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Introduction

Since its excavation some 65 years ago, the Rio Rancho Folsom Site has remained poorly known and understudied among the wider pool of Paleoindian archaeologists (Huckell and Kilby 2002; Ruth 2013). This does not diminish the fact that the site's four loci (particularly 4147, AS-2, and 4148) contain large amounts of archaeological material that could easily expand our knowledge of Folsom (Huckell and Kilby 2002; Ruth 2013). With data gathered from the site's Folsom materials, this paper attempts to better characterize Folsom technological organization and material use in relation to mobility. Four previously proposed Folsom technological organization models provide a variety of explanations for the variability among Folsom assemblages, however, no single model appears to be comprehensive (Amick 1994, 1999; Hofman 1992; Ingbar 1994; Sellet 2013). The question becomes, which of these proposed models, if any, adequately describes the assemblage?

This study focuses on the Folsom flaked stone material from the Rio Rancho site held by the Maxwell Museum. In particular, the study only includes material from two of the site's four loci, 4147 and AS-2, as these loci are composed of exclusively Folsom material with no diagnostic types related to any other culture or period (Ruth 2013). This opens the site to more targeted analyses than previously, as the non-diagnostic material (i.e. debitage) can be used in the assessment of the loci in terms of Folsom alone. By using debitage, tool, and biface data from the loci along with various proposed Folsom technological models and statistical analyses, it is possible to build a better picture of Folsom mobility and technological organization through the characterization of Locus 4147/AS-2.

Background

Folsom

The Folsom people and their lifeways have fascinated archaeologists and the public alike since the discovery and excavation of the Folsom type site between 1926 and 1928, which provided the first definitive evidence of human presence in North America during the Pleistocene (Meltzer 2006a). The Folsom Paleoindian period lies roughly between 10,900 and 10,200 radiocarbon years before present (B.P.) (Meltzer 2006a). The type site along with many subsequent sites have demonstrated that the Folsom people were highly mobile, predominantly large game hunters that had once spanned much of the central portion of the North American continent (Amick 1994; Andrews et al. 2021a; Hofman 1992; LeTourneau 2000; Meltzer 2006a; Pitblado 2017; Ruth 2013). Folsom is also often considered to be one of the most mobile Paleoindian groups, as they routinely exploited the North American bison population that appears to have made up a substantial part of their diet (Andrews et al. 2021b; Hofman 1992; Sellet 2013). It is then no surprise that the Folsom people would have to adopt a type of technological organization that would facilitate a sustainable supply of toolstone even in the absence of a high-quality source for relatively long periods (Amick 1994; Hofman 1992; Huckell and Kilby 2002; Sellet 2013). Several proposed models, discussed below, work to answer this question of Folsom technological organization (Amick 1994; Hofman 1992; Ingbar 1992, 1994; Sellet 2013).

Though Folsom groups are considered highly mobile, it is also important to note that there is a fair amount of variation within and among Folsom sites (Andrews et al. 2021b; Hofman 1992; Sellet 2013). A group in the Rockies and a group on the open plains will inevitably cover different amounts of ground simply due to the variation in terrain and relative resource abundance (Andrews et al. 2021b; Ingbar 1992; Meltzer 2006b). This also plays into the apparent variability in Folsom site lithic assemblages (Amick 1994; Andrews 2021; Huckell and Kilby 2002; Ingbar 1994; Sellet 2013). The distance covered by a particular group can greatly affect the types of materials available to them (Ingbar 1992). Variations in the use of materials from different source areas and qualities can affect what types of tools are being made (Amick 1999; Hofman 1992). Folsom technological organization models attempt to explain how these various factors may affect the observed frequencies of different lithic artifact forms and materials in an assemblage.

Technological Organization Models

In order to better understand Locus 4147/AS-2, the flaked stone data is tested in relation to previously proposed models for Folsom technological organization. These models, most of which were proposed in the 1990s, attempted to produce an explanation for how the Folsom people maintained their material stocks and toolkits while on the move (Amick 1999; Hofman 1992; Huckell and Kilby 2002; Ingbar 1994). Many of these models (and archaeological models for the Paleolithic more generally) were presented as static representations of the organization of the whole Folsom culture at any given time. The sentiment at the time was usually that there should be a relatively easily identifiable common technological organization that could be applied to Folsom generally (Amick 1999; Ingbar 1994; Sellet 2013). More recently, the idea of the static model has been questioned (Sellet 2013). The highly mobile Folsom subsistence model would indeed require long-term planning in relation to mobility and technological organization, but it is unclear whether one model or another describes Folsom technological organization in all situations or environments. The four models addressed in this study were those proposed by Eric Ingbar (1992, 1994), Jack Hofman (1992), Daniel Amick (1999), and Frederic Sellet (2013). In this study, I test these different models against archaeological data. However, we must first understand each of the four models in context.

The first model is what has been referred to as the “segmented reduction” model (Huckell and Kilby 2002). Eric Ingbar (1992, 1994) challenged what appeared to be an oversimplification of the relationship between the proportions of raw materials and group mobility using data from the Hanson site in Wyoming. The presence of channel flakes and evidence of fluted point manufacture at Hanson suggested to Ingbar that Folsom groups organized their technology around the long-term utility of cores and bifaces rather than maintaining a supply of fluted points when away from lithic raw material sources (Ingbar 1992). He also noted that the Hanson site contained entire sequences of biface manufacture, but that these “sequences are not present in local materials. Rather, they are segmented in terms of raw material.” (1991: 186). Ingbar went on to further develop this “segmented reduction” model using a simple and elegant computer simulation that shows how sequential flexibility with serial or irregular movement between hypothetical raw material sources would result in only the last few visited sources being reflected in the active toolkit (1994). In this “segmented reduction” model, materials from the farthest sources would be represented as the most reduced forms (i.e. broken or resharpened fluted projectile points and complete, used tools like endscrapers and gravers) while local, most recently acquired materials would be represented in the least reduced forms like point preforms, blanks, and cores. In other words, flaked stone artifacts at Folsom sites should follow stages of reduction in proportion to how recently the raw materials were acquired.

Contrary to Ingbar, the second model, sometimes referred to as the "core size" model, posited by Jack Hofman (1992) suggests that Folsom organizational strategy focused on producing and maintaining a ready supply of complete weapons in order to capitalize on prey animals upon encounter at any moment (Huckell and Kilby 2002). In the model, Hofman hypothesizes that Folsom and Midland projectile points represent different ways of producing projectile points from cores of different sizes and stages of reduction (1992). Hofman posits that Folsom preforms would be produced from large biface flake blanks or reduced biface cores that are thinned by fluting (1992). I suggest that this process would also hold for the larger formal tools like endscrapers. The process would be followed so long as there is material of adequate size for the purpose. He also suggested that unfluted points could also be produced from thinner flake blanks as cores were reduced and became capable of yielding only smaller flakes. We can surmise that this reduction would also produce smaller tools like used flakes. Although Locus 4147/AS-2 did not produce any unfluted points, the expectations of the model can still be represented in the present fluted points, channel flakes, and other tools. If this model holds, we should expect to see a greater number of biface preforms, fluted points, channel flakes, and other tools among recently acquired materials, and a reduced number of channel flakes and other tools while points and unfluted preforms remain more abundant in less recently acquired material.

Rather than focusing mostly on projectile points, the model put forward by Daniel Amick, referred to as the "toolkit" model, addresses Folsom technological organization as it relates to the functions of two different types of tools: weapons and processing/maintenance tools (Amick 1999; Huckell and Kilby 2002). Amick argues that there is a difference between the materials used to produce these separate toolkits. He suggests that individuals who primarily used weaponry tools (often proposed to be male) would have had greater access to nonlocal raw materials while users of maintenance tools (often proposed to be female) had limited access to more distantly sourced materials thereby relying on local materials more often for their toolkits (Amick 1999; Huckell and Kilby 2002). With this in mind, material use in the manufacture of these two toolkits is related to the frequency of weapon manufacture and the availability of local raw materials at a site. In this "toolkit" model nonlocal material would have been reserved for projectile points while local material, when available, would be more common in the manufacture of maintenance tools like scrapers (Amick 1999). Amick (1994, 1999) had previously interpreted the Rio Rancho site as having minimal weaponry production, but in light of the evidence presented here and other previous investigations, it is clear that projectile point manufacture was a primary activity at the site (Huckell and Kilby 2002; Ruth 2013). However, the expectations of the model remain the same whether point manufacture is a prominent activity or not.

In contrast to the others, Frederic Sellet's more recent model, what I refer to as the "gearing up" and "replacement" model, suggests that Folsom technological organization is better explained by variability between two types of tool production (2013). The first of these production types is "gearing-up" in which a Folsom group plans for future mobility and mass produces its entire toolkit in preparation for the future scarcity of materials (Sellet 2013). This gearing up appears to use all available high-quality material, not just local material (Sellet 2013:) The comparatively more common type of production is "replacement" in which a group simply discards and replaces broken points preferentially with higher quality materials (Sellet

2013). He demonstrated this with channel flake data from the Lindenmeier site and spatial data from several other large Folsom sites. Further, he suggests that "gearing up" would have been an important but comparatively less frequent event while replacement would have been more frequent but less intensive. Planning for expected mobility and distance from an adequate raw material source is central. In this model, there are two expected outcomes. For replacement, we expect to see higher than expected numbers of discarded tools and projectile points as well as channel flakes of higher quality, less recently acquired materials and lower numbers of discarded points among lower quality and more recently acquired materials. For gearing up, we expect to see elevated numbers of channel flakes, preforms, and general debitage across all materials.

Evaluating these models at Locus 4147/AS-2 can produce a better picture of the activities at the site itself. Determining if one or more of these models fits the assemblage from the locus can also add to our understanding of Folsom technological organization within the Central Rio Grande Valley as well as organizational variability across Folsom sites in other regions.

The Rio Rancho Folsom Site

The Rio Rancho Site, originally excavated in the mid-1960s, is one of the largest Folsom sites located in the western United States (Ruth 2013) (Fig.1). The site is located approximately 20km northwest of downtown Albuquerque on the Llano de Albuquerque (Huckell and Kilby 2002; Ruth 2013). Today, vegetation at the site is a mixed grassland-scrubland consisting of mostly black grama (*Bouteloua eriopoda*) and three awn (*Aristida spp.*) grasses and tree cholla (*Opuntia imbricata*) and broom snakeweed (*Gutierrezia sarothrae*) shrubs that has developed on an eolian surface (Ruth 2013). Due to the lack of well-preserved and studied data on Pleistocene climate and vegetation in the region, it is hard to say that the vegetation on the landscape would have looked much different from that of the present during the site's occupation (Huckell et al.

2001). The first description of the site by Dawson and Judge described the prehistoric landscape surrounding the site as “dotted with lake basins and cut by several large drainages” (Dawson and Judge 1969: 156). The site sits at an elevation of 1,814 m and is situated on the crown and southern slope a 300-m long, east-west trending ridge that is surrounded by a landscape characterized by ridges and valleys (Huckell and Kilby 2002; Ruth 2013). The site is approximately 5 km east of the eastern escarpment Boarding the Rio Puerco Valley, which contains a relatively wide variety of toolstone. The head of another drainage lies north of the site. Dawson and Judge (1969) suggested that the site lay at the edge of a large Pleistocene playa lake; however, a more recent investigation revealed that the basin feature is erosional in origin rather than lacustrine (Huckell et al. 2001).

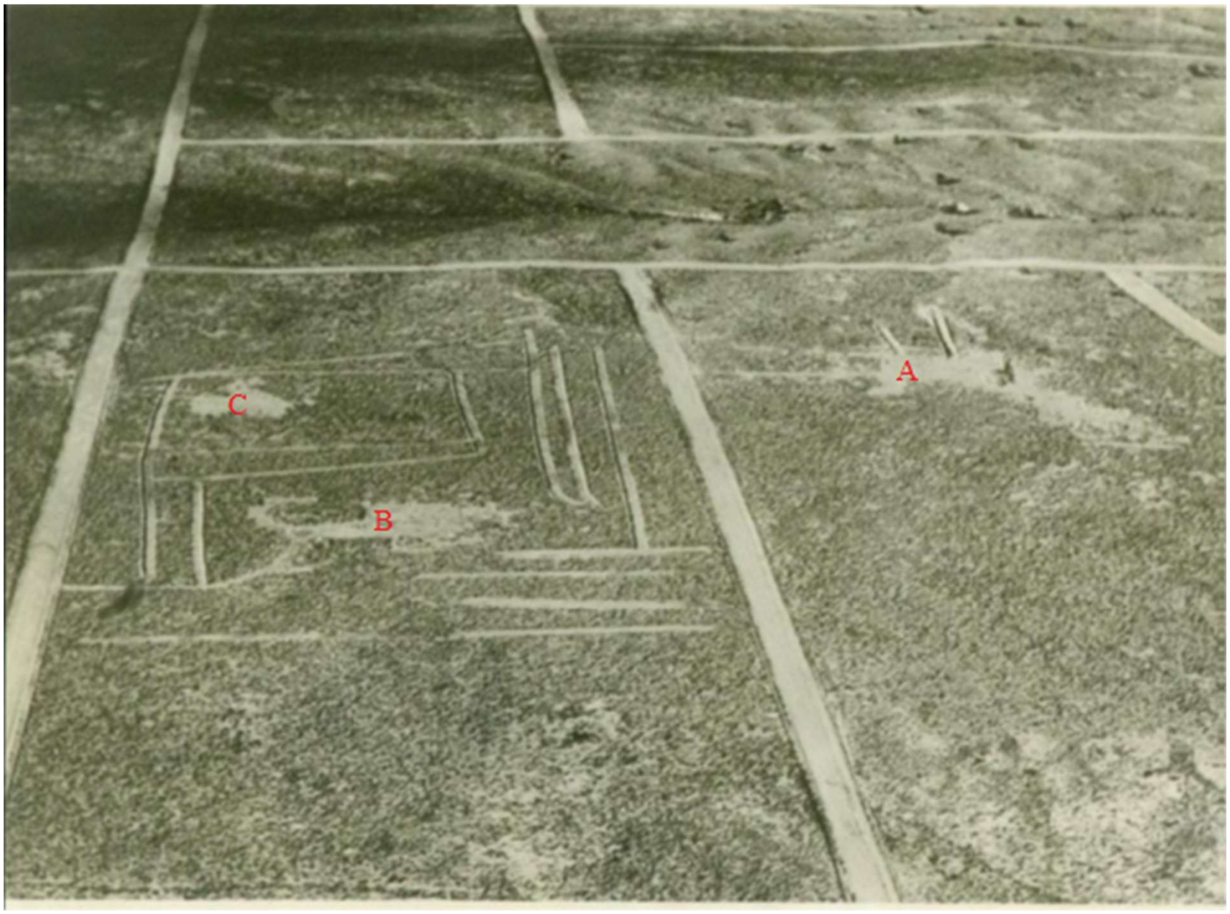

Figure (1) Aerial photo of the Rio Rancho Folsom site looking north, taken in 1967. (A) 4146, (B) 4147/AS-2, (C) 4148.

The site was initially excavated from the spring of 1965 through the fall of 1967 under the direction of Frank Hibben (Ruth 2013). Field operations were carried out by Gerald Dawson, at the time a University of New Mexico graduate student, who had intended to use the site in his dissertation (Huckell and Kilby 2002; Ruth 2013). The Albuquerque Archaeological Society assisted Dawson's excavation in the fall of 1967 at Locus AS-2, but otherwise, the majority of the excavations were done by students and volunteers or by Dawson working alone in the field (Huckell and Kilby 2002). The excavation was conducted using independent systems of 10-foot by 10-foot units at the loci, each unit shovel-stripped and passed through ¼ inch mesh screens leaving little in the way of high-resolution spatial data (Huckell and Kilby 2002; Ruth 2013). Excavation stripped poorly consolidated light reddish brown, artifact-bearing sediments down until a darker, better consolidated reddish brown clayey sand, a Pleistocene argillic horizon was excavated. These excavations recovered approximately 7,400 artifacts from the site as a whole, which were largely concentrated in the upper 20 cm of the eolian sand deposits that characterize the site (Ruth 2013). Following excavation, the collections and records became somewhat scattered, with most of the collection at the Maxwell Museum of Anthropology at the University of New Mexico (Huckell and Kilby 2002). Other portions of the collection were retrieved from the Smithsonian Institution and the Albuquerque Archaeological Society. Given the size and wide variety of artifacts, it has been suggested that the Rio Rancho Folsom site would have been a campsite possibility next to a kill site like other Folsom sites, but no faunal remains were recovered to confirm this.

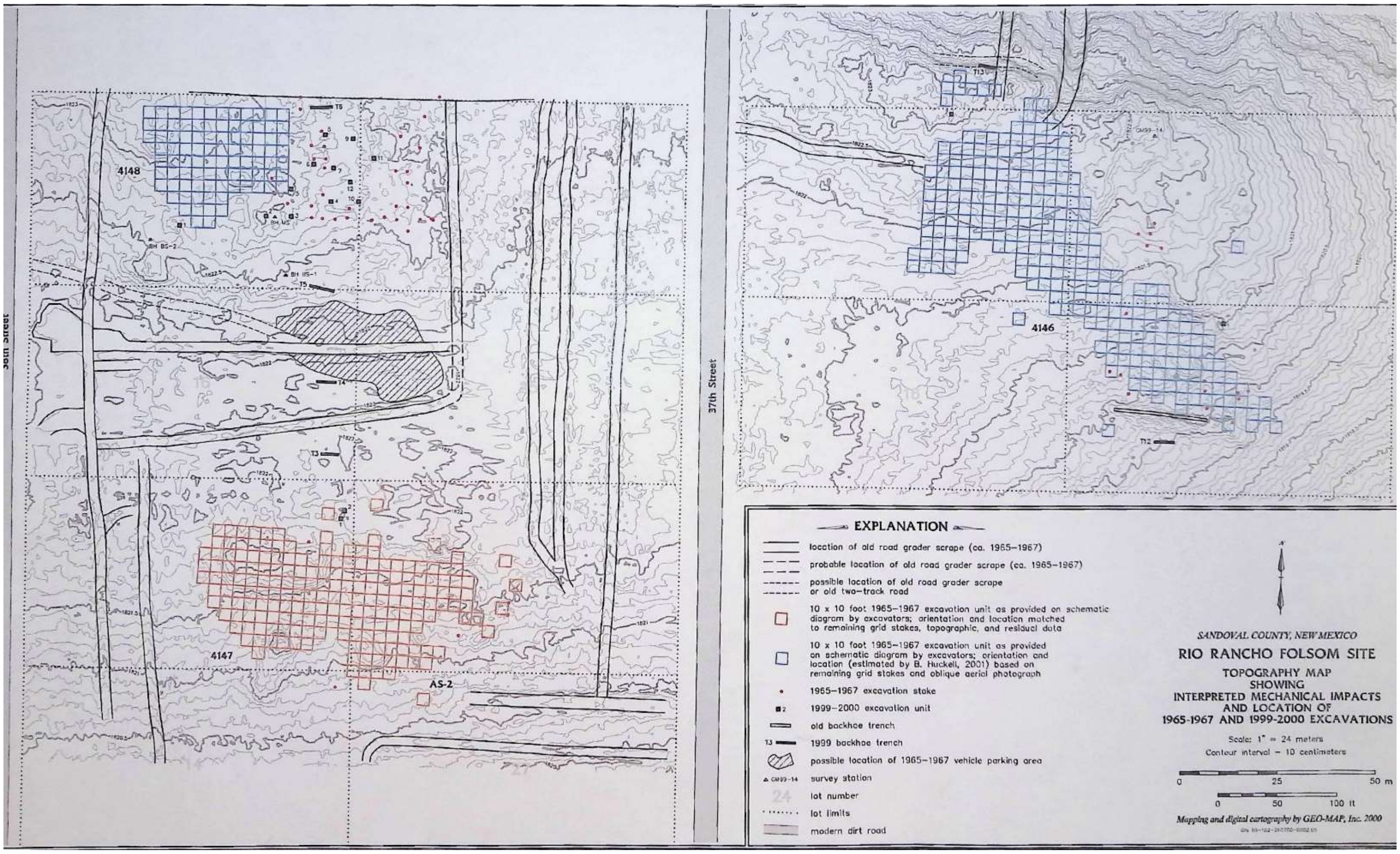

Figure (2) Topographic map of the excavated units at the Rio Rancho Folsom site.

The site consists of three loci (originally identified as five and then four): 4146 in the east/northeast, 4148 in the northwest, and 4147/AS-2 in the southwest (Huckell and Kilby 2002; Ruth 2013) (Fig. 2). The original numbering system used by Dawson and Judge (1969) corresponds as follows: Excavation Units I and II to Locus 4146, Excavation Unit III to 4147, Excavation Unit IV to AS-2, and Excavation Unit V to Locus 4148 (Ruth 2013). The specific sequence and chronology of the loci are currently unknown, leaving several unresolved questions. Were the loci all occupied simultaneously, or sequentially over some short interval of time? Do the loci represent occupations by different groups (Ruth 2013)? Loci 4146 include both Folsom material and material which postdates Folsom, including Late Paleoindian Cody Complex, Archaic, ceramic, and historic components (Huckell and Kilby 2002; Ruth 2013). This study focuses on loci 4147 and AS-2 which appear as single-component Folsom occupations (Huckell and Kilby 2002). These two loci are contiguous and hereafter will be referred to as a single continuous locus/unit for this analysis. This combination of 4147 and AS-2 has been recognized in recent investigations as well (Huckell and Kilby 2002; Ruth 2013).

Locus 4147/AS-2

Locus 4147/AS-2, located in the southwest most portion of the wider site, measures approximately 1812 m^2 making it the second largest excavated area at the site behind locus 4146 (2583 m^2) (Huckell and Kilby 2002). This study focuses on all the available flaked stone materials from this locus which are now housed at the Maxwell Museum. The artifacts represent a wide variety of toolstone materials and a variety of activities including tool production and subsistence (Huckell and Kilby 2002). The artifacts used in this analysis consist of general debitage, channel flakes, completed Folsom projectile points, Folsom point preforms, and a variety of tools including scrapers, gravers, biface fragments, utilized flakes, a drill, and cutting implements. The analyzed assemblage totals 1,993 artifacts.

Materials and Sources

The artifacts at 4147/AS-2 represent a wide range of stone materials from a variety of source locations in northwestern New Mexico (Huckell and Kilby 2002). Most of the materials from the Maxwell collection were identified based on distinct macroscopic visual traits that could be easily tied to three unique sourcing localities and five unique sources along with a variety of locally available materials (Fig. 3) (Huckell and Kilby 2002). 29 pieces of obsidian were also subjected to X-ray fluorescence (XRF) analysis (LeTourneau 2000).

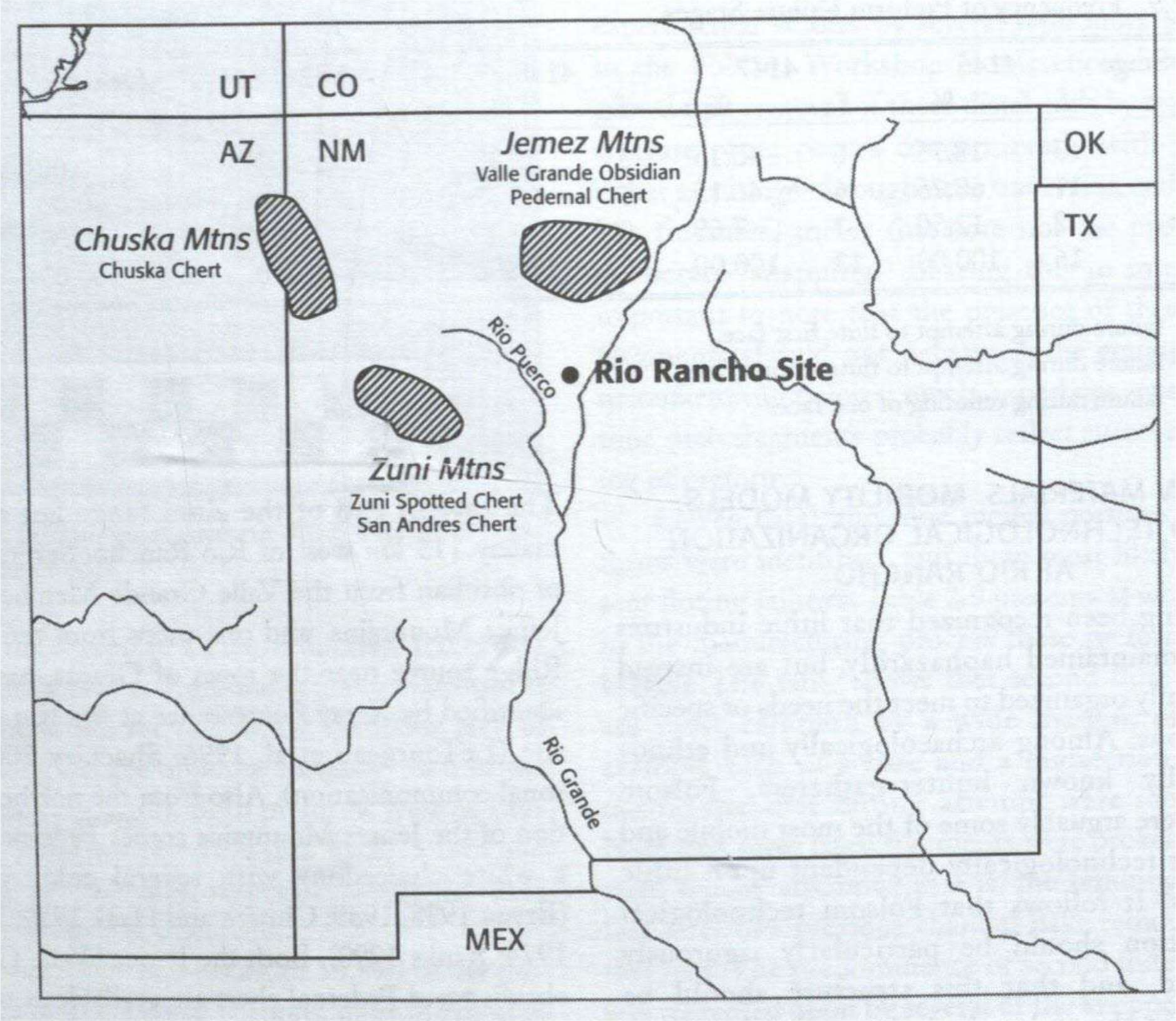

Figure (3) Map of major raw material sources (Huckell and Kilby 2002: Figure 2.7)

Several different varieties and color variations comprise locally available materials at the locus ranging from dark chalcedony (Rio Grande chalcedony, Pedernal chert) to light and dark brown chert and petrified wood. Much of this material is easily accessible in Neogene and Quaternary deposits just 5 km west of the site among ancestral Rio Puerco and Rio Grande alluvial gravels. Many of the flakes of local material at the site are of lower quality than that of nonlocal material and several of the lower quality materials are only represented as flakes at the site. Much of the local chert is a yellowish-brown variety that has yet to be assigned to a specific source (LeTourneau 2000: 483-484).

One of the less prominent materials at the site is variously known as Chuska or Washington Pass or Narbona Pass chert (Banks 1990; Huckell and Kilby 2002; Ruth 2013). This variety of chert has primary outcrops in the southern Chuska Mountain range in the far northwestern portion of New Mexico approximately 224 km west-northwest of locus 4147/AS-2 (Huckell and Kilby 2002). Chuska chert is described as primarily a pale orange-pink to reddish-orange or yellow chalcedony, often translucent with a waxy to vitreous luster (Warren 1967).

The most abundant material at the site is Zuni Spotted chert (LeTourneau 1997) which is paired with another variety often referred to as Zuni “china” or San Andres China chert. Both are derived from primary and secondary deposits in and near the Zuni Mountains (Huckell and Kilby 2002). The eastern edge of the Zuni range is approximately 112 km from the locus. Zuni Spotted chert is characterized by its yellow-brown to reddish brown and yellowish orange color with black dendritic inclusions while San Andres chert is an opaque a light cream-colored chert (LeTourneau 1997).

The second most common group of materials is a combination of obsidian out of the Valle Grande Member of the Jemez mountains (Shackley 2005) and a variety of chert called Pedernal chert which sources in primary outcrops also in the northern portion of the Jemez Mountains (Banks 1990; Huckell and Kilby 2002). The chert is highly variable in color, ranging from translucent or opaque white with reddish and bluish to black inclusions. Some primary outcrops for these materials can be found between 50 and 70 km north of the Rio Rancho Site (Huckell and Kilby 2002). Obsidian from the Jemez range is mostly a variety of black obsidian, although occasional reddish variants are present as well. X-ray fluorescence analysis has been conducted on pieces 29 from the locus, 8 reported by LeTourneau and 21 by myself through Dr. Shackley (LeTourneau 2000; Shackley 2023). The chemical composition of all 29 samples is consistent with the Cerro del Medio outcrop in the Jemez Mountains. Pedernal chert and some variants of Jemez obsidian can also be found in secondary contexts along the Rio Grande; however, the predominant variety of obsidian, Cerro del Medio (Valles rhyolite) is only available at the primary outcrop and does not appear in secondary locations (Shackley 2023).

Mobility and Routes

The five material source locations are relatively far away from the site and in an orientation relative to the site which makes mobility patterns difficult to reconstruct. There are two likely possibilities. All five of the source locations are in the northwest quarter of New Mexico. But, two of the sources lie west of the locus, and two others lie to the north while the farthest source in the Chuska Mountains lies to the northwest. In a way, the Chuska source is caught between the Jemez and Zuni mountains. A group coming from the Chuska source would have to choose between a northern and a southern route to arrive at the Rio Rancho Site as has been previously hypothesized by Huckell and Kilby (2002: 22-23). The northern route would bring people to the Jemez Mountains across the San Juan Basin and then southward to Rio Rancho (Huckell and Kilby 2002). The southern route would take people south along the southern part of the San Juan Basin into the Zuni Mountains and then east to Rio Rancho (Huckell and Kilby 2002). Given the excavation methods used and the nature of the locus's formation, it is impossible to tell if the site was occupied by one group or several. This does not however prevent the analysis of the assemblage based on either the northern or southern route in terms of technological organization.

The Locus 4147/AS-2 Lithic Assemblage

Artifact Analysis Methods

I measured the flaked stone materials from Locus 4147/AS- over the course of several months from spring 2022 through the fall of the same year. All of the flakes, points, preforms, and tools were measured using a pair of digital calipers to the nearest hundredth of a millimeter and a gram scale to the nearest tenth of a gram. Materials were identified macroscopically when possible and with the assistance of a hand lens. The pieces debitage were separated into the completeness categories from Sullivan 1987 (complete, broken, fragment, and debris). Each of the broken and complete flakes was recorded as having a plain (single faceted), multifaceted, or cortical striking platform. Completed Folsom point fragments were identified by the presence of both flutes and pressure-flaked margins.

All statistical tests, analyses, and calculations in the following examinations were conducted using Past version 4.11 (the latest version of the program at the time) on a personal computer running Windows 10. For the sake of consistency and with a lack of sufficient reason to use another standard, α is set equal to 0.05 for all statistical tests used where statistical significance is relevant to the analysis.

Debitage

The 4147/AS-2 collection produced a total of 1,822 pieces of debitage, including flakes and pieces of angular debris. This debitage included a relatively wide variety of materials, upwards of 14 different types. Most of the debitage consists of six high-quality nonlocal materials, including Pedernal chert, Jemez obsidian, Zuni Spotted chert, San Andres China chert, Chuska chert, and a relatively fine-grained quartzite of an unknown source. The remaining eight materials appear to be different varieties of locally available cherts and petrified wood. Zuni

Spotted chert makes up the largest portion of the sample at 41%(*n*=738), with Pedernal chert next at 25%(*n*=450). The combined varieties of local materials amount to the third largest portion of the sample at 17%(*n*=302). Jemez obsidian makes up 9%(*n*=172) of the sample. San Andres China chert is 3%(*n*=57), with Chuska chert comprising the smallest portion of the sample that can be tied to a known nonlocal source with <1%(*n*=13). The remaining material, a light-colored, fine-grained quartzite from an unknown source or sources, makes up the remaining number, 4%(*n*=90) (Table 1). All these pieces of debitage were placed into completeness categories according to Sullivan (1987), striking platform type categories, and measured.

Raw Material Debitage	*n*	Percentage
Zuni Spotted	738	41
Pedernal	450	25
Local material	302	17
Jemez obsidian	172	9
quartzite	90	4
San Andres China	57	3
Chuska	13	<1

Table (1) Material counts and percentages among debitage at Locus 4147/AS-2.

The Locus 4147/AS-2 non-channel flake debitage sample consists of 1168 flake fragments, 577 broken flakes, and 138 complete flakes. Incomplete flakes (broken flakes and fragments) were measured for both mass (g) and maximum dimension (mm) (Table 2). Across all material types, incomplete flakes averaged 16.06 mm in maximum dimension and 0.64 g in mass (Table 2). Kruskal-Wallis tests and post hoc examinations show that obsidian is significantly smaller in both maximum dimension (14.64mm) and mass (0.37g) from all but Chuska chert ($p<0.05$). This result is likely affected by post depositional activity and the material properties of obsidian rather than a result of cultural processes, as obsidian is more fragile and prone to fracture than the other materials. Complete flakes were measured along maximum length, width, and thickness as well as weight (Table 3). Across all material types, complete flakes averaged 15.62 mm in length, 12.44 mm in width, 2.66 mm in thickness, and 0.98 g in mass (Table 3). Intergroup analysis of complete flakes using Kruskal-Wallis tests and post hoc tests between material types shows measurements to not be significantly different from one material type to another. Also recorded was the presence of exterior cortex and those flakes that retained striking platforms (complete and broken flakes) were separated into plain (single faceted or unfaceted), multifaceted, or cortical platforms. In total, 74 flakes have exterior cortex present (30 of which had cortical platforms), 458 flakes have multifaceted platforms, 217 flakes have plain platforms, and 82 flakes have platforms that had been ground. Fourteen of the points with cortical platforms are of local material. Also, the ratio of multifaceted platforms to plain platforms is nearly 2-to-1 across all material types. This suggests that there is consistency in the knapping technique at the site, but what this means in terms of specific knapping behavior is unclear at present.

Incomp. Flakes	Standard D.	Mean	Median	Minimum	Maximum
Max. Dim.	5.69	16.06	14.82	6.94	65.84
Mass (g)	1.44	0.64	0.3	0.1	29.9

Table (2) Measurements of incomplete flakes from Locus 4174/AS-2 (mm).

Comp. Flakes	Standard D.	Mean	Median	Minimum	Maximum
Length	7.38	15.62	13.6	6.86	48.67
Width	6.09	12.44	10.44	5.54	44.17
Thickness	2.23	2.66	1.98	0.75	20.5
Mass (g)	2.14	0.98	0.3	0.1	15.8

Table (3) Measurements of complete flakes from Locus 4147/AS-2 (mm).

The assemblage also includes 91 Folsom channel flakes. The channel flakes are of the same varieties of material as the general debitage baring San Andres China chert and two-color variations of local cherts: 44 Zuni Spotted chert, 16 of local materials, 14 obsidian, 8 Pedernal chert, and 8 Chuska chert (Table 4). The channel flakes were measured in the same way as the complete (non-channel) flakes. Note that all channel flakes, fragments, broken, and complete, were measured along all parameters when able. Across all materials the length (parallel to the axis of removal) average is 12.87 mm, the width is 13.77 mm, the thickness is 1.92 mm, and the mass average is 0.43 g (Table 5). Again, Kruskal-Wallis tests and post hoc tests showed no significant difference in measurements between material types.

Raw Material Channel Flakes	*n*	Percentage
Zuni Spotted	44	49
Local material	16	18
Jemez obsidian	14	16
Pedernal	8	8.5
Chuska	8	8.5

Table (4) Material counts and percentages among channel flakes at Locus 4147/AS-2.

Channel flakes	Standard D.	Mean	Median	Minimum	Maximum
Length	3.87	12.87	12.19	5.88	23.67
Width	2.76	13.77	13.45	7.3	24.14
Thickness	0.47	1.92	1.9	1.06	3.21
Mass (g)	0.25	0.43	0.4	0.1	1.4

Table (5) Channel flake measurements from Locus 4147/AS-2 (mm).

Tools

Locus 4147/AS-2 also produced a range of tools and tool fragments that indicate a variety of tasks were likely conducted at the site. A total of 44 different tools are also in the assemblage. Many types of tools were recovered from the locus including 1 graver, 1 scraper/graver, 27 endscrapers, 1 sidescraper, 3 small bifaces, 9 utilized flakes, 1 drill, and 1 large, bifacially retouched flake. With the exception of the non-local quartzite and San Andres China chert, the tools are produced from all the full range of materials: 24 Zuni Spotted chert, 12 local material, 4 Pedernal chert, 3 obsidian, and 1 Chuska chert (Table 6). Further evidence of scraper maintenance at the site is supported by four endscraper-sharpening debitage flakes, one of which is of Chuska chert (Jelinek 1962).

Raw Material Tools	*n*	Percentage
Zuni Spotted	24	55
Local material	12	27
Pedernal	4	9
Jemez obsidian	3	7
Chuska	1	2

Table (6) Material counts and percentages among tools at Locus 4147/AS-2.

Points and Preforms

The locus also produced 20 Folsom point preforms, 15 completed Folsom projectile points, and a single pseudo fluted point. The preforms or points are only represented by basal and midsection fragments. Two projectile point tips also refit to fragments in the collection. Preforms count among the materials as follows: 6 obsidian, 4 local material, 2 quartzite, and 1 Chuska chert (Table 7). Pedernal chert and San Andres China chert are not represented among the preforms. Finished points include 6 Zuni Spotted chert, 4 Chuska chert, 2 obsidian, 1 quartzite, 1 San Andres China chert, and 1 Pedernal chert (Table 8). The local materials are not represented among the Folsom points from the locus. The majority of the completed, but broken, points are basal fragments (*n*=13) with only one midsection and one point tip representing the remaining points in the sample.

Raw Material Preforms	*n*	Percentage
Jemez obsidian	6	33
Zuni Spotted	5	28
Local material	4	22
quartzite	2	11
Chuska	1	6

Table (7) Material counts and percentages among preforms at Locus 4147/AS-2.

Raw Material Points	*n*	Percentage
Zuni Spotted	6	40
Chuska	4	27
Jemez obsidian	2	13
quartzite	1	6.3
San Andres China	1	6.3
Pedernal	1	6.3

Table (8) Material counts and percentages among points at Locus 4147/AS-2.

Using these data, we can infer several activities that are likely to have occurred at the locus as a Folsom campsite.

Locus 4147/AS-2 Activity Area and Use of Space

As previously mentioned, the locus was excavated using 10-foot by 10-foot units, so spatial data is not of a high resolution. It is, however, possible to say that there is a high artifact-density area within the western-central portion of the locus (Fig. 4). There are 118 units represented in the sample that spans the area of the site. The high-density area consists of 22 units containing a total of 1,301 pieces of debitage. The area was identified using a series of Wilcoxon nonparametric one-sample tests to determine which units contained a significantly higher number of flakes than other units in the locus. The result of the tests show that 22 of the 118 represented units haave a significantly higher frequency (greater than 23) of debitage than the remaining 96 units. This means that less than 20% of the represented units contain more than 70% of the debitage within the sample, and all 22 of these units are located adjacent to each other in a large western-central portion of the locus (Table, Fig. 4). It appears from this data that most of the knapping occurred in a large general area within the locus; however, it is very likely that the high-density area was formed as a result of post depositional processes, as it lay between two points of higher elevation. The debitage may have roll or been washed into the lower area without any human intentionality.

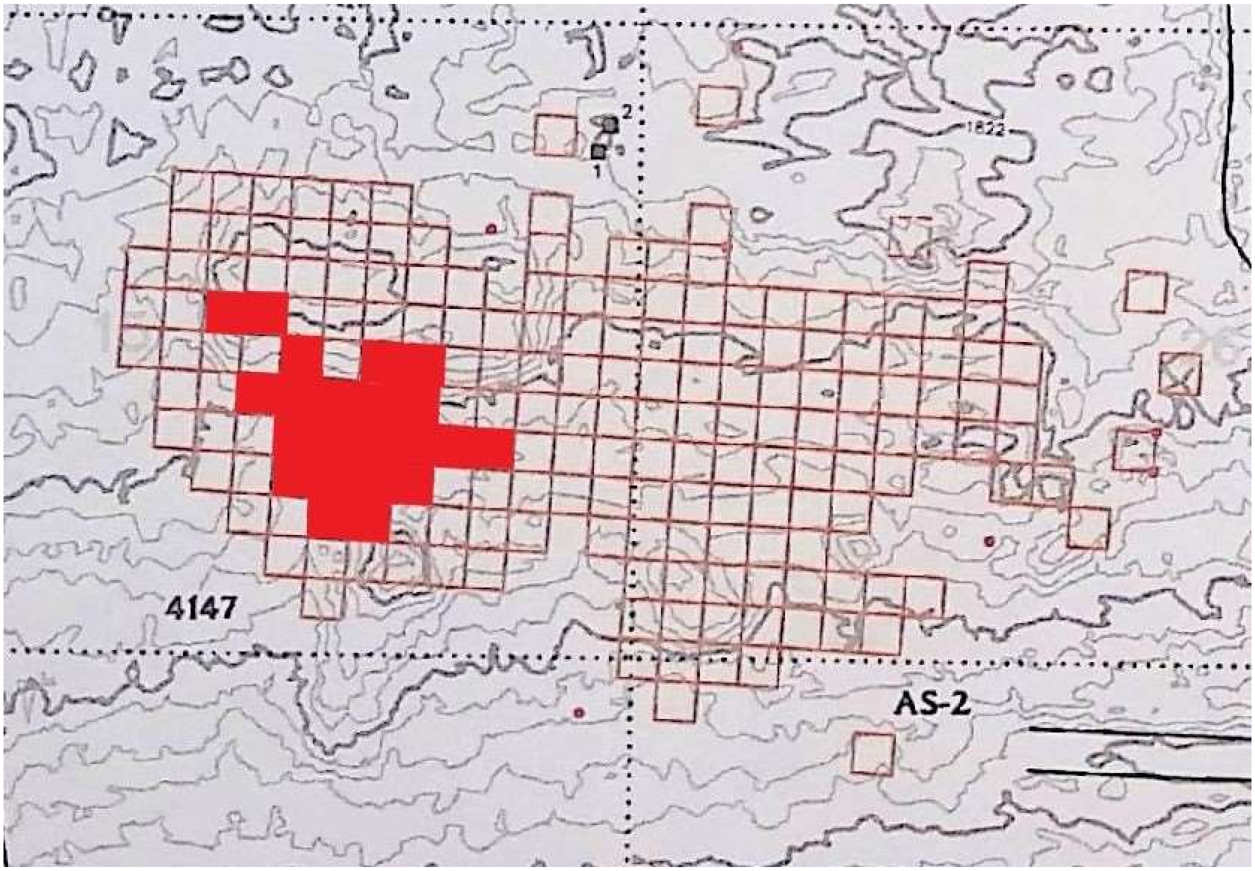

Figure (4) Units highlighted in red with significantly higher number of artifacts compared to other units using Wilcoxon nonparametric one-sample tests.

Also, through the point and channel flake data, it appears that point production and discard was an important activity in this locus. The conclusion that projectile point production and replacement were prominent activities at the wider Rio Rancho Folsom Site made by Huckell and Kilby also holds true at Locus 4147/AS-2 (2002: 20). The presence of 91 channel flakes and 20 unfinished preforms, as well as the adjacent abundance of flakes with multifaceted and ground platforms (n=540), indicates that point production was a significant activity at the locus. This is further supported by the completed points at the locus, given that all are basal fragments (n=13) with the exception of one midsection fragment and one tip fragment. It appears that the completed points at the site represent those that were replaced at camp after having been broken beyond repair during a hunt somewhere away from the locus (Huckell and Kilby 2002). Further evidence of this can be shown through statistical analysis.

The other tools at the site also represent some level of subsistence product processing. The 29 scrapers and four endscraper retouch flakes are good evidence that hide processing was a common activity at the site. Other general activities and processing are evidenced by the presence of 9 utilized flakes, 3 general bifaces, and 3 graver-type tools. The specific activities that these tools represent, however, are difficult to discern (Ruth 2013).

With Locus 4147/AS-2 now contextualized, it is possible to make comparisons that can further our understanding of the Folsom occupation in the Central Rio Grande Valley. Using the Locus 4147/AS-2 assemblage, it is possible to better characterize Folsom technological organization considering the four previously discussed organizational models.

Model-Testing Methods

Chi square predicted values can help determine if one or more of the previously discussed Folsom technological organization models is consistent with the Rio Rancho Site lithic assemblage. The following tables (Table 9) represent how the observed frequencies should compare to the calculated expected frequencies of given artifact types and material sources, above (+) or below (-) a hypothetical expected frequency, for the assemblage to fit the given model (segmented reduction, core size, toolkit, or replacement and gearing up). Each of the expected results is tied to the expectations of each of the hypothetical models. Debitage is a difficult artifact type for which to set expectations; however, I believe that it is not unreasonable to expect greater frequencies for models that expect mass production of a toolkit or reduction of larger pieces or amounts of one material over another. Another limitation of this examination is that there is no indication as to whether the assemblage represents a single or multiple occupations, as there is no well-defined stratigraphic record at the locus.

Segmented Red.	Jemez	Zuni	Chuska	Local
Debitage	+	-	-	+
Points	-	+	+	-
Tools	-	+	+	-
Channel flakes	+	-	-	-
Preforms	+	-	-	+

Core Size	Jemez	Zuni	Chuska	Local
Debitage	-	+	+	-
Points	+	+	+	+
Tools	+	-	-	+
Channel flakes	+	-	-	+
Preforms	+	+	+	+

Toolkit	Jemez	Zuni	Chuska	Local
Debitage	-	-	-	+
Points	+	+	+	-
Tools	-	-	-	+
Channel flakes	+	+	+	-
Preforms	+	+	+	-

Replacement	Jemez	Zuni	Chuska	Local
Debitage	+	-	-	+
Points	+	+	+	-
Tools	+	+	+	+
Channel flakes	+	+	+	+
Preforms	+	-	-	+

Gearing Up	Jemez	Zuni	Chuska	Local
Debitage	+	+	+	+
Points	-	-	-	-
Tools	-	-	-	-
Channel flakes	+	+	+	+
Preforms	+	+	+	+

Table (9) Expected patterns of raw material source use for given models. (+) is the expectation that the observed frequency is higher than expected and (-) is the expectation that the observed frequency is lower than expected.

In past investigations, problems of equifinality diminished the power of attempted evaluations (Huckell and Kilby 2002). This, however, was largely the result of only having projectile point and point preform data available for examination. In this examination, access to not only projectile point data, but also well-associated debitage, preforms, and other tools (e.g. endscrapers, gravers, and drills) greatly reduces the risks of equifinality when comparing organizational models. In this analysis, Zuni Spotted and Chuska chert are considered high-quality, non-local materials as their sources are more than 100 km from the locus. Jemez obsidian and Pedernal chert are also considered high-quality, nonlocal materials as their sources are 50 km away and variations of both materials within the assemblage are not found in local gravels. However, the sources for Jemez obsidian and Padernal are much closer to the locus than the other nonlocal materials which is important for some model expectations, primarily segmented reduction, core size, and replacement. It is for this reason that materials from the Jemez Mountains have shared aspects of both local and nonlocal materials in the expectations for these models. The “tools” in the examination are complete or broken endscrapers, gravers, drills, and large flaked cutting tools.

Model-Testing Results

The observed frequencies across the material and artifact types were run in a Chi square test to generate expected frequencies and residuals (Table 10, 11, 12). The results of the Chi square also show that several observed frequencies are significantly different from the expected frequencies (Table 11, 12).

Residuals	Jemez	Zuni	Chuska	Local
Debitage	0.007259	0.03843	6.18E-10	0.14448
Points	0.4322	0.73987	5.88E-10	0.11344
Tools	0.005474	0.058095	0.70763	0.36766
Channel Flakes	0.11206	0.07327	7.18E-09	0.018988
Preforms	0.50748	0.25873	0.59361	0.40522

Table (10) Chi square residuals.

p values	Jemez	Zuni	Chuska	Local
Debitage	0.0064755	0.055044	1.24E-09	0.24246
Points	0.43311	0.73761	5.61E-10	0.11257
Tools	0.0053305	0.11726	0.78019	0.16877
Channel Flakes	0.113	0.072018	6.84E-09	0.018344
Preforms	0.50621	0.26014	0.594	0.41011

Table (11) Associated *p* values for chi square. Highlighted values are significant.

Obs. (Exp.)	Jemez	Zuni	Chuska	Local
Debitage	644 (629)	782 (794)	21 (30.4)	308 (301.6)
Points	3 (4.3)	6 (5.4)	3 (0.2)	0 (2.1)
Tools	6 (14.3)	24 (18.1)	1 (0.7)	9 (6.9)
Channel Flakes	22 (28.7)	44 (36.2)	8 (1.4)	6 (13.7)
Preforms	7 (5.7)	5 (7.2)	0 (0.3)	4 (2.7)

Table (12) Observed and expected frequencies across material sources and artifact types.

The above table shows the observed and expected frequencies for each of the artifact types and material sources (Table 12). An additional table created using these values shows the difference between the observed and expected frequencies as to whether the observed frequency is above (+) or below (-) the expected value (Table 13). Some of the actual frequencies are too low to meet the expectations of a Chi square test, but for most of the data, significance can still be calculated (VanPool and Leonard 2011).

Observed Pattern	Jemez	Zuni	Chuska	Local
Debitage	+	-	-	+
Points	-	+	+	-
Tools	-	+	+	+
Channel Flakes	-	+	+	-
Preforms	+	-	-	+

Table (13) Observed patterns of raw material source use at Locus 4147/AS-2. Highlighted symbols indicate that the difference is statistically significant.

Though no single model for Folsom technological organization explains the distribution of materials across the assemblage, there are similarities between the Locus 4147/AS-2 assemblage and some of the models' expectations. While none of the models individually is able to encompass the full complexity of the organization at the locus, a combination of some of these models, to varying degrees, may serve as a better framework for explaining variance and complexity within Folsom sites.

For Locus 4147/AS-2, *the replacement model appears to be the best-fit*, but not a fully encompassing model. The expectations of the model are replicated for the observed frequencies of both Zuni and Chuska chert but not in local or Jemez material. This is especially true for the Chuska chert artifacts as the deviation from the expected frequencies for points, debitage, and channel flakes are statistically significant (Table 11). The actual frequencies of local material best fit either segmented reduction or toolkit models. The actual frequencies of local material only differ from both models' expectations in only one artifact category, making *either or both the toolkit or segmented reduction models a possible aspect of Folsom technological organization at the locus*. The observed frequency of channel flakes among local materials is also significantly lower than expected (Table 12). The materials from the Jemez Mountains appear most similar to the segmented reduction model or the gearing-up model, but seeing as the observed frequencies in the other material source categories differ so greatly from the gearing-up model, it appears that Jemez materials also fall into either or both of the segmented reduction or toolkit models. None of the observed frequencies matched the core size model in any significant way (Table 9, 13). It is also important to note that the observed tool frequency for Jemez material, predominantly obsidian, is significantly less than expected (Table 11). Using these results, it is possible to build a multifactor technological organization model that can better describe the Folsom technological organization at the locus and perhaps a model that can better explain the complexity seen in Folsom assemblages more generally.

Conclusions, a Synthesized Organization Model

Given the wide range of possible reasons or reasoning for any given technological organization model, it is difficult to put any single Folsom site — or Folsom more generally — into the proverbial "box" of any of the above-mentioned models (Amick 1999; Hofman 1992; Huckell and Kilby 2002; Ingbar 1992, 1994; Sellet 2013). People, no matter the type of society they live in, are complex decision-makers. It is clear that Folsom peoples had specific ideas of what functioned for their lifeways and what did not. As a case in point, the consistent use of the specific fluted form of the Folsom point was certainly prioritized. If this form of artifact did not serve their purposes, the form would not have been used. The decision to use one raw material type or source over another is the result of a variety of both simple and complicated factors.

From the results of the Chi square analysis, it is clear that technological organization at Locus 4147/AS-2 is not determined entirely by any single factor. The assemblage does not perfectly match the expectations of any of the tested models; however, it fits relatively well to two or three of the models. First, the replacement model only differs from the observed results in four categories: Jemez material tools, Jemez material channel flakes, Jemez material points, and local channel flakes. This suggests, beyond simple inference from the present artifacts, that people at the locus were attempting to maintain a continuously functioning toolkit of ready-to-use tools and points. Further, because Zuni and Chuska materials are well aligned with the replacement model while local and Jemez materials are not, it also appears that points were preferentially replaced using the highest-quality and least recently acquired materials. Local material is most closely aligned with either the toolkit or segmented reduction models. Local material appears in greater than expected frequencies as both less reduced forms (preforms) *and* tools. The frequency of channel flakes among local materials is also significantly lower than expected, so it appears that local material was selected against when making new Folsom points. The results for the Chuska, Zuni Spotted, and local sources suggest that broken points were replaced using high-quality, nonlocal materials that had already been reduced to some degree. Tools like endscrapers, on the other hand, are made using any available, adequate material contrary to what is proposed in the toolkit model. The toolkit model's explanation is too narrow. This is evident in the results for Chuska and Zuni Spotted materials, but also for Jemez materials which do not fit well into any model expectation (baring perhaps segmented reduction). Observed Jemez material frequency is significantly less than expected for tools while both Zuni and Chuska materials observed frequencies are greater than expected. Limited access to more distant material by "maintenance/processing" tool users as proposed by Amick (1999) does not appear to be a good explanation for the pattern seen here. Besides simple inference based on the material properties of obsidian, it is hard to say why it was not selected for the production of processing tools, but it is clear that the material was not considered adequate for those tool forms at the locus.

I propose that instead of assuming that Folsom should fall into a specific pattern of organizational behavior Folsom technological organization should be considered the product of people making conscious plans *and* logical “in-the-moment” decisions that produce variability across assemblages. The pattern of material source use at Locus 4147/AS-2 suggests that there is an overarching pattern of “replacement” —acting to maintain the necessary toolkits for Folsom lifeways— with a set of bounded, but extensive, underlying situational “if-then” patterns that manifest themselves to varying degrees in any given assemblage.

At the locus, people were maintaining their supply of tools, and because there are available high-quality, perhaps more reduced, materials from previously visited sources, those materials will be used preferentially for the most complex tool forms like Folsom points. So, *if* there is high-quality, previously reduced material —because it has been reduced over time and traversed distance— *then* it will be attractive for the production of points similar to Ingbar’s (1992, 1994) segmented reduction model.

High-quality, nonlocal material is also used in the production of maintenance and processing tools at the locus. However, local material is also used at a greater-than-expected frequency, so there does not appear to be a preference for distance to the source, reduction stage, or quality. *If* there is an adequate processing-tool material relative to other available materials and maintenance tools need to be produced, *then* that material will be used for maintenance and processing tools.

These are the “if-then” statements that can be derived from the results here, but they are by no means the only possible ones. These “in-the-moment” or “at-the-time” decisions will have differing effects on a site’s assemblage. By approaching organizational models as though they are, to a degree, movable/changeable by decision-making groups and individuals, we can better understand Folsom decision-making processes and technological organization as a whole.

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