials were the same or very similar (obsidians from Glass Buttes, Oregon and the Mineral Mountain sources in the EGB) as well as consistency in the reduction techniques. This reinforces Rolland and Dibble's (1990:486) notion of lithic artifact variability based on the factor of skill set or "toolmaking repertories" and abilities, precluding variability of tool-stone quality or blank size (materials being near equal and core size more than adequate in the two collections). Still, the mixed skill levels and repertories in prehistoric times would be present in the test collections, therefore, validating the use of varying skill sets in the control. All of the projectile points in both collections regardless of the tool making skills of the flintknapper met the IMACS type-guide as well as Thomas's criteria for ECN. This is due to the interesting observation that both type-guides exclude length, thickness, and weight as observable criteria for the projectile point type.

The second observation in Table 9.1 is the near evenness of width means and length/width ratio means between the non-rejuvenated control collections. Although the projectile points within the SP collection were on the average longer, projectile point widths were very similar.

Comparing the rejuvenated control collections (see Table 9.2) the length, width, and length/width ratios are comparatively close, with length means within the SP collection still higher than FR. Thickness means and therefore weight means and standard deviations again show higher values in the SP collection. The final assemblage sample means are shown in the last portion of Table 9.2.

Table 9.2 Flenniken-Raymond (FR) and Spencer (SP) Limited Morphometrics of Rejuvenated Projectile Point Sets after one Rejuvenation Cycle for all RSA.

FR

	Length	Width	L/W Ratio	Thickness	Weight	W/T Ratio
max	52	39	2.318	7	6.2	1.1
min	20	18	0.808	4	1.2	0.3
mean	36.3	24.0	1.525	5.1	3.5	0.670145
sd	9.2898	4.3161	0.3548	0.5909	1.2657	0.224396

SP

	Length	Width	L/W Ratio	Thickness	Weight	W/T Ratio
max	63	48	2.0323	9	15.6	1.95
min	31	24	0.939	4	4.6	0.8375
mean	47.5	31.1	1.546	6.7	8.7	1.286943
sd	8.4802	4.6933	0.2963	1.4289	3.1509	0.331931

Control Sample Means and Standard Deviation after one Rejuvenation Cycle

		sd
Length	41.9	8.8850
Width	27.5	4.5047
L/W Ratio	1.535	0.3255
Thickness	5.9	1.0099
Weight	6.1	2.2083
W/T Ratio	1.0	0.2782

EXPECTATIONS IN CONTROL AND TEST RSA SAMPLE MEANS

Table 9.3 compares the RSA control sample means and the test RSA sample means. Standard deviations are also given for each set of RSA sample means. Mean RSA signatures that could be expected under the following categorical observations and assumptions are discussed by the measured morphometric attributes.

Length

All of the RSA1 series signatures require reduction of the blade length for rejuvenation. This is especially evident in RSA1A, where the projectile point is essentially "resharpened" like a pencil to regain sharpness and functionality. The overall mean length for RSA1 series projectile points should therefore be near equal to or smaller than the control.

In RSA2 series signatures, length is relative. Length is usually not reduced when repairs or rejuvenation occurs at the ligature line or notches (RSA2N or RSA2H).

RSA3 signatures are the complete rejuvenation of a projectile point. Test collection mean lengths should be therefore near or less than the control.

Width

During the rejuvenation experiments, artifact width was conserved where length was usually sacrificed. Width measurements should appear to be basically constant across assemblages. Width is also greatly influenced by the topographic location where it is measured. Width measurements are taken at the ligature line at the widest portion of the projectile point. This topographical location is less prone to be affected by any of the RSA signatures. Table 9.3 should show little variation in width means across all collections if width was also conserved in the prehistoric collections.

Length/Width Ratios

If width means were fairly constant, then projectile point lengths would be the factor to most affect the length/width ratio. For RSA1 and RSA2 series points where reduced lengths would be anticipated, Table 9.3 should demonstrate this. The possible exception is Cowboy Cave where early on it was observed that the projectile points were usually longer; rejuvenated or non-rejuvenated. It has been previously discussed that rejuvenation (as well as lithic industries in general) was not a high priority at this site due to concentration on other subsistence activities (small seed gathering) and close access to high quality tool stone materials.

Thickness

Projectile point thickness also appears to be a fairly close constant between assemblages and RSA signatures. This may be due to where the measurement is taken: at the thickest point of the artifact adjacent to the ligature line. Unless new basal thinning occurs (RSA2H) during rejuvenation, thickness is usually not significantly reduced during the rejuvenation of projectile points. Table 9.3 should confirm this. Intra-collection variability problems, however, exist within the control. The thickest projectile points occurred in the Spencer collection which tended to make the control collection trend towards thick projectile point means.

Weight

Significant reduced mean weights should be anticipated with RSA1 and RSA3 series rejuvenation strategies. As a projectile point gets smaller, it should weigh less. Again, problems with projectile point lengths, thickness, and weights in the Spencer collection may skew the weights in the Control set to be in a higher range.

Weight/Thickness Ratio

If thickness is a near constant within the collections and weight of the artifact decreasing as rejuvenation increases, then weight/thickness ratio means should be near or at the control levels if rejuvenation is occurring. It is anticipated that this should be reflected in Table 9.3.

	Control		Danger Cave		Hogup Cave		Cowboy Cave		Sudden Shelter	
RSA1 Series	n=37	sd	n=143	sd	n=69	sd	n=19	sd	n=42	sd
Length	39.8	7.4	37.6	0.8820	35.0	0.7443	39.8	0.9203	35.0	0.7171
Width	27.5	2.1213	21.4	0.3430	21.9	0.3448	20.8	0.3563	21.4	0.3192
L/W Ratio	1.4596	0.1367	1.7933	0.4929	1.6311	0.4197	1.9844	0.6255	1.6563	0.3419
Thickness	6	0.7071	4.8	0.1273	5.2	0.1141	4.5	0.1124	4.8	0.2151
Weight	5.75	1.6263	3.58	1.3890	3.79	1.3827	4.14	1.1256	3.550	1.2078
W/T Ratio	0.9335	0.3957	0.7531	0.2254	0.7319	0.2113	0.9772	0.3898	0.8006	0.2433
RSA2 Series	n=37	sd	n=101	sd	n=40	sd	n=7	sd	n=6	sd
Length	40	3.5355	37.9	0.8249	35.2	0.7036	39.75	0.8313	30.1	0.7655
Width	27.5	2.1213	21.9	0.3551	21.5	0.3211	20.8	0.2598	21.4	0.3731
L/W Ratio	1.4769	0.1612	1.77917	0.4725	1.6669	0.4005	1.9572	0.5096	1.4228	0.3681
Thickness	6.5	0.0507	4.9	0.1215	5.2	0.1305	5	0.1044	5.2	0.2455
Weight	5.45	0.4950	3.702	1.3454	3.9	1.4806	4.18	0.9562	3.42	1.2400
W/T Ratio	0.8106	0.0804	0.7707	0.2319	0.7482	0.2116	0.8535	0.1823	0.7048	0.2518
RSA3 Series	n=7	sd	n=68	sd	n=30	sd	n=17	sd	n=12	sd
Length	38.5	13.4350	42.25	0.92161	39	0.9359	48	0.6998	37.25	0.4093
Width	25.5	2.1213	21	0.25992	21.8	0.2483	21.6	0.3872	20.75	0.3194
L/W Ratio	1.4612	0.3851	2.041	0.50240	1.8215	0.4840	2.2557	0.4657	1.8358	0.3523
Thickness	6.5	0.4680	4.6	0.12009	5.4	0.1129	5	0.1000	4.5	0.0674
Weight	6.5	3.6062	3.5	1.25729	4	1.5767	5.4	1.4372	3.7	1.2010
W/T Ratio	0.8516	0.4000	0.7895	0.23047	0.7601	0.2562	1.1222	0.4045	0.8211	0.2842

Table 9.3 Comparison of the RSA control sample means and the test RSA sample means with mean standard deviations. Length, Width, Thickness in millimeters. Weight in grams. L/W =Length / Width Ratio. W/T=Weight / Thickness Ratio.

OBSERVATIONS

RSA1 Series

Test collection length and width sample means were equal to or less than control length and width sample means for all collections. This meets expectations. Arguments for RSA1A series length/width ratios, weight, thickness and weight/thickness ratios failed to meet expectations.

RSA2 Series

Comparison expectations were met in nearly all of the parameters. Length, width, thickness, and weight sample means were relative across the board with Cowboy Cave being the exception for length/width ratios. Cowboy Cave projectile points were generally longer, thus a high (1.9+) length/width ratio; the highest of all comparisons.

RSA3 Series

RSA3 comparison expectations were not met for any of the parameters except mean widths. For example, the control has a mean length of 38.5 mm and a standard deviation of 13.4350. The length is comparable with the other mean lengths from the collections (again, except for Cowboy Cave with a mean length of 48 mm) but the standard deviation is unacceptably high. This is largely due to the control collection skew towards longer, thicker, heavier projectile points. Width again, remains a near constant.

POSSIBLE FACTORS AFFECTING OBSERVATIONS

The problem of differences in “toolmaking repertories” and flintknapper abilities has been previously discussed. The control collection had longer, thicker and heavier projectile points which can be directly attributed to a flintknapper’s skill set. One tool maker’s repertories skewed the data towards heavier sample means for these variables. Three other factors were also unaccounted for when the experiments were originally designed: combined RSA used in rejuvenation trajectories, multiple rejuvenation cycles, and regional variation.

Combined RSA used in Rejuvenation Trajectories

First, RSA signatures were most often used in combination, forming a reduction trajectory. For example, RSA1A (reduction retouch of the blade) was most often used in conjunction with RSA1C (edge and margin retouch) and RSA2N (retouch of the ligature line). As the data indicates from Chapter 8 (e.g. see Table 8.9 A-D) several dozen different permutations of rejuvenation trajectories were recorded. Although the analysis in Table 9.3 attempted to isolate RSA1 and RSA2 series strategies, the reality is that they most frequently occurred together. RSA3 is based on the anticipation of RSA1 series and RSA2 series signatures used to produce a new projectile point that is morphologically similar to a projectile point at the beginning of the manufacturing/rejuvenation continuum. The control set was not designed to account for combinations of rejuvenation trajectories within the RSA signatures.

Multiple Rejuvenation Cycles

Second, multiple rejuvenations would occur with an increase of intensification within a reduction continuum. Danger and Hogup Caves show just such multiple rejuvenations. As discussed previously, it was often not the problem to determine if rejuvenation was occurring, but the intensity of rejuvenation cycles that occurred.

Absence of multiple rejuvenation cycles is also difficult to account for. There is a marked absence in multiple rejuvenation cycles at Cowboy Cave and Sudden Shelter. Indeed, all evidence points to reduced rejuvenation pressures at both of these sites.

Regional Variations

Third, it appears that regional variations were occurring within the projectile point assemblages. This is especially apparent in RSA signatures and analysis of projectile points from Cowboy Cave. Projectile points appear to be initially manufactured with longer lengths and widths from this location, which is in the transition area from the EGB to the Colorado Plateau. For example, it was here that the RSA3 signatures were the longest, widest, and thickest, and heaviest of the lot. This was also reflected in the length/width ratios as well as the weight/thickness ratios. The most comparable assemblages were those from Sudden Shelter, where proximity to high grade tool stone as well as competing subsistence activities (plant gathering and processing) also occurred.

All of these factors or any combination thereof may have compromised the experiment for morphometric analysis. The methodologies creating the observed RSA signatures and the application protocols, however, are still valid.

CONCLUSIONS

When comparing the RSA means between the control and test collections in Table 9.3, inferences can be drawn that rejuvenation is occurring in the test collections within the RSA signature trajectories. Measuring these rejuvenation trajectories through means and standard deviations, however, was not entirely successful. Cowboy Cave and Sudden Shelter do not comfortably fit the proposed rejuvenation model; however, they appear to be closely related to each other. Based on morphometic comparison of mean length, width, thickness, weight, length/width ratios, and weight/thickness ratios, it can be inferred that this is not the best method of quantifying the rejuvenation model and other methods should be investigated.

CHAPTER 10

DISCUSSION AND CONCLUSIONS

INTRODUCTION

The research goal of this study was to create an analytical technique to recognize, record, and measure rejuvenation in atlatl dart points; specifically EGB atlatl dart points. Three major research goals were desired. First, a proof-of-test for this new experimental technique was required. Second, to assess if RSA can assist in supporting empirically proved models of curation and use-life for projectile point usage at the research sites. Third, and probably most critical, to put to rest a stylist vs. functionalist question, i.e., the validity of using Great Basin and Colorado Plateau projectile points as temporal markers (Bettinger, O'Connell, and Thomas 1991; Wilke and Flenniken 1991).

After study of past projectile point fracture and rejuvenation experiments and conducting a carefully structured rejuvenation experiment of my own, I created the technique of Rejuvenation Signature Analysis (RSA). I then applied this analytical technique to atlatl dart points found within the contextual strata of four important eastern Great Basin caves and rock shelters. RSA signatures studied in these projectile point assemblages were recognized, recorded, and measured. What follows are the inferred conclusions of this study discussed in relative order of significance. The discussion addresses the validity of the morphologically derived projectile point types, the importance of RSA as an analytical tool, unexpected observations, accomplishment of research goals, and how RSA can be applied in future studies.

MORPHOLOGICALLY DERIVED TYPES RECONSIDERED

A persistent question in the Flenniken-Thomas debate was, "Are morphologically derived types described from projectile point assemblages found at Great Basin archaeological sites morphologically stable?" Based on the RSA analysis of Danger Cave, Hogup Cave, and Sudden Shelter the answer is, no. The notion that a projectile point "type" based on an unchanging morphology through several maintence and repair cycles is unsupported by this current study. RSA signatures that are the most sensitive to type-change (RSA2N, RSA2H, and RSA3) were observed between 62% and 76% in the test assemblage populations (mean=69.75%). Rejuvenation trajectories that could change type were occurring about 70% of the time during the last analyzed rejuvenation cycle. With multiple rejuvenation trajectories and multiple rejuvenation cycles (especially in Danger and Hogup Caves), the rejuvenation pressures to change type were considerable and probably overwhelming.

A second question at the heart of the Flenniken-Thomas debate was, "Did projectile points mostly break near the tip or upper blade, leaving the ligature line and hafting element intact?" Again, the answer is, no. RSA signatures indicated that repairs to the blade occurred only from

23% to 38% (mean=30%) of the time. It was also observed that if breakage occurred at the mid-blade line it was unrecoverable and there was a high probability that neither of the fragments would or could be rejuvenated. This was a “terminal break” or non-recoverable scenario. Fortunately, breakage on this part of the projectile point was rare. Typological schema, especially those employed by Holmer (1976) and Thomas (1981:14), have at their core the assumption that the majority of projectile point breakage occurs on blades at the tips. The assumption is that the hafting elements remain unchanged. This assumption is strongly in error. This is the kernel of the debate involving the question of using projectile points as temporal markers. The question being, “Should the types derived from these cave assemblages be used as temporal markers, especially at archaeological sites where context is missing (surface sites)?” The inferred conclusion from this RSA study is no; no for at least two reasons. First, there is a very high probability that a projectile point observed at the surface site has been rejuvenated (and changed both in morphology and type) during its use-life. Second, the argument that the archetype from which type was derived has always, and will forever remain the original archetype regardless of rejuvenation, is flawed. RSA analysis of the control and test assemblages has shown that any projectile point remaining morphologically static throughout its use-life is highly unlikely.

Finally, most practicing Great Basin archaeologists that use Thomas' dichotomous key as a basis for typing projectile points assert that if a projectile point cannot be placed within a typological-temporal schema, then that projectile point is "un-diagnostic". The same applies to those projectile points that " . . . fall out of key" (Thomas 1981:25). These assertions are wrong and place a prejudiced bias on the analysis that if a projectile point cannot be typed (i.e. un-diagnostic) then its scientific value has been diminished. RSA analysis has shown that all of the rejuvenated projectile points and projectile point fragments contain diagnostic information for both technological and cultural processes. The absence of rejuvenation also contains technological and cultural processes information. The RSA signatures are intrinsically diagnostic of these processes. If "un-diagnostic" narrowly means that a projectile point cannot be used to date an archaeological site by type and therefore its scientific usefulness ends, then RSA analysis has added two major contributions to the science. First, if the process of rejuvenation places type within a continuum, then all projectile points must be un-diagnostic *per se* at sometime during that continuum. Second, with projectile point types being suspect, RSA analysis augments the data by substitution of temporal markers with the notion of using projectile points as potential sources of technological and cultural process information. A large number of rejuvenated projectile points cannot comfortably be placed within these suspect "temporal marker" categories. Rejuvenation may also be the same process that caused these projectile points to "fall out of key".

THE IMPORTANCE OF RSA AS AN ANALYTICAL TOOL

RSA's major contributions as an analytical tool are in its capabilities of deducing both technological and inferred cultural processes. Both processes are essential in understanding the creation and maintenance of lithic artifacts, artifact variability in the archaeological record, and artifact use-life in general. RSA has been shown to infer use-life and curation continuum models for Danger Cave, Hogup Cave, Cowboy Cave, and Sudden Shelter (see Figure 8.9).

Implications for Field Archaeologist

Field archaeologists in the EGB routinely assign types to the projectile points they find both in stratified archaeological contexts and in open sites where the context has been compromised. In stratified contexts, it is recommend that rather than relying on morphology for projectile point types and using the types as temporal markers, perhaps reliance on ^{14}C materials should always be given preference over projectile point types. In open sites, perhaps it is best to determine if these projectile points are atlatl dart points or arrowheads. This will roughly assess relative age to the open site. In both cases, the projectile points could then be subjected to RSA analysis to determine technological and cultural processes present at the site in question. Presently, most field archaeologists must also assess site significance for eligibility to National Register of Historic Places, 36CFR60. It has generally been the practice to dismiss eligibility at open sites if no “diagnostic” projectile points were observed (i.e. lithic scatters). RSA analysis can support a determination of eligibility under 36CFR50.4(d) by demonstrating projectile point information that, “D. Have yielded or may be likely to yield, information important in prehistory or history.” Many lithic scatters that have either projectile point fragments or “un-diagnostic” projectile points have been written-off as non-significant. RSA is an analytical tool that could expand and augment field analysis and eligibility determinations.

Implications for Lithic Specialists

Lithic specialists can use RSA as another analytical tool in lithic studies. By adding RSA to attributes recorded in lithic analysis, information to augment other studies (raw material sourcing, use-life, curation, etc.) can be accomplished almost simultaneously. The greatest importance of using RSA as an analytical tool for the lithic specialist is its designed function of determining and measuring rejuvenation. Before, lithic analysts examining projectile point assemblages were largely left to the conclusion, “It sure looks reworked”. RSA is presently only used for description of atlatl dart points. It is proposed by examination and experimentation with other lithic tool classes, other working versions of RSA can be proposed.

Implications for Other Archaeologists

RSA implications for other archaeologists may be a paradigm adjustment. By application of RSA to other stone tool assemblages, analyses may change or other alternate conclusions offered. By reaffirming the concept of reduction and maintence continuums in stone tool assemblages, typing schema based totally on the concepts of static types may be modified.

For those who hold to *chaîne opératoire* or normative-empiricist views where the final end products of lithic reduction are cognitive and deliberately produced, RSA will prove less useful. However, it holds in common with those of these persuasions that RSA does strive to infer cultural processes through examination of a technical process.

Applied RSA

For example, one of the major observations affecting cultural processes was rejuvenation intensity. Both assemblages in Danger Cave and Hogup Cave appear to have greater levels of rejuvenation intensity than Cowboy Cave and Sudden Shelter. This infers and supports that:

a) Acquisition of high quality tool stone at Danger and Hogup Caves was a greater resource concern than at Cowboy Cave and Sudden Shelter. As shown by the tool stone distribution models in Chapter 8, quality tool stone (obsidian and ignimbrite) was often located 100+ km from the occupation sites at Hogup and Danger Caves. High quality ccs was relatively close at hand for Sudden Shelter and Cowboy Cave inhabitants.

b) Other subsistence activities took priority over hunting and lithic manufacturing/repair industries at Cowboy Cave and Sudden Shelter.

Other applied RSA processes observed are how projectile points are rejuvenated to accommodate hafting, how projectile points fracture, how they are recovered by fracture type, when fractures determine rejuvenation potential, and rejuvenation trajectories employed during refurbishment. It is interesting to note that in the Danger Cave and Hogup Cave assemblages, the real difficulties came not in determining if the projectile point had been rejuvenated, but how many rejuvenation cycles the projectile point had completed.

Equally important are other applied cultural processes inferred by RSA analysis. RSA describes and measures criteria used in making curation/discard decisions. RSA measures rejuvenation trajectories that can factor artifact variability. These artifacts are used to determine site-types and intra-site processes.

UNEXPECTED OBSERVATIONS

Several of the observations recounted here were serendipitous and well outside of the observations scheduled to be recorded. These unexpected observations are of secondary importance. They are basically divided into observations made during the replication/simulated hunt and those recorded during the analysis of the research collections.

During the Replication/Simulated Hunting Experiment

First, all of the experimenters had difficulties in replicating consistent “clones” of the Elko Corner-notched projectile point that exactly met criteria in Thomas’ dichotomous key. Although similar on a “gross” inspection, many individual differences can be seen (especially in length, weight and thickness). This may be due to the experimenters’ flintknapping skill sets or differences in materials used. Although most of the materials came from Oregon obsidians obtained at Glass Buttes, different obsidian qualities occur at different parts of this tool stone source. Based on current methods of establishing archetype and “type”, different types would be determined by the flinknappers’ idiosyncrasies as shown in this study. What constraints, other than hafting a projectile point successfully on an armature, would prehistoric flintknappers be faced with? Flintknapping skills probably played a significant factor in rejuvenation choice. Flintknapping skill sets strongly influenced the lack of success in morphometric comparisons discussed in Chapter 9.

Next, all of the experimenters used different targets during the simulated hunting portions of their experiments. These were soft, hard, combinations of organic and inorganic, and carcass. It really did not seem to matter. The atlatl projectile points broke in one of five expected ways or combinations thereof. I had originally planned on using a bison carcass. It would have been an unneeded and unnecessary expense.

Finally, all of the experimenters lost projectile points during simulated hunting, even when measures were taken to recover projectile points and fragments. Lost projectile points should be a part of any site formation / use-life model where projectile points are analyzed.

During the Analysis of the Research Collections

Sinew and pine pitch mastic were observed on projectile points in both the control and research collections. These substances occurred in sufficient quantities on several projectile points in the research collections for AMS dating. This would be a reliable and relatively inexpensive way to verify the last date that these projectile points were hafted. Destructive sampling, however, is currently not permitted by the University of Utah Natural History Museum.

Pine pitch mastic also appeared to make the projectile points more brittle, thus facilitating fracture and breakage. This is a desirable outcome to produce multiple projectile point fragments within an animal struck by an atlatl dart point. Perhaps future experiments could test the fracture rate and brittleness between dart points with pitch mastic and those without to confirm and quantify this observation.

Another unanticipated observation was the regional differences within an artifact assembly. For example, it was noted that Cowboy Cave had longer mean projectile point lengths. This also affected the morphometric analysis of Chapter 9.

Finally, the type and frequencies for RSA signatures within an artifact assemblage as well on individual projectile points (especially multiple RSA signatures on a projectile point) seem to infer that the greater number of rejuvenation frequencies, the higher probability that the projectile point has experienced type changing rejuvenation trajectories. This observation, however, requires a more in depth analysis of the rejuvenation assemblages.

RECOMMENDED FUTURE RSA STUDIES

RSA is a stand-alone analytical tool that can measure and record types of RSA signatures and RSA trajectories, however, it is best used to support other studies. Four additional studies are suggested: a) Use of RSA to fine-tune use-life and rejuvenation continuums within individual strata (at the research sites or other Archaic stratified sites). In the study area alone, there are 28 other major Archaic sites recorded (see Figure 2.4); b) Apply RSA to caches or cached lithic materials (especially finished, nearly finished, or fragmentary projectile points); c) Conduct RSA in assemblages of bifaces, scrapers, and other clearly non-projectile point lithic tools where rejuvenation was used, and d) Augment lithic material sourcing and procurement studies with RSA analysis. For example, extensive lithic tool stone source analysis has been conducted for the eastern Great Basin and Danger Cave (Hughes 1984, 1997; Jones et al. 1997; Jones et al. 2002; Jones et al. 2003; Jones and Madsen 1989; Page 2008; Page and Skinner 2008). RSA could help describe tool stone procurement costs, rejuvenation pressures due to acquisition distance, and tool stone production and curation/discard decisions. Again, much of the analysis has already been completed.

In summary, RSA as it now exists can be part of any dart point assemblage study. With the experimental protocols to establish RSA signatures for the lithic tool assemblage to be analyzed, RSA could be adapted to a wide range of lithic studies where rejuvenation was part of lithic tool use-life.

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APPENDIX I: Glossary and Abbreviations

Several of the terms in the following glossary have been modified to especially clarify definitions, phrases, and abbreviations found in this thesis. Many glossary terms included here were influenced from Crabtree (1972), Bradley (1975), as well as **LITHICS-*Net*** (www.lithicsnet.com) and www.archaeologywordsmith.com

Abrading Stone: a stone, typically sandstone or limestone that was used to smooth or sharpen antler, bone, wood, copper and/or other stone. Also used to create platforms on preforms. See Figure A. 1.3 item F.

Acute: severe short angles coming to a sharp point.

AMS: Accelerator Mass Spectrometry radiocarbon dating.

Archaic: a cultural period in the eastern Great Basin composed of three periods: Early Archaic (7500 B.C. to 200B.C.); Middle Archaic (2000 B.C. to 500 A.D.); and Late Archaic (500 A.D. to European Contact). Early references also call this the “Desert Archaic”.

Armature: The wooden shaft on to which the dart point is mounted (Figure A1.1). See foreshaft.

Arrowhead or Arrowpoint: arrowheads are projectile points used in the bow-and-arrow weapon system. These projectile points were manufactured from stone, bone, metal, glass or other material. Arrowheads are generally less than 1 inch in length (25 mm) and weigh 6 grams or less.

Assemblage: a group of artifacts which represent a culture or archeological unit. A group of artifacts related to each other based upon recovery from a common archaeological context.

Asymmetrical: in reference to projectiles points or tools, asymmetrical refers to opposing sides of an object which have dissimilar contours, shape or form.

Atlatl: a composite spear throwing weapon system consisting of four parts: A) the slender wooden paddle with finger loops fitted with a groove and "spur" to receive a spear. This is often referred to as the

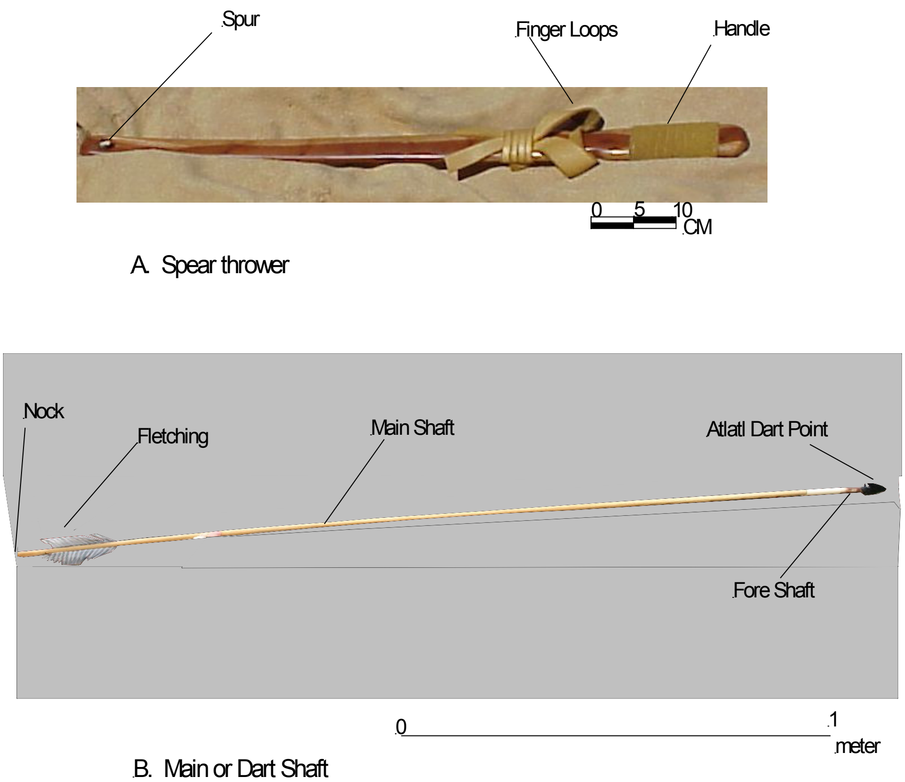


Figure A1.1. Atlatl Nomenclature.

"spear thrower". B) a fletched spear (usually 1.5 to 2 meters in length) fitted with a nock to fit into the spear thrower spur. This spear is often called the "mainshaft" or "dart". The mainshaft can terminate in a projectile point which is directly hafted to this shaft. The most commonly observed example in the Western United States, however, is usually fitted with a socket to receive a foreshaft. C) a detachable smaller shaft which is in turn fitted with a hafted stone projectile point. This smaller shaft is referred to as the "foreshaft" (also see armature). The stone projectile point hafted on the foreshaft is called the D) atlatl dart point or atlatl point.

Atlatl dart point: is the flinknapped stone projectile point that can be hafted to an atlatl mainshaft or foreshaft (see Figure A1.1[B] and Figure A1.2).

Barb: a projection on the terminal lateral margins of a projectile point found near the base and forming the ligature line. A barb is formed as a projection created by a notch (see Figure A1.2).

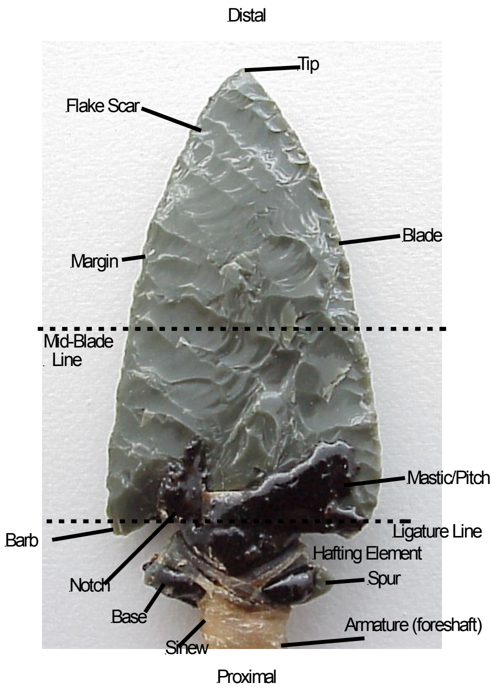


Figure A1.2. Anatomy of an atlatl dart point.

Base: the proximal portion of the projectile point (see hafting element). Refer to Figure A1.2.

Baton: club-like rod of material other than stone used in soft hammer percussion technique of flintknapping; may be antler, horn, bone, wood, or copper (see Figure A1.3 , items A-C).

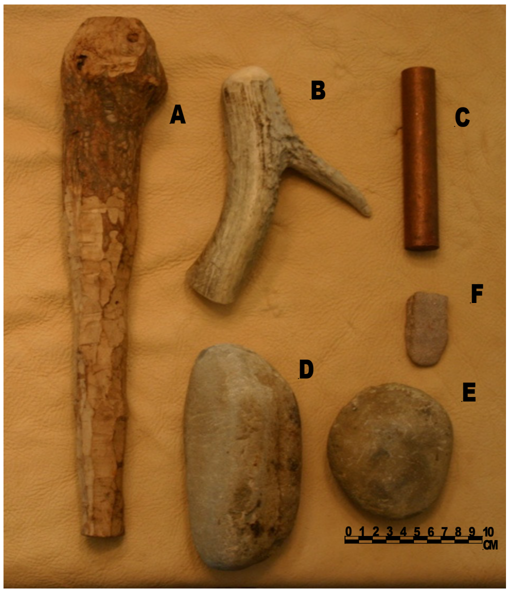


Figure A1.3. A-C Batons. A. Hardwood. B. Antler. C. Copper. D-E Soft hammerstones (welded volcanic tuff). F. Abrader (sandstone).   All except “A” and “C” used with the Spencer Experiment .

Basal Thinning: the final step in flintknapping a projectile point where small longitudinal pressure flakes are removed from the base to facilitate hafting. An example of basal thinning is seen in Figure A1.4.

Basalt: A volcanic (igneous) extrusive stone. When used as a tool stone source, it is usually fine grained and dense. More vitreous forms are known as "glassy basalts".

Bending fracture: A fracture type (usually on a preform or near-finished tool) caused during manufacture by percussion flaking on the distal or proximal end. This results in energy transfer to the midline of the object being flintknapped and subsequently, the energy bending through the artifact and exiting through the opposite face. This results in the snapping in-two of the artifact. This can also be produced as an impact fracture. This is not a desired fracture.

Biface: flaked stone artifact exhibiting evidence of facial thinning on both dorsal and ventral faces. See also blank and preform.

Bilaterally symmetrical: an artifact that shows "mirrored" symmetry, or has similar morphology on both margins.

Billet: see baton.

Black Rock Period (4000 B.C. to 500 A.D): a transitional cultural period bridging the Early and Middle Archaic. Also known as the "Desert Archaic".

Blade: elongated flake with parallel or sub-parallel lateral edges, at least twice as long as it is wide; also, the distal portion of a projectile point forming the area from the ligature line to the tip (see Figure A1.2). In a knife, the portion from the ligature line to the tip (if hafted). For unhafted knives, it is the entire artifact.

Blank: any piece of lithic material modified to an intended stage of a lithic reduction sequence in a specified assemblage. Used in this thesis as an early stage in the reduction continuum where the roughed-out blank could be flinknapped into most of the projectile point types found in the assemblage. This is opposed to the next reduction phase, a preform.

Blunt or **Bunt:** a projectile point that has a rounded distal margin that usually occurs at what would be mid-blade. Bunts deliver bone-breaking impact rather than piercing penetration. Bunts may also be laterally recycled projectile points that are now used as hafted scrapers. Bunts can also be hard wood or bone projectile points that resemble a nodule with a spur to be hafted into a atlatl mainshaft.

Bonneville Period (9000 B.C. to 7500 B.C.): named after Pleistocene Lake Bonneville, this is the earliest cultural period in the eastern Great Basin. See "Pre-Archaic" and "Paleoindian".

Bulb of force: the bulbar part on the ventral face at the proximal end of a flake. Also known as a bulb of applied force or bulb of percussion.

Burin: a chisel-like tool class derived from a flake, blade or other artifact form made by removing all or part of an edge using percussion oriented along the long axis of the piece. A stone tool used to incise wood or bone. The specialized flake removed as a result of the burin break is called a burin blade or spall.

Burin fracture: a specific burin-like breakage on a projectile point. Usually an impact fracture caused by direct contact with a hard surface.

Cache: a storage feature associated with curation. In lithic artifacts, a cache can usually refer to multiple tools that are at a similar stage in the reduction continuum or type found within a restricted associated context.

Chaîne opératoire: the lithic reduction process from acquisition of raw material to final discard or loss of the artifact.

Chalcedony: a translucent to clear cryptocrystalline silicate with a waxy appearance. It is sometimes referred to as a semi-translucent agate.

Channel Flake: a long longitudinal percussion flake removed in the fluting process. See flute flake or eraillure**.**

Chert: a very fine grained cryptocrystalline silicate. It is vitreous (sometimes resembling chewed gum) and is usually white, pinkish, brown, gray, or blue-gray in color. In North America, high grade glossy chert is often called "flint".

Context: the three dimensional physical surroundings of any *in situ* archaeological artifact or feature.

Concave: descriptive of a projectile point base to describe a base which is indented and curves inward.

Conchoidal fracture: diagnostic fracture on a plane surface which resembles and has the characteristics of half a bivalve shell. A necessary attribute of raw material selected for flaked stone tool manufacture.

Convex: a term to describe an outline which curves outward. It can be applied to the distal end of a projectile point bunt or the proximal end of a projectile point base.

Core: any “parent” raw material from which one or more flakes have been intentionally removed.

Cortex: natural chemical, mechanical or weathered surface or rind on tool stone.

Curation: the physical retention of an artifact for future use or repair. Defined by Binford (1979) as the spatial and/or temporal separation of tool manufacturing loci and tool use/discard loci.

Cryptocrystalline silicate (ccs): A silicate mineral with a submicroscopic crystalline structure (unable to detect crystal structure with the naked eye). In North America, ccs is used to lump flintknappable materials of agate, chert, flint, chalcedony, and sometimes quartz crystal into a “generic” analytical category.

Debitage: the waste lithic material resulting from flintknapping.

Distal: the edge of a flake or tool opposite the striking platform, or where the flake terminates (detaches from the core). This is usually the “point “section of a projectile point.

Figure A1.4. Typical ECN, near actual size.

Dorsal: the “outside” face of a flake or uniface, visible to the flintknapper before the original flake has been removed from the core. The dorsal face of an artifact may exhibit cortex, one or more negative flake scars and ridges, and ripple marks (compressions rings) within the flake scars.

Ears: pointed or rounded projections from the base or hafting area of certain projectile points (see tang).

EGB: Eastern Great Basin.

Elko corner-notch (ECN): a type of Great Basin atlatl dart projectile point defined by Thomas (1981:25). Thomas defined this corner-notched projectile point as having a W_B > 10.0 mm, 110° ≤ PSA 150° and a BIR > .93. Where:

W_B = Basal width

PSA = Proximal shoulder angle

BIR = Basal Indentation Ratio. See Figure A1.4.

Eraillure: a channel-like basal thinning flake, usually resulting in a "flute". See also flute flake.

Expedient tool: any tool produced using a minimum of effort for the express immediate need. This also can refer to a tool used for another purpose than the original for which the tool was initially manufactured, *e.g.*, using a tip of a pocket knife blade for a screw driver tip.

Expention: the stage in the use-life of a projectile point where it is discarded and/or a replacement is manufactured.

Finger-vise: a flintknapping method of holding the projectile point in the fingers for notching.

Figure A1.5. Use of finger-vise in notching. (Photo Credit: L. Spencer).

Flake: any piece of stone intentionally removed from a larger piece of stone by flintknapping. Usually defined as "primary" (containing cortex remnant on ventral side), "secondary" (no cortex but often retaining flake scars on dorsal side), and "tertiary" (small pressure produced secondary flakes).

Flaking, Alternate: when used in reference to a flaked projectile point or tool, alternate implies the opposite face of opposing edges was flaked.

Flaking, Oblique: a flaking strategy in which the removal of flakes from a biface results in long diagonal parallel flake scars which extend from one side of the blade across the blade face to the other side of the blade.

Flaking, Parallel: the removal of flakes is performed in a strategy where flakes of similar size, depth, length and direction results in flake scars which are parallel.

Flaking, Random: the removal of flakes with a strategy towards a morphological shape, rather than a parallel alignment of flake scars.

Flaking, Regular: the removal of closely aligned flakes of similar lengths and widths which result in a systematic flake scar pattern.

Flaker: a flintknapping tool with a sharp tip used in pressure flaking, often made of antler, tooth, or copper (see Figure A1.6).

Flintknapping: the production of flaked stone tools by percussion and/or pressure flaking.

Flute flake: See channel flake.

Fluted point: a projectile point bearing one or two longitudinal eraillure scars from base toward the tip on one or both faces, *e.g.*, Folsom or Clovis types.

Flenniken-Raymond Experiment (FR): a rejuvenation use-life experiment using non-carcass targets. See Flenniken and Raymond (1986).

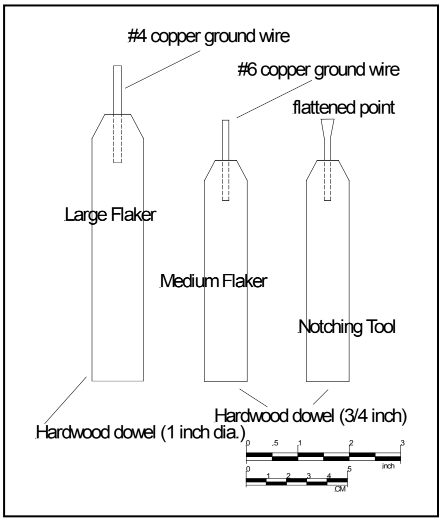


Figure A1.6. Flakers and notching tool used in the Spencer Experiment.

Fremont: a generalized term for a cultural period in the eastern Great Basin beginning at 500 A.D. and abruptly terminating 1350 A.D. This culture emphasized use of ceramics, horticulture, bow-and-arrow, and specialized styles of rock-art.

Frison Effect: the process of rejuvenation during the use-life maintence of lithic tools where fractures or resharpening can occur and the repaired tool can be returned into service. See Jelinek (1976).

Ground stone: a stone tool class exhibiting one or more faces planed smooth through use and/or manufacture.

Haft or Hafting element: the proximal portion of a tool, modified to be securely attached to a shaft or handle (see Figure A1.2).

Hafted Biface Retouch Index (HRI): as advanced by Andrefsky (2006) this is an index that measures and compares the amount of retouch on hafted bifaces; specifically tested on projectile points.

Hammerstone (hard): a hammerstone used to flinknap dense and hard tool stone. Hard hammerstones absorb less impact energy during percussion flaking therefore transferring energy into the object being flintknapped. Usually hard hammerstones are manufactured from cobbles of hard stone such as basalt, indurated quartzite, and the like.

Hammerstone (soft): soft hammerstones absorb part of the impact during percussion flaking, therefore reducing the likelihood of shattering the object being flintknapped. For example, welded tuff or sandstone is used as soft hammerstones to flintknap obsidian, whereas arkos, cherty limestone, or other hard materials (basalt) are used to flintknap chert. Chert usually requires a hard hammerstone during percussion. See Figure A1.3.

Hinge Fracture: see bending fracture.

Ignimbrite: a rhyolitic vitrophyre which is usually more vitreous than glassy basalt and less vitreous than obsidian. Ignimbrite sources for artifacts analyzed in this thesis were found in browns and blacks with major sources located near Browns Bench (Jackpot), Nevada.

Implement: any piece of lithic material that has been modified to an intended stage of a lithic reduction sequence in a specified assemblage (see tool). It must be at its the final intended stage and is not intended for further modification (other than by use).

Industry: artifact assemblages of a particular material or function that are found so consistently in a region of like archaeological sites that they are believed to represent the work of a single society.

Invasiveness: the measured level of retouch on a unifacial or bifacial artifact.

Invasiveness index: from Kuhn (1990). Kuhn proposes a geometric index of reduction for unifacial stone tools. This index is used in measuring the amount of material removed from a unifacially flaked artifact over a sequence of retouching events.

Lanceolate: lance or spear-like. Usually un-notched.

Lateral recycling: a stone tool that is recycled to an alternate use rather than the original use intended for that tool. For example, remanufacturing a broken hafted projectile point into a hafted scraper would be lateral recycling. See Schiffer (1972).

Length: the overall measurement from distal to proximal indices of a projectile point.

Length-width Ratio: the ratio of greatest length over the greatest width.

Ligature: in this thesis, elk or deer leg sinew used as ligature to bind and attach an atlatl dart point to the foreshaft armature.

Ligature line: a morphological topographical location on an atlatl dart point that demarks the juncture of the blade and hafting element. See Figure A1.1

Lithic: any stone tool or debris from its manufacture.

Mastic: produced from pine pitch and charcoal (see pitch sticks) and used as an adhesive and waterproofing for projectile points hafted with sinew.

Mocronate: a "nipple-like" projectile point tip.

Modification: usually refers to a flake or tool that has been retouched.

Modified flake: any flake tool (not a uniface or biface) with one or more retouched and/or utilized edges. Also see "utilized flake".

Morphology: the structure and three dimensional form of an artifact, exclusive of its function.

Nodule core: roughly spherical cobbles/boulders of tool stone.

Notch: Basal, Corner, Side

> **Basal:** A notch on the proximal (base) or hafting element usually made to facilitate hafting. See Figure A1.7(A).
>
> **Corner Notch:** A projectile point that has had notches for hafting struck into the corners of the base. See Figure A1.7(B).

Side Notch: A projectile point with notches manufactured on the lower margins of the blade and above the corners and base. See Figure A1.7(C).

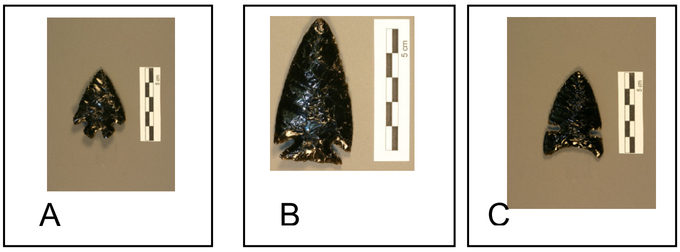


Figure A1.7. (A) Basal notching. (B) Corner notching. (C) Side notching.

Notching flake: flakes produced by pressure flaking with a specialized notching tool (see Figure A1.6). These flakes are the most distinctive of flake types. They are small, lunate flakes with a distinctive "v" shaped platform. Due to their size and fragility, they are also often broken or crushed during the notching process.

Notching platform: a manufactured platform on the finished projectile point preform on which the notching tool rests until notching pressure is applied.

Obsidian: an igneous rhyolitic vitrophyre produced by extreme flash cooling of the lava. See referred to as "volcanic glass".

Paleoindian: see Pre-Archaic.

Palm-vise: a flintknapping method of holding the projectile point in the palm for notching.

Figure A1.8. Use of palm-vise in notching. (Photo Credit: L. Spencer).

Patina: a surface discoloration, film, or outer crust of an artifact due to chemical changes resulting from weathering.

Patination: a loss of minerals from the surface of an artifact which results in a color change usually to a lighter shade. Patination is the result of the aging process of stone tools. It varies by material and by geographical location. It can be an indicator of age. The acidic environment in which the artifact is found may have a marked effect on the extent of patination.

Percussion: a flintknapping process where the artifact is struck by a baton or hammerstone to produce flakes.

Pitch Sticks: heated pine pitch poured over ground charcoal and rolled into "cigar" shaped lozenges. See Gibby (1993).

Platform: the table or surface area receiving the force necessary to detach a flake or blade. Platforms can be either natural or prepared.

Pre-Archaic: the earliest prehistoric cultural tradition in the eastern Great Basin starting with the Bonneville Period (9000 B.C. to 7500 B.C). Also known in North America as "Paleoindian" or "Clovis".

Preform: an unfinished, unused biface. It is also a production stage following a blank with relatively symmetrical outline form, less sinuous edges, shallower flake scars and smaller size such that fewer tool options exist for it.

Pressure: a flintknapping technique where a flaker is applied to a tool platform (edge or margin) and pressure is applied to cause flake detachment.

Primary core: any piece of raw material that has had flakes struck from it, the desired product being the flakes.

Primary flake: any flake removed from a primary core for the purpose of further modification. Primary flakes still retain a portion of cortex on the dorsal surface.

Proximal: when referring to projectile points, the proximal portion is the hafting element or base. See Figure A1.2.

Quartzite: a fine grained metamorphic (sedimentary) derivative of sandstone. Usually not as vitreous as cherts and/or volcanic glasses, it is often used to flintknap “course-grained” tools.

Raw material: any unmodified piece of lithic material that is structurally and morphologically suitable for modification into stone tools. See tool stone.

Racloir: side scraper (French).

Rejuvenation: to convert a broken, non-functional tool into a similar functioning tool that is returned to the use-life stream.

Resharpening: retouching a non-broken dulled tool edge to produce an edge of similar sharpness as one first obtained from the initial manufacturing step (Hayden 1989).

Retouch: pressure flaking technique used to thin, straighten, sharpen, smooth and make the artifact more regular in form.

Reworking: see rejuvenation and retouch.

Rejuvenation Signature Analysis (RSA): an analytical tool designed to identify the following rejuvenation signatures.

- **RSA1A:** resharpening of the projectile point blade.
- **RSA1B:** rejuvenation of a broken blade to form a bunt.

RSA1C: rejuvenation of blade edges or margins.

RSA1D: resharpening to form a “nipple-like” tip.

RSA2N: partial rejuvenation of the ligature line and notches.

RSA2H: complete rejuvenation of the ligature line and hafting Element.

RSA3: complete rejuvenation of the projectile point.

Rhyolite: derived from igneous rock, rhyolite’s mineral composition is mostly silica and therefore often contains mineralization of quartz, feldspars, biotite, and hornblende. Rhyolites can form highly viscous lavas. Those lavas that cool rapidly often form vitrophyre, or volcanic glasses called obsidian. More gradual cooling causes crystallizations which can be micro and macroscopic. When vitreous, these forms of rhyolite were also used as materials for flaked-stone tool manufacture.

Scraper: flaked stone tool class including unifaces, bifaces and flake tools all characterized by one or more beveled edges with a working angle usually > 30°.

Serrations: small consecutive notches on the edge of a projectile point formed by removing notching flakes. Serration is often a form of RSA1C edge modification/recovery.

Shatter: usually flintknapped materials where breakage occurs along existing cracks and fissures within the core producing amorphous debris lacking flake characteristics. Can also refer to debitage where flakes have been crushed or fractured to the extent that flake type is no longer discernable.

Siltstone: a sedimentary stone of cryptocrystalline particles. Similar to “mudstones” or shales. Siltstone was a preferred tool-stone type in Danger and Hogup Cave artifact assemblages.

Spall: a type of percussion fracture occurring during flintknapping that produces discoidal flakes with feathered edges. An impact fracture to an artifact (usually projectile point) producing an errailure type flake with a discoidal type shape is an example of spalling.

Spencer Experiment (SP): a rejuvenation experiment which formed the basis for Rejuvenation Signature Analysis.

Stem: a haft element; also refers to unnotched tool forms with straight or contracting hafting element edges.

Step fracture: a flake scar that terminates abruptly in a right angle break at the point of truncation. Step fractures occur when the flaking force meets a high level of mass on the artifact and terminates abruptly. Usually not a desired outcome.

Tang: a basal projection on the hafting element (base). See Figure A1.2.

Titmus-Woods Experiment (TW): a projectile point breakage experiment to determine fracture types. See Titmus and Woods (1986).

Tool stone: raw materials used to make stone tools.

Uniface: an artifact flintknapped on one side only.

Use wear: any damage along a tool edge or on a tool face produced as a by-product of tool use.

Utilized flake: see modified flake.

Ventral: the "inside" face of a flake or uniface, invisible to the flintknapper until the original flake has been removed from the core. The ventral face may exhibit a bulb of force/percussion, an eraillure, fissures, and/or compression rings.

Warburton – Towner Experiment (WT): a rejuvenation experiment to determine if rejuvenation signatures could be observed in debitage. See Towner and Warburton (1990).

Wendover Period (7500-4000 B.C.) The place name comes from Wendover, Utah and perhaps is derived from "wending across the desert" when early 20th century steam engines used Wendover as a mid-desert watering stop. This is an Early Archaic cultural period in the EGB.

APPENDIX II: Summary of Projectile Point and Other Rejuvenation Experiments: An Adaptation and Update of Knecht (1994).

Year	Reference	Questions addressed	Projection Device	Target	n=	Point Material	Point Type	Haft Material
1936	Tyzzer (1936)	hafting posibilities; effectiveness; breakage patterns; morphological change with rejuvenation of bone points	bow	gravelly loam; gravel bank; soft wood	9	cow bone	spindle-shaped; two-pronged arrow	ligature & adhesive
1971	Ahler (1971)	relationship between formal types and functional types; wear and breakage patterns	hand	rock free topsoil	5	"Dover" chert	?	ligature
1974	Van Buren (1974)	distance and accuracy of spears of various lengths and weights propelled by spearthrower; penetration tests	spearthrower	flat grassy field; bales of hay and carpeting; weathered maple	~270	various stones	various	ligature
1982	Barton & Bergman (1982)	comparison of impact damage with that on Mesolithic points	bow	fallow deer carcass	17	chalk, flint	non-geometric microliths	adhesive;ligature; ligature & adhesive
1983	Guthrie (1983)	perfomance characteristics of caribou antler compared to other organic materials as projectile point raw materials.	compound bow	moose carcass	50?	antler & bone from various species	single-beveled base	ligature & adhesive
193	Bergman & Newcomer (1983)	impact fracture of lithic points	bow	simulated carcass	26	flint	Ksa Akil points; pointes a face plan	adhesive
1983	Broglio, Chelidonio,& Longo (1983)	wear and breakage patterns; depth of penetration	bow	artificial targets	?	flint	Solutrean shouldered	ligature & adhesive

Year	Reference	Questions addressed	Projection Device	Target	n=	Point Material	Point Type	Haft Material
1984	Fischer, Vemming, Hansen Rasmussen (1984) Fischer (1985)	macrowear and microwear traces diagnostic of projectile point function	bow	simulated carcass; fresh carcass. fish; trees;bushes;grass	153	flint	Bromman tanged; transverse arrowheads; miscellaneous	ligature; ligature & adhesive
1985	Flenniken (1985)	relationship between morphological variation and rejuvenation after use and / or breakage	hand-thrown	live feral goats	11	obsidian	corner-notched; side-notched; lanceolate	ligature; ligature & adhesive
1985	Towner & Warburton (1985)	projectile point production, breakage, and rejuvenation	spearthrower	dead ponderosa pine tree	29	obsidian	Elko corner-notched	ligature & pitch mastic
1985	Woods (1988)	diversity in projectile point form as related to function and durability	spearthrower	see Titmus & Woods (1986)	40	obsidian	Elko corner-notched; Wahmuza lanceolate	ligature & adhesive
1986	Odell & Cowan (1986)	effectiveness and penetrating characteristics of, and damage to, different projectile tips	spearthrower bow	fresh dog carcass	80	chert	bifacial points; unretouched flakes	ligature & Elmers Glue
1986	Titmus & Woods (1986)	differentiation of manufacturing-induced and use-related breakage of projectile points	spearthrower	sand,gravel, cinders, loose bark dirt, sod, wood	34	obsidian	Elko corner-notched	adhesive
1986	Flenniken & Raymond (1986)	relationship between morphological variation and rejuvenation after use and / or breakage	spearthrower	trees; soft loamy soil; underbrush	30	obsidian	Elko corner-notched Elko eared	ligature & adhesive

Year	Reference	Questions addressed	Projection Device	Target	n=	Point Material	Point Type	Haft Material
1986	Arndt & Newcomer (1986)	impact damage of organic points	bow	fresh ewe carcass stimulated carcass	20	antler, bone, ivory	double-beveled base; bipoint	adhesive; ligature & adhesive
1988	Shea (1988) Shea (1993)	comparison of wear patterns on experimental and archaeological Middle Paleolithic triangular flakes and Mousterian points	hand-thrust; hand-thrown bow	cow, horse, donkey, white-tailed deer gazelle, and goat carcasses	>100	stone	unretouched flakes; Mousterian points	ligature & adhesive
1989	Cox & Smith (1989)	comparison of breakage of knives and arrow points	bow	fresh deer carcass simulated carcass	21	stone	Perdiz points	adhesive; no adhesive
1989	Frison (1989)	performance characteristics of Clovis points	hand-thrust spearthrower	elephant carcass	7	chert; quartzite; obsidian	Clovis	ligature & adhesive
1990	Stodiek (1990)	suitability and durability of various hafting methods; impact damage on points; impact damage on points; impact damage on bones of carcass; depth of penetration	calibrated crossbow to simulate spearthrower	fallow deer carcass	28	reindeer antler	single-beveled base double-beveled base	adhesive; ligature & adhesive
1991	Chadelle, Geneste & Plisson (1991) Geneste & Plisson (1993) Pisson & Geneste (1989)	hafting techniques; wear and breakage patterns	bow; calibrated crossbow to simulate spearthrower	goat carcass	>400	flint	Solutrean shouldered	adhesive; ligature & adhesive

Year	Reference	Questions addressed	Projection Device	Target	n=	Point Material	Point Type	Haft Material
1993	Cattelain & Perpère (1993)	use of Gravette points as projectile points; performance and damage characteristics of spearthrower vs bow	spearthrower prehistoric bow long bow	goat carcass	100	flint	Gravette points	ligature & adhesive
1993	Pokines (1993)	effectiveness, durability, and breakage patterns of antler points	hand-thrown	goat carcass	20	elk antler	single-beveled base	ligature & adhesive
1994	Knecht (1994)	performance and rejuvenation characteristics of bone and antler spearpoints	calibrated crossbow	goat carcass	23	antler and bone	antler split-based point antler lozenge-shaped point antler spindle-shaped point	ligature & adhesive
1994	Callahan (1994)	hafting techniques; relative effectiveness of hand-thrown vs spearthrower-propelled spears	spearthrower	elephant carcass	32	quartzite; chert	Clovis points	ligature & adhesive
1999	Hutchings (1997) Hutchings (1999)	lithic fracture velocity to determine armature type	spear thrower javlin bow dropped	beef ribs quartzite concrete	160	obsidian	Clovis	ligature
2006	Andrefski (2006)	retouch index on bifaces	none---saw through wooden twigs and leather	none	7	obsidian	side notched corner notched stemmed	ligature

APPENDIX III: TABULAR DATA FOR ALL COLLECTIONS

Tabular data was originally hyperlinked to photographs of the collections. Hyperlinked photographs are available in Appendix III. Spreadsheets with hyperlinks are available on CD upon request from alanspencer@sbcglobal.net.

Table AIII.1 Table 1 of 8 of Danger Cave specimens 1-29.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG	POT. REJUV.	FRACT.	MAT.
281	281	281	281	4.1	4.2	1.9	0.6								1	1	3	6
299	299	299	299	2.3	2.6	1.6	0.3								1		3	1
288	288	288	288	2.5	3.5	2	0.5					1						1
282	282	282	282	1.7	3	2	0.4	1		1			1					1
135	135	135	135	2.3	3.2	2	0.5	1				1	1				3	3
286	286	286	286	3.1	3.8	2.3	0.4							1				1
293	293	293	293	7.5	3.2	3.5	0.5	1		1		1					3	1
289	289	289	289	3	4.2	2	0.5							1				1
342	342	342	342	3.3	3.4	2.7	0.4				1	1						1
304	304	304	304	6.2	4.4	1.8	0.9									1	3	1
312	312	312	312	3.2	4	2.1	0.6			1								4
333	333	333	333	2.3	4.5	1.6	0.4			1								5
332	332	332	332	1.7	2.8	2.1	0.3	1		1	1	1						1
331	331	331	331	1.6	2.5	2.5	0.2									1		1
340	340	340	340	3.2	2.9	2.5	0.55			1	1		1					1
316	316	316	316	3	2.4	1.9	0.6								1		4	1
319	319	319	319	4.3	3.7	2.5	0.4					1				1	3	1
326	326	326	326	5	5.6	1.9	0.5	1					1	1				1
336	336	336	336	3.3	3.2	2.3	0.4	1	1			1						1
335	335	335	335	2.6	2.9	2.1	0.5	1		1	1		1					1
334	334	334	334	3.9	3.6	2.2	0.5	1		1		1						1
337	337	337	337	3.9	3.8	2	0.5	1		1								1
345	345	345	345	1.9	2.3	2.4	0.5			1		1					3	1
303	303	303	303	1.6	1.5	2.2	0.5								1		3	1
315	315	315	315	3.4	3.1	2.7	0.5			1		1				1	3	5
169	169	169	169	4.4	4.3	1.5	0.6		1	1		1	1	1				4
158	158	158	158	5.7	5.2	2.6	0.6	1		1	1	1		1				1
159	159	159	159	5.1	4.8	2.4	0.6			1	1			1				1
160	160	160	160	4.1	4.4	2.5	0.5			1	1			1				4

Table AIII.2 Table 2 of 8 of Danger Cave specimens 30-59.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG	REJUV.	POT.	FRAC.	MAT.
161	161	161	161	2.7	3.9	2.6	0.4	1		1	1								1
154	154	154	154	3.3	3.8	2.3	0.4	1				1	1						1
193	193	193	193	3.6	3.7	2.2	0.5		1	1	1								1
198	198	198	198	4.5	6.3	1.8	0.4				1			1					1
144	144	144	144	1.6	2.3	1.7	0.4		1									4	1
164	164	164	164	3.1	4.1	1.8	0.5			1	1	1							3
317	317			1.4	1.2	2.2	0.4								1			3	1
192	192	192	192	2.9	3.6	2	0.5							1					3
168	168	168	168	3.3	3	2	0.5								1		1	5	2
197	197	197	197	4.5	4.5	2.5	0.5			1	1	1	1						1
199	199	199	199	2.7	4.5	2	0.5							1					1
188	188	188	188	4.1	4.3	2.1	0.5			1	1	1	1						1
148	148	148	148	2	1.7	2	0.4								1				2
142	142	142	142	1.5	3.5	1.3	0.3								1		1	3	2
174	174	174	174	5	3.3	2.2	0.7	1	1	1		1							1
189	189	189	189	5.5	3.9	2.7	0.6	1		1								3	1
152	152	152	152	2.5	2.9	1.8	0.5					1					1	3	1
162	162	162	162	3.8	4.3	2.4	0.4			1				1					1
190	190	190	190	6.6	5.5	2.7	0.6			1			1						1
191	191	191	191	3.7	4.1	2.2	0.5							1					1
176	176	176	176	6.4	4.7	2.1	0.7							1					1
187	187	187	187	6.4	5	2.1	0.6			1		1							1
140	140	140	140	1.1	2.1	2	0.2								1				1
149	149	149	149	5.3	4	2.8	0.6	1		1	1	1							4
143	143	143	143	3.3	3.8	1.7	0.3	1							1		1	3	1
44	44	44	44	1.4	3	2.1	0.2								1			3	1
70	70	70	70	4	4	1.9	0.6		1	1		1							4
62	62	62	62	1.9	3.1	2.2	0.3	1		1									1
86	86	86	86	2.9	3	2.3	0.5		1	1		1							1
40	40	40	40	2	3.8	1.6	0.3				1				1		1	3	2

Table AIII.3 Table 3 of 8 of Danger Cave specimens 60-89.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRAC.	MAT.
57	57	57	57	3.7	4.5	2.4	0.5							1				1
50	50	50	50	3.6	4.8	2.2	0.4							1				1
52	52	52	52	3.1	3	2.7	0.3					1			1	1	3	4
79	79	79	79	3.5	3.7	2.4	0.3				1		1	1				5
84	84	84	84	3.3	3.5	2.2	0.5					1						4
51	51	51	51	3.1	3.7	2.1	0.6				1			1				4
36	36	36	36	2	3.3	1.7	0.5				1						3	1
46	46	46	46	2.4	2	2.2	0.5								1		3	1
31	31	31	31	2.6	3.4	1.7	0.6			1		1				1	3	1
91	91	91	91	2.4	3.2	2.1	0.5								1	1	2	1
38	38	38	38	2.5	2.3	2.1	0.5								1	1	3	1
42	42	42	42	4.8	4.3	2.1	0.3								1	1	3	4
56	56	56	56	2	3.2	1.8	0.6				1	1	1					1
88	88	88	88	3	4.4	2.2	0.3							1				1
99	99			0.5		2	0.2								1		3	1
30	30	30	30	2.9	4	2.1	0.4					1		1				1
93	93	93	93	2.8	3.2	2.4	0.5					1				1	5	1
75	75	75	75	4.9	4.7	2.2	0.6				1	1		1				1
69	69	69	69	0.9	2.9	1.3	0.2	1										1
34	34			1.7	3	1.2	0.3				1							1
63	63	63	63	4.9	3.7	1.5	0.6								1	1	3	4
60	60	60	60	1.7	2.8	1.6	0.5	1						1				2
53	53	53	53	3.7	5.2	1.5	0.6								1		3	1
89	89	89	89	2.3	3.4	1.7	0.3				1			1				4
95	95	95	95	2.5	3.2	1.7	0.4	1	1	1		1						2
45	45	45	45	2.2	2.1	1.7	0.6							1				3
55	55	55	55	1.9	2.8	1.8	0.4							1				1
68	68	68	68	3.4	4.2	2	0.5							1				1
66	66	66	66	3	3.2	1.9	0.4			1		1					5	2
85	85	85	85	2.5	3	2	0.6			1							3	2

Table AIII.4 Table 4 of 8 of Danger Cave specimens 90-119.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRAC.	MAT.
61	61	61	61	3.8	2.8	1.9	0.6			1		1			1		1	1
64	64	64	64	4	3.7	1.6	0.6									1	3	1
N1				4.3	5.2	1.7	0.5											1
N2	NC2	NC2	NC2	2.8	2.7	2.3	0.5	1						1				1
N3	NC3	NC3	NC3	5	6.2	2.2	0.4					1		1				1
N4		NC4	NC4	3.4	5.3	1.9	0.6	1		1				1				1
356	356	356	356	4	4.5	2.5	0.5							1			3	1
358	358	358	358	2.5	2.6	1.9	0.5	1		1				1				1
359	359	359	359	5.3	5.5	2	0.5							1				1
360	360	360	360	7.2	5.7	1.8	0.7								1	1	3	1
361	361	361	361	3.2	4	2.2	0.4			1	1							1
362	362	362	362	5.8	4.6	2.8	0.5		1									1
364	364	364	364	7.6	5.1	2.2	0.7	1		1		1						1
363	363	363	363	4.7	4.7	2.3	0.5					1				1	3	1
367	367	367	367	4.6	3.7	2	0.7			1								1
373	373	373	373	4.4	3.7	2.7	0.6	1		1	1		1					1
370	370	370	370	4.9	5.1	2.4	0.5			1	1							1
377	377			4	2.8	2.7	0.5	1	1	1		1						1
397	397	397	397	7.7	4.5	2.5	0.7	1				1					2	1
365	365	365	365	4.7	4.4	2.4	0.4							1				1
372	372	372	372	4.1	4.6	2.6	0.4			1	1							1
366	366	366	366	2.8	2.6	2.3	0.4	1		1		1					1	1
379	379	379	370	2.3	3.2	2.1	0.3	1				1						1
390	390	390	390	2	2.6	2.2	0.4	1		1							3	1
393	393	393	393	5.1	4.9	2.6	0.5							1				1
394	394	394	394	4.2	5.1	2.2	0.4			1	1	1		1				1
395	395	395	395	4.4	5	2.2	0.4							1				1
338	338	338	338	8	6.3	2.3	0.6							1				1
389	389	389	389	6.6	5.1	2.6	0.7							1				1
381	381	381	381	2.2	3.8	1.8	0.3	1			1						3	1

Table AIII.5 Table 5 of 8 of Danger Cave specimens 120-149.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
243	243	243	243	3.4	4.2	2.3	0.3							1				1
244	244	244	244	4.9	4.9	2.2	0.6			1		1						4
240	240	240	240	2.9	4.6	2.7	0.4							1				1
241	241	241	241	2.2	3.1	2.2	0.4						1	1				1
239	239	239	239	5.6	5.2	1.7	0.8			1	1							1
237	237	237	237	4.9	5	2.3	0.4	1			1		1					7
236	236	236	236	2.5	2.8	2.4	0.3	1			1							1
127	127	127	127	2.9	3	2	0.4			1		1					3	1
129	129	129	129	3.7	4.5	1.9	0.4							1				4
133	133	133	133	2.5	3.2	2.2	0.6					1		1				4
128	128	128	128	2.2	2.7	1.5	0.3	1									1	1
132	132	132	132	3.7	3.2	2.3	0.3		1			1					3	1
134	134	134	134	2.3	3.5	1.6	0.6			1		1				1	3	1
138	138	138	138	1.8	2.5	1.7	0.3					1			1	1	3	1
234	234	234	234	3.3	4.1	2	0.5				1	1	1					1
231	231	231	231	2.9	3	2	0.6	1										1
246	246	246	246	4.6	4	2.9	0.4		1									4
247	247	247	247	5.8	5.4	2.5	0.6					1	1					4
262	262	262	262	3.4	4	2.1	0.5	1								1		6
248	248	248	248	4.5	3.8	2.2	0.5								1	1	5	1
269	269	269	269	2.1	3.2	1.7	0.3					1						1
267	267	267	267	4.3	4.3	2.1	0.5	1			1	1						1
264	264	264	264	4	3.8	2	0.6					1				1		1
258	258	258	258	2.2	2.9	2.5	0.5	1										1
259	259	259	259	4.7	3.7	2.7	0.6					1	1			1		1
260	260	260	260	3.1	3.8	1.7	0.4	1	1	1		1						1
257	257	257	257	3.1	4.1	2.5	0.4				1							1
256	256	256	256	4.4	4.2	2.2	0.5			1		1						4
255	255	255	255	4.5	4.4	2.4	0.7			1	1	1	1					1
253	253	253	253	2.4	4.4	1.6	0.3					1		1				1

Table AIII.6 Table 6 of 8 of Danger Cave specimens 150-179.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
254	254	254	254	4.8	5	2	0.7					1		1				1
265	265	265	265	3.2	4.1	1.7	0.4			1			1					1
250	250	250	250	4.8	3.3	2.2	0.6								1			1
251	251	251	251	3.1	4	2.1	0.5	1			1		1					4
223	223	223	223	2.9	4	2	0.6					1		1				1
220	220	220	220	3.8	3.8	2.1	0.6				1		1					1
217	217	217	217	6	5	2.1	0.6	1		1		1						1
224	224	224	224	3.9	3.5	2.4	0.6				1	1	1			1	3	1
216	216	216	216	2.1	3.6	1.9	0.3							1				7
219	219	219	219	4.2	4.3	2.1	0.5			1	1			1				1
222	222	222	222	3	3.6	2	0.5							1				1
225	225	225	225	2.7	3.6	1.9	0.3	1			1							4
227	227	227	227	4.9	4	2.3	0.6	1								1	3	1
71	71	71	71	2	2.2	2	0.5	1						1				4
87	87	87	87	2.9	3.8	2.2	0.6	1				1		1				1
92	92	92	92	2.5	3	2.2	0.3	1		1	1	1						1
116	116	116	116	3.2	4.5	2.2	0.3							1				5
117	117	117	117	2.2	3.2	2	0.3							1				1
115	115	115	115	3.7	4.5	2	0.3			1		1				1		1
114	114	114	114	3.2	4	1.5	0.3								1	1	3	2
113	113	113	113	2	2.9	1.8	0.3	1						1				2
119	119	119	119	3.6	4	2.2	0.6								1	1		1
121	121	121	121	2	2.7	2	0.4		1	1								1
122	122	122	122	3.7	4.9	2.1	0.3					1						4
123	123	123	123	5.3	3.3	2.6	0.7	1		1						1	3	1
124	124	124	124	2.5	3.2	2.3	0.4					1						1
125	125	125	125	2.8	4	2.2	0.3							1				1
39	39	39	39	3.9	3.5	2.3	0.5	1		1					1			2
76	76	76	76	3.6	4.1	2.1	0.5					1		1				1
59	59	59	59	2.4	3.5	2	0.4							1				1

Table AIII.7 Table 7 of 8 Danger Cave specimens 180 – 207.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
106	106	106	106	3.1	3.2	1.5	0.6		1									2
107	107	107	107	1.9	2.5	1.7	0.4			1		1				1	3	1
111	111	111	111	3	2.7	1.5	0.6								1	1	3	1
108	108	108	108	3.9	2.4	2.9	0.5					1					3	1
112	112	112	112	2.2	2.7	2.2	0.3								1	1	3	1
109	109	109	109	2.2	2.8	1.9	0.2								1	1	3	1
110	110	110	110	4.2	2.7	2.2	0.7	1		1	1	1						1
104	104	104	104	4.6	3.1	3	0.5						1		1	1	3	1
102	102	102	102	1.9	2.2	2.1	0.4								1		3	4
289	289	289	289	3.1	4.2	2.1	0.4					1		1				1
136	136	136	136	1.7	2.5	1.8	0.4	1		1	1							2
284	284			2.3	3.4	2.2	0.3							1				4
229	229	229	229	5	4.1	2.1	0.7			1		1					3	3
215	215	215	215	4.3	5	2.1	0.4							1				1
211	211	211	211	5.4	4.7	2.7	0.6						1					1
202	202	202	202	2.3	1.8	2.2	0.6								1		3	1
204	204	204	204	4.6	3.2	2.2	0.7	1		1	1							1
205	205	205	205	4.9	3.2	2.2	0.8	1	1	1		1						1
207	207			4.1	3.7	1.7	0.6								1		3	4
208	208	208	208	2.7	4.2	1.3	0.4	1		1		1	1					1
210	210	210	210	3.7	4.7	1.9	0.3				1			1				1
214	214	214	214	4	4	2.1	0.5	1		1	1							1
200	200	200	200	2.9	5.2	1.9	0.4							1				1
201	201	201	201	4.6	3.2	2	0.8								1			4
26	26	26		2.7	3.3	1.5	0.8				1							1
5	5	5	5	2.2	3.7	1.6	0.4	1		1		1						1
7	7	7	7	4.5	5.2	1.9	0.6							1				1
8	8	8	8	3.1	3.4	2	0.3			1		1				1	3	4

Table AIII.8 Table 8 of 8 Danger Cave specimens 208-225.

SAMPLE	ID	BACK	FRONT	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	Pot. Rejuv.	FRACT.	MAT.
9	9	9	9	2	3	1.7	0.5	1		1							3	1
1	1	1	1	2.3	4.2	2.2	0.3					1		1				1
14	14	14	14	3.1	3.4	2.2	0.5	1		1							3	1
16	16	16	16	5.8	4.2	2.1	0.6		1	1		1						4
17	17	17	17	2	3.7	1.6	0.3								1	1	3	1
28	28	28	28	2.6	3	2	0.5	1							1		3	1
19	19	19	19	3	3.7	2.1	0.5			1	1			1				1
18	18	18	18	4	4.7	2	0.5	1		1		1		1				1
15	15	15	15	1.9	2.9	2.2	0.4	1					1					1
2				2.9	2.8	1.4	0.7								1			1
20	20			3.9	5.4	1.5	0.5							1				1
126	126	126	126	2.3	2.7	2	0.5			1		1					3	1
273	273	273	273	4	4	2.3	0.5		1	1			1					1
279	279	279	279	3.3	4.9	2.1	0.4				1		1					1
278	278	278	278	3.1	3.5	1.8	0.5							1				1
271	271	271	271	0.9	2.9	2	0.1							1				1
270	270	270	270	3.9	3.2	2.2	0.4		1	1								1
275	275	275	275	2	3.3	2	0.2	1		1	1	1	1					1

Table AIII.9 Table 1 of 4 Hogup Cave specimens 1-29.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
289-31	289-31	289-31	289-31	3.6	4.2	1.7	0.7			1	1	1						1
289-154	289-154	289-154	289-154	3.9	3.5	2.4	0.6			1			1	1				1
640-24	640-24	640-24	640-24	6.2	4.7	2.9	0.6			1	1	1					3	1
648-37	648-37			4.3	4	2.2	0.5			1	1	1						1
259-34	259-34	259-34	259-34	2.5	2.7	2.1	0.5	1		1		1						
669-165	669-165	669-165	669-165	3.8	3.4	2.2	0.6	1				1		1				
633-13	633-13	633-13	633-13	5.1	4.2	2.5	0.6			1	1							
277-5	277-5	277-5	277-5	2.5	3.2	2.2	0.4								1	1	3	1
404-268	404-268	404-268	404-268	4.2	3.5	2.5	0.6	1		1			1					
698-555	698-555	698-555	698-555	4.6	3.8	2.7	0.4	1								1	3	
744-41	744-41	744-41	744-41	1.8	2.3	2.2	0.5	1		1	1	1		1				
693-109	639-109	639-109	639-109	1.6	3	1.8	0.6	1				1		1				1
720-161	720-161	720-161	720-161	3.8	4.1	2	0.5					1		1				2
179-13	179-13	179-13	179-13	6.3	5.3	1.8	0.7			1		1						3
325-3	325-3	325-3	325-3	3.8	3.8	1.7	0.7								1	1	3	1
734-27	734-27	734-27	734-27	3.3	3	2.1	0.5	1					1	1				2
206-18	206-18	206-108	206-108	2.8	3.1	2	0.6	1				1				1		2
613-69	613-69	613-69	613-69	3.4	3.8	2	0.6							1				1
504-49	504-49	504-49	504-49	2.1	3.2	2	0.3				1	1	1					2
464-121	464-121	464-121	464-121	6.5	3.8	2.7	0.7	1			1	1						1
485-5	485-5	485-5	485-5	2	3.2	1.9	0.4	1				1				1	3	2
461-64	461-64	461-64	461-64	3.5	3.7	2.4	0.5	1		1	1			1				2
197-733	197-733	197-733	197-733	2.3	2.9	1.9	0.4	1								1	3	3
416-193	416-193	416-193	416-193	3.6	4	2.2	0.5	1			1	1		1				1
227-33	227-33	227-33	227-33	1.9	1.9	2	0.5								1		3	2
245-37	245-37	245-37	245-37	2.2	3.1	1.7	0.4	1		1		1	1					2
701-254	701-254	701-254	701-254	1.8	3.2	1.8	0.3	1		1		1						1
412-298	412-298	412-298	412-298	2.7	3	2.5	0.4							1				1
254-16	254-16	254-16	254-16	3.2	2.8	1.9	0.5		1	1		1						2

Table AIII.10 Table 2 of 4 Hogup Cave specimens 30-59.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG	POT.REJ UV.	FRACT.	MAT.
623-62	623-62	623-62	623-62	4.5	2.5	3	0.5								1			2
259-44	259-44	259-44	259-44	2.9	2.4	2.6	0.5	1		1					1		3	2
246-14	246-14	246-14	246-14	5.5	3.8	2.2	0.6					1			1	1	3	3
669-160	669-160	669-160	669-160	5	3.9	2	0.6	1		1		1					5	3
142-40	142-40	142-40	142-40	5	3	2.2	0.6			1		1	1		1	1	7	3
669-128	669-128	669-128	669-128	3.1	2	2.7	0.5								1		3	2
712-17	712-17	712-17	712-17	4.1	3	2.6	0.5								1		3	3
243-11	243-11	243-11	243-11	4.7	2.7	2.3	0.5								1		3	2
237-11	237-11	237-11	237-11	3	2.1	2.2	0.6								1		5	1
627-21	627-21	627-21	627-21	6.1	3.7	3.6	0.5								1	1	3	1
438-62	438-62	438-62		3	3.7	1.5	0.5								1	1	3	2
621-106	621-106	621-106	621-106	4.5	2.9	1.9	0.5		1	1		1				1	5	2
30-15	30-15	30-15		3.8	2.9	2.9	0.4	1	1	1						1	3	2
640-41	640-41	640-41	640-41	1.1	2.1	1.1	0.4								1		5	2
412-311	412-311	412-311	412-311	3.2	2	2.7	0.4								1		3	1
713-22	713-22	713-22	713-22	4.9	3.3	2.5	0.6	1		1					1	1	3	3
9-5	9-5	9-5	9-5	4	2.8	2.2	0.6					1			1		3	3
720-151	720-151	720-151	720-151	3.3	3.2	2.1	0.3					1					3	3
734-36	734-36	734-36	734-36	5.1	2.4	2.7	0.6			1							3	2
84-150		84-150	84-150	1.7	1.8	1.8	0.4								1		3	1
642-40		642-40	642-40	5	4	2.4	0.3								1	1	5	1
135-37	135-37	135-37	135-37	4.6	3.3	3.2	0.6					1			1	1	3	2
88-87	88-87	88-87	88-87	1.9	2	2.2	0.3								1		3	2
476-88	476-88	476-88	476-88	3.5	4.2	1.4	0.4								1	1	3	2
108-68	108-68	108-68	108-68	3.7	2.6	2.6	0.5		1	1					1			2
415-175	415-175	415-175	415-175	3	2.7	2.2	0.5			1					1		3	2
260-35	260-35	260-35	260-35	2.1	3.2	1.6	0.4	1		1						1	3	2
448-182		448-182	448-182	1.9	2.2	2	0.4								1		3	1
734-42	734-42	734-42	734-42	2.4	2.2	2	0.5		1	1		1					3	2
238-171	238-171	238-171	238-171	4.4	4	2.2	0.5	1		1		1						2

Table AIII.11 Table 3 of 4 Hogup Cave specimens 60-89.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
664-34	664-34	664-34	664-34	3.4	3	1.7	0.5								1	1	3	2
533-96	533-96	533-96	533-96	4.1	3.2	2.2	0.6	1		1	1							2
669-156	669-156	669-156	669-156	2.2	2.4	2.1	0.5	1		1	1							2
699-466	699-466	699-466	699-466	3.1	2.8	2.2	0.5	1										2
278-37	278-37	278-37	278-37	4.3	3.3	2.4	0.6	1		1	1	1	1					2
36-14	36-14	36-14	36-14	5.5	4.9	2.3	0.6							1				3
704-229	704-229	704-229	704-229	3.6	3.1	2.5	0.5	1										2
474-70	474-70	474-70	474-70	3	3	2.1	0.5	1		1		1		1				2
443-62	443-62	443-62	443-62	8	5	2	0.8		1		1	1	1	1				3
445-41	445-41	445-41	445-41	6.8	5.8	2.7	0.6							1				2
461-16	461-16	461-16	461-16	4.7	4.2	2.2	0.6		1	1								2
266-4	266-4	266-4	266-4	3.6	3.1	2.4	0.3		1			1						1
82-73	82-73	82-73	82-73	2.3	3.8	1.9	0.3	1		1	1	1		1				1
640-56	640-56	640-56	640-56	4.3	3.6	3.2	0.6	1			1							3
56-5	56-5	56-5	56-5	4.9	3.2	2.7	0.6	1		1								1
303-8	303-8	303-8	303-8	5.7	5	2.5	0.5					1		1				1
720-125	720-125			3.3	3.2	1.9	0.6	1						1				2
476-69	476-69	476-69	476-69	6.8	6.2	1.8	0.7							1				2
443-512	443-512	443-512	443-512	2.5	3.2	1.9	0.4	1		1				1				2
197-134	197-134	197-134	197-134	2.7	3.5	2.3	0.4	1										2
719-33	719-33			4.6	3.5	2.5	0.5		1	1								2
240-5	240-5	240-5	240-5	4.9	4.8	2.2	0.4	1		1								2
647-63	647-63	647-63	647-63	3.3	3.8	1.7	0.5	1		1		1						2
159-57	159-57	159-57	159-57	2.8	3.5	2.6	0.3					1						1
999	999	999	999	1.4	3.2	1.5	0.4	1		1								1
649-37	649-37	649-37	649-37	2.8	3.2	1.6	0.6								1	1	4	1
491-40	491-40	491-40	491-40	2.6	3.8	1.9	0.4								1	1	3	2
283-11	283-11	283-11	283-11	2.8	3.5	2.2	0.4							1				4
10-3	10-3	10-3	10-3	6	4	2.2	0.7	1		1	1	1						2
138-45	138-45	138-45	138-45	4.4	4.2	2.1	0.6	1		1	1	1						2

Table AIII.12 Table 4 of 4 Hogup Cave specimens 90-102.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
414-93	414-93	414-93	414-93	4.3	2.8	2.4	0.7	1	1	1				1			5	5
288-39	288-39	288-39	288-39	2.4	3.5	1.8	0.3	1			1							2
193-178		193-178	193-178	4.5	4.2	2.1	0.6							1		1	1	3
713-21		713-21	713-21	6	5.5	2.1	0.5				1			1				1
720-124		720-124	720-124	5.7	4.6	2.4	0.4							1				4
206-1		206-1	206-1	6	4.7	2.2	0.6	1		1				1				1
218-7		218-7	218-7	3.7	3.6	2.2	0.4	1		1				1				1
699-439		699-439	699-439	3.5	3.5	2.6	0.4	1						1				3
131-54		131-54	131-54	2.4	3.7	1.7	0.5	1		1								1
491-21		491-21	491-21	3	3	2	0.3	1		1	1	1	1					1
493-148		493-148	493-148	3.5	3.4	2	0.7	1		1				1				1
650-243	650-243	650-243	650-243	3	3.7	1.8	0.6				1			1				2
243-14		243-14	243-14	3.1	3.6	2.5	0.5	1		1	1			1				2

Table AIII.13 Table 1 of 2 Cowboy Cave specimens 1-24.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG	POT.REJ UV.	FRACT.	MAT.
2170-10	2170-10	2170-10	2170-10	7.1	4.9	2.9	0.4							1				1
1765-10	1765-10	1765-10	1765-10	3.1	3.1	2.2	0.5								1	1	3	1
1126	1126	1126	1126	4.3	3.4	1.9	0.6					1			1	1	3	1
330-8	330-8	330-8	330-8	4.2	3.3	1.6	0.5			1						1	3	1
2263-11	2263-11	2263-11	2263-11	3.6	3.7	1.9	0.6			1		1				1	3	1
2259-7	2259-7	2259-7	2259-7	3.3	2.2	2.6	0.5								1		3	1
413-16	413-16	413-16	413-16	5	5	2	0.5					1		1		1	3	1
837-8	837-8	837-8	837-8	3.9	4.7	1.9	0.6			1	1	1						1
709-8	709-8	709-8	709-8	4.2	3.2	2.2	0.5	1						1				1
1983-4	1983-4	1983-4	1983-4	4	4	2	0.5							1				1
938-10	938-10	938-10	938-10	3.4	3.4	2.1	0.6								1	1	3	1
537-9	537-9	537-9	537-9	3.4	2.6	2.8	0.5	1							1		3	1
1843-21	1843-21	1843-21	1843-21	3.6	4	1.8	0.5							1				1
231-10	231-10	231-10	231-10	4.2	4	2	0.4	1						1				1
1801-4	1801-4	1801-4	1801-4	6.4	5.7	2	0.6			1		1		1				1
411-10	411-10			4.3	4	2.2	0.5			1		1						1
2290-5	2290-5	2290-5	2290-5	4.1	3.2	2.1	0.5								1	1	3	1
239-4	239-4	239-4	239-4	3.8	4.5	1.9	0.4			1	1			1				1
991-4	991-4	991-4	991-4	4.1	3.5	2.2	0.6					1				1	3	1
1552-38	1552-38	1552-38	1552-38	3.8	2.8	2.3	0.5	1	1								4	1
1112-6	1112-6	1112-6	1112-6	5.4	5.7	1.7	0.4			1				1				1
592-1	592-1	592-1	592-1	3.2	2.9	2.2	0.5								1		3	1
757-15	757-15	757-15	757-15	2.7	4.2	1.8	0.3	1		1		1						1
387-3	387-3	387-3	387-3	4.8	4.5	1.8	0.6							1			3	1

Table AIII.14 Table 2 of 2 Cowboy Cave specimens 25-44.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG	POT.REJ UV.	FRACT.	MAT.
721-7	721-7	721-7	721-7	6.9	5.5	2.5	0.7							1				1
1397-7	1397-7	1397-7	1397-7	4.9	4.7	2.2	0.5							1				1
1983-5	1983-5	1983-5	1983-5	2.7	2.2	2.3	0.5								1		3	1
713-7		713-7	713-7	4.5	4.2	2	0.3			1						1	5	1
411-3	411-3	411-3	411-3	4.5	4.8	1.8	0.6		1	1								1
5578-11	5578-11	5578-11	5578-11	2.3	2	2.2	0.5								1		3	1
2060-7	2060-7	2060-7	2060-7	4	2.8	2	0.5								1		3	1
515-12	515-12	515-12	515-12	3.1	2	2.7	0.3								1		3	1
325-6	325-6	325-6	325-6	4	4.8	2	0.5							1				1
1594-4	1594-4	1594-4	1594-4	2.1	2.7	2.2	0.3	1										1
2165-4	2165-4	2165-4	2165-4	8.9	4.4	3.2	0.5								1	1	3	1
1897-5	1897-5	1897-5	1897-5	6.8	4.7	3	0.3				1			1				1
173-5		173-5	173-5	8.5	5.7	2.7	0.6							1				1
1546-8	1546-8	1546-8	1546-8	6.8	5.2	2.2	0.5							1				1
160-5	160-5	160-5	160-5	2.9	3.2	2	0.4					1			1	1	3	1
1943-4	1943-4	1943-4	1943-4	4.6	2.7	2.8	0.4					1			1		3	1
2126-8	2126-8	2126-8	2126-8	5.5	5	1.9	0.6							1				1
1396-11	1396-11	1396-11	1396-11	4.2	4	2.1	0.4	1		1		1	1					1
1740-13	1740-13	1740-13	1740-13	3.1	2.9	2.4	0.3	1		1	1							1
515-10	515-10	515-10	515-10	4.2	3.6	2.1	0.5					1	1					1

Table AIII.15 Table 1 of 4 Sudden Shelter specimens 1-29.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG	POT.REJ UV.	FRACT.	MAT.
1129-86	1129-86	1129-86	1129-86	3	3	2	0.6								1	1	3	1
178-1700	178-1700	178-1700	178-1700	3.1	3.2	2.1	0.4								1	1	3	1
582-7	528-7	528-7	528-7	2.3	3.2	1.6	0.4	1		1					1	1	3	1
219-95	219-95	219-95	219-95	2.2	3.6	1.6	0.3			1						0	3	1
637-27		637-27	637-27	5.6	3.2	3	0.4								1	1	3	1
367-15	367-15	367-15	367-15	6.2	4.8	2.4	0.7			1		1	1			1	3	1
1850-23	1850-23	1850-23	1850-23	5.8	4.4	2.6	0.6			1						1	3	1
1844-1	1844-1	1844-1	1844-1	5.6	5.4	2.2	0.4			1					1	1	3	1
384-55	384-55	384-55	384-55	2.9	2	2	0.6								1		3	1
436-50	436-50	436-50	436-50	3	2.5	3	0.5								1		3	1
1252-10	1252-10	1252-10		5.4	4.2	2.2	0.5			1						0	3	1
271-32	271-32	271-32	271-32	6	3.7	2.5	0.5					1			1	1	3	1
1545-17	1545-17	1545-17	1545-17	2.5	3.5	1.9	0.5	1								0	3	1
1099-1	1099-1	1099-1	1099-1	3.6	3.8	1.8	0.5			1		1		1		0		1
1323-71	1323-71	1323-71	1323-71	2.6	3.2	2.1	0.5	1		1	1					0		1
1932-1	1932-1	1932-1	1932-1	3.7	3.9	2.3	0.5			1				1		1	3	1
667-9	667-9	667-9	667-9	2.9	3.4	2.1	0.3			1			1			1	3	1
1545-20	1545-20	1545-20	1545-20	3.5	3.5	2.2	0.5				1			1		1		1
1214-8	1214-8	1214-8	1214-8	4.7	3.2	1.8	0.5					1			1	1	3	1
4487-11	4487-11	4487-11	4487-11	2.3	3.1	1.8	0.5								1	1	3	1
2-270	2-270	2-270	2-270	4.6	3	2.7	0.4								1	1	3	1
674-152	674-152	674-152		6	3.6	3	0.5					1			1	1	3	1
1550-74		1550-74	1550-74	3.1	3	2.4	0.4								1	1	3	1
1288-705	1288-705	1288-705		3.7	3.2	2.2	0.4								1	1	3	1
1077-16	1077-16	1077-16		2.7	1.9	2.3	0.5								1	0	3	2
215-14	215-14	215-14	215-14	2.3	2.9	2.2	0.4	1		1				1		0		1
1335-51	1335-51	1335-51		3.1	2.6	2	0.5								1	0	3	1
590-55	590-55	590-55		2.4	2.7	1.8	0.4	1	1	1						0		1
136-43	136-43	136-43	136-43	2	2	2.1	0.4								1	1	3	1

Table AIII.16 Table 2 of 4 Sudden Shelter specimens 30-59.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAGMENT	POT.REJ UV.	Fracture	Material
1246-65		1246-65	1246-65	1.5	1.6	1.3	0.3	1				1				0	3	1
192-30	192-30	192-30	192-30	2.9	3.2	2.2	0.4							1		0		1
452-301	452-301	452-301	452-301	3.8	3.8	2	0.5								1	1	3	1
519-115	519-115	519-115		3.3	3.8	1.8	0.5							1		0		1
170-800	170-800	170-800		2.3	3.2	1.7	0.4					1				0		1
563-103	563-103	563-103	563-103	3.2	3.6	2	0.4	1		1	1					1		1
1211-169	1211-169	1211-169	1211-169	3.6	2.8	2.5	0.6								1	0	3	1
177-2	177-2	177-2		1.2	1.6	1.7	0.3					1			1	0	3	1
320-17	320-17	320-17	320-17	2.9	2.8	1.8	0.3								1	1	3	1
175-2	175-2	175-2	175-2	5.4	4.2	1.7	0.6								1	1	3	1
680-2	680-2	680-2		2.1	1.8	2.3	0.6					1			1	0	3	1
357-9	357-9	357-9	357-9	2	1.6	2	0.7						1		1	0	3	1
998?-48	998-48	998-48	998-48	3.6	3.1	2.3	0.5	1							1	1	5	1
187-75		187-75		5.8	3.8	1.7	0.8								1	1	3	1
190-46	190-46	190_46	190-46	2.8	2.5	2.5	0.5			1					1	1	3	1
440-117	440-117	440-117	440-117	2.5	2.5	2.2	0.3								1	1	3	1
1935-229	1935-229	1935-229	1935-229	4.8	4.6	2.2	0.4			1	1					0		1
1754-81	1754-81	754-81	1754-81	1.9	2.2	1.9	0.3		1	1		1				0		1
1367-143	1367-143	1367-143	1357-143	4.1	3.3	2.1	0.6								1	1	3	1
485-44	485-44	485-44	485-44	3.8	3.8	2.4	0.5					1			1	1		1
1557-200	1557-200	1557-200	1557-200	2.7	3.2	2.4	0.5	1		1	1	1	1			0		1
778-104	778-104	778-104	778-104	3.6	3	2.2	0.6					1			1	1	4	1
996-2	996-2	996-2	996-2	1.9	2	1.5	0.5								1	1	5	1
452-500	452-500	452-500	452-500	2.2	2.8	2	0.3	1		1						0		1
1047-77	1047-77	1047-77	1047-77	4.2	4.2	2.5	0.5	1			1					0	3	1
174-400	174-400	174-400	174-400	5.7	3.5	3	0.5								1	1	3	1
578-74	578-74	578-74	578-74	6.3	3.8	2.3	0.5			1					1	1	3	1
1917-53	1917-53	1917-53	1917-53	5.2	4	2.5	0.5	1	1	1						0		1
1337-26	1337-26	1337-26	337-26	3.5	3.7	2.3	0.2								1	1	3	1
417-300	417-300	417-300	417-300	3.8	3.2	2.3	0.4		1							0		1

Table AIII.17 Table 3 of 4 Sudden Shelter specimens 60-89.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
1152-14	1152-14	1152-14	1152-14	4.7	3.1	2.1	0.5								1	1	3	1
1659-30	1659-30	1659-30		3.1	2.8	2	0.4								1	1	3	1
625-63	625-63	625-63	625-63	2.6	3.7	1.6	0.4	1		1						1	3	1
178-320	178-320	178-320	178-320	4.8	3.5	2.2	0.5								1	1	3	1
254-10	254-10	254-10	254-10	3.8	3.9	2	0.4					1			1	1	3	1
1859-34	1859-34	1859-34	1859-34	6.3	3.7	2.6	0.4								1	1	3	1
434-66	434-66	434-66	434-66	3	2.7	2	0.5					1			1	1	3	1
563-102	563-102	563-102	563-102	4.9	3	2.6	0.5								1	0	3	1
1246-43	1246-43	1246-43	1246-43	3.4	3	2	0.4								1	1	3	1
1959-34	1959-34	1959-34	1959-34	3.9	3.4	2.2	0.5			1		1	1		1	1	3	1
1856-30	1856-30	1856-30	1856-30	4.4	3	2.6	0.6						1		1	0	3	1
1856-49	1856-49	1856-49	1856-49	4.5	3.8	1.8	0.5								1	0	4	1
274-6	274-6	274-6	274-6	2.3	2.7	1.9	0.4			1						1	3	1
351-22	351-22	351-22	351-22	3.6	2.6	2.2	0.5					1			1	0	3	1
1746-46	1746-46	1746-46	1746-46	3.7	3.1	2.4	0.5		1	1						1	3	1
185-104	185-104	185-104	185-104	2.2	2.2	2.5	0.4					1				0	3	1
1288-701	1288-701	1288-701	1288-701	3	3.2	2	0.3			1						1	3	1
311-29	311-29	311-29	311-29	3.8	3.2	2.4	0.5		1	1		1				0		1
422-67	422-67	422-67	422-67	2.3	2.2	1.8	0.3								1	1	3	1
671-50	671-50	671-50	671-50	1.1	2	1.9	0.3								1	0	3	1
260-32	260-32	260-32	260-32	2.1	2	2.2	0.4								1	0	3	1
607-261	607-261	607-261	607-261	1.3	1.6	2.3	0.3								1	0	3	1
943-33	943-33	943-33	943-33	2.5	2	2	0.6								1	0	5	2
1653-31	1653-31	1653-31	1653-31	2	1.7	2.1	0.4								1	0	3	1
1220-52	1220-52	1220-52	1220-52	4.3	3.7	2	0.6			1						1	3	1
1901-87	1901-87	1901-87	1901-87	3.2	3.2	1.9	0.4			1		1	1		1	1	3	2
1724-14	1724-14	1724-14	1724-14	3.7	2.4	3	0.4								1	0	3	1
1886-25	1886-25	1886-25	1886-25	4.7	3.6	2.2	0.6								1	1	4	1
1935-256	1935-256	1935-256	1935-256	3	2.6	2.1	0.4					1	1			1	3	1
1563-28	1563-28	1563-28	1563-28	2	1.8	2.1	0.4								1	0	3	1

Table AIII.18 Table 4 of 4 Sudden Shelter specimens 90-102.

SAMPLE	ID	FRONT	BACK	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG.	POT.REJ UV.	FRACT.	MAT.
531-501	531-501	531-501	531-501	3.8	2.6	2.6	0.6					1			1	0	3	1
929-3	929-3	929-3	929-3	2.7	3.1	1.7	0.6			1			1		1	0	3	1
1916-9	1916-9	1916-9	1916-9	1.2	1.5	1.6	0.5								1	0	3	1
360-406	360-406	360-406	360-406	3.8	3.2	1.8	1.7	1		1		1				0		1
359-15	359-15	359-15	359-15	2.8	2.4	2	0.6					1			1	0	4	1
321-92	321-92	321-92	321-92	1.3	1.6	1.9	0.4								1	0	3	1
1288-702	1288-702	1288-702	1288-702	2.9	3.9	1.8	0.4				1			1		0		1
2-325	2-325	2-325	2-325	5.3	4.2	1.9	0.6							1		0		1
101-500	101-500	101-500	101-500	3.3	3.9	2	0.4					1		1		0		1
174-500	174-500	174-500	174-500	6.2	4.4	2	0.4							1		0		1
1955-13	1955-13	1955-13	1955-13	4.6	4.2	2.2	0.4	1								0		1
737-16	737-16	737-16	737-16	4.8	3.7	2.9	0.4				1	1		1		0		1
624-21	624-21	624-21	624-21	2.2	3.5	1.8	0.4							1		0		1

Table AIII.19 Flenniken and Raymond projectile points A and B groups.

SAMPLE	WEIGHT	LENGTH	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG. NO RSA	LOST
1A	3.1	2.7	2.2	0.5								1	
2A	3.8	4.0	2.6	0.5	1				1				
3A	4.8	4.5	2.6	0.5	1				1				
4A	1.2	2.0	1.8	0.4	1		1		1	1	1		
5A	2.4	2.9	2.1	0.5							1		
6A	3.6	4.3	2.2	0.6	1		1		1	1	1		
7A	2.3	3.2	2.1	0.5						1			
8A	5.4	4.9	2.9	0.5						1			
9A	4.4	4.5	2.5	0.5				1		1			
10A		0.0	0.0	0.0								1	
11A	4.8	4.4	3.9	0.5	1				1				
12A	2.6	2.1	2.6	0.5								1	
13A	1.9	2.7	2.2	0.4	1		1		1	1			
14A	4.4	4.8	2.5	0.5								1	
15A	4.5	4.2	2.7	0.5	1			1		1			
1B	2.6	3.1	2.3	0.5							1		
2B	2.9	3.3	2.3	0.5			1		1	1	1		
3B	3	3.1	2.2	0.5	1		1		1				
4B	4.8	3.9	3.1	0.5	1								
5B	6.2	5.1	2.2	0.7	1				1				
6B	2.2	2.0	2.0	0.5								1	
7B	3.4	4.3	1.9	0.6					1				
8B	5.5	5.2	2.7	0.5						1			
9B	4	3.8	2.5	0.6	1								
10B	3.9	3.7	2.7	0.6	1								
11B	2	2.6	2.0	0.5	1								
12B	2.4	3.6	2.1	0.5				1	1				
13B	2.1	3.1	2.0	0.5				1		1			
14B		0.0	0.0	0.0									1
15B	3.1	3.7	2.2	0.5					1				

Table AIII.20 Spencer 1-30

SAMPLE	WEIGHT	Length	WIDTH	THICK	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG. NO RSA	LOST
1	10	5.0	3.2	0.6	1								
2		0.0	0.0	0.0								1	
3		0.0	0.0	0.0	1								
4	7.8	4.5	3.0	0.8					1				
5	8.4	4.9	3.0	0.8					1				
6	6.7	3.8	3.0	0.8	1		1		1	1	1		
7		0.0	0.0	0.0									
8	15.2	6.3	3.1	0.9			1			1	1		
9a	6.4	3.5	3.0	0.6	1	1							
9b	4.7	4.7	2.4	0.4						1			
10	6.7	4.5	2.8	0.6	1					1			
11	6	3.8	3.0	0.6	1					1			
12	13.1	5.9	3.2	0.8						1			
13	9	6.0	3.5	0.6				1		1			
14		0.0	0.0	0.0								1	
15		0.0	0.0	0.0									1
16	5.2	4.3	2.4	0.4			1		1				
17	8.4	5.3	3.0	0.6	1					1			
18	8.2	4.7	3.2	0.7				1		1			
19		0.0	0.0	0.0								1	
20	9.1	5.4	3.5	0.5				1					
21	10.9	5.1	3.6	0.7	1		1		1				
22	4.6	3.1	3.3	0.5	1	1							
23	15.6	5.5	4.8	0.8	1								
24	6.3	4.8	2.6	0.7						1			
25	10.5	4.9	2.9	0.9	1					1			
26	6.6	4.1	3.2	0.6	1					1			
27	7.5	4.1	2.8	0.6	1					1			
28	14	6.0	3.0	0.8	1					1			
29		0.0	0.0	0.0									1
30	7.1	3.8	3.2	0.8	1					1			

Table AIII.201. Towner and Warbrton 1-30

SAMPLE	LENGTH	WIDTH	RSA1A	RSA1B	RSA1C	RSA1D	RSA2N	RSA2H	RSA3	FRAG. NO RSA	LOST
1	3.9	2.3						1			
2	NA	NA									
3	3.8	2.5					1	1			
4	NA	NA									1
5	3	2.2						1			
6	4.5	2.7					1				
7	NA	NA								1	
8	1.8	2							1		
9	3.5	2						1			
10	NA	NA									1
11	3.7	2.7	1			1					
12	3.7	3.3	1		1	1					
13	3.5	2.3						1			
14	4	2.4				1		1			
15	2.7	2.3	1		1						
16	4.3	2.5	1		1	1					
17	2.7	3	1					1			
18	4	2.7						1			
19	2.5	2.5	1								
20	4.1	3							1		
21	3.2	3.3	1								
22	3	2.1	1				1				
23	3.2	2.3						1			
24	4.5	2.2	1		1						
25	3.8	2.6	1		1						
26	3.5	2.5	1		1						
27	3.5	2.7	1		1	1					
28	2.3	2							1		
29	4.5	2.3						1			
30	4.1	2.4	1		1		1				

APPENDIX IV: PHOTOGRAPHS OF STUDY COLLECTIONS


DC_154 fro


DC_154 bac


DC_193 fro


DC_193 bac


DC_198 fro


DC_198 bac


DC_144 fro


DC_144 bac


DC_164 fro


DC_164 bac


DC_192 fro


DC_192 bac


DC_168 fro


DC_168 bac


DC_197 fro


DC_197 bac


DC_199 fro


DC_199 bac


DC_188 fro


DC_188 bac


DC_334 fro


DC_334 bac

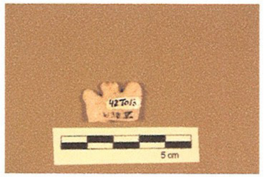

DC_337 fro


DC_337 bac


DC_345 fro


DC_345 bac


DC_303 fro


DC_303 bac


DC_315 fro


DC_315 bac


DC_169 fro


DC_169 bac


DC_158 fro


DC_158 bac


DC_159 fro


DC_159 bac


DC_160 fro


DC_160 bac

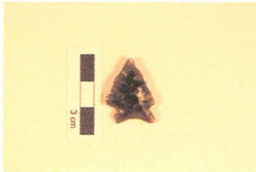

DC_161 fro

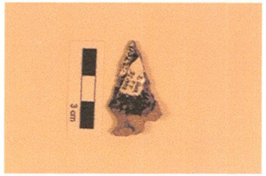

DC_161 bac


DC_NS1 fro

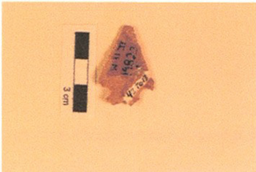

DC_NS1 bac

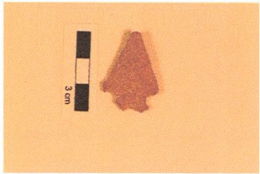

DC_NS2 fro


DC_NS3 fro


DC_288 fro


DC_288 bac


DC_282 fro


DC_282 bac


DC_135 fro


DC_135 bac


DC_286 fro


DC_286 bac


DC_293 fro


DC_293 bac


DC_289 fro


DC_289 bac


DC_342 fro

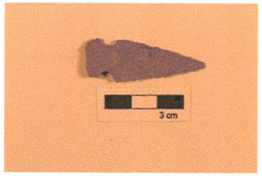

DC_342 bac


DC_304 fro


DC_304 bac


DC_312 fro

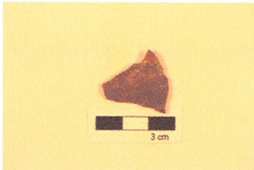

DC_312 bac


DC_333 fro


DC_333 bac


DC_332 fro


DC_332 bac


DC_331 fro


DC_331 bac


DC_340 fro


DC_340 bac


DC_316 fro


DC_316 bac

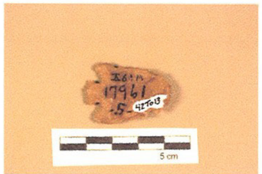

DC_319 fro


DC_319 bac


DC_326 fro


DC_326 bac


DC_336 fro


DC_336 bac


DC_335 fro


DC_335 bac

DC_148 fro

DC_148 bac

DC_142 fro

DC_142 bac

DC_174 fro

DC_174 bac


DC_189 fro


DC_189 bac


DC_152 fro


DC_152 bac


DC_162 fro


DC_162 bac


DC_190 fro


DC_190 bac


DC_191 fro


DC_191 bac


DC_176 fro


DC_176 bac


DC_187 fro


DC_187 bac


DC_140 fro


DC_140 bac


DC_149 fro


DC_149 bac


DC_143 fro


DC_143 bac


DC_44 fro


DC_44 bac


DC_70 fro


DC_70 bac


DC_62 fro


DC_62 bac


DC_86 fro


DC_86 bac


DC_40 fro


DC_40 bac


DC_57 fro


DC_57 bac


DC_50 fro


DC_50 bac


DC_79 fro


DC_79 bac


DC_84 fro


DC_84 bac


DC_51 fro


DC_51 bac

DC_36 fro

DC_36 bac

DC_46 fro

DC_46 bac

DC_31 fro

DC_31 bac

DC_91 fro

DC_91 bac

DC_38 fro

DC_38 bac

DC_56 fro

DC_56 bac

DC_88 fro

DC_88 bac

DC_93 fro

DC_93 bac

DC_75 fro

DC_75 bac

DC_69 fro

DC_69 bac

DC_63 fro

DC_63 bac

DC_60 fro

DC_60 bac

DC_53 fro

DC_53 bac

DC_89 fro

DC_89 bac

DC_95 fro

DC_95 bac

DC_45 fro

DC_45 bac

DC_55 fro

DC_55 bac

DC_68 fro

DC_68 bac

DC_66 fro

DC_66 bac

DC_85 fro

DC_85 bac

DC_61 fro

DC_61 bac

DC_64 fro

DC_64 bac

DC_356 fro

DC_356 bac

DC_356 bac 2

DC_358 bac

DC_358 fro

DC_359 fro

DC_359 bac

DC_360 bac

DC_360 fro

DC_361 bac

DC_361 fro

DC_362 bac

DC_362 fro

DC_364 bac

DC_364 fro

DC_363 bac

DC_363 fro

DC_367 fro

DC_373 bac

DC_373 fro

DC_370 bac

DC_370 fro

DC_397 fro

DC_397 bac

DC_30 bac

DC_30 fro

DC_42 bac

DC_42 fro

DC_52 bac

DC_52 fro

DC_64 bac

DC_64 fro

DC_365 bac

DC_365 fro

DC_372 bac

DC_372 fro

DC_366 bac

DC_366 fro

DC_379 bac

DC_379 fro

DC_390 bac

DC_390 fro

DC_393 bac

DC_393 fro

DC_394 bac

DC_394 fro

DC_395 bac

DC_395 fro

DC_338 bac

DC_338 fro

DC_389 bac

DC_389 fro

DC_381 fro

DC_381 bac

DC_243 fro

DC_243 bac

DC_244 bac

DC_244 fro

DC_240 fro

DC_240 bac

DC_241 bac

DC_241 fro

DC_239 fro

DC_239 bac


DC_237 bac


DC_237 fro


DC_236 fro


DC_236 bac


DC_127 bac


DC_127 fro


DC_129 bac


DC_129 fro


DC_133 bac


DC_133 fro


DC_128 fro


DC_128 bac


DC_132 fro


DC_132 bac


DC_134 fro


DC_134 bac


DC_138 fro


DC_138 bac


DC_234 fro


DC_234 bac


DC_231 fro


DC_231 bac


DC_246 fro


DC_246 bac


DC_247 fro


DC_247 bac


DC_262 bac


DC_262 fro


DC_248 fro


DC_248 bac


DC_269 fro


DC_269 fro 2


DC_269 bac


DC_267 fro


DC_267 bac


DC_264 bac


DC_264 fro


DC_258 bac


DC_258 fro


DC_259 fro


DC_259 bac


DC_260 bac


DC_260 fro


DC_257 fro


DC_257 bac


DC_256 bac


DC_256 fro


DC_255 bac


DC_255 fro


DC_253 bac


DC_253 fro


DC_254 bac


DC_254 fro


DC_265 bac


DC_265 fro


DC_250 fro


DC_250 bac


DC_251 bac


DC_251 fro


DC_223 fro


DC_223 bac


DC_220 bac


DC_220 fro


DC_217 bac


DC_217 fro


DC_224 bac


DC_224 fro


DC_216 bac


DC_216 fro


DC_219 bac


DC_219 fro


DC_222 bac


DC_222 fro


DC_225 fro


DC_225 bac


DC_227 bac


DC_227 fro


DC_71 bac


DC_71 fro


DC_87 bac


DC_87 bac 2


DC_87 fro


DC_92 bac


DC_92 fro


DC_116 bac


DC_116 fro


DC_117 bac


DC_117 fro


DC_115 bac


DC_115 fro


DC_114 bac


DC_114 fro


DC_113 bac


DC_113 fro


DC_119 bac


DC_119 fro


DC_121 bac


DC_121 fro


DC_122 bac


DC_122 fro


DC_123 bac


DC_123 fro


DC_124 bac


DC_124 fro


DC_125 bac


DC_125 fro


DC_39 bac


DC_39 fro


DC_76 bac


DC_76 fro


DC_59 bac


DC_59 fro


DC_106 bac


DC_106 fro


DC_107 bac


DC_107 fro


DC_111 bac


DC_111 fro


DC_108 bac


DC_108 fro


DC_112 bac


DC_112 fro


DC_109 bac


DC_109 fro


DC_110 bac


DC_110 fro


DC_104 bac


DC_104 fro


DC_102 bac


DC_102 fro


DC_289 bac


DC_289 fro


DC_293 bac


DC_293 fro


DC_286 bac


DC_286 fro


DC_286 fro 2


DC_135 bac


DC_135 fro


DC_282 bac

DC_282 fro

DC_288 bac

DC_288 fro


DC_136 bac


DC_136 fro


DC_299 bac


DC_299 fro


DC_281 bac


DC_281 fro


DC_229 bac


DC_229 fro


DC_215 bac


DC_215 fro


DC_211 fro


DC_211 bac


DC_202 bac


DC_202 fro


DC_204 bac


DC_204 fro


DC_205 bac


DC_205 fro


DC_209 bac


DC_209 fro

DC_208 bac

DC_208 fro

DC_210 bac

DC_210 fro

DC_214 bac

DC_214 fro

DC_200 bac

DC_200 fro

DC_201 bac

DC_201 fro

DC_26 bac

DC_5 bac

DC_5 fro

DC_5 bac 2

DC_7 bac

DC_7 fro

DC_8 bac

DC_8 fro

DC_9 bac

DC_9 fro

DC_1 bac

DC_1 fro

DC_14 bac

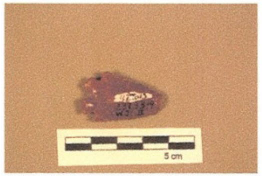
DC_14 fro

DC_16 bac

DC_16 fro

DC_17 fro

DC_17 bac



DC_28 bac

DC_28 fro

DC_19 bac

DC_19 fro

DC_18 bac

DC_18 fro

DC_15 bac

DC_15 fro

DC_12 bac

DC_12 fro

DC_126 bac

DC_126 fro

DC_273 bac

DC_273 fro

DC_279 bac

DC_279 fro

DC_278 bac

DC_278 fro

DC_271 bac

DC_271 fro

DC_270 bac

DC_270 fro

DC_275 bac

DC_275 fro

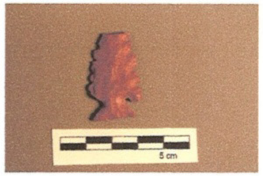
Projectile Points from Cowboy Cave

CB_1546-8 bac

CB_1546-8 fro

CB_160-5 bac

CB_160-5 fro



CB_160-5 fro2

CB_1943-4 fro

CB_1943-4 bac

CB_1943-4 bac2

CB_2126-8 con

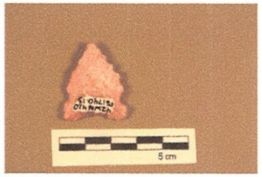
CB_2126-8 bac

CB_2126-8 fro

CB_1396-11 bac

CB_1396-11 fro

CB_1740-13 fro



CB_1740-13 bac

CB_515-10 bac

CB_515-10 fro

CB_515-12 bac

CB_515-12 fro

CB_325-6 bac

CB_325-6 fro

CB_1594-4 bac

CB_1594-4 fro

CB_2165-4 fro

CB_2165-4 bac

CB_2165-4 bac2

CB_2165-4 fro2

CB_1897-5 con

CB_1897-5 bac

CB_1897-5 bac2

CB_1897-5 fro

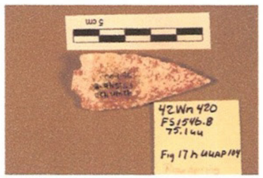
CB_1897-5 fro2

CB_173-5 bac

CB_173-5 fro

CB_173-5 fro2

CB_173-5 bac2



CB_1546-8 con


CB_721-7 bac


CB_721-7 fro


CB_721-7 fro2


CB_721-7 fro3


CB_1397-7 bac

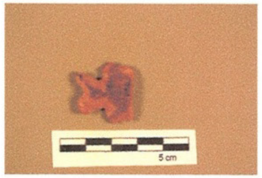

CB_1397-7 fro


CB_1397-7 fro2


CB_1983-5 con


CB_1983-5 bac


CB_1983-5 fro2


CB_1983-5 fro


CB_713-7 bac


CB_713-7 fro


CB_713-7 fro2


CB_411-3 fro


CB_411-3 bac


CB_5578-11 bac


CB_5578-11 fro


CB_2060-7 bac


CB_2060-7 fro


CB_231-10 fro


CB_231-10 bac


CB_1801-4 bac


CB_1801-4 fro


CB_2290-5 bac


CB_2290-5 fro


CB_239-4 bac


CB_239-4 fro


CB_991-4 bac


CB_991-4 fro

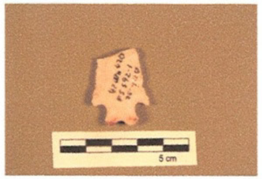

CB_1552-38 bac


CB_1552-38 fro


CB_1112-6 bac


CB_1112-6 fro


CB_592-1 fro


CB_592-1 bac


CB_757-15 bac


CB_757-15 fro


CB_387-3 bac


CB_387-3 fro


CB_330-8 bac


CB_330-8 fro


CB_2263-11 bac


CB_2263-11 fro


CB_2259-7 bac


CB_2259-7 fro


CB_413-16 bac


CB_413-16 fro


CB_837-8 bac


CB_837-8 fro


CB_709-8 bac


CB_709-8 fro


CB_1983-4 bac


CB_1983-4 fro


CB_938-10 bac


CB_938-10 fro


CB_537-9 bac


CB_537-9 fro


CB_1843-21 bac


CB_1843-21 fro

Projectile Points from Hogup Cave

HG_193-178 bac

HG_193-178 bac2

HG_193-178 fro

HG_713-21 bac

HG_713-21 bac2

HG_713-21 fro

HG_720-124 bac

HG_720-124 bac2

HG_720-124 fro

HG_206-1 bac

HG_206-1 fro

HG_206-1 fro2

HG_206-1 bac2

HG_218-7 bac

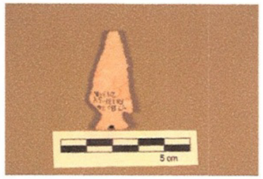
HG_218-7 fro

HG_218-7 bac2

HG_699-439 bac

HG_699-439 bac2

HG_699-439 fro



HG_131-54 bac


HG_131-54 bac2


HG_131-54 fro


HG_491-21 bac


HG_491-21 fro


HG_493-148 bac


HG_493-148 fro


HG_493-148 bac2


HG_650-243 bac


HG_650-243 fro


HG_243-14 bac


HG_243-14 fro


HG_243-14 bac2


CB_2170-10 bac


CB_2170-10 fro


CB_2710-10 fro2


CB_1765-10 bac


CB_1765-10 fro


CB_1765-10 fro2


CB_1126 bac


CB_1126 fro

HG_649-37 bac

HG_649-37 fro

HG_649-37 fro2

HG_491-40 fro

HG_491-40 bac

HG_491-40 bac2

HG_491-40 fro2

HG_283-11 bac

HG_283-11 fro

HG_10-3 bac

HG_10-3 bac2

HG_10-3 fro

HG_138-45 bac

HG_138-45 fro

HG_414-93 bac

HG_414-93 fro

HG_414-93 fro2

HG_288-39 con

HG_288-39 bac

HG_288-39 fro


HG_56-5 bac


HG_56-5 fro


HG_303-8 bac


HG_303-8 fro


HG_476-69 bac


HG_476-69 fro


HG_476-69 fro2


HG_443-512 bac


HG_443-512 fro


HG_197-134 bac


HG_197-134 fro


HG_240-5 con


HG_240-5 bac

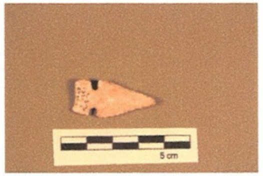

HG_240-5 fro


HG_647-63 bac


HG_647-63 fro


HG_159-57 bac


HG_159-57 fro


HG_999 bac


HG_999 fro

Projectile Points from Sudden Shelter, Utah


SS_1129-86 bac


SS_1129-86 fro


SS_178-1700 bac


SS_178-1700 fro


SS_528-7 bac


SS_219-95 bac


SS_637-27 bac


SS_637-27 fro


SS_637-27 fro2


SS_367-15 con


SS_367-15 fro


SS_367-15 bac


SS_1850-23 fro


SS_1850-23 bac


SS_1844-1 fro


SS_1844-1 bac


SS_384-55 bac


SS_384-55 fro


SS_436-50 fro


SS_436-50 bac


SS_1252-10 fro


SS_1252-10 fro2


SS_271-32 bac


SS_271-32 fro


SS_1545-17 bac


SS_1545-17 fro


SS_1099-1 bac


SS_1099-1 fro


SS_1323-71 bac


SS_1323-71 fro


SS_1932-1 fro


SS_1932-1 bac


SS_667-9 bac


SS_667-9 fro


SS_1545-20 bac


SS_1545-20 fro


SS_1214-8 bac


SS_1214-8 fro


SS_4487-11 bac


SS_2-270 fro

SS_2-270 bac

SS_674-152 fro

SS_674-152 fro2

SS_1550-74 bac

SS_1550-74 fro

SS_1550-74 fro2

SS_1288-705 fro

SS_1288-705 fro2

SS_1288-705 bac

SS_1077-16 fro

SS_1077-16 fro2

SS_215-14 fro

SS_215-14 bac

SS_1335-51 fro

SS_1335-51 fro2

SS_590-55 fro

SS_590-55 fro2

SS_136-43 bac

SS_136-43 fro

SS_192-30 bac


SS_192-30 fro


SS_452-301 bac


SS_452-301 fro


SS_519-115 fro


SS_519-115 fro2


SS_170-800 fro


SS_170-800 fro2


SS_1211-169 bac


SS_1211-169 fro


SS_177-2 fro


SS_177-2 fro2


SS_320-17 bac


SS_320-17 fro


SS_175-2 bac


SS_175-2 fro


SS_680-2 fro


SS_680-2 fro2


SS_357-9 bac


SS_357-9 fro


SS_998-48 bac


SS_998-48 fro


SS_187-75 fro


SS_187-75 fro2


SS_190-46 bac


SS_190-46 fro


SS_440-117 bac


SS_1935-229 bac


SS_1935-229 fro


SS_1754-81 bac


SS_1754-81 fro


SS_1367-143 fro


SS_1367-143 bac


SS_485-44 bac


SS_485-44 fro


SS_485-44 fro vert

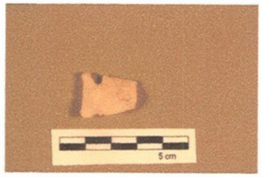

SS_1557-200 fro


SS_1557-200 bac

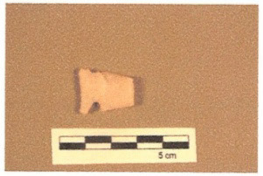

SS_778-104 bac


SS_778-104 fro


SS_778-104 fro vert



SS_996-2 fro



SS_996-2 bac

SS_452-500 bac vert

SS_452-500 bac

SS_452-500 fro

SS_1047-77 bac 2

SS_1047-77 bac

SS_1047-77 fro

SS_1047-77 fro vert

SS_174-400 bac

SS_174-400 fro

SS_174-400 bac 2

SS_578-74 bac

SS_578-74 bac 2

SS_578-74 fro

SS_1917-53 bac

SS_1917-53 bac 2

SS_1917-53 fro

SS_1337-26 bac

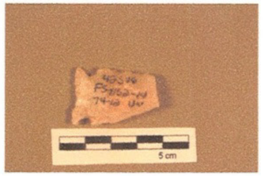
SS_1337-26 fro

SS_1337-26 fro vert

SS_417-300 bac

SS_417-300 bac 2

SS_417-300 fro



SS_1152-14 bac

SS_1152-14 fro

SS_1152-14 fro vert

APPENDIX V: SCIENTIFIC TAKE PERMIT

Arkansas Game & Fish Commission

2 Natural Resources Drive Little Rock, Arkansas 72205

Scott Henderson
Director

Mike Gibson
Deputy Director

David Goad
Deputy Director

Loren Hitchcock
Deputy Director

September 30, 2008

Alan C. Spencer
25 Lance
Conway, AR 72032

Dear Scientific Collector:

Enclosed is your Scientific Collection Permit, which allows for the collection of aquatic and terrestrial specimens by approved methods in the State of Arkansas. Due to revisions made to the policies and procedures of the Scientific Collection Permit Process, please be sure to read all enclosures. If this permit allows for the use of electro-shocking devices, you must notify the Fisheries Division office, in writing, at least two weeks prior to date of collection by electro-shocking and you must notify the Enforcement Supervisor in the nearest Regional Office to where the electro-shocking is to be done (at least 48 hours prior to the collection) of date(s) and exact location of collection (refer to enclosures). **Please note that other permits from land owning agencies may be necessary to collect on those lands. U.S. Forest Service and Natural Heritage Commission lands do require permits for collecting. If collecting on AGFC Wildlife Management Areas, permission must be granted by the Regional Wildlife Supervisor. Reports should include a description of the location (e.g. Hwy 7 bridge) and location point coordinates using Latitude/Longitude, UTM coordinates, or Township-Section-Range description (as a last resort).** Be sure to include what datum is used for GPS coordinates. No threatened, endangered, and species of special concern (list attached) can be collected, unless noted otherwise on the permit.

Enclosed you will find an 8½" by 11" page detailing the conditions upon, and specific activities allowed under this permit. Please carry a copy of this permit during field collection activities. It is recommended that you maintain the original in a safe place. You are reminded to please follow the guidelines for the submission of a written report upon expiration of this permit (format enclosed). Failure to comply will result in denial of future permits.

Sincerely,

Brian Wagner
Nongame Aquatics Biologist
Fisheries Division

BW:ad

Enclosures

Phone: 501-223-6300 Fax: 501-223-6448 Website: www.agfc.com

Arkansas Game & Fish Commission

#2 Natural Resources Drive Little Rock, Arkansas 72205

Scott Henderson
Director

Scientific Collection Permit

Permit Number: 092620081

Expiration Date: 9/30/09

Permittee: Alan C. Spencer
25 Lance
Conway, AR 72032

Sponsor: University of Leicester
School of Archaeology and Ancient History
Univeristy Rd., Leicester LE1 7RH
United Kingdom

Purpose: Scientific Research

# of Trips: Less than 5

Location(s): Applicant's private land located in Faulkner County

Species Type:	Collection Methods	Disposition	Removed
Mammals other than Bats	Salvage & Firearms if salvage isn't available	Killed for study purposes	**1 White-tailed deer**

This Permit grants the permittee listed above or the designated sub-permittee listed below with the privileges accorded under AGFC Code 15.15. This permit is issued on the conditions set forth hereon and becomes effective on the date of issue. A Federal Permit is also required for Migratory and/or Threatened/Endangered Species.

Permittee must also possess a valid Arkansas hunting or fishing permit, as appropriate, to employ recreational hunting / fishing methods.

This permit does not allow collection of Species of Special Concern.

Please contact the nearest Arkansas Game and Fish Commission Regional Office prior to electrofishing.

This permit is not valid until signed in ink by the permittee. Signature constitutes acceptance of all rules and requirements pertaining to this permit. This permit may be suspended or revoked at the discretion of the Director of the Arkansas Game and Fish Commission. This permit is non-transferable. This permit does not authorize trespass or collection on private or other agency lands. It is incumbent upon the individual collector to obtain appropriate permission to collect from the landowner, whether private or state/federal government.

Permittee Signature *AGFC Authorization*

Sign here to Authenticate photocopy. *Circle Sub-Permittee, if this copy is assigned to them.*