

**A MICROWEAR STUDY OF CLOVIS BLADES FROM THE GAULT SITE,  
BELL COUNTY, TEXAS**

A Thesis

by

SCOTT ALAN MINCHAK

Submitted to the Office of Graduate Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

August 2007

Major Subject: Anthropology

**A MICROWEAR STUDY OF CLOVIS BLADES FROM THE GAULT SITE,  
BELL COUNTY, TEXAS**

A Thesis

by

SCOTT ALAN MINCHAK

Submitted to the Office of Graduate Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Approved by:

Chair of Committee, Michael R. Waters  
Committee Members, Harry J. Shafer  
Honqxing Liu  
Head of Department, David L. Carlson

August 2007

Major Subject: Anthropology

**ABSTRACT**

A Microwear Study of Clovis Blades from the Gault Site, Bell County, Texas.

(August 2007)

Scott Alan Minchak, B.A., Drew University

Chair of Advisory Committee: Dr. Michael R. Waters

Prehistoric quarries in America are poorly understood and thus problematical to take into account when making inferences about past behavior. A microwear analysis of Clovis blades from the 2000 Texas A&M University excavations at the Gault site (41BL323), located in southern Bell County, Texas, provided a window into this problem. Texas A&M excavations on the site produced an extraordinarily large number of Clovis artifacts in two bounded geologic units, 3a and 3b. Included in the artifact types are blades, specialized elongate flakes associated with a core and blade technology. In conducting a microwear analysis of the Clovis blades from Gault, I proposed the following questions: (1) were the Clovis blades utilized at Gault?; (2) is there a difference in the use-wear patterns of Clovis blades from the geological units 3a and 3b?; and (3) is Gault, as a quarry/workshop site, a place to just obtain raw materials or did it also serve as a craft site?

Observations from experiments, stereomicroscope analysis, compound microscope analysis, and SEM/EDS analysis led to answers for two research questions: (1) blades were used at Gault and (2) there is a difference between Clovis units 3a and

3b. Eight Clovis 3a blades, or 3.0% of the total Clovis 3a blade/blade fragment population (n=264), exhibit use-wear. Six Clovis 3b blades, 3.3% of the total Clovis 3b blade/blade fragment population (n=182), exhibit use-wear. In general, Clovis 3b blades were used on harder contact materials (wood to bone) than those in Clovis Unit 3a (softer contact materials similar to grass, sinew, and rawhide).

The function(s) of quarries and quarry-related workshops were interpreted by William Henry Holmes as a place to obtain raw materials, while Kirk Bryan interpreted them as a place to bring other materials to work in craft activities. Following the microwear analysis of Clovis blades/blade fragments at Gault, I compared Gault to three other Paleoindian quarry-workshop sites (Wells Creek, Dutchess Quarry, and West Athens Hill). My intent is to provide supplemental data for the consideration when applying Holmes' and Bryan's respective hypotheses.

## ACKNOWLEDGMENTS

I wish to acknowledge the benefit and support of the following individuals and agencies.

I would like to thank Dr. Michael R. Waters for mentoring, supporting, and first offering this experience. His patience, advice, and encouragement provided me with the needed even keel to reach the end. Thanks to Dr. Harry J. Shafer for providing a green graduate student with the opportunity to work on the Gault lithics in the microscopic realm. The late Dr. Robson Bonnicksen deserves special thanks for providing the patience, advice, scientific grounding, and the necessary equipment.

The other graduate students working on the Gault site project from Texas A&M University deserve thanks for their aid, comments, discussion, and camaraderie. Charlotte Pevny provided me with valuable role of a compass in directing my initial research in Gault. Along with this, Charlotte provided numerous discussions and comments – illustrating the importance of post-depositional modification on artifacts. Bill Dickens supplied me, as well as the other team members, with the much-needed foundation of the technological analysis of the Gault Clovis artifacts. His work and insights allowed important questions and comments on the blades. Jim Wiederhold was the rock of the use-wear analysts for the project. His assistance on the microscopes, experience, comments, discussion, and insights were invaluable to my microwear learning curve. Ashley Smallwood provided discussions and aid while we both trudged through the microwear curve. Heidi Luchsinger provided encouragement and valuable information on the micromorphology at Gault. Although not a part of the Gault project,

special thanks go to my former roommate Jason Barrett for providing the impetuses for the occasional needed push or break while at school.

I would like to thank the Texas A&M University Department of Anthropology for their support and funding. I would also like to thank Dr. Alston Thoms and Pat Clabaugh for their help and advice upon my first arrival to Texas. Thanks to Dr. D. Bruce Dickson for helping to break me down and rebuild me upon my entry into graduate school. In addition, I am indebted to the generosity and warm personality of Lori Lind in the Center for the Study of the First Americans for helping me get through the isolated microscopic work.

My gratitude and thanks go to my friends and colleagues at LaPorta and Associates (LPA) for the funding and support throughout my graduate tenure. I would like to thank Philip LaPorta and Margaret Brewer for their help, advice, and conversation for the graduate school life. In particular, Philip LaPorta provided invaluable insights and comments on multiple aspects of my thesis. His knowledge of geology, mineralogy, geomorphology, chemistry, anthropology, and archaeology helped to pioneer a revised view of prehistoric quarries and workshops. Our frequent discussions and quarry investigations provided me with a necessary prehistoric quarry base.

Last, but certainly not least, I would like to thank my family. They have stood by me, afforded opportunities, and have provided more support than I can properly attribute. Thanks to my parents Eugene and Ellen Minchak for unending love and support; to my siblings Mark and Christine for their encouragement and prodding; to my

grandparents who are more help than I know or will be able to learn; and to the more recent additions of my sister-in-law Kerri and nieces Kaitlin and Jami.

## TABLE OF CONTENTS

|  | Page |
|--|------|
| ABSTRACT.....  | iii  |
| ACKNOWLEDGMENTS .....  | v    |
| TABLE OF CONTENTS .....  | viii |
| LIST OF FIGURES.....   | x    |
| <br>CHAPTER  |      |
| I INTRODUCTION.....  | 1    |
| II A BRIEF VIEW OF PREVIOUS MICROWEAR<br>RESEARCH .....                                  | 7    |
| Brief History of Microwear Research .....  | 7    |
| Microwear Analyses of Blades .....   | 10   |
| Discussion.....  | 12   |
| III METHODS.....   | 14   |
| Microwear Schools of Thought and Practice:<br>Traceology, Low Power, and High Power..... | 14   |
| Analytical Variables .....   | 14   |
| Gault Blade Analysis Procedures.....   | 20   |
| IV EXPERIMENTAL PROGRAM.....   | 26   |
| Rationale, Procedures, and Characteristics of the<br>Experiments .....                   | 27   |
| Experimental Variables .....   | 30   |
| Compound Experiments and Observations .....  | 31   |
| Discussion of Observations and Conclusions.....  | 41   |

| CHAPTER | Page   |
|---------|--|
| V       | ANALYSES OF THE CLOVIS BLADES FROM THE<br>2000 TEXAS A&M UNIVERSITY EXCAVATIONS<br>AT THE GAULT SITE ..... 44                                    |
|         | Clovis Blades at the Gault Site ..... 45   |
|         | Stereomicroscope Analysis..... 45  |
|         | Limitations Within Microscope Use: Determining the<br>Analysis and Bridging the Gap Between Stereo and<br>Compound..... 50                       |
|         | Compound Analysis ..... 51   |
|         | SEM/EDS Analysis ..... 63  |
|         | Summary and Conclusions: Trends and Spatial<br>Characteristics ..... 67  |
| VI      | CONCLUSIONS AND DISCUSSION ..... 72  |
|         | Experimental Blades and Clovis Blades Used at<br>the Gault Site: Summary and Conclusions ..... 72  |
|         | Non-Extractive Activities at Quarries and Quarry-<br>Related Workshops: Supplemental Discussion on<br>the Holmes and Bryan Alternatives ..... 74 |
|         | REFERENCES CITED ..... 88  |
|         | APPENDIX A..... 101  |
|         | APPENDIX B ..... 105   |
|         | APPENDIX C ..... 123   |
|         | APPENDIX D..... 143  |
|         | APPENDIX E ..... 152   |
|         | APPENDIX F..... 190  |
|         | VITA..... 215  |

## LIST OF FIGURES

| FIGURE | Page  |
|--------|---|
| 1      | Location of the Gault site with TAMU excavations and 1991 UT excavations. .... 2  |
| 2      | Organizational chart for the Clovis Blades excavated by Texas A&M at the Gault site. Letters represent the following terms: W = whole; P = proximal; M = medial; D = distal, Dt = denticulate; Pf = perforator; S = scraper. .... 21    |
| 3      | Experiment: (a) reaping grass; (b) cleaning sinew; (c) cutting rawhide; (d) scraping wood; (e) sawing wood; (f) sawing horn; (g) planing horn..... 32   |
| 4      | Experimental Blades: (a) FUTR43, polish from sawing cane; (b) FUTB44, polish from reaping grass after 1500 strokes; (c) NNWXP2, reaping grass polish after 1000 strokes. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um..... 33 |
| 5      | Experimental Blade: (a) NWXP3, polish from cleaning sinew; (b) NWXP4, polish from cutting rawhide. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um. .... 36  |
| 6      | Experimental Blades: (a) GRT 4-1, polish from scraping wood; (b) NNWXP1, polish from sawing wood. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um. .... 38   |
| 7      | Experimental Blades: (a) NWXP1, polish from sawing horn after 500 strokes; (b) NNWXP1, polish and striations from planing horn after 1000 strokes. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um. .... 40                      |
| 8      | (a) Layout of 1-x-1 m units at the TAMU Gault Site excavations; (b) generalized profile showing locations of the 3A and 3B units. .... 46   |

| FIGURE  | Page |
|---|------|
| 9 Stereomicroscope patterns: (a) continuous scar example on AM261 at 20x; (b) discreet scars example on AM392V2 at 40x; (c) isolated scars example on AM244T2 at 20x; (d-f) rounding and fossils on AM319E3 at 20x, 40x, and 100x; (g) black residue pattern on AM408I at 40x; (h) black residue on AM392X at 100x; (i) orange-brown residue on AM392X at 100x; (j) homogenous residue on AM285B at 40x; (k) quartz vug in AM261 at 20x. Scales: 20x = 1.25 mm; 40x = 0.50 mm; 100x = 0.250 mm..... | 49   |
| 10 Clovis 3a Blade Refit AM322 (Cat #279) and AM328B2 (Cat #278): (a) location of polish on peninsula on AM322; (b) location of polish on peninsula for AM328B2. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um.....  | 53   |
| 11 Clovis 3a Blade AM252O2 (Cat #436): (a) location of weakly linked polish; (b) location of discreet planed polish. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50um.....   | 54   |
| 12 Clovis 3a Blade AM408i (Cat #671): (a) location of deep u-shaped grooves in Fe-Mg-Ca; (b) location of u-shaped arc grooves on faceted plateau in Fe-Mg-Ca. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um.....   | 56   |
| 13 Clovis 3a Blade AM424E2 (Cat #698): (a) location of oblique striations and polish; (b) location of discreet deep u-shaped striations. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um. ....   | 57   |
| 14 Clovis 3b Blade AM347F2 (Cat #301): (a) compound microscope location of polish at the distal break before cleaning ; (b) compound microscope same location the polish, post-cleaning. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um.....  | 59   |
| 15 Clovis Blade AM291H (Cat #443) : (a) location of well-linked polish; (b) multiple-direction shallow u-shaped striations. Scales: 100x = 200 um; 200x = 200 um; and 500x = 50 um.....   | 61   |
| 16 Clovis 3b Blade AM285B (Cat #265): (a) location of densely packed u-shaped striations; (b) polish on high spot. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um.....  | 62   |

| FIGURE   | Page |
|--|------|
| 17 Clovis 3a Blade AM408 I (Cat #671): (a-b) locations of EDS readings; (c) EDS reading of residue staining at Location 9; (d) EDS reading of clear spot at Location 3. .... | 64   |
| 18 Clovis 3a Blade AM285B (Cat #265): locations of the EDS analyses (a) EDS reading of Location 1, calcium carbonate; (b) EDS location of chert.....                         | 66   |
| 19 Distribution of Clovis 3a blade/blade fragments in the TAMU 1-x-1 m units.....  | 68   |
| 20 Distribution of Clovis 3b blade/blade fragments in the TAMU 1-x-1 m units.....  | 71   |
| 21 Locations of sites, as discussed in the text: (1) Gault; (2) Wells Creek; (3) Dutchess Quarry; and (4) West Athens Hill. ....   | 79   |

## CHAPTER I

### INTRODUCTION

While artifacts themselves are evidence of human presence, human activities are more difficult to discern. Regarding this, the purpose of this paper was to present a microwear (Seitzer-Olausson 1980:48) analysis study conducted on Clovis-age blades from the Gault quarry/workshop site to determine their possible use.

The Gault site (41BL323) is located in the 7.5 minute Youngsfort quadrangle (Figure 1) along the Buttermilk Creek in southern Bell County near the Bell County/Williamson County border. Physiographically, the site is located in the Edwards Plateau (Bureau of Economic Geology 1996) with a vegetation cover of oak, mesquite, and juniper (Bureau of Economic Geology 2000). The site is underlain by the Comanche and Edwards formations, each composed of limestone and the latter of which is known for its chert nodules and strata (Adkins and Arick 1930; Proctor et al. 1981). Chronologically, the site encompasses Clovis, Folsom, Late Paleoindian, Archaic, Late Prehistoric, and Historic periods. The work of the 2000 Texas A&M excavations on the site produced an extraordinarily large number of Clovis artifacts in two bounded geologic units, 3a and 3b.

Blades are classically defined as flakes that are twice as long as wide (Bordes 1961:6; Collins 1999:7). A “true” blade as a specialized elongated flake with parallel or sub-parallel lateral edges; the length being equal to, or more than, twice the width (Bordes and Crabtree 1969:1; Crabtree 1972:42). Other noted distinctions are the cross sections, crests, and associations. Blades are associated with a prepared core and blade

---

This thesis follows the style of *American Antiquity*.

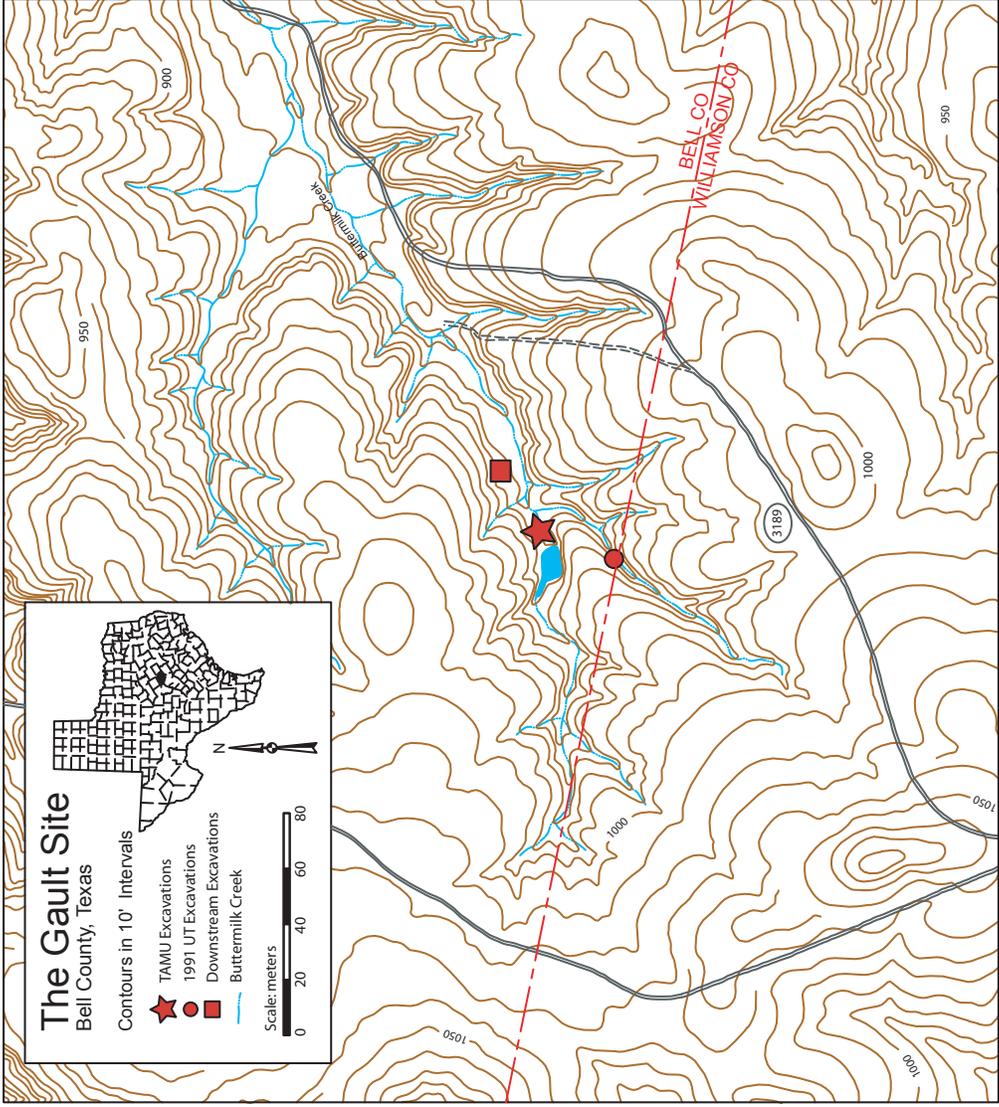


Figure 1. Location of the Gault site with TAMU excavations and 1991 UT excavations.

technique, showing that a blade is not a random flake. This implies technological significance for blades, but does not address functional significance, if any. Collins (1999:32) notes that there is a difference between blades and “bladelike” flakes that meet the classic definition of a blade, but are flakes that are retouched to look like blades. The difference is again technological, but the differentiation is problematical with a lack of lithic reduction debris. Blades from the Gault site are made from Edwards Formation, a chert-bearing limestone and dolomite, depending on the location of the exposure, of Lower Cretaceous Age (Fischer and Rodda 1969). Adkins and Arick (1930:35) label the parent rock as limestone and describe the chert as locally present in the rock and is characterized by prominent conchoidal fractures.

While blades are noted in the Old World (Bordes 1961), their occurrence in North America (Parry 1994) are relegated to nine industries. These are (Parry 1994): Clovis (9000-8000 B.C.), Mesoamerican obsidian blades (1100 B.C.-A.D. 1600), Mayan chert blades (900 B.C.-A.D. 900), Hopewell bladelets (100 B.C.-A.D. 400), Poverty Point bladelets (1700-600 B.C.), Alaskan microblades (8500-1000 B.C.), Californian microblades (A.D. 900-1785), Mesoamerican microblades (900 B.C.-A.D. 1500), and Cahokia microblades (A.D. 900-1150). Clovis is the term used to define the oldest clearly defined techno-cultural complex in America (Haynes 1993). Clovis assemblages are typified by the diagnostic fluted lanceolate points, large prismatic blades, large flake tools, polyhedral blade cores, and bone artifacts (Collins 1999; Haynes 1993; Stanford 1991). Early notations of blades in Clovis assemblages come from the type-site in New Mexico (Warnica 1966; Green 1963), Oklahoma (Hammatt 1970), and eastern United

States (Sanders 1990; Witthoft 1952). Clovis blades and blade cores were also found in other Texas sites of Evant (Goode and Mallouf 1991), Keven Davis (Collins 1999; Young and Collins 1989), and Pavo Real (Henderson and Goode 1991).

Proposed function(s) of blades stems from two sources: ethnographic/ethnoarchaeological sources (see below) and use-wear experiments (see CHAPTER IV). Schiffer (1978:230) defines ethnoarchaeology as “the study of material culture in systemic context for the purpose of acquiring information, both specific and general, that will be useful in archaeological investigation,” a goal not always realized in ethnologies. When incorporating ethnographic data into archaeological interpretation, one assumes a continuity of human/materials relationships (Tringham 1978:185). Gould (1978:7) goes further by stating, “patterns that may reflect shared norms within a human society must be discovered by the ethnoarchaeologist through empirical examination of processes of human residue formation.” Robert Paton (1994) conducted ethnoarchaeological research of an aboriginal community in northern Australia on information transmission through trade using leilira blades, boomerangs, digging sticks, and hair belts. Blades are made from quartzite, which occurs as natural cobbles and boulders that are dug up with wooden sticks and heated (Paton 1994:174). After heating the cobbles, the Aborigines removed blades using chert hammers or metal axe heads. Only a few were taken from the quarry, with most left for later collection and left bundled together or left on the surface at the place of production (Paton 1994:174-175). Paton (1994:175-176) notes that 25 percent of the artifacts found at habitation sites were

leilira blade segments, which he believes were deliberately broken. Patton (1994) did not mention how the blades were used.

Quarry and quarry-workshop sites have generally been interpreted as a place to obtain raw materials (Holmes 1890b) or a place to bring other materials to work in craft activities (Bryan 1950). Regardless, the amount of products and half-products produced in a quarry provide ample tools and tool edge to conduct non-quarrying activities (Nash 1986). Use-wear studies can help to elucidate this problem. This thesis will attempt to reconstruct patterns of behavior by studying microwear observed on the Texas A&M excavated Gault Clovis blades. Similar studies were performed on bifaces and projectile points (Ashley Smallwood), end scrapers (Wiederhold 2004), and modified flakes (Charlotte Pevny). I performed a microwear analysis on blades from the geologic units 3a and 3b to address blade-use between the two Clovis units as well as the question of quarry function.

I propose the following questions: (1) Were the Clovis blades utilized at Gault? (2) Is there a difference in the use-wear patterns of Clovis blades from the geological units 3a and 3b? (3) Is Gault, as a quarry/workshop site, a place to just obtain raw materials or did it also serve as a craft site? The primary objective of this thesis is to infer cultural behavior from Clovis blades. In doing so, the thesis will:

1. Select a representative sample of blades to analyze;
2. Describe use on blades, offering potential functions on an artifact-by-artifact basis;

3. Provide other investigators with the use-wear information for a more refined interpretation of the Gault site; and
4. Place the use-wear analysis of Clovis blades from the Gault site into the larger picture of Clovis quarry and subsistence related pattern.

## CHAPTER II

### A BRIEF VIEW OF PREVIOUS MICROWEAR RESEARCH

Seitzer-Olausson (1980:48) defines use-wear as alteration of material due to use and microwear is the microscopic study of alteration on human modified materials. The techniques and methods were devised to look at a number of variables (microflaking, edge rounding, striations, and polishing) of a prepared example and then comparing it to the use-wear found on archaeological materials. In addition, there becomes a problem of natural modifications and incidental modifications (such as trampling) that can affect use-wear interpretation (Levi-Sala 1988; 1996). I will first present a brief history of microwear research that focuses on some of the major texts that have guided the field. For more detailed discussions, see Seitzer-Olausson (1980), Vaughan (1985), Grace (1989), Juel-Jensen (1994), and Levi-Sala (1996). This is followed by a summary and discussion of microwear studies on blades, paying particular attention to Clovis blades.

#### **Brief History of Microwear Research**

The use of a microscope to determine the function of stone tools is not new. Seitzer-Olausson (1980) notes the inception of the practice in 1838 when S. Nilsson noted that wear patterns could be used to determine tool function. It was, however, not until the Russian-language monograph by S.A. Semenov that archaeologists were supplied with the first rigorous treatment of controlled experiments and detailed observation. The 1964 English translation by M.W. Thompson (Semenov 1964) provided Western archaeologists with the principles used in his systematic investigation. Semenov (1964:22-23) used both a binocular microscope (MBS-1) up to 180x to and a mettalographic microscope (MIM-6) from 300x to 500x. Semenov's more holistic

approach to microwear is evident in his description on the manufacture of tools, materials of the tools studied (stone tools and bone tools), and variables considered in his conclusions.

The 1970s saw a tremendous surge in use-wear analysis in both New World and Old World studies as researchers grappled with its procedures, applications, and theories (Hayden 1979, Keeley 1974; Odell 1975, Tringham et al. 1974). Tringham et al. (1974) provided systematic low-power (40x – 60x) analysis of experimental stone tools on experiments from use to water action and trampling – so that the results could be applied to edge damaged artifacts from eastern Europe. The hypothesis (Tringham et al. 1974:178) was that “a tool made of a specific raw material, whose edge is activated in a specific direction and in a specific direction across a specific worked material will develop a distinctive pattern of edge damage of a kind that is recognizable on stone tools.” Within this, Tringham et al. (1974:189-191) experimented on broader description of materials worked (soft, hard, medium). While no artifact analyses were presented, holistic implications are evident.

Lawrence Keeley’s (1980) seminal text became the driving force in the following two decades of use-wear analysis by introducing the importance of polish as an indicator, stating the he could distinguish on what material the tool was used. In an effort to “rectify some of the methodological failings” that Keeley (1980:xi) observed, he used a high-power (WILD M20 incident-light scope – up to 400x) to distinguish tool use by differences in polishes (wood, meat, hide, etc...) that corresponded to experimental pieces (Keeley 1980:12-14). Keeley (1980:84-85) then analyzed archaeological collections from Swanscombe lower loam (Clactonian), Clacton Golf Course site

(Clactonian), and Hoxne (Acheulean) – finding evidence of butchering, hide scraping, plant cutting, and wood working.

Newcomer et al. (1986) produced a paper on blind tests and concluded that there is no convincing demonstration of consistent polish identification. However, they noted that there should be more experimentation, more objective characterization of polishes, work on the nature of polish, and the method of presentation. This provoked a series of papers on blind sampling for efficiency (Bamforth 1988; Hurcombe 1988; Newcomer et al. 1988) that hinted on a broader interpretive base than just polishes, as was noted previously by Keeley (1974). The blind tests served as experiments themselves to test microwear procedures.

In the late 1980s to early 1990s, two volumes from British Archaeological Reports (B. A. R.) emerged as major texts that attempted to standardize microwear (Grace 1989) and treat the problem of post-depositional modification (Levi-Sala 1996). Grace (1989) provided a further step in the systematization of microwear analysis by providing constraints for variables under consideration (polish, striations, etc...) and developing a computer program for integration of tools from Kumartepe (Turkey). Levi-Sala (1996) ceased her microwear study on artifacts from Hengistbury Head (England) and Kebara (Israel) when she discovered the scope of problems posed by natural modifications to stone tools, and created experiments to account for post depositional modifications (PDMs).

### **Microwear Analyses of Blades**

Although there are microwear analyses on Old World (Semenov 1964; Juel Jensen 1994) and non-Paleoindian new World (Kimball 1992; Yerkes 1983) blades, I will concentrate on studies conducted on Paleoindian blades.

#### **Use-Wear Research on Clovis and Paleoindian Blades**

Two early references to inferred Clovis blade use come from New Mexico (Green 1963) and Oklahoma (Hammat 1970). Green (1963:156) infers scraping on the basis of worn edges on blades from the Clovis type-site in Clovis, New Mexico. He also notes that the flake scars on both convex and concave aspects of the blades suggest that the blades were used in the “fashioning or preparation” of wooden shafts or bone foreshafts (Green 1963:156). Hallett H. Hammat (1970) analyzed blades from the Anadarko cache in southwestern Oklahoma following the Semenov (1964) method using binocular and petrographic microscopes. He observed a fine polish on the dorsal ridge and “hollows” of the edges (Hammat 1970:151) that was matched to Semenov’s presentation of meat polish. He then infers that they were used as butchering knives to cut and dismember flesh based on association with choppers (Hammat 1970:150).

With the Keven Davis Cache, Kay (1999) examined the wear patterns on 10 blades from a 14-blade cache disturbed by mechanical stripping. Kay’s analysis concluded that the blades were broken by earth moving machinery and that only two (blades 10 and 11) showed definitive signs of use-wear with likely use-wear on blade 9. Blades show bright linear indicators and sometimes-deep striations and were snapped into multiple segments. Blade 9 (Kay 1999:135-136) exhibits striations (parallel and transverse to the blade axis) – attributed to cutting or sawing – that have overlying

mechanical striations. Blade 10 contained a cutting stroke parallel to the edge and is consistent with bone-derived striations on an experimental biface used by Kay to butcher game (Kay 1999:134). Blade 11 contains striations parallel and transverse to the edge, which are consistent with Kay's experiment on cutting of a hard surface or cutting something that is backed by a hard surface (Kay 1999:137). Kay concludes that the blades were originally cached whole and broken mechanically. A short use ("incidental") duration is inferred by Kay (1999:141) with the evidence on blades 10 and 11.

Elijah Ellerbusch (2004) analyzed 319 prismatic blades technologically from the Nuckolls site (40Hs60) in Tennessee. The blades are part of a collection by avocational John Nuckolls and donated to the University of Tennessee in 1950. Of the 319 blades, Ellerbusch selected a sample of 16 (selection rationale not provided the author) for high power analysis. Ellerbusch (2004:36-37) concluded that the blades were used in a variety of tasks, of which tool fabrication was the principle activity. Blades were used to scrape and cut hide (19.62%), butcher (11.76%), and cut or shred soft plant (3.92%).

#### Previous Use-Wear Research on Gault Clovis Blades

Aside from the presentations at Society for American Archaeology meetings by the author (Minchak 2004, and 2006) and Marilyn Shoberg (Shoberg and Beers 2004), the only documented analysis is from a short write-up in *TARL Research Notes*. Betty Inman and Dale Hudler (1998) applied use-wear to four Clovis blades at the Gault Site, from 1998 investigations by The University of Texas. All four exhibited polish and striations. Inman and Hudler noted the possible use of one blade on silicates (one with bright polish – attributed to plants) and animal processing (one as a knife).

## Discussion

Microwear studies have often been criticized on the lack of standardization and the depth of field. I will discuss these matters more in CHAPTER III. Aside from these, personal criticisms of previous microwear analyses fit into three trends: (1) the assumption that experimental results are proof; (2) provide little information on methods or procedures; and (3) do not show the connection between experimental and artifact analyses.

The assumption that experimental analogs as proof is erroneous and dangerous. As Coles (1979:47) states that if a test is successful, it does not necessarily mean that the tool was used that way in the past. Alternately, if a test eliminates a possible function, then the opposite of that function is likely the positive one. Unfortunately, this requires further testing.

Studies that provide little on methods and procedures compound the assumption problem discussed above. Levi-Sala (1996) and Grace (1989) give a more detailed treatment to methods and procedures. The most frequent lack of disclosure is with the experiments. Many even fail to mention the experiments from which they base their conclusions (see Green 1963 and Hammatt 1970 for the most glaring examples).

A connection between the experimental observations and artifact observations is the foundation of an analysts interpretations and inferences of past behavior. Microwear analysts frequently presented data, almost exclusively microscope images, on an artifact attributed to wear of a particular activity. A problem is that they do not present the corollary data to show how they obtain that connection, or a reference to available data

for the connection. At times, only a table of attributed uses is provided. Contrary to many use-wear studies, use-wear images require a place on a tool.

These interrelated criticisms allow a direction that I will present in the following two chapters that outline my methods and experiments.

## CHAPTER III

### METHODS

Microwear procedures vary, but not greatly. Presentations of studies in this sub-discipline begin with the experimental pieces, trying to match microscopic observations on experimental pieces with archaeological pieces. The methods and techniques vary depending upon the aspects studied. I divided this chapter into 3 sections: (1) microwear schools of thought; (2) analytical variables; and (3) procedures.

#### **Microwear Schools of Thought and Practice: Traceology, Low Power, and High Power**

“Traceology” is used to describe the work of S.A. Semenov (1964:16-21), who studied “traces” of wear on experimental tools and artifacts. Traceological studies stem from the work of Semenov and the Russian school of use-wear. This technique employs the use of striations to provide evidence on how a tool was used and lesser degree on what it was used (Kay 1996 316; Semenov 1964 50, 68-83). During the 1970s and 1980s, the high power (HP) versus low power (LP) debate dominated the microwear literature. The interpretation of polishes is the prime determinant of use in high power, or “Keeley Method” (Kay 1996 316; Keeley 1980 23), as opposed to rounding and microflaking in low power analyses (Tringham et al. 1974). While the “Keeley Method” has been more highly utilized over the past two decades, it is my contention to blend traceology, LP, and HP to yield results more agreeable to replication.

#### **Analytical Variables**

There are numerous variables to consider when conducting a microwear analysis of artifacts. Aside from artifact specifics, there are background considerations such as:

context and association. Natural factors include geological forces acting on the site during and after artifact discard. Gault geological units (3a and 3b) contain the Clovis blades. Unit 3a consists of clay derived from a ponding event, while unit 3b overlies unit 3a and consists of silty-clay to clay from an overbank deposit (Luchsinger 2002). These are not characteristics of dynamic environments, which can tumble artifacts to produce edge damage, but of a low-energy environment incapable of such an action (Waters 1992:121-122, 208-209). However, artifacts at the base of 3a rest on gravels of units 1 and 2 (decomposing limestone and colluvium). In addition, some areas of 3a, there were artifacts resting on artifacts with no clay between them – with slight (1 foot) movement of artifacts during flood events (Waters, personal communication). These imbricate placements of artifacts are more likely to produce an environment for trampling. The three main categories discussed and used are: (1) raw material variability; (2) blade morphology; and (3) microwear characteristics of microfractures, striations, and polish.

### **Variability in Edwards Formation Chert**

Blades for this study, artifacts and experimental pieces, were manufactured from Edwards Formation chert. Chert is defined as a sedimentary rock made up of silica in the form of microcrystalline quartz (Folk and Weaver 1952; Longwell et al. 1969:646) that forms as either original precipitates or by replacement of carbonates. Archaeologists, especially when deriving archaeological models on flintknapping (Whittaker 1994) and fracture (Cotterell and Kamminga 1987), often assume the homogeneity of chert and/or other raw material. Chert, however, is not homogenous, especially viewing that its diagenesis frequently involves the replacement of parent material with silica (Folk and

Weaver 1952; Hesse 1990a, 1990b; Knauth 1994; Maliva et al. 2005; Meyers 1977; Siever 1957).

The Edwards Formation (Fm) is a chert-bearing limestone and dolomite, depending on the location of the exposure, of Lower (Early) Cretaceous (145 – 96 MYA) age (Fischer and Rodda 1969) and underlies aspects of the Gault site (Adkins and Arick 1930; Fischer and Rodda 1969). The Edwards Fm was deposited in a shallow-water and medium → high-energy marine platform. Edwards contains chert commonly as nodules and plates (Proctor et al. 1981) and the volume varies from bed to bed with some intervals free of chert. Fischer and Rodda (1969:70) note that Edwards chert “typically contains relict structures and fossils of enclosing limestone” that indicates a secondary origin. The considerations for chert origin in the Edwards Fm are: (1) a secondary origin; (2) permeability control due to association of chert with carbonate grainstone deposited in a medium- to high-energy environment; (3) regional coextensive distribution of chert and dolomite marginal to a restricted carbonate-evaporite lagoon; and (4) consistent absence of chert in the reef-core and reef-flank environments within the cherty grainstone facies, suggesting an environmental control of the silica source (Fischer and Rodda 1969:70-71).

Three basics of the chert problem are: (1) source of silica; (2) depositional environment; and (3) diagenesis of chert and chert-bearing rocks (Hesse 1990a; Knauth 1994; Siever 1957). Possible sources of silica (Hesse 1990b:261; Siever 1957:827-834) come from both biogenic (silica-secreting organisms) and non-organic sources (for example dissolution of quartz and smectite to illite transformation during burial. Little is known about the conditions for silicification of ancient carbonate rocks (Hesse 1990b:253-254). Chertification involves pore-filing silica that occurs either before

and/or after carbonate cementation, but is usually a volume-for-volume replacement by silica that can preserve organic structures such as that seen in petrified wood (Hesse 1990b:253; Knauth 1994:245). Carbonate cementation and chertification are mutually exclusive with the possible exception of dolomitization. Evidence shows that chertification occurs at different times in diagenetic history (Hesse 1990b:259). Chert itself is also commonly thought of as part of the maturation process from opal to quartz of the period of millions of years (Knauth 1994:234).

In addition to the possible biogenic source of silica, the silica replaced limestone with biological remnants. Fisher and Roda (1969:61) identified miliolid foraminifera in the chert-bearing platform facies of the Edwards Fm. I observed chalcedonic replaced forms that are allothenous rolled miliolid fragments in blades (Fisher and Rodda 1969; Scholle 1978:31). Also, as a sedimentary rock, chert is constrained by the stratigraphic and structural controls of bedding, joints, and cleavage (LaPorta 2001, 2004). Since the Edwards chert is in the 3<sup>rd</sup> tectonic province (LaPorta 2001), they are largely unmetamorphosed (Knauth 1994:244), with the exception of burial metamorphism, and should not affect the micro- or macroflaking. Therefore, diagenetic and biogenic aspects of the chert are determinants of material constraints on the recording of wear.

### **Blade Morphology**

The location of observations on a blade, either artifact or experimental, must be placed in context of the rest of the blade. How is the form of the blade associated with use? I began to tackle this based on the definition of a blade and the separation of blades into technological categories by Bill Dickens (2005) and describe in the procedures section. Cortical coverage is noted and provides a constraint as to what can be used.

Curvature and protrusions are noted and a separate category was made for modified (deliberately retouched) blades.

Spine and edge angle measurements (Hayden 1979:139-140; Tringham et al. 1974) provide the measurements on the basic design of the tool. Spine angle (Tringham et al. 1974:179-180) is the measurement between the ventral and dorsal surfaces as a cross section from the edge to the ridge, not affected by edge damage. Edge angle (Tringham et al. 1974:179-180; Wilmsen 1970:14) is the measurement of the angle between the ventral and dorsal surfaces that contain either retouch or scars. Other investigators recommend measuring the locations of possible use (Hayden 1979:140). Since there is a problem with a change in the continuum, measurements were made after the compound microscope stages to determine if there is a correlation between similar patterns on Gault and experimental blades. I took measurements with a goniometer, and range between 0-90°.

### **Microfractures, Striations, and Polish**

Generally, the three most studied aspects of microwear are microfractures, striations, and micropolishes. Fractures are caused by compression and stress forces. While this is the basis of most lithic technology discussions of flake manufacture and flintknapping, it is also the driving force for edge damage and microfractures (Odell 1981:197). Cotterell and Kamminga (1987) describe the phases of breakage in a brittle solid as initiation, propagation, and termination. The fracture is initiated by force, the force propagates along the fracture, and the force terminates resulting in volumetric removal. This is commonly seen in the production of flakes and microflakes, or scalars, seen in edge damage (Keeley 1980:24-25). Fractures result from human alteration

(Tringham et al. 1974) or natural alteration (Pryor 1988; Tringham et al. 1974). I classified microfractures, using the stereomicroscope, as: conchoidal, stepped, and snapped. Conchoidal scars leave a negative flake scar and end with a feathered termination. Stepped scars leave a negative scar like conchoidal scars, but terminate abruptly in hinge fractures. Snapped scars are crescent-shaped where the edge has broken off, leaving no negative scar.

Striations are caused by hard mineral particles, such as silica sand, that create friction when dragged across a surface (Semenov 1964:69-71, 88). Terry DelBene's (1979:168-170) concerned discussion on striations notes the importance of hardness, mineralogical structure of the material, and problems resulting from optical constructs of the "mind's eye" when viewing geometric patterns under the microscope. The first two facets, hardness and structure, result from the petrofabric and structural history of the rock and applicable to fracture and polish observations as well. The third facet, optical constructs, is less quantifiable and dependent of the first two facets. At the suggestion of Dr. Marvin Kay, University of Arkansas – Fayetteville, I identified striations in terms of profile shape left (v-shaped and u-shaped).

As defined by Grace (1989), "polish is the visible alteration of the flint surface so that the reflectivity of the flint surface is increased when viewed through the microscope." The formation of polish, however, is a problem not just for archaeologists (Diamond 1979; DelBene 1979; Levi-Sala 1996:3-4; Semenov 1964; Unger-Hamilton 1984; Witthoft 1967), but for material research scientists as well (Steigerwald et al. 1997). Formation is generally separated into deposition of silica on the surface (Witthoft 1967); subtraction of the surface (Diamond 1979; Semenov 1964), or both deposition and

abrasion (Levi-Sala 1996; Unger-Hamilton 1984). There are noted as deriving from wood, bone, hide, and other plant material (Keeley 1980; Grace 1989; Diamond 1979). Use-wear stemming from hafting (Hudler 1997:9; Kay 1996:328-330; Rots 2003, 2004) is also considerations. It is also important to note at this time that there are also natural forms of polish through patination, water-born sediments, wind-born sediments, and soil movement effects (DelBene 1979:171-172; Keeley 1980:28-35; Semenov 1964:11-12).

### **Gault Blade Analysis Procedures**

I plan to follow procedures (see APPENDIX B for microscope and software specifications, as well as more detailed step-by-step procedures) where the observations on experimental pieces test the observations of the artifacts. As such, I will divide procedures into 1) assemblage and sample extraction, 2) cleaning of the sample pieces, 3) documenting pieces, 4) microscopes used, and 5) photomicrographs. Experimental procedures, when differing from those used below, are discussed in CHAPTER IV.

### **Assemblage and Sample**

There are 498 artifacts from the Texas A&M excavations at Gault that follow the provided definition of blades. Of these, 468 blades are from the Clovis units of Unit 3a and Unit 3b.

The initial separation of blades by geological unit is followed by the technologically based divisions (similar to other analyses like Nash 1986, but as a subdivision of a particular technological type) of Gault blades laid forth in the doctoral dissertation of William Dickens (2005). Blades can be separated into four basic technotypes: 1) cortical blades, 2) secondary blades, 3) interior blades, and 4) modified blades (Figure 2). Cortical blades represent initial blade removal, with the dorsal side fully

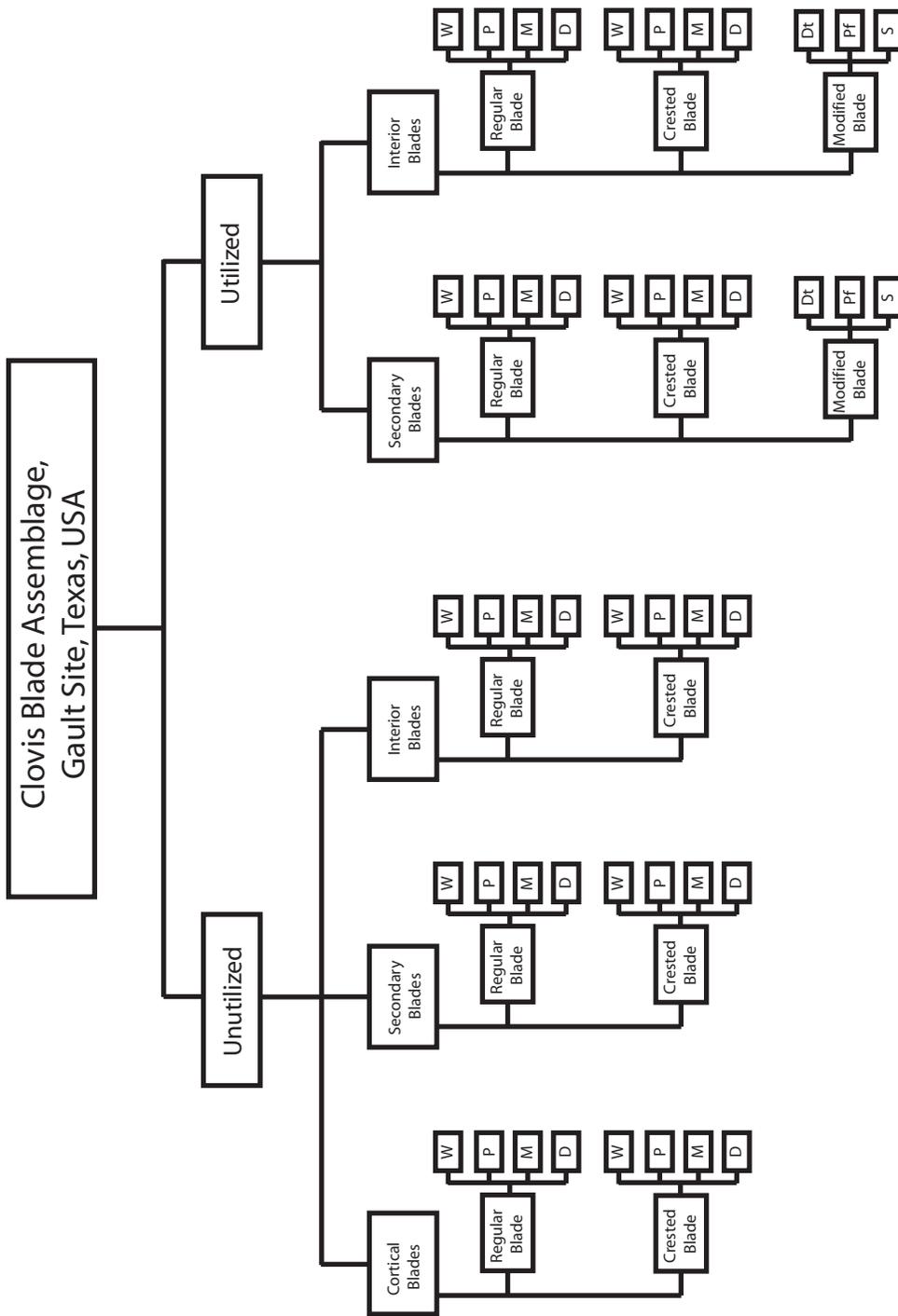


Figure 2. Organizational chart for the Clovis blades excavated by Texas A&M at the Gault Site. Letter represent the following in terms: W = whole; P = proximal; M = medial; D = distal; Dt = denticulate; Pf = perforator; S = Scraper.

covered by cortex (approximately 50% of the surface area). Secondary blades constitute blades that are removed at the intermediate stage of blade production and still have cortical backing that comprises 50% of the dorsal side (approximately 25% of the surface area). Interior blades represent blades in the final stages of blade manufacture and preserve no cortex (0% of the surface area). Each category has separations as to the blade edge regularity and completeness of blades. In addition to technological separations, four modified blades were placed into a separate category indicating possibility of more cultural information to extract. Two of these blades, from 3a, can be refitted to form a denticulate blade; the third blade from 3a is modified on one edge; and two blades from 3b are modified on one end.

Vaughan (1984-1986) recommends separating pieces that appear to have edge removal from the collection for use-wear analysis, eliminating pieces unlikely to yield use-wear information (i.e. patinated, heavily burnt, or coarse raw material pieces). In addition to this, edge damage becomes an important variable when determining possible use-wear (Keeley 1980:19; Tringham et al 1974:180; Vaughan 1985:22-23). The general rule becomes that the more acute the edge angle of an artifact, the more likely it is to be heavily damaged from use or by other means. Building on this, certain ranges of edge angles have been described by Vaughan (1985:59) and Keeley (1980:42) as being used for certain tasks.

I used my naked eyes and a Bausch and Lomb hand lens (16x) to separate the initial blade sample from the Gault blade population. My variables were: flake scar patterns, rounding, possible residue (AM408I), amount of cortex and subcortex, and burnt pieces. My criteria for advancement were: an edge without cortex, a non-burnt

blade, and flake scars on edge. Using the above, I separated the blades into 233 (3a = 143, 3b = 85, and Modified = 5) blades analyzed under the stereomicroscope. My variables for stereomicroscope analysis were: flake scar patterns, edge and ridge rounding, polish, possible residue, placements of the above, and relationship between all the above. My criteria for advancement were: rounding, polish, and residue (especially if a combination was visible). Of the stereomicroscope blades, 24 blades from Clovis units 3a and 3b were analyzed under the compound microscope. My criteria for analysis were the classically described (see section on variables): polish, striations, residue, and microflaking.

### **Cleaning**

Cleaning is the first step, and potentially most important one due to the extraneous material deposited on the artifact. This is especially true with the material from the Gault Site, which have a calcareous patination and has been handled by human hands, which include oils, dirt, and other substances. The cleaning sequence is as follows: 1) examine the artifact to determine the extent of the deposit, and 2) wipe with spirits (generally H<sub>2</sub>O) and cleaner to remove human oils and soils. Grace (1989) has found that the chemical treatments visibly alter the surface of the specimen, as well as destroying possible blood residue or other organics. Juel Jensen (1994:18) notes that chemical cleaning is unnecessary in most instances. In addition, artifacts were cleaned with alcohol and/or a sonic cleaner to remove loose particles.

### **Documenting Pieces**

After cleaning the blades, I photographed each analyzed artifact and experimental blade using the digital camera Cannon EOS Digital Rebel during microscope analysis.

Each blade was photographed from multiple angles that included: dorsal, ventral, laterals, proximal, and distal. Lateral and distal shots were omitted if covered by cortex or calcium carbonate. In addition, I traced and outlined ridges, as well as other landmarks, to aid in the location of microphotographs.

### **Microscopes**

Microscopes used for the analysis are stereographic and compound microscopes available through the Center for the Study of the First Americans. I used the Leica M12.5 and Leica DM LA microscopes to scan artifacts for potential use-wear and then to determine patterns of use-wear. The Leica M12.5 scope is a stereomicroscope that has a numerical aperture of 0.2, an objective of 1.6x, and an eyepiece of 10x. This allows for a magnification of 12.8x to 180x. To standardize the stereomicroscope process, I took images at 20x, 40x, and 100x. Occasionally, additional images were taken at 12x to show the broader location. The Leica DM LA microscope is an optical compound microscope, provides magnification from 100x to 500x. To standardize the compound microscope process, I took images at 100x, 200x, and 500x.

### **Photomicrographs**

Media Cybernetics' *Cool SNAP-Pro Color* is the digital camera used by both microscopes. The programs and *In-Focus v 1-60* (stereomicroscope) and *Scope-Pro Plug-In* (compound microscope), by Media Cybernetics and Meyers Instruments respectively, controls the microscope movements in a repeated manner allowing for reproducible results. The computer software used to view and analyze the digital images is *Image-Pro Plus* version 4.5 by Media Cybernetics. The images are taken in Tagged Image File Format (TIFF). To attain the focus of a larger area, in regards to depth of

field, Image-Pro Plus creates a composite image from a sequence file (\*.sqr) of photographs.

## CHAPTER IV

### EXPERIMENTAL PROGRAM

Tringham (1978:170) defines experimental archaeology as comprising “a series of observations on behavior that is artificially induced.” Coles (1979:1-2) provides a more generalized view of experimental archaeology as an attempt to reproduce former events and circumstances that can help the archaeologist better understand the rationale of another. Experimentations on the “by-products” of human behavior test the natural and cultural phenomena that direct archaeological sites and remains (Tringham 1978:182). Natural versus cultural implies equifinality, the same outcome from two different processes (Bonnichsen 1996:268; Shea and Klenck 1993:176), a concept present at multiple levels in the study of use-wear and archaeology as a whole. Context then becomes a vital factor in determining edge modification and other forms of wear (see CHAPTER III for more detailed discussion of Gault context). Possibilities noted for cultural modifications are as follows: manufacture, intentional retouch, and trampling. I excluded excavation and transportation damage due to the noticeable difference between a fresh flake scar and the stained/patinated surface that is diagnostic of the Clovis artifacts at Gault. In regards to manufacture, notable candidates for difficulty are proximal and dorsal remnants of blade manufacture. Although there is more to address on the effects of the manufacturing process on microwear, I will further discuss intentional retouch and trampling.

The differentiation between intentional retouch and trampling is problematic, with some researchers (Flenniken and Haggarty 1979:211) that claim to be able to classify trample-modified flakes into formal tool types. Previous research differentiates between

these using experiments (Flenniken and Haggarty 1979; Gifford-Gonzalez et al. 1985; McBrearty et al. 1998; Nielsen 1991; Pryor 1988; Shea and Klenck 1993; Tringham et al. 1974) as well as blind tests (Young and Bamforth 1990; Shea and Klenck 1993). With the exception of Flenniken and Haggarty (1979), researchers generally agree with Tringham et al. (1974:192) with three criteria for the presence of edge damage from trampling: (1) a random distribution of flake scars; (2) flake scars isolated on one surface; and (3) scars are elongate, but do not have a fixed orientation. Differences are attributed to sample size, type of matrix, time trampled, and other variables (Gifford-Gonzalez et al. 1985; Pryor 1988).

The basis of inference in microwear analysis is conducting experiments (Grace 1989; Keeley 1974, 1980; Levi-Sala 1996; Odell 1980; Semenov 1964; Tringham et al. 1974; Vaughan 1985). Experiments, created through lithic replication, test the results of the use-wear analysis. This is commonly employed at the beginning of use-wear studies, but act as the guiding force of the analysis instead of as an analogy. Lithic replication pieces were be used on various materials for various time/duration and then compared to the Gault artifacts. Comparison entailed comparing the use-wear patterns from the experimental pieces to the Gault blades (see APPENDIX C for specific descriptions).

### **Rationale, Procedures, and Characteristics of the Experiments**

My original goal for experiments was to combine tests for natural and cultural modification, the latter of which was separated into trampling and use. This was an overlap with the work of Charlotte Pevny. With her technological and microwear analysis of modified flakes well underway, I decided to redefine my objectives to experiment on the hardness and softness of contact materials on which blades may have

been used. The purpose of use-wear experiments for my thesis was to aid in distinguishing wear by soft and hard contact materials. I chose and conducted my experiments due to the following characteristics: (1) varying degrees between hardness and softness; (2) providing a continuation of recording as the wear happens; and (3) practicality. I combined this with Coles' (1979:46-48) list of eight "fundamentals" to observe: (1) use what would have been available to them; (2) methods should not exceed their presumed competency; (3) carry out analytical techniques before, during, and after experimentation; (4) assess and fairly state the scale of work; (5) repeat in order to avoid outlier results; (6) improvisation should be considered when problems arise; (7) results from experiments should not be taken as proof; and (8) be honest in descriptions, evaluation, and conclusions of the experiment(s). A thorough example of this is the work done by Suzanne Lewenstein (1987) in her microwear study of stone tools from Cerros, Belize. She conducted 36 experiments using Colha chert for formal tools and informal flakes, along with El Chayal obsidian for prismatic blades.

The procedure for experimentation was generally set up before experimentation with intended flexibility. I was unable to record the manufacture of the experimental blades by Bill Dickens, since he did so prior to my involvement with Gault. Before experimentation, I photographed the blades and analyzed them under the stereomicroscope and compound microscope (see CHAPTER III for specific methodology on microscope analysis) anticipating possible use locations. After recording the pre-use observations, I collected the contact material. Before use, select blades (NNWXP1, NNWXP2, NWXP1, and NWXP4) were hafted using asphaltum or hide glue and sinew. The exception to this was FUTB44, which was hafted after 500

strokes. Experiments were recorded with a digital camcorder (Sony MiniDV Handycam) when available to show nuances of kinematics during use. A 35 mm camera (Yahica AutoFocus 300) was used to take supplemental photographs. I created forms before the experiment to account for all above variables recorded below. To trace the development of polish and striations, most experiments were stopped after intervals of time, stroke, or measurement. During these breaks, the experimental blades were photographed and analyzed. After the final interval of experimentation, I again photographed and analyzed the blades.

The materials used and worked on are considered available at the time of Clovis. If none could be found, then reasonable proxy materials were utilized. The pollen record for central Texas during this time indicates a steady warming and drying trend from 14,000 to 11,000 B.P. (Bryant and Hollaway 1985:52). Grasslands and deciduous forests gave way to an oak savanna. Faunal remains from the period can be separated into three general categories: (1) large extinct forms, (2) extant species no longer in central Texas, and (3) species still occurring in central Texas (Lundelius 1967:289, 296, and 297). All experimental blades were manufactured from Edwards Formation chert, collected near the Gault site, by Bill Dickens. Wood used in the experiments was locally available oak. Cow horn and bison hides were used as proxy, as neither species was present at that time. Siliceous plant material was selected, along with various softness and hardness, from locally available cane and grass. In addition to the contact material, mastic material (asphaltum, hide glue, and sinew) was used to replicate what was available (Collins 1979, 1981; Schmidt 1991).

### Experimental Variables

The variables of the experiments are slightly different from those used for the Gault blades by its nature, due to their known use. The six variables considered are:

1. Location of Use – location of used portion on the blade;
2. Contact Material – name and whether the material was (a) hard or (b) soft;
3. Action – whether (a) longitudinal or (b) transverse;
4. Duration – time, number of strokes, dimension of area worked, length, and intervals analyzed;
5. Condition of Contact Material – whether the contact material was wet or dry and freshness; and
6. Tool Morphology – spine and edge angles.

The location of use is self explanatory, but works in conjunction with tools morphology. Contact material was named and separated into two categories: soft and hard. Soft materials are listed as grass, cane, and hide. Hard materials are listed as bone, antler, wood, and horn. Other analysts (Grace 1989; Odell and Odell-Vereeken 1981:101) note the difficulty of giving an accurate assessment of the absolute hardness of the materials and have made their own differentiations. Odell and Odell-Vereeken (1981:101) separated theirs into four categories: (1) soft, (2) soft medium, (3) hard medium, and (4) hard. Grace (1989) separated his into (1) soft, (2) medium, and (3) hard. While this is not a separation into absolute hardness, it reflects a general ease of use with stone tools. The action of use refers to how the experimental tool was used. The divisions are separated into two categories: longitudinal and transverse. Longitudinal is an action running lengthwise. Transverse is an action that goes across a contact surface.

Longitudinal actions listed are: cutting, sawing, and possible graving. Transversal actions listed are: scraping, graving, and reaping. Duration refers to the amount of time a tool was used on a task, the number of times the tool was used, and/ or the dimensional measurements on what a tool was used. Time was recorded in minutes, number of strokes as one full use (or half use for sawing), and dimensions in metric (centimeters and meters). The condition of the material was noted as being either wet or dry and freshness. The tool morphology consists of spine and edge angle measurements (Tringham et al. 1974) to compare to Gault blades that show similar microwear patterns.

### **Compound Experiments and Observations**

I conducted nine experiments, divided into the types of contact material described in the variables section above of: soft and hard (Figure 3). Five soft contact experiments were conducted on six blades. Four hard contact experiments were conducted on four blades.

#### **Soft Contact Materials**

Soft contact experiments were reaping grass (with two blades FUTB44 and NNWXP2), circumscribing cane (FUTR42), sawing cane (FUTR43), cleaning sinew (NWXP3), and cutting rawhide (NWXP4). Each soft contact experiment was conducted at the Wiederhold home in Caldwell, Texas.

My first two experiments consisted of using unhafted experimental blades to cut fresh (green) cane. The first blade, FUTR42, was used to circumscribe 2 stalks of cane using 78 strokes before they were manually broken. Analysis revealed no change and no images were recorded. The second blade, FUTR43 (Figure 4), was used to cut the two stalks of cane into sections. I finished cutting the first cane with 401 strokes, while the



a



b



c



d



e



f



g

Figure 3. Experiment: (a) reaping grass; (b) cleaning sinew; (c) cutting rawhide; (d) scraping wood; (e) sawing wood; (f) sawing horn; (g) planing horn.

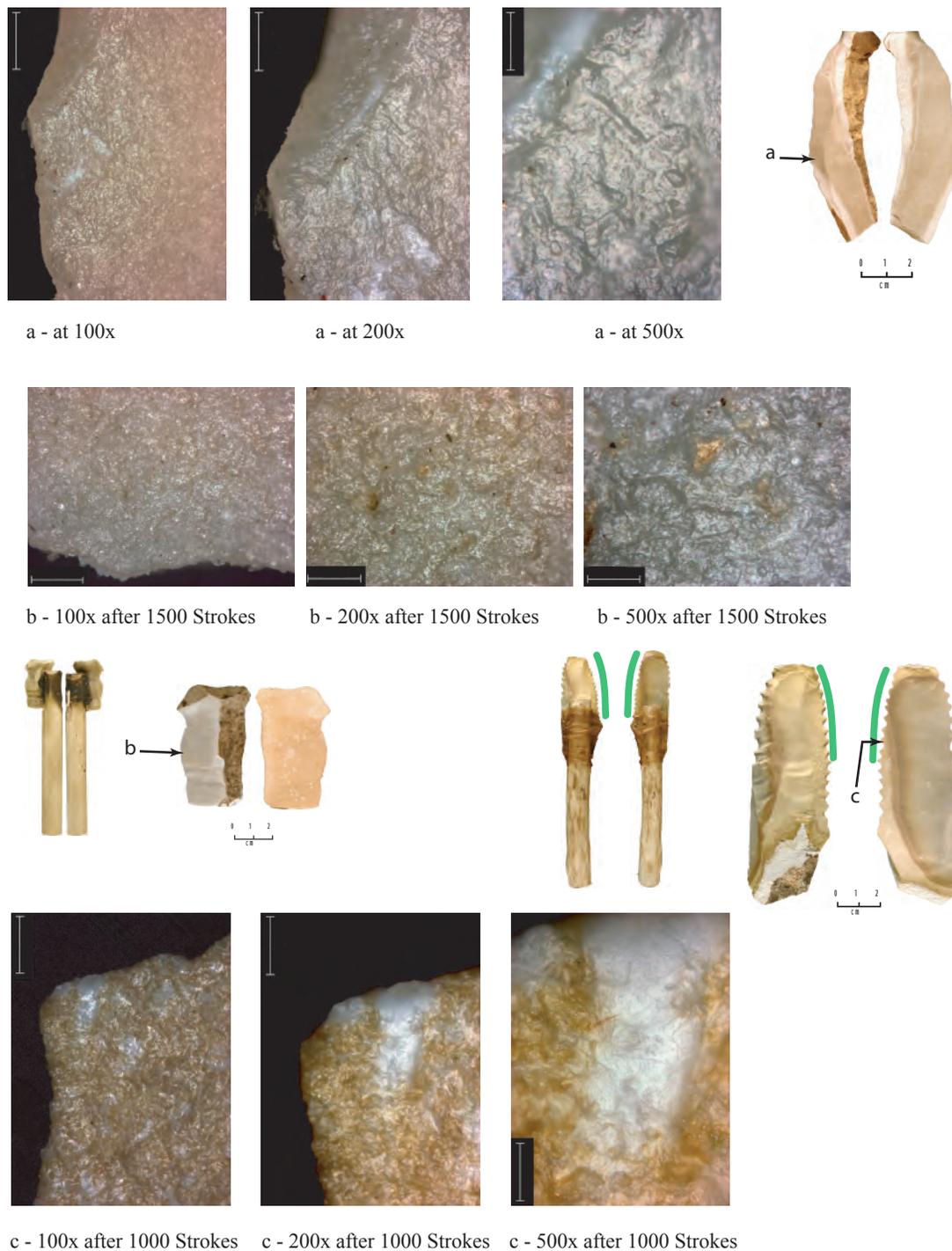


Figure 4. Experimental Blades: (a) FUTR43, polish from sawing cane; (b) FUTB44, polish from reaping grass after 1500 strokes; (c) NNWXP2, reaping grass polish after 1000 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

second required 390 strokes. Due to the curvature of the blade, presence of right lateral cortex, and angles of the left lateral edge, I used the middle left lateral edge of the blade (34-35° spine angle). This experiment provided minor ridge rounding, and uneven polish. Polish concentrated more on mid to low mid left lateral. Microtopography remained mostly intact, with some minor changes.

One initially unhafted blade, FUTB44 (Figure 4), was used to reap grass. FUTB44 went through two iterations: (1) unhafted and used for 500 strokes; and (2) hafted and used for 1,500 more strokes and the same lateral edge. I used the middle right lateral (5-9° spine angle) and the lower right lateral (24° spine angle), due to the shape of the blade fragment. FUTB44 was used with the distal side up and the cortical side resting against the hand and haft. Little change was evident after 500 strokes. The low right lateral dorsal showed a change at 1,500 strokes in the initial development of polish as linear, trending towards the distal end at an oblique angle, to a more uniform polish that was altering the microtopography after 2,000 strokes. The prominotry on the lower right lateral showed polish and rounding developing from 1,500 strokes to 2,000 strokes. Polish became more linked and hit but did not grind the asperities.

Following this, and testing the possible use of the Gault serrated blade (AM328B2 and AM322 – refit), is the hafted experimental serrated blade NNWXP2 (Figure 4). This experiment had two purposes: (1) to provide a secondary testing for soft plant wear; and (2) to view the affects of the wear on the different later diagenetic part of the chert. Due to the curvature of the blade and my right-handedness, the left lateral edge of the blade (19-27° spine angle and 48-54° edge angle) was the contact area. This made harvesting the grass easier than with the FUTB 44 experimental blade. One readily noticeable

change was the rounding on the distal facing edges of the serrations. After 1,000 strokes, the polish was viewable on the ventral face and not very invasive. It was also noticeable that the white chalcedony took on polish quicker than the surrounding late diagenetic chert. After 2,000 strokes, the edge rounding was more pronounced but the polish changed little.

At the suggestion of Jim Wiederhold, I cleaned bison sinew with the unhafted experimental blade NWP3 (Figure 5), running the sinew over the lower left lateral. The sinew would later serve as part of the binding for Ashley Smallwood's hafted experimental bifaces. After 500 strokes, the blade incurred microflaking on the ventral face. Compound analysis showed that polish was linked, heavy, and thin on the dorsal face. Polish was present on the lower left lateral (38-41° spine angle) on the ventral face, but only away from the edge as unlinked high spots where asperities were polished. The edge itself is heavily rounded. U-shaped striations perpendicular to the edge are evidence of the concentrated movement of the sinew across the edge.

My final soft contact material experiment was to cut the rawhide from Jim Wiederhold's butchered 2-year-old bison bull using the hafted experimental blade NWP4 (Figure 5). Two hides were strung on a wooden square to provide tension for Wiederhold's (2004) endscraper experiments and secondarily for cutting with NWP4. Due to the thickness and density of the rawhide at the ends, I began and ended the incisions with a metal exacto-knife. Incisions measured 192 cm and 200 cm. Strokes were not counted due to the tough nature of the rawhide that prevented clean strokes. Polish developed in high spots on the ventral face of the mid right lateral edge (38-45° spine angle). The mid-right ridge exhibited a heavier polish with oblique shallow u-

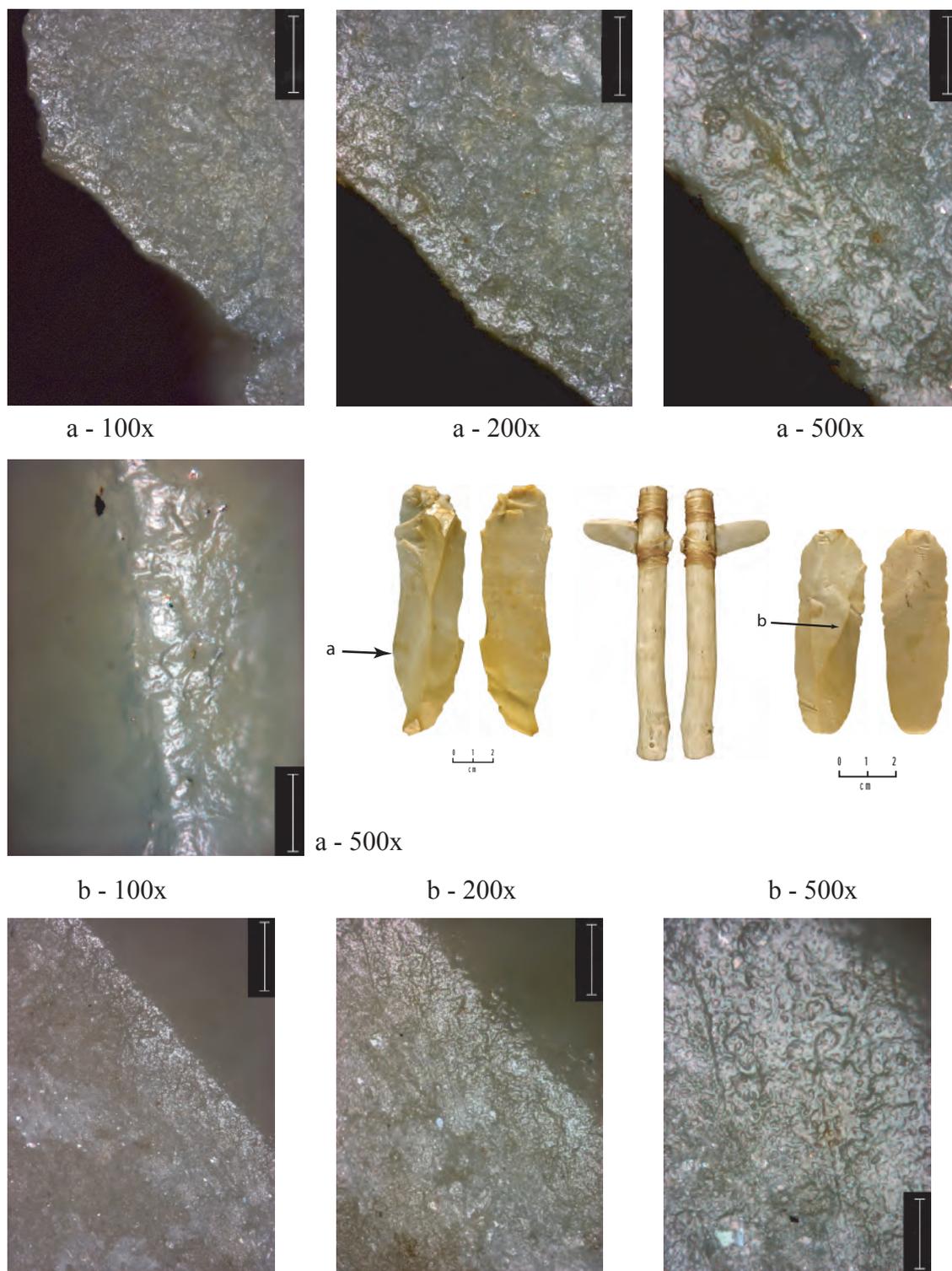


Figure 5. Experimental Blade: (a) NWXP3, polish from cleaning sinew; (b) NWXP4, polish from cutting rawhide. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

shaped striations. Due to the thickness and angle of the blade when cutting, to achieve an approximately straight line, the ridge was constantly in contact. This presents an interesting problem where a blade exhibits use-wear on the ridge that is neither from hafting or direct use, but from coming into contact with the rawhide.

### **Hard Contact Materials**

Hard contact experiments were scraping wood (GRT-4-1), sawing wood (NNWXP2), sawing horn (NWXP1), and scraping horn (NNWXP2). Wood and horn served as the contact materials to test the affect of softer hard materials (wood) to more dense hard materials (horn), both of which may have been used for subsistence or tool working. Wood scraping and sawing took place at the Wiederhold home in Caldwell, Texas. Horn sawing and scraping took place at the Center for the Study of the First Americans conference room in the Anthropology Building at Texas A&M University, College Station, Texas.

My first hard contact material experiment was scraping wood (oak) with unhafted experimental blade GRT-4-1 (Figure 6). The practicality of this was to clean the bark of sections of oak that were to be used as handles for other experimental blades. The lower left lateral edge (34° spine angle) comprised almost the entire use at 2,177 strokes – both scraping away and towards. The upper left lateral was used for 30 strokes. I finished when the blade became dull to the point of inefficiency. Compound scope analysis showed that polish was present on dorsal and ventral edges as thin and varying invasive. The edge itself was heavily rounded. The microtopography, save for the edge, was mostly intact with the asperities receiving the brunt of the contact.

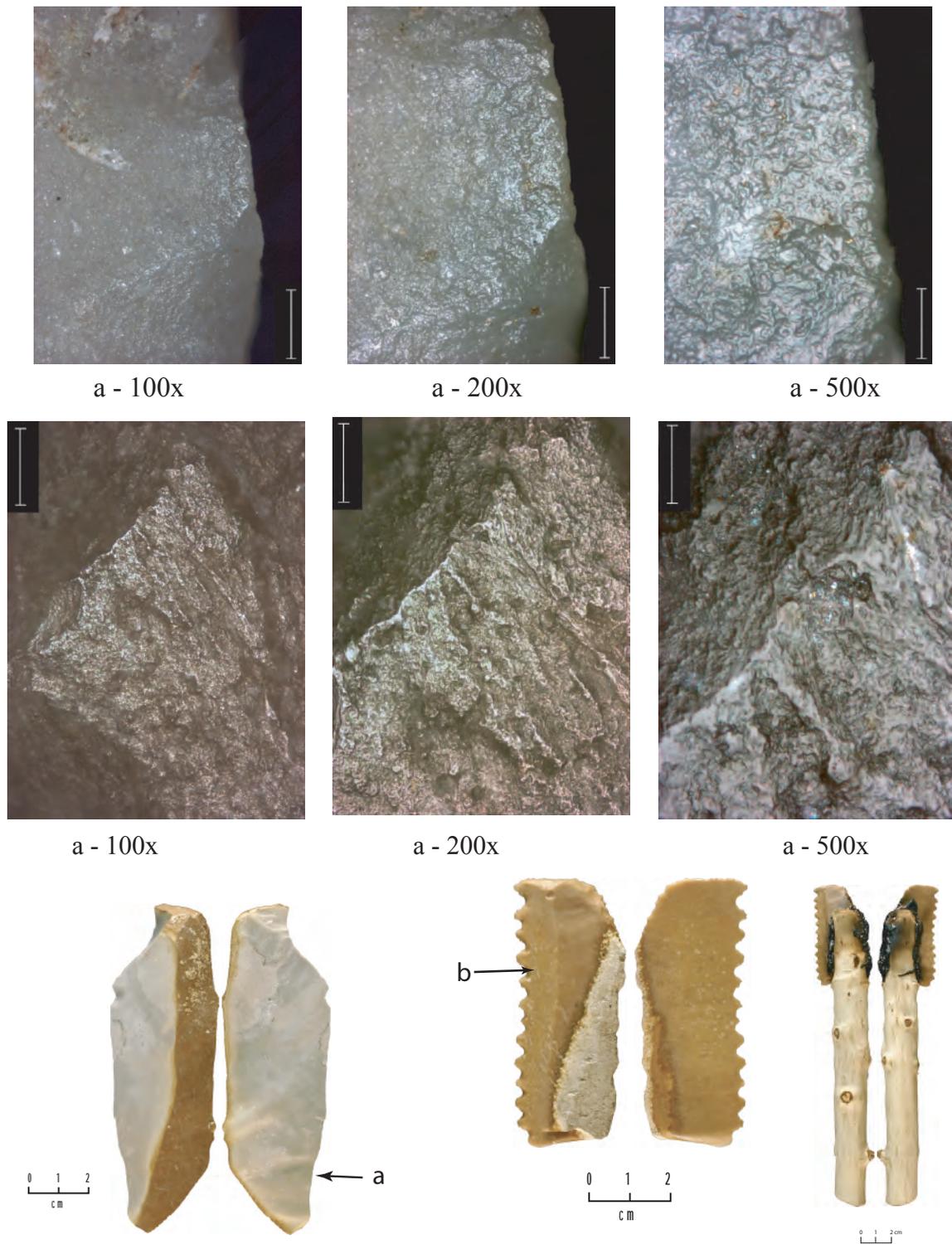


Figure 6. Experimental Blades: (a) GRT 4-1, polish from scraping wood; (b) NNWXP1, polish from sawing wood.

The serrated lateral edge (30-33° spine angle and 55-75° edge angle) of the hafted experimental blade NNWXP1 (Figure 6) was used to saw wood. The most evident result was the mechanical failure of the serrations that came into contact, which began on the first stroke. While I suspected that this would happen, it was important to definitively eliminate the harder material as a possible contact for the Gault serrated blade (AM328B2 and AM322 – refit) in even as basic a level. I sawed a thin branch of oak 710 times (355 back-and-forth motions), stopping when it became visibly more difficult. This was hampered by the slight curvature of the blade. When analyzed under the compound microscope, polish was present on the high spots and negatives from the original serration and on the dorsal face. The polish was gapped and not linked, hitting the high spots with noticeable plastic deformation.

Edge straightness again became a factor when trying to saw cow horn with the hafted experimental blade NWXP1 (Figure 7). The lower right lateral (spine angle of 62-80° and an edge angle of 82-87°), sitting upwards in the haft, was the primary location of contact with the oak. Analysis after 500 strokes (250 back and forth) shows polish and linear indicators trending parallel to the edge. After 1,000 strokes (500 back and forth) the same area contained few polish with linear indicators. The upper right lateral (spine angle of 20°), sitting downwards in the haft, caught its wear while pulling the blade back. The 500x image at 500 strokes shows the polish linkage, which increases after 1,000 strokes.

Planing horn proved interesting and insightful. Experimental blade NNWXP1 (Figure 7; see wood sawing description for hafting details) was used to plane cow horn with the modified proximal edge (approx. 66°). After 500 strokes, faint polish and

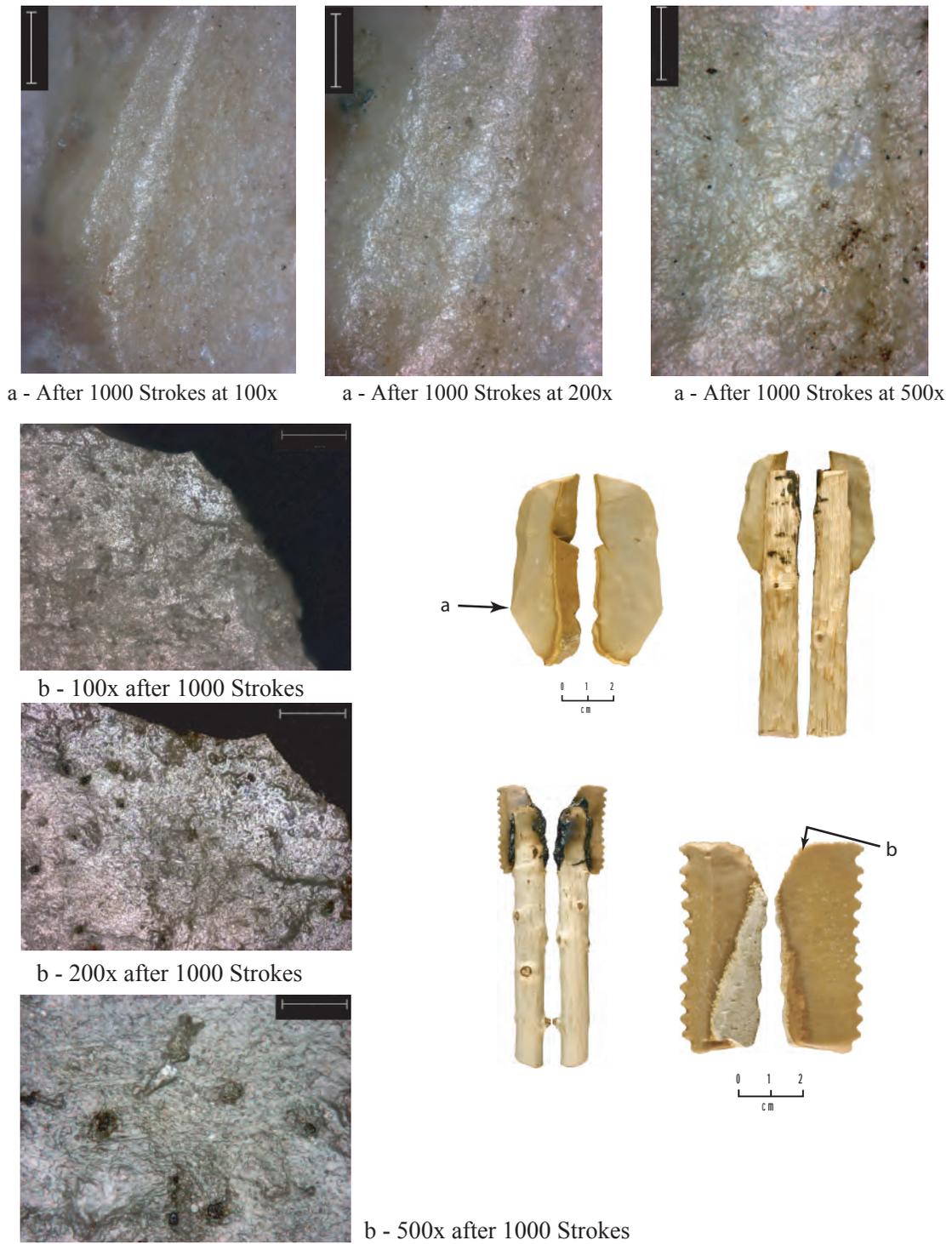


Figure 7. Experimental Blades: (a) NWXP1, polish from sawing horn after 500 strokes; (b) NNWXP1, polish and striations from planing horn after 1000 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

striations were visible. The polish is more concentrated along the edge while the striations are further inland. After 1,000 strokes, the location on the blade took on more intense polish and striations. Polish by this point is much heavier than at 500 strokes. The striations are further from the edge and more pronounced than those at 500 strokes and vary in thickness.

### **Discussion of Observations and Conclusions**

There are a number of issues raised by these experiments: raw material affect; mechanical failure; microtopography change; and the relationship between these to determining hard versus soft contact materials.

Raw material definitively plays a role in the recording of use-wear on rock. The right lateral of experimental blade NNWXP2 is what I term the late diagenetic phase of the chert that is yellow, coarser grained than chert, and white inclusions. The white inclusions are chalcedony, an early phase of quartz (Folk and Weaver 1952; Hesse 1990a, 1990b; Knauth 1994; Maliva et al. 2005; Meyers 1977; Siever 1957) that is softer than chert. This means that it takes on polish and striations faster than the early diagenetic chert. The yellow coarser grained material also takes on polish and rounding quicker than the early diagenetic chert, but less than the chalcedony. Since chalcedony takes on more wear than the surrounding chert, it is susceptible to wear (cultural or natural). More experiments are required to test this hypothesis.

Microflaking was present when using the experimental blades on hard contact materials. I even noticed the attrition while using them in the experiments. Mechanical failure of edges is most notable in the wood sawing experiment with the serrated blade NNWXP1. While this is the most notable occasion, there was microflaking noticeable

while using that resulted from all hard contact material experiments, as well as the soft contact material experiment of cutting rawhide (NWXP4). Otherwise, soft contact material experiments did not sustain much edge damage. The edge angle ( $66^\circ$ ) of the distal planing end of NNWXP1 resulted in microflaking during use, but the edge did not fail. FUTB44 ( $5-9^\circ$  and  $24^\circ$  spine angles) received little to no attrition. What does happen, as seen with both NNWXP2 (after 1,000 and 2,000 strokes) and FUTB44 (after 2,000 strokes) is pronounced evolution of edge rounding – one not seen in the hard contact experiments.

Mictotopography, polish, and striations are prime indicators not only of use, but also hardness of contact material and direction. In terms of defining use, the hardness of the contact material has a direct relationship with the alteration of the surface microtopography. Soft contact materials, in general, have a greater range of polish on the microtopography, such as that seen in NNWXP2 and FUTB44. Hard contact materials hit the asperities, or high points. More surface area polished is achieved by planing of the asperities, such as in NNWXP1 and NWXP1.

Characterizing hardness and softness of the contact materials from use-wear, the main goal of these experiments, shows some overlap and the necessity to define what is hard and what is soft. Soft contact materials place the following record on chert: less microflaking, a lack of mechanical edge failure, polish of more surface topography, and a rounding of the edges. Hard contact materials place the following record on chert: more microflaking, pronounced to beginning mechanical edge failure, generalized polish confined to the asperities, and a lack of edge rounding. Overlap into these categories

emerge through two routes: (1) rawhide cutting experiment; and (2) the evolution of macro- and microscopic characteristics, most specifically polish.

**CHAPTER V**  
**ANALYSES OF THE CLOVIS BLADES FROM THE 2000 TEXAS A&M**  
**UNIVERSITY EXCAVATIONS AT THE GAULT SITE**

At the beginning of this project I proposed the following questions: (1) Were the Clovis blades utilized at Gault? (2) Is there a difference in the use-wear patterns of Clovis blades from the geological units 3a and 3b? (3) Is Gault, as a quarry/workshop site, a place to just obtain raw materials or did it also serve as a craft site? In this chapter I intend to answer the first two questions. While I do not plan to definitively answer the third question, I will discuss its ramifications to the Gault site using the blades as a test.

Before proceeding, I would like to reiterate a few vital observations from the previous chapter on experiments, which will have an impact on the analysis presented in this chapter. Raw material plays a role in the recording of use-wear, and microwear in general, on rock. There are early diagenetic phases of the chert (finer grained) and late diagenetic phase (coarser grained than chert, sometimes with inclusions) of the chert. The late diagenetic phase, especially the chalcedony-infilled allocthenous rolled miliolid fragments, take on wear faster than the early diagenetic chert. Soft contact materials place the following record on chert: less microflaking, a lack of mechanical edge failure, polish of more surface topography, and a rounding of the edges. Hard contact materials place the following record on chert: more microflaking, pronounced to beginning mechanical edge failure, generalized polish confined to the asperities, and a lack of edge rounding. Overlap, however, was observed with polish.

Taking these experimental observations into account, I will address the presence of use and differences of use (if present) among the different Clovis units. Since the

logic of the procedures drove the analysis – and the selection of blades/blade fragments for higher levels of analysis – I will present the analysis of the artifacts accordingly: (1) a brief treatment of the blades at the site; (2) stereomicroscope analysis of 233 blades; (4) compound analysis of 24 blades selected from the stereomicroscope sample; (5) two blade fragments selected for SEM/EDS analysis due to the presence of potential residue; and (6) spatial distribution of blades with use-wear.

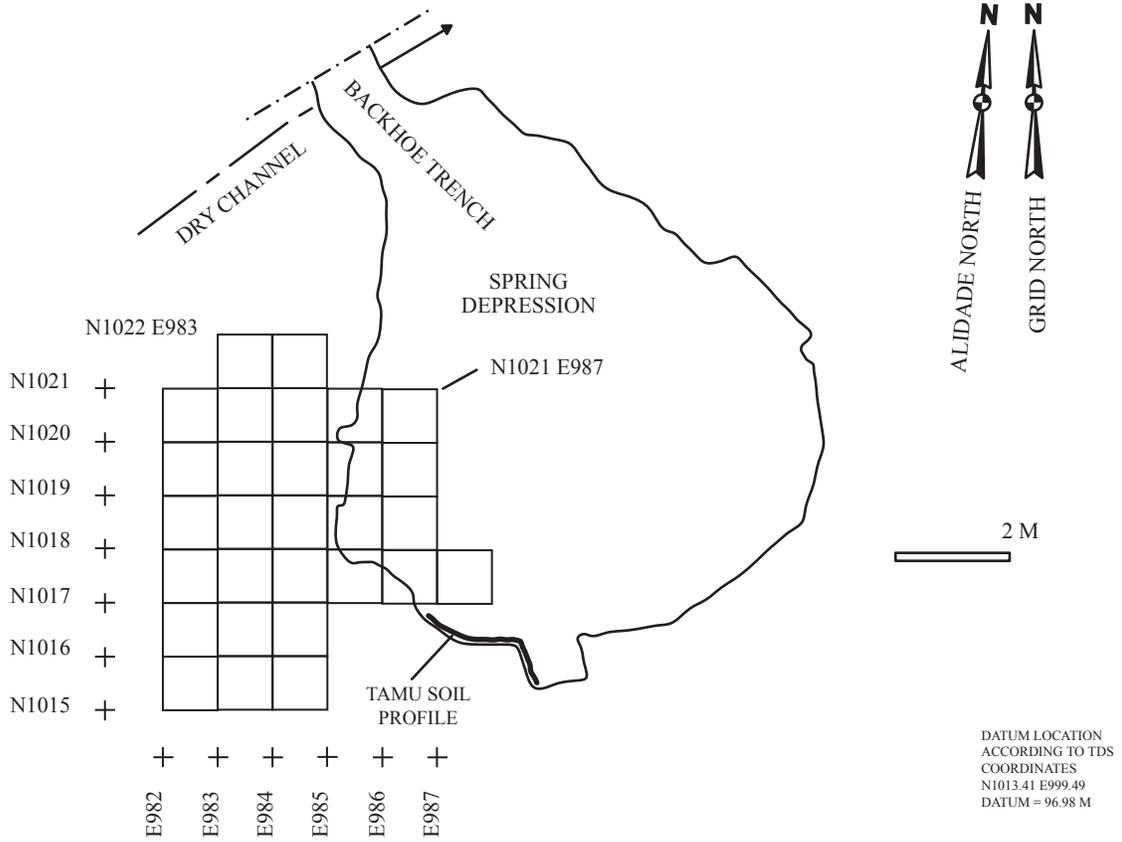
### **Clovis Blades at the Gault Site**

Investigators from the 2000 Texas A&M fieldschool excavated 29 1-x-1 m contiguous units (Figure 8). They recovered blades from three different geological units (Clovis 3a clay, Clovis 3b overbank silty-clay, and Paleoindian 4b). Due to the research focus, blades from 4b were not analyzed. Due to the gradational contact between 4b and 3b, as well as the more important 3a and 3b (designated as 3a/3b), blades excavated from levels of uncertainty were left out of analysis. With these constraints, I selected blades solely from Clovis 3a (268) and Clovis 3b (158), providing a total viable blade population of 426. As discussed in Chapter III (METHODS), the method of organization is based on Bill Dickens' separation of blades by technological categories (cortical, secondary, and interior) as well as completeness (whole, proximal, medial, and distal).

### **Stereomicroscope Analysis**

From the blade population, I separated 233 blades, from the naked eye/hand lens analysis using the attributed described in Chapter III (METHODS). I divided these blades into three main categories: 3a blades, 3b blades, and modified blades. Within the Clovis geological unit separations, I further split the blades by completeness (whole, proximal, medial, and distal), along with a separate designation for crested blades.

a



b

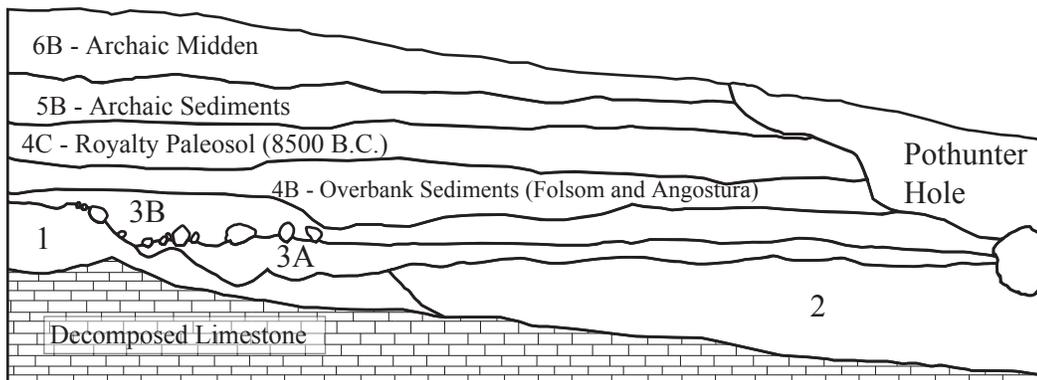


Figure 8. (a) Layout of 1-x-1 m units at the TAMU Gault Site excavations; (b) generalized profile showing locations of the 3A and 3B units.

As stated in Chapter III (METHODS), the variables I used were flake scar patterns, edge and ridge rounding, polish, possible residue, placements of the above, and relationship between all the above. My criteria for advancement included the relationship of the above, rounding, polish, and residue (especially if a combination was visible). A more detailed analysis is provided in the analysis table in APPENDIX D.

### **Blades from Clovis Geological Units 3a and 3b**

Of the stereomicroscope population, 148 (63.5%) blades were from the Clovis clay unit. Of the 148, 73 (49.3%) were interior blades and 75 (50.7%) were secondary blades. Three of the secondary blades were laterally modified. In general, the interior blades showed more rounding and scarring than the secondary blades with high frequencies in all categories except for crested blades. Two blades fragments (AM326 B2 and AM322) and one whole blade (AM304T) were laterally modified. Two other blades (AM347F2 and AM408I) exhibit both polish and striations. The combination for AM408I corresponds with the possible residue, while that on AM347F2 correspond to around the ridge and by the break.

Of the stereomicroscope population, 85 (36.5%) blades were recovered from the Clovis overbank unit 3b. Of the 85, 49 (57.6%) were interior blades and 36 (42.4%) were secondary blades. Compared to the blades from 3a, the 3b blades exhibit a lower frequency of rounding and microflaking. Three interior blades (AM240A, AM291I, and AM285B) were distally modified, a modification not seen in 3a blades. In general, proximal and medial blade fragments exhibit the most rounding and scarring. Two blades (AM187B and AM175D) exhibited possible polish while none exhibited striations.

### **Clovis 3a and 3b Modified Blades**

Of the 3a and 3b blades, there were 5 blades initially separated from the population as modified, or intentionally shaped, blades. Modified blades from Clovis 3a include two (AM328B2 and AM322) are deeply serrated refits along with a laterally shaped blade (AM304T). Both Clovis 3b modified blades are distally shaped with comparatively limited lateral scarring. Of all blades analyzed, these were the ones originally intended to receive the full spectrum of microwear analysis from the beginning. In stereomicroscope analysis, I observed no polish or striations on the modified blades, but rounding was visible, to certain extents.

### **General Observations**

Certain patterns (Figure 9) emerged from the stereomicroscope analysis of the Gault blades. I observed few instances of polish with the stereomicroscope. Of particular note was the 3a Interior medial blade AM347F2, which had highly visible polish and striations even at 12x magnification (see APPENDIX E, Figure E-11a). Evidence of striations was almost nonexistent on the blades while using the stereomicroscope, with the exception of the two 3a interior medial blades AM347F2 and AM408I (see APPENDIX F Figures F-1 and F-4). On numerous occasions, I noticed that substances adhered to blades and considered them possible residues until further investigated. I separated them into five categories (1) orange-brown and black; (2) isolated orange-brown spots; (3) glue-like homogenous; (4) black-dark blue; and (5) calcium carbonate. The substances for all of these categories appeared to be on the surface, adhering as noted by Levi-Sala (1996). I also noted the occurrence of flake scars (isolated, discreet, continuous) and rounding of edges. Finally, commensurate with the

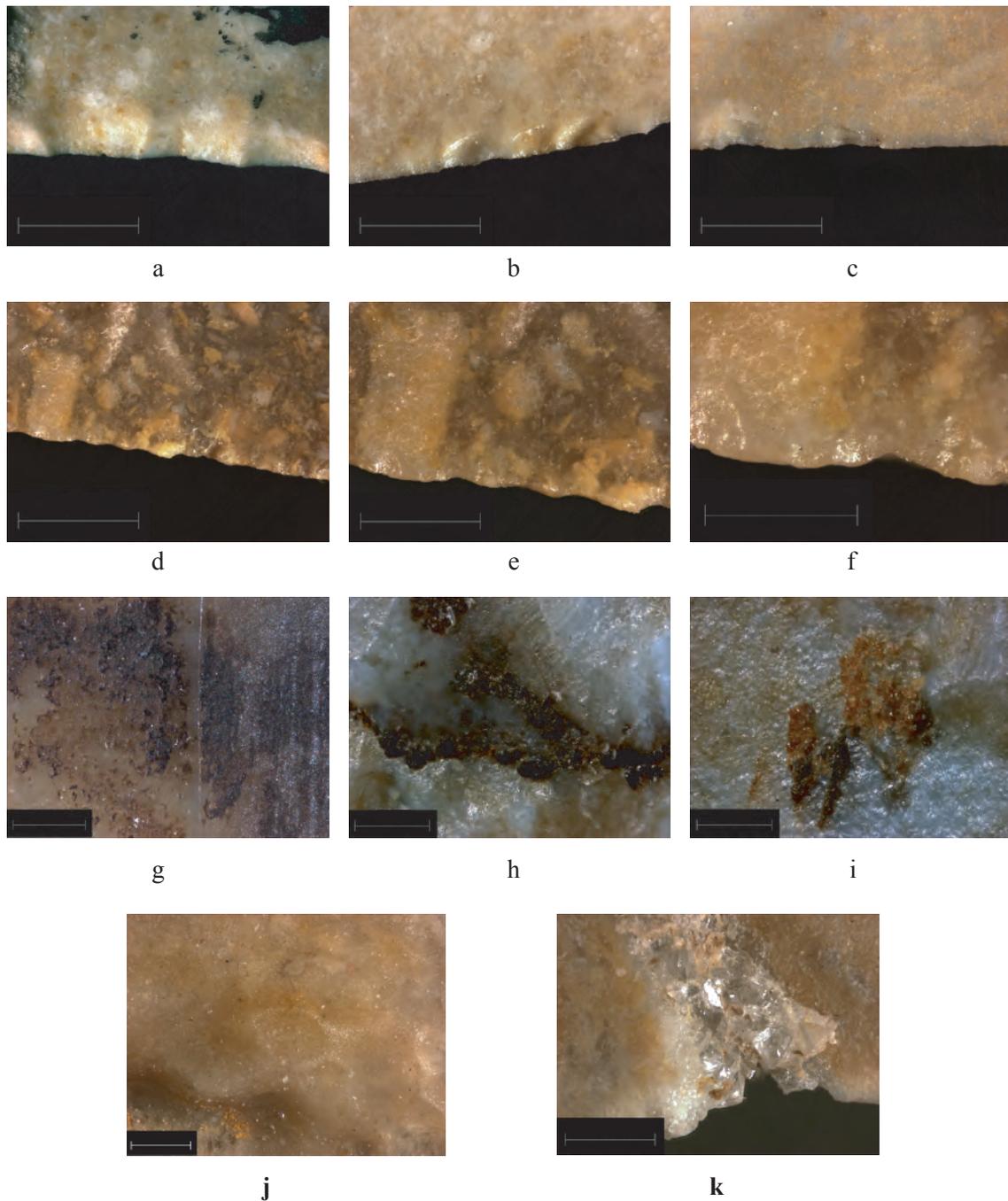


Figure 9. Stereomicroscope patterns: (a) continuous scar example on AM261 at 20x; (b) discrete scars example on AM392V2 at 40x; (c) isolated scars example on AM244T2 at 20x; (d-f) rounding and fossils on AM319E3 at 20x, 40x, and 100x; (g) black residue pattern on AM408I at 40x; (h) black residue on AM392X at 100x; (i) orange-brown residue on AM392X at 100x; (j) homogenous residue on AM285B at 40x; (k) quartz vug in AM261 at 20x. Scales: 20x = 1.25 mm; 40x = 0.50 mm; 100x = 0.250 mm.

variability noted in the Edwards chert (see CHAPTER III), the following characteristics were noted: (1) quartz infilling; (2) grainy rhombohedral-like crystals in the cortex; and (3) fossils, the best evidence of which is available in the 3a interior whole blade AM319E3 (see APPENDIX E Figure E-12). It was the fossiliferous chert that retained the most rounding.

### **Limitations Within Microscope Use: Determining the Analysis and Bridging the Gap Between Stereo and Compound**

During stereomicroscope analysis I observed a lack of distinguishable polish and striations, save for AM347F2. Keeley (1980:12) notes stereomicroscope limitations as a deterioration of image beyond 50X magnification and difficulty with photographing the large depth of field. Since my stereomicroscope work revealed little in terms of polish and striations, I proceeded with three hypotheses as to why I was not able to see these characteristics: (1) I could not recognize these attributes, (2) there is less of a degree of blade use than previously thought, and (3) there are limitations to the stereomicroscope for distinguishing between polish and striations.

I was fortunate enough to look at a Mississippian hoe from Ohio, generously lent for viewing by William Dickens. Aside from macroscopically visibly polish and striations, patterns were more so visible under the stereomicroscope. Although not a robust sample by any means, I considered this a reinforcement of my ability to recognize polish and striations under the stereomicroscope. AM187B proved a similar sample and my experimental pieces exhibited little presence under the stereomicroscope, necessitating the reliance on the compound analysis.

My research questions covered the use presence/absence of use-wear and difference of use-wear patterns between sedimentary units 3a and 3b. I realized an erroneous assumption on my part while reviewing this, my aforementioned ability to recognize use-wear, and my overall lack of success finding extensive use under the stereomicroscope. I held the assumption that use-wear was, when present, easily recognizable. My experiments, although eluding the falseness of the assumption, were biased by my control of where the patterns were placed.

I observed both of Keeley's limitations while working with the Leica Z12.5 stereomicroscope. Distortion was especially evident from 80X up, even through the microscope's oculars and lenses and not just the translation through the digital camera. Scope-Pro and In-Focus corrected for most of the second problem, except at the lowest magnifications and large depth of field. Using the Leica DM LA microscope would be an additional test to the limitations of the stereomicroscope.

### **Compound Analysis**

Of the 231 stereomicroscopically analyzed Gault blades, I selected 24 for analysis under the Leica DM LA compound microscope. Sixteen blades were from Clovis 3a and 8 were from Clovis 3b. These were separated into two categories: blades and blade fragment from Clovis Unit 3a (s=16); and blades and blade fragments from Clovis Unit 3b (s=8).

#### **Clovis 3a Blades and Blade Fragments**

Sixteen of the 24 artifacts examined under the compound scope were found in the Clovis Unit 3a clay deposit. Eight of the artifacts are interior blades and eight are secondary. Six are whole blades (AM319E3, AM424E2, AM412A, AM304T, AM392J1,

and AM264D), one is a proximal fragment (AM252O2), five are medial fragments (AM408I, AM347F2, AM322, AM332, and AM334J), three are distal fragments (AM320V, AM244A2, and AM328B2), and one crested (AM392X1). One whole blade (AM304T) and one medial/distal refit (AM328B2 and AM322) show intentional modification (see Appendix A for definition) on lateral edges. Of these sixteen artifacts, 8 (including AM332/AM203 refit) showed use-wear (see APPENDIX E for analyses and interpretations). Of these, 6 (AM328B2/AM322; AM252O2; AM408I: AM347F2; and AM424E2) are discussed below.

The three modified artifacts from Clovis 3a exhibit lateral edge modification. Of these, the refit of AM328B2 and AM322 (Figure 10) shows the best chance for ephemeral use. The lateral edges of AM328B2 and AM322 form an almost complete serrated blade. Patina obscured most of the dorsal viewing, but a few spots of polish and rounding (on projections and in scars) are visible. A thin band of polish is on the ventral edge on the peninsulas of the denticulates (location B – spine angle of 26° and an edge angle of 47°). Polish on the edge of the scars, as well as right up to the steps, suggest an angled position favoring the ventral face, such as that seen for the dorsal face of the sinew cleaning (NWXP3) and rawhide cutting (NWXP4) experiments. The location of the polish, on the distal facing portion of the denticulate, suggests one motion directed toward the distal end, similar to NNWXP2 (reaping grass). The duration of use is most likely on soft material and ephemeral, also owing to the unusually well preserved denticulates, minor rounding, and shallow invasiveness.

A proximal blade fragment AM252O2 (Figure 11) is modified on the right lateral edge. A weak polish is present on the right and left lateral edge (location A, spine angle

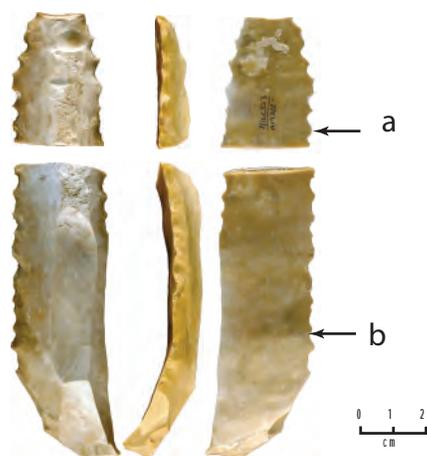
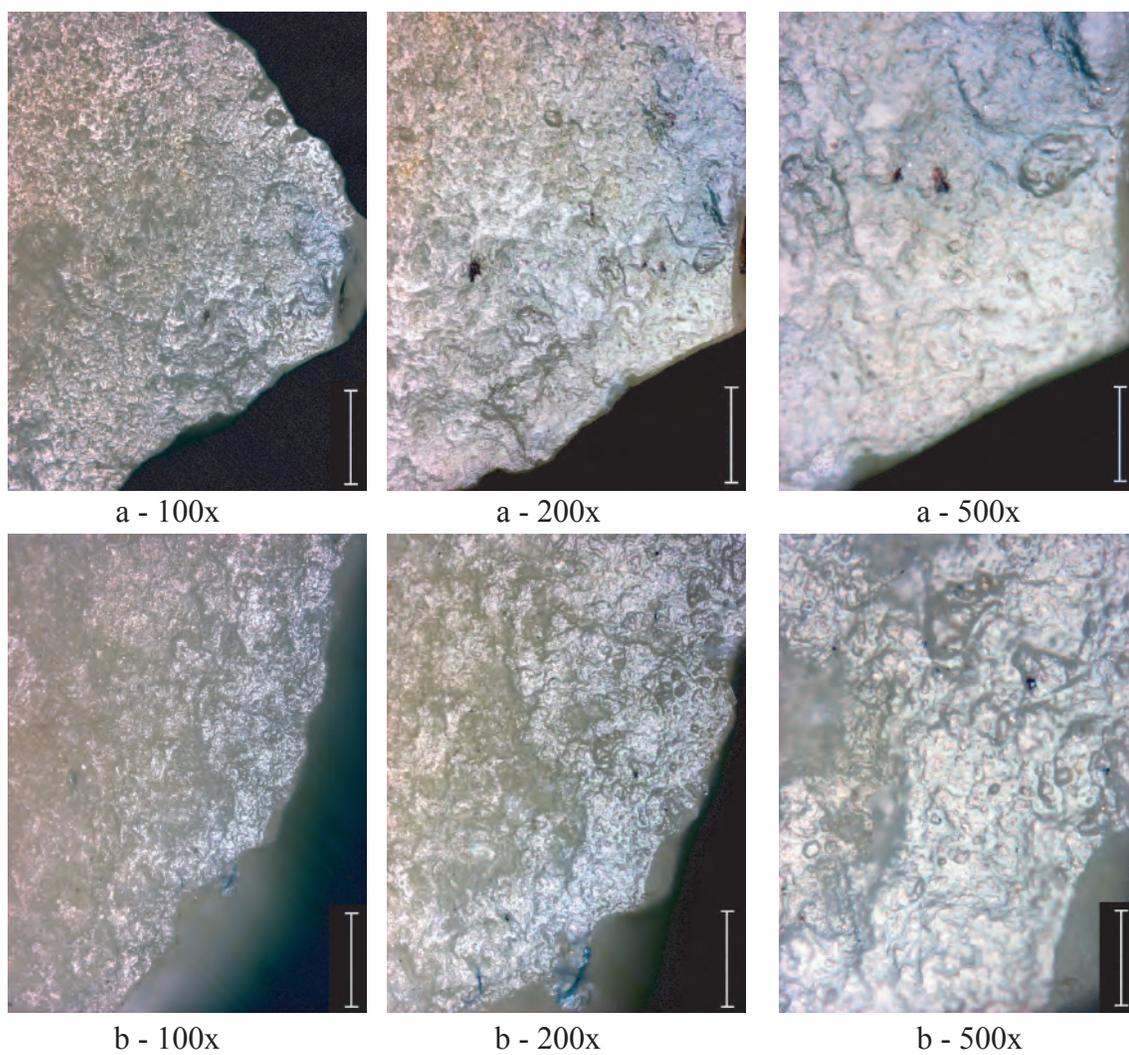


Figure 10. Clovis 3a Blade Refit AM322 (Cat #279) and AM328B2 (Cat #278): (a) location of polish on peninsula on AM322; (b) location of polish on peninsula for AM328B2. Scales: 100x = 200um; 200x = 100 um; and 500x = 50 um.

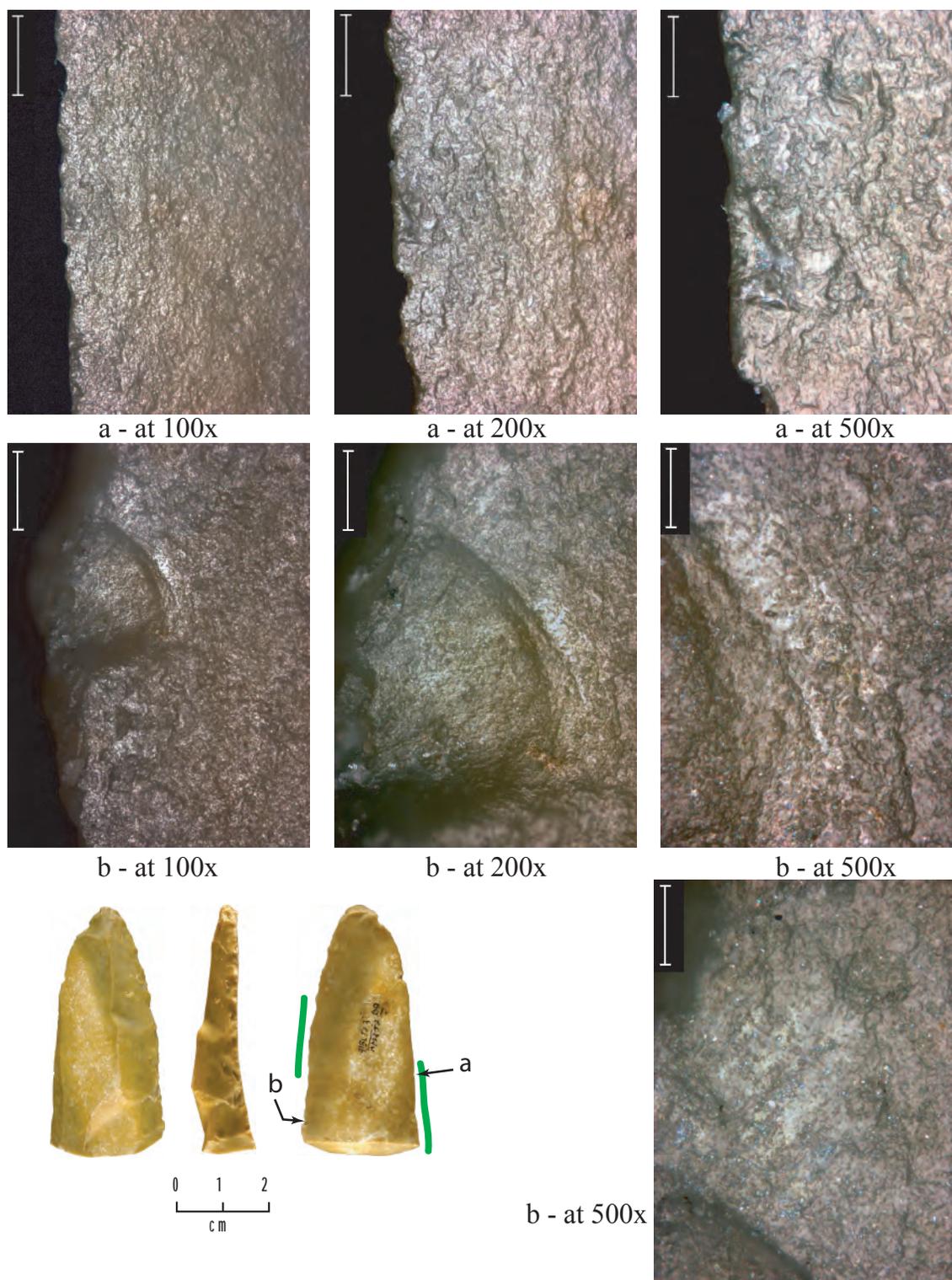


Figure 11. Clovis 3a Blade AM25202 (Cat #436): (a) location of weakly linked polish; (b) location of discreet planed polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

62°), with no topographic changes. The lower right lateral edge of the dorsal face (location B, spine angle of 47° and edge angle 58°) had sporadic spots of heavily linked polish similar to that seen on locations C and D of AM320V (APPENDIX E). The weakly rounded edges and weakly linked polish on both lateral edges (location A) most closely resembles GRT 4-1 (scraping wood). The planar polish (location B) most closely resembles the polish seen on NNWXP1 (sawing wood). Based on the analyses and experimental results, the blade was most likely a multi-use artifact. Investigations were inconclusive as to use before or after breakage.

Blade AM408I (Figure 12; see also SEM/EDS section in this chapter, as well as APPENDIX F) contains grooves and scratches on the residue band in multiple locations. The grooves (location A – spine angle of 38°) have regularity in spacing and are a 200<sup>th</sup> of a millimeter deep. No polish was observed. Thinner striations are located on the central scar, sometimes referred to as “plateau”, with spine angles of 38°. These striations are arc-shaped going multiple directions. There is no direct evidence for blade use. No polish was located on the edges. Polish was observed only on the residue strip on the dorsal side.

The five other whole blades, in general, exhibit little evidence for use with the exception of AM424E2. Polish on AM424E2 (Figure 13) is weak grading into heavily linked towards spots on the edge on the ventral face of the mid left lateral edge (location A, 68° spine angle just catching part of another blade removal). The striations are wide u-shaped, except for near the microflaking (dense and u-shaped), oblique to the edge. The polish pattern is most similar to that seen on experimental blade NWXP3, used to clean sinew (38-41° spine angle). If any experimental work matches the striations, it is

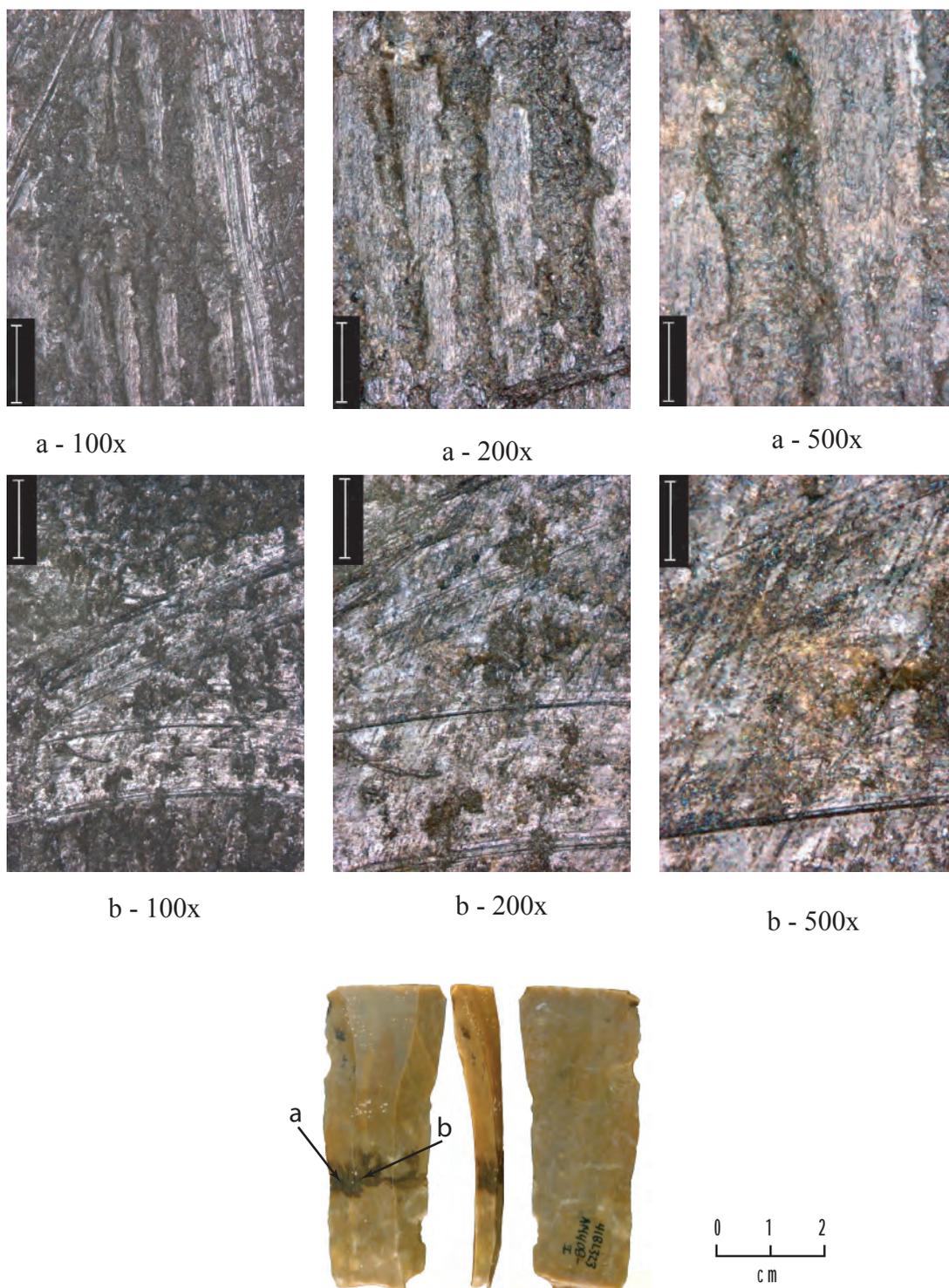


Figure 12. Clovis 3a Blade AM408i (Cat #671): (a) location of deep u-shaped grooves in Fe-Mg-Ca; (b) location of u-shaped arc grooves on faceted plateau in Fe-Mg-Ca. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

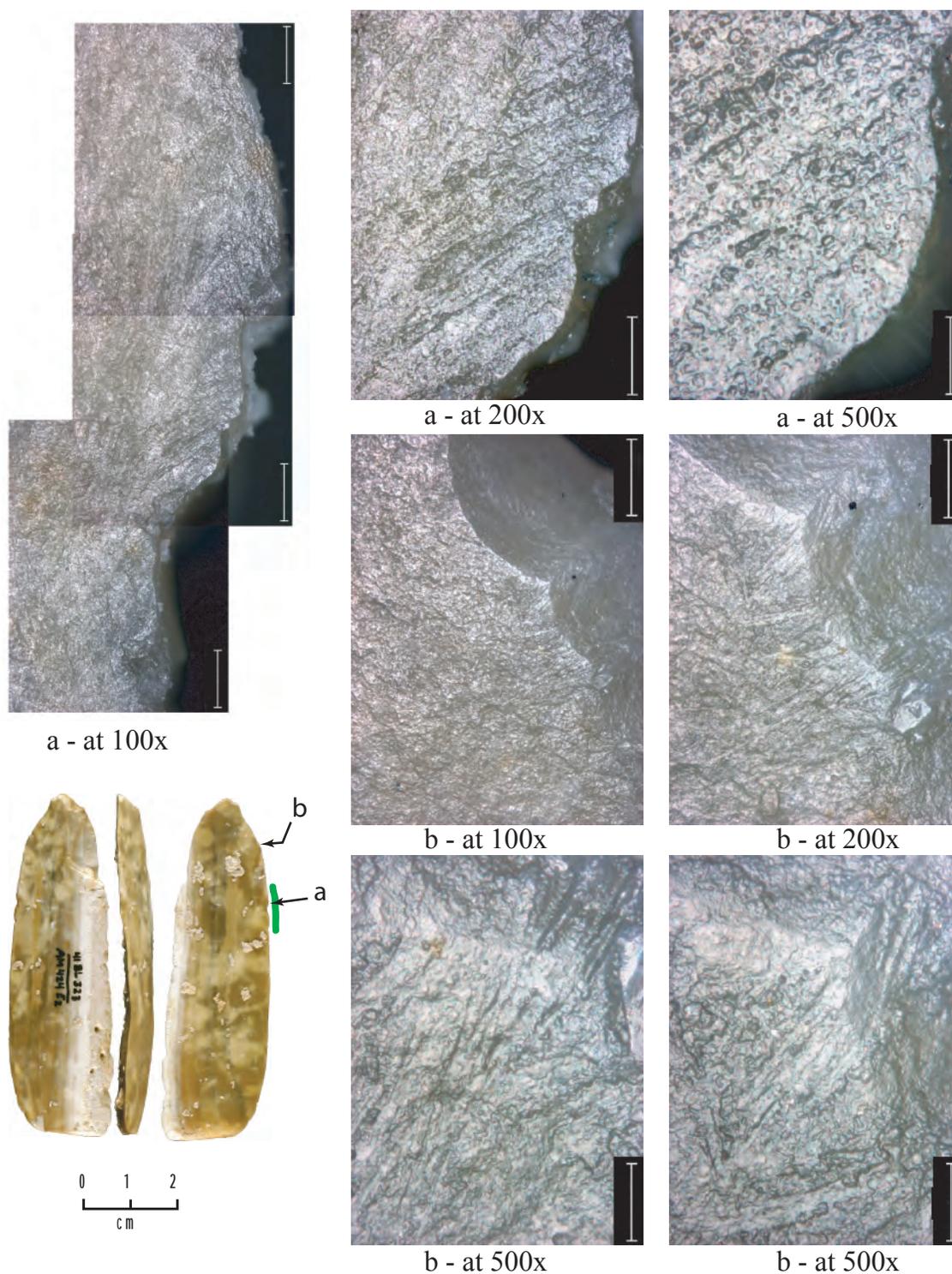


Figure 13. Clovis 3a Blade AM424E2 (Cat #698): (a) location of oblique striations and polish; (b) location of discreet deep u-shaped striations. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

NWXP4 (cutting rawhide). The degree of polish, similar directions of striations, and lack of heavy microflaking lead to a multiple direction (see 100x images) motion (most likely sawing or a mixture of sawing and cutting) of a harder soft material comparative to rawhide, but at a longer duration.

Blade AM347F2 (Figure 14), a medial fragment, shows what looks like lengthwise directional polish on the dorsal face up to the break (edge angle of 87°). Compound analysis revealed a thick, or heavily planar, and uneven polish. Due to the location on the break of an artifact at 87°, Jim Weiderhold and I tested the polish with acetone and a toothpick after careful documentation. Upon reexamination, a majority of the polish disappeared. We were left with a portion of the polish remaining and new linear polish marks based on the toothpick motions. At 500x, I could not see if the surface microtopography was similar to other pieces. A possible explanation for the polish disappearance is a shift in surface angle, as suggested by Dr. Marvin Kay. As seen in the analyses of other blades, even a slight shift of which can change the pattern. If used, the blade was used before breakage and heavily used on soft material, closest to those seen on experimental blades NWXP3 (sinew cleaning) and NWXP4 (rawhide cutting), but under a longer duration. Due to the problematical nature of this blade, I am inconclusive as to the positive identification of the polish and, if positive, the use of the blade.

### **Clovis 3b Blades and Blade Fragments**

Eight of the 24 artifacts examined under the compound slope are from Clovis Unit 3b overbank deposit. Six of the eight are interior blades and two are secondary. Three blades (AM187B, AM291H, and AM171) are whole. Two fragments (AM303J and

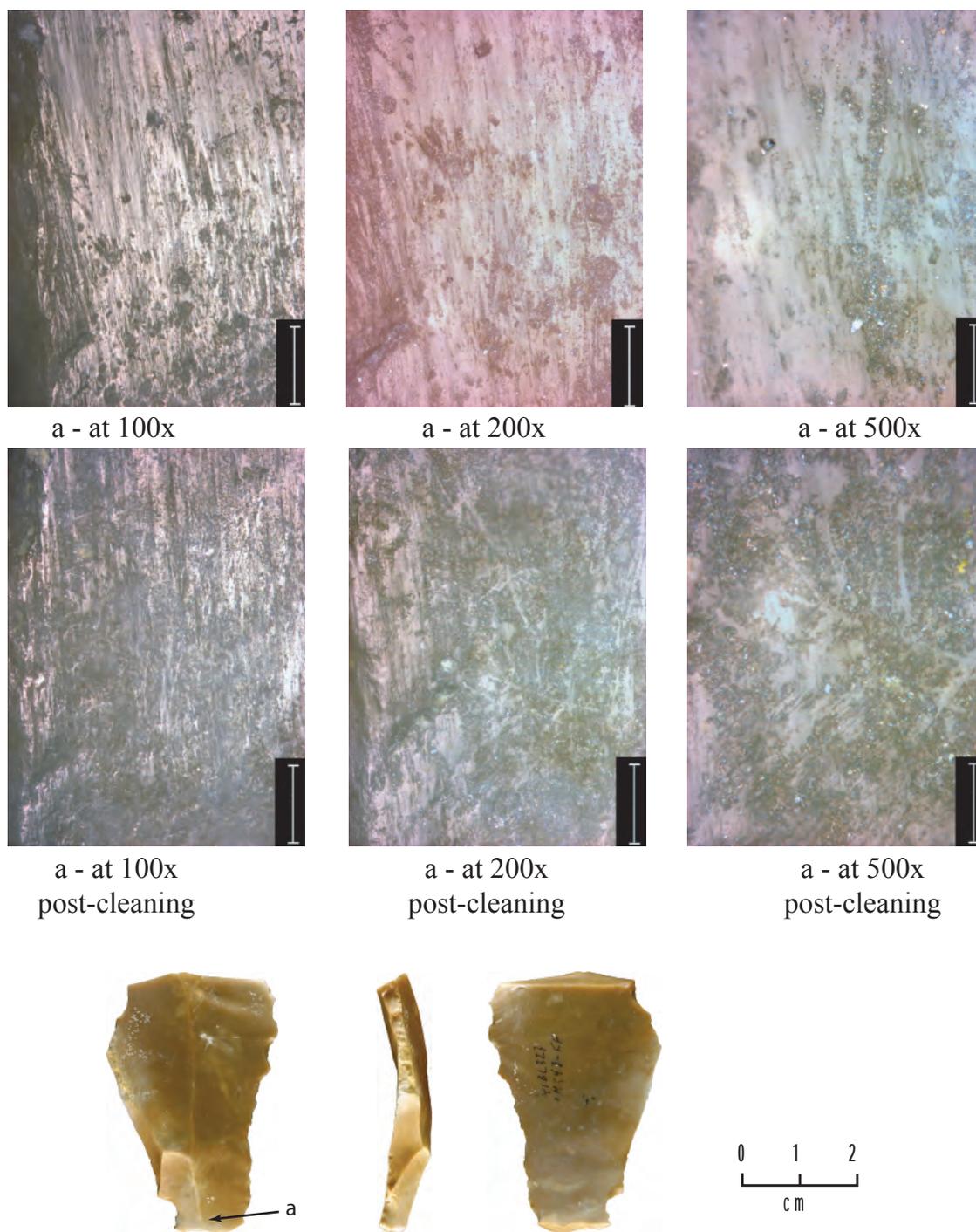


Figure 14. Clovis 3b Blade AM347F2 (Cat #301): (a) compound microscope location of polish at the distal break before cleaning ; (b) compound microscope same location the polish, post-cleaning.

AM175D) are medial and three fragments (AM285B, AM240A, and AM203) are distal. Two whole blades (AM291H and AM187B) and two distal fragments (AM240A and AM285B) show intentional modification on their respective distal ends. Presented here are the blades AM291H and AM285B.

Blade AM291H (Figure 15), a distally and laterally modified whole blade, shows two directions of u-shaped striations arcs going transversal to the lateral edges and distal end (Figure 15, location B). The striations are densely packed and of varying sizes. The arc-shaped striations overlap the oblique straight shaped striations (location B at 200x and 500x). This location has a spine angle of  $42^\circ$  and an edge angle of  $60^\circ$ . Well-linked polish is visible on the dorsal face of the upper left lateral (location A). This well-developed polish, located above the flake scar and on the later diagenetic chert portion of the blade, hit the asperities and suggests an origin from a hard contact material. This blade was used for scraping, or possibly planing hard materials (hard wood or most likely bone) due to its similarity to the horn planing of experimental blade NNWXP1 (with a used edge angle of  $66^\circ$ ).

Blade AM 285B (Figure 16), a distally and laterally modified whole blade, showing deep, thin, and densely packed u-shaped striation going transverse to the distal edge. The microtopography is visible between the thin striations and eradicated in the wider u-shaped striations in-between. A pattern emerged from the striations of a package of dense striations (six visible in the 500x image of location A), followed by one wide striation, followed by a package of dense striations, and so on. A faint pattern of the striations was visible in the flake scars. Aside for the striations, there is linked polish on the ridges between the flake scars (location B). The angle of the edge is  $42^\circ$  on a bifacial

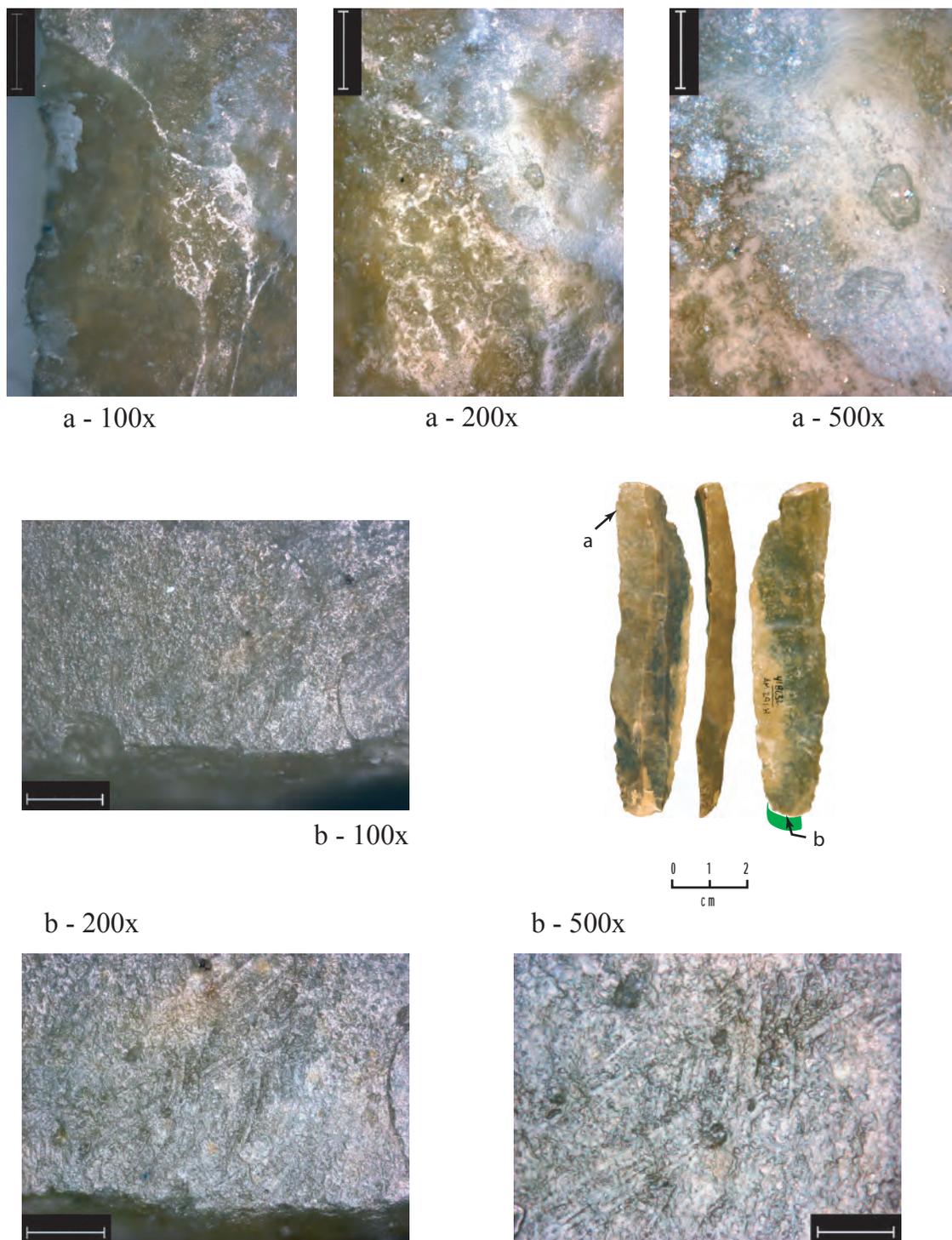


Figure 15. Clovis Blade AM291H (Cat #443) : (a) location of well-linked polish; (b) multiple-direction shallow u-shaped striations. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; 500x = 50  $\mu$ m.

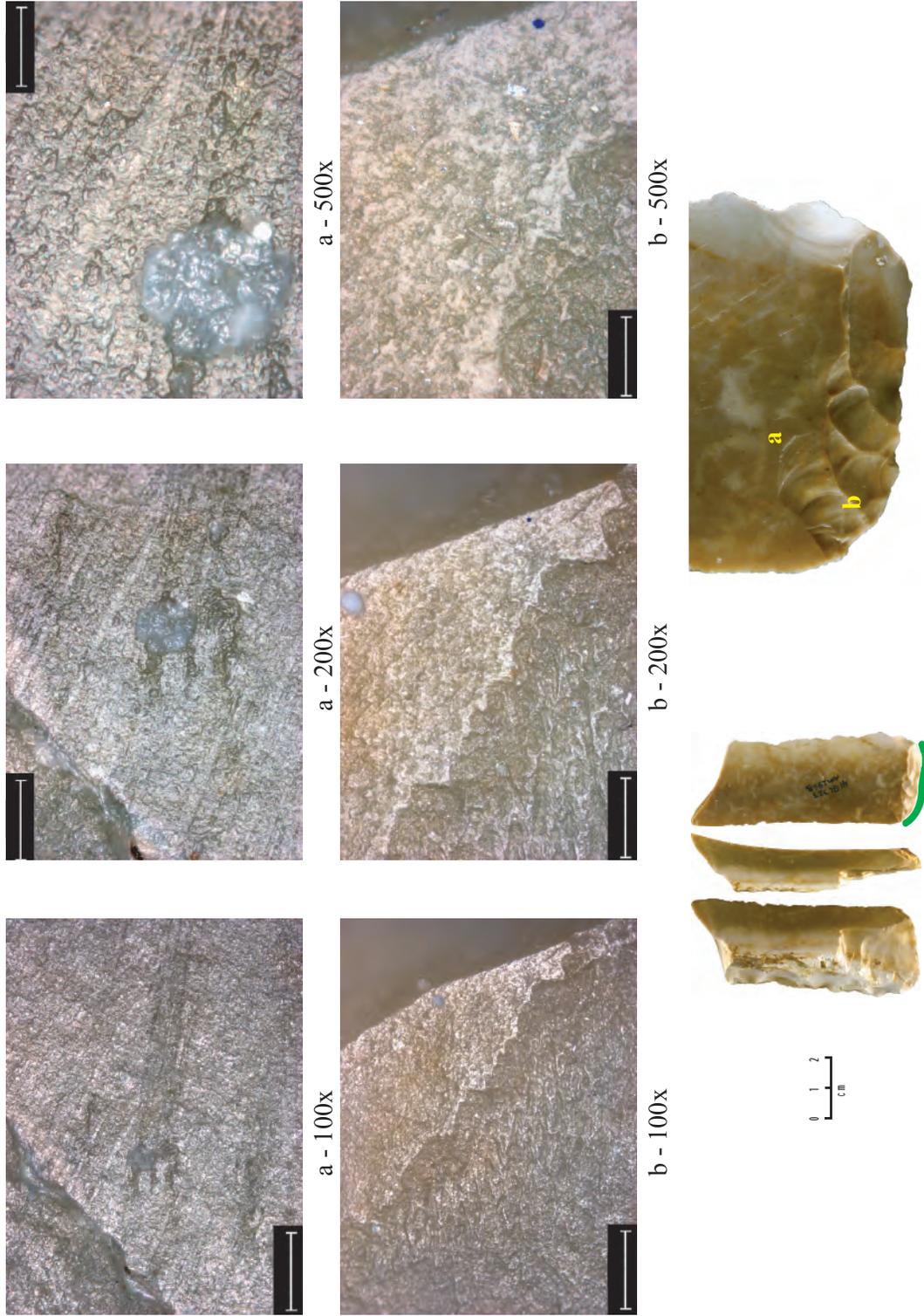


Figure 16. Clovis 3b Blade AM285B (Cat #265): (a) location of densely packed u-shaped striations; (b) polish on high spot. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

edge. AM285B was used for planing, or possibly scraping hard materials (most likely bone) due to its similarity to the horn planing of experimental blade NNWXP1 (proximal edge of 66°). The motion of AM285B was one direction on a consistent surface. A lack of polish on the rest of the blade gives rise to the inference of only distal edge use. An early hypothesis was hafting, especially given the “glue-like substance” (early remark on its homogeneity) on the ridge toward the break (see SEM/EDS Analysis section and APPENDIX F for a more detailed analysis of the adhering substance).

### **SEM/EDS Analysis**

As discussed previously, residues were discovered on blades during stereomicroscope and compound microscope analyses. To test these, I conducted SEM and EDS analyses on AM408I and AM285B. For a more detailed treatment, see APPENDIX F. With the discovery of substances on blades from Gault, I formulated two working hypotheses: (1) the substance(s) are residues from hafting or use; and (2) the substances are from natural accretions or staining and not related to hafting or use.

I conducted the analysis under the guidance of Dr. Marvin Rowe of the Department of Chemistry at Texas A&M University. Dr. Michael Pendleton, of the *Microscopy and Imaging Center* at Texas A&M University, provided operation of the equipment. The *Microscopy and Imaging Center* provided SEM and EDS equipment. The JSM-6400 is equipped with a Princeton Gamma Tech (PGT) Prism Digital Spectrometer EDS System.

### **Results for AM408I**

For the SEM/EDS analysis of AM408I (Figure 17), we took a total of 16 readings. Of these 16, 10 were taken on what was thought to be residue. Of these 10, four are

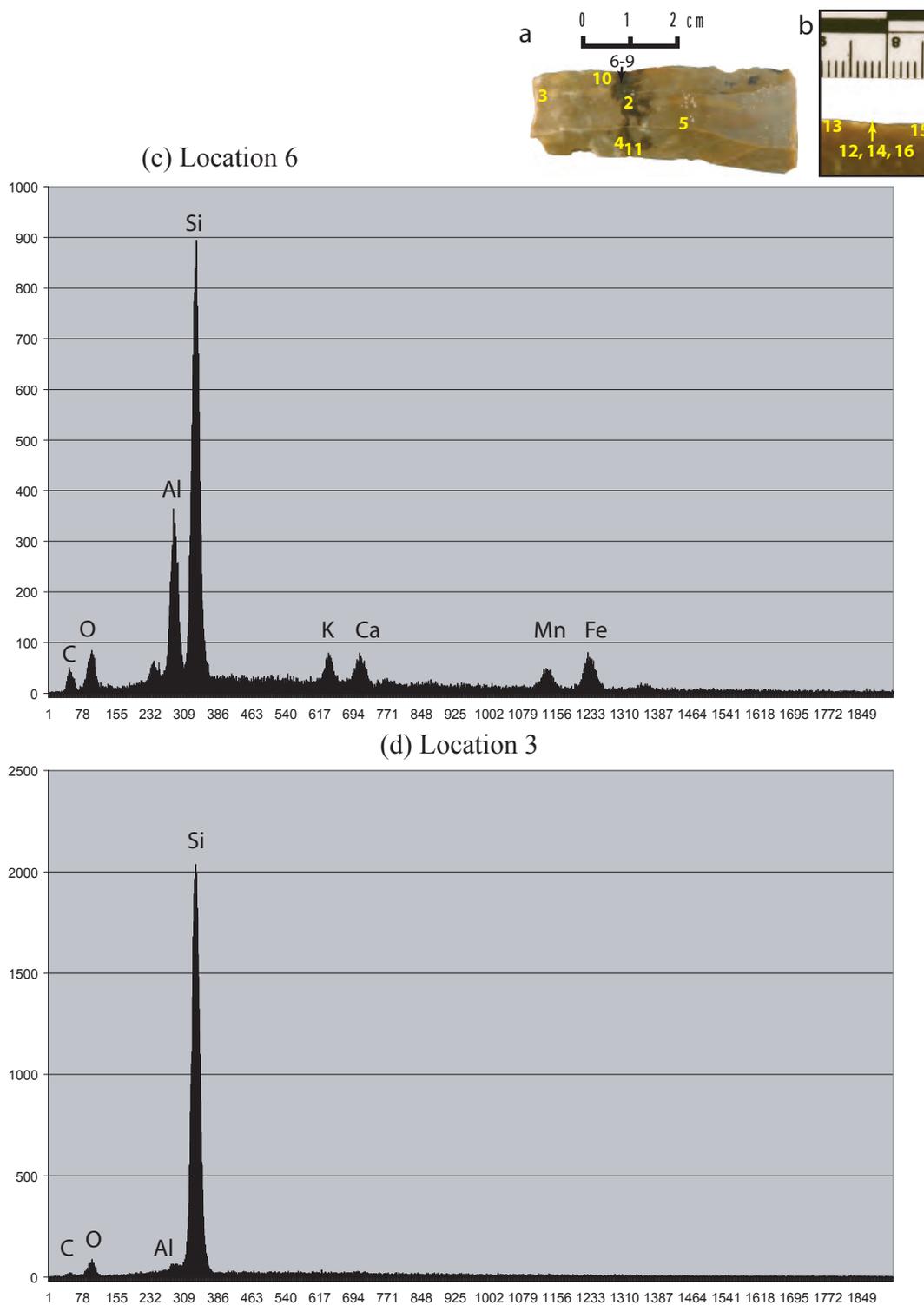


Figure 17. Clovis 3a Blade AM408 I (Cat #671): (a-b) locations of EDS readings; (c) EDS reading of residue staining at Location 9; (d) EDS reading of clear spot at Location 3.

interpreted as chert without anything adhering to the surface (labeled “clear”). The six other EDS readings show a marked difference from the others. Although the high ratio of silica (Si) remains consistent, there are elevated ratios of aluminum (Al), carbon (C) oxygen (O), and iron (Fe). In addition is the presence of manganese (Mn), magnesium (Mg), potassium (K), and calcium (Ca) show a marked difference from the “clear” areas.

### **Results for AM285B**

SEM/EDS analysis of AM285B, we took a total of four readings (Figure 18). Of these, three were calcium (Ca), silica (Si), and aluminum (Al) – with lower ratios of carbon (C), oxygen (O), and iron (Fe). The presence and distribution of these provides the identification of calcium carbonate. The “cortex” spot was a high ratio of silica (Si) to oxygen (O), with no other elements distinguishable. This indicates that that the EDS reading was taken on chert.

### **SEM/EDS Conclusions**

Upon completion of the SEM/EDS analysis, Dr. Rowe and I interpreted the results and inferred the following conclusions:

1. The possible residues are not organic,
2. Blade AM408I has iron-magnesium calcium staining,
3. Blade AM285B has a partial ridge covering of calcium carbonate.

Limestone (Comanche Fm) and dolomite (Edwards Fm) provide sources for calcium (Ca) and magnesium (Mg). With the redox conditions in units 3a and 3b, along with a fluctuation of groundwater levels and the mobilization of the iron (Fe) and magnesium (Mg) provide a source for the occurrence of the elements on the EDS results of the “residue” band of AM408I.

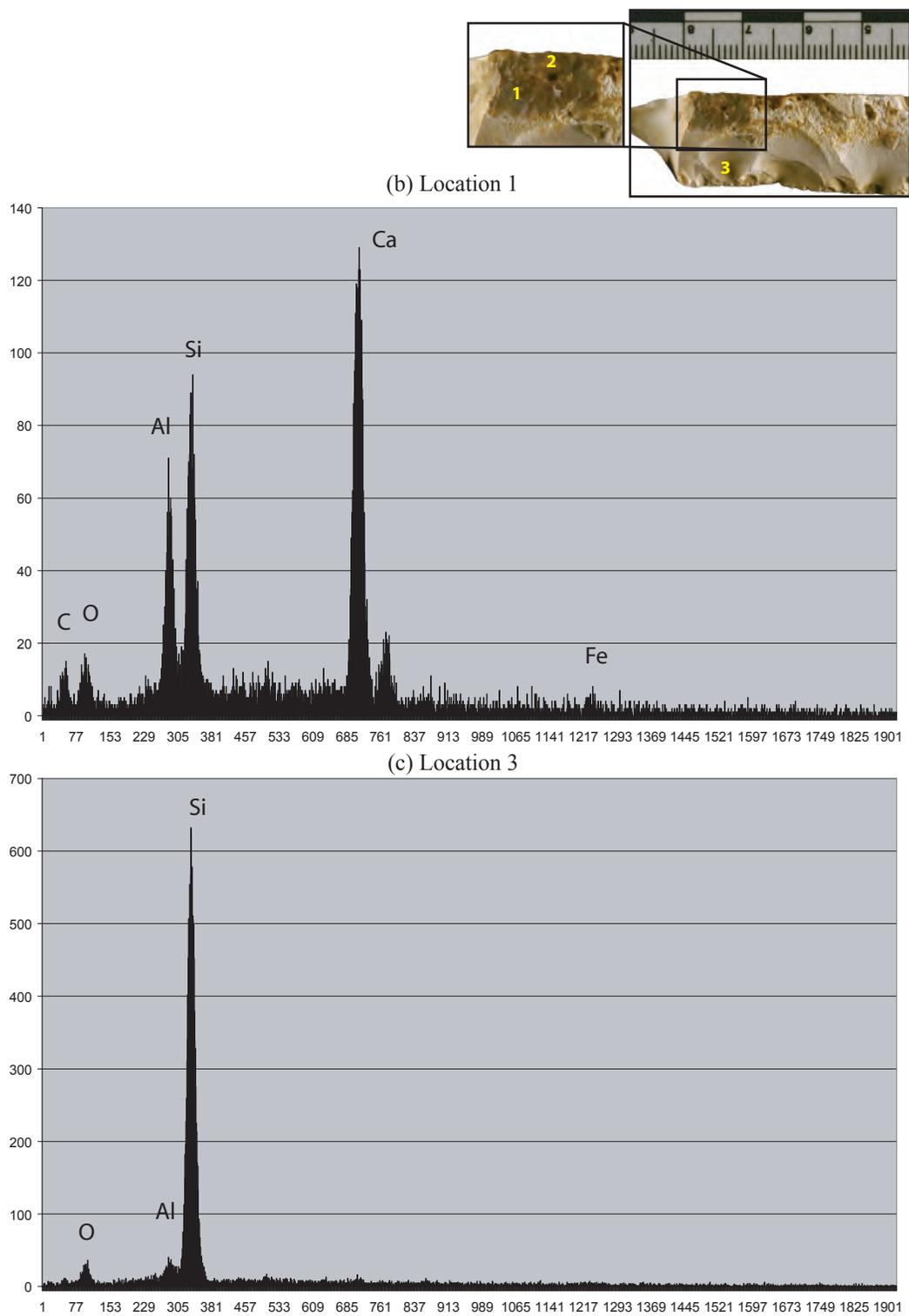


Figure 18. Clovis 3a Blade AM285B (Cat #265): locations of the EDS analyses (a) EDS reading of Location 1, calcium carbonate; (b) EDS location of chert.

The possible reasons for these stains/coatings are offered by the following alternative hypotheses:

1. The stain (AM408I) is part of the chert.
2. The chert had organic material and went into an anoxic stage.
3. The chert (AM408I) had a painted strip – remote.

### **Summary and Conclusions: Trends and Spatial Characteristics**

Fourteen of the twenty-four analyzed blades exhibited use-wear to varying degrees: 8 from Clovis Unit 3a and 6 from Clovis Unit 3b. In general, Clovis 3b blades were used on harder contact materials (wood to bone) than those in Clovis Unit 3a (softer contact materials similar to grass, sinew, and rawhide). The blade distributions (Figures 19 and 20) are described below.

#### **3a Blades and Blade Fragments**

Eight Clovis Unit 3a blade artifacts exhibit use-wear (Figure 19). AM328B2 (N1017.65, E984.68) and AM322 (N1017, E984) refit as a thick serrated blade that was used on soft material with a unidirectional stroke towards the distal end. AM252O2 (N1020.43, E983.7) was a multi-use artifact on hard contact material. AM424E2 (N1018.1, E983.61) was used for cutting and/or sawing on harder soft contact materials, like that seen on the rawhide cutting experiment. AM347F2 (N1017.97, E984.58) was used before breakage and heavily used on soft material closest to those seen on experimental sinew cleaning and rawhide cutting blades. AM304T (N1020.26, E984.44) was used on the upper left lateral, upright placement when used, and has a closest pattern is the cutting of rawhide. AM264D (N1017.63, E985.21) and AM334J (N1017.45, E982.58) have ephemeral use-wear, most likely from soft contact material.

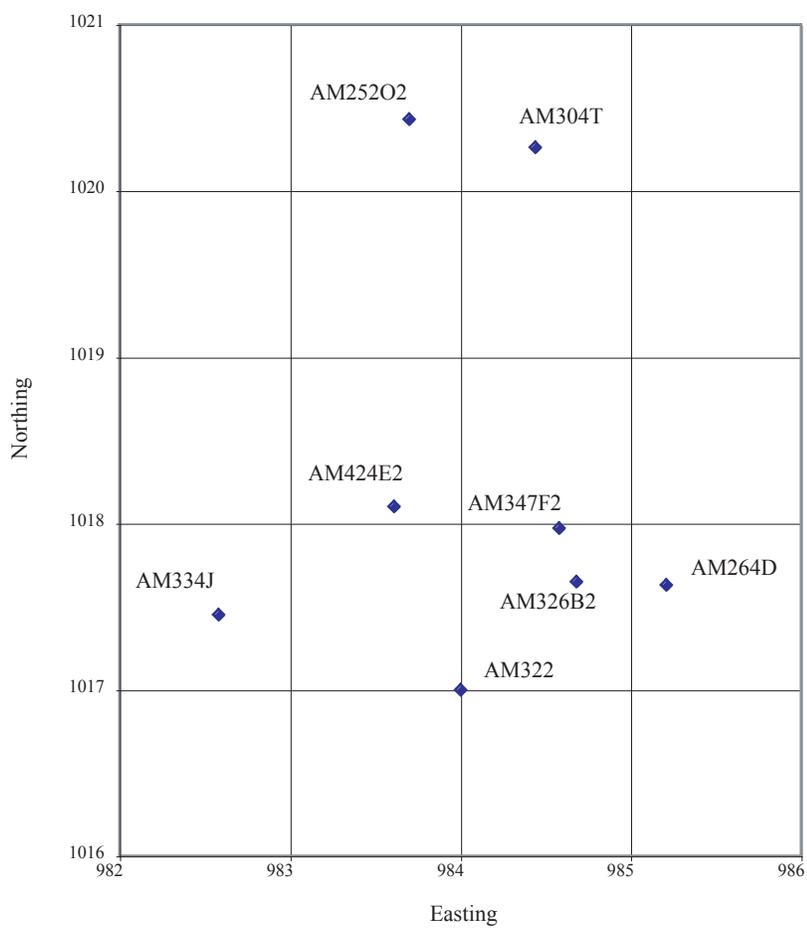


Figure 19. Distribution of Clovis 3a blade/blade fragments in the TAMU 1-x-1 m units.

Nine Clovis Unit 3a blade artifacts were not used. These include: AM412A (N1017.64, E983.85), refit AM332 (N1018, E984)/AM203 (and N1018, E982), AM319E3 (N1017.58, E983.15), AM244A2 (N1019.75, E982.55), AM392J (N1017.9; E938.78), AM320V (N1018.93, E984.32), and AM392X (N1017.7; E938.38). AM408I (N1018.17, E984.7) was not used, but exhibited an interesting band of iron-magnesium calcium staining/encrustation on its dorsal face.

Blades AM328B2, AM347F2, and AM264D are in the N1017, E984/985 intersection of units. AM322 was not piece plotted, but comes from N1017, E984. These are, with the exception of AM347F2, associated with use on soft contact materials. About 1 m west of AM347F2 is AM424E2, with AM334J approximately 1 m to the latter's southwest. Blades AM252O2 and AM304T, associated with harder contact materials, are closest to each other, under 1m, in N1020 E983/984.

### **3b Blades and Blade Fragments**

Distally modified blades AM291H (N1020.21, E984.95) and AM285B (N1017.92, E982.28) were used to plane hard material, but were excavated > 2m from one another. AM240A (N1021.68, E984.16), a distally modified blade showing no or very little use-wear, came from the northern units of excavation.

The other 3b blades (AM303J, AM187B, AM171, and AM175D) come from dispersed locations. AM303J (N1018.7, E984.23) has a well-linked polish most similar to the bark scraping of experimental blade GRT-4-1. In opposition to the harder contact material, AM187B (N1016.47; E982.76) has weak and does not match experimental patterns, save for the early formative polish of hard contact material (see NNWXP1 – sawing wood). Since this is on the opposing side of the flake scarring, the use is more

likely a result of soft contact. Location C on AM171A (N1017.80, E983.65) looks like the pattern on NWXP1 (sawing horn) location C, indicating rubbing/abrasion from a hard material with the blade angled for that ridge to come into contact. Location A is much more linked than the wood sawing experimental blade (NNWXP1). The right lateral edge was used on hard material, commensurate with the microflaking on the right lateral edge, but most likely on finer work. AM175D (N1019.95, E982.58) pattern (locations B and C) most resembles wood sawing (NNWXP1) due to its limitation, but is most likely not due to its localization and blade morphology (thin spine angle and presence of microflaking along the edge).

When plotted (Figure 20), the blades produce an evenly dispersed pattern. Each blade is in a separate 1-x-1 m unit. Based on these observations, as well as a small sample size ( $s=7$ ), I cannot conclude activity loci.

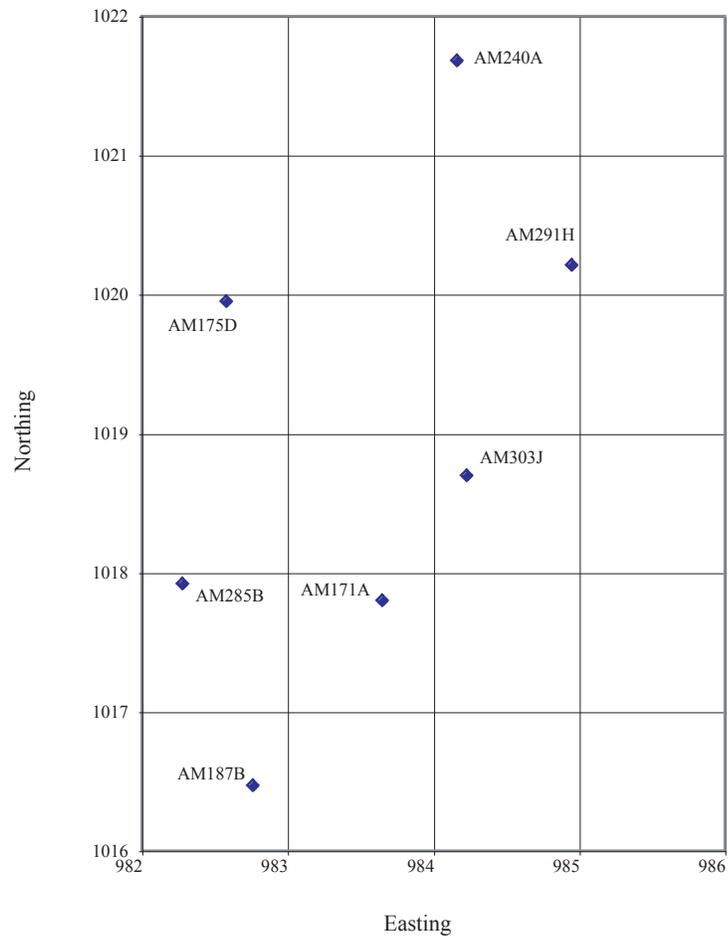


Figure 20. Distribution of Clovis 3b blade/blade fragments in the TAMU 1-x-1 m units.

## **CHAPTER VI**

### **CONCLUSIONS AND DISCUSSION**

The final chapter represents: (1) the conclusions of the previously presented microwear research on Gault Clovis blades; and (2) a literature review of hypotheses for non-extractive industries at quarries and workshops; and (3) a supplemental comparison of Gault with three other quarry-workshops in the United States, based on their relationship to the raw material, geomorphology, and relationship to water resources.

#### **Experimental Blades and Clovis Blades Used at the Gault Site: Summary and Conclusions**

The first two research questions proposed for this thesis are: (1) were Clovis blades used; and (2) if they were used, is there a difference in use between the sedimentologically separate Clovis units 3a (ponded clay) and 3b (overbank deposit). Before I attribute function to Gault Clovis blade specimens, I would like to remind the reader of John Coles' (1976:47) seventh experimentation law (see Chapter IV for complete listing): "results from experiments should not be taken as proof." That said, microwear analysis is not a method to achieve a concrete answer, but to allow archaeologist greater precision in inferring site behavior.

Microwear analysis of the TAMU Gault blades, disregarding the experimental portion, consisted of three levels that went from macro-scale to micro-scale: (1) naked eye and hand lens inspection; (2) stereomicroscope inspection; and (3) compound microscope inspection. The process as a whole was to winnow the blade/blade fragment population to analyze what was possibly utilized under the compound microscope. SEM

analysis of potential residues, only used on two blades, acts as a mutually exclusive test for possible use.

Based on observations in these procedures I conclude that: (1) blades were used at Gault and (2) there is a difference between Clovis units 3a and 3b. In addition, few blades from 3a and 3b that show use. Eight Clovis 3a blades, or 3.0% of the total Clovis 3a blade/blade fragment population (n=264), exhibit use-wear. In addition, six Clovis 3b blades, 3.3% of the total Clovis 3b blade/blade fragment population (n=182), exhibit use-wear. Weakly developed use-wear, with approximately 3% of used blades identified from the blade populations, lead to the inference of limited use. Certain differences are at first macroscopically visible between some of the utilized blades of Clovis units 3a and 3b. Blades/blade fragments with distal modifications are limited to unit 3b, while blades/blade fragments with lateral modifications are found almost completely in unit 3a. This observation leads to a morphological difference that is not necessarily restricted from function and use. Stereomicroscope analysis observations also pointed to more scarring and rounding on blades/blade fragments from Clovis 3a than Clovis 3b. Polish and striation patterns observed under compound analysis, when compared to experimental blades, show another difference between blades and blade fragments from 3a and 3b. Polish patterns from 3a correspond to the soft contact experiments, while polish and striation patterns from 3b correspond to the hard contact experiments. In general, the polish and striations on blades and blade fragments for both units are not well developed.

Artifacts represent human modification and minimally human activity (human presence in a general sense) at a location. In his study of Australian aboriginal blades,

Patton (1994) noted that only a few were taken from the quarry, with most left for later collection and left bundled together or left on the surface at the place of production (Paton 1994:174-175). This is a possibility for most of the TAMU Gault blades, although the presence of bundles cannot be substantiated. Microwear analysis of TAMU Clovis blades, along with comparisons to experiments, illustrates that multiple craft or subsistence activities were in operation at Gault, in addition to quarrying and workshop activities. While this study is tempting to make greater statements about behavior at the Gault site, it is important to remember these caveats: (1) blade and blade fragments are only one aspect of the chert chipped stone and are not a proxy for the other lithics or non-lithics; and (2) due to the high amount of chert (within bedrock, eroded, and in streams) in and around the site, I made the assumption of blade use at the site.

#### **Non-Extractive Activities at Quarries and Quarry-Related Workshops:**

##### **Supplemental Discussion on the Holmes and Bryan Alternatives**

Quarries are defined as places where rock is removed from the earth or from a large mass of associated rock. As such, quarries have been an important resource for prehistoric groups, especially given preservation of artifacts lends to the view of an economy of stone that can denote trade, exchange, and even territoriality. While quarries are recognized by archaeologists for the “cradle to grave” implications regarding artifacts from other sites (Bryan 1950:34; Dockall and Shafer 1993; Lech 1981; Shafer 1991; Torrence 1986), prehistoric behavior at quarries is rarely treated or discussed. Two figures shaped the direction behavior in prehistoric quarry studies, William Henry Holmes and Kirk Bryan.

### **William Henry Holmes and Kirk Bryan: Extractive Industry and Factories**

Holmes's (1890a, 1890b, 1891, 1900, 1901, 1903, 1919) quarry experience spanned over the United States, and into Mexico, along with raw materials including quartzite, steatite, chert, obsidian, novaculite, iron, mica, and native copper. In his first writing on Potomac Formation quartzite gravels at Piney Branch (outside of Washington D.C.), he invoked the following statement, "having reached a definite conclusion that the blades [Holmes' term for bifaces] were the exclusive product of the property, I was led to investigate their subsequent history" (Holmes 1890a:18). This was stated after Holmes (1890a:17) conceded that some "rude" forms may have been used in emergencies or shaped for a special reason (such as quarrying soapstone or girdling trees), but these quarry forms were not made to be used. Holmes' (1894, 1919:201-209) Investigating Arkansas novaculite quarries (Holmes 1891, 1919:196-200), he also noted blades and conical quarry pits, but did not address further activity. In his short treatment of Flint Ridge (of the Pennsylvanian-age Vanport Formation in Licking and Muskingum counties, Ohio), Holmes (1919:181) mentions "minute flake blades, which probably served as knives." He further notes, "this is the only quarry so far studied in which this particular work was extensively carried on" (Holmes 1919:181).

Kirk Bryan (1950:3) posited two hypotheses: (1) many previously termed "blanks" and "rejects" were used as tools; and (2) many flint quarries were also factories where wood and bone were also worked. His work was based on three quarries (Bryan 1950:8-18): (1) "Spanish Diggings" in Oklahoma; (2) Alibates quarry (Permian dolomite-replaced chalcedony) near Amarillo, Texas; and (3) Cerro Pedernal quarry (Abiquiu Formation chert) in New Mexico. Bryan (1950:21) noted the presence of a great quantity

of flakes and blades (in the definition by Bordes (1961), as opposed to Holmes' "blades" (refined bifaces) that were utilized on wood and bone and then discarded. Heavy bifaces were used for splitting and shaping logs (Bryan 1950:22-25).

### **Activities at Quarries: Refining the Extraction, On-Site "Reduction" Processes, and Use-Wear**

Before addressing non-extraction activities at quarries, Holmes (1890a) differentiated between the point of raw material extraction from where additional work took place, hinting at a possible task subdivision. An early twentieth century paper by Arthur C. Parker (1924) on a Normanskill Formation chert quarry (at Flint Mine Hill, Cocsackie, New York) offered a view on the task subdivision (no gender assignments) to the prehistoric quarrying. Kirk Bryan (1950:33) suggested, "more detailed archaeological work in the debris of flint quarries would yield data adequate for the recapitulation of the technical sequences of flintworking." Philip C. LaPorta (1994, 1996, 2001, 2004), identifying hundreds of Cambro-Ordovician prehistoric chert quarries on the Wallkill River Valley (New York-New Jersey), helped to refine the activity at quarries. LaPorta's basic quarry prediction model rests upon level of deformation to the lithology and presence of a stable platform. Refinement of the rock happens closer to the source in areas of greater tectonic activity. Using LaPorta's model, tasks at Gault could then be further away from the point of acquisition. His mineral resource model is one hinted at by Bryan (1950:26).

With this subdivision of labor offered by Parker and LaPorta, where does a workshop place in the continuum from quarry to use? William H. Holmes (1890a) was the first to present a quarry workshop at Piney Branch outside of Washington D.C. He

noted that there were clear differences between the quarrying and testing of the Mesozoic-age Potomac Formation quartzite boulders and the down-the-line reduction/refinement by the absence of “rude” forms and failures (Holmes 1890:25). Based on his work on early farming communities in Poland, Jacek Lech (1983) offered a useful separation between different types of workshops: (1) mine-related; and (2) village-related. Bryan (1950), Godoy (1985), and LaPorta (personal communication) note the connection between historical mining, mining terminology, and the potential for multiple functions at quarry and mine sites.

Microwear at quarries and quarry-related workshops (*sensu* Lech) then become a different matter. As previously mentioned, Holmes rarely noted use beyond extraction. His exception to this came in the investigation at Flint Ridge in Ohio. Holmes (1919:181) postulated that the “flake blades” were “probably” used as knives. In Kirk Bryan’s (1950) volume, he references evidence of flake and blade use by edge modification. It is interesting to note that Bryan (1950), emphasizing the need for scientific standards of definition and hypothesis testing, that he assumed edge wear meant that an artifact was utilized.

### **Quarry Sites and Factors in Development and Non-extraction Activities**

Gault is not the sole quarry-workshop site, nor is it the sole Clovis/Paleoindian quarry-workshop site. Holmes and Bryan present their observations and interpretations on large quarries that show little deformation. Little discussion is paid to the interaction of settings and the presence of other resources. I do not test against Holmes’ and Bryan’s respective quarry-use hypotheses due to: (1) my work in Gault is limited and my results are not meant to represent the character of the entire site; and (2) such work is beyond the

scope of this thesis. Instead, I intended to supplement the works of Holmes and Bryan by including a select number of Paleoindian quarry-workshop sites as discussed within the framework of contextual variables. Contextual variables of note include: (1) geomorphology (physiography, underlying geology, and proximity to nearest reliable water source); and (2) raw material geology and geomorphology of the area (regional and local). I chose not to include faunal and floral resources, as their placement in time is less predictable and not every site contains their remains. I will briefly discuss the following sites (Figure 21): Gault site; Wells Creek; Dutchess Quarry; and West Athens Hill.

*Gault.* Due to the extended discussion of Gault in this work, I will only briefly outline how Gault meets the abovementioned factors. To summarize, the Gault Site (41BL323) is a multicomponent quarry-workshop located in Bell County, Texas. Artifacts range from Clovis to historic periods.

Gault is located on the extreme western portion of the Grand Prairie of the Edwards Escarpment (Fenneman 1938:105-106). The characteristic topography is a yearly level plain with steep slope erosion valleys. The surface takes on a relief of  $\leq 100$  feet (30.5 m). Gault is located at the head of a low-relief valley. The underlying geology of the site is the Cretaceous-age chert-bearing Edwards Formation limestone/dolomite (Fischer and Rodda 1969) and non-chert-bearing Cretaceous age Comanche Formation limestone (Proctor et al. 1974). A spring, with Buttermilk Creek dissecting the site, provide ample water source for use during and since Clovis occupation. Lundelius (1998) confirmed faunal and floral presence at Gault.

The Gault site has three possible sources of material: (1) Edwards Formation outcrops with chert nodules; (2) eroded Edwards Formation chert nodules resting on the

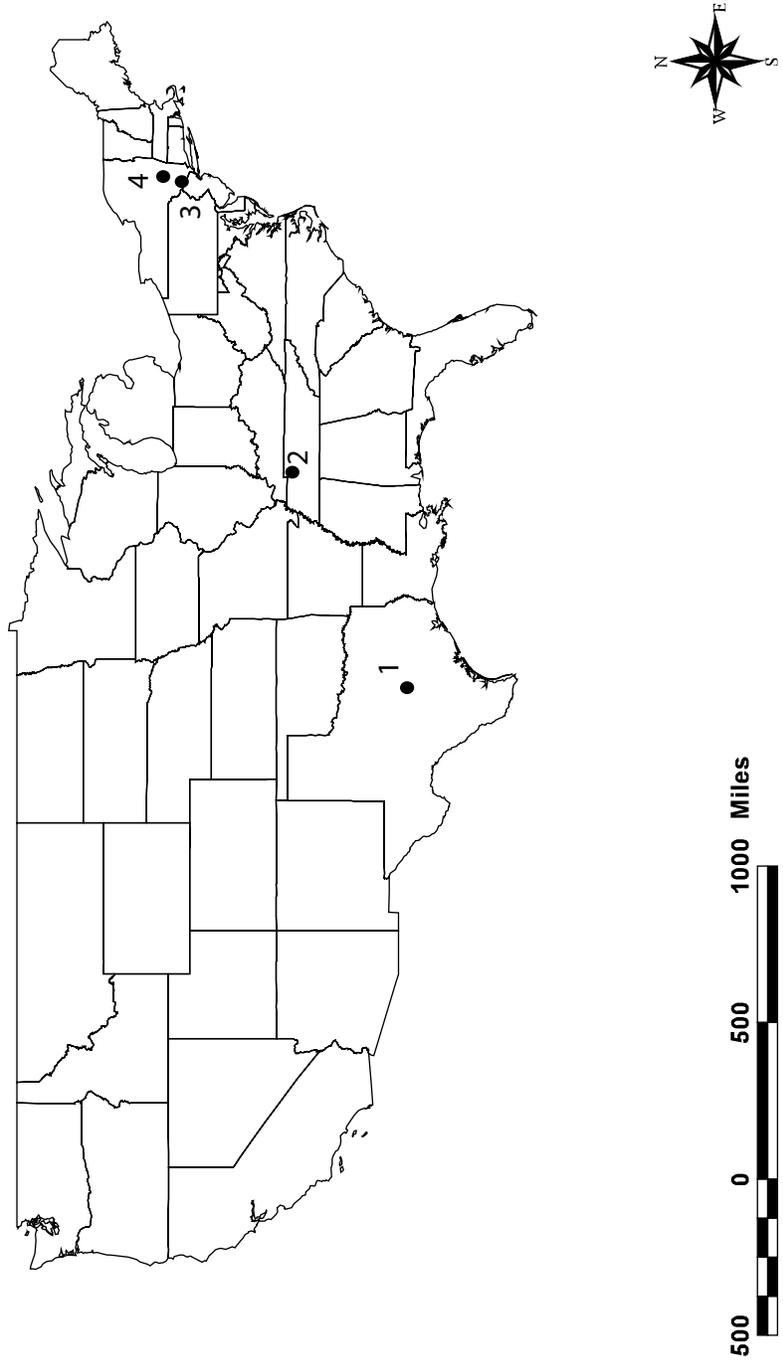


Figure 21. Locations of sites, as discussed in the text: (1) Gault; (2) Wells Creek; (3) Dutchess Quarry; and (4) West Athens Hill.

slopes; and (3) Edwards Formation cobbles found in Buttermilk Creek. This is similar to other quarries in the area (see Shafer 1991 for discussion), but the abundance and easy access of the chert along the eastern and southern Edwards Escarpment creates a lack of archaeological interest for quarrying and quarries (Shafer 1991:52). Gault blades analyzed by the author were all fashioned from Edwards Formation chert. Aside from the Gault site, chert is outcrops widely in the Edwards Plateau (Fishcer and Rodda 1969). The combination of abundant chert,

*Wells Creek.* Wells Creek (40SW63) is a single component Paleoindian site located in Stewart County, Tennessee (Dragoo 1973:1-2). The site is located on a Central Hill and is surrounded on the east and north by Wells Creek. Don W. Dragoo (Dragoo 1973:7) served as the Principal Investigator. Wells Creek site was systematically surface surveyed and excavated in 1965. The recovered artifacts are attributed to Paleoindian and Early Archaic.

The Wells Creek site is physiographically located in the Highland Rim section of the Interior Low Plateau physiographic Province (Fenneman 1938:415-416). The location of the site puts it in the Pennyroyal district, characterized by a continuous plain of hilltops with relief created by solution of the Mississippian age limestone (Fenneman 1938:419-420). The area is also characterized by drainage basins that flow into sinks and singular funnel-shaped sinks. This leads to underground streams in this mature karstic landscape (Fenneman 1938:21). Fenneman (1938:418) also notes a rim of Fort Payne chert around the Nashville Basin (just southeast) and that the soils and drainages contain a large admixture of chert to the north and south. The Wells Creek sites overlays a geological structure that resulted from a  $200 \pm 100$  MYA meteor impact that compressed

the rock concentrically (Dragoo 1973:2-3; Miller 1994:55-56). The result is a circular series of horsts and grabens with a central up-lift area that contains a megabreccia. The megabreccia includes material from the Ordovician-age Knox Group (Miller 1994; Miller et al. 1966). The surrounding horsts and grabens are progressively younger than the central core, emanating outside from the Knox Group, to the Ordovician-age Hermitage shale, to Silurian and Devonian, to the Mississippian-age chert-bearing Fort Payne Formation (Miller et al. 1966). The site is surrounded to the east and north by Wells Creek, which itself flows north into the Cumberland River. The Cumberland River is less than 1.25 miles (2 km) from Central Hill (Dragoo (1973:5).

Wells Creek investigations produced a large amount of bifaces, cores, end scrapers, side scrapers, unifacial tools, choppers, spokeshaves, chisels, picks, and core tools. Dragoo (1973:27) notes the presence of “true blades,” which exhibit “wear and retouching.” Dragoo (1973:9) identifies the raw material for the artifacts as Fort Payne, from the Mississippian-age Fort Payne Formation. The chert occurs in horsts of the impact structure and in the valleys and streams of the area (Dragoo 1973:9). Although Dragoo (1973:9) mentions chert locations, he only mentions quarries in so far as to say that the Fort Payne chert on the site was originally brought from a quarry as “blocks or plates” (Dragoo 1973:10). Due to the volume of recovered materials by Dragoo, a reasonable assumption is that a quarry is nearby and the site represents a potential quarry workshop.

As LaPorta et al. (2007a, 2007b) note, a detailed understanding of the tectonics, stratigraphy, and sedimentology of an area to predict for quarries. The descriptions for the Mississippian chert-bearing limestones contain too many inconsistencies and overlaps

(LaPorta et al. 2006a:10). In addition, the cherts and their respective formations are different, requiring different models (LaPorta et al. 2007b:23).

*Dutchess Quarry.* Dutchess Quarry is a multicomponent site located in the Town of Goshen, Orange County, New York (Funk and Steadman 1994:9). The site was investigated over the period of approximately 30 years by three different groups (Funk and Steadman 1994:9): (1) 1964-1989 by the Orange County Chapter, with the aid of Robert Funk; (2) by J.S. Kopper of Long Island University in 1974-1978; and (3) as a Cultural Resource Management (CRM) project in 1991-1992 by Hartgen and Associates, Inc. Philip LaPorta (1996) identified five loci of quarry activity, for the 1991-1992 CRM project, on top of Mount Lookout (the hill containing Dutchess Quarry). The quarries are located within the Beaver Run and Harmonyvale members of the Ontelaunee Formation (LaPorta 1996:80). Due to the relative chert deficiency in the dolomite, the quarries were failed prospects with the exception of Locus 3 where the chert beds jutted out of a moderate slope. The Locus 3 chert beds contained cusped surfaces, evidence of quarrying. The artifacts encountered included: blocks of chert, flakes, cores, hammerstones (quartzites and conglomerates), and slabs of dolomite (Funk and Steadman 1994:52; LaPorta 1996:80).

Dutchess Quarry is located in the Ridge and Valley physiographic province (Fenneman 1938:195). The topography of the region is largely a product of geologically recent uplift, glacial activity during the last ice age, and differential erosion of the various rock types present. This erosional pattern has resulted in the formation of valleys in areas dominated by easily weathered limestone, and ridges in areas dominated by more resistant sandstones, conglomerates, and metamorphic rocks. Within this province, the

Wallkill Valley consists of 300-400 foot limestone and shale valley floor, bounded to the east (1600 foot Schunemunk Mountains) and west (900-1000 foot Kittattiny-Shawangunk Mountains) by Devonian conglomerates and sandstones (Fenneman 1938:209-210). Terry Offield (1967) mapped the underlying geology of the site as Halcyon Lake calc-dolomite. Most of the Halcyon consists of lustrous, fine- to medium-crystalline, mottled medium-gray and medium dark-gray dolomite that weathers white or very light gray with abundant medium- to dark-gray chert scattered as nodules, lenses, and discontinuous layers as much as 2 1/2 feet (76 cm) thick (Offield 1967:47). The correlates to the northeast are also termed Halcyon Lake. Correlates to the southwest in New Jersey are the chert-bearing Crooked Swamp Member of the Rickenbach Formation, Branchville, Big Springs, and Lafayette Members of the Epler Formation; and the chert-bearing Beaver Run and Harmonyvale Members of the Ontelaunee Formation (LaPorta 1996). Offield (1967:58-64) notes structural deformation of rocks from the Ordovician to the Triassic in the area, which folded and faulted the Halcyon Lake calc-dolomites. The nearest mapped water source is ca. 60 m to the east of the Wallkill River. Kopper et al. (1994:69 [1978]) noted the presence of a sinking stream 750 m south of Cave 1 and three small dolines (sediment-filled sinkholes).

Within Cave 8, Funk and Steadman (1994:29), Kopper excavated two Cumberland-type fluted points from a feature in Stratum 3. The two points were made from Normanskill and Kalkberg cherts, none of which outcrop in the area (Offield 1967) but are available in glacial till, as personally observed by the author. Kopper recovered a third fluted point, fashioned from jasper, in Stratum 5. In later excavations, Funk discovered another fluted point fashioned from jasper (Funk and Steadman 1994:30) in

strata 4 and 5. The points are associated with Pennsylvania jasper that naturally occurs ca. 100 miles to the southwest of the cave, but is present in local collections from with artifacts typed to Paleoindian to Woodland times (Scott Minchak, personal communication). Funk and Steadman (1994:30) reference LaPorta as assigning most of the debitage to Beaver Run and Harmonyvale, but the authors describe them in-text (Funk and Steadman 1994:30-31) as gray and black. Although none of the attributed Paleoindian artifacts are made from local chert, the lack of chert identification for debitage in the Paleoindian strata (4 and 5) leaves open the possibility of Paleoindian quarry use during occupation.

*West Athens Hill.* West Athens Hill (Funk 2004; Ritchie and Funk 1973) is multicomponent site located in Greene County, New York. The site was discovered in 1962, tested in 1963-1965, and systematically excavated in the summers of 1966, 1967, 1969, and 1970 (Funk 2004:4). The principal investigator was Robert E. Funk, former New York State Archaeologist. Funk's (2004:10, 13) excavations were separated into six areas: Area A (on top of a hill), Area B (on flat below hill containing Area A), Area C (bench on downslope to the east of Area A), Area D, (north and east of Area C), Area E (north and east of Area C), and Area F (north and east of Area C). Artifact-bearing deposits varied differently between the areas (Funk 2004:15). Quarrying activity was identified in areas C, E, and F (Funk 2004:21-22).

Physiographically, the West Athens Hill site is also located in the Ridge and Valley physiographic province (Fenneman 1938:195). The province, within the Hudson-Champlain valley, is produced under similar circumstances described for the Dutchess Quarry site. The site, however, is on the 6-8 mile (10-13 km) wide belt, to the east of the

Catskill Mountains (Fenneman 1938:211), composed of a miniature version of the ridge and valley that expands to the south in width and height. The site rests on two ridges, 200-250 feet above the surrounding area (Funk 2004:91). The underlying geology of West Athens Hill is the chert-bearing Normanskill Formation (Funk 2004:9). Less than 1 mile to the east is the Helderberg Escarpment, composed of Lower to Middle Devonian shales and limestones. Included in these are Kalkberg, New Scotland, Becraft, Alsen, and Onondaga – each of which are chert-bearing formations. West Athens Hill is located on a north-south trending ridge with the Hans Vosen Kill 600 m to the west and the Corlaer Kill, 600 m to the east.

The artifact inventory includes fluted points, bifaces, scrapers, retouched flakes, utilized flakes, pieces esquilles, hammerstones, and anvils (Funk 2004:81). Aside from the quarry and cherts on the Helderberg Escarpment, chert is available in the glacial till (Fullerton et al. 1992), along with hammerstone materials. These were concentrated in areas A, B, and C. Funk (2004:71-75) conducted use-wear experiments on artifacts from the site using a 5x – 25x microscope. He experimented using unmodified chert flakes to cut wood, scrape bone, and scrape wood (Funk 2004:71). Rounding and gloss were located on some of the Stage 3 bifaces, interpreted by Funk (2004:72) as bifacial knives. He found rounding and gloss was more evident on the unifaces (side and end scrapers) in Area C than on those from areas A and B – and used to scrape and puncture hide (Funk 2004:73). Funk's (2004:73) conclusions on retouched flakes were for scraping, but the material scraped was inconclusive.

*Summary and Recommendations.* Three sites (Wells Creek, Dutchess Quarry, and West Athens Hill) are prominent locations in their respective areas, each ca. 200 feet

above the surrounding topography, while Gault rests in an incised valley. Dutchess Quarry and West Athens Hill contain Ordovician age cherts that record multiple deformation events. As opposed to this, Wells Creek and Gault contain the youngest cherts (Mississippian and Cretaceous respectively), with little more than overburden deformation. Gault has the nearest water source with the spring on the site. Wells Creek is at the base of the Central Hill, on which the Wells Creek site rests. West Athens Hill rests between two valleys that contain creeks, approximately 600 m from each water source. With Kopper's (1994[1978]) notation of springs near Dutchess Quarry, the possibility of more dolomite springs deserves further investigation.

Microwear analyses were conducted at two of the aforementioned sites (Gault and West Athens Hill). Aside from my findings on limited use-wear on blades, other researchers conducted additional microwear studies on artifacts from Gault. I applaud Robert Funk (2004:71-75) for taking the first steps in conducting experiments to test microwear patterns on the West Athens Hill artifacts. His work suggests other activities at West Athens Hill, but Funk's analysis contains two crucial problems: (1) no comparisons between the experiments and artifacts; and (2) a lack of higher power microscope analysis.

Non-quarrying/processing activities at prehistoric quarries and quarry-workshops depend on a number of factors, of which only one is proximity to water. Based on research and work at the Gault site, I realize that the information available provides an uneven basis for site comparison. Before comparing, an important problem is prehistoric quarry recognition, as seen in Dutchess Quarry where the prehistoric quarry pits were originally thought to be sinkholes (Funk and Steadman 1994:52). To address the roles of

quarries and quarry-workshops, I recommend two items for future investigators. First, provide a more detailed contextual (physiography, geology, hydrology, etc...) framework for that site that is based on predictable resources through time. To accomplish this, one must conduct additional site investigations, as well as converse and work with experts (geologists and geographers) on the nuances of the static environmental factors that might affect site function(s). Sites require detailed contextual statements to provide the necessary detail to account for variation and provide enough data for even the most basic inter-site connections. Second, I encourage investigators to conduct microwear analysis as a test for alternative quarry functions. To do so requires a strict program based on experimental testing and rigorous controls over analysis. By nature, this analysis is time and cost intensive since the experiments must replicate patterns on the rocks (chert, obsidian, quartzite, quartz, etc...) present in the artifact assemblages.

## REFERENCES CITED

- Adkins, W. S., and M. B. Arick,  
1930 *Geology of Bell County*. The University of Texas Bulletin, No. 3016. The University of Texas at Austin, Austin.
- Bamforth, Douglas B.  
1988 Investigating Microwear Polishes with Blind Tests: The Institute Results in Context. *Journal of Archaeological Science* 15:11-23.
- Binford, Lewis R.  
1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1:5-31.
- Bordes, Francois  
1961 *Typologie du Paléolithique: Ancien et Moyen*. Delmas, Bordeaux, France.
- Bordes, Francois, and Donald Crabtree  
1969 The Corbiac Blade Technique and Other Experiments. *Tebiwa* 12(2):1-21.
- Bonnichsen, Robson  
1996 Discussion. In *Proceedings of the International Meeting on the Peopling of the Americas, São Raimundo Nonato, Piauí, Brasil (1993)*, edited by A.-M. Pessis, pp.266-269. Revisita Fundação Museu do Homen Americano Vol.1, No.1. Fundação Museu do Homen Americano, São Raimundo Nonato.
- Bryan, Kirk  
1950 *Flint Quarries – The Sources of Tools and, at the Same Time, the Factories of the American Indian*. Papers of the Peabody Museum of American Archaeology and Ethnology Vol. 17, No. 3. Harvard University, Cambridge.
- Bryant, Vaughn M., Jr., and Richard G. Holloway  
1985 A Late-Quaternary Paleoenvironmental Record of Texas: An Overview of the Pollen Evidence. In *Pollen Records of Late-Quaternary North American Sediments*, edited by V. M Bryant, Jr., and R. G. Holloway, pp.39-70. American Association of Stratigraphic Palynologists Foundation, Dallas.
- Bureau of Economic Geology  
1996 *Physiographic Map of Texas*. Bureau of Economic Geology, University of Texas at Austin, Austin.
- 2000 *Vegetation / Cover Types of Texas*. Bureau of Economic Geology, University of Texas at Austin, Austin.

- Crabtree, Donald E.  
1972 *Introduction to Flintworking*. Occasional Papers of the Idaho State University Museum, No. 28. Pocatello.
- Coles, John  
1979 *Experimental Archaeology*. Academic Press, New York.
- Collins, Michael B.  
1979 *Excavations at Four Archaic Sites in the Lower Ohio Valley, Jefferson County, Kentucky*. Dept. of Anthropology, University of Kentucky, Lexington.  
  
1981 The Use of Petroleum by Late Archaic and Early Woodland Peoples in Jefferson County, Kentucky. *Journal of Field Archaeology* 8:55-64  
  
1999 *Clovis Blade Technology: A Comparative Study of the Keven Davis Cache, Texas*. Texas Archaeology and Ethnohistory Series. The University of Texas Press, Austin.
- Cotterell, B. and J. Kamminga  
1987 The Formation of Flakes. *American Antiquity* 52:675-708.
- DelBene, Terry A.  
1979 Once Upon a Striation: Current Models of Striation and Polish Formation. In *Lithic Use-Wear Analyses*, edited by Brian Hayden, pp.167-177. Academic Press, New York.
- Diamond, George  
1979 The Nature of So-Called Polished Surfaces on Stone Artifacts. In *Lithic Use Wear Analyses*, edited by Brian Hayden, pp.159-166. Academic Press, New York.
- Dickens, W.  
2005 *Biface Reduction and Blade Manufacture at the Gault Site (41BL323): A Clovis Occupation in Bell County, Texas*. Unpublished Ph.D. Dissertation, Department of Anthropology, Texas A&M University, College Station.
- Dockall, John D., and Harry J. Shafer  
1993 Testing the Producer-Consumer Model for Santa Rita Corozal, Belize. *Latin American Antiquity* 4:158-179.

Dragoo, Don W.

1973 Wells Creek – An Early Man Site in Stewart County, Tennessee. *Archaeology of Eastern North America* 1:1-56.

Ellerbusch, Elijah C.

2004 Paleoindian Prismatic Blade Economy from the Nuckolls Site (40Hs60), Lower Tennessee River Valley, Tennessee. *Current Research in the Pleistocene* 21:35-38.

Fenneman, Nevin M.

1938 *Physiography of Eastern United States*. Mc-Graw Hill, New York.

Fischer, W. L., and Peter U. Rodda

1969 Edwards Formation (Lower Cretaceous), Texas: Dolomitization in a Carbonate Platform System. *The American Association of Petroleum Geologists Bulletin* 53:55-72.

Flenniken, J. Jeffrey, and James C. Haggarty

1979 Trampling as an Agency in the Formation of Edge Damage: An Experiment in Lithic Technology. *Northwest Anthropological Research Notes* 13:208-214.

Folk, Robert L., and Charles E. Weaver

1952 A Study of the Texture and Composition of Chert. *American Journal of Science* 250:498-510.

Fullerton, David S. William D. Sevon, Ernest H. Muller, Sheldon Judson, Robert F. Black, Philip W. Wagner, Joseph H. Hartshorn, William F. Chapman, and William D. Cowan

1992 *Quaternary Geologic Map of the Hudson 4° x 6° Quadrangle, United States and Canada*. Miscellaneous Investigation Series Map I-1420 (NK-18). United States Geological Survey.

Funk, Robert E.

2004 *An Ice-Age Quarry Workshop: The West Athens Hill Site Revisited*. New York State Museum Bulletin 504. New York State Education Department, Albany, New York.

Funk, Robert E. and David W. Steadman

1994 *Archaeological and Paleontological Investigations in the Dutchess Quarry Caves, Orange County, New York*. Persimmon Press, Buffalo.

- Gifford-Gonzalez, Diane P., David B. Damrosch, Debra R. Damrosch, John Pryor, and Robert L. Thunen  
1985 The Third Dimension in Site Structure: An Experiment in Trampling and Vertical Dispersal. *American Antiquity* 50:803-818.
- Godoy, Ricardo  
1985 Mining: Anthropological Perspective. *Annual Review of Anthropology* 14:199-217.
- Goode, G. T., and R. J. Mallouf  
1991 The Evant Cores: Polyhedral Blade Cores from North-Central Texas. *Current Research in the Pleistocene* 8:67-70.
- Gould, Richard A.  
1978 From Tasmania to Tuscon: New Directions in Ethnoarchaeology. In *Explorations in Ethnoarchaeology*, edited by Richard A. Gould, pp.1-10. University of New Mexico Press, Albuquerque.
- Grace, Roger  
1989 Interpreting the Function of Stone Tools: A Quantification and Computerisation of Microwear Analysis. B.A.R. International Series 474. Electronic document. <http://www.hf.uio.no/iakk/roger/lithi/bar/> , accessed June, 2002.
- Green, F. E.  
1963 The Clovis Blades: An Important Addition to the Llano Complex. *American Antiquity* 29:145-165.
- Hammat, Hallat H.  
1970 A Paleo-Indian Butchering Kit. *American Antiquity* 35:141-152.
- Hayden, Brian [editor]  
1979 *Lithic Use-Wear Analysis*. Academic Press, New York.
- Haynes, C. Vance, Jr.  
1993 Clovis-Folsom Geochronology and Climate Change. In *From Kostenki to Clovis: Upper Paleolithic-Paleo-Indian Adaptations*, edited by O. Soffer and N.D. Praslov, pp.219-236. Plenum Press, New York.
- Henderson, J., and G. T. Goode  
1991 Pavo Real: An Early Paleoindian Site in South-Central Texas. *Current Research in the Pleistocene* 8:26-28.

Hesse, Reinhard

1990a Origin of Chert: Diagenesis of Biogenic Siliceous Sediments. In *Diagenesis*, edited by Ian A. McIlreath and David W. Morrow, pp.227-252. Geoscience Canada Reprint Series 4. Geological Association of Canada, Newfoundland.

1990b Silica Diagenesis: Origin of Inorganic and Replacement Cherts. In *Diagenesis*, edited by Ian A. McIlreath and David W. Morrow, pp.253-276. Geoscience Canada Reprint Series 4. Geological Association of Canada, Newfoundland.

Holmes, William H.

1890a A Quarry Workshop of Flaked-Stone Tool Implement Makers in the District of Columbia. *American Anthropologist* 3:1-26.

1890b Excavations in an Ancient Soapstone Quarry in the District of Columbia. *American Anthropologist* 3:321-330.

1891 Aboriginal Novaculite quarries in Garland, Nevada. *American Anthropologist* 4:313-316.

1894 *An Ancient Quarry in Indian Territory*. Bureau of American Ethnology, Bulletin 21.

1900 The Obsidian Mines of Hidalgo Mexico. *American Anthropologist* (New Series) 2:404-416.

1901 Aboriginal Copper Mines of Isle Royale, Lake Superior. *American Anthropologist* (New Series) 3:684-696.

1903 Traces of Aboriginal Operations in an Iron Mine near Leslie, Missouri. *American Anthropologist* (New Series) 5:503-507

1919 *Handbook of Aboriginal American Antiquities*. Bureau of American Ethnology, Bulletin 60.

Hudler, Dale

1997 *Determining Clear Fork Tool Function Through Use-Wear Analysis: A Discussion of Use-Wear Methods and Clear Fork Tools*. Studies in Archaeology 25, Texas Archaeological Research Laboratory Studies, University of Texas, Austin.

Hurcombe, Linda

1988 Some Criticisms and Suggestions in Response to Newcomer et al. (1986). *Journal of Archaeological Science* 15:1-10.

Inman, Betty J., and Dale B. Hudler

1998 Preliminary Results from a Use-wear Analysis of Clovis Blades from the Gault Site. *TARL Research Notes* 6(1):18-20.

Juel Jensen, Helle

1994 *Flint Tools and Plant Working: Hidden Traces of Stone Age Technology*. Aarhus University Press, Aarhus.

Kay, Marvin

1996 Microwear Analysis of Some Clovis and Experimental Stone Tools. In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by George H. Odell, pp.315-344. Plenum Press, New York.

1999 Microscopic Attributes of the Keven Davis Blades. In *Clovis Blade Technology*, by Michael B. Collins, pp.126-143. University of Texas Press, Austin.

Keeley, Lawrence

1974 Technique and Methodology in Microwear Studies: A Critical Review. *World Archaeology* 5:323-336.

1980 *Experimental Determination of Stone Tool Uses*. University of Chicago Press, Chicago.

Kimball, Larry R.

1992 The Function of Hopewell Blades from the Southeast. *McClung Museum Research Notes* 12. Electronic document.  
<http://mcclungmuseum.utk.edu/research/renotes/rn12txt.htm> , accessed March, 2005.

Kopper, John S., John Froeschauer, Stephen Sadowski, and Byron Hagedwood

1994 [1978] Archaeological Surveys in the Dutchess Quarry Cave Region, 1977-1978. In *Archaeological and Paleontological Investigations in the Dutchess Quarry Caves, Orange County, New York*, by Robert E. Funk and David W. Steadman, pp.65-69. Persimmon Press, Buffalo.

Knauth, L. Paul

1994 Petrogenesis of Chert. In *Silica: Physical Behavior, Geochemistry and Materials Applications*, edited by P. J. Heaney, C. T. Prewitt, and G. V. Gibbs, pp.233-258. Reviews in Mineralogy volume 29, Mineralogical Society of America, Washington D.C.

LaPorta, Philip C.

1994 Lithostratigraphic Models and the Geographic Distribution of Prehistoric Chert Quarries within the Cambro-Ordovician Lithologies of the Great Valley Sequence, Sussex County, New Jersey. In *Recent Research into the Prehistory of the Delaware Valley*, edited by Christopher A. Bergman and John F. Doershuk, pp.47-66. *Journal of Middle Atlantic Archaeology*, Vol. 10.

LaPorta, Philip C.

1996 Lithostratigraphy as a Predictive Tool for Prehistoric Quarry Investigations: Examples from the Dutchess Quarry Site, Orange County, New York. In *A Golden Chronograph for Robert E. Funk*, edited by Chris Lindner and Edward V. Curtin, pp.73-83.

2001 *The Stratigraphic and Structural Relations of Prehistoric Chert Quarries in the Wallkill River Valley, New York and New Jersey*. Paper presented at the 66<sup>th</sup> Annual Society for American Archaeology Meeting, New Orleans.

2004 *Criteria for the Development of Quarries in Eastern Appalachia*. Paper presented at the 69<sup>th</sup> Annual Society for American Archaeology Meeting, Montreal.

LaPorta, Philip C., Margaret C. Brewer, and Scott A. Minchak

2007a *Phase IA Archaeological Geology Report: LaPorta Prehistoric Quarry Model for Fletchers Fork, Skinners Creek, and Ross Branch Drainages, Fort Campbell Military Reservation, Kentucky-Tennessee*. Report submitted to BHE Environmental Inc., Cincinnati, Ohio by LaPorta and Associates, L.L.C., Inc., Warwick, New York.

2007b *Phase IB Cultural Resource Test of the LaPorta Model in Fletchers Fork, Skinners Creek, and Ross Branch Drainages, along with a Sinkhole in Fort Campbell Military Reservation, Kentucky-Tennessee*. Report submitted to BHE Environmental Inc., Cincinnati, Ohio by LaPorta and Associates, L.L.C., Inc., Warwick, New York.

Lech, Jacek

1981 Flint Mining Among the Early Farming Communities of Central Europe: Part I. *Przeglad Archeologiczny* 28:5-55.

1983 Flint Mining Among the Early Farming Communities of Central Europe: Part II. *Przeglad Archeologiczny* 30:47-80.

Levi-Sala, Irene

1986 Use-Wear and Post-Depositional Surface Modification: A Word of Caution. *Journal of Archaeological Science* 13:229-244.

1996 *A Study of Microscopic Polish on Flint Implements*. B. A. R. International Series 629. Tempus Reparatum, Oxford, England.

Lewenstein, Suzanne M.

1987 *Stone Tool Use at Cerros: The Ethnoarchaeological and Use-Wear Evidence*. University of Texas Press, Austin.

Lohse, E. S.

1996 A Computerized Descriptive System for Functional Analysis of Stone Tools. *Tebiwa* 26:3-66.

Longwell, Chester R., Richard Foster Flint, and John E. Sanders

1969 *Physical Geology*. John Wiley and Sons, New York.

Luchsinger, Heidi M.

2002 *Micromorphological Analysis of the Sediments and Soils from the Gault Site, a Clovis Site in Central Texas*. M.A. Thesis, Department of Anthropology, Texas A&M University.

Lundelius, Ernest L., Jr.

1967 Late Pleistocene Faunal History of Central Texas. In *Pleistocene Extinctions: The Search for a Cause*, edited by P. Martin, pp.289-320. Yale University Press, New Haven.

1998 Vertebrate Fauna at the Gault Site. *TARL Research Notes* 6:17.

McBrearty, Sally, Laura Bishop, Thomas Plummer, Robert Dewar, and Nicholas Conrad

1998 Tools Underfoot: Human Trampling as an Agent of Lithic Artifact Edge Modification. *American Antiquity* 63:108-129.

Maliva, Robert G., Andrew H. Knoll, and Bruce M. Simonson

2005 Secular Changes in the Precambrian Silica Cycle: Insights from Chert Petrography. *GSA Bulletin* 117:835-845.

Meyers, William J.

1977 Chertification in the Mississippian Lake Valley Formation, Sacramento Mountains, New Mexico. *Sedimentology* 24:75-105.

Miller, Robert A.

1994 *The Geological History of Tennessee*. Tennessee Division of Geology, Bulletin 74.

Miller, Robert A., William D. Hardeman, Donald S. Fullerton, C. Ronald Sykes, and R. Keith Garman

1966 *Geologic Map of Tennessee: West-Central Sheet*. State of Tennessee, Department of Conservation, Division of Geology.

Minchak, Scott A.

2004 *Use-Wear Analysis on Clovis Blades from the Gault Site, Bell County, Texas*.

Paper presented at the 69<sup>th</sup> Annual Society for American Archaeology Meeting, Montreal.

2006 *Subsistence Activities at Quarries and Quarry-Related Workshops: Testing the Holmes and Bryan Alternatives with Blades from the Gault Site*. Poster presented at the 71<sup>st</sup> Annual Society for American Archaeology Meeting, San Juan.

Nash, Michael A.

1986 *A Functional Analysis of Two Lithic Tool Collections from Colha, Belize*.

Unpublished M.A. Thesis, Department of Anthropology, Texas A&M University, College Station, Texas.

Newcomer, Mark, Roger Grace, and Romana Unger-Hamilton

1986 Investigating Microwear Polishes with Blind Tests. *Journal of Archaeological Science* 13:203-217.

1988 Microwear Methodology: A Reply to Moss, Hurcombe, and Bamforth. *Journal of Archaeological Science* 15:25-33.

Nielsen, Axel E.

1991 Trampling the Archaeological Record: An Experimental Study. *American Antiquity* 56:483-503.

Odell, George H.

1975 Micro-Wear in Perspective: A Sympathetic Response to Lawrence H. Keeley. *World Archaeology* 7:226-240.

1981 The mechanics of Use-Breakage of Stone Tools: Some Testable Hypotheses. *Journal of Field Archaeology* 8:197-209

Odell, George H., and Frieda Odell-Verecken

1980 Verifying the Reliability of Lithic Use-Wear Assessments by 'Blind Tests': The Low Power Approach. *Journal of Field Archaeology* 7:87-120.

Offield, T.W.

1967 *Bedrock Geology of the Goshen-Greenwood Lake area*. New York State Museum Map and Chart Series Number 9. Albany, New York.

Parker, Arthur C.

1924 *The Great Algonkin Flint Mines at Coxsackie*. New York State Archaeological Association Research Transactions 4. Rochester, New York.

Parry, William J.

1994 Prismatic Blade Technologies in North America. In *The Organization of North American Prehistoric Chipped Stone Tool Technologies*, edited by Philip J. Carr, pp.87-98. Archaeological Series 7. International Monographs in Prehistory, Ann Arbor, Michigan.

Paton, Robert

1994 Speaking Through Stones: A Study from Northern Australia. *World Archaeology* 26(2):172-184.

Proctor, C. V., Jr., T. E. Brown, J. H. McGowen, N. B. Waechter, and V. E. Barnes

1981 *Austin Sheet*. Francis Luther Whitney Memorial Edition, 1974, revised 1981, reprinted 1995.

Pryor, John H.

1988 The Effect of Human Trample Damage on Lithics: A Consideration of Crucial Variables. *Lithic Technology* 17:45-50.

Ritchie, William E., and Robert E. Funk

1973 *Aboriginal Settlement Patterns in the Northeast*. Memoir 20. New York State Education Department, Albany, New York.

Rotts, Veerle

2003 Towards and Understanding of Hafting: The Macro- and Microscopic Evidence. *Antiquity* 77:805-815.

2004 Prehensile Use-Wear on Flint Tools. *Lithic Technology* 29:7-32.

Sanders, Thomas N.

1990 *Adams: The Manufacturing of Flaked Stone Tools at a Paleoindian Site in Western Kentucky*. Persimmon Press, Buffalo, New York.

- Schiffer, Michael B.  
1978 Methodological Issues in Ethoarchaeology. In *Explorations in Ethnoarchaeology*, edited by Richard A. Gould, pp.229-247. University of New Mexico Press, Albuquerque.
- Schmidt, Jeffrey R.  
1991 Animal and Fish Glues. *Bulletin of Primitive Technology* 1(2):37-40.
- Scholle, Peter A.  
1978 *A Color Illustrated Guide to Carbonate Rock Constituents, Textures, Cements, and Porosities*. AAPG Memoir 27. American Association of Petroleum Geologists, Tulsa.
- Seitzer-Olausson, Deborah  
1980 Starting from Scratch: The History of Edge-Wear Research from 1838 to 1978. *Lithic Technology* 9:48-60.
- Semenov, Sergei A.  
1964 *Prehistoric Technology: an Experimental Study of the Oldest Stone Tools and Artefacts from Traces of Manufacture and Wear*. Translated by W. M. Thompson. Barnes & Noble, Inc., New York.
- Shafer, Harry J.  
1991 *Research potential of Prehistoric Quarry Sites*. In *Archaeological Site Testing and Evaluation on the The Henson Mountain Helicopter Range*, edited by David L. Carlson, pp. 45-59. Ft. Hood, USAFH report No. 26.
- Shea, John J., and Joel D. Klenck  
1993 An Experimental Investigation of the Effects of Trampling on the Results of Lithic Microwear Analysis. *Journal of Archaeological Science* 20:175-194.
- Shohberg, Marilyn, and James Beers  
2004 *Use-Wear on Stone Tools from the BYU and UT Excavations at the Gault Site in Central Texas*. Paper presented at the 69<sup>th</sup> Annual Society for American Archaeology Meeting, Montreal.
- Siever, Raymond  
1957 The Silica Budget in the Sedimentary Cycle. *American Mineralogist* 42:821-841.
- Stanford, Dennis  
1991 Clovis Origins and Adaptations: An Introductory Perspective. In *Clovis: Origins and Adaptations*, edited by R. Bonnicksen and K. L. Turnmire, pp.1-13. Center for the Study of the First Americans, Corvallis.

- Steigerwald, Joseph M., Shyam P. Murarka, and Ronald J. Gutmann  
1997 *Chemical Mechanical Planarization of Microelectronic Materials*. John Wiley and Sons, New York.
- Torrence, Robin  
1986 *Production and Exchange of Stone Tools: Prehistoric Obsidian in the Aegean*. Cambridge University Press, Cambridge.
- Tringham, Ruth  
1978 Experimentation, Ethoarchaeology, and the Leapfrogs in Archaeological Methodology. In *Explorations in Ethnoarchaeology*, edited by Richard A. Gould, pp.169-199. University of New Mexico Press, Albuquerque.
- Tringham, Ruth, Glenn Cooper, George Odell, Barbara Voytek, and Anne Whitman  
1974 Experimentation in the Formation of Edge Damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology* 1:171-196.
- Unger-Hamilton, Romana  
1984 The Formation of Use-Wear Polish on Flint: Beyond the “Deposit versus Abrasion” Controversy. *Journal of Archaeological Science* 11:91-98.
- Vaughan, Patrick C.  
1984-1986 A Sampling Method for Use-Wear Analysis of Large Flint Assemblages. *Early Man News* 9-11(1):183-186.
- 1985 *Use-Wear Analysis of Flaked Stone Tools*. University of Arizona Press, Tucson.
- Warnica, James M.  
1966 New Discoveries at the Clovis Site. *American Antiquity* 31:345-357.
- Waters, Michael R.  
1992 *Principles of Geoarchaeology: A North American Perspective*. University of Arizona Press, Tucson.
- Whittaker, John C.  
1994 *Flintknapping: Making and Understanding Stone Tools*. University of Texas Press, Austin.
- Wiederhold, James E.  
2004 *Toward the Standardization of Use-Wear Studies: Constructing an Analogue to Prehistoric Hidework*. Unpublished M.A. Thesis, Department of Anthropology, Texas A&M University.

Wilmsen, Edwin N.

1970 *Lithic Analysis and Cultural Inference: A Paleo-Indian Case*. Anthropological Papers of the University of Arizona Press No.16, University of Arizona Press, Tucson.

Witthoft, John

1952 A Paleo-Indian Site in Eastern Pennsylvania: An Early Hunting Culture. *Proceedings of the Philadelphia Academy of Natural Sciences* 96(4):464-495. Philadelphia.

1967 Glazed Polish on Flint Tools. *American Antiquity* 32:383-388.

Yerkes, Richard W.

1983 Microwear, Microdrills, and Mississippian Craft Specialization. *American Antiquity* 48:499-518.

Young, Donald, and Douglas B. Bamforth

1990 On the Macroscopic Identification of Used Flakes. *American Antiquity* 55:403-409.

Young, B., and M. B. Collins

1989 A Cache of Blades with Clovis Affinities from Northeastern Texas. *Current Research in the Pleistocene* 6:26-28.

## APPENDIX A

### DEFINITIONS OF TERMS

**Allocthonous** – rocks and materials formed elsewhere than their present place; of foreign origin.

**Artifact** – an object made by human beings belonging to an earlier time or cultural stage.

**Asperities** – the high points of a rough surface.

**Automated Laboratory Microscope** – see *Compound Microscope*.

**Blade** – is a specialized elongated flakes with parallel or sub-parallel lateral edges; the length being equal to, or more than, twice the width. Blades are associated with a prepared core and blade technique, showing that a blade is not a random flake and is technologically significant.

**Blade-Like Flake** – flakes that have been retouched to look like blades.

**Carbonate** – sediment formed of calcium, magnesium, and/or iron (e.g. limestone and dolomite).

**Chert** – a hard and dense sedimentary rock made up of silica in the form of microcrystalline or cryptocrystalline quartz that forms as either original precipitates or by replacement of carbonates; forms as nodules or bedded layered deposits.

**Chertification** – silicification by fine-grained quartz or chalcedony.

**Clovis** – oldest clearly defined techno-cultural complex in America; typified by the diagnostic fluted lanceolate points, large prismatic blades, large flake tools, polyhedral blade cores, and bone artifacts.

**Compound Microscope** (*Automated Laboratory Microscope*) – microscope with an objective lens and an eyepiece arranged to give greater magnification; objective and eyepiece each consist of a lens or combination of lenses mounted at either end of a telescoping tube so they can be focused by a gear.

**Conchoidal Scar** – a flake scar that occurs from pressure from one edge and leave a negative scar that is a negative of half of a Hertzian fracture, ending with a feather termination; force seems applied to the edge of the flake surface.

**Cortex** – rind or external enveloping of parent rock (limestone or dolomite) around chert; altered or weathered surface of a stone.

**Cortical** – relating or pertaining to the cortex.

**Cortical Blade** (*Primary Blade*) – represent initial blade removal, with the dorsal side and edges fully covered by cortex.

**Culture** – those things learned, shared, and transmitted. In general, these work with three components: mental/symbolic, behavioral, and material.

**Diagenesis** – the changes undergone by sediment after its initial deposition, exclusive of weathering and metamorphism.

**Distal** – (1) refers to the end of the blade situated away from the point of origin (point of detachment); (2) refers to the completeness of a blade where the distal end is present and the proximal end is absent.

**Dolomite** – sedimentary rocks composed of calcium-magnesium carbonate [ $\text{CaMg}(\text{CO}_3)_2$ ] with rhombohedral crystals and is most commonly a replacement of limestone through the introduction of magnesium ions in a solution of pore water.

**Dorsal Surface** – refers to outer surface of a flake, the side from which previous flakes were detached; opposite is *ventral surface*.

**Electron Dispersive X-ray (EDX)** – accessory to the SEM which provides elemental analysis with the ejection of an atomic electron by an electron in the beam ionizes the atom, which is then quickly neutralized by other electrons. In the neutralization process an x-ray with an energy characteristic of the parent atom is emitted. By collecting and analyzing the energy of these x-rays, the constituent elements of the specimen can be determined.

**Evaporite** – sedimentary rocks, such as salt and anhydrite, caused by evaporation of water.

**Facies** – overall lithology of strata representing environment of deposition.

**Flake** – piece of lithic material intentionally detached from another piece of lithic material, showing definable outer (dorsal) and inner (ventral) surfaces.

**Flake Scar** – the negative impression left by the removal of a flake from a mass of material.

**Formation** – most fundamental local rock division of stratigraphic classification; based on distinctive homogeneity of color, texture, fossil content, etc; generally named for geographic locality.

**Hand Lens** – a foldable magnifying lens.

**Interior Blade** – blades in the final stages of blade manufacture and preserve no cortex.

**Lateral** – refers to the edge of a lithic artifact.

**Limestone** – sedimentary rock composed of calcium carbonate (CaCO<sub>3</sub>), a chemically deposited sedimentary rock of various thicknesses.

**Medial** – (1) refers to the middle portion of the blade; (2) refers to the completeness of the blade where neither proximal nor distal ends are present.

**Microwear** – the microscopic study of alteration on human modified materials.

**Microtopography** – the physical characteristics, collectively, referring to the relief viewed under the compound microscope.

**Modified Blade** – blades modified from retouch and are distinguished by the shaping blade parts with retouch flakes.

**Planar** – pertaining to the smoothing AND leveling of a surface; includes polish.

**Polish** – the visible alteration of the flint surface so that the reflectivity of the flint surface is increased when viewed through the microscope; smoothing of a surface.

**Primary Blade** – see *Cortical Blade*.

**Proximal** – (1) the end of the blade that is situated toward the point of origin (point of detachment); (2) the completeness of a blade where the proximal end is present and the distal end is absent.

**Quarry** – an excavation or a pit, usually in the open air, from which rock ore is obtained.

**Scanning Electron Microscope (SEM)** – microscope in which a finely focused beam of electrons is repeatedly moved across the specimen to be examined, and the reflected and emitted electron intensity is measured and displayed, sequentially building up an image where a great depth of field is obtained.

**Secondary Blade** – blades that are removed at the intermediate stage of blade production and still have cortical backing that comprises 50% of the dorsal side and one edge.

**Snapped Scar** – occurs when the edge of the blade breaks off under bending stress and leaves no negative scar, ending in a snap or hinge termination.

**Step Scar** – occurs when force is applied to the edge and leaves a 90° (or almost 90°) “step” termination; sometimes a ladder-like arrangement or orientation; step or hinge terminations; and leaves negative scar.

**Stereomicroscope** – a form of compound microscope with two eyepieces permitting rays of light from an object to pass into both eyes of the observer, providing a three dimensional view.

**Striation** – linear features appearing on the surface as furrows or grooves.

**Tectonic** – structural behavior of large parts of crust through significant geological time.

**Trample** – to tread or step heavily, noisily, roughly, carelessly, or crushingly; tread underfoot.

**Use-Wear** – alteration of material due to use.

**Utilized Blade** – refer to blades modified from use-wear and exhibit characteristics of use-wear.

**Ventral Surface** – refers to the inner surface of a flake, the side from which the flake was detached; opposite is *dorsal surface*.

**Whole** – refers to the completeness of a blade whereas a whole blade is complete.

## **APPENDIX B**

### **FORMS, EQUIPMENT, AND PROCEDURES**

The scientific process necessitates systematics in research. Throughout the analyses and experiments, I tried to keep the observations I recorded consistent by filling out forms for each artifact and experimental blade analyzed. First shown are examples of the forms I used for the experiments, stereomicroscope analyses, and compound microscope analyses conducted. As such, I present the specifications for the equipment and software used as well as steps for acquiring and manipulating images. Dr. Robson Bonnicksen and Dr. Michael Waters provided the equipment and software through the Center for the Study of the First Americans (CSFA) at Texas A&M University for use in conducting microwear analyses on Gault artifacts. Although presented separately, the hardware and software were used in conjunction with one another, as seen below. Information on the Scanning electron microscope (SEM) and energy dispersive X-Ray (EDS), used to analyze the possible residues, are presented in APPENDIX F. Also presented below are the methods and steps for conducting the image acquisition and manipulation.

#### **Forms**

The following forms were used in the experimental procedures, stereomicroscope analyses, and compound microscope analyses. The original documents were created using Microsoft Word and photocopied for mass use. Due to my relative inexperience with SEM/EDS work, I used a notebook rather than create any forms.

**EXPERIMENTAL BLADE USE FORM**

EXP BLADE # \_\_\_\_\_ Raw Material: \_\_\_\_\_  
 Cortical / Secondary / Interior Completeness: \_\_\_\_\_

**RECORDING:**

Recording Device(s): \_\_\_\_\_  
 Film Type: \_\_\_\_\_ Tape/Roll/CD/DVD#(s): \_\_\_\_\_  
*\* - See photolog if camera is used for specific information - \**

**HAFTING (if present):**

Hafting Present: yes / no Hafting Adhesive: \_\_\_\_\_  
 Sinew Present: yes / no Hafting Type: \_\_\_\_\_  
 Notes: \_\_\_\_\_

**MATERIAL(S) WORKED: *\*If more than one, list in notes\****

Material: Hard / Soft Type: \_\_\_\_\_  
 Common Name: \_\_\_\_\_ Scientific Name: \_\_\_\_\_  
 Condition of Material: \_\_\_\_\_  
 Notes: \_\_\_\_\_

**ACTION(S):**

Longitudinal: Cutting / Sawing  
 Transversal: Scraping / Graving / Reaping  
 Notes: \_\_\_\_\_

**QUANTIFICATION & INTERVALS:**

Interval #(s): \_\_\_\_\_ Duration(s): \_\_\_\_\_  
 # of Strokes: \_\_\_\_\_ Dimension(s): \_\_\_\_\_  
 Notes: \_\_\_\_\_

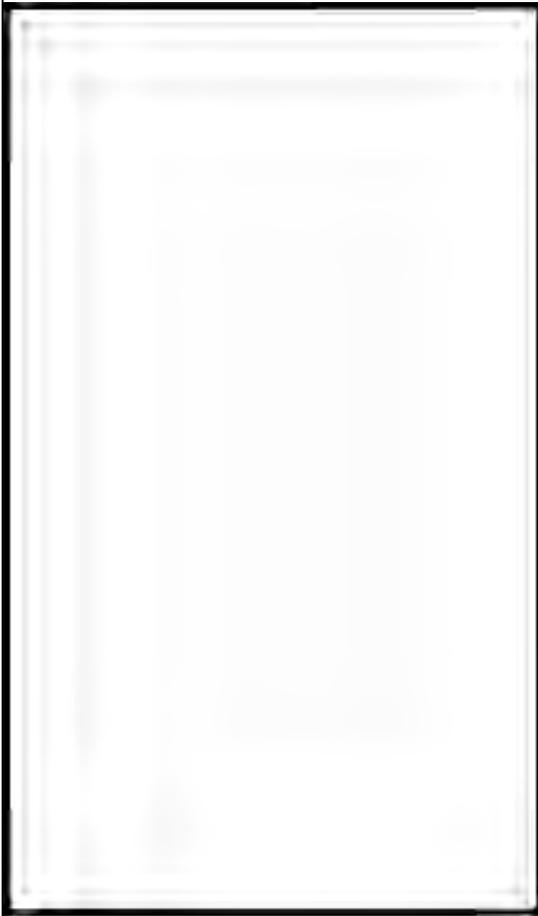


**EXPERIMENTAL BLADE STEREOMICROSCOPE ANALYSIS FORM**

#: \_\_\_\_\_  
Pre-experiment / Post-experiment

Cortical / Secondary / Interior  
Completeness: \_\_\_\_\_

Notes:



\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Patterns:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Images:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**BLADE EXPERIMENT COMPOUND MICROSCOPE ANALYSIS  
FORM**

EXP# \_\_\_\_\_

Cortical/Secondary/Interior

Completeness: \_\_\_\_\_

\*\*\*\*\* **Note:** The drawing of the artifact, as well as compound image spots other than those from the stereomicroscope analysis is, are placed on the photocopy of the stereomicroscope analysis form for the blade. \*\*\*\*\*

Notes:

---

---

---

---

---

---

---

---

Patterns:

---

---

---

---

---

---

Images:

---

---

---

---

---

Mark if Continued





**GAULT BLADE COMPOUND MICROSCOPE ANALYSIS FORM**

AM# \_\_\_\_\_ CAT# \_\_\_\_\_  
3a/3b Cortical/Secondary/Interior Completeness: \_\_\_\_\_  
Stereomicroscope Pattern: \_\_\_\_\_ Unit: 10\_\_/98\_\_ Lvl: \_\_\_\_\_

\*\*\*\*\* **Note:** The drawing of the artifact, as well as compound image spots other than those from the stereomicroscope analysis, are placed on the photocopy of the stereomicroscope analysis form for the blade. \*\*\*\*\*

Notes:

---

---

---

---

---

---

---

---

---

---

Patterns:

---

---

---

---

---

---

---

---

Images:

---

---

---

---

---

---

---

---

Mark if Continued



## Equipment

The microscope study was made possible through the use of five separate pieces of equipment: (1) Baush and Lomb Hand Lens; (2) Leica MZ12.5 Stereomicroscope; (3) Leica KL1500 LCD; (4) Leica DM LA Automated Laboratory Microscope; and (5) CoolSNAP-Pro CF Color Digital Camera. Two of these, the stereomicroscope and KL1500 LCD were used together. The CoolSNAP-Pro digital camera was alternated between microscopes when needed. Below are the equipment specifications.

### Loupe / Hand Lens

Manufacturer: Baush and Lomb

Magnification(s): 16x

### Leica MZ12.5 Stereomicroscope

Design Principle: Multiple-coated, parfocal high-performance optical system with two parallel beams (infinity optics) and one main objective (CMO), lead-free.

Numerical Aperture: 0.2x

Resolution: 600 line-pairs/mm

Objective: 1.6x planapochromatic

Eyepiece: 10x/21B

Total Magnification: 12.8x to 160x

Working Distance: 19 mm

Dioptric Correction: +5 to -5

Binocular Tubes: ErgoTube 10° to 50° with synchronized interpupillary adjustment

Interpupillary Distance: 52 to 76 mm

### Leica KL1500 LCD

Used w/: Leica MZ12.5 Stereomicroscope

Adjustments: color temperature; light intensity

Dimensions (H x W x D): approx. 200 x 265 x 170 mm

Weight: approx. 4.8 kg

Cooling: low-noise fan

Operating Voltage (120 V version): 120 V ~ 50/60 Hz; 120 V ~ 60 Hz

Operating Voltage (230 V version): 200 V ... 240 V ~ 50/60 Hz

Protection: Class II

Lamp Type: Halogen Reflecting Lamp

Lamp Voltage Rating: 15 V

Lamp Power Rating: 150 W

Average Lamp Service Life (Level 4): 1500 hours

Average Lamp Service Life (Level 5): 150 hours

Maximum Luminous Flux: 600 lm

Light Control: electrical and mechanical  
Active Light Guide Diameter: 9 mm

### **Leica DM LA Automated Laboratory Microscope**

Design Principle: ergonomic automated stage microscope

Objective: 10x, 20x, 50x

Eyepiece: 10x

Total Magnification: 100x, 200x, 500x

Motorized focus Drive: travel 25 mm; smallest increment 0.015 micrometer; max speed 5 mm / second; max load 4 kg; dovetailed for different stages

Revolving Motorized Nosepiece: absolute encoding; 6-fold for brightfield objectives; slot for DIC prisms and Pol compensators

Motorized X/Y Stage: direct stepper motorized drive; outer dimensions of 234 x 157 mm; zero position defined by end switches; travel range is 76 x 50 mm; smallest increment is 0.3 micrometers

Electronic Box CTR MIC (Separate Control Unit and Functions): motorized Z-focus drive; motorized x/y stage; motorized revolving nosepiece; 100W or LED supply for illumination; PC interface RS 232C

Microscope Automation User Control: SmartMove

### **CoolSNAP-Pro CF Color Digital Camera**

CCD Sensor: Sony ICX205AK with Bayer color mask

CCD Type: interline progressive scan HAD CCD

CCD Format: 1392 x 1040, 4.65 micron pixels

Digitizer: 12-bit a 20Mhz w/ Primary Point Dig™

Cooling: thermoelectric cooling

Interface: PCI interface card

Camera Power: provided by interface card

Readout Modes: B&W focus and color

Dark Current: <2 e/p/s @ 20°C

I/O: TTL expose out; RS-170 out

Dimensions: 4.5" x 5" x 2.5" (1.9 lbs)

Software Interface: IPP or Image-Pro Express Driver

Shutter: electronic shutter

Camera Window: IR blocking window (700nm cutoff)

Safe C-Mount Depth: 0.47 in. (11.9 mm)

Flange Focal Distance: 0.69 in. (17.5 mm)

### **Software**

The microscope study was made further possible with the aid of the software available through CSFA and the Department of Anthropology at Texas A&M

University. Five separate software components were used: (1) Image-Pro Plus; (2) Scope-Pro Plus; (3) In-Focus; (4) Adobe Photoshop; and (5) Adobe Illustrator. Three programs (Image-Pro Plus, Scope-Pro Plus, and In-Focus) were used in conjunction with the equipment mentioned above. Adobe Photoshop was used to enhance images to bring out the texture and details. Adobe Illustrator was used at the end to construct figures and plates for the thesis and to aid in analysis and interpretation.

### **Image-Pro Plus**

Version: 4.5

Company: Media Cybernetics Inc.

Capture: live preview; capture multiple images; playback sequence (stack) of images; capture support for 24-, 36-, and 48-bit color as well as 8-, 12-, and 16-bit gray scale input devices

Composite Imaging: image stitching and tiling tools; create in-focus images from partially in-focus source image stacks with EDF (extended depth of field)

Enhance: manually or automatically enhance color and contrast using equalization, gamma correction, contouring, or thresholding

Processes: perform spatial and logical arithmetic and image alignment operations

Filter: enhancement filters (Low-Pass, Hi-Pass, Gaussian, Hi-Gaussian, Sharpen, Flatten, Median, Rank, Local Equalization, and Despeckle in user-definable kernel sizes); outline objects with edge filters (Sobel, Roberts, Laplace, Variance, Phase, Horizontal, and Vertical); process objects with morphological filters (Erode, Dilate, Open, Close, Top Hat, Well, Branch/End, Watershed, Thinning, Pruning, Distance, and Reduce in user-definable kernel sizes); large spectral filters (Fast-acting, large kernel size (up to 4000 x 4000) filters including Low-Pass, Hi-Pass, Band-Pass, and Edge filters)

Fast Fourier Transformation (FFT): forward and inverse transforms; Low-Pass, Hi-Pass, unsharpen, spike cut, and spike boost

Color Channels: RGB, HIS, HSV, TIQ

Calibrate: create and display spatial calibration markers; use pre-defined spatial calibration units; save and recall all calibrations

Count and Size: count and size object automatically; measure (areas, perimeters, lengths, roundness, major and minor axes, aspects, angles, centroids, holes, population density – over 50 measurements); group objects based on measurements; resolve clustered objects in Watershed, Auto-Split, and Cluster tools

Measure: length, area, perimeter, angle, best-fit line, arc, circle; max, min, and average thickness between lines

Analyze: scattergram, histogram, line profile, intensity values in a 3D surface plot, analyze color channels,

Multi-Dimension Imaging: control and program the movement of automated microscope with *Scope-Pro Plug-in* module; manage combinations of acquisition mode (Time, Focus, Channel, Stage Position) with AFA Plug-in Module

Image Data and File Format Support: read (TIFF, IPW, JPEG, Flat (binary), TGA, BMP, PhotoCD, PICT, CUT, PCX, GEL, PCT, and HDF); write and convert (TIFF, IPW,

JPEG, Flat, TGA, BMP, PICT, PCX, and EPS); stack and confocal file support (SEQ (Image-Pro sequence), STK (Metamorph Stack), PIC (Biorad confocal), LSM (Leica confocal), DEB and AVZ (Autoquant Stack), LEI (Leica confocal), and DM3 (Digital Micrograph)); read and write (SEQ and AVI); compression supported (JPEG, LZW, RLE); batch convert files; output data for input for spreadsheets (ASCII, WK1, or XLS)

### **Scope-Pro Plug-in**

Version: n/a

Company: Media Cybernetics Inc.

Purpose: designed for Image-Pro Plus and Image-pro Discovery software to control and program the movement of automated microscope and/or stage

### **In-Focus**

Version: 1.6.0

Company: Meyer Instruments

Purpose: designed to work with Image-Pro Plus software and the Leica MZ12.5 Stereomicroscope

### **Adobe Photoshop**

Version: CS

Company: Adobe Systems Inc.

Description: Image manipulation and processing software.

### **Adobe Illustrator**

Version: CS

Company: Adobe Systems Inc.

Description: Raster and vector support for drafting graphics.

## **Image Acquisition and Manipulation**

The acquisition and manipulation of images takes place in three steps: (1) acquisition through the microscope and necessary software; (2) combining the images into an in-focus extended depth of field (EDF) image; and (3) manipulating the image in Scope-Pro Plus and/or Adobe Photoshop.

The acquisition of images from the microscope can be separated into two types: (1) from the stereomicroscope and (2) from the automated laboratory microscope (compound microscope).

### **Stereomicroscope Analysis and Image Acquisition**

What follows is not only a description of the steps for image acquisition, but also steps in analyzing artifacts. Acquisition of images using the Leica MZ12.5 stereomicroscope are as follows:

1. Uncover the Leica MZ12.5 Stereomicroscope.
2. Make sure the CoolSNAP-Pro CF Color Digital Camera is in the photography tube for the Leica MZ12.5 Stereomicroscope.
3. Turn on microscope, Leica KL1500 LCD, and CoolSNAP-Pro CF Color Digital Camera before turning on the computer.
4. Turn on the computer and double click the Image-Pro icon on the desktop.
5. Set up the sample on the microscope stage. The method of set-up is dependent upon the artifact, its constraints, and the peripheral object at hand. I used soft clips, a board with a cushion, and rubber covered bendable wires to achieve the desired position and angle of the specimen.
6. Use the motor control to adjust the objective so that the sample is in focus. Click the black button on the motor control to toggle between coarse and fine focus adjustments. Focus with the red knob.
7. Make sure that the tab above the objective is in all the way, so that you can view the image with both eyes. When the tab is out, the light is cut off from the eyepieces and goes to the camera.
8. Using the knobs on the side, adjust the magnifications control between 12.8x and 160x as needed.
9. Adjust the lighting with the left knob to control the voltage and right to control the intensity. Generally, the higher the magnification the greater the light intensity needed.
10. Analyze artifact. While proceeding in my analysis, I mark spots to take images on my analysis form. For this, I begin by looking at the dorsal and ventral faces and ridges. I then begin closer inspection of the lateral edges on both dorsal and ventral faces. I then finish by looking at the proximal and distal end.
11. Once the image locations are ready, move the tab to the left out to the left so that the light goes to the camera.
12. Click on the camera icon on the menu bar in Image-Pro Plus. In the CoolSNAP-Pro dialog box, the default tab is "Preview." Click the bottom "Start Preview"

- tab. This brings up a window showing the live image at 1392 x 1040 size 24-bit depth. Adjust the exposure time (milliseconds to hours – use milliseconds) to change the over- or underexposure to achieve desired results. Note – Steps 11 and 12 can be done before analysis. My preference is to analyze through the eyepieces.
13. To begin capturing images, open In-Focus version 1.6.0 through the Programs Menu from the Start Menu. When the window is open, choose the “Automatic” tab. When in this tab, go through the following steps:
    - a. Focus on the top of the specimen to define the top.
    - b. Focus on the bottom of the specimen to define the bottom.
    - c. Set the sample increment to provide the number of images you will take.
    - d. Click on “Start Capture” to begin taking images.
  14. Wait for the microscope to take the images.
  15. Once the images are taken, they are displayed in the Image-Pro Plus window in a sequence (SEQ) file and played as a slideshow.
  16. To create a composite image of the sequence, go to the Image-Pro Plus window. On the menu bar, click “Process” and select “Extended Depth of Field” from the drop down menu. This brings up a window. Complete the following substeps:
    - a. Highlight the image sequence in the left half of the window.
    - b. Click the “Add” button.
  17. Once the above is done, and when still in the same window, select the next tab and complete the following substeps:
    - a. Click on “Generate composite best to focus the image.”
    - b. Click on “Normalize illumination.”
    - c. Click on “Maximum local contrast.”
    - d. Click “Create” button at the bottom of the window. The EDF composite image appears on the screen.
  18. Click the “wrench” icon from the menu bar. This brings up the window to set the spatial calibration. The following substeps are:
    - a. Select the type of scale (background/foreground colors – set uniformly to black/white).
    - b. Bring up the menu of pre-set spatial calibrations (for both microscopes) and select the one for the stereomicroscope and its magnification. Then click “ok.”
    - c. The scale appears on the image. Left-click on the scale and drag it to the desired placement (lower right unless it blocks a salient feature). Right-click on the scale when done. It is now part of the image.
  19. If the image is acceptable, save the composite image to the hard drive. If not, retake the image. The image saves as a 1392 x 1040 size 24-bit depth image in a tagged image file format (TIFF).
  20. Clear the sequence from the window. These were not saved due to the size of the sequence (>50 MB) and the amount of images taken.

21. Move on to the next magnification of images to take or to the next artifact to analyze. Note – For each image location, I took images at 20x, 40x, and 100x along with extra lower or higher magnification if needed for a specific feature.

### **Compound Microscope Analysis and Image Acquisition**

What follows is not only a description of the steps for compound microscope image acquisition, but also steps in analyzing artifacts. There is an overlap since both microscopes use Image-Pro Plus. However, the EDF is created from compound scope sequences through Image-Pro Plus and not In-Focus 1.6.0. Jim Wiederhold operated the compound microscope for CSFA, especially due to the idiosyncratic nature of the microscope right after taking images. Acquisition of images using the Leica DM LA Automated Laboratory Microscope are as follows:

1. Uncover the Leica DM LA Automated Laboratory Microscope
2. Make sure the CoolSNAP-Pro CF Color Digital Camera is in the photography tube for the Leica DM LA Automated Laboratory Microscope.
3. Turn on the microscope MIC CTR and light.
4. Wait for the microscope's stage to calibrate.
5. Turn on the computer and double click the Image-Pro icon on the desktop.
6. Click on the camera icon on the menu bar in Image-Pro Plus. In the CoolSNAP-Pro dialog box, the default tab is "Preview." Click the bottom "Start Preview" tab. This brings up a window showing the live image at 1392 x 1040 size 24-bit depth. When two people are working, the screen becomes the primary way to view the specimen under magnification.
7. Set up the sample on the microscope stage. The method for securing the specimen on the compound scope differs slightly from the stereomicroscope. The first method used placing the specimen in a clip, which is then fixed to a mass of clay that rests on the motorized slide-holder part of the stage. When a specimen is large or oddly balanced in this method, additional clay is placed on the other side of the motorized portion. A second method was to use a glass slide, in the slide-holder, with clay under the artifact. Both methods necessitated frequent wipes with alcohol. Although the user must move the specimen frequently, careful attention must be made to make sure the surface is level with the objective (allowing polish to show).
8. Using the "SmartMove" motorized control, move the specimen along its x-, y-, and z-axes until a clear view is achieved through the microscope.
9. Adjust the exposure time (milliseconds to hours – use milliseconds) to change the over- or underexposure to achieve desired results in the "Preview" tab. Also adjust the levers on the upper right side of the microscope if needed.
10. Analyze artifact. If I were the only one working on the microscope, the method of analysis would be similar to what is described under the stereomicroscope analysis and image acquisition section of this appendix. Since I worked with Jim Wiederhold, we worked off the image shown in the monitor. Periodically, if we had a problem in identification, the microscope offered a way to double check

what we were seeing. With the trouble of leveling, as well as orienting, the specimen properly, images were taken while analyzing. Edges, tips, and ridges were thoroughly scanned. Transects, usually every c.a. 5 cm were viewed from the edge to the ridge (dorsal), or edge to middle (ventral), or edge to edge (ventral).

11. Begin capturing images.
12. Once the images are taken, they are displayed in the Image-Pro Plus window in a sequence (SEQ) file and played as a slideshow.
13. To create a composite image of the sequence, go to the Image-Pro Plus window. On the menu bar, click "Process" and select "Extended Depth of Field" from the drop down menu. This brings up a window. Complete the following substeps:
  - a. Highlight the image sequence in the left half of the window.
  - b. Click the "Add" button.
14. Once the above is done, and when still in the same window, select the next tab and complete the following substeps:
  - a. Click on "Generate composite best to focus the image."
  - b. Click on "Normalize illumination."
  - c. Click on "Maximum local contrast."
  - d. Click "Create" button at the bottom of the window.
15. Click "Create" button at the bottom of the window.
16. Click the "wrench" icon from the menu bar. This brings up the window to set the spatial calibration. The following substeps follow:
  - a. Select the type of scale (background/foreground colors – set uniformly to black/white).
  - b. Bring up the menu of pre-set spatial calibrations (for both microscopes) and select the one for the compound scope and its magnification. Then click "ok."
  - c. The scale appears on the image. Left-click on the scale and drag it to the desired placement (lower right unless it blocks a salient feature). Right-click on the scale when done. It is now part of the image.
17. If the image is acceptable, save the composite image to the hard drive. If not, retake the image. The image saves as a 1392 x 1040 size 24-bit depth image in a tagged image file format (TIFF).
18. Clear the sequence from the window. It was not saved due to the size of the sequence (>50 MB) and the amount of images taken.
19. Move on to the next magnification of images to take or to the next artifact to analyze. Note – For each image location, we took images at 100x, 200x, and 500x.

Manipulation of the images is different for the stereomicroscope and compound microscope images. While the stereomicroscope images required little to no processing to enhance features, compound microscope images sometimes required more extensive and involved enhancements.

### **Image Manipulation of the Stereomicroscope Images**

Enhancing the images from the stereomicroscope fall into two categories: (1) no modification and (2) light modification. Images in the first category, as it states, received no modification from software and thus require no further explanation beyond the acquisition process. Images receiving light modification were done in Image-Pro Plus.

1. Turn on the computer.
2. Double click on the Image-Pro Plus icon on the desktop.
3. Open the image in Image-Pro Plus.
4. From the menu bar, select the icon in the menu bar to adjust the levels (brightness/contrast/gamma). This opens a separate window.
5. The contrast remained the same, the brightness was lessened (from 49 to 47), and the gamma ray was brought up (from 1.0 to 1.1).
6. Save image.

### **Image Manipulation of the Compound Microscope Images**

Enhancing the compound microscope images was done in Adobe Photoshop. The same steps were followed for each image, with variation on the amount changed.

1. Turn on the computer.
2. Double click on the Adobe Photoshop CS icon on the desktop (or Start Menu → Programs → Adobe Photoshop CS).
3. Open the image in Adobe Photoshop.
4. From the menu bar, click “Image” → “Adjust” → “Auto Contrast.”
5. From the menu bar, click “Edit” → “Fade” (generally between 60 – 80%). The fade command fades the last selection made so that it will work for the next steps (auto levels and auto colors) as well.
6. From the menu bar, click “Image” → “Adjust” → “Auto Levels.”
7. From the menu bar, click “Edit” → “Fade” (generally between 60 – 80%).
8. From the menu bar, click “Image” → “Adjust” → “Auto Colors.”
9. From the menu bar, click “Edit” → “Fade” (generally between 60 – 80%).
10. From the menu bar, click “Image” → “Adjust” → “Brightness/Contrast.” This will bring up a window allowing you to adjust the brightness and contrast separately in an either negative or positive direction from the current settings. For 100x, the settings are closer to the current settings and at 500x the settings are further removed.
11. Save as a separate file.

## APPENDIX C

### EXPERIMENTS

The following contains expanded procedure information and the data acquired from the experiments conducted to provide analogs for the microscope patterns found on the Gault Clovis blades. Interpretations and conclusions are found in the body of the text.

The experiments conducted can be separated by work on soft and hard materials. The soft experiments were reaping grass (with two blades), sawing cane, cleaning sinew, and cutting rawhide. Hard experiments were scraping wood, sawing horn, and scraping horn.

#### “Soft” Experiments

1. Blade NNWXP2 – Reaping Grass
  - a. Blade Details
    - i. Raw Material: Edwards Chert
    - ii. Blank Type: Secondary
    - iii. Completeness: Whole
    - iv. Modifications(s): Serrated on both edges
    - v. Figure: C-1
  - b. Pre-Use Analysis
    - i. Notes: the blade is half chert and half “subcortex”
    - ii. Polish:
      1. Distribution: none
      2. Invasiveness: none
      3. Polish Development: none
      4. Microtopography: intact
    - i. Linear Indicators: none
  - c. Experiment Details
    - i. Hafting
      1. Present: yes
      2. Hafting Adhesive: hide glue
      3. Sinew Present: yes
    - ii. Material(s) Worked
      1. Material: Soft
      2. Type: Grass
      3. Name(s): Not Available
      4. Condition: dry / wet
    - iii. Actions(s): reaping grass
    - iv. Intervals and Strokes:
      1. Interval One: 1000 Strokes
      2. Interval Two: 1000 Strokes (2000 Stroke Total)
  - d. Analysis after 1000 Strokes (Compound)

- iii. Notes: edges are rounded and the chalcedony has polished quicker than the surrounding chert
- iv. Polish:
  - 1. Distribution: edge only / even
  - 2. Invasiveness: > 0.5 cm diameter
  - 3. Polish Development: individual elements (A+)
  - 4. Microtopography: undulating evening of the surface (due to difference in material and softness of grass)
  - i. Linear Indicators: none
- e. Analysis after 2000 Strokes (Compound)
  - v. Notes: edges are rounded and the chalcedony continues to polish quicker than the surrounding chert
  - vi. Polish:
    - 1. Distribution: edge only / even
    - 2. Invasiveness: > 0.5 cm diameter
    - 3. Polish Development: individual elements (A+)
    - 4. Microtopography: undulating evening of the surface (due to difference in material and softness of grass)
    - i. Linear Indicators: faint striations(?) viewable at 500x
- f. After 2,000 strokes, the edge rounding was more pronounced but the polish changed little.

## 2. Blade FUTB44 – Reaping Grass

- a. Blade Details
  - i. Raw Material: Edwards Chert
  - ii. Blank Type: Secondary
  - iii. Completeness: Distal
  - iv. Modifications(s): None
  - v. Figure: C-2
- b. Pre-Use Analysis (Stereomicroscope)
  - i. Notes: Use projected to be in mid right lateral
  - ii. Patterns: Five Patterns
  - iii. Images: Two images
- c. Experiment Details
  - i. Hafting
    - 1. Present: no (before 500 strokes) / yes (after 500 strokes)
    - 2. Hafting Adhesive: asphaltum
    - 3. Sinew Present: no
  - ii. Material(s) Worked
    - 1. Material: Soft
    - 2. Type: Grass
    - 3. Name(s): Not Available
    - 4. Condition: dry / wet
  - iii. Actions(s): reaping/cutting

- iv. Intervals and Strokes:
  1. Interval One: 500 Strokes, not hafted
  2. Interval Two: 1000 Strokes (1500 Stroke Total), hafted
  3. Interval Three: 500 Strokes (2000 Stroke Total), hafted
- v. Notes:
- d. Analysis after 500 Strokes: little change evident
  - i. Polish:
    1. Distribution: edge only / asymmetric
    2. Invasiveness: edge only
    3. Polish Development: individual elements (A)
    4. Microtopography: intact
  - ii. Linear Indicators: none
- e. Analysis after 1500 Strokes:
  - i. Polish:
    1. Distribution: edge only / asymmetric
    2. Invasiveness: > 0.5 cm diameter
    3. Polish Development: individual elements (A+) → linked (B), with linear (D)
    4. Microtopography: rounding of asperities begins
  - ii. Linear Indicators: linear polish features
- f. Analysis after 2000 Strokes:
  - i. Polish:
    1. Distribution: edge only / asymmetric
    2. Invasiveness: > 0.5 cm diameter
    3. Polish Development: linked (B → B+)
    4. Microtopography: smoothing of asperities on the edge and high spots that come into contact, but relict microtopography still noticeable
  - ii. Linear Indicators: none...those present in 1500 interval were combined with the polish of the surrounding area
- g. Polish Development: polish became evident and more linked from the 1500 stroke interval to the 2000 stroke interval. The polish, however, did not grind the asperities, but rounded them (see Location A on figure).

### 3. Blade FUTR43 – Sawing Cane

- a. Blade Details
  - i. Raw Material: Edwards Chert
  - ii. Blank Type: Secondary
  - iii. Completeness: Whole
  - iv. Modifications(s): None
  - v. Figure: C-3
- b. Pre-Use Analysis
  - i. Polish:
    1. Distribution: none

- 2. Invasiveness: none
      - 3. Polish Development: none
      - 4. Microtopography: intact
    - ii. Linear Indicators:none
  - c. Experiment Details
    - i. Hafting
      - 1. Present: no
      - 2. Hafting Adhesive: none
      - 3. Sinew Present: no
    - ii. Material(s) Worked
      - 1. Material: Soft
      - 2. Type: Cane
      - 3. Name(s): Not Available
      - 4. Condition: wet
    - iii. Actions(s): Sawing
    - iv. Intervals and Strokes:
      - 1. Interval One: 791 Strokes
  - d. Analysis after 791 Strokes: Strokes:
    - i. Polish:
      - 1. Distribution: edge only / asymmetric
      - 2. Invasiveness: > 0.5 cm diameter
      - 3. Polish Development: linked (B → B+)
      - 4. Microtopography: slight rounding of the asperities and nearby chert high points
    - ii. Linear Indicators: none
  - e. Polish Development: none, only analyzed after one interval
4. Blade FUTR42 – Circumscribing Cane
  - a. Blade Details
    - i. Raw Material: Edwards Chert
    - ii. Blank Type: Secondary
    - iii. Completeness: Whole
    - iv. Modifications(s): None
    - v. Figure: N/A
  - b. Pre-Use Analysis
    - i. Polish:
      - 1. Distribution: none
      - 2. Invasiveness: none
      - 3. Polish Development: none
      - 4. Microtopography: intact
    - ii. Linear Indicators:none
  - c. Experiment Details
    - i. Hafting
      - 1. Present: no

- 2. Hafting Adhesive: no
      - 3. Sinew Present: no
    - ii. Material(s) Worked
      - 1. Material: Soft
      - 2. Type: Cane
      - 3. Name(s): Not Available
      - 4. Condition: dry / wet
    - iii. Actions(s): Circumscribed Cutting
    - iv. Intervals and Strokes:
      - 1. Interval One: 78 Strokes
  - d. Analysis after 78 Strokes:
    - i. Polish:
      - 1. Distribution: none
      - 2. Invasiveness: none
      - 3. Polish Development: none
      - 4. Microtopography: that of unaltered chert
    - ii. Linear Indicators: none
  - e. Polish Development: none, only analyzed after one interval
5. Blade NWXP3 – Cleaning Sinew
  - a. Blade Details
    - i. Raw Material: Edwards Chert
    - ii. Blank Type: Secondary
    - iii. Completeness: Whole
    - iv. Modifications(s): None
    - v. Figure: C-4
  - b. Pre-Use Analysis
    - i. Polish:
      - 1. Distribution: none
      - 2. Invasiveness: none
      - 3. Polish Development: none
      - 4. Microtopography: intact
    - ii. Linear Indicators: none
  - c. Experiment Details
  - d. Analysis after 500 Strokes
    - i. Polish:
      - 1. Distribution: edge only / asymmetric
      - 2. Invasiveness: < 0.5 cm diameter
      - 3. Polish Development: linked (B → B+)
      - 4. Microtopography:
    - ii. Linear Indicators: u-shaped grooves, perpendicular to edge and on edge (visible when viewing edge straight on)
  - e. Polish Development: none, only analyzed after one interval

6. Blade NWXP4 – Cutting Rawhide
  - a. Blade Details
    - i. Raw Material: Edwards Chert
    - ii. Blank Type: Interior
    - iii. Completeness: Whole
    - iv. Modifications(s): None
    - v. Figure: C-5
  - b. Pre-Use Analysis
    - i. Polish:
      1. Distribution: none
      2. Invasiveness: none
      3. Polish Development: none
      4. Microtopography: intact
    - ii. Linear Indicators: none
  - c. Experiment Details
    - i. Hafting
      1. Present: yes
      2. Hafting Adhesive: hide glue
      3. Sinew Present: yes
    - ii. Material(s) Worked
      1. Material: Soft/Hard
      2. Type: Rawhide
      3. Name(s): Bison Rawhide
      4. Condition: dry
    - iii. Actions(s): cutting
    - iv. Intervals and Strokes:
      1. Interval One: 61 Strokes
      2. Interval Two: 60 Strokes (121 Stroke Total)
    - v. Notes:
  - d. Analysis after 121 Strokes (242 cm of Rawhide Cut)
    - i. Polish:
      1. Distribution: gapped
      2. Invasiveness: > 0.5 cm
      3. Polish Development: individual elements (A+) on ventral and linked (B+) on dorsal ridge
      4. Microtopography:
        - i. Linear Indicators: oblique from lateral edge, located over the ridge; u-shaped, shallow, and isolated
  - e. Polish Development: none, only analyzed after the second interval (both of which occurred during the same hour)

## “Hard” Experiments

1. Blade GRT4-1 – Scraping Wood
  - a. Blade Details
    - i. Raw Material: Edwards Chert
    - ii. Blank Type: Secondary
    - iii. Completeness: Whole
    - iv. Modifications(s): None
    - v. Figure: C-6
  - b. Pre-Use Analysis
    - i. Polish:
      1. Distribution: none
      2. Invasiveness: none
      3. Polish Development: none
      4. Microtopography: intact
    - ii. Linear Indicators: none
  - c. Experiment Details
    - i. Hafting
      1. Present: no
      2. Hafting Adhesive: none
      3. Sinew Present: no
    - ii. Material(s) Worked
      1. Material: Hard
      2. Type: Wood
      3. Name(s): Oak
      4. Condition: green
    - iii. Actions(s): Scraping
    - iv. Intervals and Strokes:
      1. Interval One: 633 Strokes
      2. Interval Two: 916 Strokes
      3. Interval Three: 265 Strokes
      4. Interval Four: 363 Strokes
      5. Interval Five: 30 Strokes (in separate area)
    - v. Notes: intervals happened on different pieces of wood during the same day
  - d. Analysis after 2177 Strokes
    - i. Notes: Polish uneven and present on both dorsal and ventral faces, polish also on some flake scar breaks.
    - ii. Polish:
      1. Distribution: edge only / asymmetrical (dorsal and ventral)
      2. Invasiveness: < 0.5 cm in diameter
      3. Polish Development: linked
      4. Microtopography: mostly intact, hit asperities

- iii. Linear Indicators: none
  - e. Polish Development: none, analyzed after final interval
- 2. Blade NNWXP1 – Sawing Wood
  - a. Blade Details
    - i. Raw Material: Edwards Chert
    - ii. Blank Type: Secondary
    - iii. Completeness: Whole
    - iv. Modifications(s): Serrated on left lateral edge and modified on distal tip
    - v. Figure: C-7
  - b. Pre-Use Analysis
    - i. Polish:
      - 1. Distribution: none
      - 2. Invasiveness: none
      - 3. Polish Development: none
      - 4. Microtopography: intact
    - ii. Linear Indicators: none
  - c. Experiment Details
    - i. Hafting
      - 1. Present: yes
      - 2. Hafting Adhesive: asphaltum
      - 3. Sinew Present: no
    - ii. Material(s) Worked
      - 1. Material: Hard
      - 2. Type: Wood
      - 3. Name(s): Oak
      - 4. Condition: dry
    - iii. Actions(s): Sawing
    - iv. Intervals and Strokes:
      - 1. Interval One: 710 Strokes (355 Back and Forth)
    - v. Notes:
  - d. Analysis after 710 Stokes (355 Back and Forth)
    - i. Notes: heavy edge scarring in middle of blade, heavier polish on margins of micro flake scars
    - ii. Polish:
      - 1. Distribution: gapped
      - 2. Invasiveness: > 0.5 cm diameter
      - 3. Polish Development: low linked
      - 4. Microtopography: polish is hitting high spots
    - iii. Linear Indicators: none
  - e. Polish Development (Pre-Use → 500 Strokes → 1000 Strokes)

3. Blade NWXP1 – Sawing Horn
  - a. Blade Details
    - i. Raw Material: Edwards Chert
    - ii. Blank Type: Secondary
    - iii. Completeness: Whole
    - iv. Modifications(s): None
    - v. Figures: C-8
  - b. Pre-Use Analysis
    - i. Polish:
      1. Distribution: none
      2. Invasiveness: none
      3. Polish Development: none
      4. Microtopography: intact
    - ii. Linear Indicators:
  - c. Experiment Details
    - i. Hafting
      1. Present: yes
      2. Hafting Adhesive: asphaltum
      3. Sinew Present: no
    - ii. Material(s) Worked:
      1. Material: Hard
      2. Type: Horn
      3. Name(s): Cow horn
      4. Condition: dry
    - iii. Actions(s): Sawing
    - iv. Intervals and Strokes:
      1. Interval One: 500 Strokes (250 Back and Forth)
      2. Interval Two: 500 Strokes (Total of 1000 Strokes, 500 Back and Forth)
  - d. Analysis after 500 Strokes
    - i. Notes: uneven edge
    - ii. Polish:
      1. Distribution: gapped
      2. Invasiveness: > 0.5 cm diameter
      3. Polish Development: linked (B)
      4. Microtopography: polish on high spots, getting hit continuously
    - iii. Linear Indicators: striations, u-shaped, broad and spaced
  - e. Analysis after 1000 Strokes
    - i. Notes: uneven edge
    - ii. Polish:
      1. Distribution: gapped
      2. Invasiveness: > 0.5 cm diameter
      3. Polish Development: linked (B)

- 4. Microtopography: polish still on high spots, still getting hit continuously but spreading out
- iii. Linear Indicators: striations, u-shaped, broad and spaced
- f. Polish Development: This is one of the best experimental pieces to track polish development.

#### 4. Blade NNWXP1 – Scraping Horn

- a. Blade Details
  - i. Raw Material: Edwards Chert
  - ii. Blank Type: Secondary
  - iii. Completeness: Whole
  - iv. Modifications(s): Serrated on left lateral edge and modified on distal tip
  - v. Figure: C-9
- b. Pre-Use Analysis
  - i. Notes: looks like hitting of the asperities, probably due to manufacture
  - ii. Polish:
    - 1. Distribution: none
    - 2. Invasiveness: none
    - 3. Polish Development: individual elements
    - 4. Microtopography: intact
  - iii. Linear Indicators: none
- c. Experiment Details
  - i. Hafting
    - 1. Present: yes
    - 2. Hafting Adhesive: asphaltum
    - 3. Sinew Present: no
  - ii. Material(s) Worked:
    - 1. Material: Hard
    - 2. Type: Wood
    - 3. Name(s): Oak
    - 4. Condition: dry
  - iii. Actions(s): Scraping
  - iv. Intervals and Strokes:
    - 1. Interval One: 500 Strokes (250 Back and Forth)
    - 2. Interval Two: 500 Strokes (Total of 1000 Strokes, 500 Back and Forth)
- d. Analysis after 500 Strokes
  - i. Notes: Polish and faint striations visible (polish best at 100x and 200x; striations best at 200x and 500x)
  - ii. Polish:
    - 1. Distribution: edge only / asymmetric
    - 2. Invasiveness: < 0.5 cm diameter

3. Polish Development: linked (B)
4. Microtopography:
- iii. Linear Indicators: faint striations, hard to photograph
- e. Analysis After 1000 Strokes
  - i. Notes: Polish and striations visible (polish best at 100x and 200x; striations best at 200x and 500x)
  - ii. Polish:
    1. Distribution: edge only / asymmetric
    2. Invasiveness: < 0.5 cm diameter
    3. Polish Development: linked (B+)
    4. Microtopography:
  - iii. Linear Indicators: Curved striations
- f. Polish Development: polish and striations increase visibly from 500 strokes to 1000 strokes.

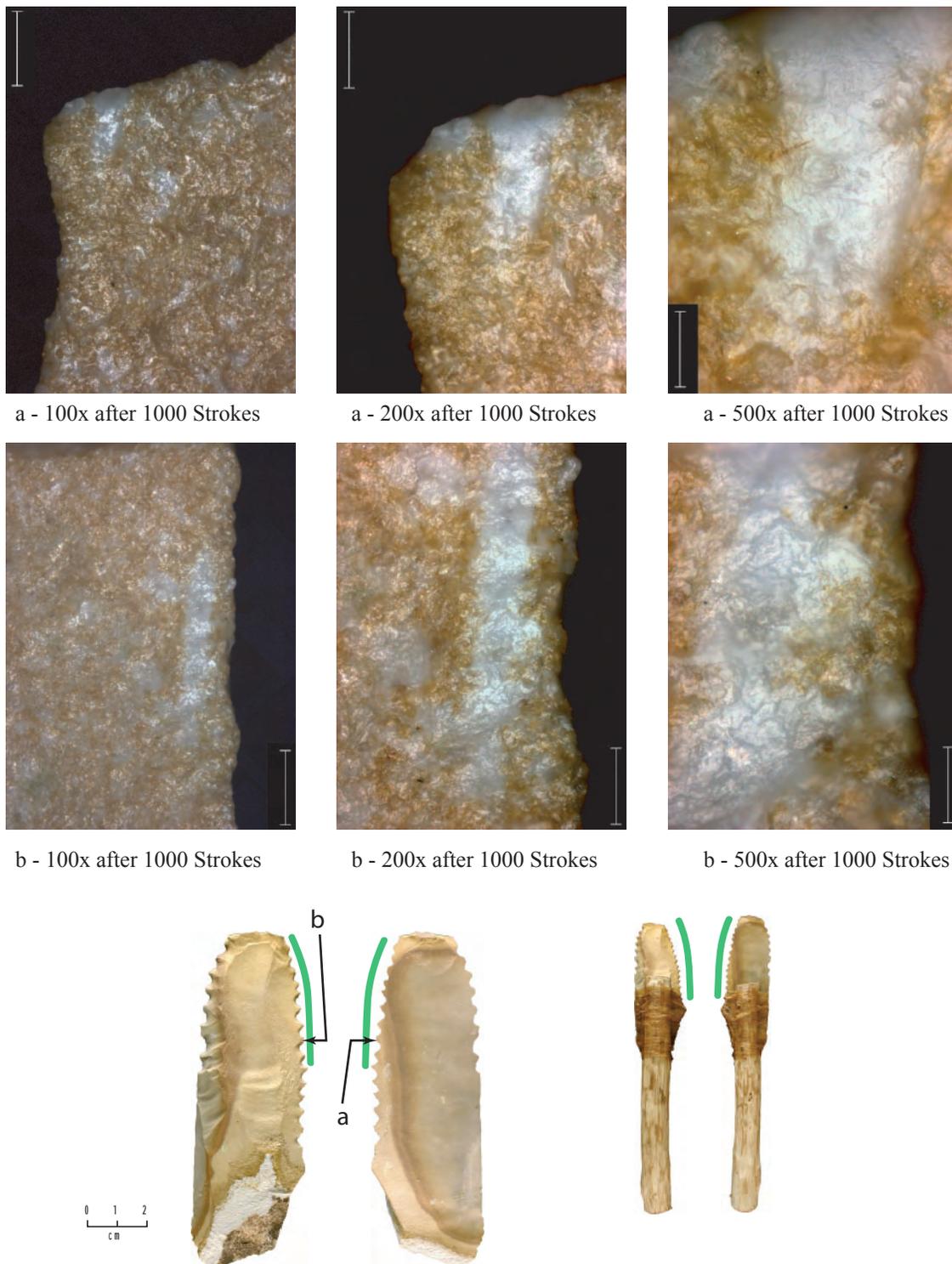


Figure C-1. Experimental Blade NNWXP2 (reaping grass): (a) polish and rounding after 1000 strokes; (b) polish and rounding after 1000 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

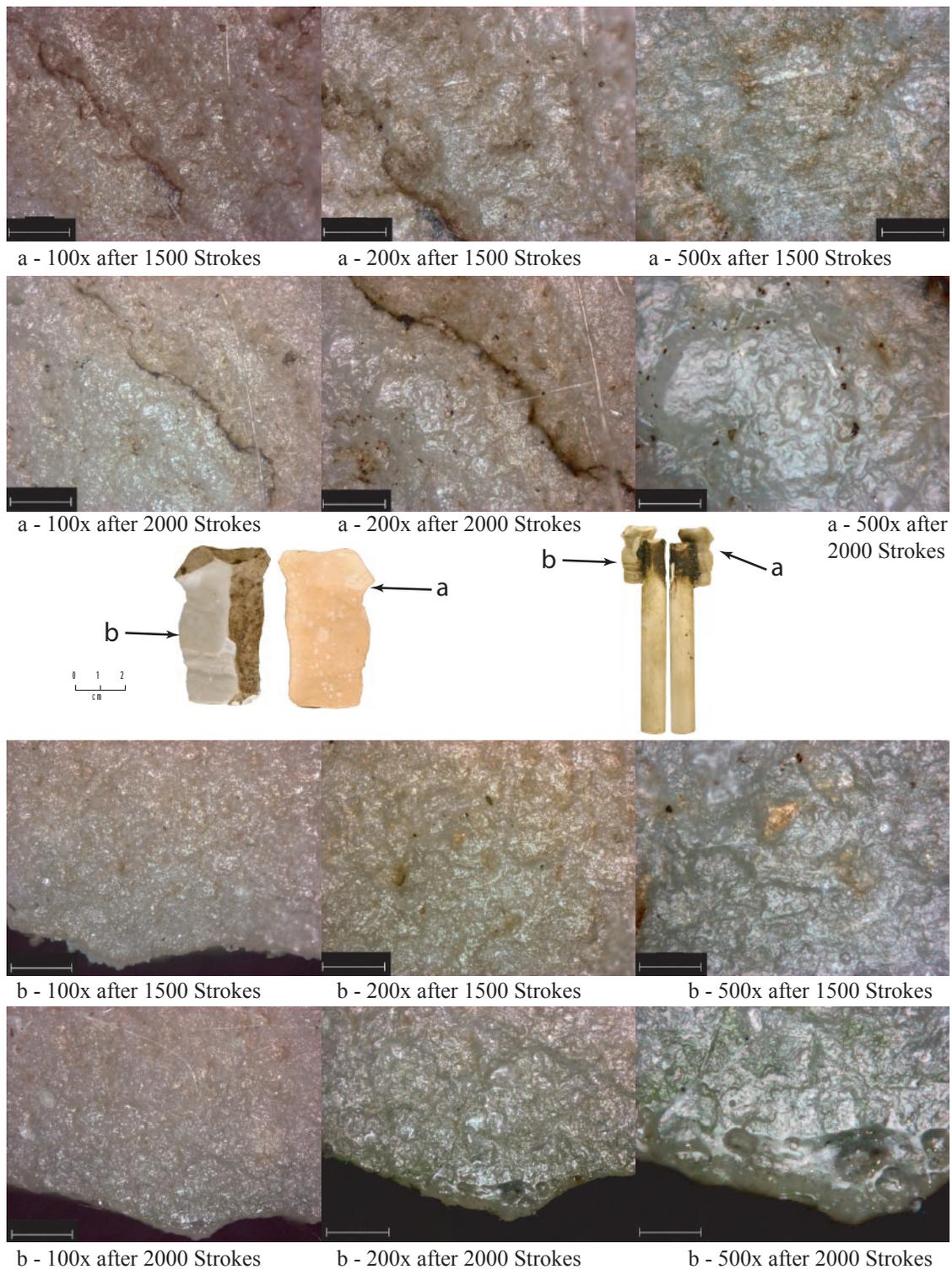


Figure C-2. Experimental Blade FUTB44 (reaping grass): (a) polish and rounding after 1500 and 2000 strokes; (b) polish and rounding after 1500 and 2000 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

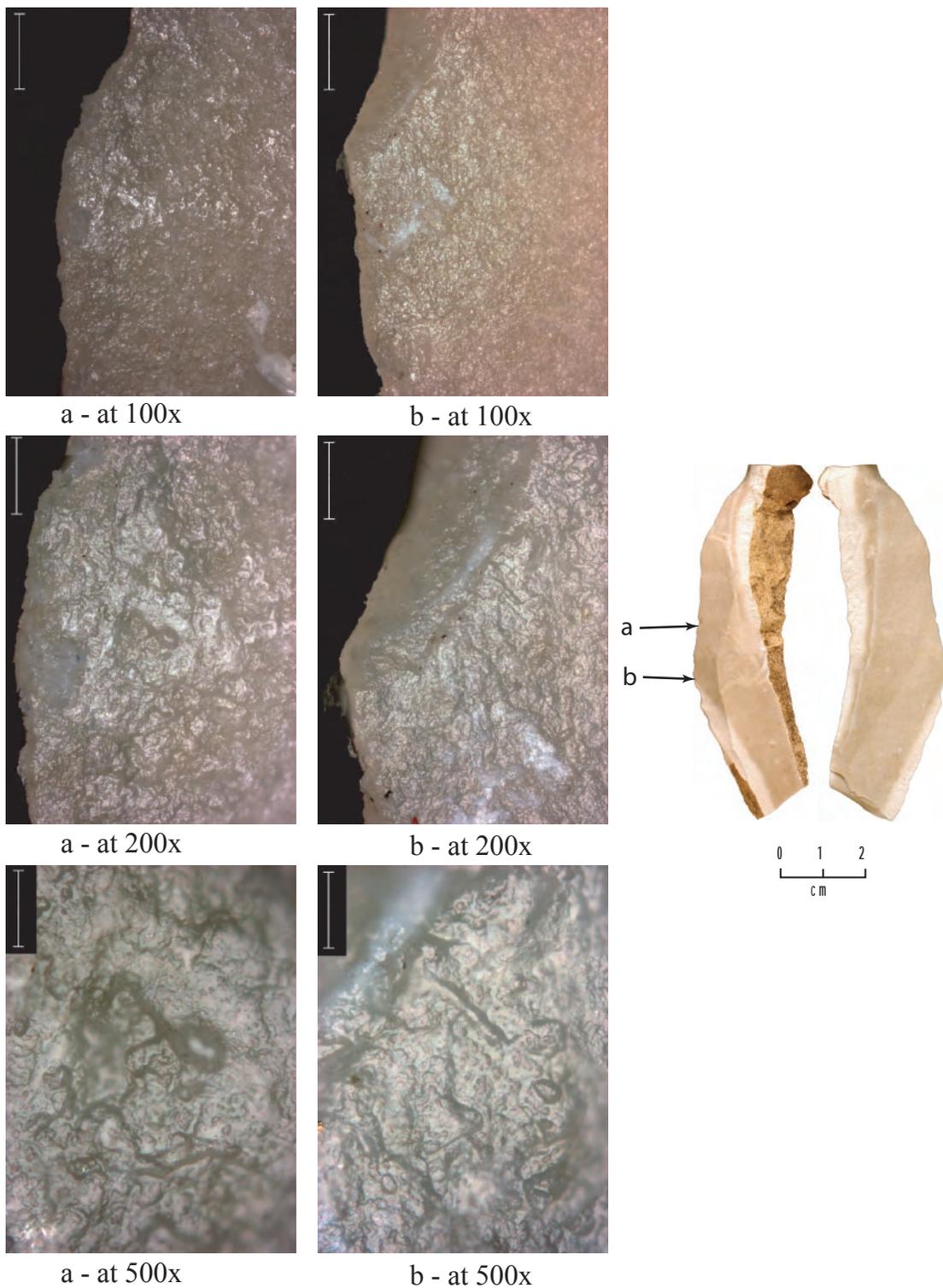


Figure C-3. Experimental Blade FUTR43 (sawing cane): (a) weak polish and rounding after 791 strokes; (b) weak polish and rounding after 791 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

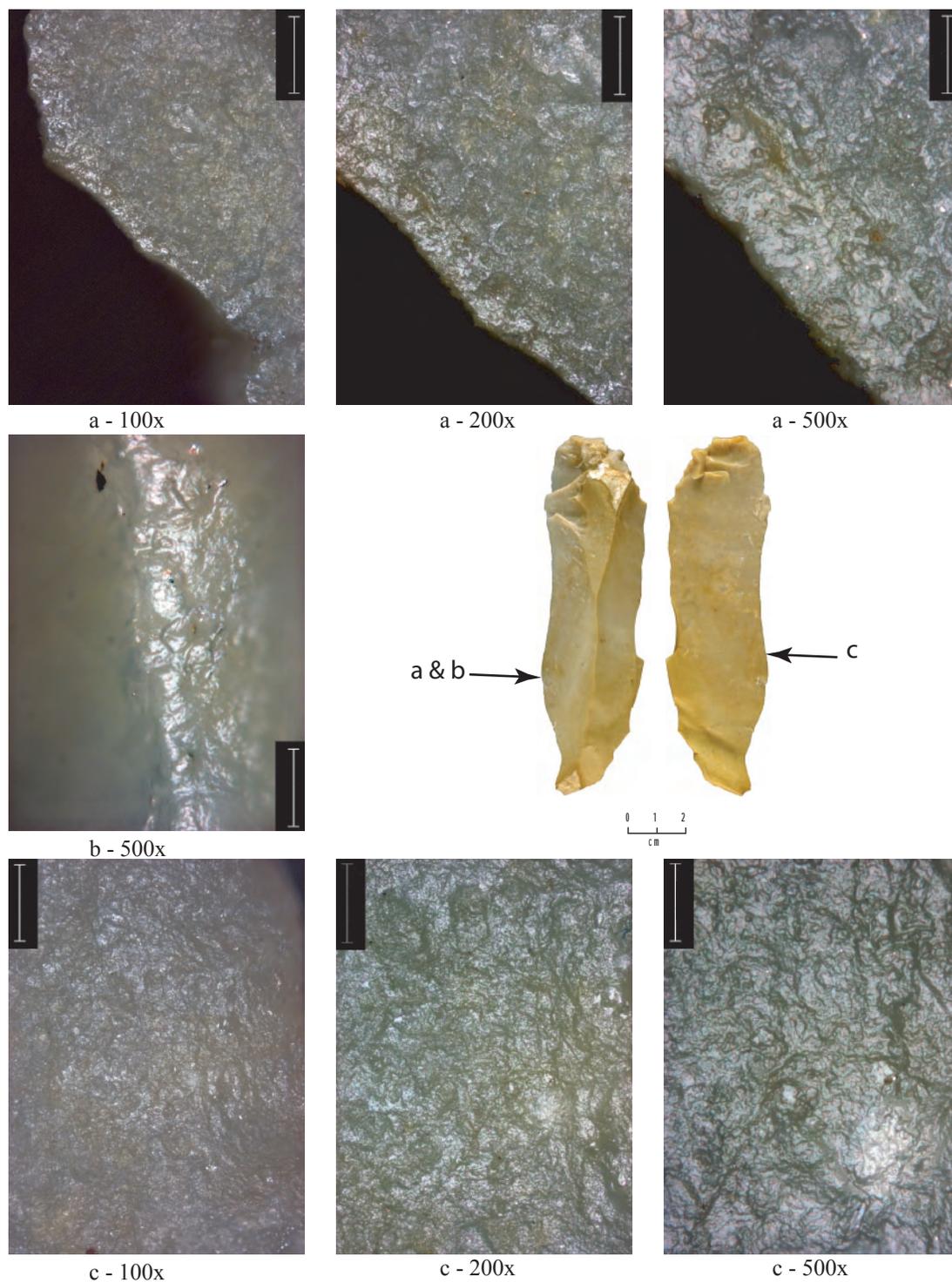


Figure C-4. Experimental Blade NWXP3 (cleaning sinew): (a) polish and rounding on dorsal face after 500 strokes; (b) polish and rounding on edge after 500 strokes; (c) weak polish on ventral face after 500 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

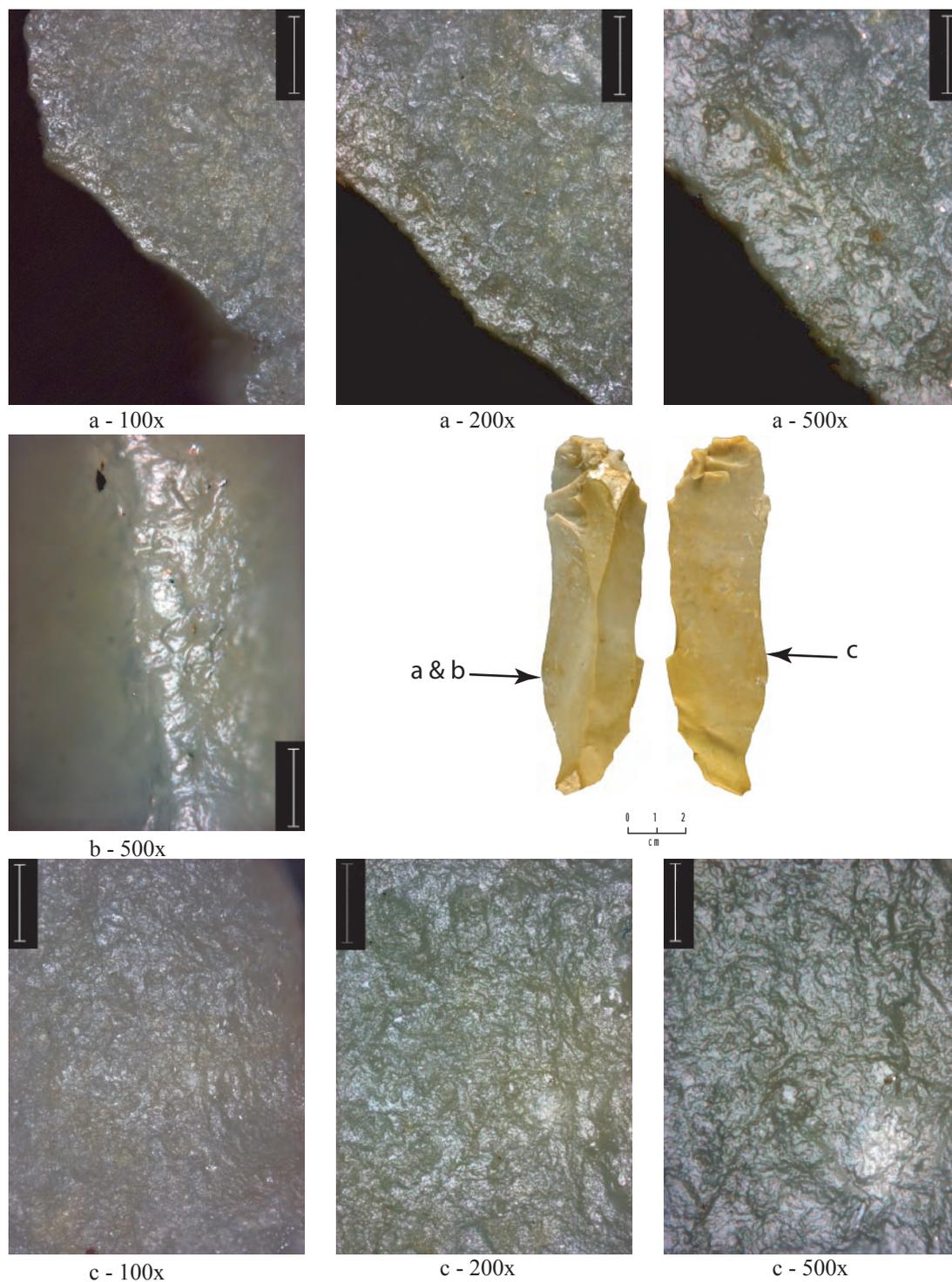


Figure C-4. Experimental Blade NWXP3 (cleaning sinew): (a) polish and rounding on dorsal face after 500 strokes; (b) polish and rounding on edge after 500 strokes; (c) weak polish on ventral face after 500 strokes. Scales: 100x = 200  $\mu\text{m}$ ; 200x = 100  $\mu\text{m}$ ; and 500x = 50  $\mu\text{m}$ .

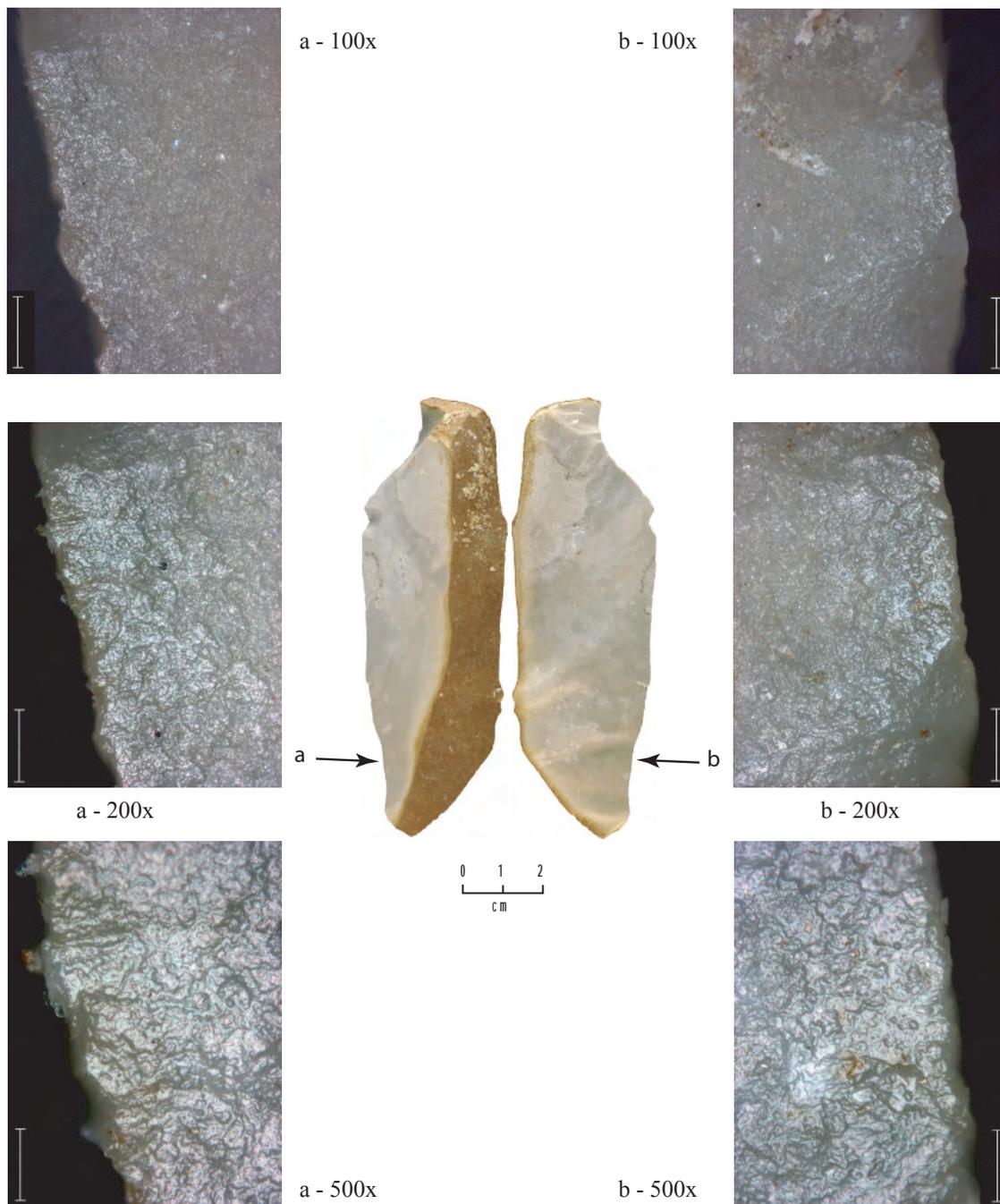


Figure C-6. Experimental Blade GRT 4-1 (scraping wood): (a) polish on dorsal face after 2177 strokes; (b) heavier polish and rounding on ventral face after 2177 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

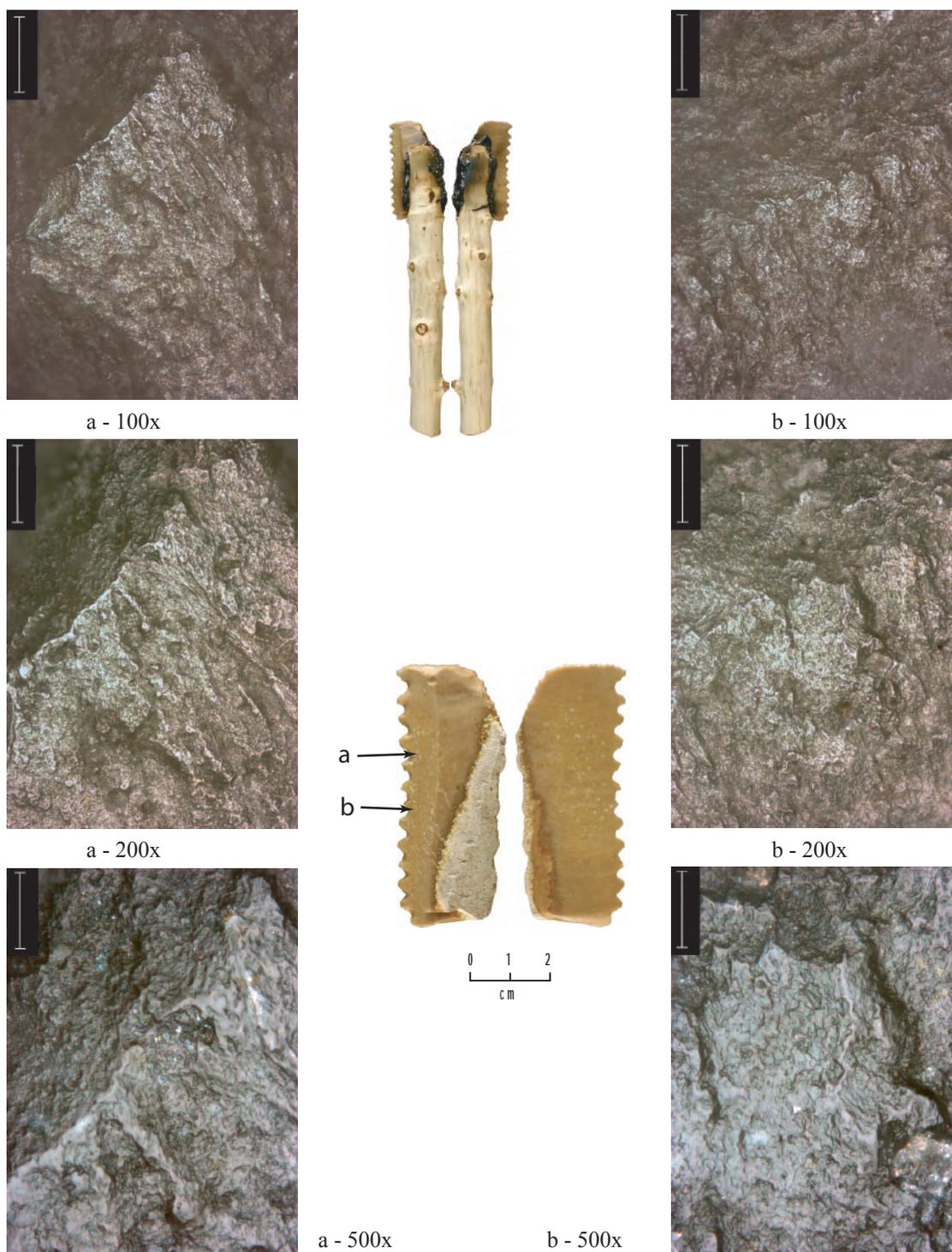


Figure C-7. Experimental Blade NNWXP1 (sawing wood): (a) polish inbetween flake scars on distal facing side after 710 strokes; (b) polish on upper portion of flake scar after 710 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

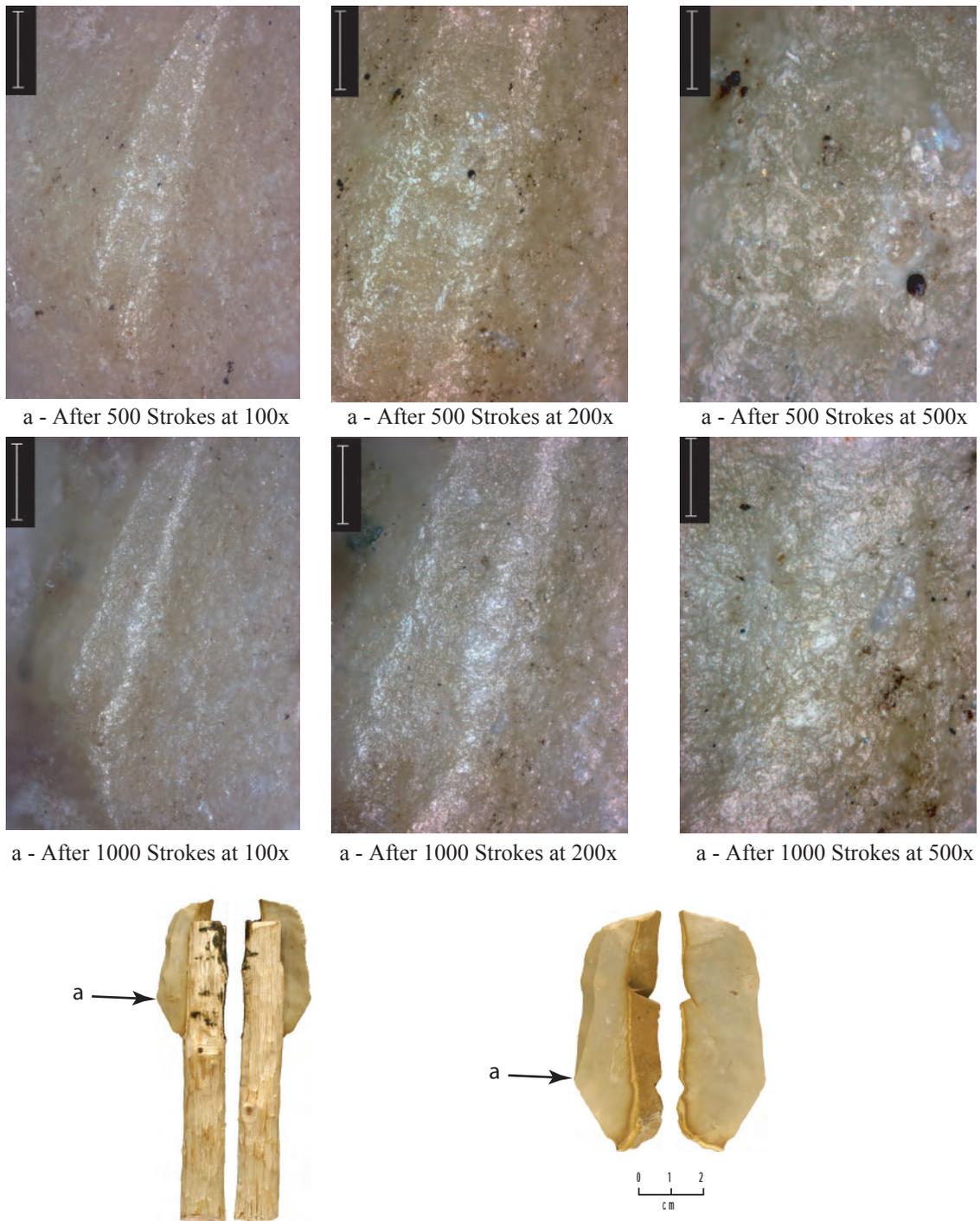


Figure C-8. Experimental Blade NWXP1 (sawing horn): (a) polish on inside ridge after 500 strokes; (a - cont.) more linked polish on ventral face after 1000 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

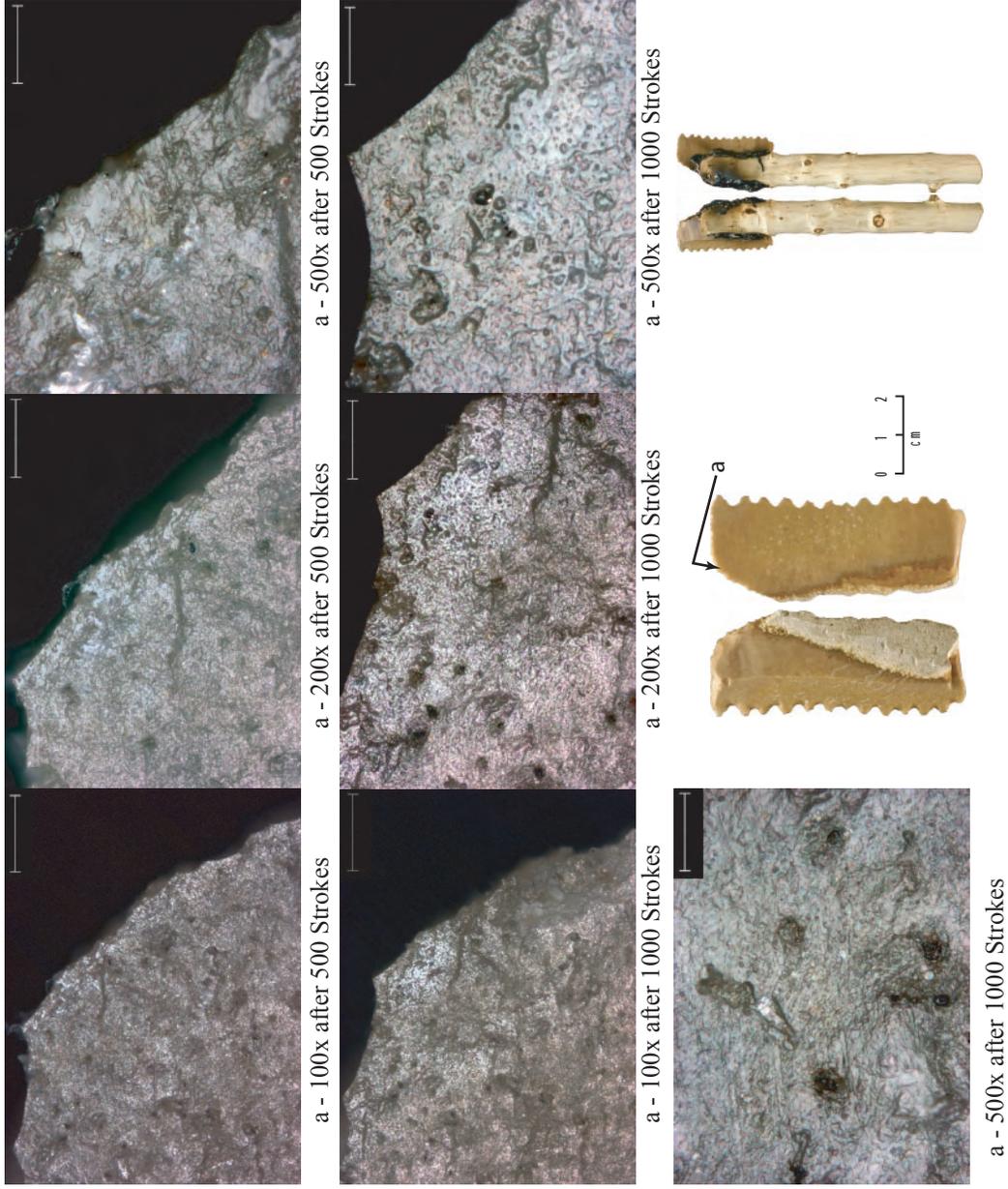


Figure C-9. Experimental Blade NWXP1 (planing horn): (a) well linked polish on ventral face after 500 strokes; (b) polish with striations visible on ventral face after 1000 strokes. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

## APPENDIX D

### STEREOMICROSCOPE-ANALYZED GAULT BLADES

Below are location designations used in the rounding and continuous scar columns.

| Number | Meaning                      |
|--------|------------------------------|
| 0      | not present                  |
| 1      | proximal dorsal              |
| 2      | proximal ventral             |
| 3      | distal dorsal                |
| 4      | distal ventral               |
| 5      | right lateral dorsal         |
| 6      | right lateral ventral        |
| 7      | upper right lateral dorsal   |
| 8      | upper right lateral ventral  |
| 9      | middle right lateral dorsal  |
| 10     | middle right lateral ventral |
| 11     | lower right lateral dorsal   |
| 12     | lower right lateral ventral  |
| 13     | left lateral dorsal          |
| 14     | left lateral ventral         |
| 15     | upper left lateral dorsal    |
| 16     | upper left lateral ventral   |
| 17     | middle left lateral dorsal   |
| 18     | middle left lateral ventral  |
| 19     | lower left lateral dorsal    |
| 20     | lower left lateral ventral   |
| 21     | ridge                        |
| 22     | upper ridge                  |
| 23     | middle ridge                 |
| 24     | lower ridge                  |
| 25     | 15 and 17                    |
| 26     | 16 and 18                    |
| 27     | 7 and 19                     |
| 28     | proximal break               |
| 29     | distal break                 |
| 30     | all edges and ridges         |
| 31     | 5 and 13                     |
| 32     | upper laterals               |
| 33     | 3 and 13                     |
| 34     | lower laterals               |
| 35     | 9 and 17                     |
| 36     | laterals and distal          |

| Number | Meaning  |
|--------|----------|
| 37     | laterals |

Below are notations for presence and absence (used in polish and striation columns).

| Number | Meaning  |
|--------|----------|
| 0      | presence |
| 1      | absence  |

| Number | Meaning   |
|--------|---|
| 0      | not selected for compound                         |
| 1      | selected for compound initially, but weeded out   |
| 2      | selected for compound and analyzed under compound |

Above are the designations for the selection process from stereomicroscope analysis to compound microscope analysis. The below analysis contains the following unexplained abbreviations: “CONT SCAR” (locations of continuous flake scars) and “SFC” (selected for compound analysis).

| SAC | SUBSAC | CAT # | GEOL UNIT | BLANK TYPE | COMPL | POLISH | STRIAE | ROUNDING | CONT SCAR | SFC | COMMENTS                     |
|-----|--------|-------|-----------|------------|-------|--------|--------|----------|-----------|-----|------------------------------|
| 294 | L      | 276   | 3a        | INT        | WHL   | 0      | 0      | 11       | 17        | 0   |                              |
| 422 | N      | 689   | 3a        | INT        | WHL   | 0      | 0      | 21       | 0         | 0   |                              |
| 228 | C2     | 557   | 3a        | INT        | WHL   | 0      | 0      | 21       | 0         | 0   |                              |
| 314 | W      | 685   | 3a        | INT        | WHL   | 0      | 0      | 0        | 0         | 0   |                              |
| 353 | E2     | 714   | 3a        | INT        | WHL   | 0      | 0      | 25       | 25        | 0   |                              |
| 305 |        | 291   | 3a        | INT        | WHL   | 0      | 0      | 7        | 7         | 0   |                              |
| 299 | U      | 267   | 3a        | INT        | WHL   | 0      | 0      | 26       | 26        | 0   |                              |
| 392 | V2     | 399   | 3a        | INT        | WHL   | 0      | 0      | 11       | 11        | 0   |                              |
| 347 | A      | 298   | 3a        | INT        | WHL   | 0      | 0      | 12       | 12        | 0   |                              |
| 412 | H      | 405   | 3a        | INT        | WHL   | 0      | 0      | 0        | 13        | 0   |                              |
| 383 | D      | 716   | 3a        | INT        | WHL   | 0      | 0      | 21       | 0         | 0   |                              |
| 261 |        | 606   | 3a        | INT        | WHL   | 0      | 0      | 15       | 15        | 0   |                              |
| 392 | V2     | 400   | 3a        | INT        | WHL   | 0      | 0      | 9        | 15        | 0   |                              |
| 364 | K      | 387   | 3a        | INT        | WHL   | 0      | 0      | 27       | 27        | 0   |                              |
| 228 | K      | 737   | 3a        | INT        | WHL   | 0      | 0      | 0        | 0         | 0   |                              |
| 412 | A      | 412   | 3a        | INT        | WHL   | 0      | 0      | 0        | 9         | 0   |                              |
| 261 | O2     | 599   | 3a        | INT        | WHL   | 0      | 0      | 0        | 32        | 0   |                              |
| 314 |        | 618   | 3a        | INT        | WHL   | 0      | 0      | 0        | 13        | 0   |                              |
| 244 | T2     | 481   | 3a        | INT        | WHL   | 0      | 0      | 0        | 7         | 0   |                              |
| 392 | K      | 393   | 3a        | INT        | WHL   | 0      | 0      | 0        | 15        | 0   |                              |
| 421 | K      | 693   | 3a        | INT        | WHL   | 0      | 0      | 0        | 17        | 0   |                              |
| 364 | M      | 379   | 3a        | INT        | WHL   | 0      | 0      | 0        | 17        | 0   |                              |
| 299 | M      | 255   | 3a        | INT        | WHL   | 0      | 0      | 0        | 11        | 1   |                              |
| 319 | E3     | 352   | 3a        | INT        | WHL   | 0      | 0      | 30       | 37        | 2   |                              |
| 314 | A2     | 617   | 3a        | INT        | WHL   | 0      | 0      | 0        | 11        | 1   |                              |
| 392 | J      | 392   | 3a        | INT        | WHL   | 0      | 0      | 0        | 17        | 2   |                              |
| 364 | D3     | 371   | 3a        | INT        | WHL   | 0      | 0      | 0        | 17        | 0   | refit                        |
| 347 | F2     | 301   | 3a        | INT        | MED   | 1      | 1      | 21       | 5         | 2   | heavy polish viewable at 12x |
| 408 | I      | 671   | 3a        | INT        | MED   | 1      | 1      | 0        | 11        | 2   | black residue band           |
| 228 | G3     | 559   | 3a        | INT        | MED   | 0      | 0      | 0        | 0         | 0   |                              |
| 261 | L2     | 596   | 3a        | INT        | MED   | 0      | 0      | 29       | 0         | 1   |                              |
| 261 |        | 601   | 3a        | INT        | MED   | 0      | 0      | 6        | 6         | 1   |                              |
| 332 |        | 659   | 3a        | INT        | MED   | 0      | 0      | 30       | 0         | 2   |                              |
| 228 | O      | 736   | 3a        | INT        | MED   | 0      | 0      | 28       | 9         | 1   |                              |
| 244 | F4     | 478   | 3a        | INT        | MED   | 0      | 0      | 5        | 0         | 0   |                              |
| 392 |        | 401   | 3a        | INT        | MED   | 0      | 0      | 13       | 0         | 0   |                              |
| 261 |        | 603   | 3a        | INT        | MED   | 0      | 0      | 5        | 0         | 0   |                              |
| 244 | F3     | 488   | 3a        | INT        | MED   | 0      | 0      | 28       | 13        | 0   |                              |
| 264 | A      | 311   | 3a        | INT        | MED   | 0      | 0      | 0        | 11        | 0   | generic polish around CaCO3  |

| SAC | SUBSAC | CAT<br># | GEOL<br>UNIT | BLANK<br>TYPE | COMPL | POLISH | STRIAE | ROUNDING | CONT<br>SCAR | SFC | COMMENTS                           |
|-----|--------|----------|--------------|---------------|-------|--------|--------|----------|--------------|-----|------------------------------------|
| 305 | P      | 277      | 3a           | INT           | MED   | 0      | 0      | 0        | 0            | 0   |                                    |
| 314 | H      | 615      | 3a           | INT           | MED   | 0      | 0      | 12       | 6            | 0   |                                    |
| 319 | W5     | 343      | 3a           | INT           | MED   | 0      | 0      | 0        | 8            | 0   |                                    |
| 228 | S2     | 558      | 3a           | INT           | MED   | 0      | 0      | 19       | 0            | 0   |                                    |
| 228 |        | 1083     | 3a           | INT           | PRX   | 0      | 0      | 21       | 11           | 0   |                                    |
| 364 | N4     | 382      | 3a           | INT           | PRX   | 0      | 0      | 17       | 15           | 1   |                                    |
| 314 | T      | 613      | 3a           | INT           | PRX   | 0      | 0      | 21       | 7            | 1   |                                    |
| 347 | U      | 296      | 3a           | INT           | PRX   | 0      | 0      | 21       | 11           | 0   |                                    |
| 261 |        | 612      | 3a           | INT           | PRX   | 0      | 0      | 13       | 7            | 0   |                                    |
| 261 |        | 608      | 3a           | INT           | PRX   | 0      | 0      | 0        | 17           | 0   |                                    |
| 279 | H      | 438      | 3a           | INT           | PRX   | 0      | 0      | 21       | 15           | 0   |                                    |
| 364 | E      | 386      | 3a           | INT           | PRX   | 0      | 0      | 0        | 0            | 0   |                                    |
| 248 | F      | 517      | 3a           | INT           | PRX   | 0      | 0      | 9        | 0            | 0   |                                    |
| 252 | O2     | 436      | 3a           | INT           | PRX   | 0      | 0      | 0        | 5            | 2   | modified right lateral edge        |
| 228 | D2     | 734      | 3a           | INT           | PRX   | 0      | 0      | 9        | 20           | 0   |                                    |
| 412 | B      | 410      | 3a           | INT           | PRX   | 0      | 0      | 19       | 11           | 0   |                                    |
| 261 | J      | 598      | 3a           | INT           | PRX   | 0      | 0      | 31       | 0            | 0   |                                    |
| 304 | L      | 448      | 3a           | INT           | PRX   | 0      | 0      | 11       | 17           | 0   |                                    |
| 244 | Q4     | 487      | 3a           | INT           | PRX   | 0      | 0      | 0        | 9            | 0   |                                    |
| 279 | O      | N/A      | 3a           | INT           | DST   | 0      | 0      | 0        | 7            | 0   |                                    |
| 364 | P3     | 372      | 3a           | INT           | DST   | 0      | 0      | 3        | 3            | 1   |                                    |
| 320 | V      | 706      | 3a           | INT           | DST   | 0      | 0      | 30       | 5            | 2   |                                    |
| 320 | C      | 653      | 3a           | INT           | DST   | 0      | 0      | 0        | 0            | 0   |                                    |
| 228 | I      | 556      | 3a           | INT           | DST   | 0      | 0      | 21       | 0            | 0   |                                    |
| 319 |        | 366      | 3a           | INT           | DST   | 0      | 0      | 22       | 0            | 0   |                                    |
| 320 |        | 654      | 3a           | INT           | DST   | 0      | 0      | 0        | 13           | 0   |                                    |
| 268 | C      | 504      | 3a           | INT           | DST   | 0      | 0      | 21       | 19           | 0   |                                    |
| 319 | U5     | 361      | 3a           | INT           | DST   | 0      | 0      | 3        | 0            | 0   |                                    |
| 268 |        | 503      | 3a           | INT           | DST   | 0      | 0      | 20       | 20           | 0   |                                    |
| 314 | A      | 616      | 3a           | INT           | DST   | 0      | 0      | 15       | 15           | 0   |                                    |
| 347 | X      | 295      | 3a           | INT           | DST   | 0      | 0      | 0        | 11           | 0   |                                    |
| 288 | H3     | 49       | 3a           | INT           | CRS   | 0      | 0      | 0        | 0            | 0   |                                    |
| 261 | M2     | 597      | 3a           | INT           | CRS   | 0      | 0      | 0        | 17           | 0   |                                    |
| 424 | C2     | 757      | 3a           | SEC           | WHL   | 0      | 0      | 0        | 11           | 1   | orange brown residue upp right lat |
| 299 | Q      | 260      | 3a           | SEC           | WHL   | 0      | 0      | 0        | 7            | 1   | poss residue on up right           |
| 328 |        | 280      | 3a           | SEC           | WHL   | 1      | 0      | 21       | 0            | 1   | bright spot                        |
| 328 | C2     | 281      | 3a           | SEC           | WHL   | 0      | 0      | 21       | 15           | 1   | orange brown residue upp left lat  |

| SAC | SUBSAC | CAT # | GEOL UNIT | BLANK TYPE | COMPL | POLISH | STRIAE | ROUNDING | CONT SCAR | SFC | COMMENTS                           |
|-----|--------|-------|-----------|------------|-------|--------|--------|----------|-----------|-----|------------------------------------|
| 412 | A      | 407   | 3a        | SEC        | WHL   | 0      | 0      | 11       | 32        | 2   | dark residue on upper right dorsal |
| 424 | E2     | 698   | 3a        | SEC        | WHL   | 0      | 0      | 15       | 17        | 2   | orange brown residue upp left lat  |
| 332 | Z2     | 710   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 19        | 1   | orange brown residue low left lat  |
| 328 |        | 306   | 3a        | SEC        | WHL   | 0      | 0      | 7        | 0         | 1   | orange brown residue low right lat |
| 423 |        | 640   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 261 |        | 609   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 347 |        | 304   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 412 | M      | 409   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 5         | 0   |                                    |
| 277 | O      | 457   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 5         | 0   |                                    |
| 364 | A      | 380   | 3a        | SEC        | WHL   | 0      | 0      | 7        | 0         | 0   |                                    |
| 383 | B2     | 718   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 19        | 0   |                                    |
| 364 | P      | 388   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 392 | N3     | 395   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 8         | 0   |                                    |
| 397 | W      | 722   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 5         | 0   |                                    |
| 319 | H2     | 357   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 244 | D4     | 491   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 18        | 0   |                                    |
| 228 |        | 476   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 253 | A      | 672   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 19        | 0   |                                    |
| 397 | Y      | 721   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 353 | R2     | 666   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 364 | P4     | 370   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 228 | Y      | 560   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 392 | S      | 403   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 13        | 0   |                                    |
| 319 | Y4     | 345   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 294 |        | 274   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 244 | C4     | 499   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 264 | D4     | 947   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 17        | 2   |                                    |
| 397 |        | 720   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 347 |        | 303   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 319 | F4     | 351   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 9         | 0   |                                    |
| 392 | T4     | 397   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 347 | A2     | 300   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 32        | 0   |                                    |
| 364 | I2     | 384   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 3         | 0   |                                    |
| 424 | W      | 697   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 17        | 0   |                                    |
| 287 | B2     | 315   | 3a        | SEC        | WHL   | 0      | 0      | 21       | 12        | 0   |                                    |
| 328 | I      | 283   | 3a        | SEC        | WHL   | 0      | 0      | 0        | 11        | 0   |                                    |

| SAC | SUBSAC | CAT # | GEOL UNIT | BLANK TYPE | COMPL | POLISH | STRIAE | ROUNDING | CONT SCAR | SFC | COMMENTS                           |
|-----|--------|-------|-----------|------------|-------|--------|--------|----------|-----------|-----|------------------------------------|
| 334 | J      | 269   | 3a        | SEC        | MED   | 0      | 0      | 30       | 11        | 2   | prev identified as quartzite       |
| 299 | J      | 259   | 3a        | SEC        | MED   | 0      | 0      | 0        | 15        | 1   | orange brown residue low right lat |
| 244 | I      | 493   | 3a        | SEC        | MED   | 0      | 0      | 0        | 0         | 0   |                                    |
| 332 |        | 661   | 3a        | SEC        | MED   | 0      | 0      | 21       | 13        | 0   |                                    |
| 244 | E3     | 497   | 3a        | SEC        | MED   | 0      | 0      | 0        | 0         | 0   |                                    |
| 332 |        | 660   | 3a        | SEC        | PRX   | 0      | 0      | 13       | 13        | 1   |                                    |
| 408 |        | 723   | 3a        | SEC        | PRX   | 0      | 0      | 17       | 17        | 0   |                                    |
| 422 | K      | 628   | 3a        | SEC        | PRX   | 0      | 0      | 21       | 0         | 0   |                                    |
| 268 | W      | 502   | 3a        | SEC        | PRX   | 0      | 0      | 0        | 0         | 0   |                                    |
| 335 | F      | 686   | 3a        | SEC        | PRX   | 0      | 0      | 0        | 9         | 0   |                                    |
| 322 | Y      | 286   | 3a        | SEC        | PRX   | 0      | 0      | 0        | 0         | 0   |                                    |
| 244 | W      | 492   | 3a        | SEC        | PRX   | 0      | 0      | 21       | 0         | 0   |                                    |
| 299 | E      | 258   | 3a        | SEC        | DST   | 0      | 0      | 0        | 17        | 1   | orange brown residue distal end    |
| 412 | N1     | 408   | 3a        | SEC        | DST   | 0      | 0      | 0        | 7         | 0   | refit                              |
| 244 | A2     | 480   | 3a        | SEC        | DST   | 0      | 0      | 0        | 0         | 1   | staining                           |
| 364 | O      | 373   | 3a        | SEC        | DST   | 0      | 0      | 36       | 0         | 1   |                                    |
| 244 | G4     | 484   | 3a        | SEC        | DST   | 0      | 0      | 0        | 3         | 1   | residue on ridge                   |
| 364 | S      | 374   | 3a        | SEC        | DST   | 0      | 0      | 0        | 0         | 0   |                                    |
| 347 |        | 302   | 3a        | SEC        | DST   | 0      | 0      | 0        | 34        | 0   |                                    |
| 298 | B      | 317   | 3a        | SEC        | DST   | 0      | 0      | 0        | 19        | 0   |                                    |
| 252 | X2     | 433   | 3a        | SEC        | DST   | 0      | 0      | 0        | 19        | 0   |                                    |
| 283 | G      | 508   | 3a        | SEC        | DST   | 0      | 0      | 0        | 3         | 0   |                                    |
| 347 | B      | 297   | 3a        | SEC        | DST   | 0      | 0      | 0        | 0         | 0   |                                    |
| 228 | L2     | 729   | 3a        | SEC        | DST   | 0      | 0      | 21       | 0         | 0   |                                    |
| 242 | D      | 511   | 3a        | SEC        | DST   | 0      | 0      | 0        | 0         | 0   |                                    |
| 397 | S      | 948   | 3a        | SEC        | DST   | 0      | 0      | 0        | 11        | 0   |                                    |
| 424 |        | 756   | 3a        | SEC        | CRS   | 0      | 0      | 0        | 7         | 1   |                                    |
| 277 |        | 458   | 3a        | SEC        | CRS   | 0      | 0      | 0        | 0         | 0   |                                    |
| 319 | X      | 350   | 3a        | SEC        | CRS   | 0      | 0      | 0        | 0         | 0   |                                    |
| 392 | X      | 404   | 3a        | SEC        | CRS   | 0      | 0      | 0        | 0         | 2   | black and orange residues          |
| 244 | S4     | 482   | 3a        | SEC        | CRS   | 0      | 0      | 0        | 0         | 1   | black residue                      |
| 422 | P2     | 688   | 3a        | SEC        | CRS   | 0      | 0      | 19       | 0         | 1   | residue                            |
| 326 | B2     | 278   | 3a        | SEC        | MOD   | 0      | 0      | 21       | 13        | 2   | serrated edges                     |
| 322 |        | 279   | 3a        | SEC        | MOD   | 0      | 0      | 21       | 37        | 2   | serrated edges                     |
| 304 | T      | 447   | 3a        | SEC        | MOD   | 0      | 0      | 13       | 13        | 2   |                                    |
| 187 | B      | 319   | 3b        | INT        | WHL   | 1      | 0      | 13       | 33        | 2   |                                    |

| SAC | SUBSAC | CAT<br># | GEOL<br>UNIT | BLANK<br>TYPE | COMPL | POLISH | STRIAE | ROUNDING | CONT<br>SCAR | SFC | COMMENTS                               |
|-----|--------|----------|--------------|---------------|-------|--------|--------|----------|--------------|-----|--|
| 319 | B3     | 341      | 3b           | INT           | WHL   | 0      | 0      | 0        | 0            | 0   |  |
| 246 | G      | 509      | 3b           | INT           | WHL   | 0      | 0      | 21       | 11           | 0   |  |
| 422 |        | 627      | 3b           | INT           | WHL   | 0      | 0      | 0        | 0            | 0   |  |
| 191 |        | 514      | 3b           | INT           | WHL   | 0      | 0      | 0        | 7            | 0   |  |
| 247 | L      | 683      | 3b           | INT           | WHL   | 0      | 0      | 0        | 0            | 0   |  |
| 291 | P2     | 444      | 3b           | INT           | WHL   | 0      | 0      | 0        | 34           | 0   |  |
| 306 | E      | 461      | 3b           | INT           | WHL   | 0      | 0      | 0        | 9            | 0   |  |
| 423 |        | 642      | 3b           | INT           | WHL   | 0      | 0      | 0        | 0            | 0   |  |
| 255 | H      | 530      | 3b           | INT           | WHL   | 0      | 0      | 0        | 7            | 0   |  |
| 197 | C      | 676      | 3b           | INT           | WHL   | 0      | 0      | 0        | 11           | 0   |  |
| 175 | D      | 466      | 3b           | INT           | MED   | 10     | 0      | 5        | 0            | 2   |  |
| 303 | J      | 702      | 3b           | INT           | MED   | 0      | 0      | 15       | 7            | 1   |  |
| 303 |        | 701      | 3b           | INT           | MED   | 0      | 0      | 0        | 5            | 0   |  |
| 227 |        | 325      | 3b           | INT           | MED   | 0      | 0      | 21       | 0            | 0   |  |
| 243 | D      | 271      | 3b           | INT           | MED   | 0      | 0      | 0        | 9            | 0   |  |
| 221 | C      | 677      | 3b           | INT           | MED   | 0      | 0      | 0        | 28           | 0   |  |
| 192 |        | 420      | 3b           | INT           | MED   | 0      | 0      | 0        |              | 0   |  |
| 205 | D      | 538      | 3b           | INT           | MED   | 0      | 0      | 16       | 29           | 0   |  |
| 215 | N3     | 555      | 3b           | INT           | MED   | 0      | 0      | 0        | 0            | 0   |  |
| 192 |        | 419      | 3b           | INT           | MED   | 0      | 0      | 9        | 17           | 0   |  |
| 215 | G3     | 544      | 3b           | INT           | MED   | 0      | 0      | 0        | 32           | 0   |  |
| 182 | E      | 470      | 3b           | INT           | MED   | 0      | 0      | 24       | 0            | 0   |  |
| 203 |        | 1042     | 3b           | INT           | PRX   | 0      | 0      | 30       | 31           | 2   |  |
| 423 | W2     | 635      | 3b           | INT           | PRX   | 0      | 0      | 30       | 32           | 1   | rounding w/<br>olive green<br>staining |
| 247 | D      | 681      | 3b           | INT           | PRX   | 0      | 0      | 0        | 35           | 1   | possible<br>orange residue             |
| 311 |        | 579      | 3b           | INT           | PRX   | 0      | 0      | 21       | 32           | 0   |  |
| 422 | D      | 629      | 3b           | INT           | PRX   | 0      | 0      | 0        | 0            | 0   |  |
| 150 |        | 533      | 3b           | INT           | PRX   | 0      | 0      | 21       | 7            | 0   |  |
| 215 | V2     | 545      | 3b           | INT           | PRX   | 0      | 0      | 0        | 0            | 0   |  |
| 93  |        | 414      | 3b           | INT           | PRX   | 0      | 0      | 0        | 0            | 0   |  |
| 205 | F      | 539      | 3b           | INT           | PRX   | 0      | 0      | 21       | 9            | 0   | sporadic ridge<br>rounding             |
| 192 |        | 421      | 3b           | INT           | PRX   | 0      | 0      | 0        | 0            | 0   |  |
| 182 | C      | 469      | 3b           | INT           | PRX   | 0      | 0      | 21       | 19           | 0   | lateral<br>abrasion                    |
| 422 | E      | 626      | 3b           | INT           | PRX   | 0      | 0      | 0        | 0            | 0   |  |
| 423 | A      | 631      | 3b           | INT           | PRX   | 0      | 0      | 0        | 15           | 0   |  |
| 285 | I2     | 266      | 3b           | INT           | PRX   | 0      | 0      | 0        | 15           | 0   |  |
| 247 |        | 594      | 3b           | INT           | DST   | 0      | 0      | 24       | 0            | 0   |  |
| 147 |        | 424      | 3b           | INT           | DST   | 0      | 0      | 15       | 15           | 0   |  |
| 243 | I      | 270      | 3b           | INT           | DST   | 0      | 0      | 0        | 0            | 0   |  |

| SAC | SUBSAC | CAT # | GEOL UNIT | BLANK TYPE | COMPL | POLISH | STRIAE | ROUNDING | CONT SCAR | SFC | COMMENTS                           |
|-----|--------|-------|-----------|------------|-------|--------|--------|----------|-----------|-----|------------------------------------|
| 187 | C      | 320   | 3b        | INT        | DST   | 0      | 0      | 0        | 0         | 0   |                                    |
| 215 | D3     | 550   | 3b        | INT        | DST   | 0      | 0      | 0        | 11        | 0   |                                    |
| 215 | D2     | 553   | 3b        | INT        | DST   | 0      | 0      | 0        | 0         | 0   |                                    |
| 423 | K      | 634   | 3b        | INT        | DST   | 0      | 0      | 0        | 5         | 0   |                                    |
| 215 | D      | 554   | 3b        | INT        | DST   | 0      | 0      | 0        | 17        | 0   |                                    |
| 205 | K      | 728   | 3b        | INT        | CRS   | 0      | 0      | 0        | 11        | 0   |                                    |
| 315 | L2     | 730   | 3b        | INT        | CRS   | 0      | 0      | 0        | 9         | 0   |                                    |
| 205 |        | 536   | 3b        | SEC        | WHL   | 0      | 0      | 0        | 11        | 1   |                                    |
| 186 | E      | 418   | 3b        | SEC        | WHL   | 0      | 0      | 21       | 7         | 1   |                                    |
| 4   |        | 565   | 3b        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 243 | C      | 946   | 3b        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 215 | C      | 546   | 3b        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 4   |        | 567   | 3b        | SEC        | WHL   | 0      | 0      | 21       | 0         | 0   |                                    |
| 182 | D      | 468   | 3b        | SEC        | WHL   | 0      | 0      | 0        | 15        | 0   |                                    |
| 274 | S      | 250   | 3b        | SEC        | WHL   | 0      | 0      | 0        | 0         | 0   |                                    |
| 188 | A      | 724   | 3b        | SEC        | WHL   | 0      | 0      | 0        | 17        | 0   |                                    |
| 4   |        | 51s2  | 3b        | SEC        | WHL   | 0      | 0      | 0        | 15        | 0   |                                    |
| 246 | X      | 431   | 3b        | SEC        | WHL   | 0      | 0      | 17       | 15        | 0   |                                    |
| 173 | E      | 415   | 3b        | SEC        | MED   | 0      | 0      | 21       | 5         | 1   | poss. residue on break             |
| 179 | G      | 429   | 3b        | SEC        | MED   | 0      | 0      | 0        | 5         | 0   | highly reflective, white patina    |
| 179 | A      | 430   | 3b        | SEC        | MED   | 0      | 0      | 0        | 0         | 0   |                                    |
| 215 | Z      | 548   | 3b        | SEC        | MED   | 0      | 0      | 0        | 0         | 0   |                                    |
| 250 | E      | 452   | 3b        | SEC        | MED   | 0      | 0      | 21       | 0         | 0   |                                    |
| 4   |        | 568   | 3b        | SEC        | PRX   | 0      | 0      | 21       | 0         | 1   |                                    |
| 261 | J      | 607   | 3b        | SEC        | PRX   | 0      | 0      | 21       | 0         | 1   | possible residue on upper dors.    |
| 303 |        | 649   | 3b        | SEC        | PRX   | 0      | 0      | 21       | 5         | 0   |                                    |
| 182 | H      | 467   | 3b        | SEC        | PRX   | 0      | 0      | 0        | 8         | 0   |                                    |
| 205 | J      | 540   | 3b        | SEC        | PRX   | 0      | 0      | 24       | 11        | 0   |                                    |
| 312 | J      | 650   | 3b        | SEC        | PRX   | 0      | 0      | 0        | 0         | 0   |                                    |
| 208 | E2     | 522   | 3b        | SEC        | DST   | 0      | 0      | 0        | 5         | 1   | possible orange residue            |
| 227 |        | 324   | 3b        | SEC        | DST   | 0      | 0      | 0        | 3         | 1   |                                    |
| 285 | B      | 265   | 3b        | SEC        | DST   | 0      | 0      | 3        | 36        | 2   | poss. orange and glue-like residue |
| 153 |        | 425   | 3b        | SEC        | DST   | 0      | 0      | 21       | 34        | 1   | poss. staining and residue         |
| 179 | F      | 426   | 3b        | SEC        | DST   | 0      | 0      | 0        | 11        | 1   |                                    |
| 4   |        | 566   | 3b        | SEC        | DST   | 0      | 0      | 0        | 0         | 0   |                                    |
| 274 | P      | 262   | 3b        | SEC        | DST   | 0      | 0      | 0        | 3         | 0   |                                    |

| SAC | SUBSAC | CAT<br># | GEOL<br>UNIT | BLANK<br>TYPE | COMPL | POLISH | STRIAE | ROUNDING | CONT<br>SCAR | SFC | COMMENTS             |
|-----|--------|----------|--------------|---------------|-------|--------|--------|----------|--------------|-----|----------------------|
| 291 | X      | 446      | 3b           | SEC           | DST   | 0      | 0      | 0        | 9            | 0   |                      |
| 225 | S      | 465      | 3b           | SEC           | DST   | 0      | 0      | 0        | 0            | 0   |                      |
| 197 | A      | 520      | 3b           | SEC           | DST   | 0      | 0      | 0        | 19           | 0   |                      |
| 291 | H2     | 510      | 3b           | SEC           | DST   | 0      | 0      | 0        | 0            | 0   |                      |
| 258 |        | 441      | 3b           | SEC           | DST   | 0      | 0      | 0        | 15           | 0   |                      |
| 197 | I      | 762      | 3b           | SEC           | CRS   | 0      | 0      | 0        | 17           | 0   |                      |
| 312 | B      | 703      | 3b           | SEC           | CRS   | 0      | 0      | 0        | 0            | 0   |                      |
| 240 | A      | 678      | 3b           | INT           | MOD   | 0      | 0      | 30       | 3            | 2   | shaped distal<br>end |
| 291 | I      | 443      | 3b           | INT           | MOD   | 0      | 0      | 3        | 3            | 2   | shaped distal<br>end |

## APPENDIX E

### COMPOUND-ANALYZED GAULT BLADES

From the Stereomicroscope-analyzed sample of 231 blades, twenty-four (24) blade and blade fragments were selected from 3a and 3b geological units. Polish classifications are based on those of Roger Grace (1989).

#### Modified Blades

Modified blades are defined as blades intentionally shaped. This includes five blades, two of which refit (AM 328 B2 [Cat #278] and AM 322 [Cat# 279]).

1. AM 328 B2 (Cat #278) – REFIT with AM 322 (Cat#279):
  - a. Unit and Level: N1017 E984, L. 26
  - b. Geological Unit: 3a
  - c. Blank Type: Secondary
  - d. Completeness: Distal – Modified
  - e. Stereomicroscope Analysis Summary: little rounding found and polish not observed, but recommended for compound analysis due to serrations.
  - f. Compound Microscope Analysis Summary: Patina obscured most of the dorsal viewing, with a few shots of polish and rounding on projections and in scars visible. A thin band of polish is on the ventral edge on the peninsulas of the denticulates (location B – spine angle of 26° and an edge angle of 47°).
    - i. Figure: E-1&2
    - ii. Polish: located sporadically on the left lateral ventral on the extrusion of the denticulates
      1. Distribution: gapped (location B)
      2. Invasiveness: <0.5 cm
      3. Polish Development: B (linked)
      4. Microtopography: intact
    - iii. Linear Indicators: none
  - g. Preliminary Conclusion: Polish on the edge of the scars, as well as right up to the steps, suggest an upright position. The duration of use is most likely on soft material and ephemeral, also owing to the unusually well preserved denticulates. The action of use was toward the distal end, similar to NNWXP2.
2. AM 322 (Cat #279) – REFIT with AM 328 B2 (Cat#278):
  - a. Unit and Level: N1017 E984, L. 25
  - b. Geological Unit: 3a
  - c. Blank Type: Secondary
  - d. Completeness: Medial – Modified

- e. Stereomicroscope Analysis Summary: Little rounding found and polish not observed, but recommended for compound analysis due to serrations.
  - f. Compound Microscope Analysis Summary: Polish was observed on ventral and dorsal projections of the serrations. Clean break (except for crylon) indicate that the blade was used before breakage. Patina obscured most of the dorsal viewing, with a few shots of polish and rounding on projections and in scars visible. A thin band of polish is on the ventral edge on the peninsulas of the denticulates (location A – spine angle of 30° and an edge angle of 45°).
    - i. Figure: E-1&2
    - ii. Polish: located on the lower left lateral, ventral face, near the break
      - 1. Distribution: edge/asymmetrical
      - 2. Invasiveness: <0.5 cm
      - 3. Polish Development: B (linked)
      - 4. Microtopography: intact
    - iii. Linear Indicators: none
  - g. Preliminary Conclusion: Polish on the edge of the scars, as well as right up to the steps, suggest an upright position. The duration of use is most likely on soft material and ephemeral, also owing to the unusually well preserved denticulates. The action of use was toward the distal end, similar to NNWXP2.
3. AM 291 H (Cat #443):
- a. Unit and Level: N1020 E984, L. 16
  - b. Geological Unit: 3b
  - c. Blank Type: Interior
  - d. Completeness: Whole – Modified
  - e. Stereomicroscope Analysis Summary: Rounding and possible polish observed, shaped distal end and lower left lateral gave an indication for need of compound.
  - f. Compound Microscope Analysis Summary: AM291H, a distally and laterally modified whole blade, shows two directions of u-shaped striations arcs going transversal to the lateral edges and distal end. The striations are densely packed and of varying sizes. This location has a spine angle of 42° and an edge angle of 60°.
    - i. Figure: E-3
    - ii. Polish: upper left lateral edge dorsal and distal ventral face
      - 1. Distribution: gapped; edge only/even (distal end)
      - 2. Invasiveness: <0.5 cm
      - 3. Polish Development: B+ to C; and D (distal end)
      - 4. Microtopography: intact/partially-covered; intact/removed (distal end)
    - iii. Linear Indicators: arc-shaped shallow u-shaped striations running oblique to perpendicular to distal end (location B)

- g. Conclusion: This blade was used for scraping, or possibly planing hard materials (hard wood or most likely bone) due to its similarity to the horn planing of experimental blade NNWXP1 (proximal edge of 66°).
4. AM 304 T (Cat 447):
- a. Unit and Level: N1020 E984, L. 17
  - b. Geological Unit: 3a
  - c. Blank Type: Interior
  - d. Completeness: Whole – Modified
  - e. Stereomicroscope Analysis Summary: Edge rounding and knife-like shaping on the left lateral edge made it a good candidate.
  - f. Compound Microscope Analysis Summary: There is polish on the upper left lateral (where it was expected on this knife-shaped piece). Polish is located on the upper right lateral edge, dorsal and ventral, by the curve of the blade. Location A (spine angle of 21° and edge angle of 38°) is on the dorsal face and shows polish on the ripple of a step scar with polish similar to the rawhide cutting experiment, and to a lesser extent the sinew cleaning experiment. Location B (spine angle of 21° and edge angle of 38°) is a moderately linked polish on high spots by the edge, suggesting a material hard but flexible.
    - i. Figure: E-4
    - ii. Polish:
      1. Distribution: gapped (location A); edge/asymmetrical (location B)
      2. Invasiveness: <0.5 cm
      3. Polish Development: B (linked) for both locations
      4. Microtopography: mostly intact
    - iii. Linear Indicators: none
  - g. Preliminary Conclusion: This blade was used on the upper left lateral. Mid left lateral polish in a scar suggests upright placement when used. The closest pattern is the cutting of rawhide (NWXP4).
5. AM 240 A (Cat #678):
- a. Unit and Level: N1021 E984, L. 15
  - b. Geological Unit: 3b
  - c. Blank Type: Interior
  - d. Completeness: Distal – Modified
  - e. Stereomicroscope Analysis Summary: Rounding on both lateral edges and distal shaping made it a good compound candidate.
  - f. Compound Microscope Analysis Summary: There is polish ventral face of the left distal tip (Location A – spine angle of 15° and edge angle of 54°). No other polish was observed on the left distal edge (early diagenetic chert), but soft polish was observed on the dorsal face of the right lateral edge (location B – spine angle of 29° and edge angle of 59°).

- i. Figure: E-5
    - ii. Polish: polish located on ventral face of distal end
      - 1. Distribution: edge/asymmetrical
      - 2. Invasiveness: <0.5 cm
      - 3. Polish Development: B (linked)
      - 4. Microtopography: intact
    - iii. Linear Indicators: faint u-shaped grooves running acutely oblique to the edge in location B
  - g. Preliminary Conclusion: Analysis is inconclusive. Either ephemeral use on softer material or not used.
6. AM 285 B (Cat#265):
- a. Unit and Level: N1017 E982, L. 21
  - b. Geological Unit: 3b
  - c. Blank Type: Secondary
  - d. Completeness: Distal
  - e. Stereomicroscope Analysis Summary: Although the edges look sharp, the beveled end suggests possible use. Also, there is possible residue on the ridge.
  - f. Compound Microscope Analysis Summary: AM 285B, a distally and laterally modified whole blade, showing deep and densely packed u-shaped striation going transverse to the distal edge. The angle of the edge is 42° on a bifacial edge.
    - i. Figure: E-6
    - ii. Polish: located on distal end, ventral face
      - 1. Distribution: edge/asymmetrical
      - 2. Invasiveness: >0.5 cm (since the striations occur beyond flake scars)
      - 3. Polish Development: B+ to D (linear – when modified by striations)
      - 4. Microtopography: intact to partially covered (polish) to removed (striations)
    - iii. Linear Indicators: densely packed u-shape striations in the ventral distal face
  - g. Conclusion: This blade was used for scraping, or possibly planing hard materials (hard wood or most likely bone) due to its similarity to the horn planing of experimental blade NNWXP1 (proximal edge of 66°).

### **Non-Modified with Residue**

One medial blade fragment (AM 408 I) and one whole blade (AM 412 A) exhibit black substances which are candidates for hafting residue remains.

7. AM 408 I (Cat#671):
- a. Unit and Level: N1017 E984, L. 26

- b. Geological Unit: 3a
  - c. Blank Type: Secondary
  - d. Completeness: Distal – Modified
  - e. Stereomicroscope Analysis Summary: The black residue band on the dorsal face of this prismatic blade looks and has depth. The possibility of manganese staining was addressed. This and the possibility of mastic (possible asphaltum) required additional study.
  - f. Compound Microscope Analysis Summary: Grooves and scratches on the residue band in multiple locations. The grooves (location A – spine angle of 38°) have regularity in spacing and are a 200<sup>th</sup> of a millimeter deep. No polish was observed. Thinner striations are located on the central scar, sometimes referred to as “plateau”, with spine angles of 38°. These striations are arc-shaped going multiple directions.
    - i. Figure: E-7
    - ii. Polish: on a dorsal strip of Fe-Mg-Ca
      - 1. Distribution: edge/away from edge/differential
      - 2. Invasiveness: >0.5 cm
      - 3. Polish Development: A to B
      - 4. Microtopography: present in some of grooved area (location A), but not in plateau of dorsal face (location B)
    - iii. Linear Indicators: numerous parallel to edge (location A) and oblique arcs (location B)
  - g. Conclusion: There is no direct evidence for blade use. No polish was located on the edges. Polish was observed only on the residue strip on the dorsal side.
8. AM 412 H (Cat#407):
- a. Unit and Level: N1017 E984, L. 26
  - b. Geological Unit: 3a
  - c. Blank Type: Secondary
  - d. Completeness: Distal – Modified
  - e. Stereomicroscope Analysis Summary: Edge rounding, residue, and patterned edge scars.
  - f. Compound Microscope Analysis Summary: AM 412H, a whole blade, shows no polish on the edges. Away from the edge and near the dark substance initially thought to be residue is dull polish with striations parallel to acutely oblique to the edge. There is a spine angle of 36°, along with an edge angle of 56°, for location A and a 25° spine angle for location B.
    - i. Figure: E-8
    - ii. Polish: located on the dorsal face of the upper right lateral
      - 1. Distribution: gapped
      - 2. Invasiveness: >0.5 cm (it is at least that far from the edge)
      - 3. Polish Development: B+ to C

- 4. Microtopography: mostly intact, except for around the striations
- iii. Linear Indicators: running parallel to acutely oblique from edge
- g. Conclusion: This blade was not used. The shape and size indicate potential for use, as does the Fe-Mg-Ca staining.

### **Other Blade Refit**

Aside from the Serrated blade (AM 328 B2 and AM 322), there were two other blade fragments (AM 332 and AM203) that refit and were analyzed.

- 9. AM 332 (Cat#659) – REFIT with AM 203 (Cat#1042):
  - a. Unit and Level: N1018 E984, L. 19
  - b. Geological Unit: 3a
  - c. Blank Type: Interior
  - d. Completeness: Medial
  - e. Stereomicroscope Analysis Summary: heavy rounding on edges and ridge.
  - f. Compound Microscope Analysis Summary: AM203 and AM332 (3a medial fragment) refit and may possibly. Both blades were manufactured from later diagenetic Edwards Fm chert, similar to that seen in NNWXP2. Analysis shows weakly connected polish that retains the microtopography and has little microflaking due to use.
    - i. Figure: E-9&10
    - ii. Polish:
      - 1. Distribution: edge only / asymmetric
      - 2. Invasiveness: <0.5 cm
      - 3. Polish Development: linked (B)
      - 4. Microtopography: mostly intact, wearing on the upper right lateral ventral corner (**see plate with AM203**)
    - iii. Linear Indicators: none
    - iv. Rounding: best visible under stereomicroscope
  - g. Conclusion: This blade fragment was not used.
- 10. AM 203 (Cat#1042) – REFIT with AM 332 (Cat#659):
  - a. Unit and Level: N1018 E982, L. 19
  - b. Geological Unit: 3b
  - c. Blank Type: Interior
  - d. Completeness: Medial
  - e. Stereomicroscope Analysis Summary: heavy rounding on edges and ridge.
  - f. Compound Microscope Analysis Summary: AM203 and AM332 (3a medial fragment) refit and may possibly. Both blades were manufactured from later diagenetic Edwards Fm chert, similar to that seen in NNWXP2. Analysis shows weakly connected polish that retains the microtopography and has little microflaking due to use.

- i. Figure: E-9&10
- ii. Polish:
  - 1. Distribution: edge only / asymmetric
  - 2. Invasiveness: <0.5 cm
  - 3. Polish Development: linked (B)
  - 4. Microtopography: mostly intact, wearing on the upper right lateral ventral corner
- iii. Linear Indicators: none
- g. Conclusion: This blade fragment was not used.

### Other Blades – 3a

These 14 blades represent the rest of the 3a blades selected for compound analysis for different reasons.

#### 11. AM 347 F2 (Cat #301):

- a. Unit and Level: N1017 E984, L. 27
- b. Geological Unit: 3a
- c. Blank Type: Interior
- d. Completeness: Medial
- e. Stereomicroscope Analysis Summary: Heavy polish (even easily viewable at 12x) on the distal (?) ridge to the break. The polish is at an odd placement, but deserved further analysis.
- f. Compound Microscope Analysis Summary: AM347F2, a medial fragment, shows what looks like lengthwise directional polish on the dorsal face up to the break (edge angle of 87°). Compound analysis revealed a thick and uneven polish. Due to the location, Jim Weiderhold and I tested the polish with acetone and a toothpick after careful documentation. Upon reexamination, a majority of the polish disappeared. A possible explanation of this is a shift in surface angle, even a slight shift of which can change the pattern.
  - i. Figures: E-11a and E-11b
  - ii. Polish: located off of distal break
    - 1. Distribution: edge only/asymmetrical
    - 2. Invasiveness: >0.5 cm
    - 3. Polish Development: C
    - 4. Microtopography: covered
  - iii. Linear Indicators: linear running parallel to axis, perpendicular to break
- g. Preliminary Conclusion: If used, the blade was used before breakage and heavily used on soft material closest to those seen on experimental blades NWXP3 and NWXP4.

#### 12. AM 319 E3 (Cat #352):

- a. Unit and Level: N1017 E983, L. 23
- b. Geological Unit: 3a

- c. Blank Type: Interior
  - d. Completeness: Whole
  - e. Stereomicroscope Analysis Summary: A high degree of edge rounding, as well as a possible indicator for different wear on microfossils, make this a good candidate. .
  - f. Compound Microscope Analysis Summary: AM319E3, although heavily rounded on edges and ridges, contained only one possible location of polish (location A, spine angle 38°) of dubious origin.
    - i. Figure: E-12
    - ii. Polish:
      - 1. Distribution:
      - 2. Invasiveness:
      - 3. Polish Development:
      - 4. Microtopography:
    - iii. Linear Indicators:
  - g. Preliminary Conclusion: Not used.
13. AM 244 A2 (Cat#480):
- a. Unit and Level: N1019 E982, L. 21
  - b. Geological Unit: 3a
  - c. Blank Type: Secondary
  - d. Completeness: Distal
  - e. Stereomicroscope Analysis Summary: Staining on the lower left (along with lower left lateral rounding) and connection of edge damage suggests possible use.
  - f. Compound Microscope Analysis Summary: The distal fragment AM244A2 contains a weak polish (ca. 2 mm thick) on the dorsal face of the lower left lateral edge (location A, spine angle 72°). Specimen is plagued by crylon spots, which were cleaned with acetone.
    - i. Figure: E-13
    - ii. Polish: located on low left lateral dorsal edge
      - 1. Distribution: edge only/asymmetrical
      - 2. Invasiveness: <0.5 cm
      - 3. Polish Development: A to A+
      - 4. Microtopography: intact
    - iii. Linear Indicators: none
  - g. Preliminary Conclusion: Not used.
14. AM 424 E2 (Cat#698):
- a. Unit and Level: N1018 E983, L. 24
  - b. Geological Unit: 3a
  - c. Blank Type: Secondary
  - d. Completeness: Whole
  - e. Stereomicroscope Analysis Summary: Moderate ridge rounding, edge rounding and shape made it a candidate for compound analysis.

- f. Compound Microscope Analysis Summary: AM424E2 exhibits the most solid evidence for use. Polish is weak grading into heavily linked towards spots on the edge on the ventral face of the mid left lateral edge (location A, 68° spine angle just catching part of another blade removal). The striations are wide u-shaped, except for near the microflaking (dense and u-shaped), oblique to the edge. The pattern is most similar to that seen on experimental blade NWXP3, used to clean sinew (38-41° spine angle).
- i. Figure: E-14
  - ii. Polish: located on upper left lateral ventral edge
    1. Distribution: edge only/asymmetrical
    2. Invasiveness: <0,5 cm
    3. Polish Development: B to C
    4. Microtopography: partially intact to covered (locations A and B at 500x)
  - iii. Linear Indicators: oblique to edge, u-shaped
- g. Conclusion: This blade was used as a knife.
15. AM 252 O2 (Cat#463):
- a. Unit and Level: N1020 E983, L. 21
  - b. Geological Unit: 3a
  - c. Blank Type: Interior
  - d. Completeness: Proximal
  - e. Stereomicroscope Analysis Summary: Heavy right lateral dorsal scarring plus slight rounding make it a candidate for compound analysis.
  - f. Compound Microscope Analysis Summary: AM252O2 is modified on the right lateral edge. A weak polish is present on the right and left lateral edge (location A, spine angle 62°), with no topographic changes. The lower right lateral edge of the dorsal face (location B, spine angle of 47° and edge angle 58°) had sporadic spots of heavily linked polish similar to that seen on locations C and D of AM320V.
    - i. Figure: E-15
    - ii. Polish: located on the ventral face and on the lower laterals by the medial break
      1. Distribution: edge only/asymmetric (location A) and gapped (location B)
      2. Invasiveness: <0.5 cm
      3. Polish Development: A (location A) to C (localized spot on location B)
      4. Microtopography: intact
    - iii. Linear Indicators:
  - g. Conclusion: limited use suggests ephemeral use or non-use.
16. AM 334 J (Cat#269):
- a. Unit and Level: N1017 E982, L. 23

- b. Geological Unit: 3a
- c. Blank Type: Interior
- d. Completeness: Medial
- e. Stereomicroscope Analysis Summary: The listed raw material is quartzite, although it may be reflective of chert formation.
- f. Compound Microscope Analysis Summary: AM334J, originally classified as quartz or quartzite, is a medial blade fragment off of a late diagenetic Edwards Fm chert that intersected a quartz-filled void and terminated. A weak polish reminiscent of the glass reaping polish on NNWXP2 is seen on the ventral face of the middle left lateral edge (location A, 76° and an edge angle of 97°).
  - i. Figure: E-16
  - ii. Polish:
    1. Distribution: edge only/asymmetrical
    2. Invasiveness: edge
    3. Polish Development: A to A+
    4. Microtopography: intact
  - iii. Linear Indicators: none
- g. Preliminary Conclusion: If used, it was either ephemerally used or the raw material or edge damage is masking the use. The rounding and polish pattern matches that of the experimental blade NNWXP2 (used to reap grass).

17. AM 392 J (Cat#392):

- a. Unit and Level: N1017 E983, L. 25
- b. Geological Unit: 3a
- c. Blank Type: Interior
- d. Completeness: Whole
- e. Stereomicroscope Analysis Summary: Scars on the right lateral edge, especially lower half, and some rounding provide reason for a compound candidate.
- f. Compound Microscope Analysis Summary: AM392J1, a whole secondary blade, showed little evidence for use. I observed a weak polish on the ventral face left lateral edge (location A, spine angle of 54°; and location B, spine angle of 45°) that I cannot match with experimental patterns.
  - i. Figure: E-17
  - ii. Polish: located on left lateral ventral edge
    1. Distribution: edge/asymmetrical
    2. Invasiveness: <0.5 cm
    3. Polish Development: B+ to C
    4. Microtopography: intact
  - iii. Linear Indicators: none
- g. Conclusion: Polish is either extremely ephemeral or more likely a result of improper cleaning. Not used.

18. AM 392 X (Cat#404):

- a. Unit and Level: N1017 E983, L. 25
- b. Geological Unit: 3a
- c. Blank Type: Secondary
- d. Completeness: Crested
- e. Stereomicroscope Analysis Summary: although clean, this blade was recommended for compound analysis because it was considered clean and because of the black substance in the mid left lateral ventral side.
- f. Compound Microscope Analysis Summary: Crested blade AM392X1, also whole, exhibited little polish save for a weak c.a. 2 mm thick band on the ventral face of the lower left lateral edge (location A, spine angle of 93°).
  - i. Figure: E-18
  - ii. Polish: low left lateral edge dorsal and ventral faces
    - 1. Distribution: edge only/even
    - 2. Invasiveness: <0.5 cm
    - 3. Polish Development: B on edge to A (individual elements) away from edge
    - 4. Microtopography: intact
  - iii. Linear Indicators: none
- g. Conclusion: With the location and high spine angle, the potential for use of this artifact are severely limited. More likely a result from trampling.

19. AM 320 V (Cat 706):

- a. Unit and Level: N1018 E984, L. 26
- b. Geological Unit: 3a
- c. Blank Type: Interior
- d. Completeness: Medial
- e. Stereomicroscope Analysis Summary: This olive-brown distal fragment is heavily rounded on all edges and ridges (and is seen on all blades with a similar color). Also, the shape of the end is scraper-like.
- f. Compound Microscope Analysis Summary: AM320V, like AM319E3, was rounded along all its edges and ridge. This weak polish, along with its olive-green color, make it similar in appearance to other artifacts (C. Donald-Pevny, personal communication) and exhibits a general weak overall polish. A stronger polish is located on the dorsal face left lateral edge (location A, spine angle 23°; location B, 21°). Two dorsal face distal end spots (location C, edge angle 81°; location D, spine angle 27°) exhibit well-linked plate-like polish where the asperities are planed.
  - i. Figures: E-19a and E-19b
  - ii. Polish: located on left lateral dorsal and distal dorsal face
    - 1. Distribution: edge only/asymmetrical and gapped
    - 2. Invasiveness: <0.5; >0.5 on distal
    - 3. Polish Development: A+ to B+

- 4. Microtopography: intact to covered by planed polish
  - iii. Linear Indicators: none
- g. Conclusion: The heavy overall rounding and discreet localized planed polish are evidence of possible localized inundation with the water table or within the Buttermilk Creek (possible paleochannel) during a previous time. A more refined conclusion rests on the geomorphological study and comparative utilized flakes studied by C. Pevny-Donald.

20. AM 264 D (Cat#947):

- a. Unit and Level: N1017 E985, L. 26
- b. Geological Unit: 3a
- c. Blank Type: Interior
- d. Completeness: Medial
- e. Stereomicroscope Analysis Summary: little to no edge rounding.
- f. Compound Microscope Analysis Summary: AM264D is a large blade on which I observed a weakly linked band (~1-2 mm) of polish on dorsal and ventral faces of the upper right lateral (location A, spine angle of 25°; location B, spine angle of 35°).
  - i. Figure: E-20
  - ii. Polish: dorsal and ventral faces of upper right lateral edge
    - 1. Distribution: edge only/asymmetrical
    - 2. Invasiveness: <0.5 cm
    - 3. Polish Development: B to C
    - 4. Microtopography: intact
  - iii. Linear Indicators: linear polish or striations perpendicular to edge
- g. Conclusion: Initially, the pattern matches the grass reaping of the experimental blade NNWXP2. Ephemeral use at best.

### Other Blades – 3b

These 4 blades represent the rest of the 3b blades selected for compound analysis for different reasons.

21. AM171 A (Cat#449):

- a. Unit and Level: N1016.47 E982.76, L. 19
- b. Geological Unit: 3b
- c. Blank Type: Interior
- d. Completeness: Whole
- e. Stereomicroscope Analysis Summary: heavy rounding on edges and ridge. Also, the right lateral edge scarring is continuous and black specs may be residue.
- f. Compound Microscope Analysis Summary: Black flecks (see Stereomicroscope summary) have a rainbow cast to them. There is weakly connected, but heavy, polish visible on the ventral face of the

right lateral (location A) and weaker polish on the dorsal face of the left ventral (locations B and C).

- i. Figure: E-21
- ii. Polish: located on upper and lower ventral faces of the right lateral edge with protrusions on the dorsal face of the left lateral edge
  1. Distribution: gapped
  2. Invasiveness: <0.5 cm
  3. Polish Development: B+
  4. Microtopography: intact/partially obscured
- iii. Linear Indicators: none
- g. Conclusions: Location C looks like the pattern on NWXP1 (sawing horn) location C, indicating rubbing/abrasion from a hard material with the blade angled for that ridge to come into contact. Location A is much more linked than the wood sawing experimental blade (NNWXP1). The right lateral edge was used on hard material, commensurate with the microflaking on the right lateral edge, but most likely on finer work.

22. AM 175 D (Cat #466):

- a. Unit and Level: N1019 E982, L. 18
- b. Geological Unit: 3b
- c. Blank Type: Interior
- d. Completeness: Medial
- e. Stereomicroscope Analysis Summary: Two bright spots and possible polish on the mid right lateral and mid ridge.
- f. Compound Microscope Analysis Summary: AM175D exhibits a thin band of polish on the medial right lateral edge over the microflaking (location A, with a spine angle of 27°).
  - i. Figure: E-22
  - ii. Polish: located on mid-right lateral dorsal
    1. Distribution: differential/edge only
    2. Invasiveness: <0.5 cm
    3. Polish Development: B+ to C on edge; A+ to B away from edge
    4. Microtopography: intact
  - iii. Linear Indicators: none
- g. Conclusion: The pattern most resembles wood sawing (NNWXP1) due to its limitation, but is most likely not due to its localization and blade morphology (thin spine angle and presence of microflaking along the edge).

23. AM 187 B (Cat #319):

- a. Unit and Level: N1017.80 E983.65, L. 18
- b. Geological Unit: 3b
- c. Blank Type: Interior

- d. Completeness: Whole
- e. Stereomicroscope Analysis Summary: Scarring on the left lateral edge and distal end, plus possible polish, make this a candidate for compound analysis. .
- f. Compound Microscope Analysis Summary: AM187B shows the least modification; with generic polish on the ventral face of the distal and lateral area, most notably due to the presence of earlier diagenetic chert in this area, spine angle of 22° and an edge angle of 55°.
  - i. Figure: E-23
  - ii. Polish: located on lower left lateral edge/left distal edge on the ventral face; also located on the protrusions of the dorsal face of the left lateral edge
    - 1. Distribution: edge only/asymmetrical
    - 2. Invasiveness: <0.5 cm
    - 3. Polish Development: B+
    - 4. Microtopography: intact
  - iii. Linear Indicators: none
- g. Conclusion: This polish, although connected, is weak and does not match experimental patterns, save for the early formative polish of hard contact material (see NNWXP1 – sawing wood). Since this is on the opposing side of the flake scarring, the use is more likely a result of soft-contact.

#### 24. AM 303 J (Cat#702)

- a. Unit and Level: N1018 E984, L. 16
- b. Geological Unit: 3b
- c. Blank Type: Interior
- d. Completeness: Medial
- e. Stereomicroscope Analysis Summary: Possible polish was noted on the lower left lateral and the upper right lateral.
- f. Compound Microscope Analysis Summary: AM303J exhibits variable, but generally wide (>2 cm) heavily linked (location B, spine angle of 50°) to moderately linked (location C, spine angle of 34°) polish on the lower ventral face lateral rounded edges.
  - i. Figure: E-24
  - ii. Polish: present on mid- and low left lateral (locations A and B), along with mid-right lateral
    - 1. Distribution: edge only/assymetrical
    - 2. Invasiveness: <0.5 cm
    - 3. Polish Development: B (linked) to C
    - 4. Microtopography: partially intact
  - iii. Linear Indicators: none observed
- g. Conclusion: This is most similar to the bark scraping of experimental blade GRT-4-1.

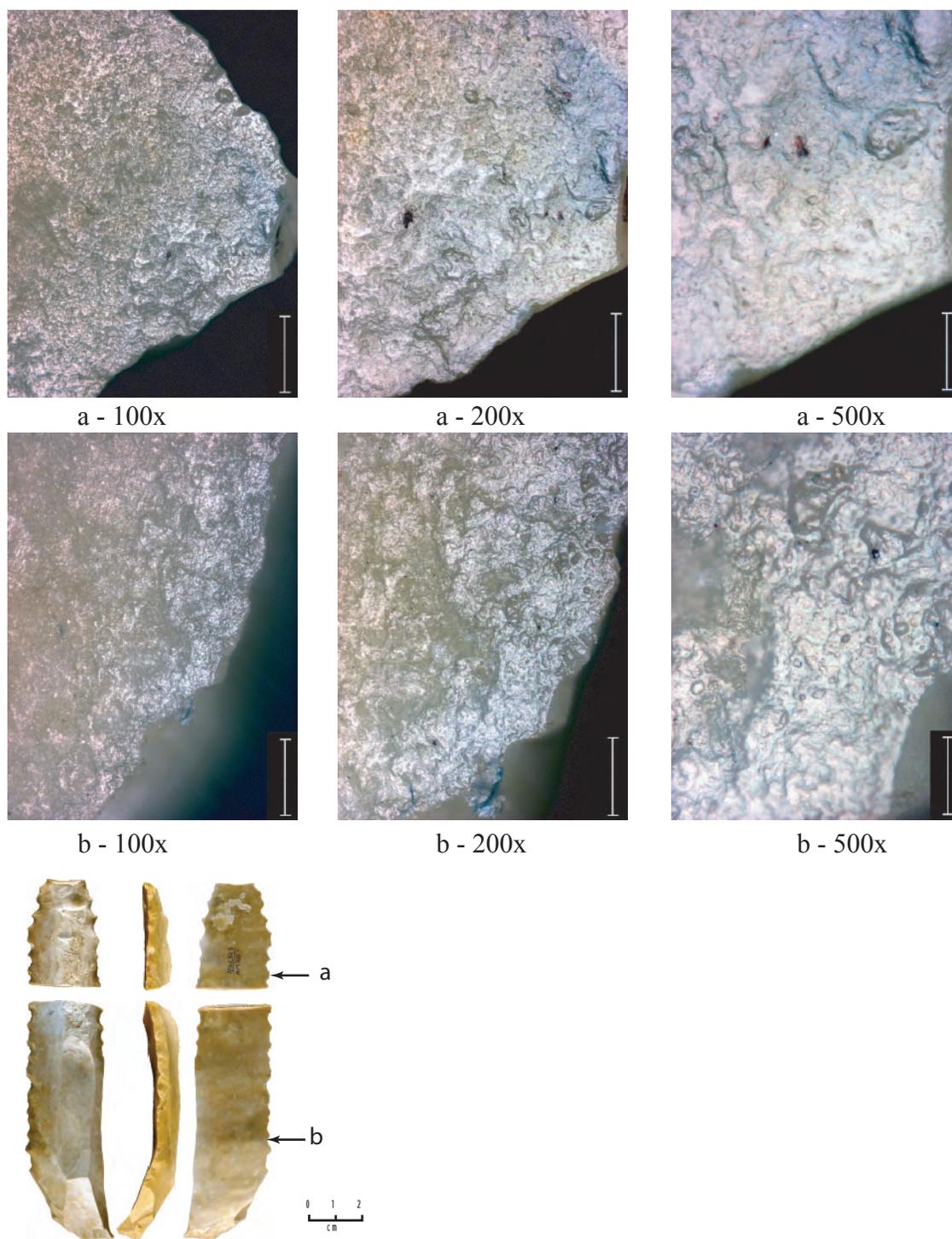


Figure E-1&2. Clovis 3a Blade Refit AM322 (Cat #279) and AM328B2 (Cat #278): (a) location of polish on peninsula on AM322; (b) location of polish on peninsula for AM328B2. . Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

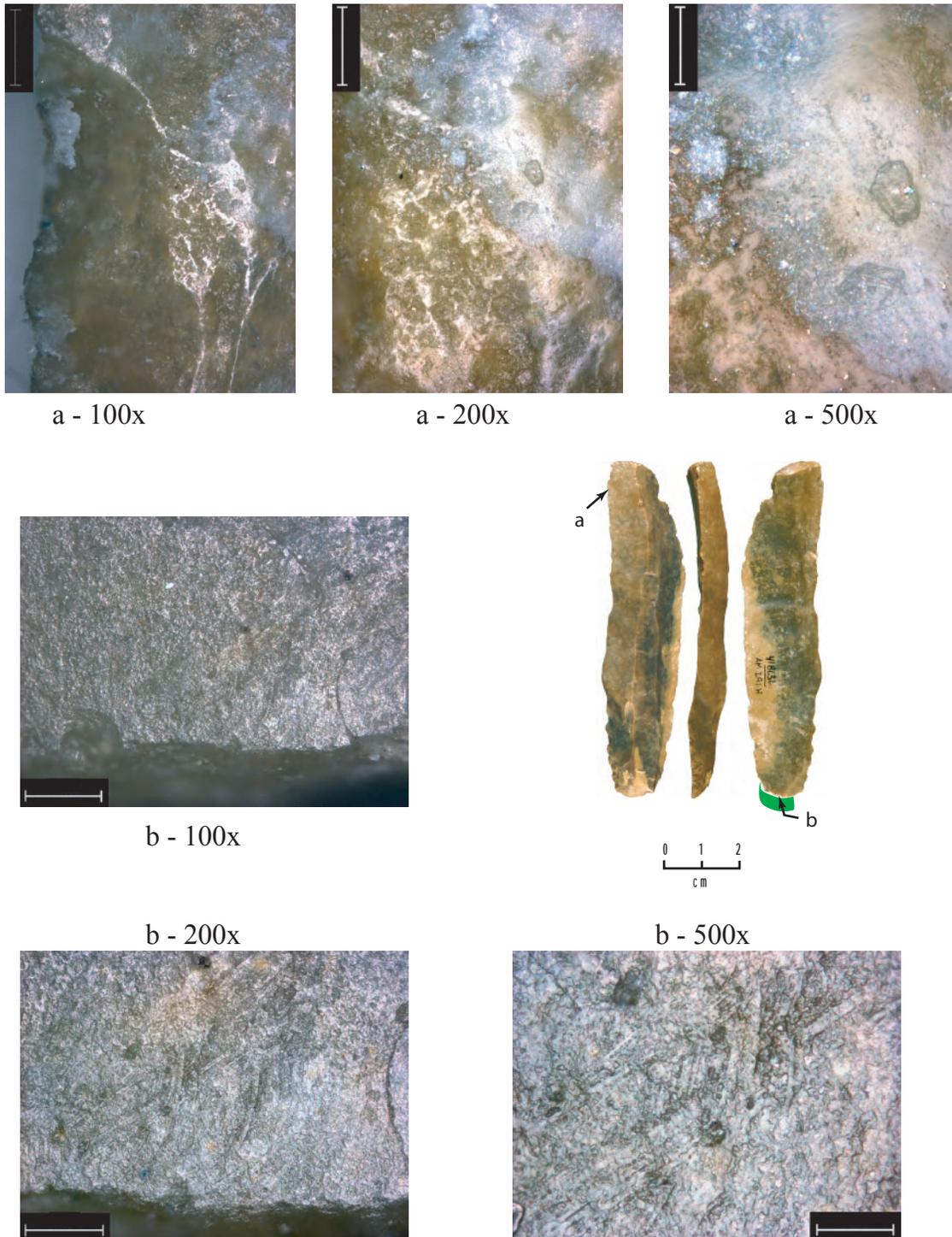


Figure E-3. Clovis Blade AM291H (Cat #443) : (a) location of well-linked polish; (b) multiple-direction shallow u-shaped striations. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

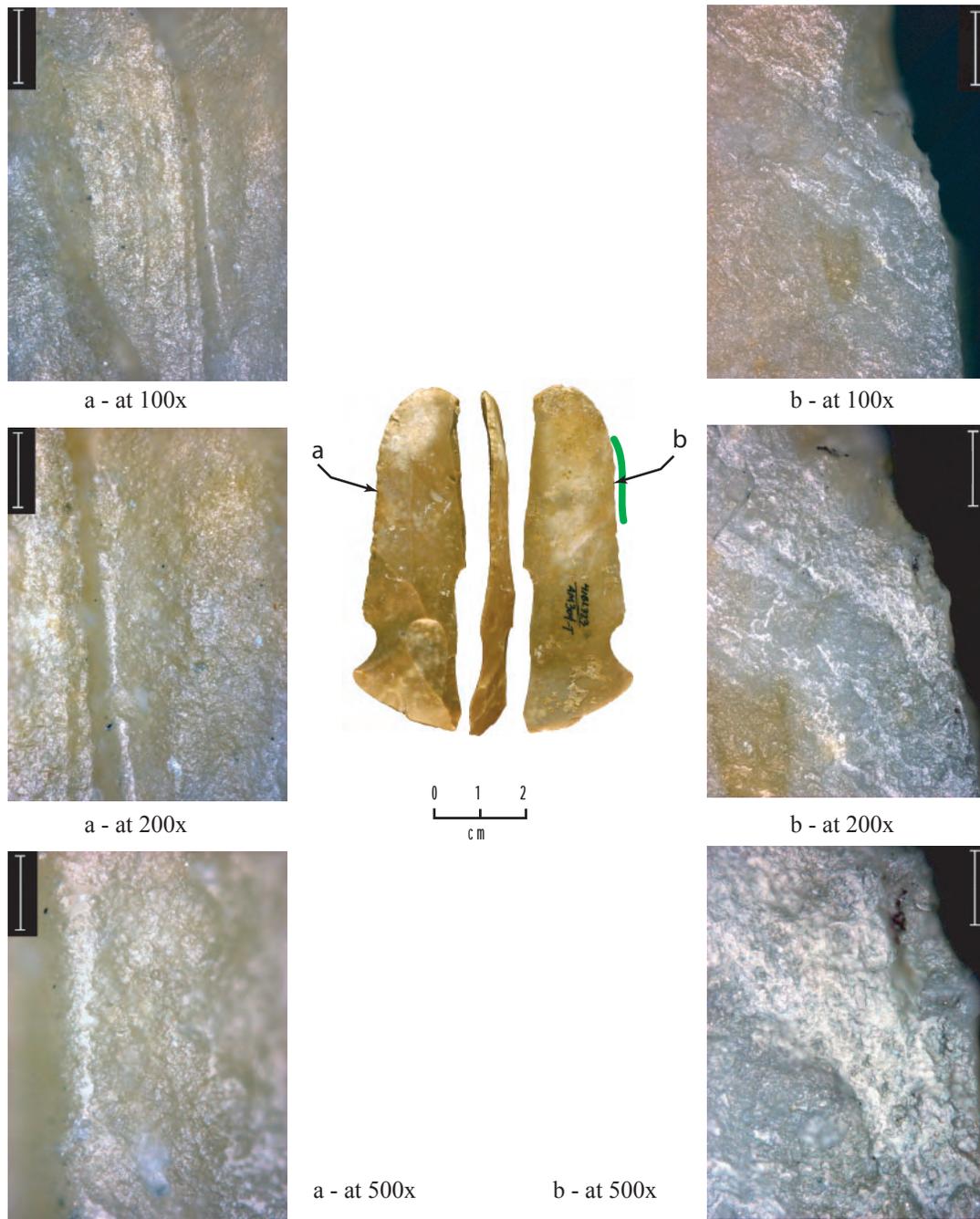


Figure E-4. Clovis 3a Blade AM304T (Cat #447): (a) polish along a ripple of a negative scar; (b) polish on high spots and hackles. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

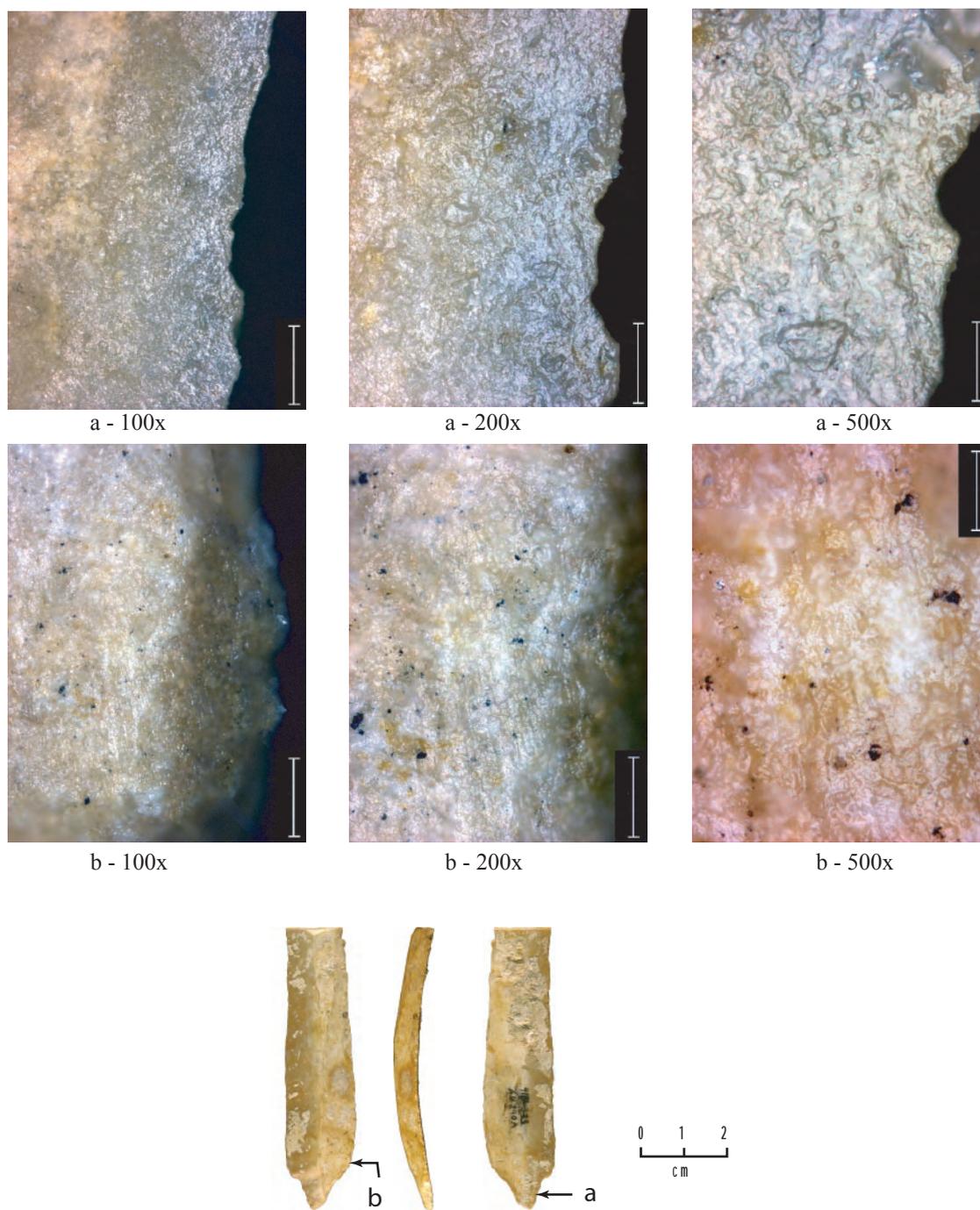


Figure E-5. Clovis 3a Blade AM240A (Cat #678): (a) location of polish by perforator-shaped end; (b) location of weak oblique striations. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

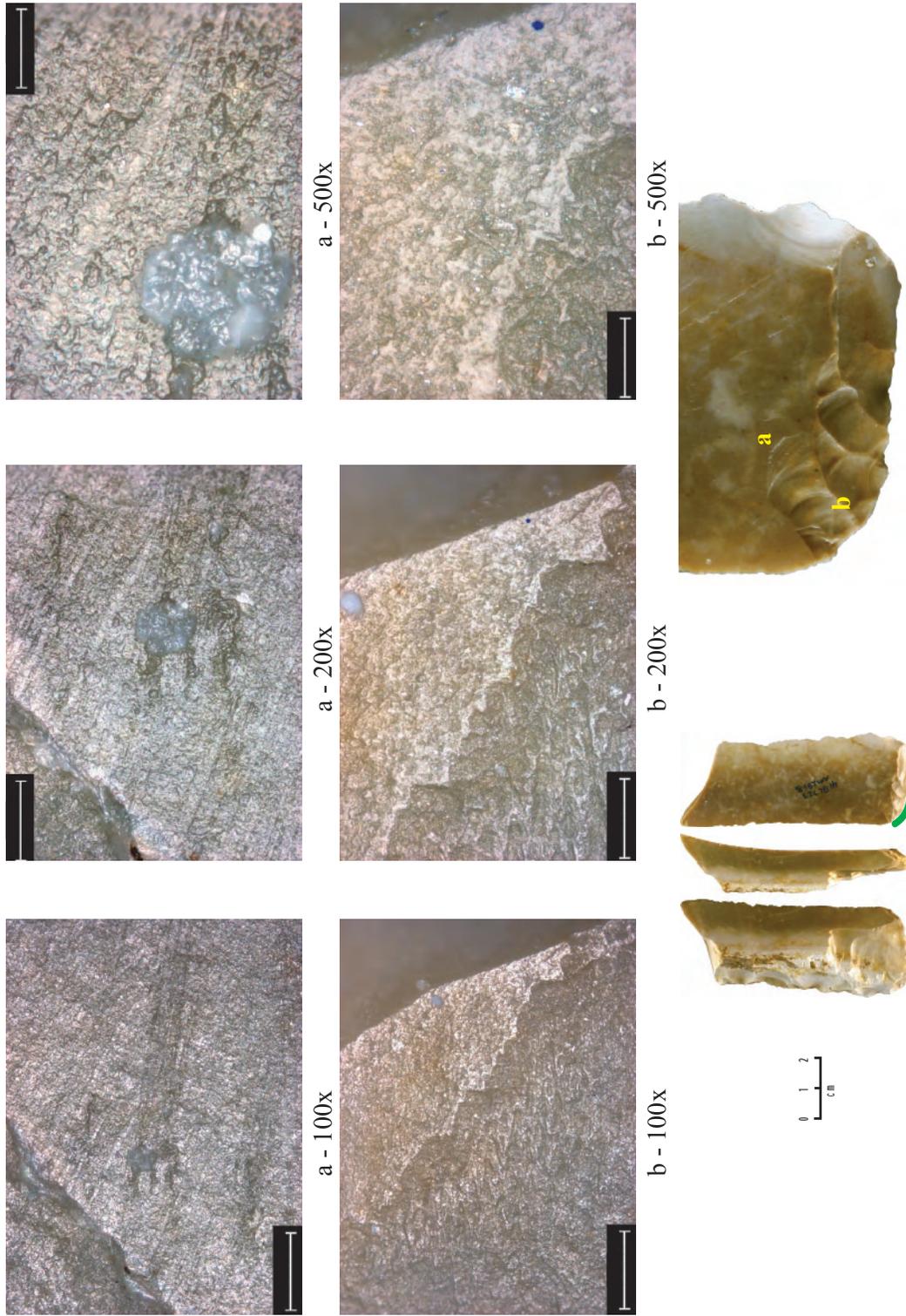


Figure E-6. Clovis 3b Blade AM285B (Cat #265): (a) location of densely packed u-shaped striations; (b) polish on high spot. Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um.

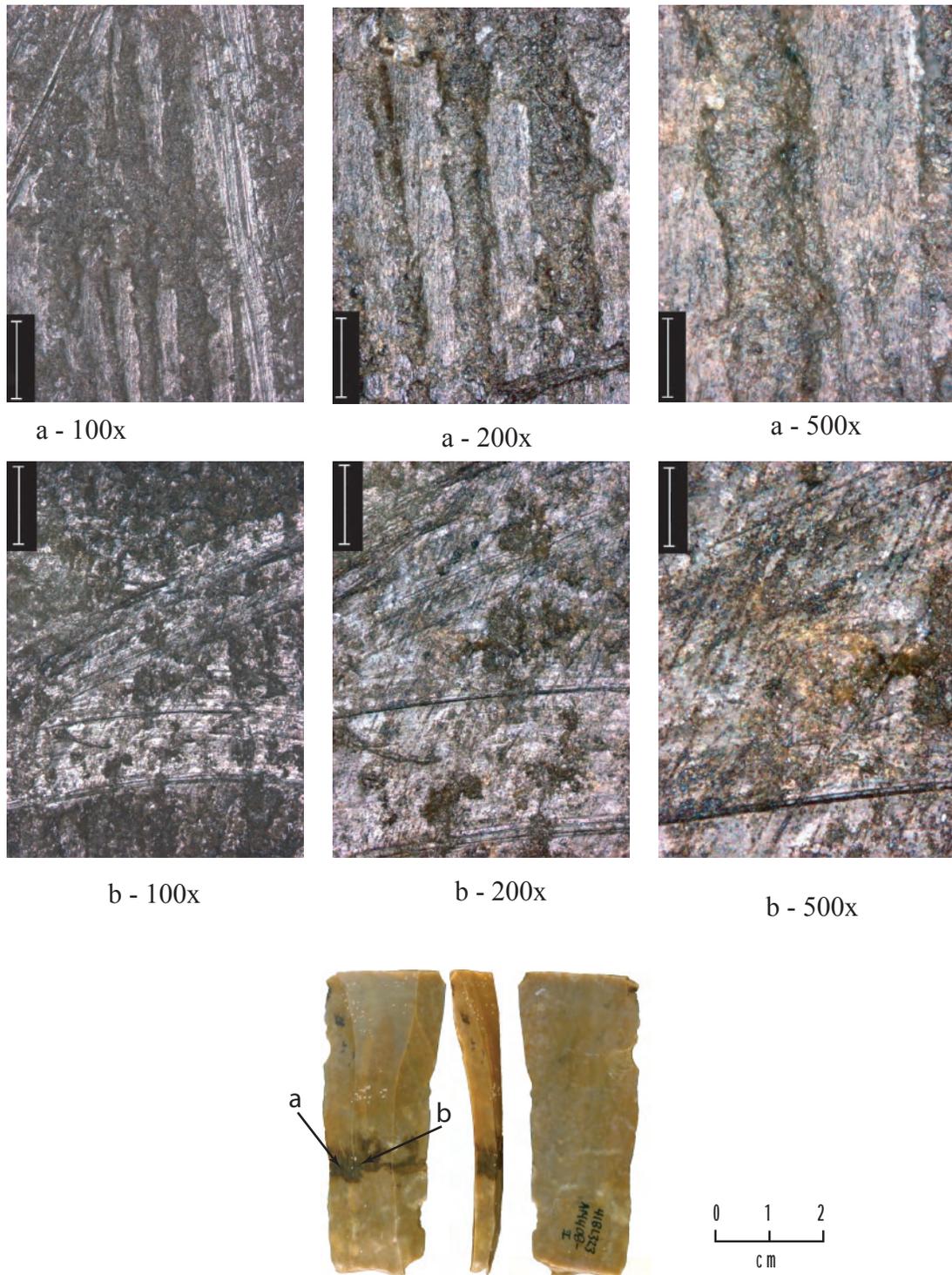


Figure E-7. Clovis 3a Blade AM408i (Cat #671): (a) location of deep u-shaped grooves in Fe-Mg-Ca; (b) location of u-shaped arc grooves on faceted plateau in Fe-Mg-Ca. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

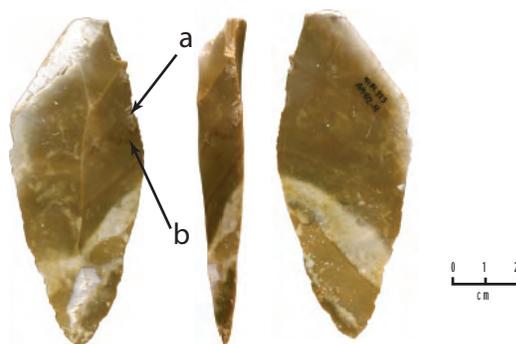
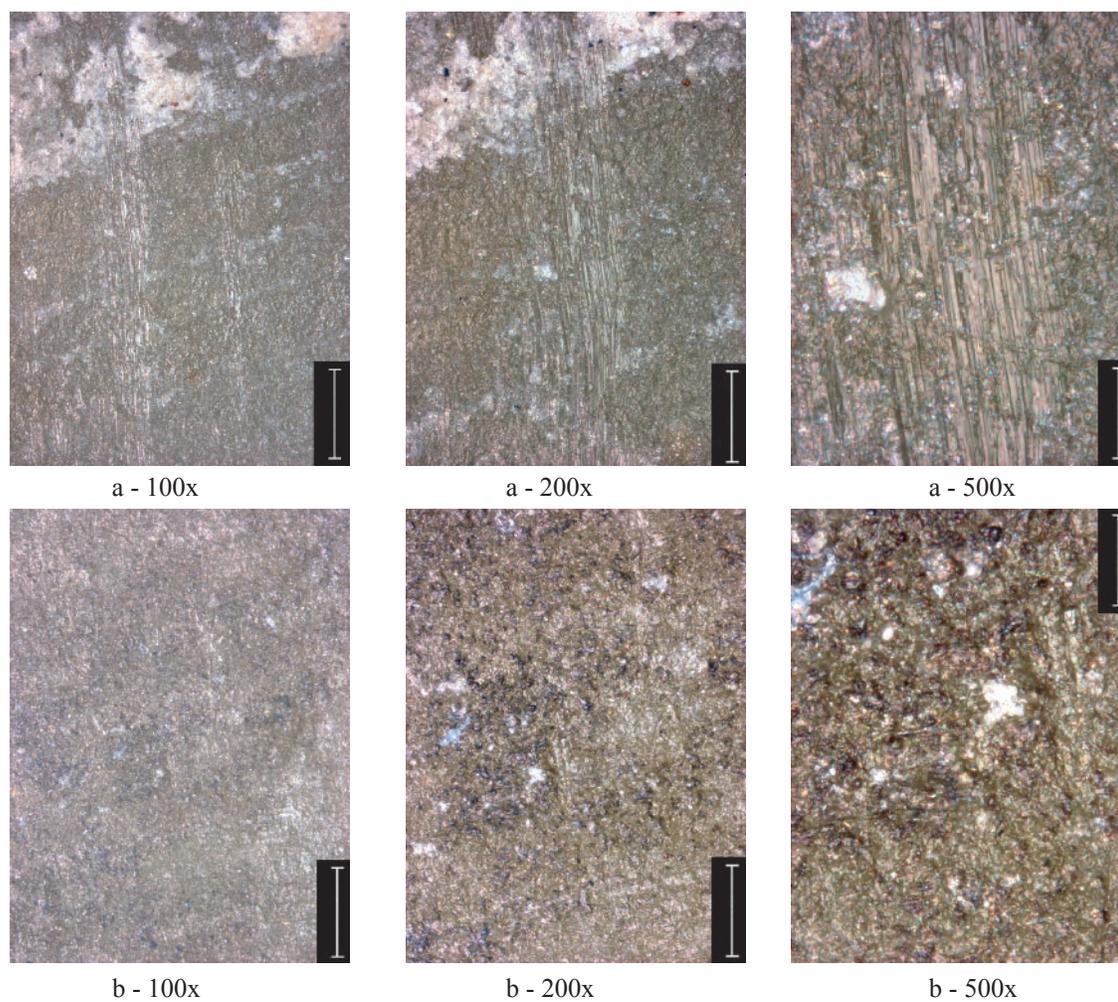


Figure E-8. Clovis 3a Blade AM412H (Cat #407): (a) location of two striations away from the edge; (b) location of Fe-Mg-Ca residue pattern. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

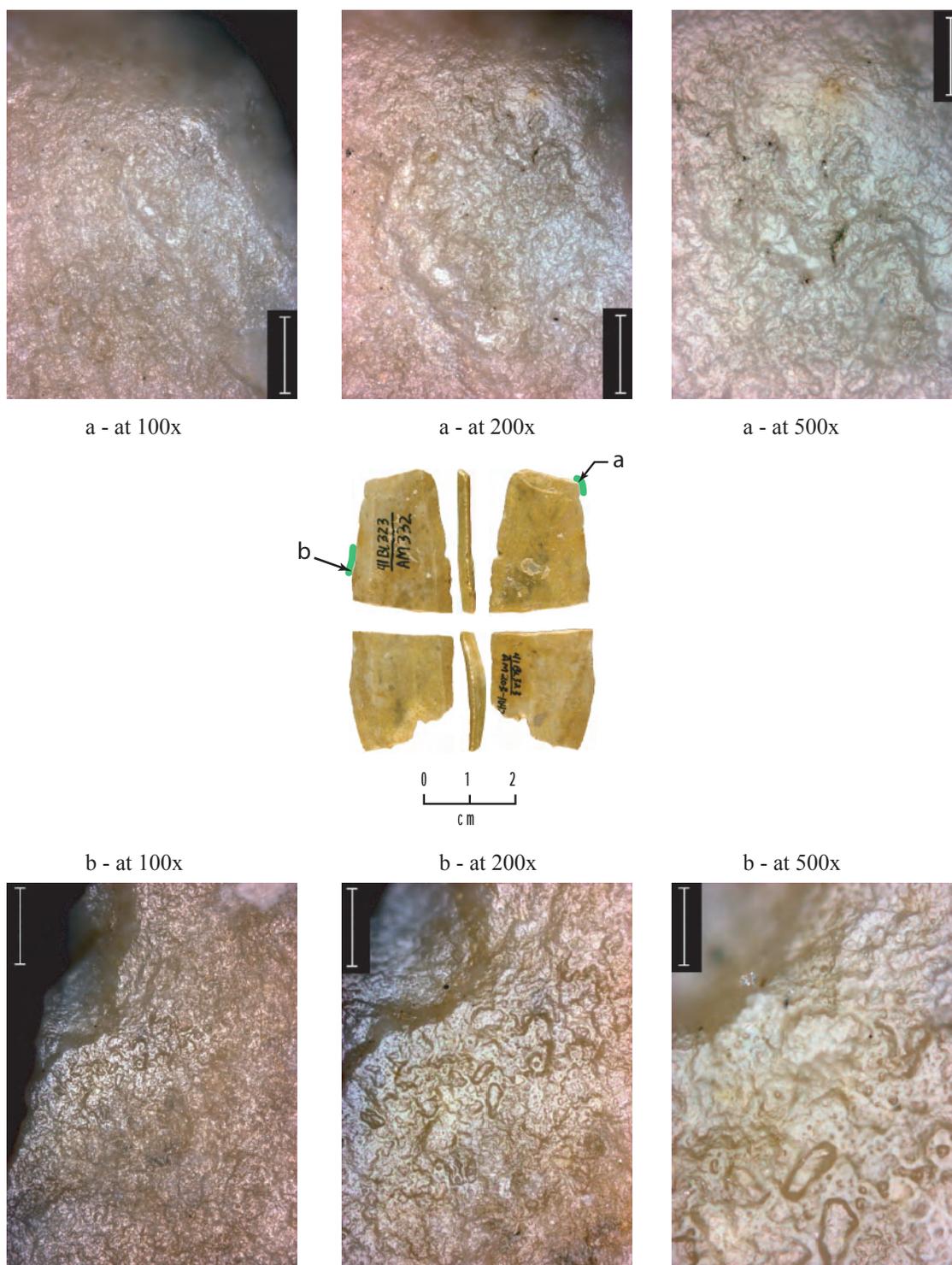


Figure E-9&E-10. Clovis Refit Blade AM332 (Cat #659) and AM203 (Cat # 1042):  
 (a) location of weakly linked polish ; (b) location of weak polish.  
 Scales: 100x = 200 um; 200x = 100 um; and 500x = 50 um.

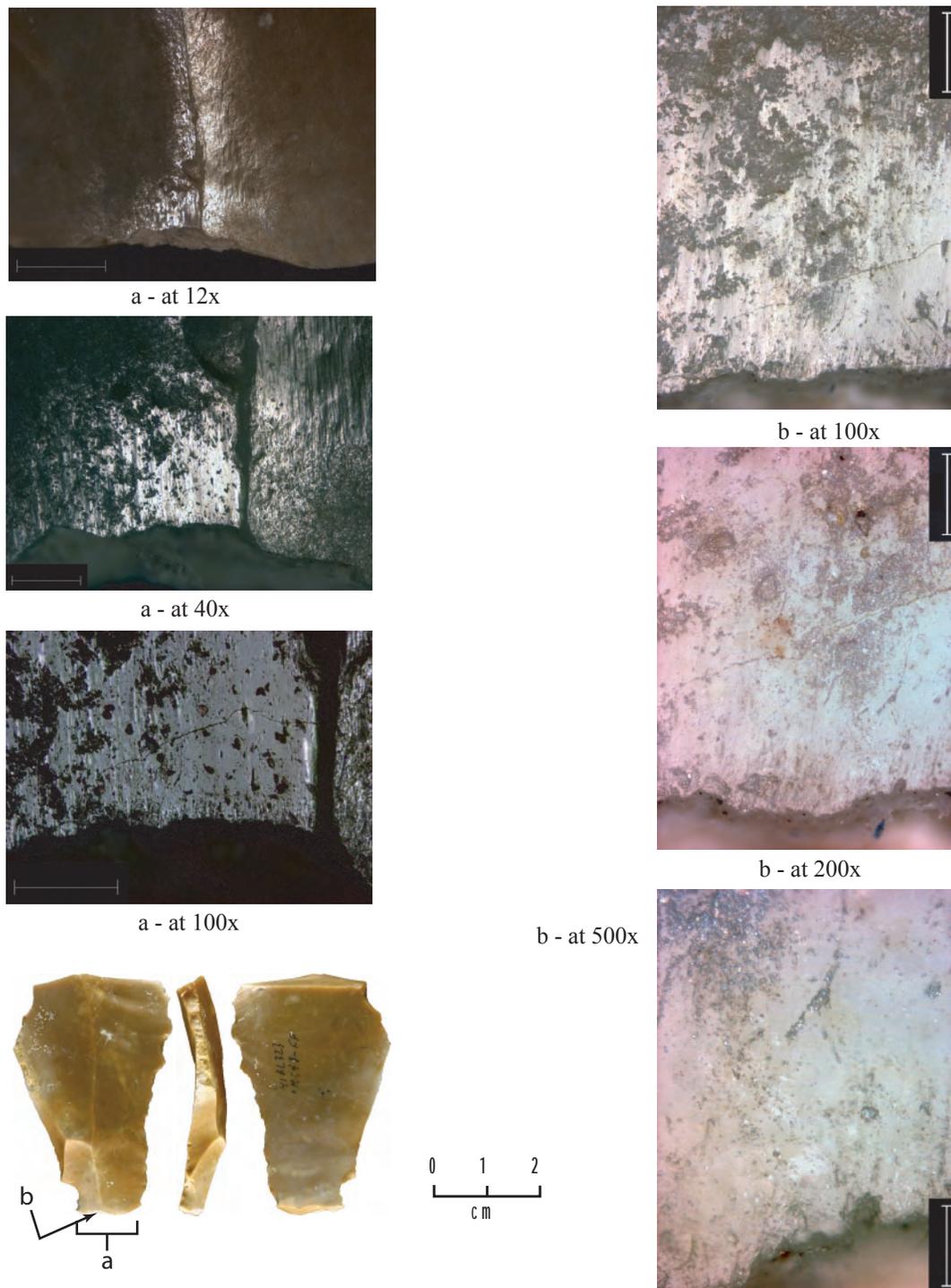


Figure E-11a. Clovis 3b Blade AM347F2 (Cat #301): (a) stereomicroscope location of polish at the distal break ; (b) compound microscope location the polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

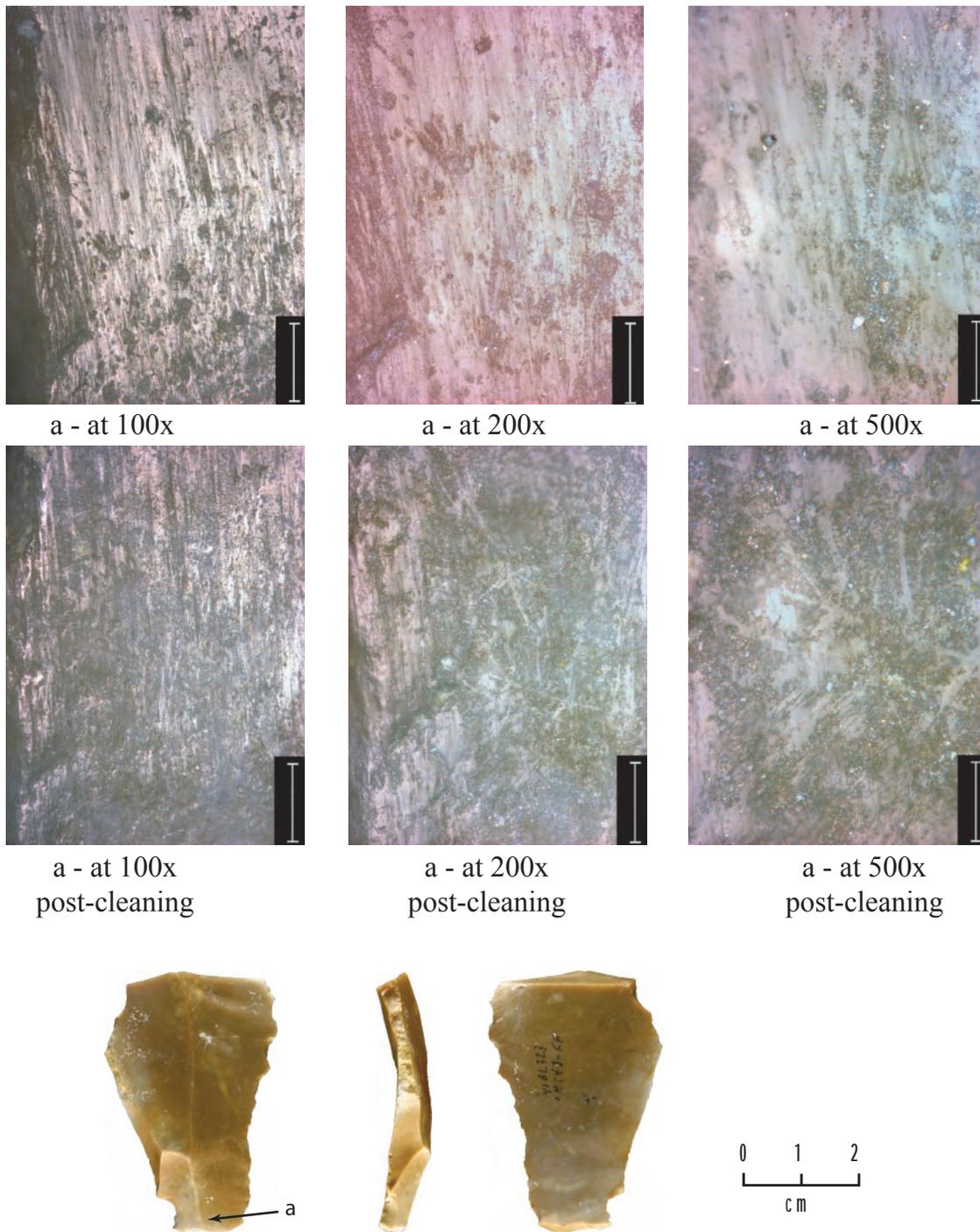


Figure E-11b. Clovis 3b Blade AM347F2 (Cat #301): (a) compound microscope location of polish at the distal break before cleaning ; (b) compound microscope same location the polish, post-cleaning. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

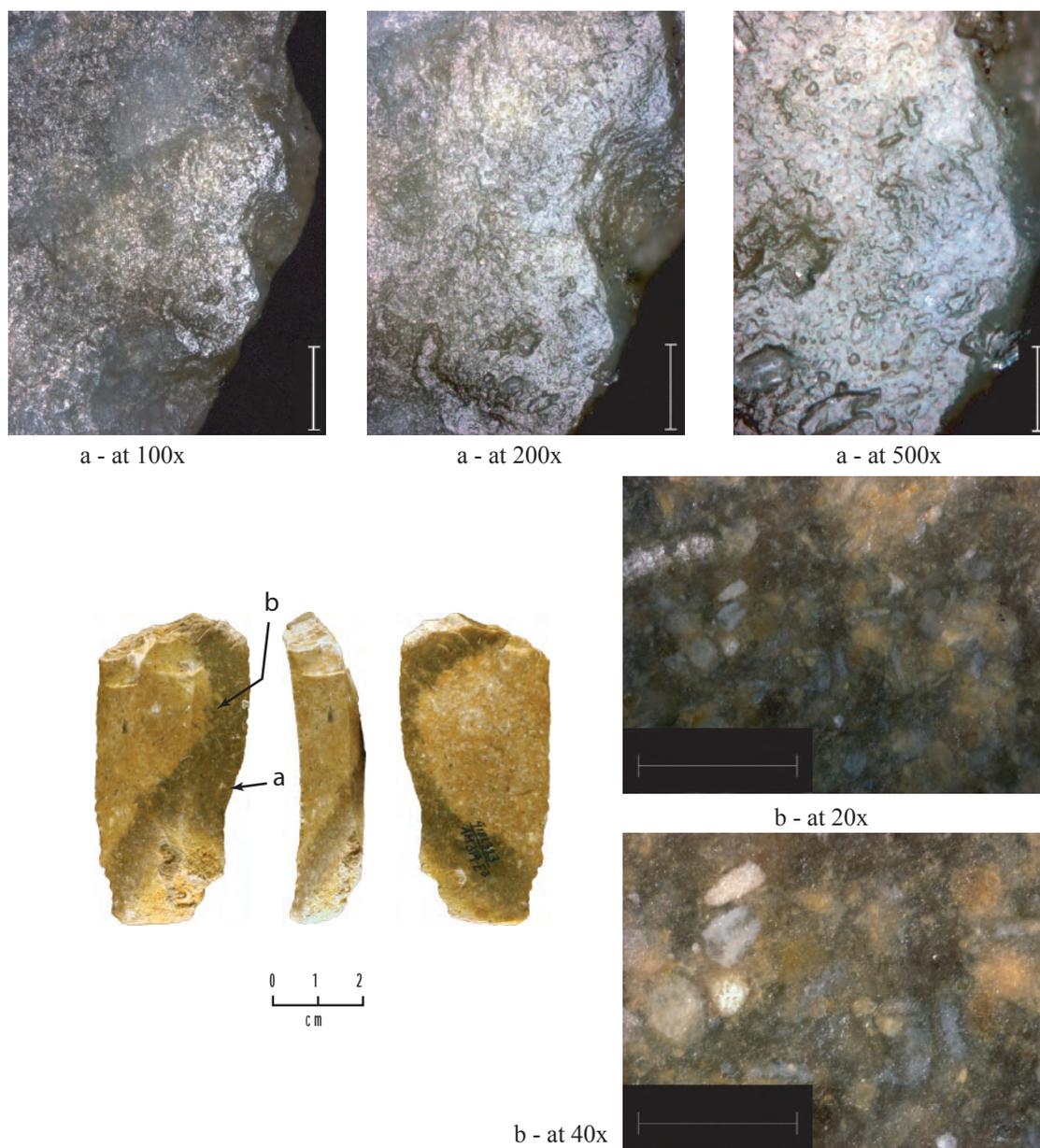


Figure E-12. Clovis 3b Blade AM319E3 (Cat #352): (a) compound location of weakly linked polish ; (b) stereomicroscope location of fossils. Scales: 20x = 1.25 mm; 40x = 0.5 mm; 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

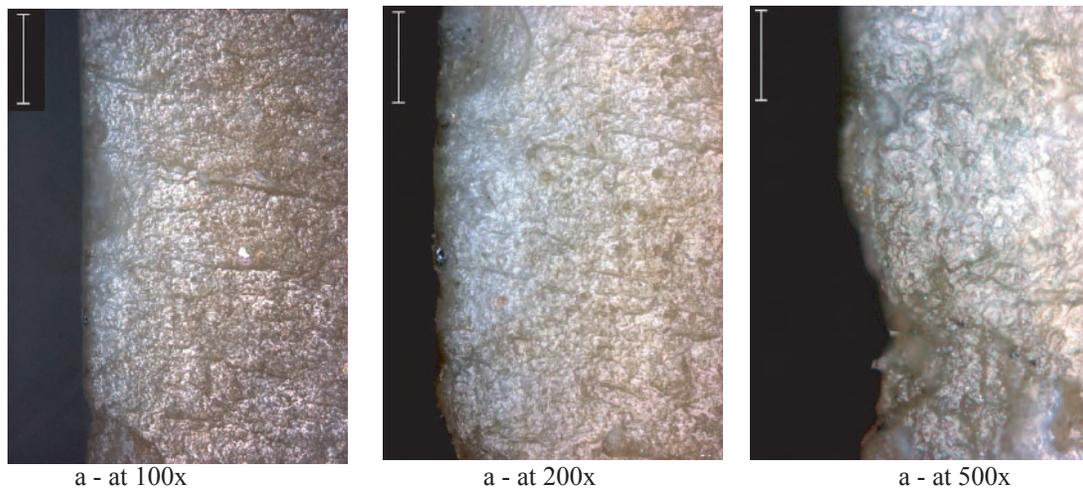


Figure E-13. Clovis 3a Blade AM244A2 (Cat #480): (a) location of weakly linked polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

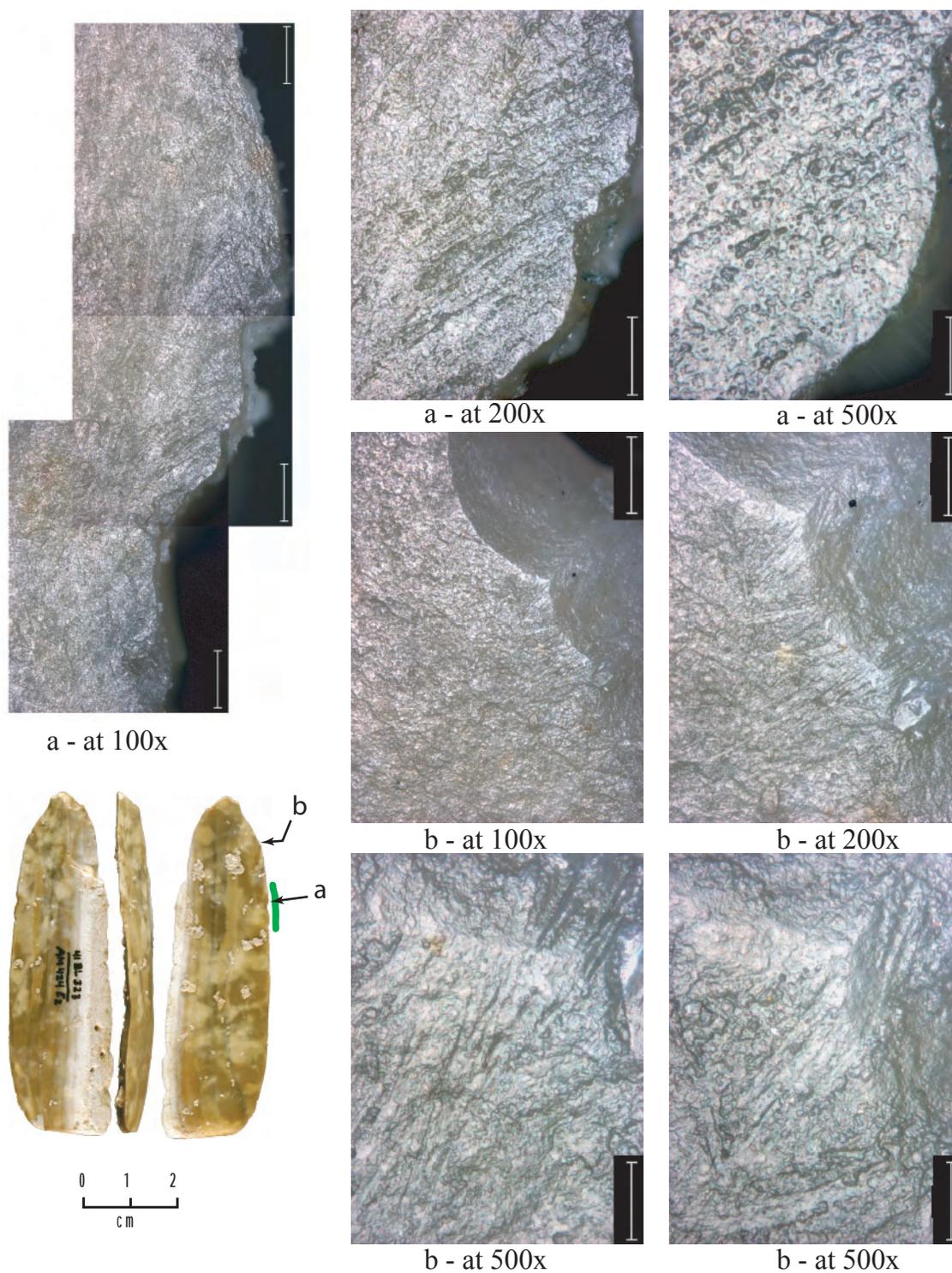


Figure E-14. Clovis 3a Blade AM424E2 (Cat #698): (a) location of oblique striations and polish; (b) location of discrete deep u-shaped striations. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

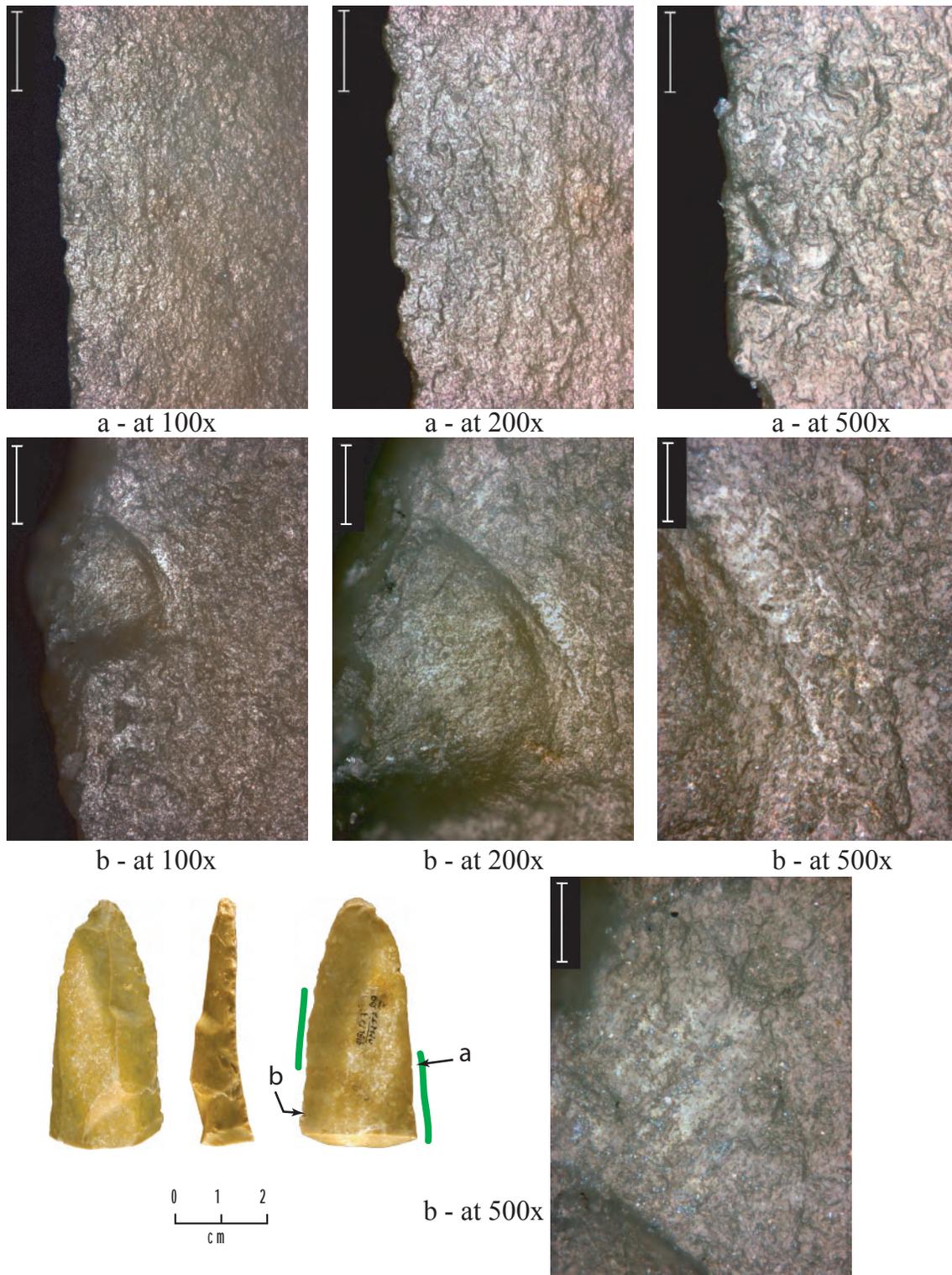


Figure E-15. Clovis 3a Blade AM25202 (Cat #436): (a) location of weakly linked polish; (b) location of discreet planed polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

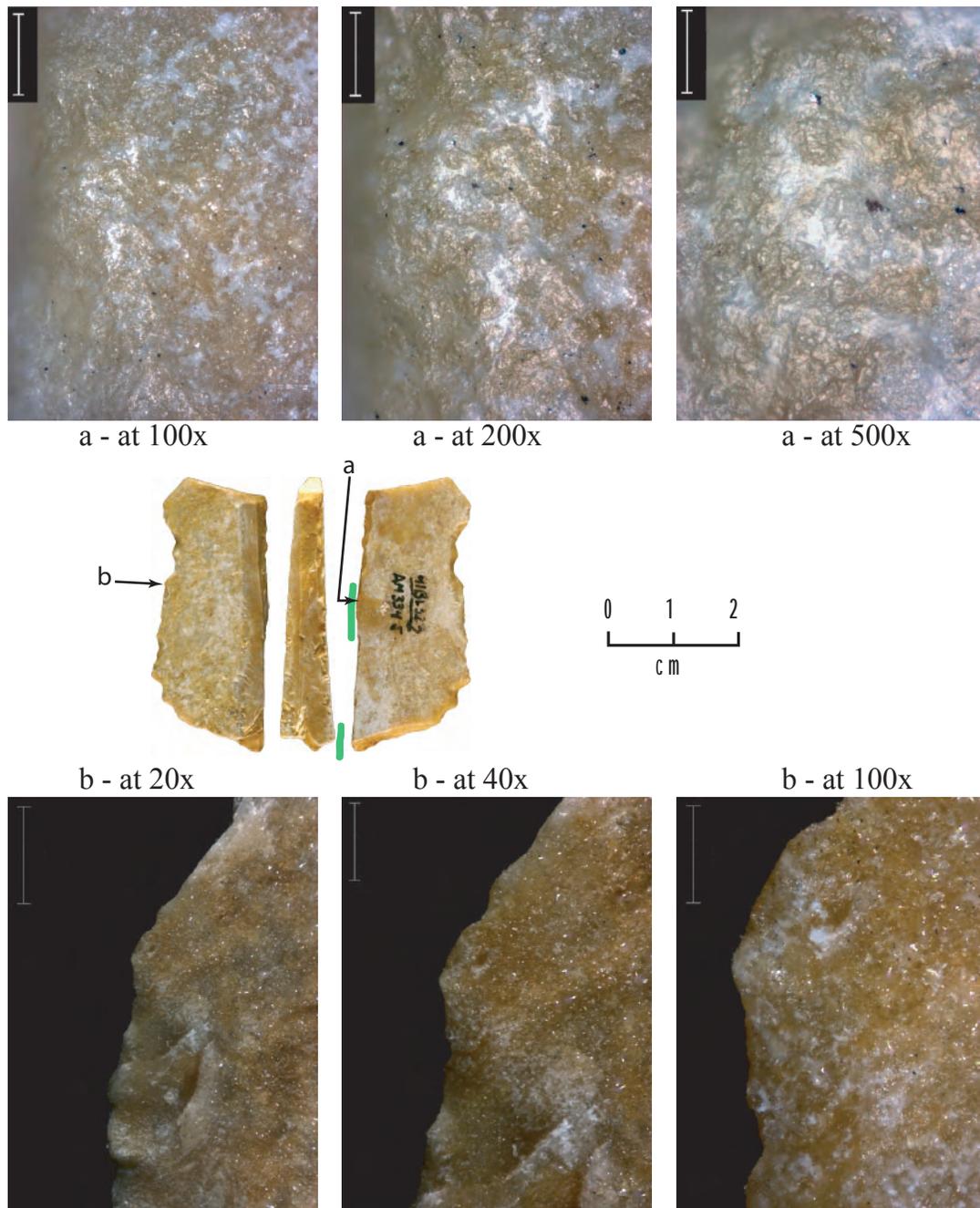


Figure E-16. Clovis 3a Blade AM334J (Cat #269): (a) compound microscope location of polish on late diagenetic chert; and (b) stereomicroscope location of edge. Scales: 20x = 1.25 mm; 40x = 0.5 mm; and 100x (Stereomicroscope) = 0.25 mm; 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

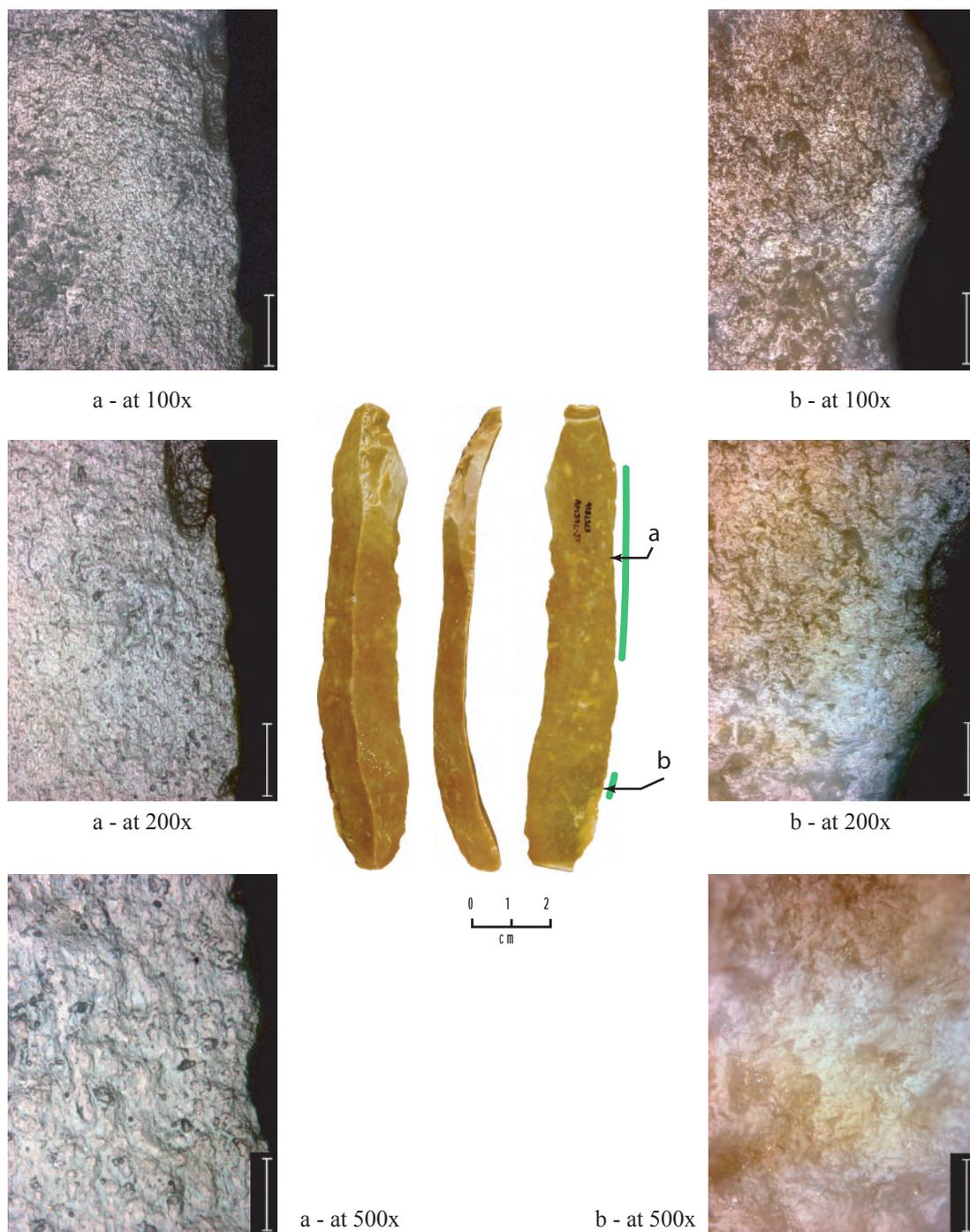


Figure E-17. Clovis 3a Blade AM92J (Cat #392): (a and b) location of dubious polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

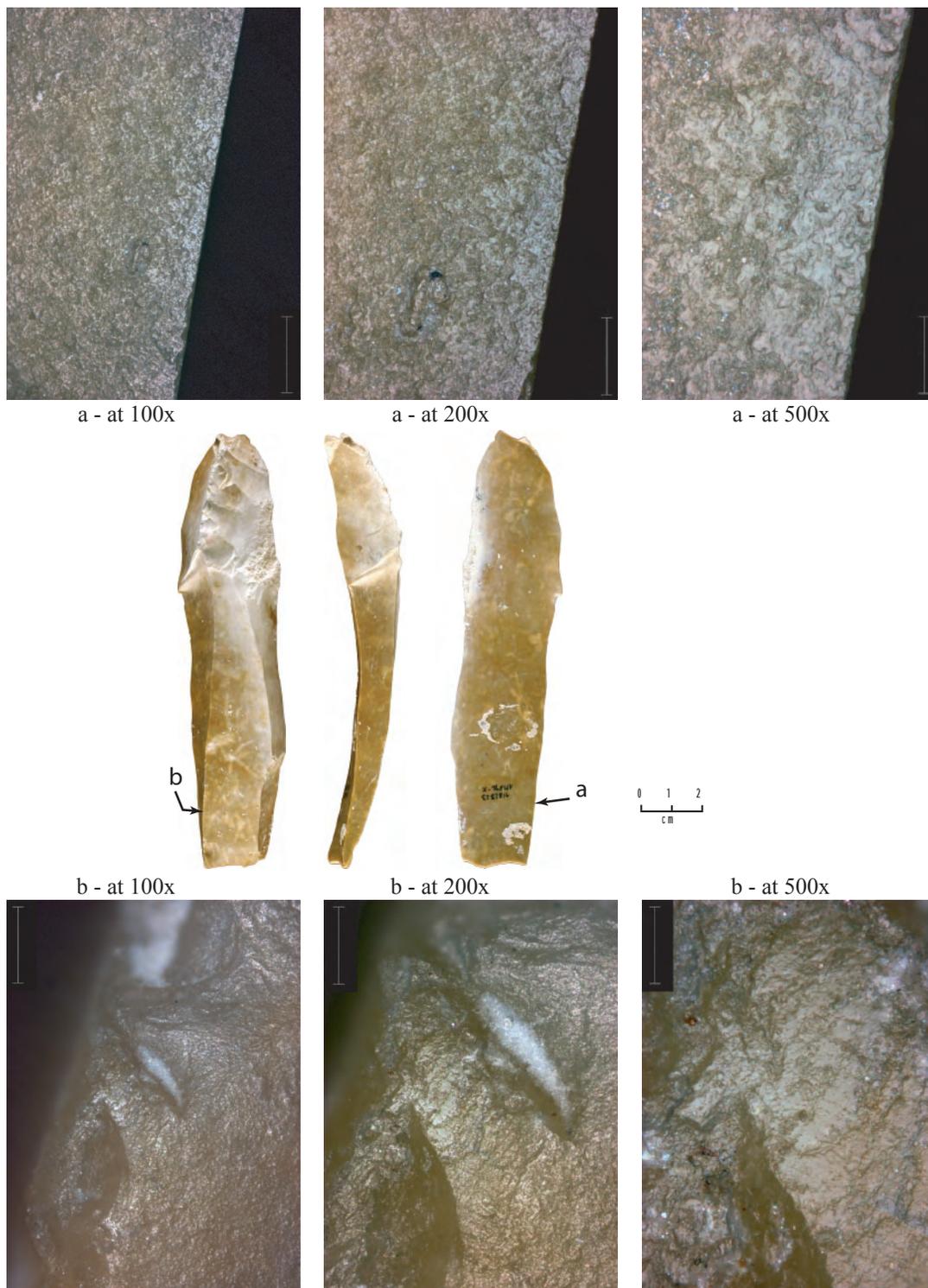


Figure E-18. Clovis 3a Blade AM392X (Cat #404): (a) location of linked polish; and (b) location of discrete planed polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

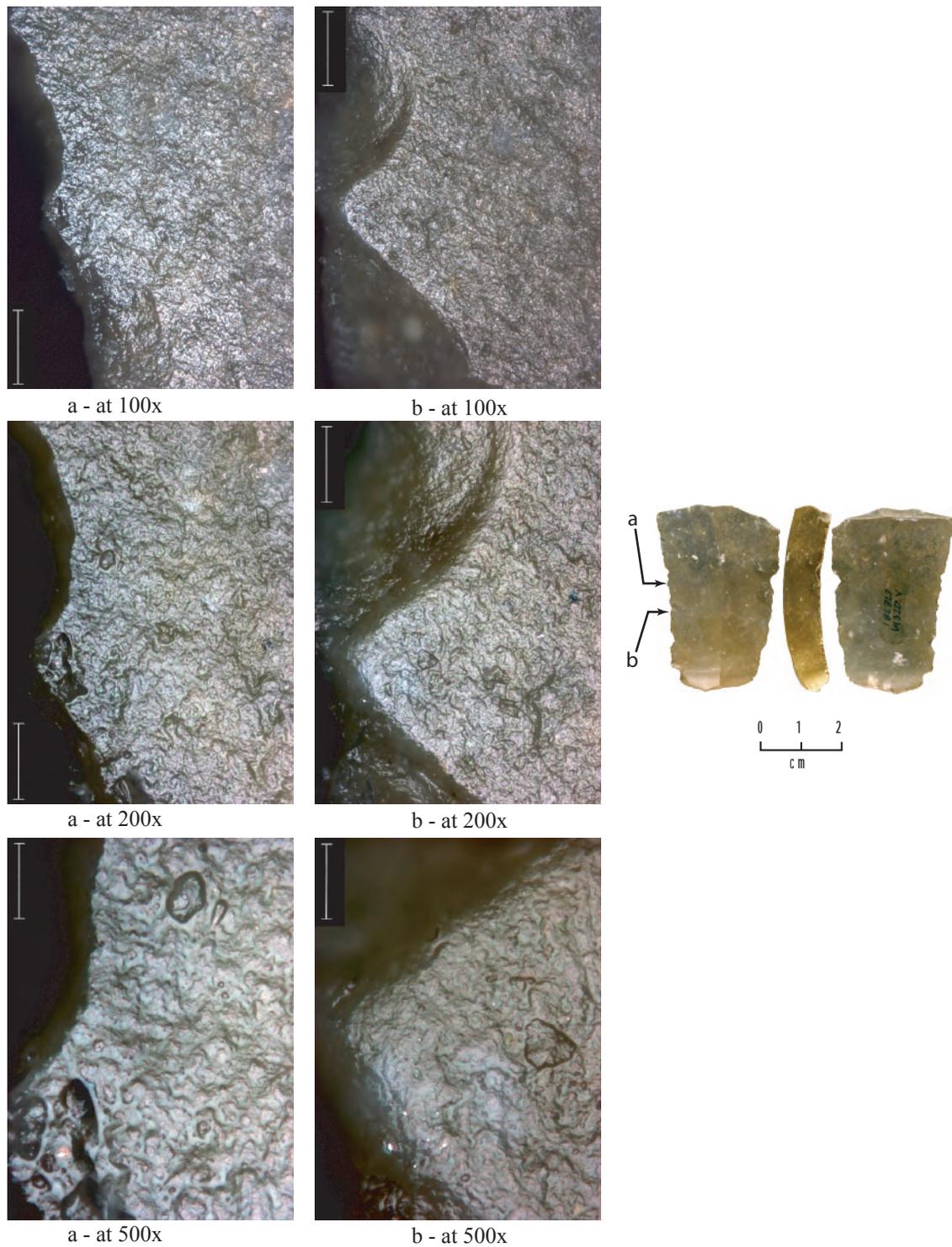


Figure E-19a. Clovis 3a Blade AM320V (Cat #706): (a and b) locations of light polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

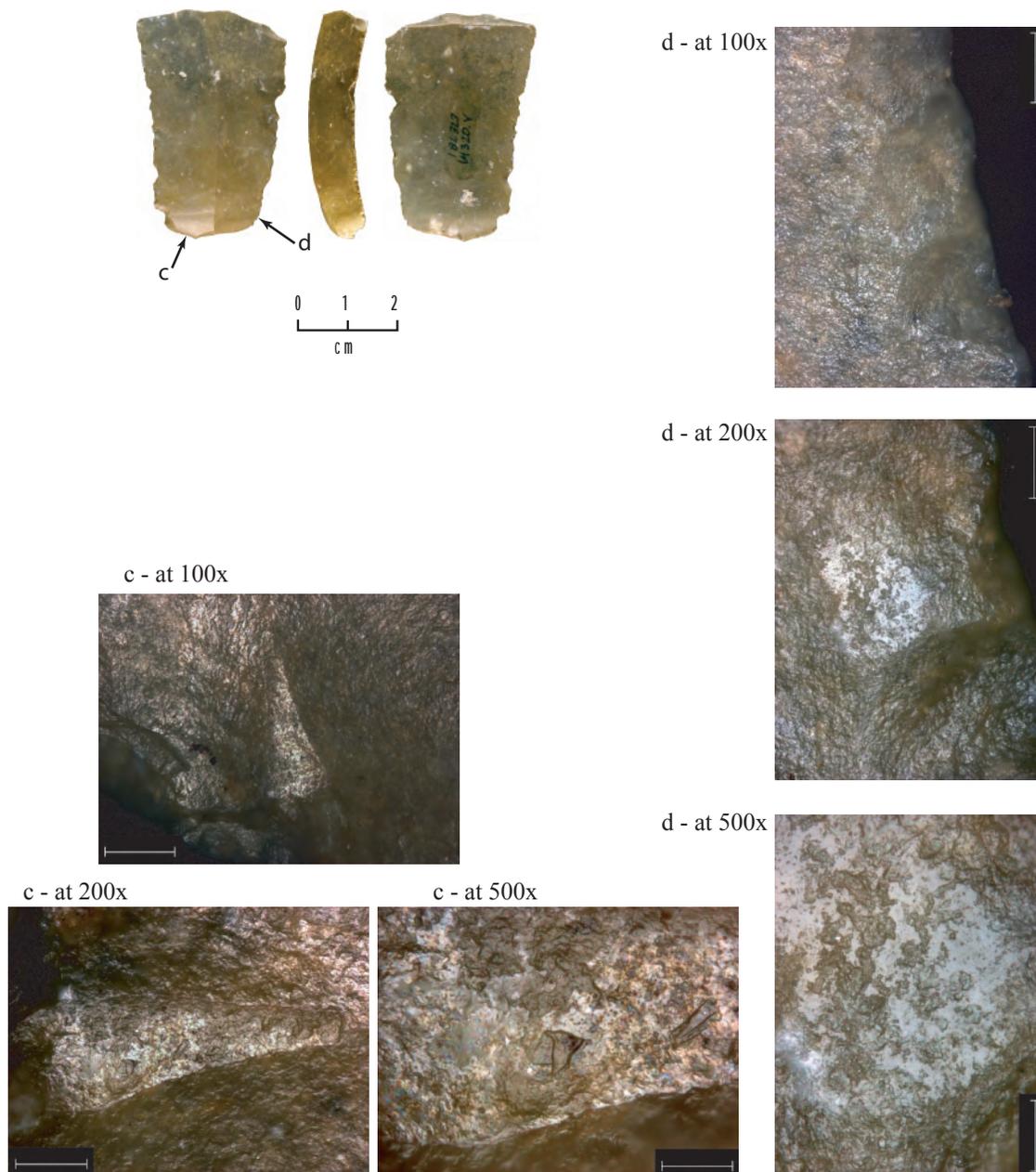


Figure E-19b. Clovis 3a Blade AM320V (Cat #706): (c and d) locations of planed polish on distal end. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

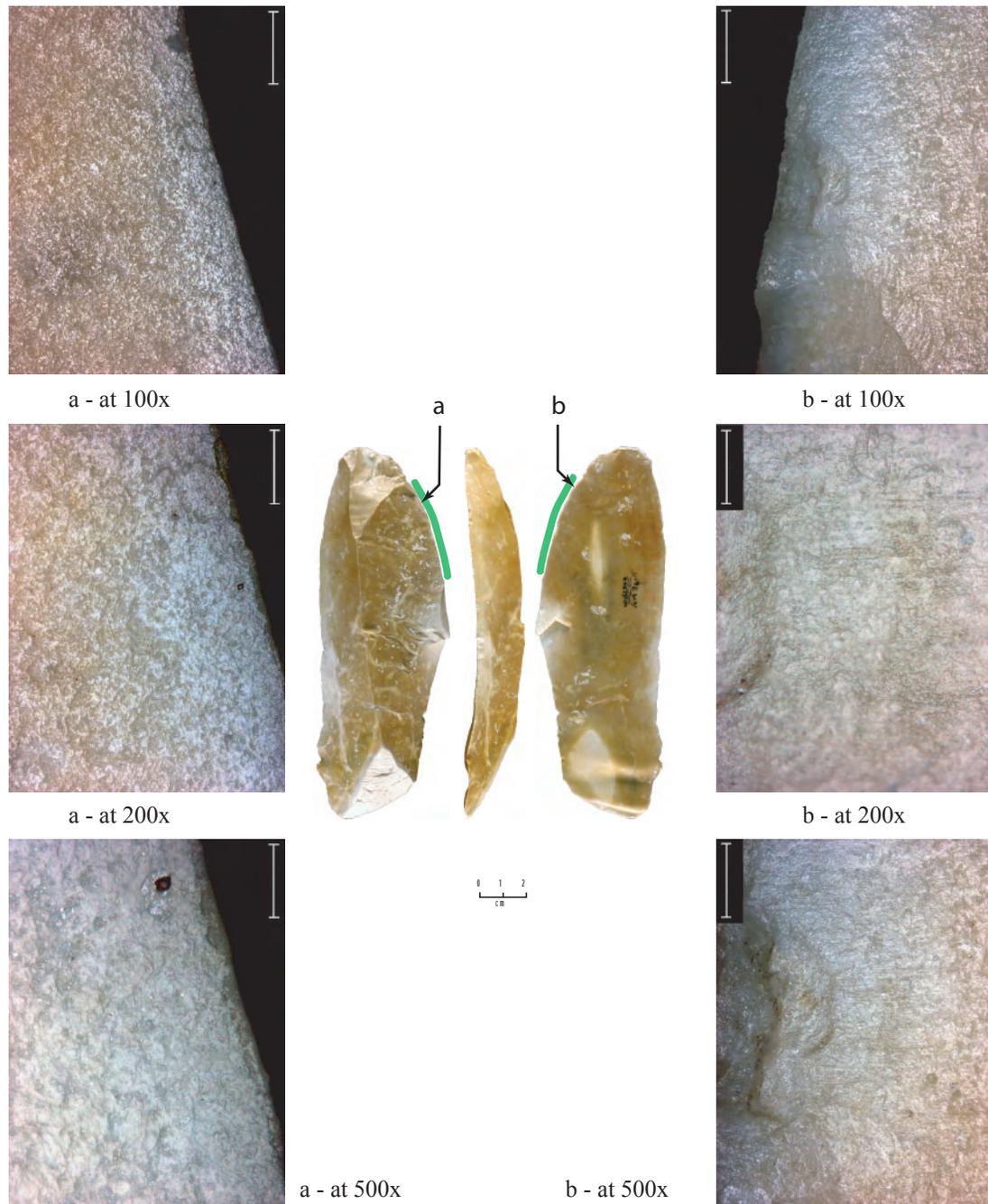


Figure E-20. Clovis 3a Blade AM264D (Cat #947): (a) location of linked polish ; (b) location of polish with perpendicular (to edge) linear pattern. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

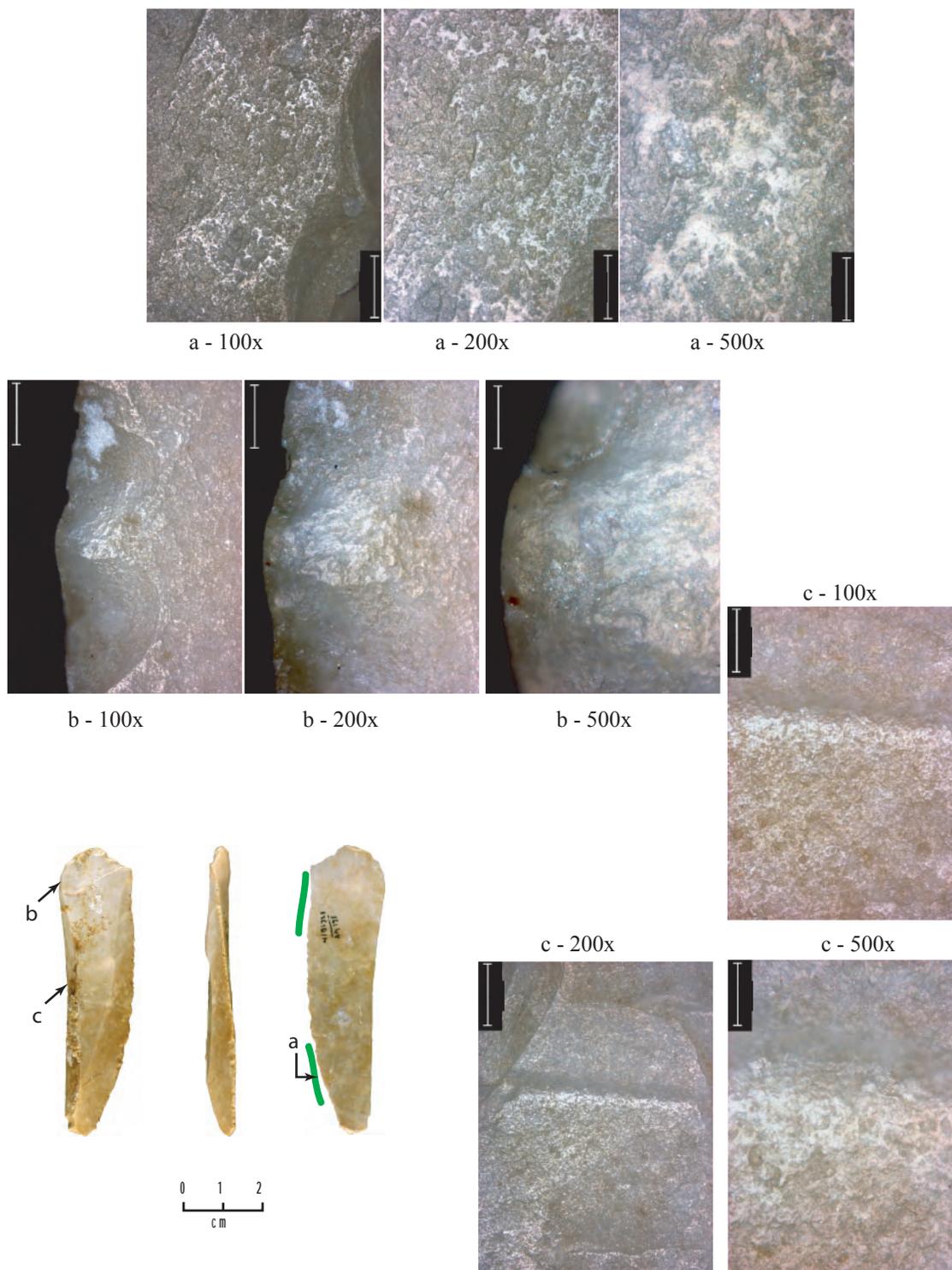


Figure E-21. Clovis 3b Blade AM171 (Cat #449): (a) location of linked polish ; (b and c) polish on ridge from flake scar. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

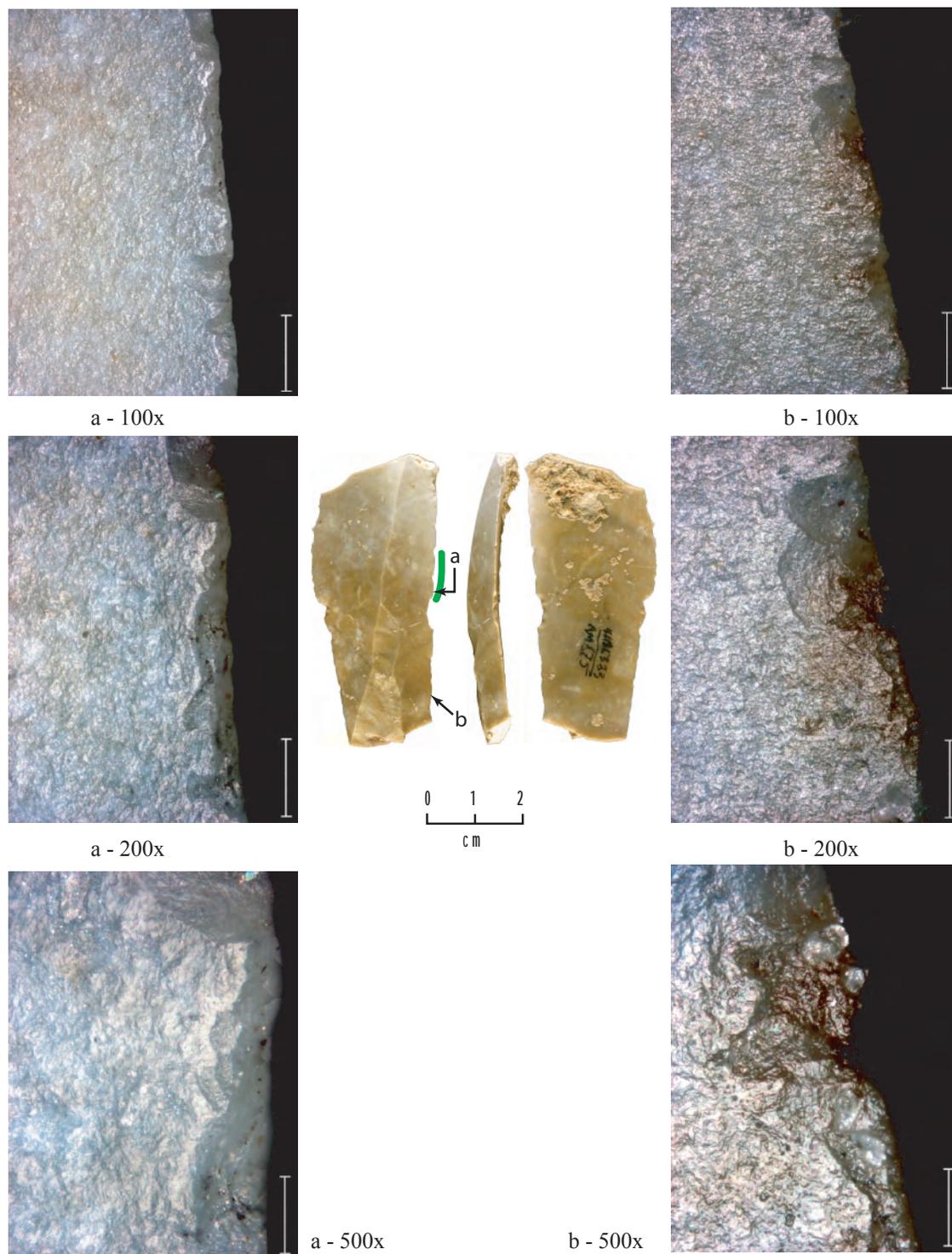


Figure E-22. Clovis 3b Blade AM175D (Cat #466): (a) location of polish heavy on edge; (b) location of weak polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

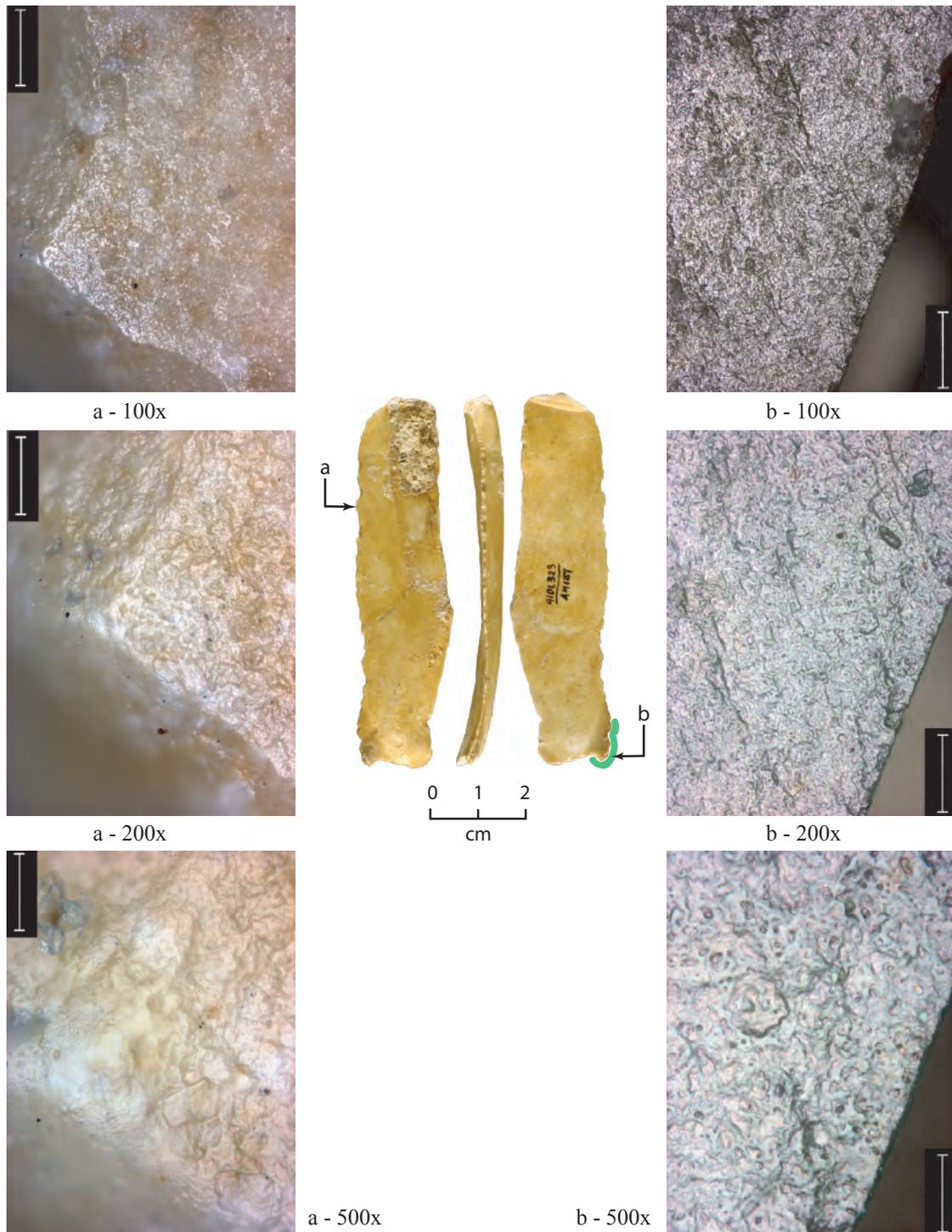


Figure E-23. Clovis 3b Blade AM187B (Cat #319): (a) location of polish on later diagenetic chert; (b) location of weakly-linked polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

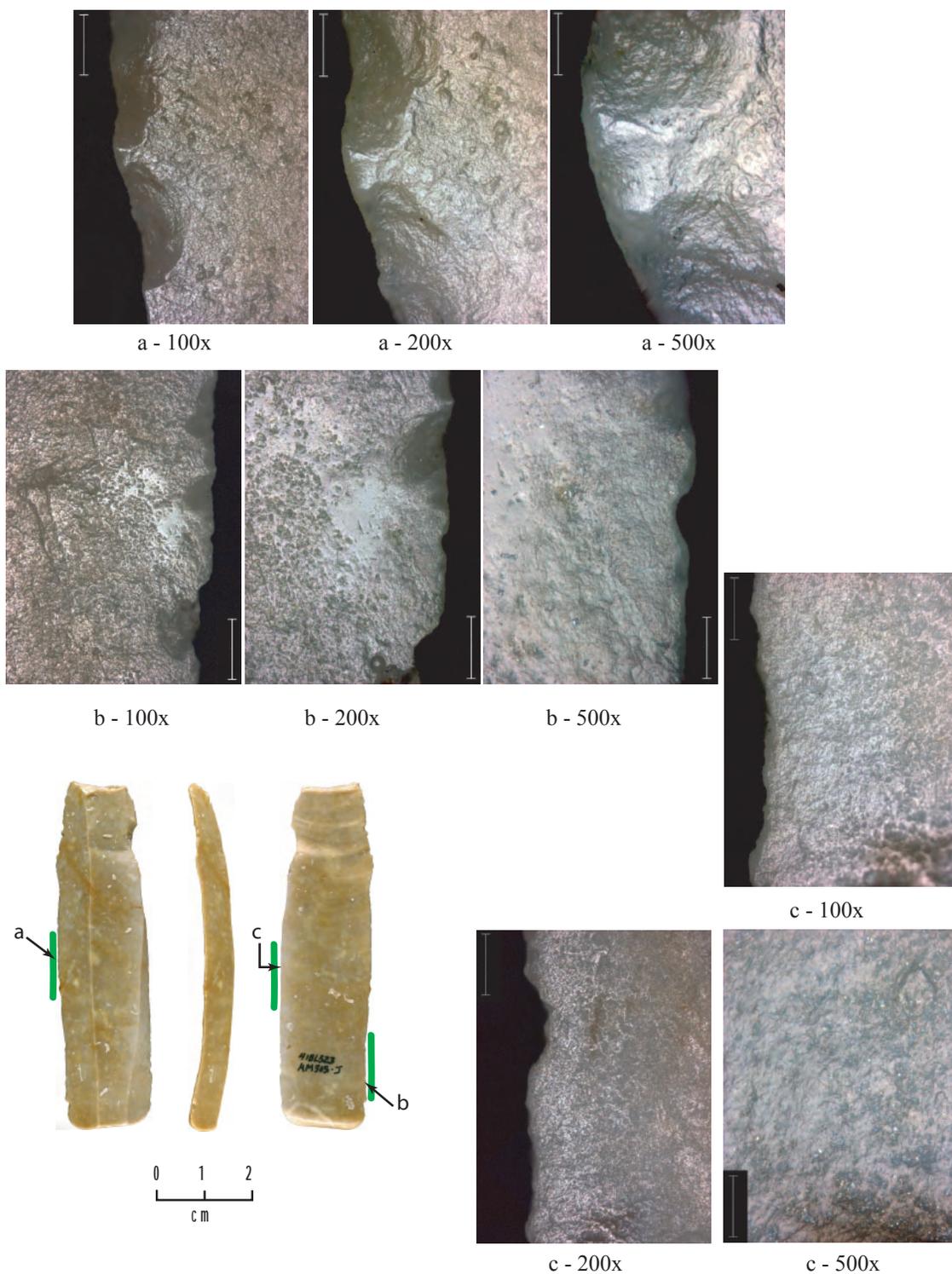


Figure E-24. Clovis 3b Blade AM303J (Cat #702): (a and b) location of heavy linked polish; (c) location of weakly-linked polish. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

## APPENDIX F

### SEM/EDS ANALYSIS

Throughout the compound analysis of the blades, magnification at 500x offered clarification of previous magnifications – sometimes with more questions. Such was the case for the Gault Clovis blades AM408I and AM285B, which exhibited substances adhering to the chert that were classified as “residues.” The meaning of the word is in-line with Levi-Sala’s (1996:ix) “adhere”, or particles adhering to the surface that cannot be removed by cleaning – not suggesting that they are fused. Although her term applies to particles through use, the same is applicable to possible non-use substances. The following is the expanded results of the SEM/EDS analysis of the substances. With the discovery of substances on blades from Gault, the author formulated two working hypotheses: (1) the substance(s) are residues from hafting or use; and (2) the substances are from natural accretions or staining and not related to hafting or use.

If the residues were from hafting, possible mastics are animal proteins, plant resins, and petroleum-based substances (Tankersley 1994:). All are organic-based. Fish and animal glues (Schmidt 1991:37) are made from fibrous proteins in a long polymer chain and made by hydrolysis. Animal glues are referred to as fusible thermoplastics, whereas fusible refers to the mode of adhesion and thermoplastic implies that glue melts when heated (Schmidt 1991:38). Michael Collins (1979:1020, 1981) notes the use of petroleum-based substances as mastics.

Work was done under the guidance of Dr. Marvin Rowe of the Department of Chemistry at Texas A&M University, with operation was provided by Dr. Michael Pendleton of the *Microscopy and Imaging Center* at Texas A&M University.

## Methods

Analysis with the SEM and EDS systems are logical outgrowths of the stereomicroscope and compound microscope analyses. Stereomicroscope and compound microscope analysis of the Gault Clovis blades revealed specific locations of the residues (see appendices D and E). Dr. Pendleton prepared the blades for analysis, operated the equipment, and aided in identification. The blades were uncoated and mounted on aluminum stubs with a glue and copper tape. They were then placed in an oven at 55 degrees to remove any remaining water content. Neither blade received gold or carbon coating. The problem with irreversibility for the gold coating negated its use and carbon coating was eliminated due to the possibility of the carbon interfering with possible organics.

The *Microscopy and Imaging Center* at Texas A&M University provided SEM and EDS equipment. The SEM used is the JEOL JSM-6400, an analytical-grade SEM that is capable of acquiring and film and digital images. Acceleration voltages from 0.2 to 40kV, a magnification range of 10x to 300,000x, and a guaranteed resolution of 3.5nm allow an operator to achieve excellent results on a wide variety of samples. The JSM-6400 is equipped with a Princeton Gamma Tech (PGT) Prism Digital Spectrometer EDS System.

The rationale for the EDS sampling was to locate the “residue” locations through macrophotos and microphotos on the SEM screen. Once done, the next reading was taken on a “clear” spot (known to be chert without residue). This alternation was done until the difference between the residue and chert was evident. A note of caution: there was a difference between microscope and SEM images, as noted by Levi-Sala (1996:10).

This is due to the different principles of operation. Stereo- and compound microscopes reflect light off a surface, while an SEM uses a laser beam to charge the electrons. Thus, polish without visible surface alteration is not visible in the SEM. Problems with the difference in views were compounded by the lack of adequate landmarks at times for AM408I.

### **Gault Clovis Bade AM408I**

The first blade analyzed was the medial Clovis 3a blade AM408I (#671) from unit excavation N1018 E984 level 23. While being the initial impetus for this level of analysis, the blade also gives the most noticeable evidence of a possible adhesive. The location of the substance on the blade is most heavily concentrated along a band three quarters up from the distal break on the dorsal face (Figure F-1) and runs perpendicular to the lateral edges. There is only a small patch of dark staining representing the band on the ventral face, which is located on the right lateral edge. Additional smaller dorsal locations are by the upper left lateral edge, with small patches also on the ventral face.

Stereomicroscope analysis images (Figure F-1) reveal what looks like an “applied” texture. Rotation of the blade also revealed a polish around the dark band (Figure F-1b). The left lateral dorsal facet (Figure F-1a) shows both black and orange-brown colors, with grooves running parallel to the edge. Compound microscope analysis of possible residue revealed grooves visible up to 500x magnification (Figure F-2 and Figure F-3) and contained a texture on the high spots between the grooves. On the plateau is a different pattern of thinner curved grooves (Figure F-2b) going in different directions. These patterns and the extent of the substance led to two hypotheses: 1) it is a magnesium-iron stain and 2) it is residue from hafting.

For the SEM/EDS analysis, we took a total of 16 readings (Figure F-4). Of these, 10 were taken on what was thought to be residue (Figure F-5). Of these, six (Figures F-5 a-f) are interpreted as chert without anything adhering to the surface (“clear”). The 10 other EDS readings (Figure F-5 g-p) show a marked difference from the others. Although the high ratio of silica (Si) remains consistent, there are elevated ratios of aluminum (Al), carbon (C), oxygen (O), and iron (Fe). In addition, the presence of manganese (Mn), magnesium (Mg), potassium (K), and calcium (Ca) shows a marked difference from the “clear” areas (Figure F-5 a-f).

### **Gault Clovis Blade AM285B**

The second blade analyzed was the medial Clovis 3b blade AM285B (#265) from excavation unit N1017 E982 level 21. The blade contains a brown homogenous looking substance located along the dorsal ridge by the proximal break (Figure 6), but continues in patches down to the modified distal end.

Stereomicroscope analysis shows that the substance covers cortex on the ridge (Figure F-6a), creating a thin veneer at some points, and remains homogenous-looking. Compound microscope analysis shows that the texture, up to 500x (Figure F-6b), is still homogenous.

For the SEM/EDS analysis of AM285B, we took a total of three readings (Figures F-7 and F-8). Of these, one was calcium (Ca), silica (Si), and aluminum (Al) – with lower ratios of carbon (C), oxygen (O), and iron (Fe). The presence and distribution of these provides the identification of calcium carbonate. The “cortex” spot was a high ratio of silica to oxygen, with no other elements distinguishable. This indicates that that the EDS reading was taken on chert.

### Geologic Explanation of Elemental Patterns

Since no organics were located in the SEM/EDS analysis of AM408I and AM285B, a geological explanation is warranted in definitions, underlying bedrock at the site, and micromorphology of the Gault site. Limestone is defined (Dott and Batten 1988:G7) as a sedimentary rock composed of calcium carbonate ( $\text{CaCO}_3$ ), made up largely of invertebrate fossils and skeletal debris. Dolomites (Dott and Batten 1988:G4; Hurlburt 1971:326) are sedimentary rocks composed of calcium-magnesium carbonate [ $\text{CaMg}(\text{CO}_3)_2$ ] with rhombohedral crystals and is most commonly a replacement of limestone through the introduction of magnesium ions in a solution of pore water. Limestone is calcium carbonate ( $\text{CaCO}_3$ ), a chemically deposited sedimentary rock of various thickness (Ladoo and Myers 1951:280; Tarr 1930:493). Dolomite, calcium-magnesium carbonate ( $\text{CaCO}_3\text{MgCO}_3$ ) is massive in form, finely to coarsely granular, gray, white, or bluish in color. It often contains iron, manganese, silica, and other impurities. Dolomite crystallizes in small rhombohedral crystals. In metamorphic form, it occurs as dolomitic marble, or marble that contains “sufficient”  $\text{MgCO}_3$ . Chert is defined as a sedimentary rock made up of silica in the form of microcrystalline quartz (Folk and Weaver 1952; Longwell et al. 1969:646) that forms as either original precipitates or by replacement of carbonates. Some chert at Gault contain high amounts of iron (Fe) staining, accounting for the diagnostic yellowish brown on its Clovis artifacts.

The underlying geology of the Gault site consists of the Comanche and Edwards formations and are Lower Cretaceous (Adkins and Arrick 1934; Fischer and Rodda 1969; Proctor et al. 1981). Comanche Fm is a fine to very fine-grained limestone, fairly hard

nodular, light gray, and weathers white (Proctor et al. 1981). Edwards Fm is comprised of limestone, dolomite, and chert (Proctor et al. 1981). Edwards limestone is aphanitic to fine-grained, and massive to thin bedded. Edwards dolomite is fine to very fine-grained, porous and medium gray to grayish brown. Fischer and Rodda (1969:69) state, “chert distribution in the Edwards Formation is coextensive with Edwards dolomite” and based on 250 field observations “...a high correlation of chert and carbonate grainstone independent of dolomite” (Fischer and Rodda 1969:70).

Micromorphology of the Gault site by Heidi Luchsinger (2002) provides evidence for the direct depositional/soilization environments in which the blades sat for approximately 11,000 years. Two sampling locations for Unit 3a (Luchsinger 2002:50-51) show a fine clay matrix with few rounded grains of quartz, calcite, chert, chalcedony, and rounded grains limestone. Voids, in the forms of vesicles, channels, vughs, and chambers. Orange redoximorphic concentrations with diffuse boundaries are scattered and disconnected voids that indicate moderate biological activity. Two sampling locations for Unit 3b (Luchsinger 2002:51-52) show a less clayey unit than 3a with fairly diffuse redoximorphic concentrations. Carbonate clasts are present, with some exhibiting iron staining and others with possible manganese staining. Moderate biological activity is also present. Fluctuating parameters promote calcium carbonate to go into solution and then to precipitate, with the local limestone providing an ample source (Luchsinger 2002:59). Unit 3a was heavily leached prior to burial and unit 3b received an increase in secondary carbonate due to leaching of unit 4c (Luchsinger 2002:63). Seasonal saturation produced the redox features of iron (Fe) and magnesium (Mg), which are oxidized in the Clovis units (Luchsinger 2002:68). The lower units were subjected to

fluctuating water table that was perched on the 60% clay unit 3a (Luchsinger 2002:Table 6).

### **Conclusions**

Limestone (Comanche Fm) and dolomite (Edwards Fm) provide sources for calcium (Ca) and magnesium (Mg). With the redox conditions in units 3a and 3b, along with a fluctuation of groundwater levels and the mobilization of the iron (Fe) and magnesium (Mg) provide a source for the occurrence of the elements on the EDS results of the “residue” band of AM408I.

Upon completion of the SEM/EDS analysis, Dr. Rowe and I interpreted the results and inferred the following conclusions:

1. The possible residues are not organic,
2. AM408I has a iron-magnesium calcium staining;
3. The possible reasons for these stains/coatings are offered by the following alternative hypotheses:
  - a. The stain (AM408I) is part of the chert.
  - b. The chert had organic material and went into an anoxic stage.
  - c. The chert (AM408I) had a painted strip – remote.
4. AM285B has a partial ridge covering of calcium carbonate.

### References Cited

- Adkins, W. S., and M. B. Arick,  
1930 *Geology of Bell County*. The University of Texas Bulletin, No. 3016. The University of Texas at Austin, Austin.
- Collins, Michal B.  
1979 *Excavations at Four Archaic Sites in the Lower Ohio Valley, Jefferson County, Kentucky*. Dept. of Anthropology, University of Kentucky, Lexington.
- 1981 The Use of Petroleum by Late Archaic and Early Woodland Peoples in Jefferson County, Kentucky. *Journal of Field Archaeology* 8:55-64
- Dott, Robert H., and Roger L. Batten  
1988 *Evolution of the Earth*. 4<sup>th</sup> Edition. McGraw-Hill, New York.
- Fischer, W. L., and Peter U. Rodda  
1969 Edwards Formation (Lower Cretaceous), Texas: Dolomitization in a Carbonate Platform System. *The American Association of Petroleum Geologists Bulletin* 53:55-72.
- Folk, Robert L., and Charles E. Weaver  
1952 A Study of the Texture and Composition of Chert. *American Journal of Science* 250:498-510.
- Hurlbut, Jr., Cornelius S.  
1971 *Dana's Manual of Mineralogy*. John Wiley and Sons, New York.
- Ladoo, R. B., and W. M. Myers  
1951 *Nonmetallic Minerals*. Second Edition. McGraw-Hill, New York.
- Levi-Sala, Irene  
1996 *A Study of Microscopic Polish on Flint Implements*. B.A.R. International Series 629.
- Longwell, Chester R., Richard Foster Flint, and John E. Sanders  
1969 *Physical Geology*. John Wiley and Sons, New York.
- Luchsinger, Heidi M.  
2002 *Micromorphological Analysis of the Sediments and Soils from the Gault Site, a Clovis Site in Central Texas*. M.A. Thesis, Department of Anthropology, Texas A&M University.
- Pettijohn, Francis J.  
1975 *Sedimentary Rocks*. 3<sup>rd</sup> Edition. Harper and Row, New York.

- Pettijohn, Francis J., P.E. Potter, and R. Siever  
1973 *Sand and Sandstone*. Springer-Verlag, New York.
- Proctor, C. V., Jr., T. E. Brown, J. H. McGowen, N. B. Waechter, and V. E. Barnes  
1981 *Austin Sheet*. Francis Luther Whitney Memorial Edition, 1974, revised 1981,  
reprinted 1995.
- Schmidt, Jeffrey R.  
1991 Animal and Fish Glues. *Bulletin of Primitive Technology* 1(2):37-40.
- Tankersely, Kenneth B.  
1994 Clovis Mastic and Hafting. *Journal of Archaeological Science* 21:117-124.
- Tarr, W. A.  
1930 *Introductory Economic Geology*. McGraw-Hill, New York.

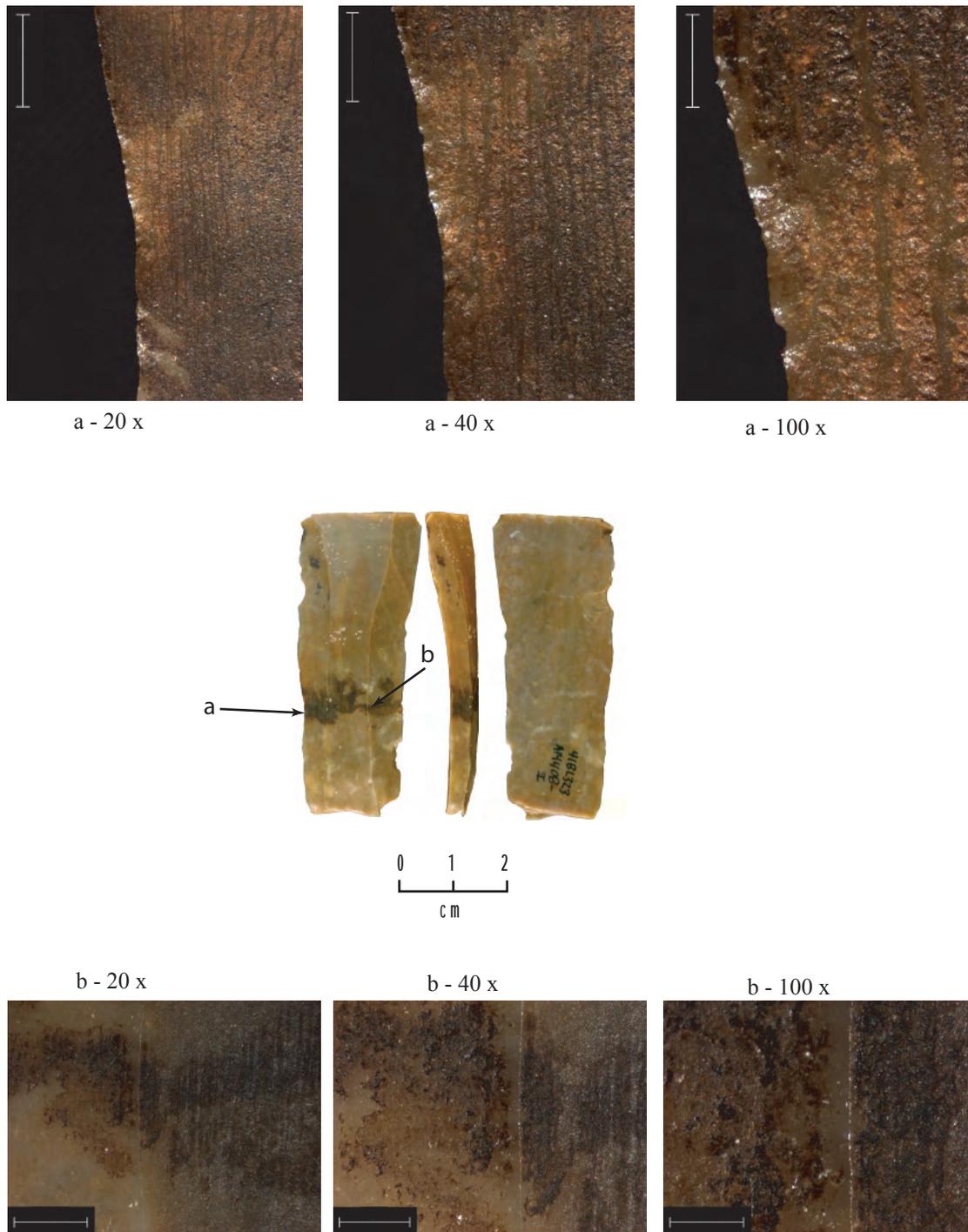


Figure F-1. Clovis 3a Blade AM408 I (Cat #671): (a) grooves parallel to edge in orange and black residue under the stereomicroscope; (b) grooves away from edge on plateau under the stereomicroscope. Scales: 20x = 1.25 mm; 40x = 0.5 mm; and 100x = 0.25 mm.

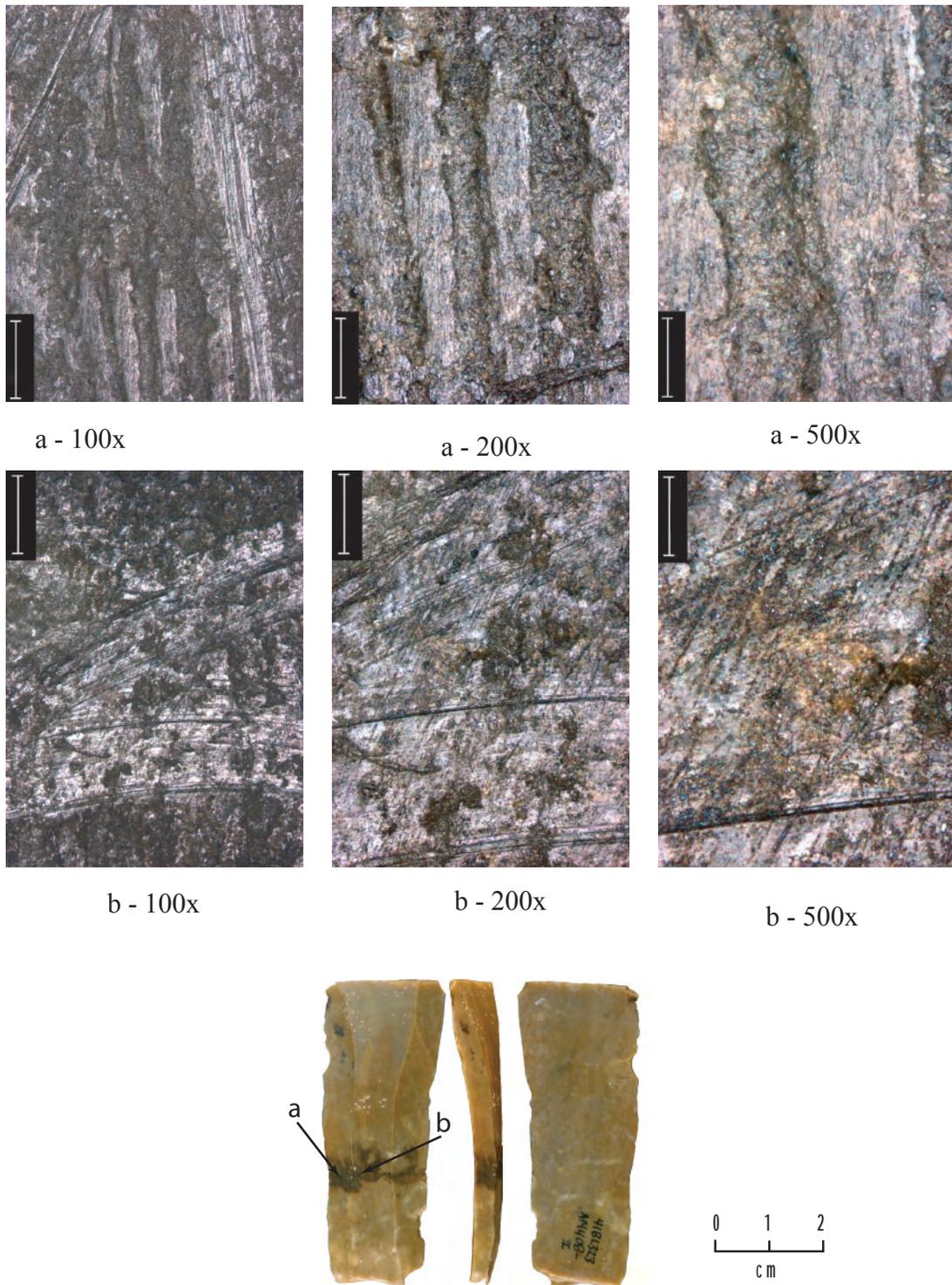


Figure F-2. Clovis 3a Blade AM408i (Cat #671): (a) location of deep u-shaped grooves in Fe-Mg-Ca; (b) location of u-shaped arc grooves on faceted plateau in Fe-Mg-Ca. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

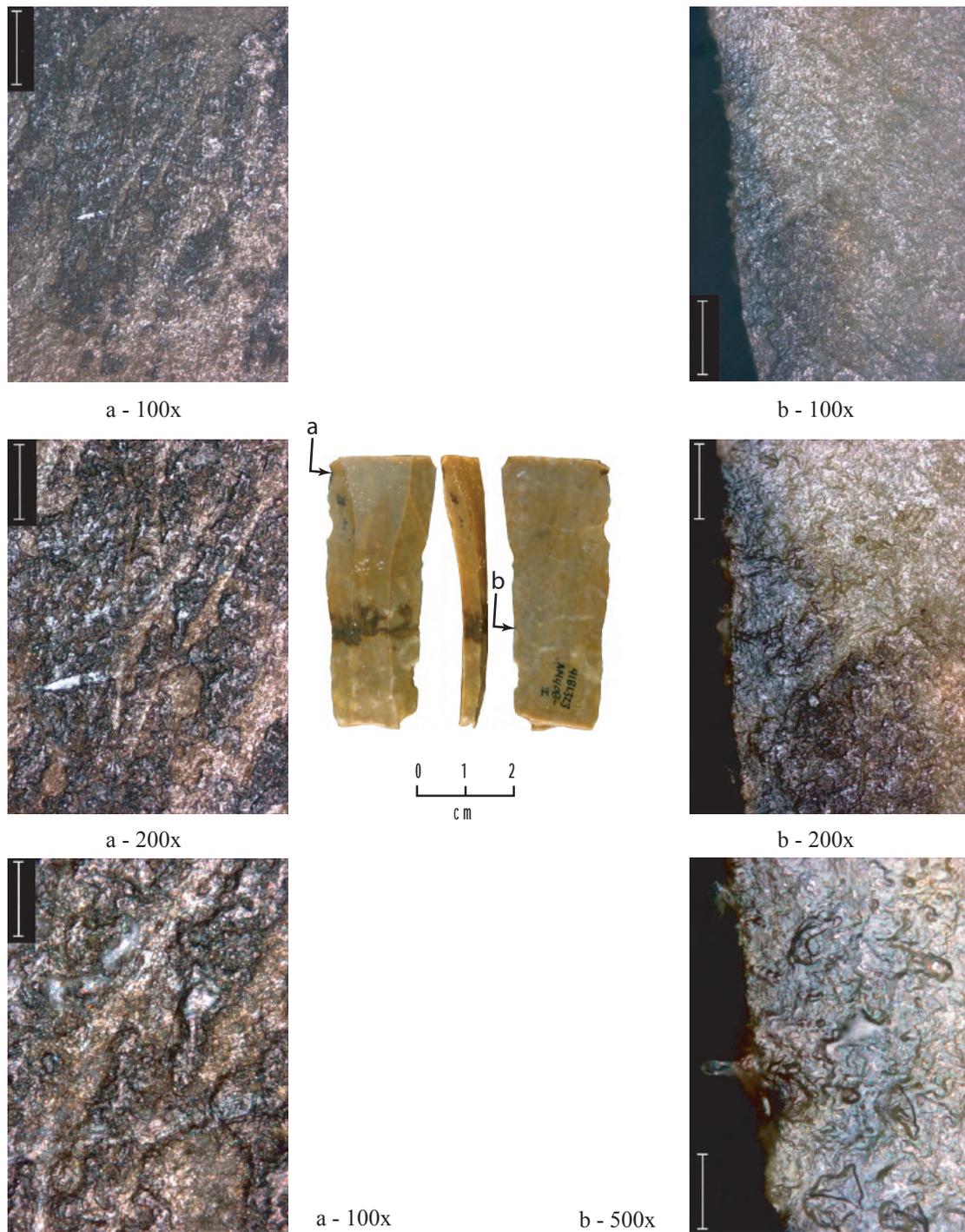


Figure F-3. Clovis 3a Blade AM408 I (Cat #671): (a) grooves oblique to edge in upper edge under the compound microscope; (b) dark substance by edge on ventral face under the compound microscope. Scales: 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

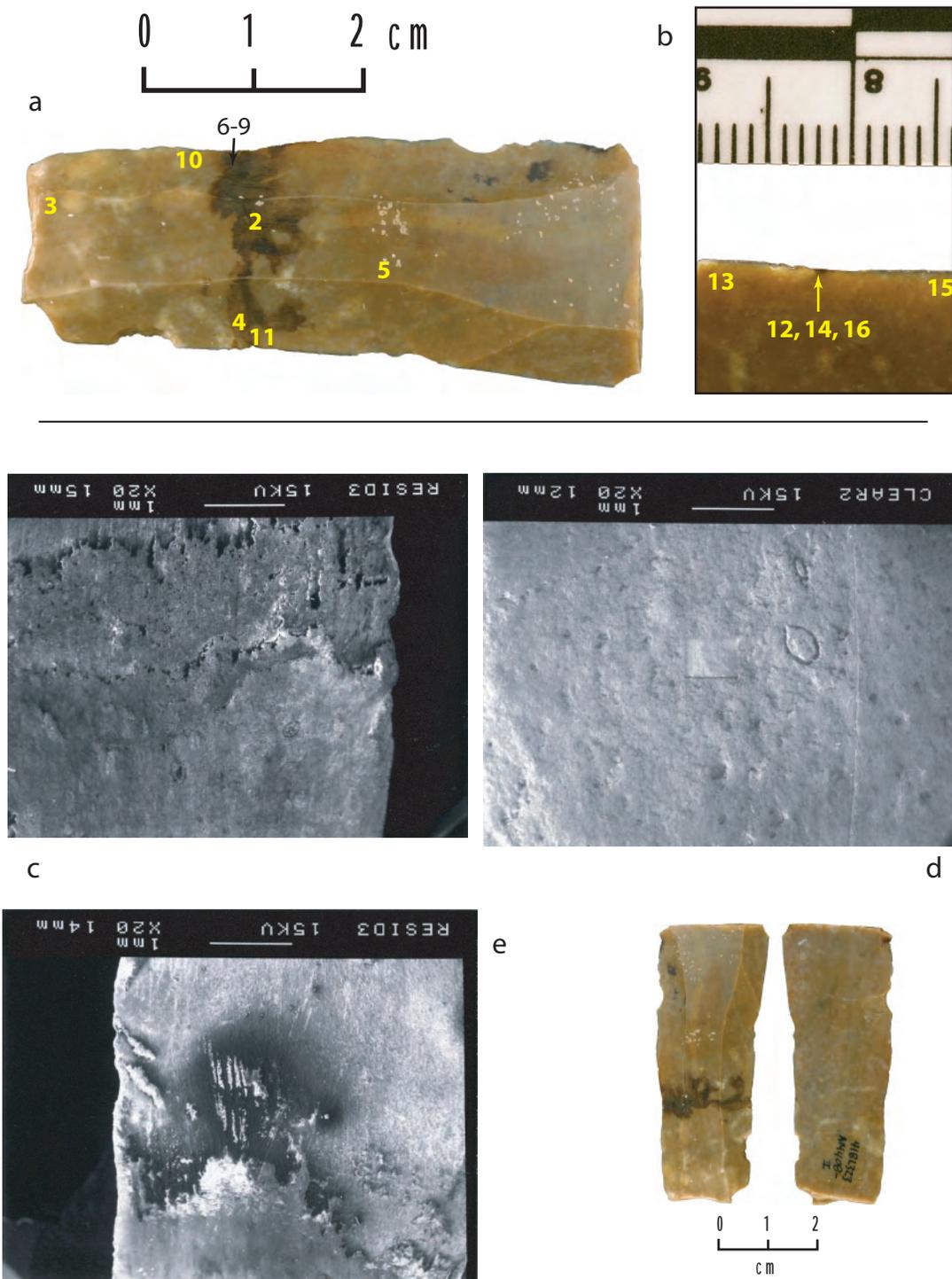
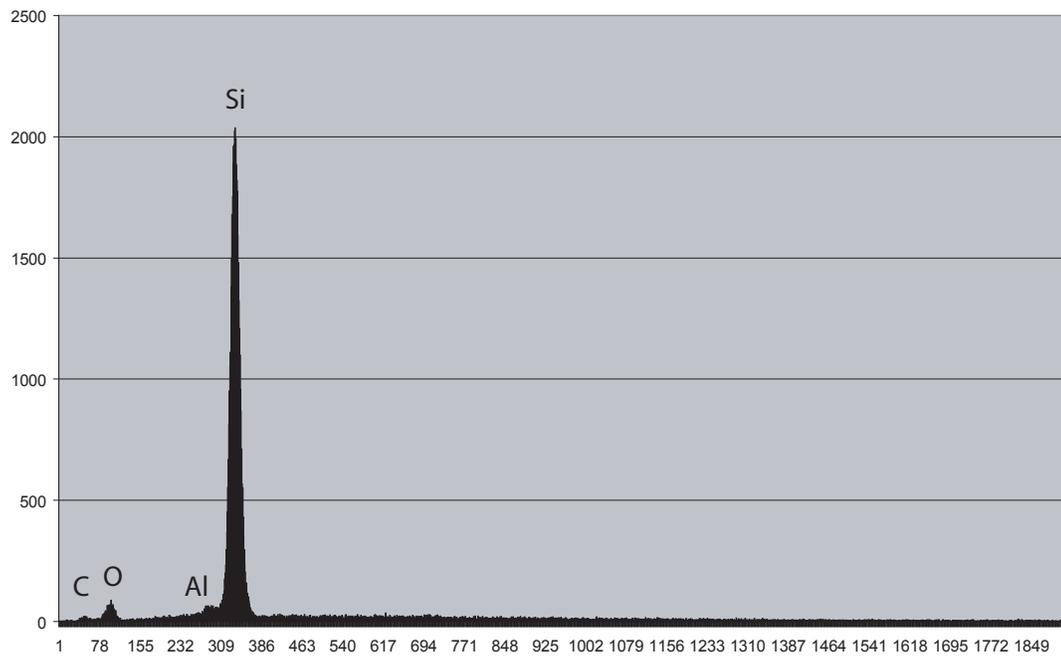


Figure F-4. Clovis 3a Blade AM408 I (Cat #671): (a-b) locations of EDS readings; (c) SEM image at 20x for locations 4 and 11; (d) SEM image at 20 for image location 5; (e) SEM location for images 6-9.

(a) Location 3



(b) Location 5

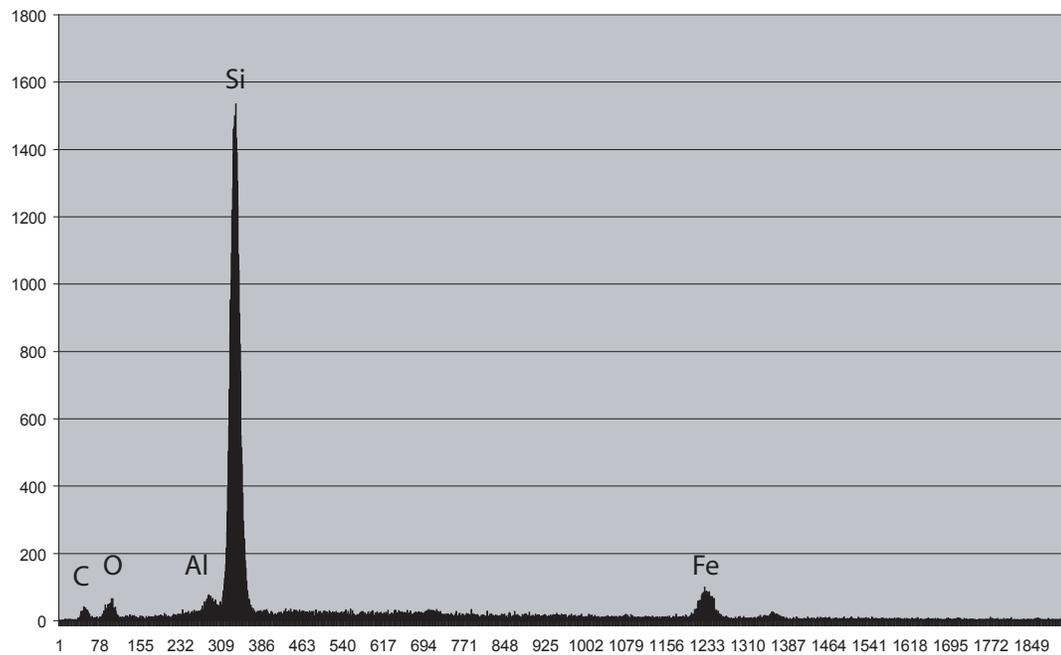
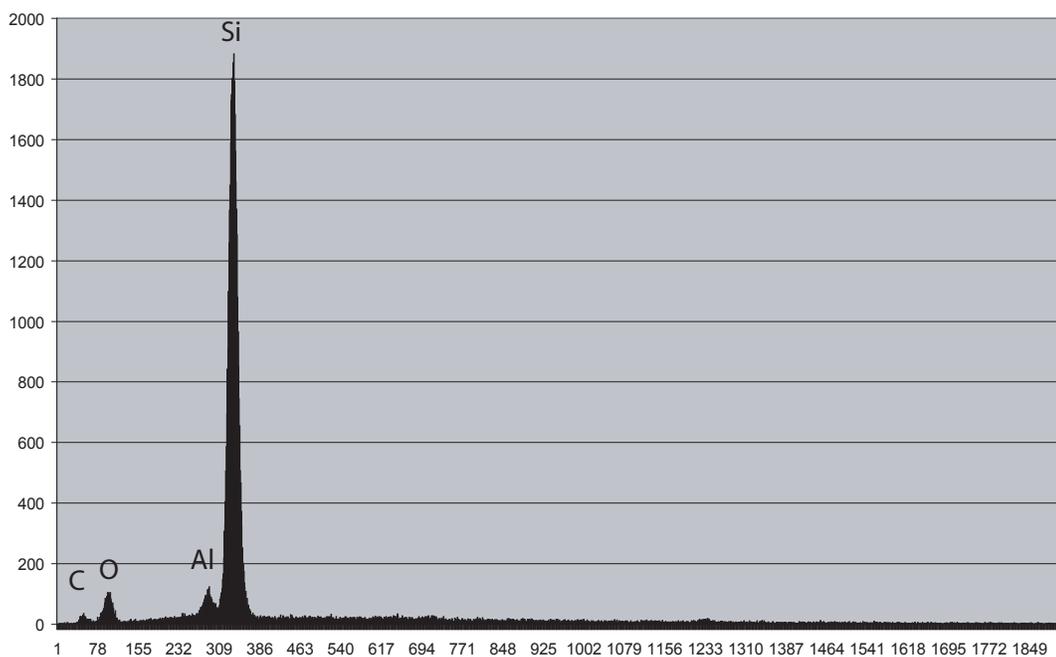


Figure F-5a-d. Clovis 3a Blade AM408 I (Cat #671): (a) EDS reading of location of 3; (b) EDS reading of location 5.

(c) Location 9



(d) Location 13

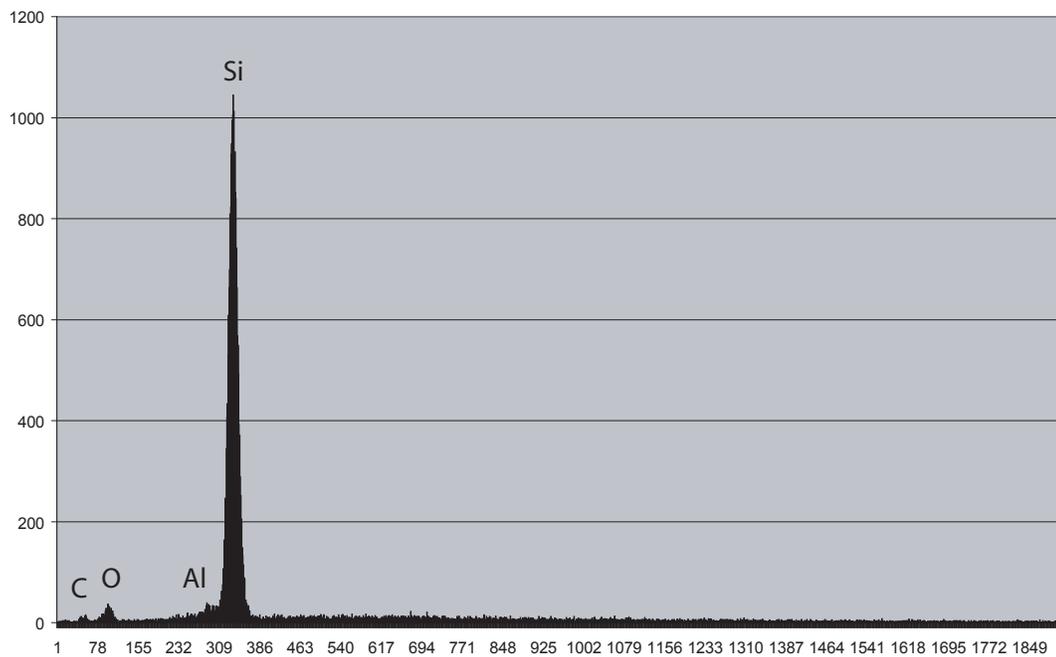
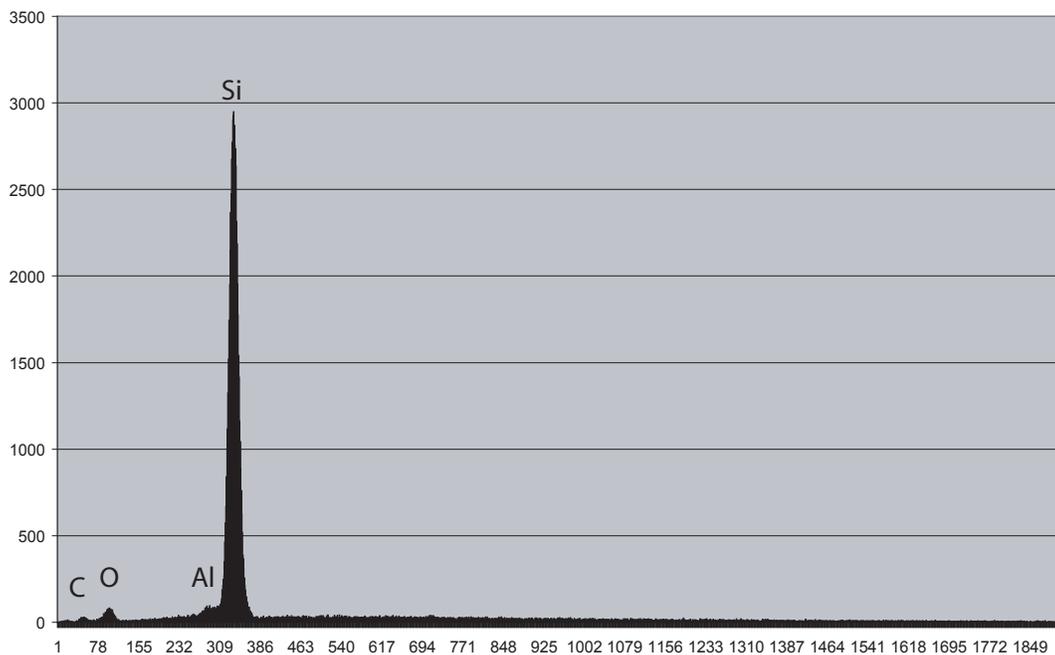


Figure F-5c&d. Clovis 3a Blade AM408 I (Cat #671): (c) EDS reading of location 9; (e) EDS reading of location 13.

(e) Location 13, 2nd reading



(f) Location 15

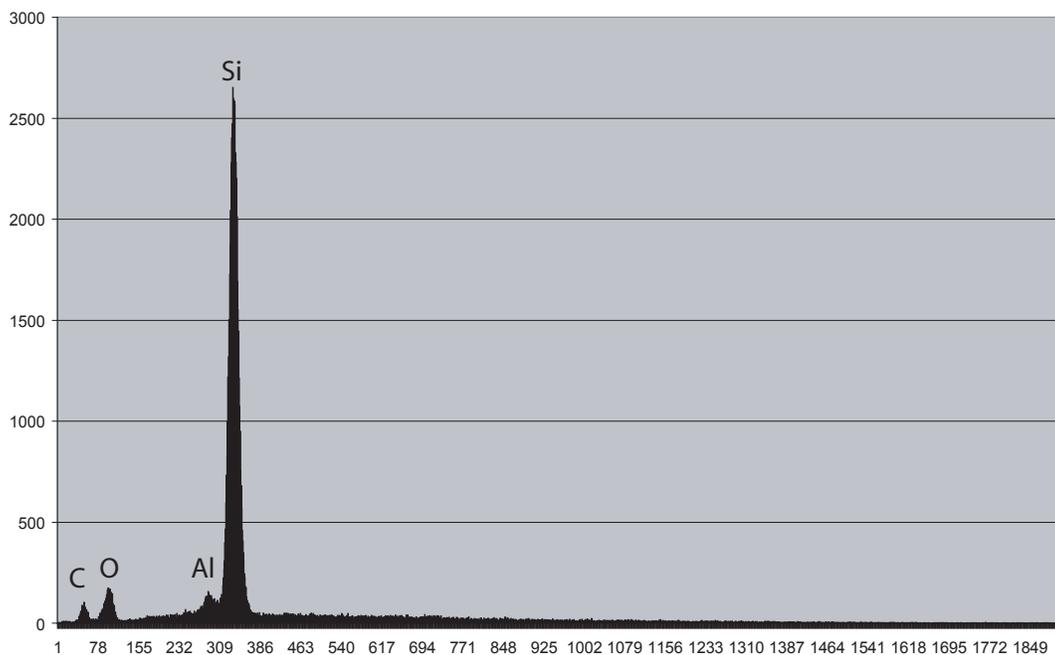
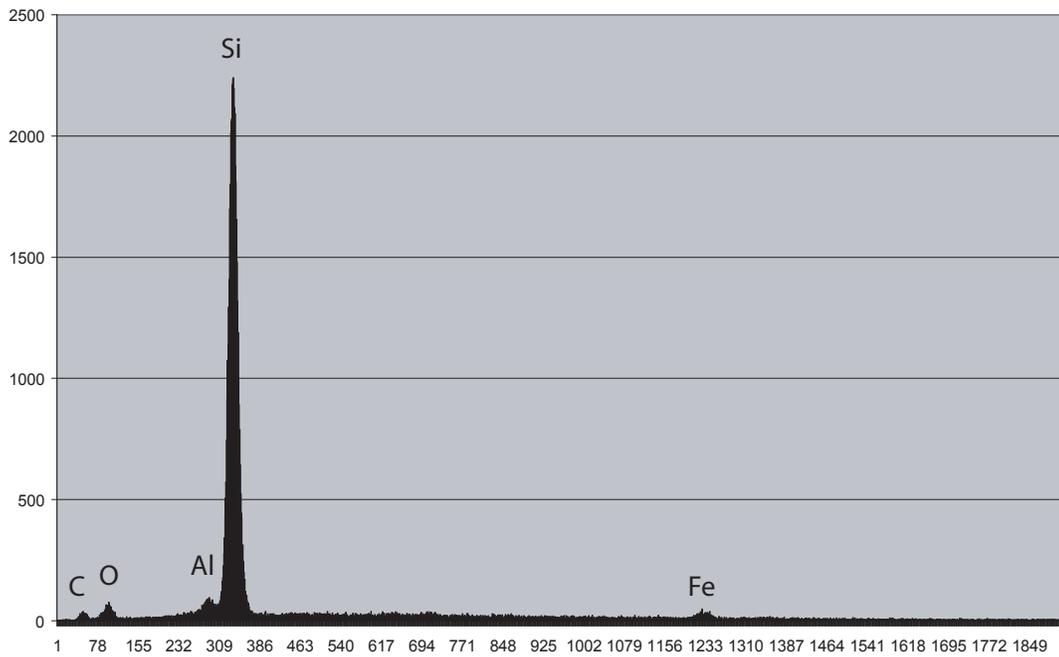


Figure F-5e-f. Clovis 3a Blade AM408 I (Cat #671): (a) EDS reading of location of 13, second reading; (b) EDS reading of location 15.

(g) Location 2



(h) Location 4

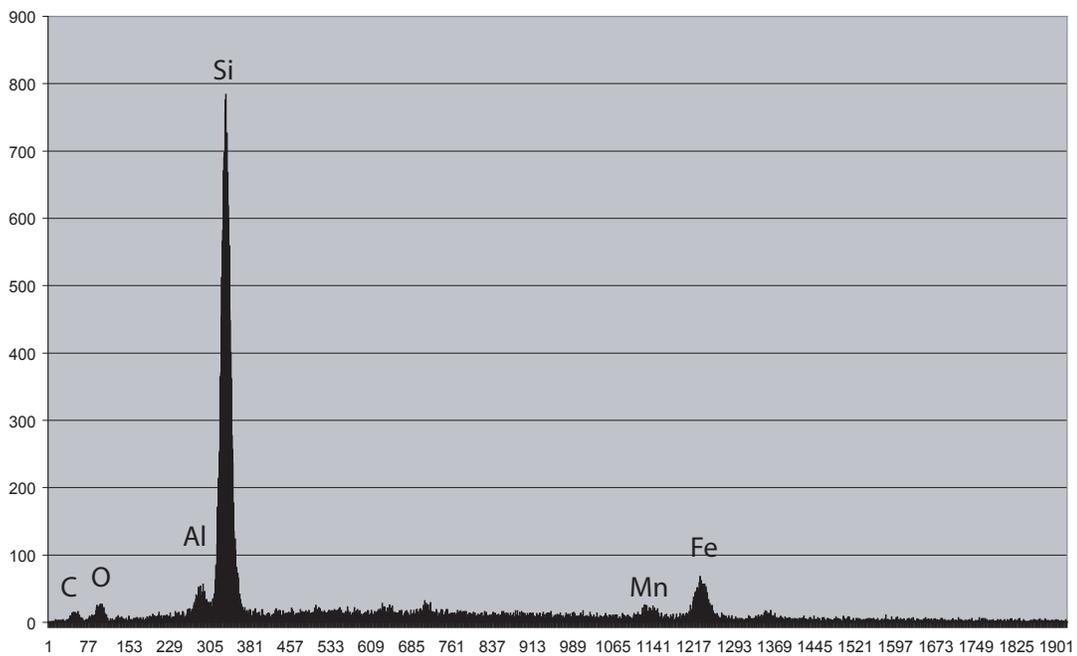
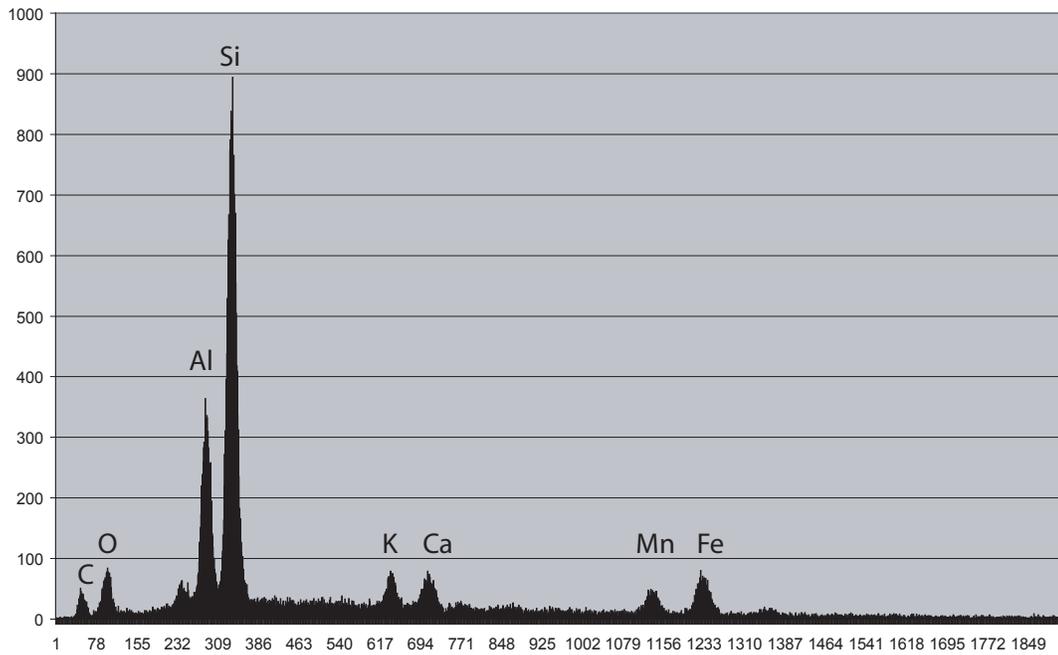


Figure F-5g-h. Clovis 3a Blade AM408 I (Cat #671): (g) EDS reading of location of 2, second reading; (h) EDS reading of location 4.

(i) Location 6



(j) Location 7

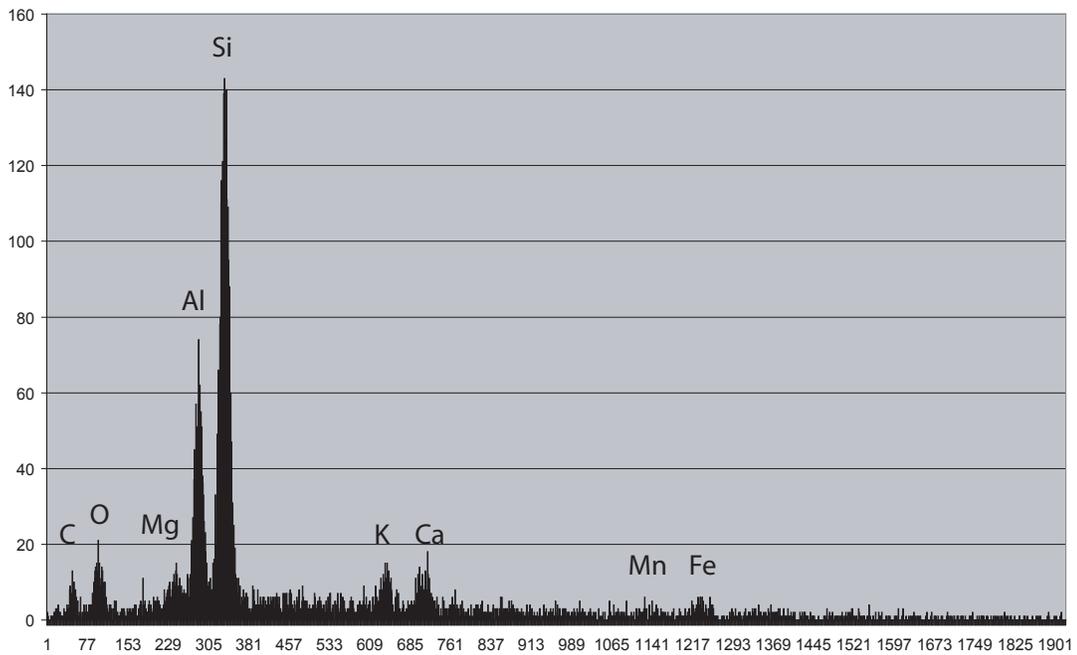
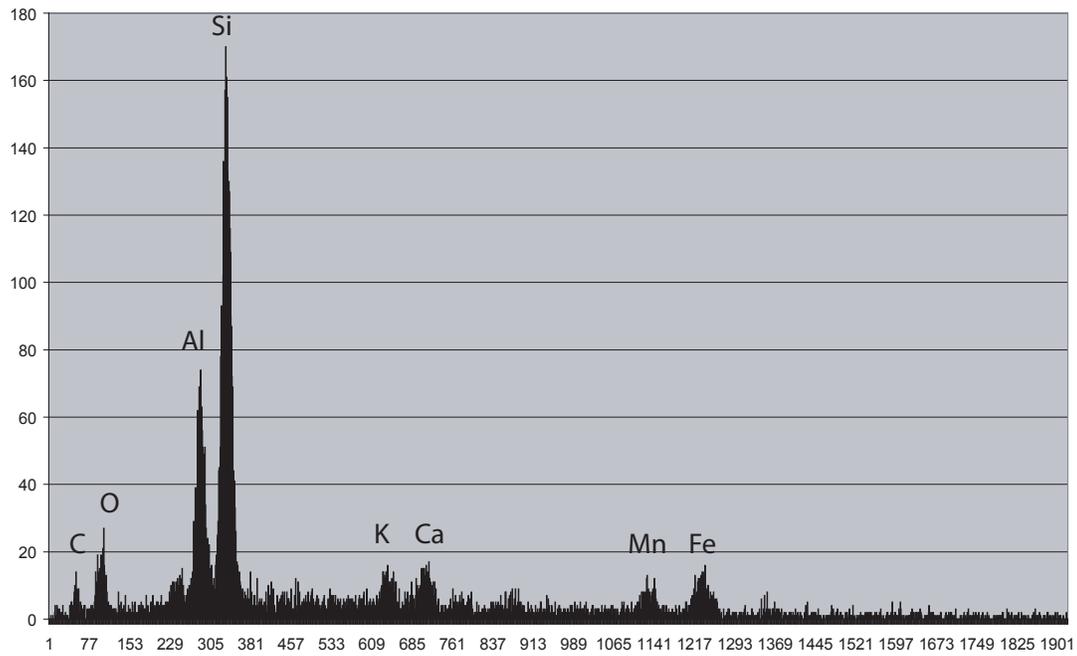


Figure F-5i-j. Clovis 3a Blade AM408 I (Cat #671): (i) EDS reading of location of 6; (j) EDS reading of location 7. .

(k) Location 9



(l) Location 11

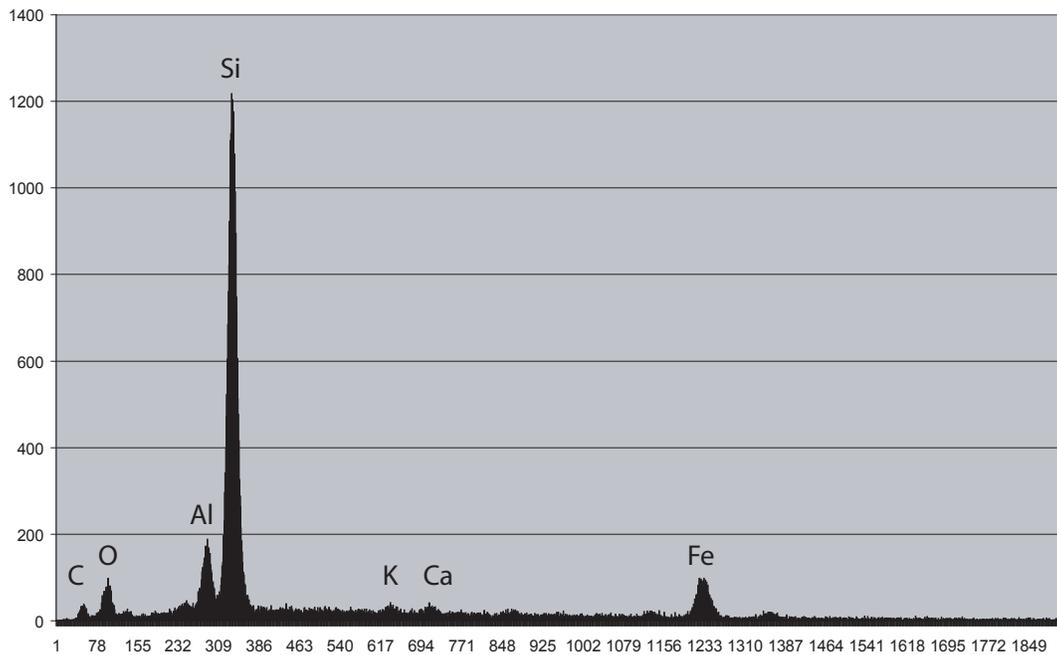
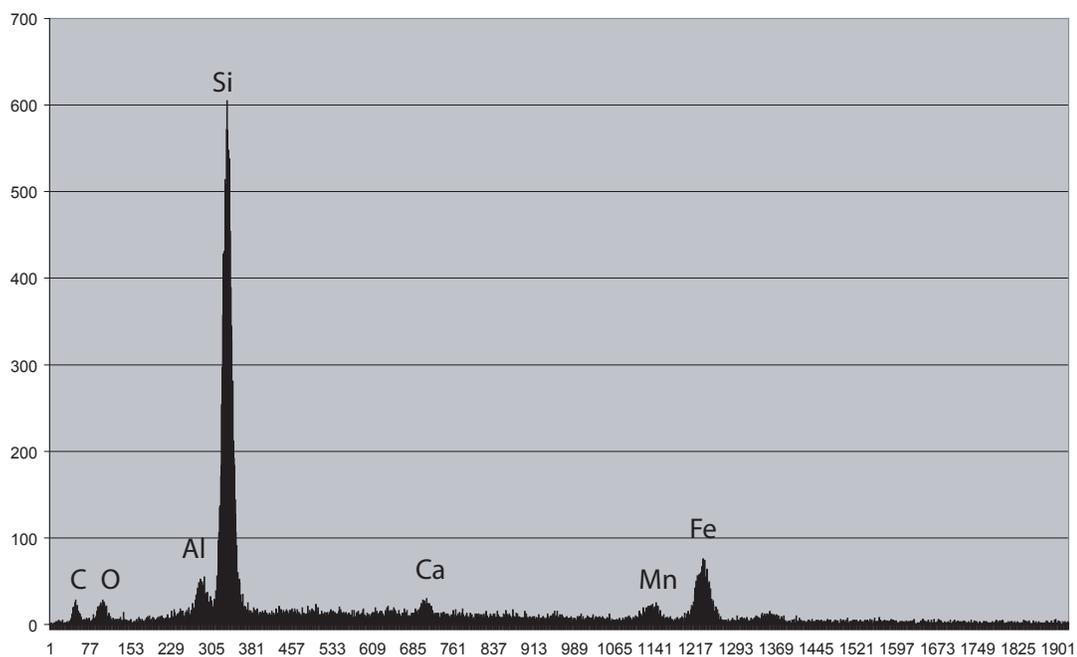


Figure F-5k-l. Clovis 3a Blade AM408 I (Cat #671): (k) EDS reading of location of 9; (l) EDS reading of location 11.

(m) Location 10



(n) Location 12

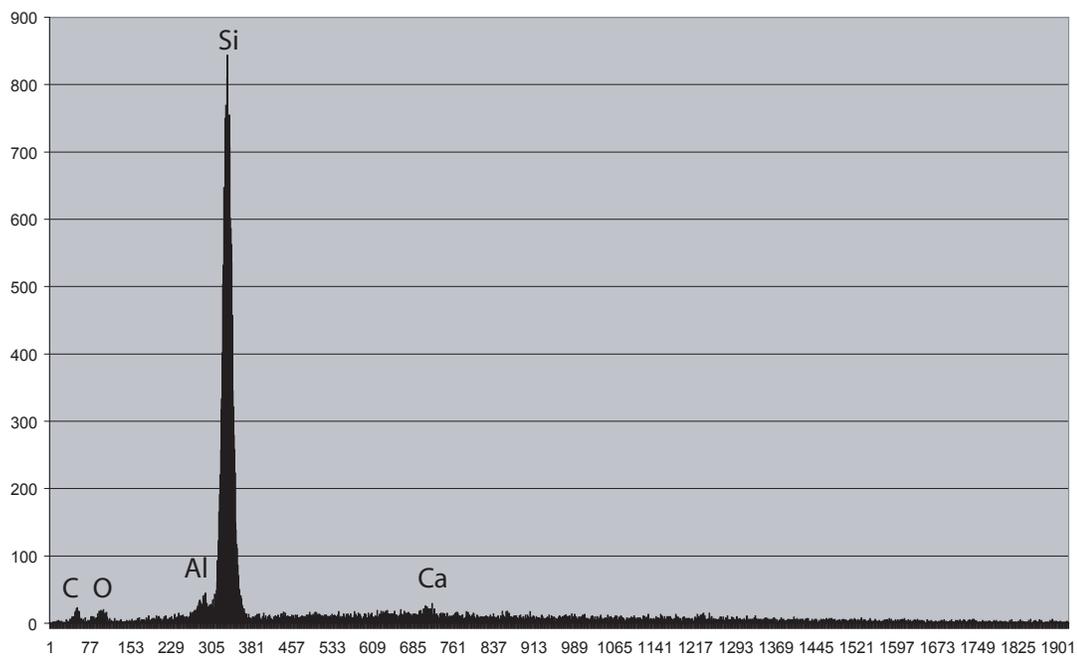
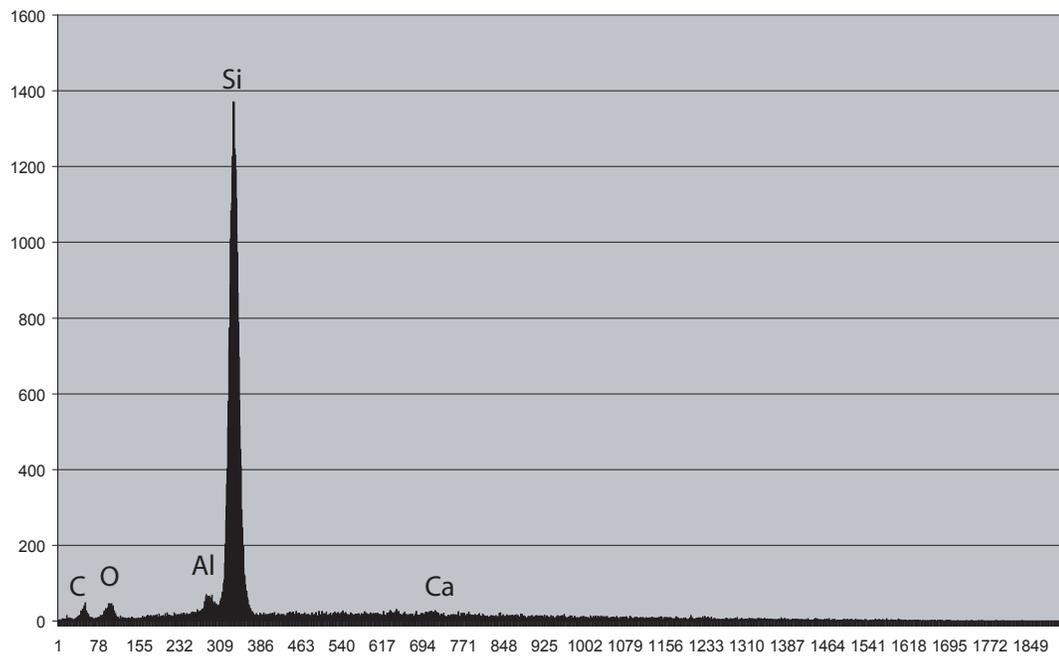


Figure F-5m-n. Clovis 3a Blade AM408 I (Cat #671): (m) EDS reading of location of 10; (n) EDS reading of location 12.

(o) Location 14



(p) Location 16

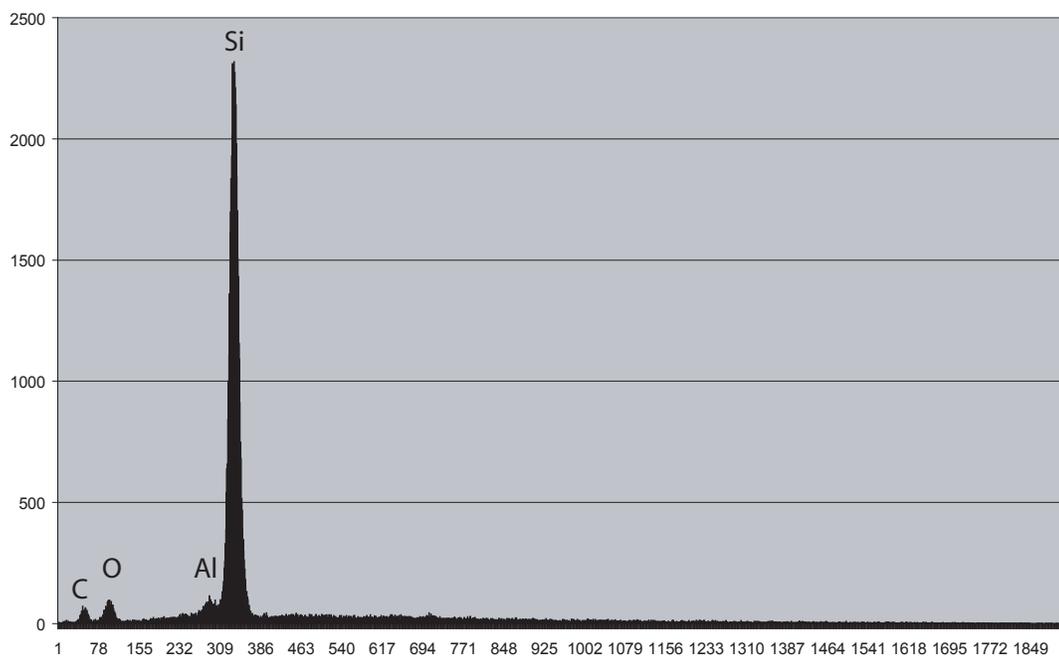


Figure F-5o-p. Clovis 3a Blade AM408 I (Cat #671): (o) EDS reading of location of 14; (p) EDS reading of location 16.

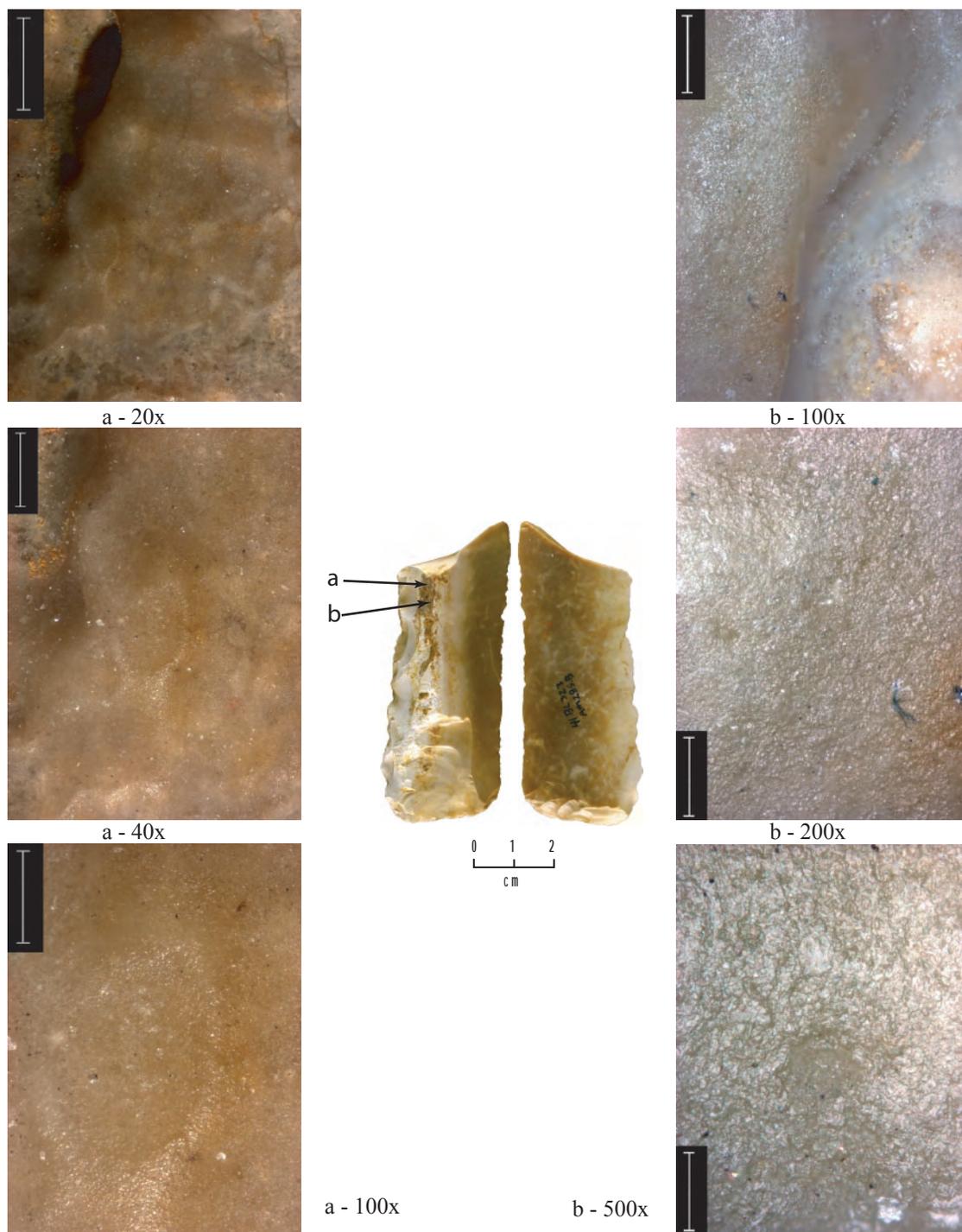


Figure F-6. Clovis 3a Blade AM285B (Cat #265): (a) homogenous appearing substance under the stereomicroscope; (b) homogenous appearing substance under the compound microscope. Scales: 20x = 1.25 mm; 40x = 0.5 mm; 100x (Stereomicroscope) = 0.5 mm; 100x = 200  $\mu$ m; 200x = 100  $\mu$ m; and 500x = 50  $\mu$ m.

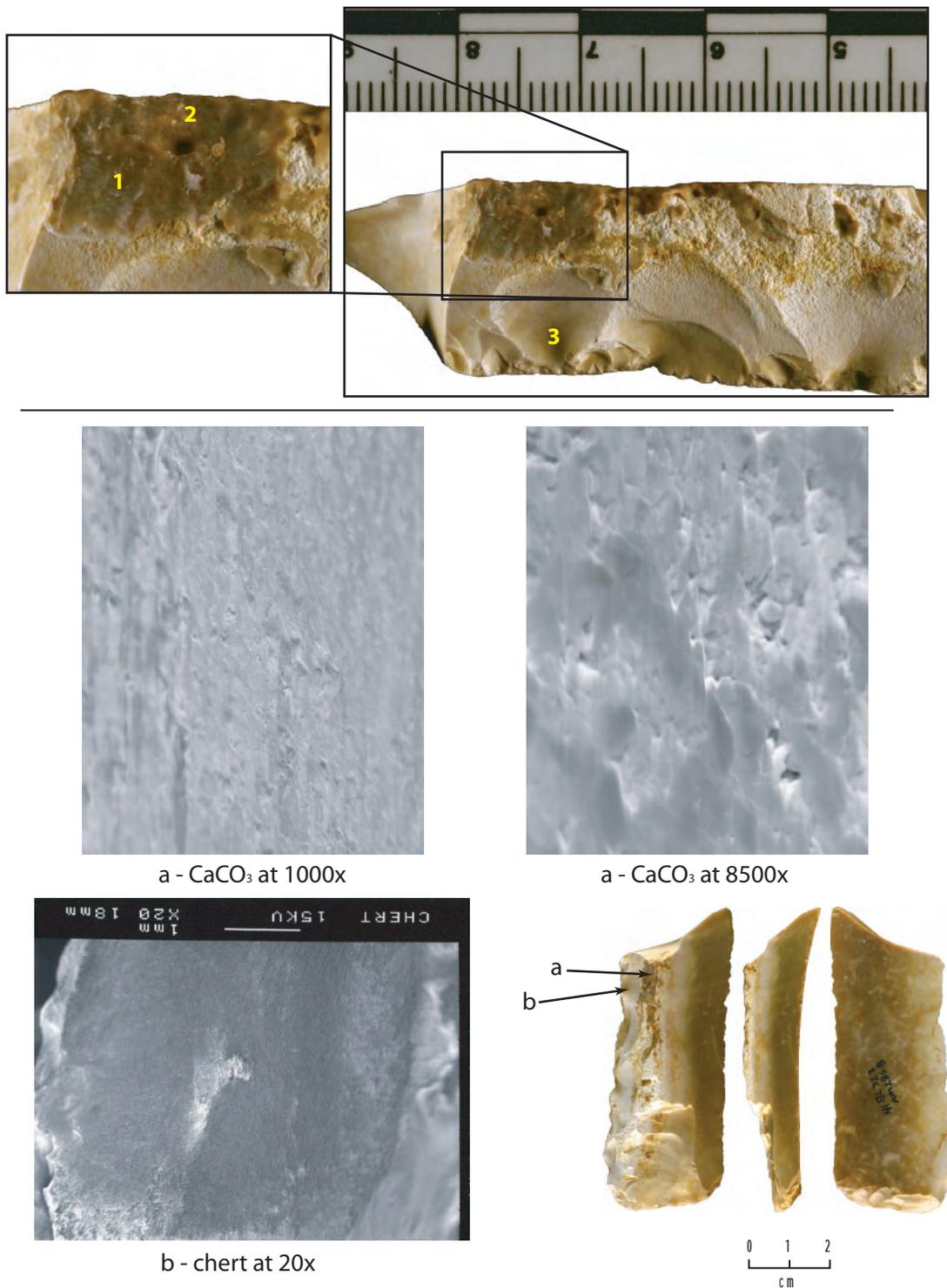
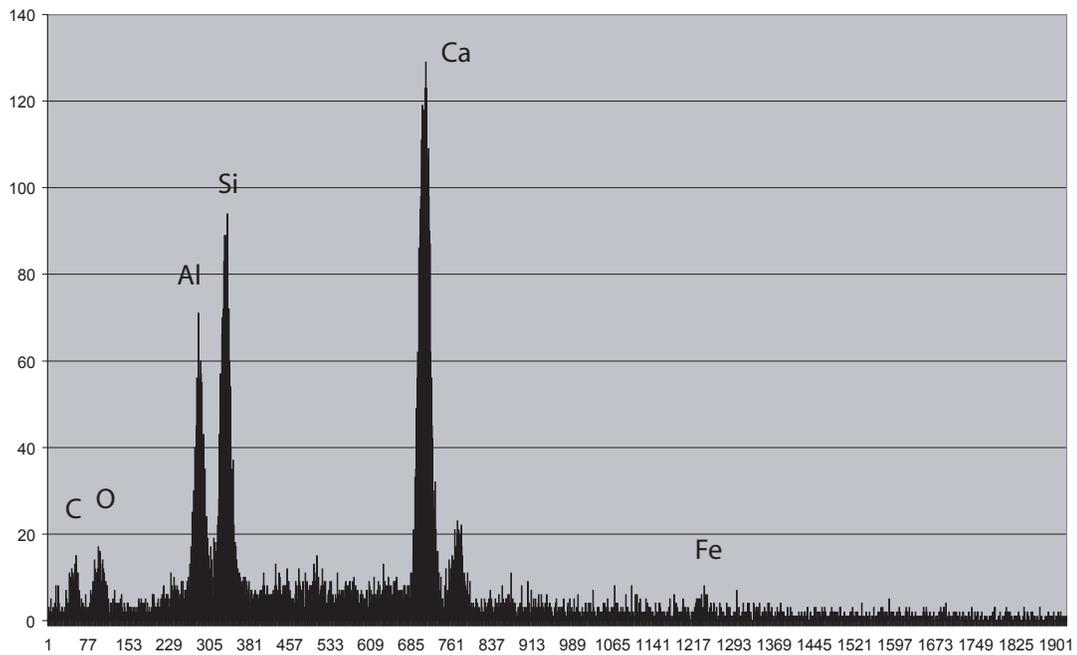


Figure F-7. Clovis 3a Blade AM285B (Cat #265): locations of the SEM/EDS analyses and SEM images (a) SEM images calcium carbonate at 1000x and 8500x; (b) SEM image of chert at 20x.

(a) Location 1



(b) Location 2

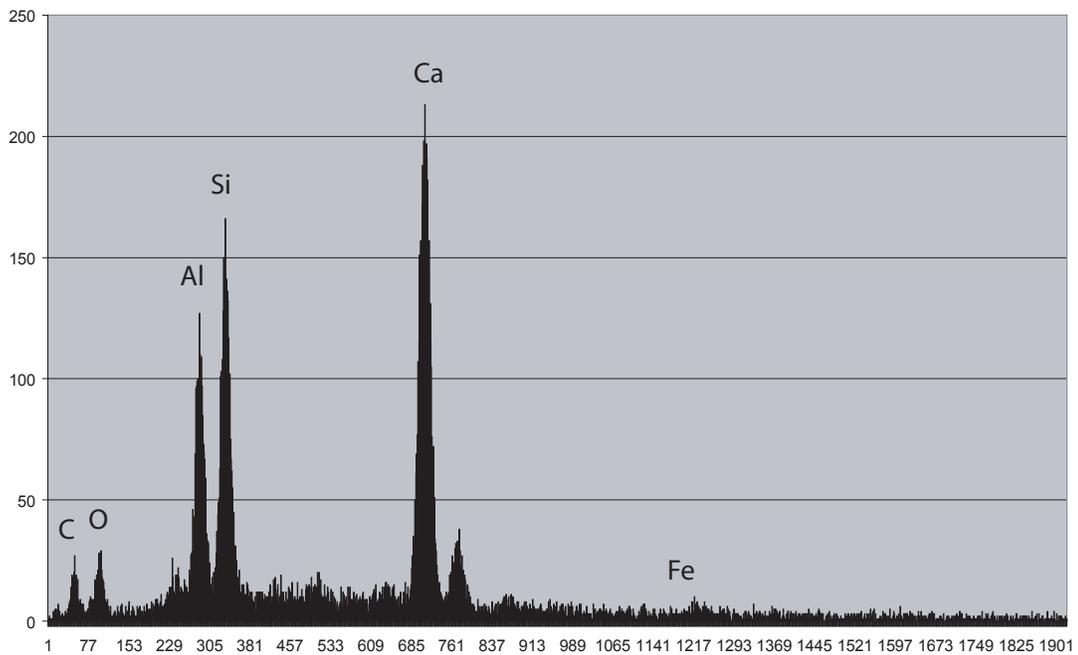
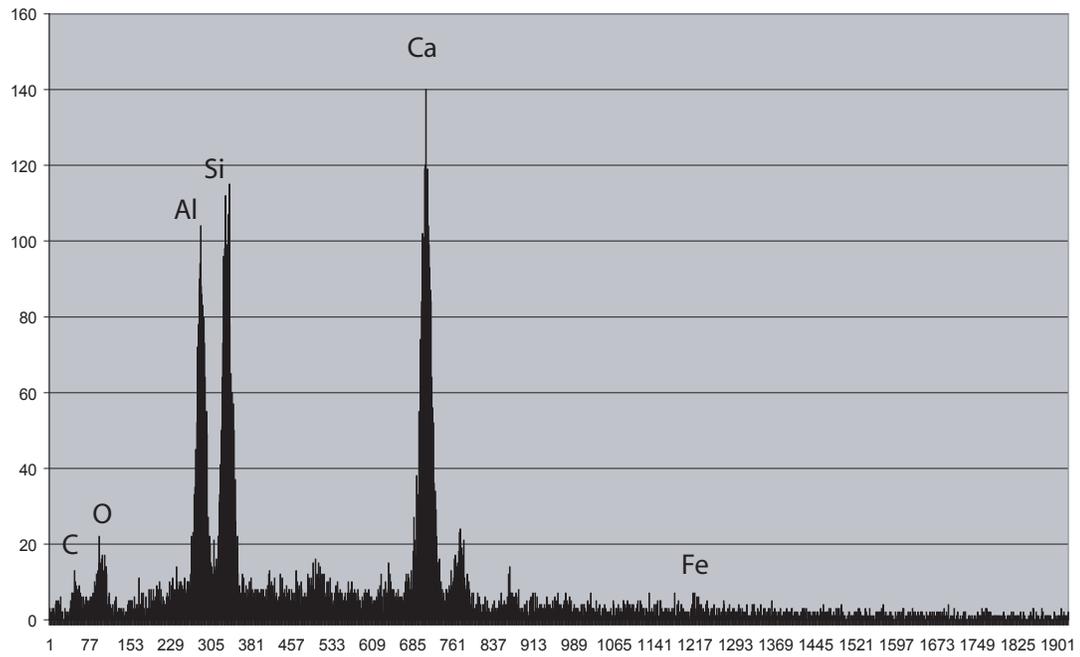


Figure F-8a-b. Clovis 3a Blade AM285B (Cat #265): (a) EDS reading of location of 1; (b) EDS reading of location 2.

(c) Location N/A



(d) Location 3

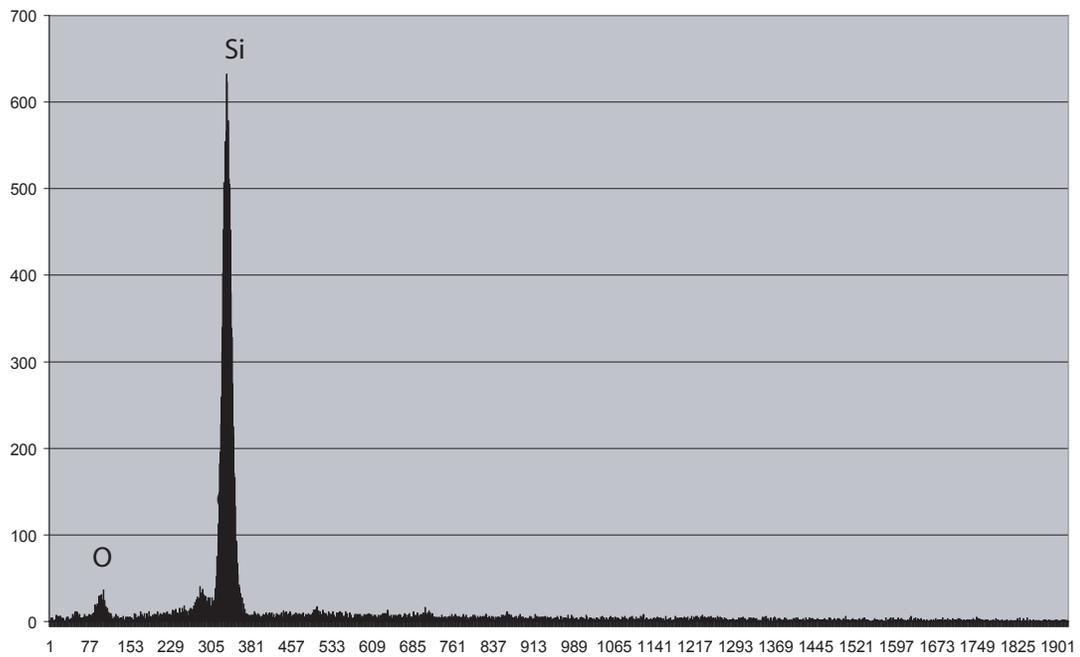


Figure F-8a-d. Clovis 3a Blade AM285B (Cat #265): (c) EDS reading of location N/A; (d) EDS reading of location 3.

**VITA**

Name: Scott Alan Minchak

Address: LaPorta and Associates, L.L.C., 5 First Street, #73, Warwick,  
New York, 10990 USA

E-mail address: [sminchak@laportageol.com](mailto:sminchak@laportageol.com)

Education: B.A., Anthropology, Drew University, 1999  
M.A., Anthropology, Texas A&M University, 2007