MUSEUM OF NEW MEXICO

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CHIPPED STONE MATERIAL PROCUREMENT AND USE: DATA RECOVERY INVESTIGATIONS ALONG NM 522, TAOS COUNTY, NEW MEXICO

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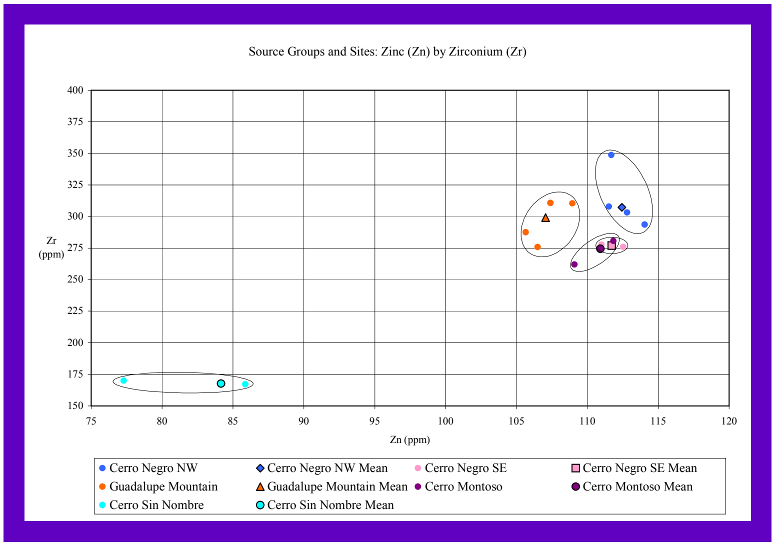

ARCHAEOLOGY NOTES 292

SANTA FE 2001 NEW MEXICO

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Jeffrey L. Boyer
James L. Moore

with a contribution by
Lisa A. Ooten

Submitted by
Timothy D. Maxwell
Principal Investigator

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ADMINISTRATIVE SUMMARY

In 1997, the New Mexico State Highway and Transportation Department (NMSHTD) conducted an archaeological survey of 13.9 km (8.7 miles) along NM 522 in Taos County, New Mexico, between the communities of Arroyo Hondo and Lama. The NMSHTD proposes to reconstruct this portion of NM 522, including building shoulders and extending culverts. Sixteen archaeological sites and sixteen isolated occurrences (IOs) were recorded during the survey. Of the sixteen sites, fifteen are scatters of chipped stone artifacts, including three quarry sites. The sixteenth site is a historic acequia.

Portions of two sites, LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528, extend into proposed project limits and could not be avoided during construction activities. At the request of the NMSHTD, the Museum of New Mexico's Office of Archaeological Studies (OAS) prepared a plan for data recovery investigations at these two sites. Between March 1 and 12, 1999, the OAS conducted archaeological data recovery investigations at the two sites, which are located near the village of San Cristobal. The sites and the project area are located on the Questa Ranger District, Carson National Forest. Timothy D. Maxwell, OAS Director, acted as project principal investigator. The field and laboratory investigations were supervised by James L. Moore (LA 115544/AR-03-02-07-523) and Jeffrey L. Boyer (LA 115550/AR-03-02-07-528). Field crew members included Susan Moga, Jessica Badner, Philip Alldritt, and Teresa Fresquez. In the laboratory, the chipped stone artifacts collected from the sites were processed and analyzed by Teresa Fresquez. X-ray fluorescence analyses of raw materials and artifacts were performed by Lisa A. Ooten and Warner Cribb of Middle Tennessee State University.

This report presents the results of data recovery investigations at the two sites. The NM 522-San Cristobal Project provided a unique opportunity to study an andesite quarry, LA 115544/AR-03-02-07-523. LA 115550/AR-03-02-07-528 provided an opportunity to examine a nonhabitation site, investigate on-site activities, and attempt to associate the site with one of the region's groups of residents. Data obtained during this project provide a preliminary baseline for identifying andesite and dacite materials recovered from other sites in the valley and for assessing the effort and expense involved in obtaining and using these materials.

Field investigations were authorized by Carson National Forest Special Use Permit No. 2017-01-443-280-0022. Funds provided by the New Mexico State Highway and Transportation Department were utilized for this project.

MNM Project No. 41.675
MNSHTD Project No. SP-OF-522-1(200)

ACKNOWLEDGMENTS

The NM 522-San Cristobal data recovery project began in the spring of 1999 and was completed in the spring of 2001. We are indebted to several people for allowing a small project to continue for what seems like an inordinately long time. At the New Mexico State Highway and Transportation Department, Daisy Levine and Blake Roxlau extended funding deadlines in order to allow us to complete XRF analyses that were beyond the original scope of the project, and to fit the project into Jeff's and Jim's responsibilities with other NMSHTD projects. Carson National Forest archaeologists Jon Young (retired), Maria Garcia, David Johnson, and Bill Westbury extended our permit deadlines, also to allow us to complete more extensive XRF analyses. They also allowed us to revisit sites to collect nonarchaeological materials for additional analyses. Paul Williams, Bureau of Land Management archaeologist, gave his blessing to our visiting quarry sites on lands administered by the BLM, also to collect nonarchaeological materials for additional analyses. At the Historic Preservation Division's Archeological Records Management Section, Steve Townsend spent a considerable amount of time going through site records with Jeff and Lisa Anne, looking for quarry sites and sites with quarry components and helping us find site records and reports. Doug Heffington, of the Geography and Geology Department at Middle Tennessee State University, first proposed a cooperative program between the OAS and MTSU, at exactly the time when Jeff and Jim were deciding on an XRF facility for the project. He then talked Lisa Anne into changing her proposed McNair federal education grant research to XRF analysis for this project. Warner Cribb, also of the Geography and Geology Department at MTSU, taught Lisa Anne to prepare and run the XRF samples. Warner later re-ran samples from LA 115544/AR-03-02-07-523 and has consulted with Jeff on many occasions about the project's XRF results and how to present them in this report. At the OAS, Tim Maxwell and Eric Blinman were very understanding and supportive when Jeff got sick and couldn't finish the final report within the project funding deadline. When Tim's own illness and work pressures kept him from reviewing this report, Yvonne Oakes completed the review and edits. We trust that the final product of the project–this report–is worthy of the efforts and cooperation of these people, although we take full responsibility for any errors–glaring or otherwise–that may be found in the project results and our conclusions. We also hope that this project has made a significant contribution to understanding prehistoric use of the geological, geographical, and archaeological landscapes of the Taos Valley.

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INTRODUCTION TO THE PROJECT

Jeffrey L. Boyer

DESCRIPTION OF THE PROJECT

In 1997, the New Mexico State Highway and Transportation Department (NMSHTD) conducted an archaeological survey of 13.9 km (8.7 miles) along NM 522 in Taos County, New Mexico, between the communities of Arroyo Hondo and Lama (Fig. 1.1; Levine and Boyer 1998). The NMSHTD proposes to reconstruct this portion of NM 522, including building shoulders and extending culverts. Funds provided by the New Mexico State Highway and Transportation Department were utilized for this project.

Sixteen archaeological sites and sixteen isolated occurrences (IOs) were recorded during the survey. Of the sixteen sites, fifteen are scatters of chipped stone artifacts, including three sites identified as quarry locations of basalt raw material. One site also has micaceous sherds, suggesting a historic component. The sixteenth site is an active historic acequia, the Acequia Atalaya, running along the north side of the Rio Hondo Valley.

Portions of six sites, while found within highway right-of-way, did not extend into the proposed project limits. Portions of five other sites, while extending into proposed project limits, had limited data potential due to the small number of artifacts within project limits. Limited shovel test investigations were conducted at these five sites to determine the subsurface data potential of the sites. No subsurface artifacts or other cultural materials were recovered and testing revealed that the portions of the sites within project limits were not likely to yield additional information (Levine and Boyer 1998). Two sites were found within the highway right-of-way but would be protected by their topographic locations. Operation of the acequia would not be affected by planned construction activities. No further investigations at any of these sites were recommended (Levine and Boyer 1998).

Portions of two sites, LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528, extended into proposed project limits and could not be avoided during construction activities. At the request of the NMSHTD, the Museum of New Mexico's Office of Archaeological Studies (OAS) prepared a plan for data recovery investigations at these two sites (Boyer 1997b). Between March 1 and 12, 1999, the OAS conducted archaeological data recovery investigations at the two sites, which are located near the village of San Cristobal. The sites and the project area are located on the Questa Ranger District, Carson National Forest. The locations of the sites on the USGS Arroyo Hondo, New Mexico 7.5' quadrangle and their UTM and legal locations are presented in the appendix to this report. (This appendix has been removed from copies in general circulation.)

Timothy D. Maxwell, OAS director, acted as project principal investigator. The field and laboratory investigations were supervised by James L. Moore (LA 115544/AR-03-02-07-523) and Jeffrey L. Boyer (LA 115550/AR-03-02-07-528). Field crew members included Susan Moga, Jessica Badner, Philip Alldritt, and Teresa Fresquez. In the laboratory, the chipped stone artifacts collected from the sites were processed and analyzed by Teresa Fresquez. X-ray fluorescence analyses of raw materials and artifacts were performed by Lisa A. Ooten and Warner Cribb of Middle Tennessee State University. Figures for this report were drafted by Jeffrey L. Boyer, James L. Moore, and Ann Noble.

BRIEF DESCRIPTION OF THE PROJECT RESEARCH ORIENTATION

This report presents the results of data recovery investigations at LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528. Although volcanic

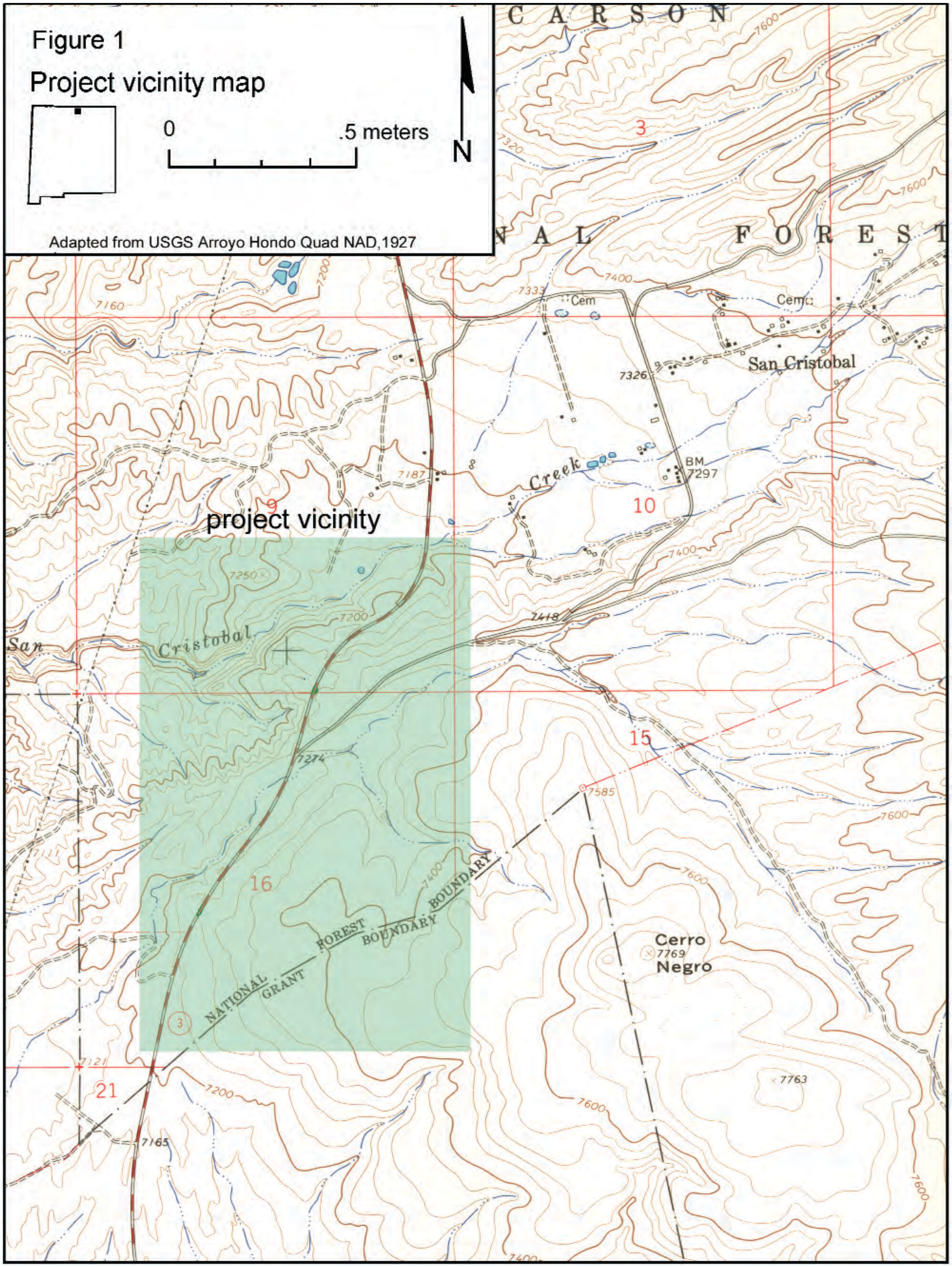

Figure 1

Project vicinity map

Adapted from USGS Arroyo Hondo Quad NAD,1927 material commonly identified by archaeologists as "basalt" is the most common chipped stone material encountered on most prehistoric sites in the Taos Valley, only a few quarries had been recorded (Renaud 1942, 1946; Rule 1973; Seaman 1983; Vierra 1984; Seaman 1987; Seaman and Chapman 1993) and only one studied on the eastern side of the valley prior to this project (Rule 1973), despite a considerable number of surveys and data recovery projects in the valley. That quarry was located on the end of a lava flow on the southeastern flank of Cerro Negro, a small volcano on the north side of the Rio Hondo. During the survey for this project, three quarries were recorded, all on the western flank of Cerro Negro (Levine and Boyer 1998). LA 115544/AR-03-02-07-523 is one of those quarries. The apparently limited distribution of quarries suggests that, although volcanic features are common in the Taos Valley, those presenting materials suitable for chipped stone tool manufacture and use are less common. If so, then raw material procurement was not a simple matter of visiting the nearest exposed material outcrop, but involved travel, material acquisition, processing, and transporation (Zimmerman and Kudo 1979; Dungan et al. 1984; Newman and Nielsen 1985) .

While quarry sites are not commonly recorded in the Taos Valley, chipped stone artifact scatters are frequently found; LA 15550/AR-03-02-07-528 is one such site. However, much of the archaeological research in the valley has focused on sites identifiable as Puebloan habitation locations, while investigations of short-term nonhabitation sites have been less common, despite the fact that the latter far outnumber the former. Clearly, short-term nonhabitation sites represent important aspects of the valley's prehistoric cultural landscapes, whether associated with pre-Puebloan, Puebloan, or contemporaneous but non-Puebloan residents of the region. LA 115550/AR-03-02-07-528 provided an opportunity to examine a nonhabitation site, to investigate on-site activities, and to attempt to associate the site with one of the region's groups of residents.

2

THE NATURAL ENVIRONMENT

Jeffrey L. Boyer

REGIONAL AND PROJECT AREA GEOMORPHOLOGY

The NM 522 project area is located in the foothills of the Sangre de Cristo Mountains on the east side of the Taos Plateau between the communities of Arroyo Hondo and Lama. The Taos Plateau, which is within the Rio Grande Depression or Trough, is a broad region bounded on the west by the San Juan Uplift (the San Juan and Tusas Mountains) and on the east by the Sangre de Cristo Mountains. The plateau is formed by block-faulting along the Rio Grande Rift that resulted in a wide trough. Accumulation of volcanic and sedimentary materials in the trough resulted in the Santa Fe formation, consisting of a variety of gravels, sandstones, volcanic rocks, breccias, cherts, and clays. Much of the area is capped by volcanic rock, primarily basaltic flows, which are a major and obvious feature of the region (Heffern n.d.; Dungan et al. 1984). In New Mexico, the plateau is known as the Taos Valley, while in Colorado it is called the San Luís Valley. The gently rolling terrain of the plateau is bisected by the Rio Grande, which has cut a gorge up to 198 m (650 ft) deep through the accumulated material. West of the gorge, the plateau is dotted by volcanoes. To the east, it is characterized by alluvial fans and terraces from the Sangre de Cristo Mountains, although volcanic features such as Ute Mountain, Guadalupe Mountain, the Questa caldera, Cerro Negro, and their associated lava flows are evident where they have not been covered by alluvial material.

The Sangre de Cristos are the southernmost extension of the southern Rocky Mountains and are made up largely of granites, schists, and quartzites. Ranging from about 2,133 m (7,000 ft) in the southern Taos Valley near Taos to 3,997 m (13,120 ft) at Wheeler Peak, the Sangre de Cristos in the vicinity of this project are the source of the Red River, the Rio San Cristobal, and the Rio Hondo. These rivers and numerous intermittent drainages such as Garrapata Creek and Alamo Creek, which cut the fans, are tributaries of the Rio Grande, which flows south through the central valley west of the project area. Subsequent to the vulcanism of the early Pleistocene, geologic processes in the region shifted to a period of extensive erosion during the late Pleistocene. The erosion resulted in the formation of the large alluvial fans extending into the valley along the margins of the mountains.

From the southern end of the project area near Arroyo Hondo to the Rio San Cristobal, NM 522 runs across ridges radiating southwest, west, and northwest from Cerro Negro, a small volcanic cone immediately north of upper Arroyo Hondo. From the Rio San Cristobal to Garrapata (Spanish for "tick") Ridge, NM 522 winds across and through sharply dissected ridges representing the remains of alluvial terraces and mountain foothills cut by Ojitos Canyon, Garrapata Canyon, and numerous unnamed drainages. Leaving Garrapata Canyon, NM 522 climbs Garrapata Ridge, the southern edge of a large alluvial fan bounded on the north by Lama (Spanish for "mud" or "ooze") Canyon and on the south by Garrapata Canyon. This fan, known as Cebolla Mesa, extends from the mountains just east of the community of Lama onto the Taos Plateau and is terminated at its western edge by the Rio Grande gorge.

The major geomorphological features of the region–the Santa Fe formation, the volcanoes, and their lava flows–are important culturally because they have provided raw lithic materials for the region's prehistoric and historic inhabitants. Of specific importance are sandstone, chert, and quartzite from the Santa Fe formation gravels and andesite, dacite, and obsidian from the volcanic features. The lava flows from Cerro Negro and other cones were important sources of andesite and dacite (Rule 1973; see also Legare 1996), while No Agua

Mountain on the western side of the valley provided a poor quality obsidian (Michels 1985). However, while studies have been conducted of the obsidians found in and used in the Taos Valley (for instance, Findlow and Bolognese 1982; Winter 1983; Michels 1985; Newman and Nielsen 1985; Stevenson and McCurry 1990; Ridings 1991), no similar study of Taos Valley "basalt" materials and sources (on the order of Latham et al. 1992) has been performed, despite the fact that material commonly identified as "basalt" is the most frequently recovered chipped stone material in the valley.

TES Units

The two sites included in the NM 522-San Cristobal Project are found in two different Terrestrial Ecosystem Survey (TES) units (Edwards et al. 1987). These units, defined in terms of the interaction of soils, climate, and plant communities, provide concise and informative descriptions of local natural environments. LA 115544/AR-03-02-07-523 is located in TES unit 145. Soils in unit 145 are fine, mixed loams formed in alluvium derived from various sources. In this case, the parent material is probably largely basalt bedrock, since the site is located on the western slope of Cerro Negro. The loams are found on nearly level elevated plains and slopes. Mean annual precipitation in the unit is 350 to 450 mm (14 to 18 in), with about 60 percent coming from winter snows. Mean annual air temperature ranges from 7 to 9 degrees C (45 to 48 F). The freeze-free season averages 130 days. These conditions support a forest community with an overstory of one-seed juniper and piñon and an understory of big sagebrush, blue grama, and sideoats grama (Edwards et al. 1987:116-117).

LA 115550/AR-03-02-07-528 is located in TES unit 159. Soils in unit 159 are very gravelly sandy loams formed in residuum derived from conglomerate and sandstone. These loams are found on the complex slopes of hills; in this case, the hills and slopes are those of alluvial terraces and foothills north and east of Cerro Negro and south of the Rio San Cristobal Valley. Although the soils in unit 159 differ from those in unit 145, climatic conditions are identical, as is the resulting juniper-piñon forest community (Edwards et al. 1987:132-133).

3

THE CULTURAL ENVIRONMENT: ARCHAEOLOGICAL BACKGROUND

Jeffrey L. Boyer

The north-central portion of the Taos Valley is one of the most poorly known regions, archaeologically, in New Mexico. Most of the archaeological work in the Taos Valley has centered on an area about 16 km (10 miles) in diameter with the town of Taos at the approximate center. The following discussion provides a general background to the prehistory and history of the region and the results of archaeological projects in the general vicinity of the project area.

Between 1941 and 1946, Dr. E. B. Renaud undertook an extensive survey of the upper Rio Grande Valley in New Mexico and Colorado (Renaud 1942, 1946). His work in this area focused on non-ceramic sites and from these sites he defined a cultural tradition that he called the "Upper Rio Grande Culture." The borders of the culture area were defined as the Sangre de Cristo Mountains on the east, the Rio San Antonio on the west, and the highway between Tres Piedras and Arroyo Hondo (now U.S. Highway 64) on the south (thus, including this project area). The northern boundary was unclear to Renaud, except that occasional sites were found in the region of Del Norte, Monte Vista, Alamosa, and the Great Sand Dunes in Colorado (Renaud 1946:29). He also found sites along the Rio San Antonio, between Monte Vista and La Jara Creek, in the Dry Lake area, and from La Sauces to the state line (Renaud 1946:29-30).

Sites of the Upper Rio Grande Culture were recognized by the presence of a diagnostic series of projectile points and by the almost exclusive use of basalt and obsidian for chipped stone tools. A site excavated in 1942 established clearly that the Upper Rio Grande Culture preceded Puebloan occupation or use of the area (Renaud 1942:31-34; 1946:30). Renaud also noted four kinds of sites: campsites, which could be divided into large, dense sites (near drainages) and "scattered finds" (small, sparse sites located some distance from a river or creek); workshops where basalt outcrops are obviously quarried and tools produced (often located near campsites); lookouts on exposed mesas, benches, or outcrops where a wide view was available; and rockshelters, such as the one which, when excavated, revealed the relative antiquity of the culture (Renaud 1946:30-33).

Renaud's findings indicated to him that there was a distinct correlation between site location and water, especially either extant rivers and creeks or sizeable arroyos that might have run in the past (Renaud 1946:33). This conclusion may actually reveal a bias in his survey strategy, which was often to drive along dirt roads looking for likely spots on or near mesas, small hills, or rivers. Thus, for instance, he surveyed the west side of San Antonio Mountain where the road is near the Rio San Antonio, but not the east side of the mountain where there are no large drainages.

More recent research on the Archaic period in northern New Mexico indicates that Renaud's Rio Grande points are fairly typical Archaic points dating from the three earliest Archaic phases of the Oshara tradition, Jay, Bajada, and San Jose (ca. 6000-1800 B.C.), as defined by Irwin-Williams (1973). Examination of the drawings of Renaud's points (1942, pl. 1) shows his "typical" Rio Grande points to be Bajada and San Jose points, while Jay points make up his "Subtype 1" and another subtype consists of other points of uncertain type.

ARROYO HONDO-SAN CRISTOBAL AREA

Several projects have recorded archaeological sites in the region of the Rio Hondo and Rio San Cristobal valleys. In 1961, the New Mexico State Highway and Transportation Department conducted a series of cultural inventory surveys in Taos

County, including a survey along NM 3 (now NM 522) from the New Mexico-Colorado border through Questa to Taos. In Arroyo Hondo, the survey recorded one site, LA 5869, a probable Developmental period, Valdez phase (ca. A.D. 1050-1225) pithouse site located at the edge of the first terrace above the Rio Hondo floodplain. No investigations have been conducted at the site.

In 1974, Loose (1974) reported on 1965 and 1967 excavations by the University of New Mexico archaeological field school at eight sites along and near Lobo Creek, an intermittent tributary of the Rio Hondo east of Cerro Negro. Seven sites included pithouses; five also had surface structures, while the eighth site is described as having only surface rooms. The sites all date to the Valdez phase of the Puebloan occupation of the Taos Valley. Several of these sites are included in a project intended to obtain chronometric dates from excavated Valdez phase sites (Boyer 1997a).

In 1977, Schaafsma (1980) collected surface artifacts from LA 58977, a Valdez Phase site located immediately west of upper Arroyo Hondo. He suspected that a pithouse was present, although no evidence of one was seen. Like LA 5869, this site is at the edge of the first terrace above the Rio Hondo floodplain.

An extensive survey of a revegetation project area was conducted in 1979 (Abbott 1979). The 152 ha (376 acre) area was located between Cerro Negro, Lobo Creek, and the road leading from NM 522 to the D. H. Lawrence Ranch. Within the area, eight sites and many isolated artifacts were recorded. Three sites were small chipped stone artifact scatters with less than 100 artifacts, mostly "basalt" flakes. Three others had assemblages larger than 200 artifacts, again with "basalt" being the dominant material. Utilized flakes made up an estimated 10 to 50 percent of the assemblages. Two sites were sherd and chipped stone artifact scatters. One had 10 "basalt" flakes and the sherds from a single large, white ware (type unidentified) bowl. The second had about 600 flakes and the sherds from a single large, gray ware (i.e., Taos Gray) bowl. Isolated artifacts consisted of "basalt" flakes and obsidian flakes and tools.

In 1983, Koczan (1983) surveyed the length of what was, at that time, NM 561, the road leading from NM 522 (then NM 3) to the D. H. Lawrence Ranch. NM 561 has since been given to Taos County and is numbered County Road B-009. During the survey, Koczan recorded LA 45733, a very large site running the length of the road. A continuous scatter of chipped stone artifacts and nine "localities" that may represent specific activity areas were observed. Three localities were defined by sherd concentrations. Others are defined by chipped stone tools or soil depressions thought to represent pithouse locations, although some of the latter may have been created by a backhoe during earlier road construction (Koczan 1983). This description largely mirrors Abbott's descriptions of the sites and general artifact scatter in the revegetation area bordering Koczan's area on the south. In 1996, Boyer (1996) re-recorded and conducted limited testing at Koczan's Locality 9, which included sherds from a single plain, gray vessel, located near the upper, eastern end of the road and site.

Also in 1983, portions of a transmission line corridor were surveyed between the Taos Substation and Questa (Viklund 1983). The corridor runs from southwest to northeast about 2.4 km (1.5 miles) west of San Cristobal. Six sites were recorded on Carson National Forest land, four near San Cristobal. All were "basalt" chipped stone artifact scatters, one with a chert En Medio projectile point. Also recorded were several isolated "basalt" artifacts, including small concentrations of flakes.

In 1987, McCrary (1987) conducted an inventory survey of Kit Carson Electric Cooperative's Arroyo Hondo-Des Montes transmission line. The line runs across the Arroyo Hondo Valley from NM 522 southeast toward upper Arroyo Hondo before climbing onto the Des Montes Plain. McCrary recorded eight sites. Four sites are probable Valdez phase artifact scatters. One has a cobble ring and two have cobble piles and historic structural components. All are in fields currently or recently under cultivation and no evidence of prehistoric structures was observed, although McCrary suspected their presence. Another artifact scatter with cobble piles and a historic component may date from the Coalition period, Pot Creek phase (ca. A.D. 1225-1270). It, too, is in a cultivated field and no structural evidence was noted. LA 61186, a chipped stone artifact scatter with hearths located near NM 522, may be a Puebloan site because of the presence of an arrow point fragment, slab metate fragments, and a two-hand mano. A large petroglyph site, LA 61185, was also found on the north side of the valley near NM 522.

In 1996, Kriebel (1996) surveyed a corridor for an electric transmission line along the southern boundary of the Carson National Forest's Questa Ranger District. He recorded two archaeological sites. LA 114186 was a scatter of Taos Gray incised sherds, probably from a single vessel, found with 22 "basalt" flakes, three obsidian flakes, one rhyolite flake, and two projectile points, one "basalt" and the other rhyolite. LA 114187 was a scatter of 28 "basalt" flakes and one obsidian flake. He also recorded eight isolated occurrences, all of which were "basalt" flakes. His survey area crossed NM 522 near but not within the site recorded during the survey for this project as LA 115545/AR-03-02-07-524 (Levine and Boyer 1998).

Cebolla Mesa

Cebolla Mesa has also been the location of several projects that provide information on human use of the region. The first of these is Valerie Hume's research on Garrapata Ridge. Her survey involved the western end of the ridge below (west of) NM 522 and revealed 32 concentrations of artifacts in an area approximately 6.4 km long by 0.4 km wide (Hume 1973, fig. 1). Hume's research was never completed and only preliminary data are available (Hume 1973, 1974, 1975). Nonetheless, her work is critical for the immediate area and for the Taos Valley, as she documented Archaic sites on the ridge and showed that Renaud's (1942, 1946) Rio Grande Culture was an Archaic tradition and probably fit within Irwin-Williams' s (1973) Oshara tradition.

Archaeological surveys on Cebolla Mesa have focused on the northern and southern sides of the mesa. On the south, surveys have encompassed most of Garrapata Ridge west of NM 522, duplicating and expanding Hume's research area. In a total of 160.7 ha (397 acres) surveyed for green fuelwood sales (McGraw 1991, 1993; Leven 1994, 1995a, 1995b), 66 sites were recorded, for an average site density of 0.4 site/ha (0.17 site/acre). Density ranged from 0.08 site to 0.71 site/ha (0.03 to 0.29 site/acre), with higher densities found to the west and lower densities to the east in the more broken terrain nearer the mountains. Sixty-three sites were scatters of chipped stone artifacts. The most common material observed was "basalt," with obsidian from the Polvadera and Jemez sources making up much smaller parts of the assemblages. Many site assemblages included projectile points, but descriptions and illustrations of the points are not available. Ten sites were identified in the site records as possibly being "Late Archaic" in date based on projectile points (McGraw 1991), although point styles are not discussed. One of these "Late Archaic" sites had sherds from a single Taos Gray incised vessel, while another had an "arrow point," indicaing the potential problems with assigning site dates based on surface artifacts. Several sites also had ground stone artifacts, particularly manos (Leven 1994, 1995a, 1995b). Again, descriptions and illustrations are not provided in the reports.

Isolated occurrences consisted primarily of "basalt" flakes, and flake scatters with "basalt" tools; there are fewer obsidian flakes and tools.

East of NM 522, Boyer (1990a, 1990b) recorded a small chipped stone artifact scatter site on a narrow point overlooking Garrapata Canyon. No temporally diagnostic artifacts were observed but biface thinning flakes were present. Since biface reduction is sometimes seen as diagnostic of hunter-gatherers, these artifacts may indicate that the site was occupied by hunter-gatherers rather than by Puebloan horticulturalists on a hunting or gathering trip.

To the north, most surveys have focused on a ridge west of NM 522 between Alamo and Lama Canyons, also conducted for fuelwood sales (McCrary 1988a; Westbury 1989; Hobbs 1989; Leven 1996). In 155 ha (375 acres), 73 sites were recorded, for an estimated density of 0.5 site/ha (0.19 site/acre), a figure consistent with those from Garrapata Ridge. Temporally diagnostic artifacts suggest that the region saw its highest use from the middle to the end of the Archaic period (ca. 2000 B.C.-A.D. 500). Probable arrow projectile points were observed at only five sites, and one had a single sherd. Interestingly, two sites have late Plains-type points, one metal, pointing to an Apachean presence in the area. This notion is supported by McCrary's (1988b) discovery of a site with a metal projectile point and a shell button from his survey for road closures in the area. This survey, which was unlike the fuelwood area surveys in not being a block survey but instead following existing roads, also supports the impression of the predominance of Archaic use of the area. Of 18 sites recorded, 13 had Archaic dart points or point fragments while only four had Puebloan pottery and three had arrow points.

Survey in the more broken terrain north of Cebolla Mesa indicates that this area was not as extensively used as the mesa itself. For instance, McCrary (1988c) surveyed 59 ha (145 acres) north of Lama Canyon for a prescribed burn. He recorded only three sites: one chipped stone artifact scatter, one post-1900 homestead, and a possible sawmill site with a chipped stone component. Similarly, McCrary's (1988d) survey of 4 ha (10 acres) in five parcels for stock tanks in the same area recorded only one site, a large chipped stone artifact scatter.

4

A PLAN FOR DATA RECOVERY ALONG NM 522

Jeffrey L. Boyer, James L. Moore, and Lisa A. Ooten

INTRODUCTION: REGIONAL PATTERNS

Archaeological surveys on Cebolla Mesa lead us to expect that sites will consist primarily of chipped stone artifacts. No prehistoric sedentary habitation sites are expected on the mesa and the archaeology appears to reflect extensive but short-term use of the area. Temporally diagnostic artifacts suggest that Cebolla Mesa was most intensively used by Archaic hunter-gatherers, with less use by later Puebloan occupants of the region. However, this interpretation is based on the presence of large projectile points thought to have been used on darts rather than on arrows, which are, in turn, linked to "earlier" (i.e., Archaic) hunter-gatherers rather than "later" (i.e., Puebloan) horticulturalists on hunting and gathering trips. The accuracy and the exclusivity of these associations between projectile point types and groups of people thought to have occupied the region at different times and to have had essentially different economies have not been clearly demonstrated, at least in this region. Further, the presence of arrow points and Puebloan pottery on sites with "Archaic" dart points shows the problems associated with dating sites using surface artifacts. At least three possibilities present themselves:

> The sites have multiple temporal components because of reoccupation through time;
>
> The earlier artifacts were collected by later people traveling through the region and were secondarily (re)deposited at these sites; or
>
> The site occupants used both darts and arrows in their hunting activities and had pottery.

The last scenario, which is not unreasonable when we consider that groups as different as eighteenth-century Hispanic New Mexicans, nineteenth-century tribes on the American Plains, and African Mbuti pygmies used both bows and darts or spears, would suggest that point types may be temporally diagnostic only in a very general sense (i.e., bows and arrows appeared later than darts or spears) and should not be used to identify groups unless otherwise substantiated. Given this, we may expect that the same concern can be applied to the use of biface flakes and the implication of biface reduction rather than core-flake reduction to distinguish between hunter-gatherers and horticulturalists at these kinds of sites (see Schutt 1980a; Moore 1994).

In contrast, archaeological activities undertaken in the foothills of the Sangre de Cristo Mountains between the Rio Hondo and Cebolla Mesa suggest that those foothills were used by prehistoric Puebloan occupants of the region both for habitation and for short-term economic activities. In this sense, the area resembles the Taos area to the south more than the Cebolla Mesa area to the north. This may have to do with the presence of permanent or semipermanent water sources in the foothills south of Cebolla Mesa, in contrast with the absence of permanent water sources on Cebolla Mesa. This is most clearly seen in the locations of Puebloan habitation sites, which have been found near permanent and semipermanent water sources (the Rio Hondo [Schaafsma 1980; McCrary 1987; Boyer and Mick-O'Hara 1991], Lobo Creek [Loose 1974; Boyer 1997a], and, perhaps, the Rio San Cristobal [Jack Boyer, pers. comm. 1988]), Koczan's (1983) possible pithouse (or backhoe) depressions notwithstanding.

Temporally diagnostic artifacts reported from artifact-scatter sites thought not to represent habitation locations include a possible Late Archaic (En Medio) projectile point and both plain and painted ceramics probably made by Puebloan occupants of the region. The presence of Puebloan artifacts at these sites may be explained as evidence of wild food resource exploitation in the foothill ridges and valleys by otherwise horticultural Puebloans. However, the meaning of the presence of ceramics is not clear. For example, among the Western Apache (Buskirk 1949; cited in Vierra 1984:32), pottery was not carried by the men on hunting or other similarly mobile excursions since it was too much of an encumbrance. If this is so, one must wonder why ceramics are present on artifact scatter sites. Traditionally, artifact scatters with ceramics are assigned to the culture of the ceramic producers. However, the concept that pottery is an encumbrance to mobility might indicate that those sites were not occupied by ceramic producers but by foragers who obtained the pottery in trade. If so, then the sites could represent forager base camps. In this regard, we should remember that two metal projectile points were found on Cebolla Mesa and that one site recorded during the survey for this project has micaceous sherds; in each case, the artifacts are thought to represent Apachean components (Levine and Boyer 1998).

The large size of sites in many cases precludes accurate assessment of the temporal components represented, at least at the survey level of investigation. The significance of variability in site size undoubtedly has to do with site function(s) and on-site activities in association with resources being exploited at or near the sites. Intensive investigation of sites is required to assess differences in site function(s) and on-site activities, and to define reasons for differing intensities of regional land use as reflected by differing site types and densities in the region.

CHIPPED STONE MATERIAL QUARRIES IN THE TAOS VALLEY

Research Perspective

Even a quick review of the archaeological literature from the Taos Valley reveals that volcanic material usually identified as "basalt" is the chipped stone material most commonly found on prehistoric archaeological sites in the area. This is true whether the site is a large pueblo (Wetherington 1968), a pithouse site (see, for instance, Loose 1974; Boyer et al. 1994), or an artifact scatter (see, for instance, Hume 1973, 1974, 1975; Boyer 1985, 1986; Seaman 1983, 1987; Seaman and Chapman 1993; Condie and Smith 1989, 1992a, 1992b; and most survey reports from the region). Given the ubiquity of this material, it is remarkable that very few quarry locations are reported (Renaud 1942, 1946; Rule 1973; Legare 1996; Seaman 1983, 1987; Seaman and Chapman 1993; Levine and Boyer 1998). LA 115544/AR-03-02-07-523, therefore, presented an unprecedented opportunity to investigate a quarry site.

One exception to the statement that basalt quarries are unreported is Rule's (1973) report of investigations at Site 54 (LA 49586). Site 54 received its number during Hume's survey of sites north of the Rio Hondo, a survey that later focused on Garrapata Ridge at the southern edge of Cebolla Mesa (Hume 1973). Site 54 was located about 1.6 km (1 mile) west of the community of Valdez on the north rim of the Rio Hondo Valley. Although Rule does not mention its geomorphological location, the site was located on the southeastern edge of the base of Cerro Negro, the same volcanic cone on whose northwestern flank the sites included in this project are found. The lava flow exploited by the occupants of Site 54 is largely covered by alluvium from the nearby Sangre de Cristo Mountains except near the valley rim. Rule (1973:5) describes the site as follows:

> The major workshop concentration mirrored those areas of the outcrop where materials extruded the furthest from the surface and occurred in the most concentrated masses. The basalt at Site 54 occurrs (sic) as both a thick, uniform mass, and in the form of cobbles and boulders. Both the massed basalt layer and the larger boulders frequently show quarrying scars, particularly at the detatched (sic) western segment of the site. There a large exactly split boulder and numerous large, amorphous basalt fragments also suggest the use of a shatter technique in the quarrying and initial subdivision of raw materials at 54.

Rule describes her preliminary analyses of artifacts collected from the site and offers a number of conclusions that relate to research issues raised here.

Research Issues

The primary focus of data recovery investigations at LA 115544/AR-03-02-07-523 was to establish "base-line data" (Boyer 1985, 1986, 1988) for the site, which include economic affiliation, chronology, and on-site activities; we wanted to know who stayed there, when they stayed there, and what they did there. However, since we know at least some of the activities carried out at the site, the questions we asked of the data are somewhat different from those we asked of the data from LA 115550/AR-03-02-07-528 (see discussion, below).

Economic Affiliation. Earlier we noted that several studies point to archaeological expectations for distinguishing hunter-gatherer and horticultural chipped stone assemblages. They include raw material selection and reduction-production strategies.

1. Raw material selection. Although LA 115544/AR-03-02-07-523 is a quarry site, we expected that some nonlocal materials might also be present. This would be particularly true if the primary users of the quarry were hunter-gatherers, as they might have brought those materials to the site when they came to obtain raw material for chipped stone tools. We would not expect nonlocal materials to be present if the site were used solely by Puebloans who lived nearby and came to the site only to obtain raw material. Although nonlocal materials should not occur in high frequencies at the site, their presence might be an indicator of hunter-gatherer use of the site.

Further indication of the presence of hunter-gatherers might be found in the condition of nonlocal material artifacts at the site. For instance, are nonlocal material artifacts found in the forms of discarded, worn out tools? This could suggest that the quarry was a location for replenishing tools, rather than simply a source for cores. We would expect the former situation to reflect hunter-gatherers and the latter to reflect a Puebloan logistical site. This is also a reduction-production issue, since, as Schutt (1980a) and Moore (1994) point out, there are reduction-production differences between hunter-gatherer and Puebloan chipped stone assemblages. Alternatively, nonlocal material artifacts could be in the form of usable tools, suggesting that the site was more than just a quarry and that other activities occurred there. This possibility is also an on-site activity issue. We deal with these issues again in following sections.

Of primary concern at LA 115544/AR-03-02-07-523 is analysis of the quarried material itself. As noted in Chapter 2, a number of studies have been conducted regarding obsidians found and used in the Taos Valley. These include chemical characterization and hydration rate development studies (Michels 1985; Newman and Nielsen 1985; Stevenson and McCurry 1990), procurement, trade, and distribution studies (Findlow and Bolognese 1982; Winter 1983), and studies of hydration dating (Ridings 1991; see also Boyer 1997). Although not all obsidian artifacts found on sites in the valley can be identified by source (Condie and Smith 1989), we are able to identify most obsidians found in the valley. In distinct contrast, although material commonly identified as basalt is the most common chipped stone material found on sites in the valley, we are not able to definitively identify basalt artifacts by their actual source because analyses of basalt materials have not been conducted. This includes artifacts and materials from quarry locations. In large measure, this is because quarry locations have not been reported or studied. Rule's (1973) Site 54 is the exception and her research did not include chemical analyses of the two materials found at Site 54. This project provides a unique and critical opportunity to begin to rectify this situation by contributing materials from a quarry source for chemical study.

The impetus for this research is a study by Latham et al. (1992), in which they subjected 56 basaltic and andesitic artifacts and samples from 68 lava flows from the Truckee area of California to X-ray fluorescence (XRF) spectrometry to define trace-element fingerprints of the materials:

> Because trace element concentrations can vary over a wider range than do major element concentrations, the concentrations of trace elements in lava flows of basaltic or andesitic composition can provide a unique fingerprint of individual flows even where many flows with similar major element chemistry are present. Thus, trace element fingerprinting of basalts and andesites could be used to answer archaeological questions relating to the provenance and transport of these raw materials, in

> the same way that analyses of obsidian are now used. (Latham et al. 1992:82)

They summarize their results as follows:

> The artifacts could be classified as (1) non-volcanic, (2) volcanic but from a source outside of the study area, and (3) volcanic and from the study area. Artifacts in the third category could be divided into those that were apparently derived from flows in the database and those which came from closely related flows. Furthermore, it was possible to determine whether or not two artifacts came from the same source, even though the source was not in the database. This information enabled us to determine how many different sources were represented in the suite of artifacts. (Latham et al. 1992:99)

However, there is one major prerequisite for the successful use of the method: because "a basaltic or andesitic volcanic province is likely to contain a large number of lava flows . . . a large geochemical data base must be obtained before provenance studies can be undertaken" (Latham et al. 1992:82). This database should contain trace-element geochemical information on most or all of the lava flows in a study area (Latham et al. 1992:99). In their case, these data were available because one of the researchers (Latham) had previously conducted a mapping survey and geochemical study of the lava flows in their study area. Although we know of no similar extensive survey of lava flows in the Taos Valley, the study of Dungan et al. (1984) involves major-element and trace-element analyses of lava flows exposed in the central Rio Grande gorge, including several flows from Cerro Negro. These analyses provide a starting point for the compilation of a regional geochemical database. Investigations at LA 115544/AR-03-02-07-523 can add to these data, since we recovered material from a Cerro Negro flow on the mountain itself, which was also a known quarry location (see Latham et al. 1992:95). Additionally, we collected materials (*not* artifacts) from the other quarry sites recorded by the project survey (Levine and Boyer 1998), LA 115543/AR-03-02-07-522 and 115545/AR-03-02-07-524, for trace-element analyses. Although these sites are located near LA 115544/AR-03-02-07-523, the cautionary note by Latham et al. (1992:82) concerning significant variation in trace-elements between related flows suggests that we should not assume that material from the three quarry sites is identical or that we cannot distinguish artifacts made from material from the three quarries.

2. Material reduction and tool production: Having addressed matters of raw material selection at LA 115544/AR-03-02-07-523, we address issues of material reduction and tool production. Although the primary activity at LA 115544/AR-03-02-07-523 was apparently quarrying, a number of questions can be asked about the techniques by which raw material was obtained and processed:

a. How large is the quarry area relative to the size of the site? This is also an on-site activity issue as it may indicate whether the site was more than just a quarry site.

b. Were different quarrying techniques used at the site? Were these techniques related to the form(s) in which material occurs at the site? For instance, Rule (1973:8) states, "Basalt occurs on Site 54 as both a thickly layered outcrop and in the form of cobbles and boulders, allowing for wide variation in the selection of raw material form . . ." She also states, "Both the massed basalt layer and the larger boulders frequently show quarrying scars, particularly at the detatched (sic) western segment of the site. There a large exactly split boulder and numerous large, amorphous basalt fragments also suggest the use of a shatter technique in the quarrying and initial subdivision of raw materials at 54" (Rule 1973:5).

c. Perhaps related to the questions concerning different quarrying techniques are these questions: were different reduction techniques used at the site and were these techniques related to different materials? For instance, Rule (1973:9-10, 30) elaborates on quarrying and reduction at Site 54 by observing that reduction techniques at the site differ according to the nature of the material:

> Site 54 basalt is extremely homogenous [sic] in composition and reflects this intrinsic value in its fracture, although the varied nature of the assemblage would initially seem to argue oth-

erwise. Characteristically, fracture is of three widely different types: 1) a highly convex fracture yielding a nearly semi-circular fragment; 2) a sheer fracture producing a flat fracture surface; 3) a highly irregular fracture reflecting numerous surface distortions. The two former of these distinctive fractures appear to be a function of the manner in which the material was worked and . . . either of these fracture surfaces could be produced at will by the manufacturer. The latter, however, the tendency of a homogenous (sic) substance to distort fracture in a mirror image of an uneven surface, was apparently uncompensated for by craftsmen and has resulted in the presence of numerous irregular flakes, chips, and chunks on the site . . . The distorted fracture of basalt is largely responsible for the frequent occurence [sic] of highly angled bulbs at the site, as well as for flakes exhibiting a wide range of dorsal deformations.

Cortical surfaces on Site 54 basalt are deceptively thin and overlie the usual fine grained basalt with no transitional layer. When, as on several artifacts, the cortical surface has been removed with no further modification of the area, the cortex was detatched (sic) in such a way that the surface of the artifact appears to have been "peared". The underlying surface is exposed, but the flake scar by which decortification was accomplished is almost undecernable (sic), having no negative bulb, and virtually no depth. Exactly how this was accomplished is not understood by this analysis, but decortification of this type can be considered a technological attribute of Site 54.

. . . it appears likely that chips and chunks at 54 represent two different technological phenomena. The chips possessing weights considerably under five grams are probably correctly identified and may primarily represent bulbar scar fragments and platform shatter. Some retouch flakes may be among them, however these were looked for and not found. The larger chunks present somewhat more of a problem. While I am confident that the majority are indeed chunks, the possibility that some, particularly the larger ones, are instead irregular flakes does exist.

Concerning the material identified as consolidated ash found at Site 54, Rule (1973:10-11) states:

> The ash at 54 occurs in fairly large masses, and in the collection area is amorphous or basically cuboidal in format. In color, it is light gray with numerous inclusions of black and white particles of variable size. The nature of the surface, both cortical and fracture, is abrasive. Site 54 ash can be flaked, but produces a blocky, irregular, usually transverse flake. Characteristic of the fracture is a diffuse but recognizable bulbar surface. The platform dimensions are usually large as compared to similarly sized basalt flakes, and may indicate extensive use of an anvil technique in flake removal.

d. To what stage are materials from LA 115544/AR-03-02-07-523 reduced before being removed from the site? Clearly, besides being a reduction-production issue, it is also related to questions of economic affiliation, mobility, and differing chipped stone reduction-production processes. Hunter-gatherer use of the site should be seen in the presence of artifacts reflecting production of basalt bifaces, particularly a range from cortex-removal to biface-shaping flakes. Further, if the basalt was being used to replace worn out tools (see previous section on Economic Affiliation), we would also expect to find evidence of production of formal tools. Conversely, Puebloan use of the site should largely be seen by evidence of the production of large cores that could be transported back to habitation locations, primarily tested cobbles and large cortex removal flakes.

Concerning this issue, Rule (1973:28-29, parentheses mine) observes in the Site 54 assemblage:

> As Site 54 was apparently solely a lithic workshop, tools recovered from the site should logically fall into one of three categories: 1) tools which were manufactured on the site and were intended to be removed from it, but were broken, lost, or otherwise discarded before they could be carried off; 2) implements not native

> to the site, but lost or discarded on the site during site utilization; or 3) implements manufactured on the site to aid in the manufacture of other implements, and then discarded. Explanation number one probably accounts for the presence of the two diagnostic artifacts on the site (one projectile point or knife fragment, one drill). Explanation two would also explain their appearance, but is generally likely and is rendered even less probable by the presence of many tools on the site which seem to be in fulfillment of explanation three. In fact, the collected area of Site 54 produced a total of 37 implements whose probable utilization was in the creation of other implements. The working angles of 25 edges recorded for tools of this apparent variety yields a mean value of 78.92 –an angle suitable for the working of wood or bone. In the general context of Site 54, it is likely that these tools were utilized in the hafting process of such artifacts as the point and the drill, and that their presence is further evidence that all stages of implement manufacture are represented among the debitage littering Site 54.

Rule's conclusions rely on her assumption that Site 54 was "solely a lithic workshop," a logistical site at which raw materials were obtained and reduced and some tools were apparently replenished. On the other hand, the presence of tool-manufacturing debris, including other tools, could be indicative of a variety of other activities at the site not directly associated with quarrying and raw material reduction.

Chronology. Establishment of chronological control is obviously vital for defining the occupation of LA 115544/AR-03-02-07-523 and for understanding the significance of the site in regional economic strategies. Consequently, we strove to collect chronometric data from the site. Since we did not observe features that could yield chronometric materials (archaeomagnetic, radiocarbon, tree-ring), we are left with hydration dating of obsidian artifacts. However, the research of Ridings (1991) and Boyer (1997a) shows that hydration dating of artifacts found on or near the modern ground surface may provide dates that are suspicious at best, while the need to have site-specific data on ground temperature and humidity is apparently critical when determining hydration dates. The small size of this project precluded obtaining ground temperature and humidity, as did the shallowness of the on-site soil.

Although we would prefer to rely on chronometric data, problems with obsidian hydration dating make such data unreliable in this case. Further, we cannot assume that all temporal components will be represented by obsidian artifacts. Consequently, we pay particular attention to artifacts considered temporally diagnostic, primarily projectile points. As discussed in Chapter 3, the natures of the sites in the vicinity of the project area suggests that assumptions regarding the temporal sequencing of different types of points may be untenable. Nonetheless, they may provide us with approximations of the timing of site occupation(s).

Additional relative temporal information may be obtained from examination of patination of the raw material. Rule (1973:11-12, parentheses ours) found that,

> At (Site) 54, patination provides evidence of site reuse over time. Although on most sites differential patination of artifacts would be a fairly risky approach to temporally dividing artifact collections, Hume has commented that "patination . . . may have a relative temporal value for mixed archaeological assemblages if the factor of material is controlled." At 54, where variation in material can be discounted and where all artifacts were recovered in a similar stage of exposure, differential patination of artifacts is inferred to indicate a minimum of two temporally distinct utilizations of the outcrop as a workshop.
>
> Differential patination of Site 54 artifacts is of three types:
> 1) artifacts displaying patination on all fracture surfaces
> 2) artifacts with "double patination," the result of the refracture of a patinated surface and producing artifacts with both fresh and stained flake scars (in Honea's estimation double patination demonstrates "a clear lapse of time between fracture and refracture")
> 3) artifacts displaying little or no patination on

fracture surfaces.

She goes on to state, "The strongest evidence of the multiple and temporally distinct utilization of the Site 54 workshop is offerred (sic) by the differential patination on recovered polyhedral cores" (Rule 1973:20). Further, "the cores chosen for re-use were the larger polyhedrals abandoned on the site, and, prior to their re-use, had had comparatively few flakes removed from them." She concludes, "Since the degree of patination exhibited upon the stained cores is advanced while the fresh scars are pristine, this should indicate, under the tenets expressed earlier in the paper, a distinct and possible lengthy lapse of time between core utilizations" (Rule 1973:21).

Unfortunately, patination (like hydration of obsidian) is a process affected by natural factors such as the composition and texture of the material, degree and length of exposure to sun, wind, and moisture, and direction of the exposed area. These factors, taken together, determine the rates at which patinas form and the thicknesses of patinas. However, it is virtually impossible to control for these factors when assessing the time involved in formation of patinas found on quarry sources and on artifacts at levels that are precise enough for archaeological dating. Consequently, no effort was made to examine patination of artifacts or quarried materials.

On-Site Activities. As discussed earlier, Vierra and Doleman's (1984) study of Archaic sites in the San Juan Basin suggests that most such sites are likely to be residential base camps. Vierra (1985a) points out that forager logistical sites are likely to be virtually invisible archaeologically because of their "search and encounter" nature. Collector logistical sites may be more easily distinguished due to their redundant nature, which should produce a specifiable artifactual assemblage.

We approached the issue of on-site activities at LA 115544/AR-03-02-07-523 through analyses of artifacts collected and of site structure. Patterns of material selection and reduction, tool production, and tool use are combined with spatial patterns in artifact location (site structure) to examine the range of activities carried out at LA 115544/AR-03-02-07-523. In particular, we are concerned with these questions: Are there features present in the forms of reduction or tool use areas? Does the site possess recognizable structure in terms of feature locations and patterning of artifacts? We attempted to define specific quarrying and reduction-chipping areas and, if possible, specific quarrying and reduction episodes, using the distributions of artifact types relative to quarry locations.

We are also concerned with the possibility that activities other than quarrying were conducted at LA 115544/AR-03-02-07-523. As noted earlier, the presence of tool-manufacturing debris, including other tools, could be indicative of a variety of other activities at the site not directly associated with quarrying and raw material reduction. It is possible that, in addition to the quarrying activities, LA 115544/AR-03-02-07-523 also has a short-term residential component or a logistical component focused on some other resource. Analyses also focus on searching for and defining such activities through study of reduction, production, and use of artifacts and of their distributions.

CHIPPED STONE ARTIFACT SCATTERS IN THE TAOS VALLEY

Research Perspective

The bias of archaeological research in north-central New Mexico toward "sedentary" habitation sites dating after approximately A.D. 1050 has been observed by several researchers (Hume 1973; Cordell 1978; Seaman 1983; Boyer 1985, 1986, 1988; and others). This bias is evident both in the kinds of sites recorded and studied and in characterizations or descriptions of the prehistory of the region. For instance, in the Taos Valley, the most well-known studies are those of pithouse sites (Blumenschein 1956, 1958, 1963; Peckham and Reed 1963; Leubben 1968; Loose 1974; Green 1976; Boyer et al. 1994; Boyer and Urban 1995), small "unit-type" pueblos (Blumenschein 1956, 1958; Jeançon 1929; Wetherington 1968; Vickery 1969), and large pueblos (Wetheringon 1968; Dick 1965; Ellis and Brody 1964; Crown 1991). Sequential phase designations rely on changes in artifacts and architecture at habitation sites. Wendorf and Reed's (1955) classification, still the most commonly used in the Rio Grande region, describes the Developmental, Coalition, and

Classic Pueblo periods, and the Taos Valley phase sequence (Wetherington 1968) describes the Valdez (late Developmental Pueblo), Pot Creek (early Coalition Pueblo), and Talpa (late Coalition Pueblo) phases, relying on changes in ceramic styles and architecture. Thus, it is clear that archaeologists have assumed that adaptive strategies characterized by the development of increasingly complex social conditions manifested archaeologically by larger and larger habitation sites and more diverse artifactual assemblages indicating extensive exchange relationships were the normal and, perhaps, only strategies at work, and were characteristic of the occupation of the region during their respective time periods.

An obvious problem with describing archaeological developments in a region solely in terms of the remains of cultural systems that were involved in increasing complexity (what Stuart and Gauthier [1981] call a "power drive") is what to do with sites that were or may have been occupied contemporaneously with the increasingly complex systems but do not, in themselves, exhibit the same evidence of artifactual and architectural complexity. Such sites are ubiquitous in the region and are most often described as "lithic" (read "chipped stone") or sherd and lithic artifact scatters. These sites lack architectural features usually associated with habitation sites, such as pithouses or pueblos, and often have very different artifact assemblages. Because of the lack of obviously "sedentary" architecture, they are presumed to represent temporarily occupied locations.

It is the place(s) of these types of sites within larger sociocultural (and archaeological) contexts that is perhaps their most confusing aspect. The initial problem is proper identification. If, during the course of recording such a site, a projectile point is found that has been otherwise identified as dating to one of the Archaic (i.e., pre-Puebloan) time periods, the site is usually recorded as an Archaic site. In the case of artifact scatters that include sherds, the site will often be recorded as occupied during the period(s) when the pottery types present were produced. It will then be assumed to have been occupied by pottery-producers who otherwise lived in permanent structures (i.e., pithouses or pueblos), making the artifact scatter a "limited activity site" associated with a sedentary habitation site somewhere else.

This issue is further confused by those artifact scatters that do not have readily identifiable, temporally diagnostic artifacts. How is one to classify a site that has no artifacts linking it to a well-known cultural tradition? The result of this situation is a continually growing number of "unknown lithic scatters" in site files. Sometimes, in what is a profound reliance on normative "power drive" classification schemes, such sites are classified as Archaic because they obviously represent a nonsedentary strategy and, so (the thinking goes), must have been occupied before the rise of later sedentary cultures. Equally confusing are those sites with artifacts dating from different time periods.

The point of this discussion is not to question the recording techniques or decisions of archaeologists who find artifact scatter sites. Rather, the point is to make clear the ambiguity inherent in such sites, particularly when the archaeologist is relying on concepts of regional developments involving increasing sociocultural and archaeological complexity. Clearly, some of the prehistoric occupants of north-central New Mexico did live in situations of increasing complexity. Their pithouses and pueblos are common and well-known features of the archaeological landscape. However, there are a great many sites in the region that do not display the characteristics that identify sedentary habitation sites. In the case of chipped stone artifact scatters, these sites may be preceramic sites (Paleoindian or Archaic), or nonceramic sites from later time periods. Examples of the former are four artifact scatters at Red Hill, northwest of this project area on the west side of the Taos Valley. Obsidian hydration dates from the sites point to occupations between 3600 and 1100 B.C. (Condie and Smith 1989). Examples of the latter are three artifact scatters at San Antonio Mountain, also northwest of this project area. Obsidian hydration dates indicate that the sites were occupied around A.D. 800, too late to place them in Paleoindian or Archaic periods as traditionally defined (Boyer 1985). Similarly, obsidian hydration dates from five chipped stone artifact scatter sites in the southern Taos Valley and the Rio Ojo Caliente drainage point to occupations between A.D. 700 and 1500. Two of the sites were identified as possible hunter-gatherer residential base camps. The three remaining sites were tentatively identified as logistical sites (Boyer 1986). This interpretation may be ill-conceived (see Vierra and Doleman 1984; Vierra 1985a), since such sites will normally be archaeologically invisible. However, the presence of nonsedentary occupants of the region, both early and relatively late in time, seems clear. The issue thus becomes whether the sites represent the activities of hunter-gatherers or of otherwise "sedentary" horticulturalists. If the former is the case, then there is evidence for hunter-gatherers occupying the regions contemporaneously with horticulturalists. If it is the latter, the question arises as to whether the sites represent normal economic activities for the horticulturalists or alternative economic activities, for instance during a period of horticultural stress. In either case, the normative "power drive" scheme for the region is challenged. The challenge is greater when we see that some chipped stone artifact scatter sites were apparently occupied during the historic period (Condie and Smith 1992a, 1992b).

Research Issues

The primary focus of data recovery investigations at LA 115550/AR-03-02-07-528 was also to establish "base-line data" for the site. In so doing, information was gathered that will add to that obtained from other chipped stone artifact scatters in the region, most of which are located on the western side of the Taos Valley. Base-line data include economic affiliation, chronology, and on-site activities.

Economic Affiliation. An important issue raised by the review of archaeological surveys in the vicinity of this project and of similar artifact scatter studies in the region is distinguishing between sites produced by hunter-gatherers and by otherwise "sedentary" horticulturalists. Differentiating between such similar sites rests on the assumption that the sites, their features, and their artifactual assemblages will have different characteristics reflecting their different origins (Binford 1980; Vierra 1985b; Schutt 1980a; Moore 1994). The basis of this assumption is the concept that the economic and mobility (land-use) patterns of mobile hunter-gatherers and sedentary horticulturalists are different. For instance, hunter-gatherers may be expected to occupy residential and logistical campsites, the latter being used by segments of the larger band who are on task-specific excursions. The two types of sites may resemble each other at first glance, but their features and artifact assemblages should differ, reflecting their different functions (Binford 1980). The residential sites of horticulturalists, on the other hand, are their villages (pithouses or pueblos, in this region). Consequently, artifact scatters associated with horticulturalists may be expected to be logistical (task-specific) in nature. The archaeological issue thus becomes, firstly, distinguishing between artifact scatter sites that reflect residential and logistical activities and, secondly, distinguishing between logistical sites used by hunter-gatherers and horticulturalists.

Several studies point to archaeological expectations for distinguishing hunter-gatherer and horticultural chipped stone assemblages:

1. Raw material selection: Vierra (1985b:6) suggests that we look for nonlocal chipped stone materials as an indicator of hunter-gatherers: "Several researchers have observed higher percentages of these materials in Archaic rather than Anasazi assemblages," apparently because hunter-gatherers collect raw materials and produce, use, and discard tools and their by-products during their seasonal rounds, often at locations far removed from the sources of the raw materials. Although we are only investigating one chipped stone scatter site in this project, comparable data are available from similar sites in other nearby project areas that allow us to examine the frequencies of local and nonlocal materials.
2. Material reduction and tool production: Schutt (1980a:393, 394) states that among the U.I.I. sites in the northern San Juan Basin, "Archaic lithic assemblages consistently exhibited higher ratios of flakes to small angular debris in all but one case" and "Chi square values indicate that in four out of five Archaic assemblages, flake to small angular debris ratios are significantly different from those found in the Anasazi lithic assemblages." This reduction-production issue is related to Moore's (1994:287) contention that:

> Two basic strategies of chipped stone reduction have been defined in the Southwest. Curated strategies entailed the manufacture of bifaces that served both as unspecialized tools and cores, while expedient strategies were based on the removal of flakes from cores for use as

> informal tools. Technology was at least partially related to lifestyle. Curated strategies were associated with a high degree of residential mobility, while expedient strategies were associated with sedentism. In theory, bifacial reduction strategies were similar to the blade technologies of Mesoamerica and western Europe in that they focused on efficient reduction with little waste. Curated strategies allow flintknappers to produce the maximum length of usable flake edge per core. By maximizing the return from cores, they were able to reduce the amount of raw material required for production of informal tools. This helped lower the amount of weight that had to be transported from camp to camp. Material waste and transport costs were not important considerations in expedient strategies. Flakes were simply struck from cores when needed.

Combining Schutt's and Moore's observations, we may argue that curated or bifacial reduction strategies produce more biface flakes and less angular debris than expedient or core reduction strategies, while expedient or core strategies produce more debris, large flakes, and expediently used, informal flake tools.

Chronology

Moore's statements are important because they remove hunter-gatherer strategies from the realm of the temporally loaded term "Archaic." As noted in the Research Perspective portion of this section, there is considerable evidence that hunter-gatherers occupied the Taos Valley both before and contemporaneously with horticultural Puebloans and even during the early historic periods. We must be careful not to assume that mobile hunter-gatherer sites are necessarily older than Puebloan sites. Establishment of chronological control is, therefore, vital for defining the occupation of LA 115550/AR-03-02-07-528 and for understanding the significance of sites in regional economic strategies. Rather than assume that, should the site be a hunter-gatherer site, it is older than Puebloan sites, we strove to collect chronometric data from the site. However, we did not find features that could yield chronometric materials (archaeomagnetic, radiocarbon, tree-ring), nor did we find obsidian artifacts that could be subjected to hydration dating. Likewise, we did not find temporally diagnostic artifacts. Consequently, we must rely on characteristics of the artifactual assemblage to attempt to define relative chronological placement of the site.

On-Site Activities

Different types of sites are classified according to the activities that took place there. The definition of artifact assemblages that reflect different activities is essential in recognizing site types. For instance, when Renaud (1942, 1946) began surveying artifact scatter sites in the northern Rio Grande Valley, he defined four kinds of sites that indicated to him that there was a distinct correlation between site size and location, especially proximity to water (Renaud 1946:33). This fact, as discussed earlier, may actually reveal a bias in his survey strategy.

A similar if more rigorous approach was taken by Reher and Witter (1977), in which they argued that local vegetative diversity was a prime consideration for the selection of occupational site locations by Archaic hunter-gatherers in the northern San Juan Basin. After measuring plant diversity in an area surrounding the densest concentration of Archaic sites in the project area, they concluded that the area of highest site density was also characterized by the highest plant diversity. However, as Miller (1980:442) points out, correlation does not imply causation and diversity and site location may both be conditioned by some other factor(s).

The same point is made by Chapman (1979), who found that vegetative diversity was not strongly correlated with Archaic site locations in the Cochiti Reservoir area, a region he describes as "one of the most vegetatively diverse areas on the North American continent." The implication, then, is that in such areas other factors must be conditioning site locations and that site locations alone do not define on-site activities.

Following Binford (1980), Vierra (1985a; see also Vierra and Doleman 1984) has surveyed the diversity of hunter-gatherer settlement and mobility in the western United States with an eye toward proposing an ethnographic model for subsistence, settlement, and mobility. After reviewing ethnographic accounts of hunter-gatherer subsistence and settlement in California, the Great Basin, and the Southwest, Vierra (1985a:35) concludes that the organization of hunter-gatherer subsistence-settlement systems in the western United States followed a forager strategy in the warm months (spring through fall) and a collector strategy in the winter (see Binford [1980] for definitions). Vierra and Doleman's (1984) study of Archaic sites in the San Juan Basin suggests that most such sites are likely to be residential base camps. Vierra (1985a) points out that forager logistical sites are likely to be virtually invisible archaeologically because of their "search and encounter" nature (although this should give pause to consider the significance of "isolated occurrences" such as projectile points or single flakes). Collector logistical sites may be more easily distinguished due to their redundant nature, which should produce a specifiable artifactual assemblage, an argument that he tests and confirms using site structural analyses.

The point is that the approach used by Renaud, Reher and Witter, and others, which focuses on deriving explanatory statements without the aid of ethnographic data (Binford's "middle-range theory"), will likely result in models of behavior that are more project-specific than adaptive-specific. A more appropriate approach takes site size (see Vierra 1985a) and location into account and includes information on intra- and intersite organization and assemblage size and composition (Vierra and Doleman 1984).

We approached the issue of on-site activities through analyses of artifacts collected and of site structure. Patterns of material selection and reduction, tool production, and tool use are combined with spatial patterns in artifact location (site structure) to examine the range of activities carried out at LA 115550/AR-03-02-07-528. Questions investigated with the analytical and structural data include:

1. What raw chipped stone materials were used on the site?
2. What kinds of reduction processes were used to produce tools and did those processes differ according to material?
3. What kinds of tools were produced (i.e., expedient or bifacial) and what do the characteristics of the tools tell us about tool use? Is there diversity or similarity in the tool assemblage or in portions of the tool assemblage (i.e., tools from different materials)?
4. Are there features present in the forms of reduction or tool use areas? Does the site possess recognizable structure in terms of feature locations and patterning of artifacts?

FIELD AND ANALYTICAL METHODS

Field Methods

Although the same general excavation methods were used at both sites, specific applications varied because of differences in topography and site structure, and the types of data expected to be recovered. General field methods are described here, and site specific applications are discussed in individual site reports.

The first step in excavation was establishment of a main datum. All vertical and horizontal measurements were referenced to this point, which was labeled as the intersection of the 100N and 100E grid lines. The ground surface at the main datum was assigned an arbitrary depth of 10 m below datum to prevent the depths of higher areas from being recorded as positive values and the depths of lower areas as negative values. A system of 1-by-1-m grids was then laid out, and each unit was identified by the grid lines that intersected at its southwest corner.

Sites were mapped by transit and stadia rod or tape, and locations of all visible cultural features, excavation units, grid lines, and topographic features were plotted. Instruments were set up at the main datum or at subdatums referenced to the main datum. The coordinates and elevations of subdatums used to take vertical measurements in grids during excavation were referenced to mapping datums.

Where surface artifacts were comparatively dense they were collected in 1-by-1-m grid units; otherwise they were point-provenienced. Potential features within project limits were investigated to determine their nature, depth, and artifact content, and to recover dateable materials if any were available. Hand tools were used for all excavation. Horizontal excavation units were 1-by-1-m grid units unless circumstances warranted otherwise. Exploratory grid units were excavated in arbitrary 10-cm levels until soil strata were defined. Following the identification of soil strata, excavation continued in natural levels when feasible. Soil from exploratory grid units and cultural strata was screened through ¼-inch mesh hardware cloth. All recovered artifacts were bagged, assigned field specimen numbers, and transported to the laboratory for analysis. Forms describing the matrix encountered and listing ending depths and field specimen numbers were completed for all excavation units. Excavation ended when sterile deposits were encountered.

When field work was finished, all deeply excavated areas were backfilled. Cultural materials recovered during these investigations are curated at the Laboratory of Anthropology, Museum of New Mexico. Field and analysis records are on file at the Archeological Records Management Section of the Historic Preservation Division.

Chipped Stone Analytical Methods

Two stages of analysis were used for LA 115544 to avoid redundancy and increase analysis speed. An initial examination classified artifacts by morphology and material type. Detailed analysis was then applied to a sample of artifacts, mostly representing materials recovered from subsurface contexts and any tools identified during the initial examination. The criteria used to select proveniences for detailed analysis are discussed in a later chapter.

All chipped stone artifacts from LA 115550 and in the detailed analysis sample from LA 115544 were examined using a standardized analysis format developed by the Office of Archaeological Studies (Office of Archaeological Studies Staff 1994). These methods were developed to increase comparability between projects completed across the state. This will eventually allow analysts to investigate specific problems with a much larger database representing sites distributed through both time and space. The OAS chipped stone analysis format includes a series of mandatory attributes that describe material, artifact type and condition, cortex, striking platform, and dimensions. In addition, several optional attributes have been developed that are useful for examining specific questions. This analysis included both mandatory and optional attributes.

The analysis format was primarily designed to include material selection, reduction technology, and tool use. These topics provide information about ties to other regions, mobility patterns, and site function. While material selection studies cannot reveal how materials were obtained, they can usually provide some indication of where they were procured. By examining the type of cortex present on artifacts it is possible to determine whether the material was obtained from a primary or secondary deposit. By studying the reduction strategy(s) employed at a site it is possible to compare how different cultural groups approached the problem of producing usable chipped stone tools from raw materials, and how the level of residential mobility affected reduction strategies. The types of tools present on a site can be used to help assign a function, particularly on artifact scatters lacking features. Tools can also be used to help assess the range of activities that occurred at a locale. In some cases chipped stone tools provide temporal data, but unfortunately they are usually less time-sensitive than other artifact classes like pottery and wood.

Each chipped stone artifact in the detailed analysis sample was examined using a binocular microscope to aid in defining morphology and material type, examine platforms, and determine whether it was used as a tool. The level of magnification varied between 15x and 80x, with higher magnification used for wear pattern analysis and identification of platform modifications. Utilized and modified edge angles were measured with a goniometer; other dimensions were measured with a sliding caliper. Analytical results were entered into a computerized database using the *Statistical Package for the Social Sciences* Data Entry software (version 4.0.1).

General Chipped Stone Analytical Methods. Three classes of chipped stone artifacts were recognized in this analysis: debitage, cores, and tools. The debitage class is comprised of materials removed from nuclei during reduction, and includes flakes and angular debris. Flakes exhibit one or more of the following characteristics: definable dorsal and ventral surfaces, bulb of percussion, and striking platform. Angular debris are pieces of shatter that lack these characteristics. Cores are the nuclei from which debitage were struck, and on which three or more negative flake scars originating from one or more platforms are visible.

Tools are divided into formal and informal categories. Formal tools are artifacts that were intentionally altered to produce specific shapes or edge angles. Alterations take the form of unifacial or bifacial retouch, and artifacts are considered intentionally shaped when retouch scars obscure their original shape or significantly alter the shape or angle of at least one edge. Informal tools are debitage that were used for various tasks without being purposely altered to produce specific shapes or edge angles. This class of tool is defined by the presence of marginal attrition caused by use. Evidence of informal use is divided into two general categories–wear and retouch. Retouch scars are 2 mm or more in length, while wear scars are less than 2 mm long.

Attributes recorded on artifacts in the detailed analysis sample include material type and quality, artifact morphology and function, amount of surface covered by cortex, portion, evidence of thermal alteration, edge damage, and dimensions. Platform information was recorded for flakes only.

Material type: This attribute was coded by gross category unless specific sources were identified. Codes are arranged so that major material groups fall into specific sequences of numbers, progressing from general material groups to named materials with known sources. The latter are given individual codes.

Material texture and quality: Texture is a subjective measure of grain size within rather than across material types. Texture is scaled from fine to coarse within most materials, with fine-grained textures exhibiting the smallest grain sizes and coarse-grained the largest. Obsidian is classified as glassy by default, and this category is applied to no other material. Quality records the presence of flaws that can affect flaking such as crystalline inclusions, fossils, visible cracks, and voids. Inclusions that would not affect flaking, such as specks of different colored material or dendrites, are not considered flaws. These attributes were recorded together.

Artifact morphology and function: Two attributes are used to provide information about artifact form and use. The first is morphology, which categorizes artifacts by general form. The second is function, which classifies artifacts by inferred use. These attributes were coded separately.

Cortex: Cortex is the chemically or mechanically weathered outer rind on nodules; it is often brittle and chalky and does not flake with the ease or predictability of unweathered material. For each artifact, the amount of cortical coverage was estimated and recorded in 10-percent increments. This attribute recorded the percentage of dorsal cortex on flakes, and the overall amount of coverage on other artifact classes.

Cortex type: The type of cortex present on an artifact can be a clue to its origin. Waterworn cortex indicates that a nodule was transported by water and deposited in a gravel or cobble bed. Nonwaterworn cortex indicates that a material was obtained where it outcrops naturally. Cortex type was identified, when possible, for any artifacts on which it was present.

Portion: All artifacts were coded as whole or fragmentary; when broken, the portion was recorded if it could be identified.

Flake platform: This attribute records the shape and any modifications to the striking platform that would facilitate removal. The type of platform present was recorded for whole flakes and proximal fragments, and the type of fracture was noted for fragments that did not include the platform.

Thermal alteration: Cherts can be modified by heating at high temperatures. This process can realign the crystalline structure, and sometimes heals minor flaws like microcracks. Heat treatment can be difficult to detect unless mistakes were made during heating. When present, the type and location of evidence for thermal alteration was recorded to determine whether or not an artifact was purposely altered.

Wear patterns: Use of a piece of debitage or core as an informal tool can result in edge damage, producing patterns of scars suggestive of the way in which it was used. Cultural edge damage denoting use as an informal tool was recorded and described when present on debitage. A separate series of codes was used to describe formal tool edges, allowing measurements for both categories of tools to be separated.

Edge angles: The angles of all modified informal and formal tool edges were measured; edges lacking cultural damage were not measured.

Dimensions: Maximum length, width, and thickness were measured for all artifacts. For angular debris and cores, length was the largest measurement, width was the longest dimension perpendicular to length, and thickness was perpendicular to width and was the smallest measurement. On flakes and formal tools length was the distance between the platform (proximal end) and termination (distal end), width was the distance between edges paralleling the length, and thickness was the distance between dorsal and ventral surfaces.

Flake Categories. Several types of flakes may be present in an assemblage, and a goal of this analysis was to distinguish between major varieties of this debitage category. Varieties can include core flakes, biface flakes, resharpening flakes, notching flakes, bipolar flakes, blades, hammerstone flakes, channel flakes, and potlids. With the exception of core and biface flakes, most categories are usually rare or absent in assemblages. Thus, distinguishing between core and biface flakes was a critical analytical need.

Flakes were divided into removals from cores and bifaces using a polythetic set of variables (Table 4.1). A polythetic framework is one in which fulfilling a majority of conditions is both necessary and sufficient for inclusion in a class (Beckner 1959). The polythetic set contains an array of conditions, and rather than requiring an artifact to meet all of them, only a set percentage in any combination need be fulfilled. This array of conditions mod-

TABLE 4.1. POLYTHETIC SET FOR DISTINGUISHING BIFACE FLAKES FROM CORE FLAKES

Whole Flakes

1. Platform:
    a. has more than one facet
    b. is modified (retouched and abraded)
2. Platform is lipped.
3. Platform angle is less than 45 degrees.
4. Dorsal scar orientation is:
    a. parallel
    b. multidirectional
    c. opposing
5. Dorsal topography is regular.
6. Edge outline is even, or flake has a waisted appearance.
7. Flake is less than 5 mm thick.
8. Flake has a relatively even thickness from proximal to distal end.
9. Bulb of percussion is weak (diffuse).
10. There is a pronounced ventral curvature.

Broken Flakes or Flakes with Collapsed Platforms

1. Dorsal scar orientation is:
    a. parallel
    b. multidirectional
    c. opposing
2. Dorsal topography is regular.
3. Edge outline is even.
4. Flake is less than 5 mm thick.
5. Flake has a relatively even thickness from proximal to distal end.
6. Bulb of percussion is weak.
7. There is a pronounced ventral curvature.

An Artifact is a Biface Flake When:

-If whole it fulfills 7 of 10 attributes.
-If broken or platform is collapsed it fulfills 5 of 7 attributes.

els an idealized biface flake and includes data on platform morphology, shape, and earlier removals. The polythetic set used here was adapted from Acklen et al. (1983). In keeping with that model, when a flake met 70 percent of the listed conditions it was considered a removal from a biface. Those that did not were considered core flakes. This percentage is high enough to isolate flakes produced during the later stages of biface production from those removed from cores, while at the same time it is low enough to permit proper identification of flakes removed from a biface that do not fulfill the entire set of conditions. While not all flakes removed from bifaces could be distinguished, those that were are considered definite evidence of biface reduction. Instead of rigid definitions, the polythetic set provides a flexible means of categorizing flakes and helps account for variability seen during experiments.

Other flake types were identified by characteristics that allowed them to be distinguished. Notching flakes are produced when the hafting element of bifaces are notched, and generally have a recessed, U-shaped platform and a deep, semicircular scallop at the juncture of the striking platform and dorsal flake surface. Bipolar flakes are evidence of nodule smashing and usually exhibit evidence of being struck at one end and crushed against an anvil at the other. Blades are long, narrow removals from specially prepared cores, and are rare in the Southwest after the Paleoindian period. Likewise, channel flakes were removed during the process of fluting Paleoindian dart or spear points and were not produced at later sites.

Other flake categories are evidence of removals from formal or informal tools, or indicate inadvertent damage during thermal processing. Resharpening flakes were removed from formal tool edges that became dull from use, and usually fit the polythetic set for biface flakes. They are often impossible to separate from other biface flakes, but can sometimes be distinguished by an extraordinary amount of damage on the platform and the section of dorsal surface adjacent to the platform. Hammerstone flakes are debitage detached from a hammerstone by use. Finally, potlids are debitage that were blown off the surface of a chipped stone artifact during thermal alteration.

X-Ray Fluorescence Analysis Procedures

Elemental composition of a solid substance can be determined using an analytical technique called X-ray fluorescence. In this technique, a spectrometer produces a beam of x-rays that strike the surface of the sample. A core electron from the atom absorbs the x-ray photon. This core electron is then ejected. When an outer electron falls into the hole created by the ejected electron, energy is given off in the form of light. This light is called fluorescence and a characteristic pattern (waves) exists for each element. Most x-ray fluorescence machines can accurately identify elements between aluminum and uranium.

Sample Collection. In cooperation with the Historic Preservation Division's Archeological Records Management Section (ARMS), previously identified quarry sites in the Taos Valley were defined from ARMS records. These sites were found on six USGS 7.5' quadrangle maps: Guadalupe Mountain, Arroyo Seco, La Segita Peaks, Arroyo Hondo, and Tres Piedras.

After locating more than 20 possible locations, 14 sites were selected and 64 rock samples were collected from within those sites. Samples were collected based on macroscopic characteristics (dense, fine grained, hard, dark, and dull in color). Only surface samples were collected, with preferences given to those with no quarrying scars in order to preserve the archaeological records of the sites.

Sample Preparation. Preparation of the samples involved a three-step process of crushing, pulverizing, and pelletizing. All preparation was performed at Middle Tennessee State University's Rock Preparation Laboratory.

The first step of crushing the samples to the size of pebbles involved two methods: cutting with a rock saw and hammering. Crushing also involved a jaw crusher with alumina ceramic plates to produce the smaller pebbles required in the next step of pulverizing.

Pulverizing took place using a shatter box, ring mill, and puck constructed of zirconium with time intervals of eight minutes. This step of the process resulted in a powder the consistency of flour. Powder of a greater consistency has been proven to produce less than adequate pellets in the final step of sample preparation.

Sample powder was then transformed to pellet discs for analysis. Each pellet contained approximately 12 g of powder. A hydraulic press was used to press the powder at approximately 24,000 pounds of pressure per square inch (psi) for a total of 20 minutes.

Sample Analysis. Samples were analyzed using an Oxford 1080+ multidispersive x-ray fluorescence spectrometer housed and maintained by the Department of Geography and Geology at Middle Tennessee State University. A series of major elemental compounds ($Si0_2$, $Ti0_2$, $Al0_3$, Fe_20_3, MnO, MgO, CaO, Na_2O, K_20, and P_20) and trace elements (barium [Ba], copper [Cu], niobium [Nb], rubidium [Rb], strontium [Sr], yttrium [Y], zinc [Zn], and zirconium [Zr]), were identified in each of these samples. A minimum of two analyses were performed on each sample. In the first analysis, major compounds were monitored in the form of weight percentages. The second analysis monitored trace elements in parts per million (ppm). In the case of a sample whose major compound percentages resulted in a sum less than 97 percent or greater than 103 percent, the process was repeated from the crushing stage of sample preparation. These methods helped to ensure the accuracy of the preparation methods as well as the mechanics of the XRF spectrometer.

LA 115544/AR-03-02-07-523 was originally

5

LA 115544/AR-03-02-07-523: AN ANDESITE QUARRY SITE

James L. Moore

recorded as a "basalt" quarry on the northwest slope of Cerro Negro (Levine and Boyer 1998; Boyer 1997b; Fig. 1.1). As first described, the site consisted of a scatter of chipped stone debris on the east side of NM 522, and measured an estimated 50-by-40 m. Levine and Boyer (1998) observed clusters of broken volcanic cobbles and debitage, and felt that the main activity conducted here was the quarrying of raw materials for chipped stone reduction. Because temporally diagnostic artifacts were lacking at this site, no date was assigned. Shovel testing was not conducted because little soil depth was anticipated within the highway right-of-way.

A piñon-juniper forest borders the NM 522 right-of-way on the east, and probably also covered the area within the right-of-way at one time. During excavation we saw a few juniper and piñon trees near the boundary fence inside the highway right-of-way, but trees were removed from elsewhere within the study area during an earlier phase of road-building. Thus, most of the site was covered by a moderate growth of low sagebrush, grasses, cactus, and snakeweed. A shallow gully forms the north edge of the heaviest concentration area (Fig. 5.1), and represents the end of an abandoned dirt road that runs in an easterly direction up the hill slope. A fair amount of road trash associated with the former use of this road and NM 522 occurred on the site surface. Since these materials were not related to the main use of LA 115544/AR-03-02-07-523, they were not collected.

More detailed inspection of the site during data recovery showed that it is far more extensive than was originally estimated. The section of LA 115544/AR-03-02-07-523 examined within the NM 522 right-of-way represents only a small part of a very large quarry. Unfortunately, time constraints precluded defining the entire extent of the site, but the scatter continues at least 100 m upslope to the east, onto lands administered by the Carson National Forest. The slope is littered with volcanic outcrops, boulders, cobbles, and gravels. Rather than basalt, as was initially reported, the material that was reduced at this site is andesite. At least two varieties of andesite were noted, the most common of which is medium to coarse-grained and charcoal gray, with occasional vesicles. A rarer variety is very fine-grained and dark black, and lacks vesicules. These correspond to descriptions provided by Lipman and Mehnert (1979:305). The latter was the primary material that was quarried, and occurs as black glassy zones within the more common brown and gray devitrified layers (Lipman and Mehnert 1979:305). Wherever boulders of fine-grained andesite occur, they are broken up and the surrounding area is littered with debitage.

The portion of LA 115544/AR-03-02-07-523 examined within the NM 522 right-of-way measured 76.4 m north to south by 11.8 m east to west, encompassing an area of approximately 901.5 sq m (Fig. 5.1). This area contained concentrations of debitage and cores around a series of broken fine-grained andesite boulders, and can be considered a procurement locality within the site as a whole. Less than 10 percent of the site was within project boundaries, and the area outside project limits contains numerous chipping stations associated with outcrops of black glassy andesite.

FIELD DATA RECOVERY PROCEDURES

Most of the portion of LA 115544/AR-03-02-07-523 within project boundaries was surface collected in 1-by-1-m grid units; a total of 578 sq m (64.1 percent of the portion of LA 115544/AR-03-02-07-523 within project limits) was examined in this way. Other surface artifacts were collected by point-provenience. This procedure allowed us to define areas that contained surface concentrations of artifacts, and the densest concentrations were

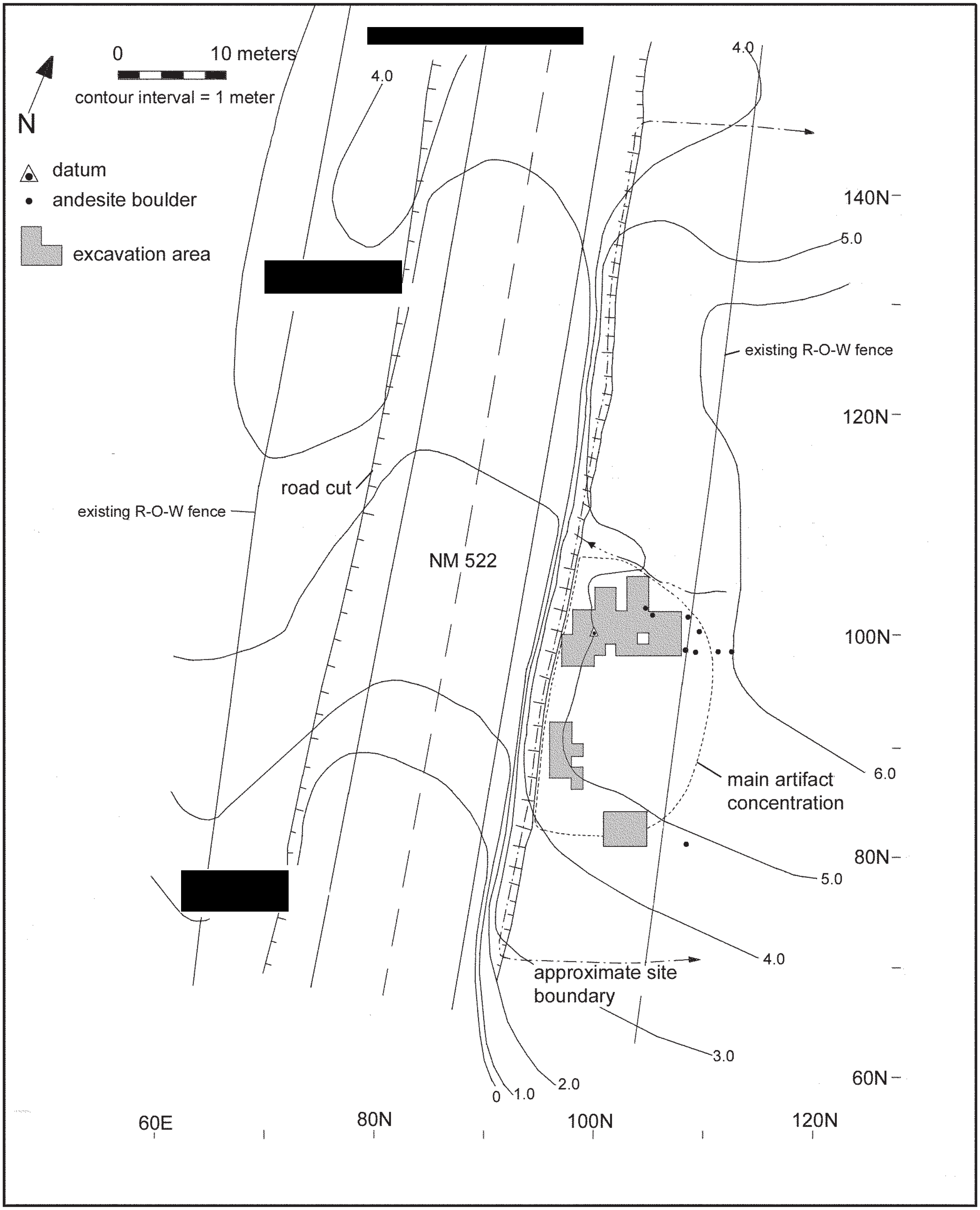

Figure 5.1. LA 115544/AR-03-02-07-523 site map.

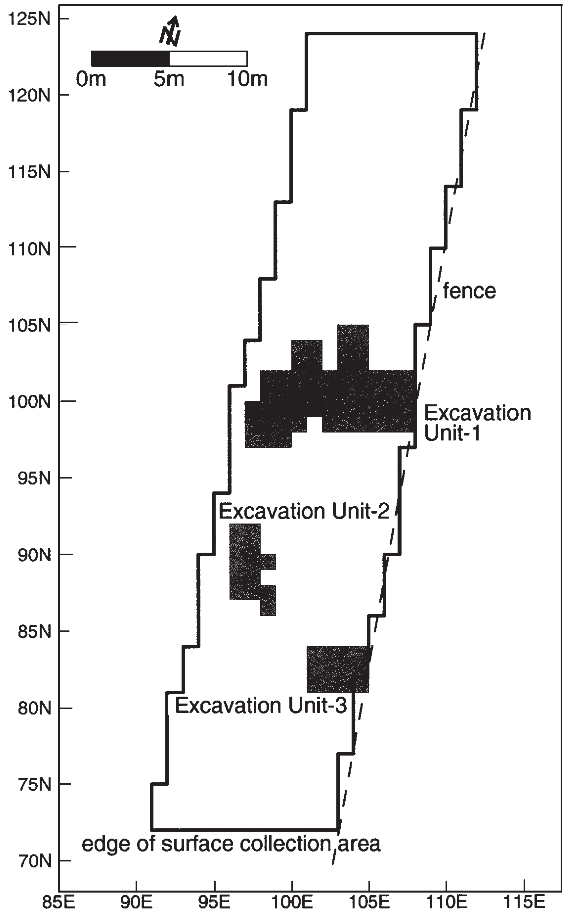

Figure 5.2. LA 115544/AR-030207-523: surface collected area; excavated areas shaded.

selected for excavation. Figure 5.2 shows the area of surface collection, with excavated grids shaded for contrast. The densest clusters of artifacts were in the southern part of the locality, adjacent to outcrops of black glassy andesite. This area is identified as the main artifact concentration in Figure 5.1, and nearly all excavation was conducted within this zone. Surface artifacts elsewhere within the locality were sparsely distributed, and no features were visible.

Excavation was conducted in 1-by-1-m grid units. A total of 78 sq m was excavated–a 25.4 percent sample of the portion of the main artifact concentration within project boundaries, and 20.1 percent of that concentration area overall. A total of 8.31 cu m of soil was removed and screened through ¼-inch mesh hardware cloth. Surface collection and excavation areas extended to the fence bordering the east edge of the NM 522 right-of-way; no materials were collected outside the right-of-way, and excavation did not extend outside this zone.

EXCAVATION RESULTS

Most cultural materials recovered by excavation were found on the surface and within the upper 3 to 4 cm of loose soil. The loose soil constituted the uppermost section of a brown silty loam mantle (Stratum 1) that covers most of the area examined. A darker brown clay (Stratum 2) was encountered in places under the silty loam, and may represent an incipient C horizon. Artifacts were found to depths of 20 cm below the surface in some areas, but the number of artifacts always dropped off considerably below the loose soil level and no cultural materials were recovered from the clay. It is likely that artifacts found deeper than 10 cm reached that level through bioturbation and natural soil movement rather than cultural deposition. Because no features or strata that could be solely attributed to cultural activity were encountered at LA 115544/AR-03-02-07-523, pollen and flotation samples were not taken. With the exception of a few pieces of obsidian, materials amenable to absolute dating were also lacking. Since the obsidian was recovered from on or just below the surface, it, too, is unsuitable for dating.

EXCAVATION AREAS

Excavation was conducted in seven excavation areas (EAs), selected because collection and inventory of surface materials indicated concentrations of chipped stone artifacts in those locales. Several excavation areas became connected as excavation proceeded (Fig. 5.3). Because of this, the original seven EAs are combined into three excavation units (EUs) to facilitate discussion and analysis. EU-1 is the northern area of excavation and includes EA-1 through 4. EU-2 is the central area of excavation and includes EA-5 and 6. The southernmost area of excavation is Excavation Unit 3, which contains EA-7. Figure 5.4 shows the relationship of EUs to the distribution of surface artifacts.

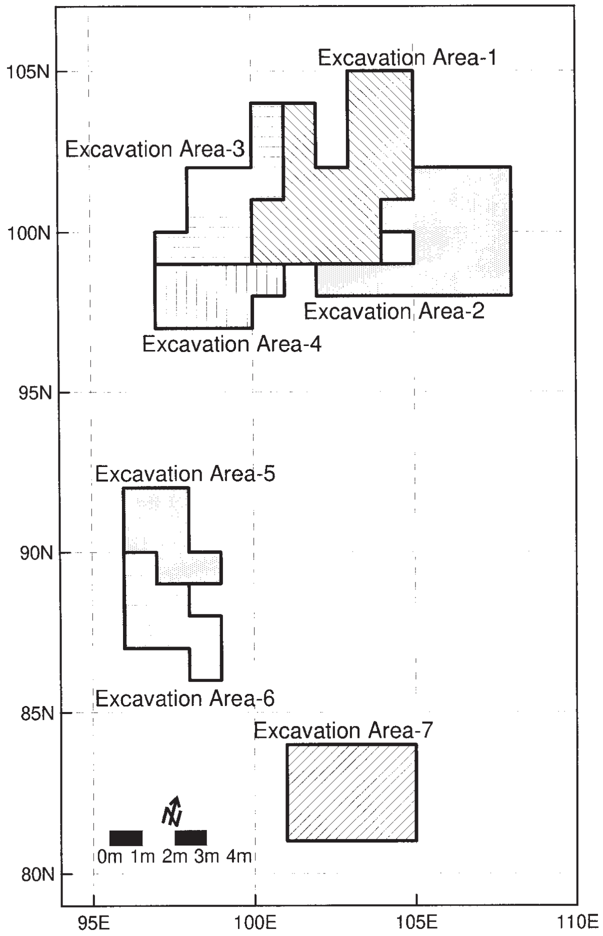

Figure 5.3. LA 115544/AR-03-02-07-523: distribution of surface artifacts.

EU-1

This unit was excavated in a comparatively flat area, though boulders and outcrops of coarse gray andesite were visible on the surface, and were most common in the eastern sector. EU-1 contained the heaviest concentration of surface artifacts within the area available for study–an average of 6.6 artifacts per sq m versus an overall mean of 1.86 artifacts per sq m, and a mean of 0.83 artifacts per sq m for areas outside of EUs. The comparatively heavy artifact concentration was undoubtedly due to the presence of two boulders of black glassy andesite within EU-1, and six others directly to the east and mostly outside project limits. The quarried boulders ranged in size between 30-by-15 cm and 90-by-50 cm, and averaged 54-by-32 cm (Figs. 5.5, 5.6).

Thirteen of the 51 grid units examined in this unit were excavated in two levels, while only one level was removed from the remaining units.

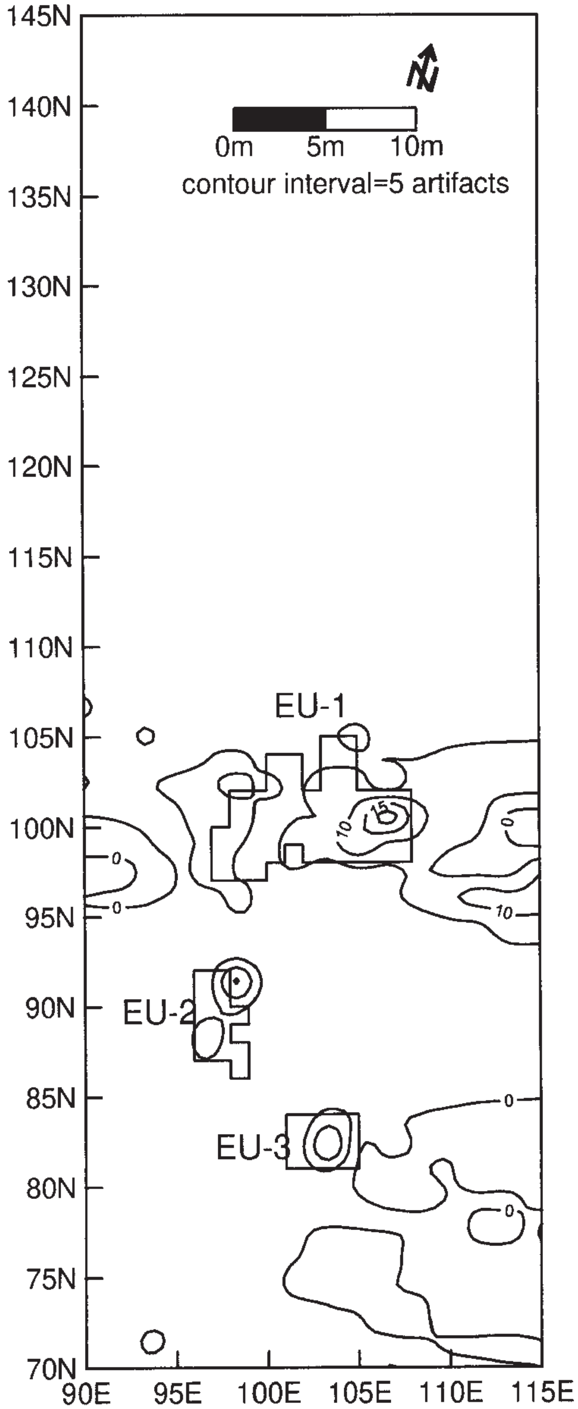

Figure 5.4. LA 115544/AR-03-02-07-523: excavation areas.

Stratum 1 was the only soil layer encountered in this area, and consisted of a brown silty loam which blanketed an andesite boulder field. Gravels were common in Stratum 1, and the unit was heavily disturbed by rodent and root action. Most artifacts

Figure 5.5. LA 115544/AR-03-02-07-523: quarried andesite boulder.

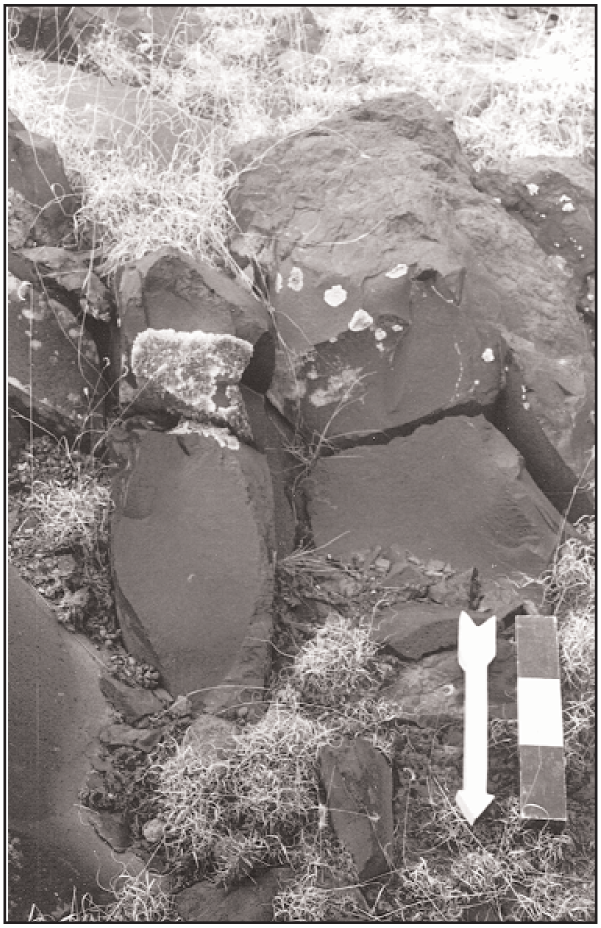

Figure 5.6. LA 115544/AR-03-02-07-523: quarried andesite boulder.

occurred in the upper 3 to 4 cm of fill, as did the highest concentration of gravels. Deflation may have compressed cultural deposits within this zone, though it is also possible that cultural materials were primarily surficial with some artifacts being carried downward by bioturbation. Unfortunately, available data are insufficient to determine which of these scenarios is correct.

Figure 5.7 shows the distribution of surface chipped stone artifacts in EU-1. Two concentrations of artifacts can be seen in this figure, one in the eastern sector of the unit and a second in the western sector. The eastern sector concentration is considerably denser, and clusters within the zone contain outcroppings of black glassy andesite boulders. The western sector concentration is next to the edge of the roadcut and appears to be distinctly separate from the eastern sector cluster. Figure 5.8 shows the distribution of chipped stone artifacts in Level 1. Artifacts were considerably more common in Level 1 than they were on the surface. Both clusters are still visible, though their centers shifted slightly. The center of the eastern sector concentration shifted to the west, and was directly adjacent to the two black glassy andesite boulders that were observed within EU-1. The center of the western sector concentration shifted to the east, and this cluster was denser in Level 1 than the one in the eastern sector. This configuration suggests that two separate activity areas may be represented in this part of the site. This is explored in more depth in Chapter 7.

EU-2

This unit was excavated in a fairly level area between the edge of the roadcut on the west and an outcrop of coarse gray andesite on the east that sloped to the west. At 2.3 artifacts per sq m, EU-2 contained a slightly higher than average concentra-

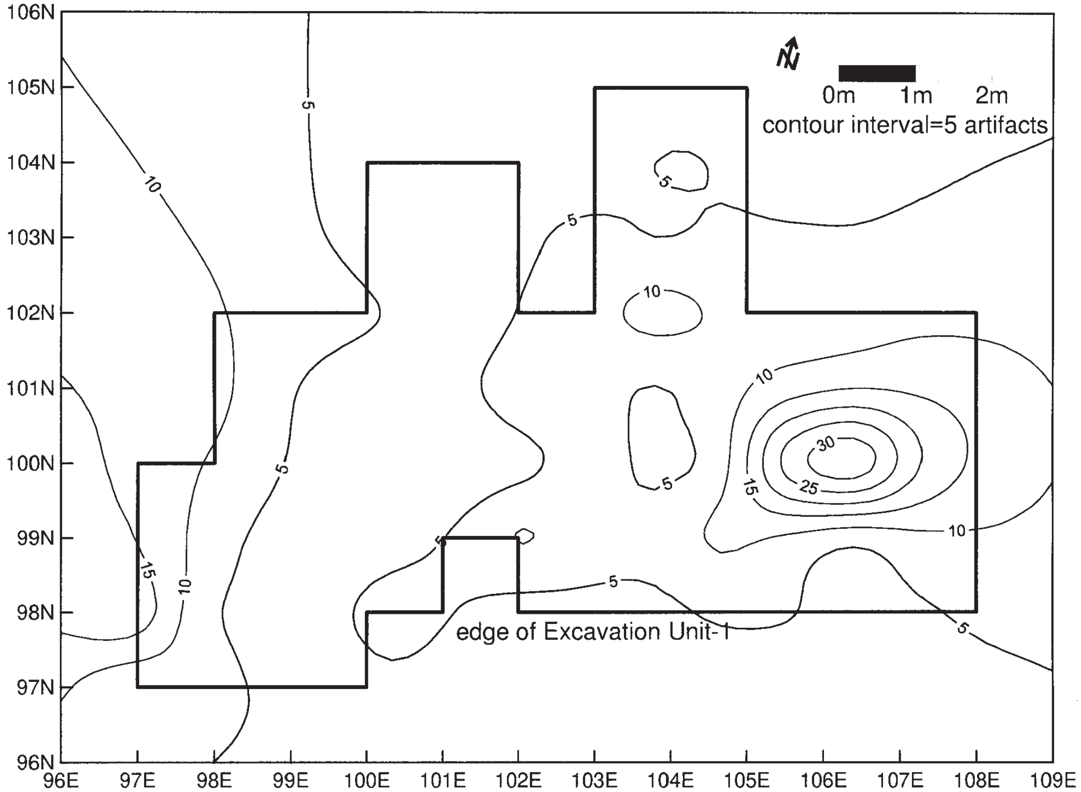

Figure 5.7. LA 115544/AR-03-02-07-523, EU-1: distribution of surface artifacts.

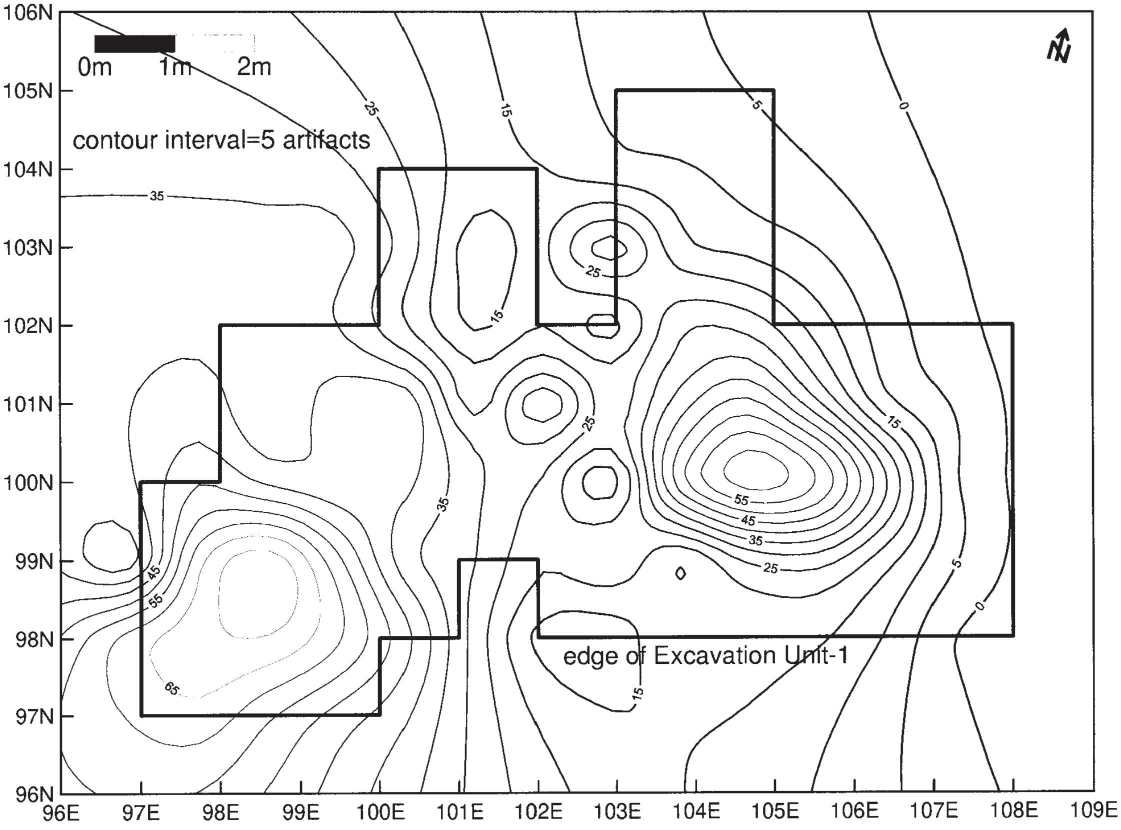

Figure 5.8. LA 115544/AR-03-02-07-523, EU-1: distribution of Level 1 artifacts.

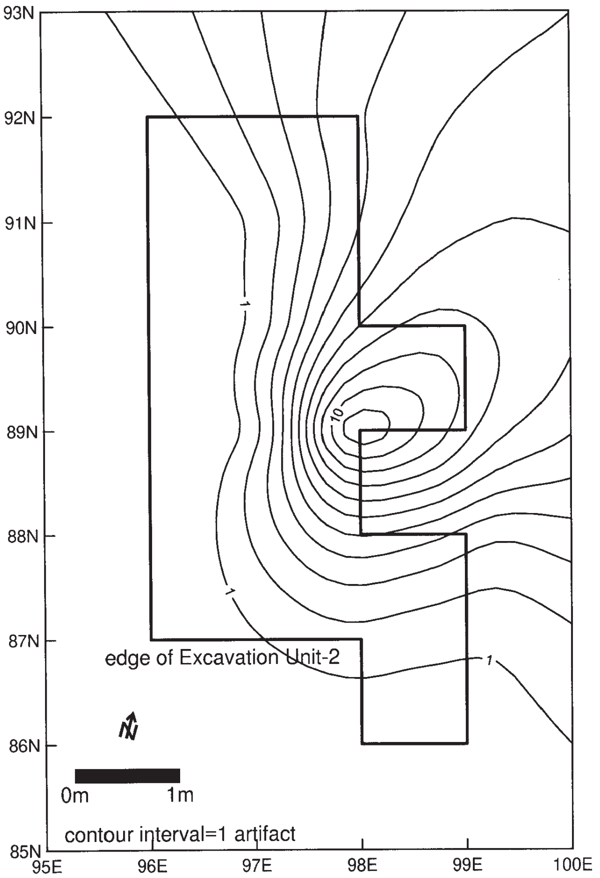

Figure 5.9. LA 115544/AR-03-02-07-523, EU-2: distribution of surface artifacts.

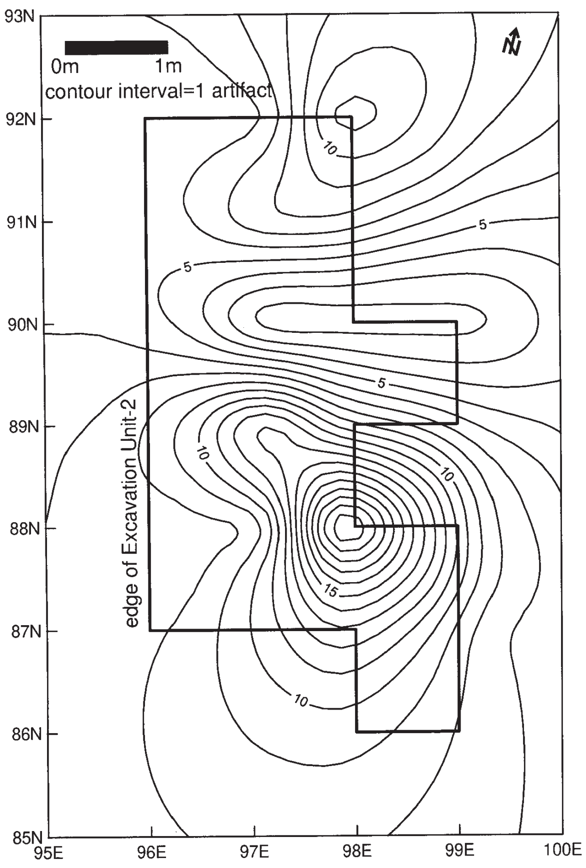

Figure 5.10. LA 115544/AR-03-03-07-523, EU-2: distribution of Level 1 artifacts.

tion of surface materials. As noted above, this compares with a mean of 1.86 artifacts per sq m for the site as a whole, and 0.83 artifacts per sq m for areas outside EUs. While the area directly east of EU-2 contained bedrock exposures of andesite, none was the black glassy variety that was the focus of quarrying activities at LA 115544/AR-03-02-07-523.

Seven of the thirteen grid units examined in this unit were excavated in two levels, while only one level was removed from the remaining units. Stratum 1 was the main soil layer encountered in this area, and consisted of a brown silty loam containing occasional flecks of charcoal. While the charcoal may have been related to cultural activity in this area, it is more likely a result of natural fires, as no concentrations were found and no association with artifacts could be defined. Gravels were common, and Stratum 1 was heavily disturbed by rodent and root action. Most artifacts occurred in the upper 3 to 4 cm of fill, as did the highest concentration of gravels. Stratum 2 was encountered beneath Stratum 1 in one grid unit, and contained no cultural materials.

Figure 5.9 shows the surface distribution of chipped stone artifacts in EU-2. Only one concentration is visible, and occurs in the east-central part of the unit. The distribution of chipped stone artifacts in Level 1 is shown in Figure 5.10. Beyond the fact that there were considerably more artifacts in Level 1 than were found on the surface, there was a significant difference between surface and subsurface artifact distributions. While only one artifact concentration was noted on the surface, Level 1 appeared to contain three distinct artifact concentrations–one in the northeast corner of the unit, one in the east-central portion (somewhat north of the surface concentration), and a third in the southeast sector. Analysis of the chipped stone assemblage should help us determine whether these concentrations represent separate activities or are related to each other and the same set of activities.

EU-3

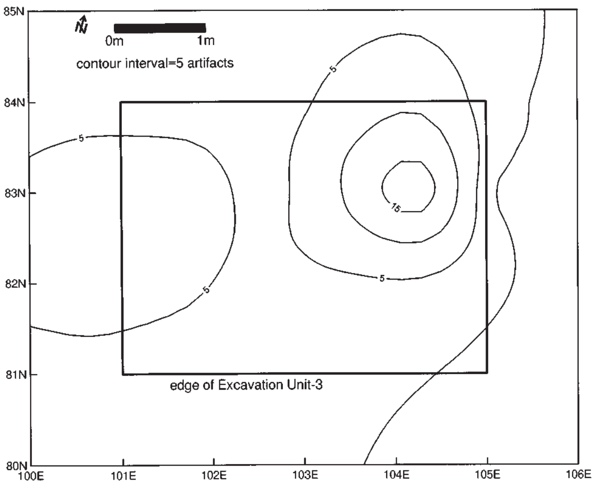

Figure 5.11. LA 115544/AR-03-02-07-523, EU-3: distribution of surface artifacts.

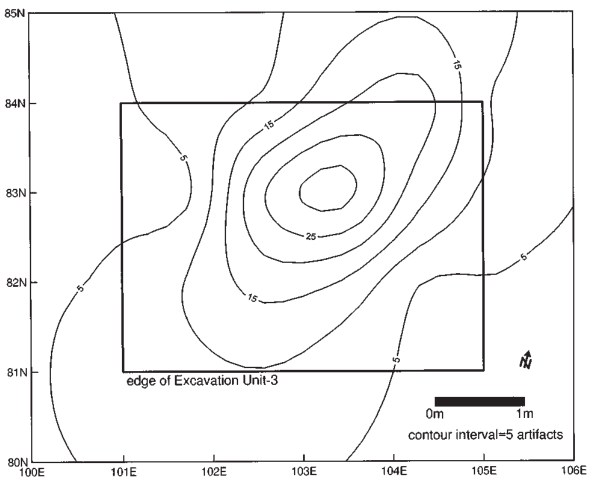

Figure 5.12. LA 115544/AR-03-02-07-523, EU-3: distribution of Level 1 artifacts.

This unit was placed in an area that sloped to the southwest and contained numerous outcropping boulders of coarse gray andesite. At 5.0 artifacts per sq m, EU-3 contained a higher than average concentration of surface materials. A quarried boulder of glassy black andesite measuring 30-by-26 cm was east of EU-3, outside project limits. Since that area was not extensively examined, other quarried boulders probably occur nearby as well. The close proximity of one or more quarried boulders may account for the cluster of surface artifacts found at EU-3. Thus, the debris in this area may reflect quarrying and initial reduction activities.

Six of the twelve grid units examined in this unit were excavated in two levels, one was excavated in three levels, and one level was removed from the remaining units. Stratum 1 was the main soil layer encountered in this area, and consisted of a brown silty loam containing occasional flecks of charcoal, probably resulting from natural fires rather than cultural activity. Gravels were common, and this layer was heavily disturbed by rodent and root action. Most artifacts occurred in the upper 3 to 4 cm of fill, as did the highest concentration of gravels. Stratum 1 ranged from 6 to 26 cm thick in this area, and averaged 15.2 cm thick. It was underlain by Stratum 2, a sterile reddish brown clay.

Figure 5.11 shows the surface distribution of chipped stone artifacts in EU-3. One concentration was present in the northeast corner of the unit. The distribution of chipped stone artifacts in Level 1 is shown in Figure 5.12. A single concentration remains visible, though its center shifted slightly to the southwest and it contained considerably more artifacts than were found on the surface. The configuration of the artifact distribution in this area suggests that a single reduction episode may have been responsible for most of the debris, possibly associated with material acquisition from nearby black glassy andesite boulders. This possibility is addressed in more depth in Chapter 7.

Summaries of Recovered Cultural Materials

Chipped Stone Artifacts

A total of 3,114 chipped stone artifacts was recovered from LA 115544/AR-03-02-07-523. Table 5.1 presents information on material type by artifact morphology. Over 96 percent of the assemblage is comprised of andesite, which was available in outcrops at the site. None of the other materials listed in Table 5.1 are available in the immediate vicinity of LA 115544/AR-03-02-07-523, and were carried in from elsewhere. Several materials, including Pedernal chert, Alibates chert, and obsidian, are exotics that were imported from considerable distances. Though most of the debitage reflects simple core-flake reduction, there is minimal evidence for biface reduction in the assemblage.

Formal tools occurred at the site, but were

TABLE 5.1. LA 115544/AR-03-02-07-523: CHIPPED STONE ARTIFACT MATERIAL TYPE BY ARTIFACT MORPHOLOGY

MATERIAL TYPE	ARTIFACT MORPHOLOGY							
	ANGULAR DEBRIS	CORE FLAKES	BIFACE FLAKES	CORES	COBBLE TOOLS	UNIFACES	BIFACES	TOTAL
Chert	9 0.8	12 0.6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	21 0.7
Pedernal chert	1 0.1	3 0.2	0 0.0	0 0.0	0 0.0	0 0.0	1 11.1	5 0.2
Alibates chert	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 33.3	0 0.0	1 0.03
Obsidian	9 0.8	59 3.1	4 66.7	0 0.0	0 0.0	1 33.3	7 77.8	80 2.6
Andesite	1,098 93.4	1,778 94.2	2 33.3	33 100.0	0 0.0	1 33.3	1 11.1	2,913 93.5
Coarse andesite	56 4.8	34 1.8	0 0.0	0 0.0	1 100.0	0 0.0	0 0.0	91 2.9
Siltstone	2 0.2	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	2 0.1
Quartzite	0 0.0	1 0.1	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1 0.03
Total Row Percent	1,175 37.7	1,887 60.6	6 0.2	33 1.1	1 0.03	3 0.1	9 0.3	3,114 100.0

Numbers in each cell are frequency and column percent.

uncommon and comprise only 0.4 percent of the recovered assemblage. The single cobble tool appears to be a chopper, though it exhibits no overt signs of having been used. We were unable to assign functions to two of the three unifaces, while the last artifact in this catagory is a scraper. Projectile points dominate the small assemblage of bifaces, comprising 55.6 percent of this category. Four specimens are examples of small corner-notched arrow points, while the last is the tip of an unidentifiable small projectile point form. The other bifacial tools include a drill shaft and three general purpose bifaces.

Faunal Artifacts

Only six fragments of bone were recovered during excavation, all from Level 1 of EU-1. Bone fragments were found in two general clusters, one in a northern extension of the excavation unit and a second in the west-central sector of the unit (Fig. 5.13). All fragments are burned, and none could be identified to the generic level. Two calcined fragments were found in Level 1 of 99N/101E. Both are pieces of large mammal bone; one is a piece of longbone shaft from a young adult, the other is an unknown fragment from a mature animal. A fragment of a mature, medium to large mammal longbone shaft was found in Level 1 of Unit 103N/101E. This specimen was burned when dry, and is calcined on the interior and blackened on the exterior. Level 1 of Unit 104N/104E contained a fragment of longbone shaft from a mature, medium to large mammal that was burned black. The final specimens were recovered from Level 1 in 101N/100E. Both are fragments of longbone shafts from mature medium to large mammals, and both were burned gray-black.

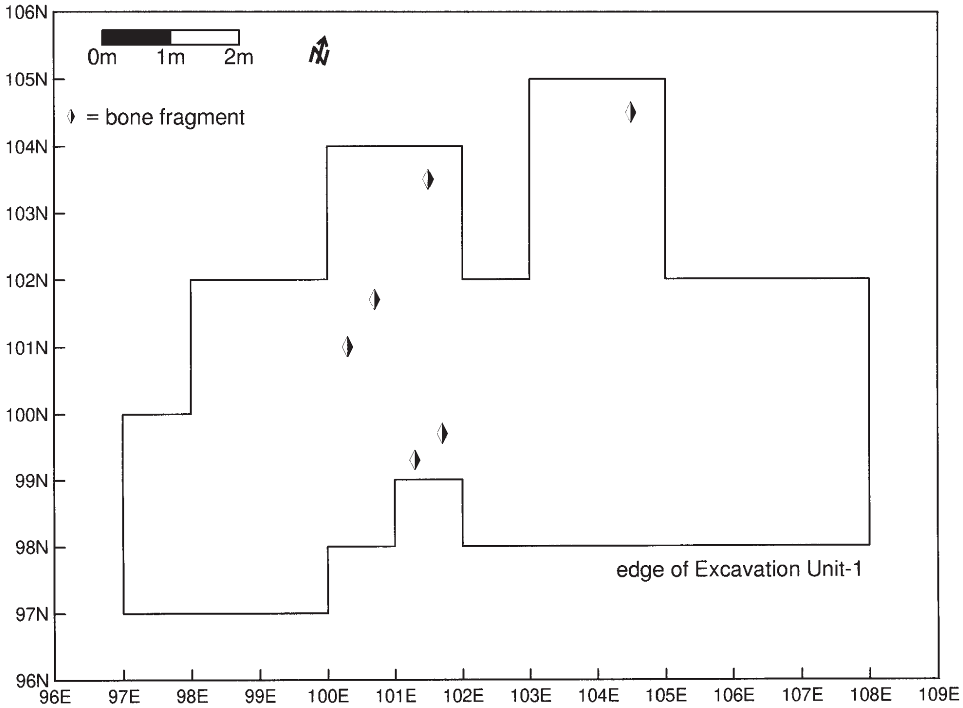

Figure 5.13. LA 115544/AR-03-02-07-523, EU-1, Level 1: distribution of bone fragments.

Discussion

LA 115544/AR-03-02-07-523 is identified as a quarry site because of the heavy use of high quality, glassy, black andesite in the assemblage, which outcrops at this location. However, the presence of other materials, especially obsidian and cherts, indicates that the procurement of andesite may not have been the only activity pursued at this site. Indeed, several formal tools also occur in the assemblage, and are indicative of a range of activities usually associated with a residential function. Thus, this portion of LA 115544/AR-03-02-07-523 may represent a short-term camp that was occupied while the andesite was being quarried. This possibility is discussed in much greater detail in Chapters 7 and 8.

Dating the Site

A lack of materials amenable to absolute dating severely cripples our ability to assign an accurate temporal range to the occupation of this part of the site. The only charcoal observed during excavation consisted of small flecks of uncertain origin. While there is a small possibility that the charcoal was produced by fires used during the human occupation of this part of the site, it is far more likely that it was actually generated by natural fires. Since the few flecks of charcoal that were noted were too small and fragile to be collected, this question cannot be addressed. Lacking any great depth of cultural deposits, the many pieces of obsidian recovered from the study area are also useless for dating this occupation.

In short, the only materials from this part of the site that might be capable of providing a date are the projectile points recovered during excavation. Use of the bow and arrow may have appeared in the Southwest by around A.D. 500 (Cordell 1984), and it is usually assumed that it rapidly supplanted the atlatl and dart. While adoption of the bow and arrow is generally considered to have accompanied the use of pottery (Cordell 1984:214), this is not necessarily true for the Northern Rio Grande region. Skinner et al. (1980) excavated an aceramic pithouse near Nambe Falls that contained evidence for the use of corn, and an array of small corner-notched arrow points. The bow and pottery may not have always been adopted together, and do not necessarily reflect a shift from hunting and gathering to a sedentary farming subsistence system. Some populations could have adopted the bow while remaining aceramic hunter-gatherers, with corn horticulture perhaps adding a seasonal surplus as is conjectured for the Late Archaic in the northern Southwest.

Unfortunately, small corner-notched projectile points are not accurate temporal indicators in the Northern Rio Grande region. Conventional wisdom has usually considered this style of projectile point to be indicative of the period between ca. A.D. 500 or 600 and 900, effectively the Early Developmental period. However, excavation of a seventeenth-century farmstead near Pecos yielded evidence for the production of this style of projectile point into the historic period (Moore n.d.a). The presence of small corner-notched arrow points in association with a lack of pottery and side-notched projectile points may be indicative of an Early Developmental period occupation. Conversely, the site could have been used as late as the seventeenth century (or even later). The former possibility is intriguing, since it suggests that the Taos area may not have been completely unused by human groups when it was initially occupied by people migrating into the area from further south during the Late Developmental period (Boyer et al. 1994). Indeed, oral traditions recorded at Taos Pueblo in the early 1900s suggest that those migrants did indeed encounter and assimilate hunter-gatherers living in or near the region (Stevenson 1906).

Unfortunately, the evidence recovered from LA 115544/AR-03-02-07-523 is simply too slim to allow us to suggest that the occupation that we examined reflects the presence of Early Developmental period hunter-gatherers. Later Puebloan residents of the region may have used this locality as a camp while collecting andesite for transport to a main residence location. Pottery does not have to have been used during this occupation, and if ceramic vessels were used, none appear to have been broken and discarded at this locality. A historic, non-Puebloan occupation is also possible. The Jicarilla Apache traded at Taos Pueblo at an early date, and, by the mid-1700s, had been driven off the Plains and into this region by the Comanche. A possible Athabaskan arrow point was noted outside project limits, 30 to 35 m to the east of our study area. Though not in direct association with our materials, the presence of this artifact probably indicates use of the quarry by Apaches. Thus, the only accurate date that can be assigned to the portion of LA 115544/AR-03-02-07-523 examined by this study is post-A.D. 500 or 600.

6

LA 115550/AR-03-02-07-528: AN ANDESITE REDUCTION SITE

Jeffrey L. Boyer and James L. Moore

LA 115550/AR-03-02-07-528 consists of a scatter of chipped stone artifacts on a narrow, east-west trending ridge approximately 2.6 km (1.6 miles) southwest of the village of San Cristobal (Fig. 1.1). The site is located on both sides of NM 522. Most of the site is within existing NMSHTD right-of-way, although the artifact scatter does extend beyond the right-of-way on both sides of NM 522 onto lands administered by the Carson National Forest.

LA 115550/AR-03-02-07-528 is approximately 122 m long east-west by 58 m wide north-south (Fig. 6.1). On the east side of NM 522 (Fig. 6.2), the site consisted of a sparse scatter of artifacts on the ridge top and northern slope. On the west side of NM 522 (Fig. 6.3), the site consisted of a sparse basalt flake scatter on the northern ridge slope and a higher-frequency scatter on the ridge top. Closer inspection of the ridge top revealed two very small concentrations of flakes thought to represent possible single-episode material reduction-tool production locations, and a larger concentration of basalt flakes thought to represent the location of several tool production and use activities.

FIELD DATA RECOVERY PROCEDURES

A site grid was established oriented to cardinal directions, with the primary site datum (Datum A; 100N/100E) placed on the west side of NM 522 (Fig. 6.1). A second datum (Datum B) was placed on the east side of the highway, in order to facilitate mapping and artifact collection on the side of the site. The site was photographed and mapped using a transit and stadia rod.

Investigations at the site began on the east side of NM 522. Surface artifacts were marked using pinflags. The distribution of surface artifacts showed that no artifact concentrations were present and that the surface artifacts were few in number and widely scattered. Additionally, the presence of gravels on the site surface indicated that the soils on the ridge were thin, allowing the gravel terrace comprising the ridge to be exposed, and minimizing the possibility of subsurface features or deposits. This conclusion is supported by the results of limited test excavations at site LA 115547/AR-03-02-07-526, located on the narrow ridge immediately north of LA 115550/AR-03-02-07-528, which showed very thin soil over the natural gravels on the east side of NM 522 (Levine and Boyer 1998). Consequently, our activities on the east side of the site were limited to mapping and to collecting, by point provenience, 23 surface artifacts on the ridge top and northern slope (Fig. 6.1).

On the west side of NM 522, surface artifacts were also marked with pinflags. An area on the ridge top 13.5 m long east-west by 7 m wide north-south had the highest surface artifact frequency. Surface artifacts in an area 20 m long east-west by 12 m wide north-south were collected in 1-by-1-m grid units, as were artifacts in nine other nearby 1-by-1-m grid units (Fig. 6.1). Figure 6.5 shows the artifact frequency in the collection area. The figure shows one small artifact concentration and a larger concentration. The second small concentration is not shown in Figure 6.5, but is represented in Figure 6.6 by the two-artifact contour line that crosses the northwest corner of Excavation Area 1.

The two small concentrations were initially designated as possible features (Features 1 and 2). Excavation areas consisting of four 1-by-1-m grid units were established around each possible feature. Their surface artifacts were photographed, mapped, and collected. A third datum (Datum C) was placed near Excavation Area 2, while Excavation Area 1 was located near Datum A. A single 10-cm level was excavated in each grid unit, the soil was

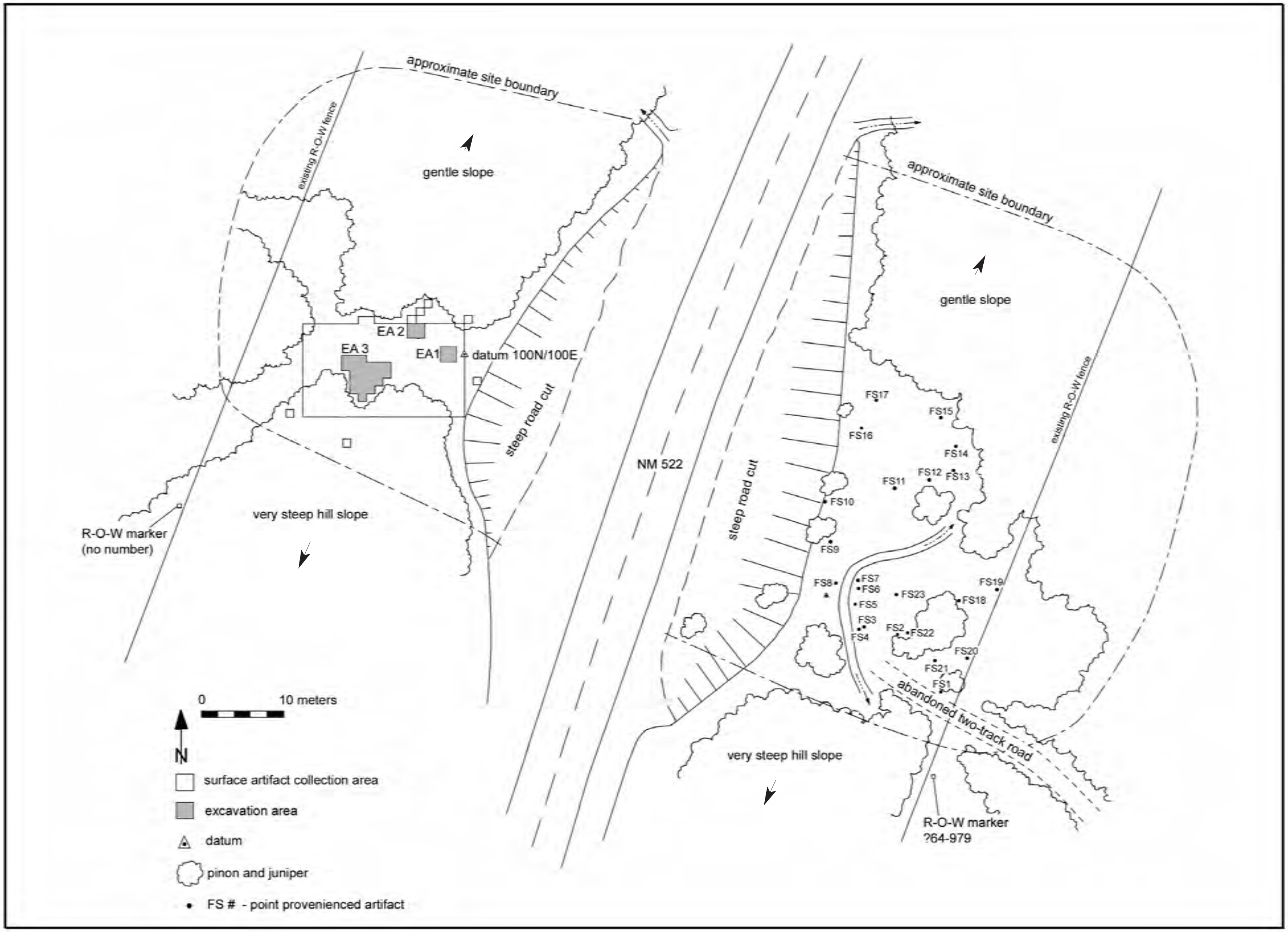

Figure 6.1. LA 115550/AR-03-02-07-528: site map

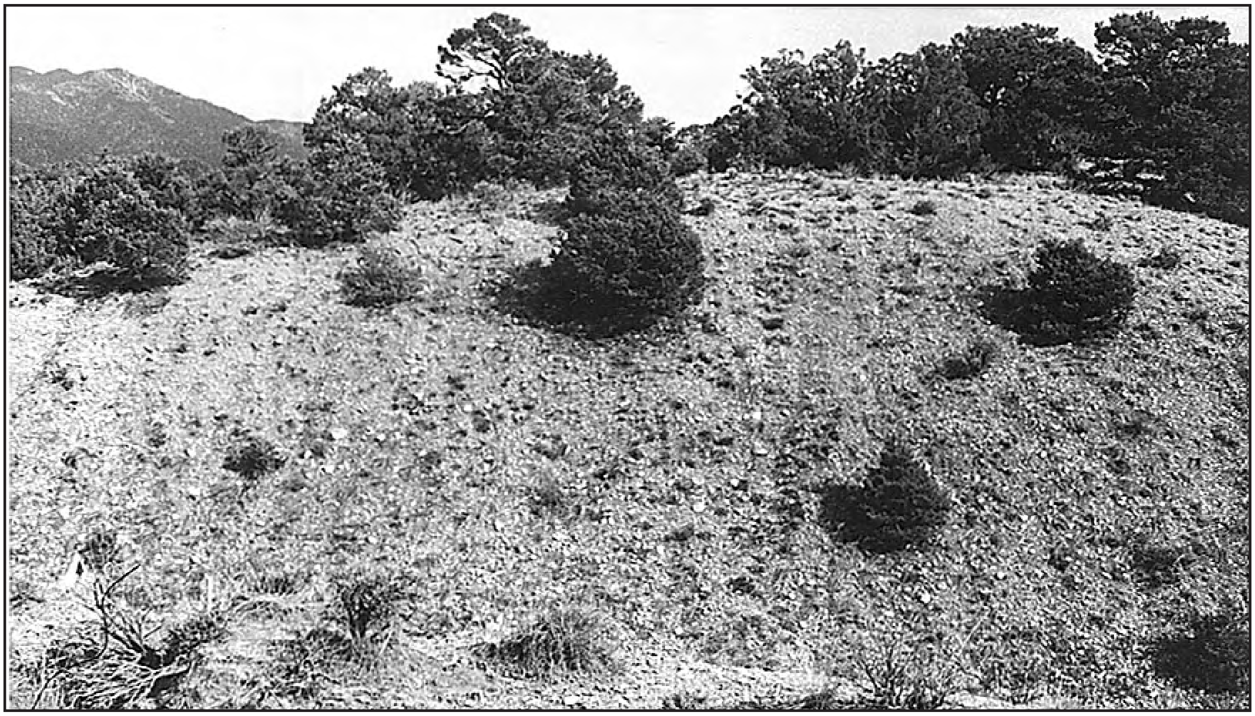

Figure 6.2. LA 115550/AR-03-02-07-528; east half of site. View from top of road cut, west side of NM 522.

Figure 6.3. LA 115550/AR-03-02-07-528; west half of site. View from top of road cut, east side of NM 522.

Figure 6.4. LA 115550/AR-03-02-07-528: Excavation Area 3. View to north.

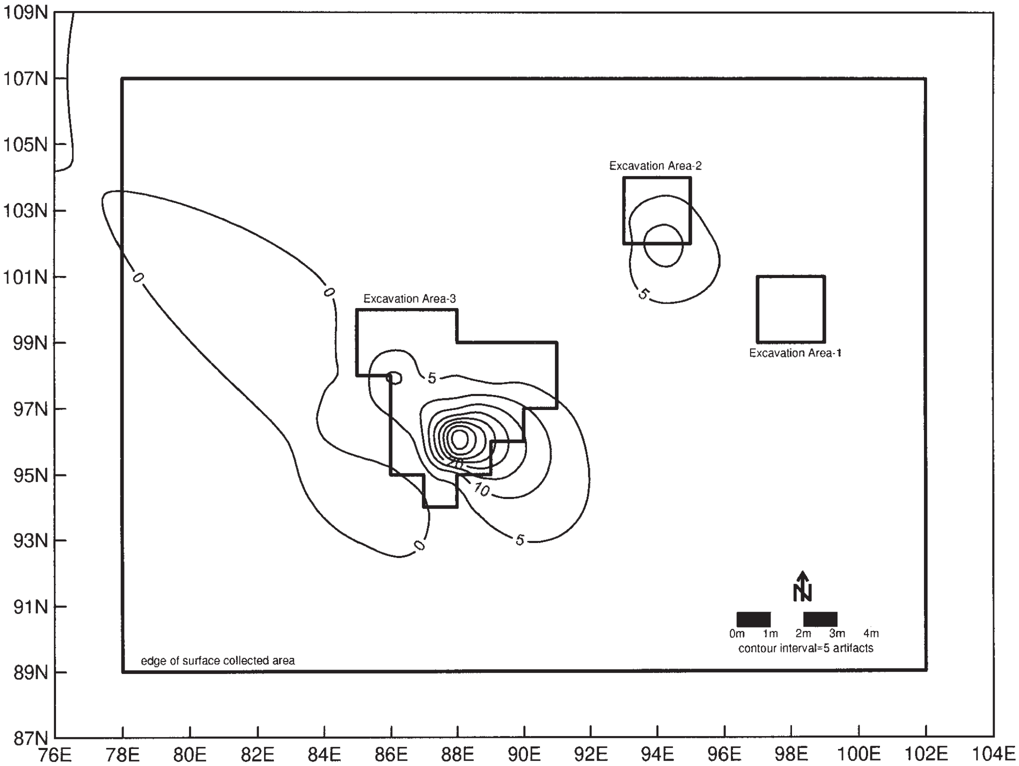

Figure 6.5. Distribution of surface artifacts in the west section of LA 115550.

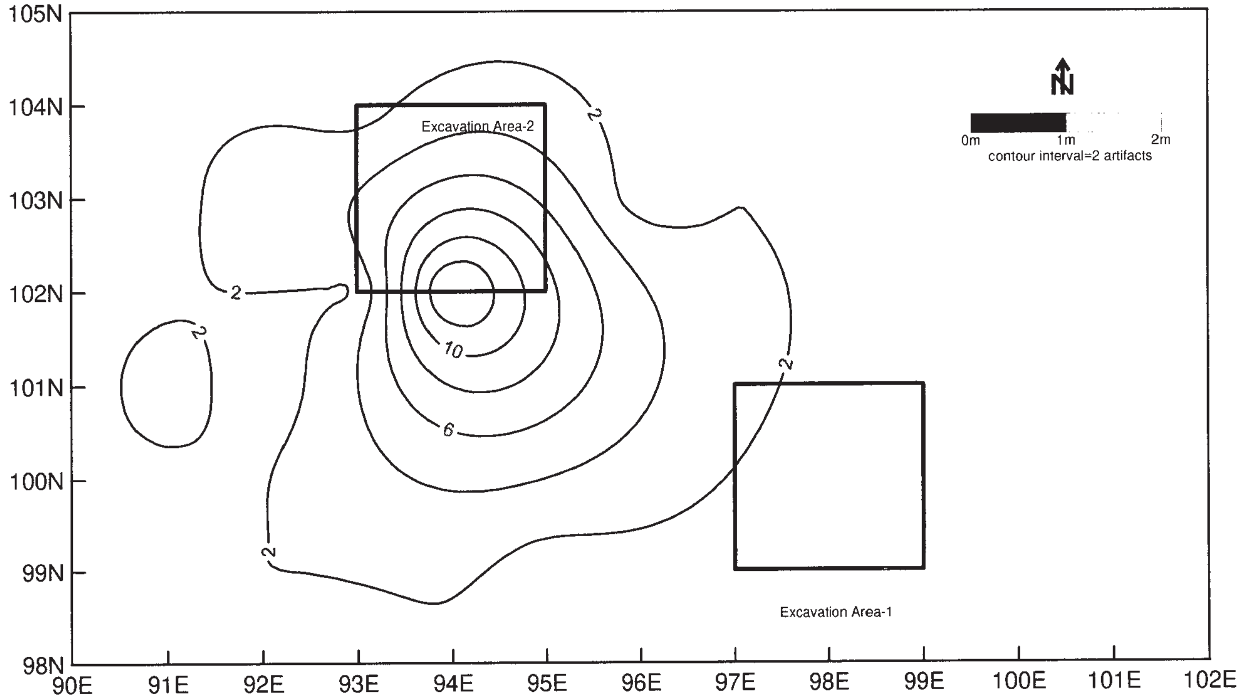

Figure 6.6. Surface distribution of artifacts in EA-1 and EA-2, LA 115550.

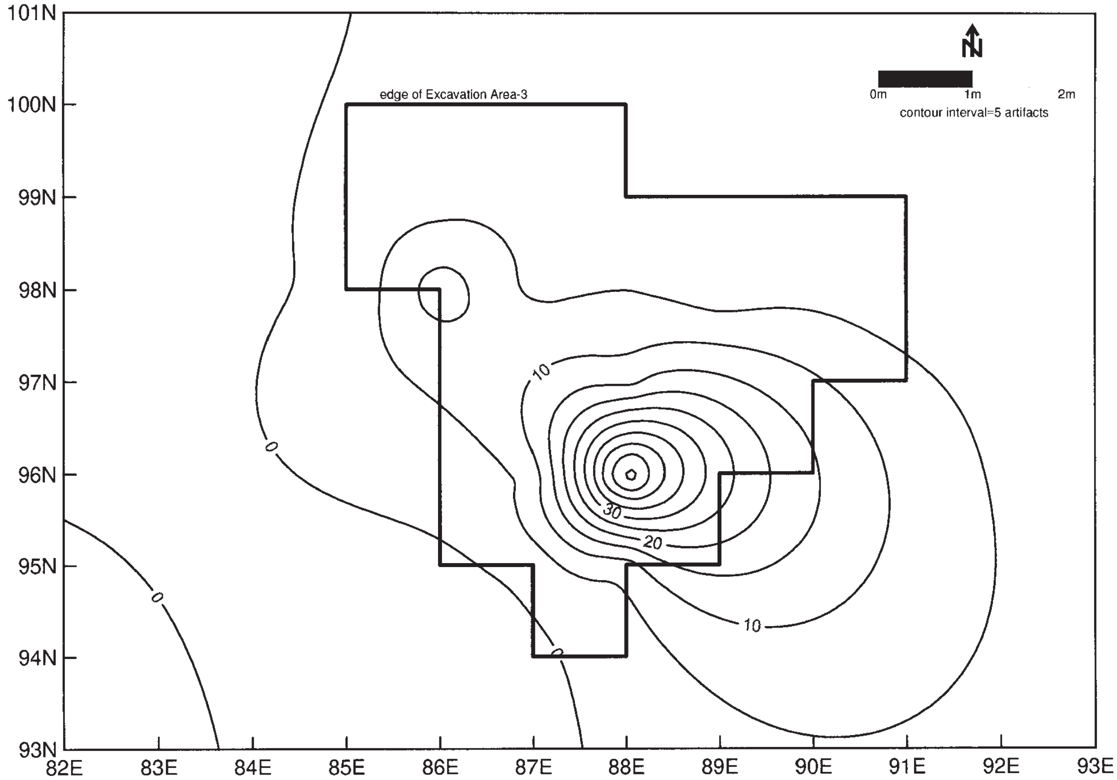

Figure 6.7. Surface distribution of artifacts in EA-3, LA 115550.

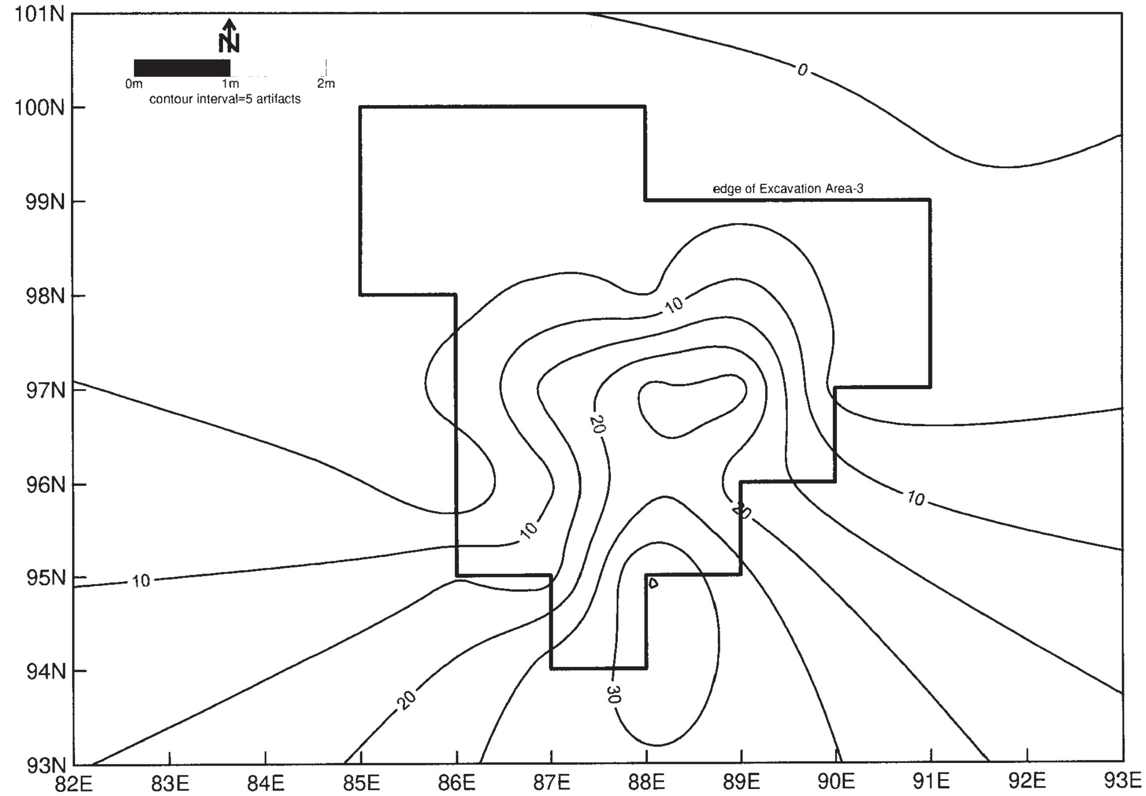

Figure 6.8. Distribution of artifacts in Level 1 of EA-3, LA 115550.

screened through ¼-inch mesh hardware cloth, and all artifacts were collected. Elevations were recorded relative to the arbitrary elevation of Datum A (10.00 m below main datum).

The larger artifact concentration was also defined by relatively high frequencies of surface artifacts, which were collected by grid unit (Figs. 6.5, 6.7). A fourth datum (Datum D) was placed near the concentration. A single 10-cm level was excavated in one 1-by-1-m grid unit within the concentration. Because it revealed the same stratigraphy as seen in Excavation Areas 1 and 2 (see description below), 21 1-by-1-m grid units were excavated by stratum, with only the topsoil stratum being removed. The soil from six units was screened through 1/8-inch mesh hardware cloth. The soil from the remaining 15 units was screened through ¼-inch mesh hardware cloth. All artifacts were collected.

Excavation Results

Excavations in Areas 1 and 2 revealed a thin stratum (3 to 5 cm) of red-brown, very gravelly, sandy clay topsoil containing organic material, small to large gravels, and large sands. Beneath this topsoil stratum was a red-brown clay lens over lenses and pockets of sands, clays, and small gravels. The latter point to the alluvial/colluvial origins of the gravel terrace. Small charcoal flakes were observed in some grid units at the transition from the topsoil stratum to the clay lens, but no association with cultural events, features, or deposits could be made. Artifacts were restricted to the topsoil stratum. Excavations did not reveal formal structure to possible Features 1 and 2, subsurface artifact frequencies were very low in these areas, and the feature designations were dropped.

Excavations in Area 3 revealed strata identical to those seen in Areas 1 and 2. However, subsurface artifact counts were considerably higher than in the other excavation areas, even in several units that yielded no surface artifacts (Fig. 6.8). Because soil from six units was screened through 1/8-inch mesh hardware cloth, many artifacts recovered are very small flakes. That the recovered artifacts range from very small flakes to core fragments suggested that a range of material reduction and tool manufacturing and use activities took place in this location. This possibility was examined during analyses and is discussed in Chapter 7. No formal features or definable deposits of artifacts were observed in Area 3.

RECOVERED CULTURAL MATERIALS: CHIPPED STONE ARTIFACTS

A total of 452 chipped stone artifacts was recovered from LA 115550/AR-03-02-07-528. Table 6.1 presents information on material type by artifact morphology for these materials. Over 99 percent of the assemblage is comprised of andesite, which was available in outcrops nearby. Other materials listed in Table 6.1 are not available in the immediate vicinity of LA 115544/AR-03-02-07-523, and were carried to the site from elsewhere. This assemblage appears to reflect simple core-flake reduction, and there is no evidence for biface reduction. No formal tools were recovered from LA 115550/AR-03-02-07-528, though a few informally used pieces of debitage were identified in the assemblage. The characteristics of the assemblage and their implications for understanding on-site activities and site structure are discussed in Chapters 7 and 8.

DATING THE SITE

No temporally diagnostic artifacts were observed on the site and no materials amenable to chronometric dating were recovered. As discussed in the project data recovery plan, determining dates for the site relies on interpreting characteristics of the artifactual assemblage. Conclusions regarding site dates are presented in detail in Chapters 7 and 8; the site probably dates to the Developmental period of the Puebloan occupation of the Taos Valley (ca. A.D. 1050-1225).

TABLE 6.1. LA 115550/AR-03-02-07-528: CHIPPED STONE ARTIFACT MATERIAL TYPE BY ARTIFACT MORPHOLOGY

MATERIAL TYPE	ARTIFACT MORPHOLOGY			
	ANGULAR DEBRIS	CORE FLAKES	CORES	TOTAL
Igneous undifferentiated	0 0.0	0 0.0	2 28.6	2 0.4
Gabbro	1 0.5	0 0.0	0 0.0	1 0.2
Andesite	193 99.5	251 100.0	3 42.9	447 98.9
Coarse andesite	0 0.0	0 0.0	1 14.3	1 0.2
Quartzite	0 0.0	0 0.0	1 14.3	1 0.2
Total Row percent	194 42.9	251 55.5	7 1.5	452 100.0

Numbers in each cell are frequency and column percent.

7

ANALYSIS OF THE CHIPPED STONE ASSEMBLAGES

James L. Moore

A total of 3,566 chipped stone artifacts was recovered from LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528. This is a larger number of artifacts than was expected, and exceeded the amount of detailed analysis permitted by the project budget. For this reason, a two-stage analytical procedure was instituted. Since the LA 115544/AR-03-02-07-523 assemblage was by far the larger, it was first rough-sorted by material type and artifact morphology, and then a sample was selected for detailed analysis. This staged approach provides material and morphology data for all artifacts recovered from LA 115544/AR-03-02-07-523, and detailed information on what is ideally a representative sample. All artifacts from LA 115550/AR-03-02-07-528 were examined in detail.

SAMPLING THE LA 115544/AR-03-02-07-523 ASSEMBLAGE

All artifacts from LA 115544/AR-03-02-07-523 were sorted by material type and artifact morphology. Each category was quantified, and information was entered into a computerized database. All potential formal and informal tools were separated for detailed analysis following the rough sort. This was done to provide a full range of data on tools that could be used to help examine site function and intrasite variation in activities. The rest of the assemblage was sampled to provide detailed information for the same analytical interests. No attempt was made to control for equivalent sample sizes between excavation units because of great difference in numbers of artifacts recovered from various parts of the site. Except for potential tools, only subsurface materials were selected for detailed analysis because they should have been less affected by cultural and noncultural disturbances.

Two rows of grid units along the 98E and 104E grid lines were selected for sampling in EU-1. Along with the potential tools identified in this area, this provided a total of 418 artifacts for detailed analysis–a 24.3 percent sample of the subsurface assemblage from this part of the site, and a 20.1 percent sample of all artifacts from this area.

Three rows of grid units were selected for analysis in EU-2, a north-south row along the 96E grid line, and two east-west rows along the 87N and 91N grid lines. Along with the potential tools identified from this area, this provided a total of 72 artifacts for detailed analysis–a 55.8 percent sample of the subsurface assemblage from this part of the site and a 45.3 percent sample of all artifacts from this area.

Along with potential tools, most artifacts from Level 1 in EU-3 were included in the detailed analysis sample. This provided a total of 169 artifacts or 92.9 percent of the subsurface materials from this part of the site, and 69.9 percent of all artifacts from this area.

In all, 664 artifacts from LA 115544/AR-03-02-07-523 were examined by the detailed analysis, a 21.3 percent sample of the total assemblage from this site. Of these artifacts, 657 are from subsurface contexts, and provide a 32.3 percent sample of materials recovered below the surface.

EXAMINATION OF THE LA 115544/AR-03-02-07-523 AND LA 115550/AR-03-02-07-528 ASSEMBLAGES

LA 115544/AR-03-02-07-523 is situated on a slope that contains outcrops of black glassy andesite and a coarser grained gray-brown variety of the same material. Most visible cobbles and small outcrops of glassy andesite exhibit quarrying scars and are surrounded by scatters of flaking debris. The coarse andesite also appears to have been used, though not as commonly as the glassy variety. LA 115550/AR-03-02-07-528 is on a shallow slope at the base of

Cerro Negro, and is not directly adjacent to a glassy andesite outcrop. Thus, it is possible that these sites served different purposes in prehistoric settlement and economic systems. Examination of the chipped stone assemblages should allow us to compare and contrast these sites, and see how they relate to other sites in the area.

Material Type and Quality Selection

The distribution of material types recovered from both sites is shown in Table 7.1. Glassy andesite is referred to simply as andesite from this point on, while coarse andesite retains its label. Both assemblages are dominated by andesites, which, when combined, comprise over 96 percent of the LA 115544/AR-03-02-07-523 assemblage and 99 percent of the assemblage from LA 115550/AR-03-02-07-528. Coarse andesite occurs in both assemblages, but comprises only small percentages. There is more material diversity in the LA 115544/AR-03-02-07-523 assemblage; this may be an effect of varying assemblage size, but it could also be indicative of differences in site function.

Table 7.1 also shows the distribution of materials in the detailed analysis sample from LA 115544/AR-03-02-07-523, with only subsurface artifacts considered. In many ways the material makeup of the sample is similar to that of the entire assemblage, but there are also differences. In particular, the sample contains fewer material types, a somewhat smaller percentage of andesite, and a higher percentage of cherts and obsidians. A chi-square analysis was used to compare these assemblages in order to test the importance of these differences. Several categories were combined to eliminate empty cells, including the various cherts, different types of obsidian, and metamorphic materials (quartzite and siltstone). At the 99 percent confidence level there is a small but strong chance that

TABLE 7.1. MATERIAL TYPES RECOVERED FROM BOTH SITES; FREQUENCIES AND COLUMN PERCENTAGES

MATERIAL TYPE	SITE AND ASSEMBLAGE		
	LA 115544	LA115544 (sample)	LA 115550
Chert	21 0.7	7 1.1	0 0.0
Pedernal chert	5 0.2	0 0.0	0 0.0
Alibates chert	1 0.03	2 0.3	0 0.0
Obsidian	55 1.8	13 2.0	0 0.0
Polvedera Peak obsidian	25 0.8	15 2.3	0 0.0
Andesite	2,913 93.5	604 91.9	447 98.9
Coarse andesite	91 2.9	16 2.4	1 0.2
Undifferentiated igneous	0 0.0	0 0.0	3 0.6
Siltstone	2 0.1	0 0.0	0 0.0
Quartzite	1 0.03	0 0.0	1 0.2
Totals	3,114	657	452

both assemblages may represent the same population (chi-square=9.538, df=4, significance=.049, phi=.0502). Standardized residuals indicate that the main differences between assemblages are in proportions of cherts and obsidians, with the sample containing higher than expected percentages of both. Thus, as far as material types are concerned, the sample represents a fair approximation of the entire assemblage, though there are significant differences.

Table 7.2 shows texture selection for each material type category represented in the LA 115550/AR-03-02-07-528 assemblage and the sample from LA 115544/AR-03-02-07-523. Medium-grained materials dominate both assemblages, though the percentage is much higher for LA 115550/AR-03-02-07-528. In both cases the dominance of medium-grained materials is determined by heavy use of andesite. However, over 25 percent of the LA 115544/AR-03-02-07-523 assemblage is comprised of glassy and fine-grained materials while less than 1 percent of materials from LA 115550/AR-03-02-07-528 are included in these categories. Comparing material texture distributions between these assemblages rather strongly indicates that they may represent different populations (chi-square=127.936, df=3, significance=<.0005, phi=.339).

The texture of a material often helped determine how it was used. Fine-grained and glassy materials are generally more suitable for the manufacture of unifacial and bifacial tools because they are easier to retouch and produce sharper edges than coarser-grained materials. Conversely, coarser-

TABLE 7.2. MATERIAL TEXTURE BY TYPE FOR LA 115550/AR-03-02-07-528 AND THE SAMPLE FROM LA 115544/AR-03-02-07-523; FREQUENCIES AND ROW PERCENTAGES

SITE AND ASSEMBLAGE	MATERIAL TYPE	MATERIAL TEXTURE			
		Glassy	Fine Grained	Medium Grained	Coarse Grained
LA 115544 (sample)	Chert	0 0.0	7 100.0	0 0.0	0 0.0
	Pedernal chert	0 0.0	1 100.0	0 0.0	0 0.0
	Alibates chert	0 0.0	2 100.0	0 0.0	0 0.0
	Obsidian	29 100.0	0 0.0	0 0.0	0 0.0
	Andesite	0 0.0	132 21.7	476 78.3	0 0.0
	Coarse andesite	0 0.0	1 5.9	16 94.1	0 0.0
	Totals	29 4.4	143 21.5	492 74.1	664
LA 115550	Undifferentiated igneous	0 0.0	0 0.0	2 66.7	1 33.3
	Andesite	0 0.0	4 0.9	443 99.1	0 0.0
	Coarse andesite	0 0.0	0 0.0	1 100.0	0 0.0
	Quartzite	0 0.0	0 0.0	1 100.0	0 0.0
	Totals	0 0.0	4 0.9	447 98.9	1 0.2

grained materials are usually better suited for activities that require a durable edge. Of course, when better quality materials were lacking, coarser-grained materials were often used for tool manufacture. When this occurred, the resulting tools often appear "clunky" and thick because of material limitations rather than the flintknapper's skill.

The high percentage of glassy and fine-grained materials in the sample from LA 115544/AR-03-02-07-523 suggest that formal tool manufacture may have been an important activity at this site. However, because most artifacts in these categories (over 83 percent) are andesite, which was quarried at the site, the higher percentage of finer-grained materials may simply be due to the presence of better quality deposits at this locality than were quarried by the occupants of LA 115550/AR-03-02-07-528.

Material Source

Materials can be divided into local and exotic categories based on the distance of their source from where they were used. Most materials from our sites were probably obtained from andesite outcrops and boulders on the west flank of Cerro Negro. A few others were probably available in nearby stream deposits. However, sources for some materials are quite distant from this area. Definite exotics include Pedernal chert, Alibates chert, and obsidian. Pedernal chert outcrops at several locations in the Chama Valley, 84 to 100 km southwest of our sites. Obsidians are unsourced except for the Polvedera Peak variety, but all were probably obtained in the Jemez Mountains about 110 km to the southwest. Alibates chert originates in the Texas Panhandle, and was obtained from quarries near present-day Amarillo over 600 km to the southeast. This was a tremendous distance to travel during the prehistoric and early historic periods when only canine and equine power were available to assist in transport.

What complicates this picture is the fact that rocks tend to move around the landscape by natural as well as artificial means. In particular, water moves rocks to places that are often quite distant from their source. For example, Pedernal chert outcrops in the Chama Valley, but is common in gravels in the Albuquerque area and occurs at least as far south as Las Cruces. Thus, we divide sources into primary and secondary types. Primary sources are locations where materials outcrop, while secondary sources are where materials were deposited by natural processes. Obsidian outcrops in several places in the Jemez Mountains, and those locales represent primary sources. It also occurs in gravel deposits along streams draining the mountains, as well as the Rio Grande where most of those streams ultimately empty. These are secondary sources.

The only way to determine whether materials were obtained from primary or secondary sources is to examine any cortex that might be present. Cortex is the outer rind on nodules, and represents material that has been altered by chemical or mechanical weathering. On nodules subjected to mechanical transport, cortex is usually battered, with sharp edges smoothed and rounded. This is rarely the case for cortex on materials at or near their source, which often evidence chemical but not mechanical weathering. Examination of cortex enables us to determine whether materials were obtained at primary or secondary sources. Of course, it must be kept in mind that many artifacts possess no cortex, and in other cases it is not possible to determine whether evidence of transport is present. Thus, any conclusions are based on a sample of the assemblage.

Table 7.3 illustrates the distribution of cortex types for LA 115550/AR-03-02-07-528 and the sample from LA 115544/AR-03-02-07-523. The only overlap in materials is in the andesite categories, which in both cases comprise over 94 percent of the cortical materials. As expected, cortex on andesites is almost exclusively nonwaterworn, indicating procurement at or near sources. The only exceptions are two pieces of coarse andesite from LA 115544/AR-03-02-07-523 for which cortex type could not be determined. These specimens are core flakes with cortical platforms and no dorsal cortex, and in both cases the amount of cortex present was too small to allow accurate identification. Considering the type of cortex on other andesite artifacts at this site and the presence of quarried outcrops and boulders, nonwaterworn cortex is probably present in both cases. Similarly, the undifferentiated igneous materials have nonwaterworn cortex and were undoubtedly procured from primary volcanic deposits, perhaps some distance from where

TABLE 7.3. CORTEX TYPE BY MATERIAL FOR LA 115550/AR-03-02-07-528 AND THE SAMPLE FROM LA 115544/AR-03-02-07-523; FREQUENCIES AND COLUMN PERCENTAGES

MATERIAL TYPE	SITE AND ASSEMBLAGE				
	LA 115544 (sample)			LA 115550	
	Waterworn	Nonwaterworn	Indeterminate	Waterworn	Nonwaterworn
Alibates chert	0	1	0	0	0
	0.0	100.0	0.0	0.0	0.0
Obsidian	1	3	0	0	0
	25.0	75.0	0.0	0.0	0.0
Andesite	0	92	0	0	64
	0.0	100.0	0.0	0.0	100.0
Coarse andesite	0	2	2	0	1
	0.0	50.0	50.0	0.0	100.0
Igneous undifferentiated	0	0	0	0	3
	0.0	0.0	0.0	0.0	100.0
Quartzite	0	0	0	1	0
	0.0	0.0	0.0	100.0	0.0
Total	1	98	2	1	68
	1.0	97.0	2.0	1.4	98.6

they were found.

As expected, cortex on the single piece of cortical quartzite is waterworn, which is indicative of procurement in secondary gravel deposits. What was not expected is that most cortical nonlocal materials reflect procurement in primary rather than secondary deposits. This includes three-quarters of the cortical obsidian and the single piece of cortical Alibates chert. Obsidian sources in the Jemez Mountains may have been within the use-range of the occupants of LA 115544/AR-03-02-07-523, though it is also possible that this material was obtained through exchange with other groups having better access to sources. In contrast, it is unlikely that the Alibates chert was collected during the seasonal rounds of the group that created this locality. Rather, it was either obtained through exchange, or was collected from an earlier site in the region.

In general, we consider materials collected from sources that are more than 10 to 15 km from a site to be nonlocal. This distance is based on ethnographic studies that suggest a 20- to 30-km round-trip is the maximum distance that hunter-gatherers will comfortably walk in a day (Kelly 1995:133). While more distant regions were probably also used, this zone represents the area that was most heavily exploited around residential sites. Sources of obsidian, Alibates chert, and Pedernal chert are all far outside the 20- to 30-km-diameter area considered to be the comfortable exploitation zone around our sites.

Other varieties of chert were not sourced and have no cortical surfaces, so we do not know whether they were obtained from primary or secondary sources. Gravel deposits along major streams that drain into the Rio Grande in this area contain some cherts, quartzites, and siltstones, and are likely sources for those materials. Using the distance-derived definitions of local and nonlocal sources, 4.8 percent of the LA 115544/AR-03-02-07-523 assemblage are nonlocal materials, and only local materials occur at LA 115550/AR-03-02-07-528.

Reduction Strategy

Debitage assemblages were examined to determine whether there was evidence for efficient or expedient reduction. Efficient reduction usually entails manufacture of tools in anticipation of use, enabling them to be transported from camp to camp until they are needed. In the Southwest, this strategy usually involved the manufacture of large bifaces that could be used for multiple purposes. Kelly (1988:731) defines three types of bifaces: (1) those used as cores as well as tools; (2) long use-life tools that can be resharpened; and (3) bifaces made to replace parts of existing composite tools. A fourth category can be added to this list–specialized bifaces. The latter were manufactured for a single purpose, and are mostly associated with expedient strategies where efficiency and weight conservation were not important. Bifaces with multiple functions and those with long use-lives were mostly associated with mobile lifestyles where efficiency was critical. It should be noted that these categories are not exclusive; mobile peoples also made and used specialized bifaces while sedentary populations manufactured general-purpose bifaces. The difference is a matter of degree–there was less use of specialized bifaces by mobile peoples, and less use of general-purpose bifaces by sedentary peoples. Thus, it is not necessarily the amount of evidence for biface manufacture in an assemblage that is indicative of reduction strategy and lifestyle, rather it is the types of bifaces that were made and used.

The first two categories of bifaces defined by Kelly (1988) were of necessity large in size. Bifaces that functioned as cores, general purpose tools, and blanks for the replacement of broken or lost tools had to be large to be useful. Similarly, bifaces manufactured with long use lives in mind had to be large enough to be resharpened. On the other hand, specialized bifaces needed to be no larger than was required by the task at hand. Projectile points provide a good contrast between these categories. In an efficient tool kit, broken projectile points can be replaced using the blanks that also served as cores and general purpose tools. Large projectile points could be used as knives, since they possess a fairly long edge and were usually set into detachable foreshafts. When broken they could often be reworked into a new form.

Small projectile points are evidence of a different focus. They were not as useful as cutting tools because their edges are short and would be awkward and inefficient to use, even when set into foreshafts. The thinness of these tools and the point of weakness created by notching often caused them to break during use, and because of their small size and the location of most breaks they usually could not be resharpened. Thus, small projectile points were effectively limited to a single function, and quite often to only one use.

Therefore, we differentiate between the manufacture of large bifaces and small bifaces in this analysis. Archaic hunter-gatherers tended to use large projectile points and large general purpose bifaces. We know little of later peoples who may also have been hunter-gatherers. However, we can suggest that hunter-gatherers in the Northern Rio Grande region probably adopted the bow and arrow when introduced (see discussion in Chapter 6). If so, large projectile points would no longer have been produced, but large general purpose bifaces should have continued to be used. Thus, late hunter-gatherers would be expected to use a combination of efficiently produced large general purpose bifaces and small specialized bifaces, the latter as tips for projectile weapons.

Efficient and Expedient Debitage Assemblages Modeled. Several attributes can be used to assess an assemblage and determine whether the reduction strategy was efficient, expedient, or a combination of both. Unfortunately, no single indicator can provide this information, so a range of attributes must be used.

Debitage assemblages reflecting a purely expedient strategy should contain lower percentages of noncortical debitage than those in which a purely efficient strategy was employed. Cortex is usually brittle and chalky and does not flake with the ease or predictability of unweathered material. This can cause problems during tool manufacture, so cortex is usually removed during the early stages of tool production. The manufacture of large bifaces is rather wasteful, and quite a bit of debitage must be removed before the proper shape is achieved. These flakes are carefully struck, and are generally smaller and thinner than flakes removed from cores. Thus, as bifaces are manufactured, large numbers of interior flakes lacking cortical surfaces are removed, and the proportion of noncortical debitage increases. Cortex removal is not as high a priority in expedient reduction, so the chance that a given piece of debitage will possess a cortical surface is higher.

The presence of biface flakes is good evidence that tools were manufactured at a site, though it is usually impossible to determine absolute number or type. A polythetic set of attributes was used to distinguish biface flakes from core flakes. Flakes fulfilling at least 70 percent of the attributes are biface flakes, while those that do not are core flakes. Biface flake length is indicative of the size of the tool being made, and lengths of 15 to 20 mm or more suggest that large bifaces were manufactured. However, when only small biface flakes are found the reverse is not necessarily true. While the presence of small biface flakes may indicate that small specialized bifaces were made, the possibility that they are debris produced by retouching large biface edges must also be considered. Large percentages of biface flakes in an assemblage suggest that tool production was an important activity. When those flakes are long, it is likely that large bifaces were made or used, and this in turn suggests an efficient reduction strategy. Though a lack of these characteristics is not definite proof of an expedient strategy, it does suggest that reduction was not focused on tool manufacture.

While platform modification is used in the polythetic set to help assign flakes to core or biface categories, it can also be used as an independent indicator of reduction strategy. This is because the polythetic set only identifies ideal examples of flakes removed during tool production. Many flakes produced during initial tool shaping and thinning are difficult to distinguish from core flakes. However, even at this stage of manufacture, platforms were usually modified to facilitate removal. While core platforms were also modified on occasion, this technique was not as common because the same degree of control over size and shape were unnecessary unless a core was being systematically reduced. Since this rarely occurred in the Southwest, it is likely that a large percentage of modified platforms in an assemblage is indicative of tool manufacture, while the opposite connotes core reduction. When there is a high percentage of modified platforms but few definite biface flakes, an early stage of tool manufacture may be indicated.

Since tool manufacture is usually more controlled than core reduction, fewer pieces of recoverable angular debris are produced. Thus, a high ratio of flakes to angular debris is considered indicative of tool manufacture, while a low ratio implies core reduction. Unfortunately, this is a bit simplistic, because the production of angular debris also depends on type of material, technique, and amount of force applied. Brittle materials shatter more easily than elastic materials, and hard-hammer percussion tends to produce more recoverable pieces of angular debris than soft-hammer percussion or pressure flaking. Use of excessive force can also cause materials to shatter. In general, though, as reduction proceeds, the ratio of flakes to angular debris should increase, and late stage core reduction as well as tool manufacture should produce high ratios.

Flake breakage patterns are also indicative of reduction strategy. Experimental data suggest there are differences in fracture patterns between flakes struck from cores and tools (Moore n.d.b). Though reduction techniques are more controlled during tool manufacture, flake breakage increases because debitage get thinner as reduction proceeds. Thus, there should be more broken flakes in an assemblage in which tools were made than in one that simply reflects core reduction. However, trampling, erosional movement, and other post-reduction impacts can also cause breakage and must be taken into account.

Much flake breakage during reduction is caused by secondary compression, in which outward bending causes flakes to snap (Sollberger 1986). Characteristics of the broken ends of flake fragments can be used to determine whether breakage was caused by this sort of bending. When a step or hinge fracture occurs at the proximal end of distal or medial fragments, the fracture indicates that the fragments were broken during manufacture. Characteristics diagnostic of manufacturing breaks on proximal fragments include "pieces à languette" (Sollberger 1986:102), negative hinge scars, positive hinges curving up into small negative step fractures on the ventral surface, and step fractures on dorsal rather than ventral surfaces. Breakage by processes other than secondary compression causes snap fractures. This pattern is common on debitage broken by trampling or erosion, but also occurs during reduction. Core reduction tends to create a high percentage of snap fractures, while biface reduction creates a high percentage of manufacturing breaks. But, since snap fractures can also indicate post-reduction damage, this may be the weakest of the attributes used to examine reduction strategy.

The presence of platform lipping is indicative of reduction technology, and is marginally related to strategy. Platform lipping is usually indicative of pressure flaking or soft-hammer percussion, though it sometimes occurs on flakes removed by hard hammers (Crabtree 1972). The former techniques were usually used to manufacture tools, so a high percentage of lipped platforms probably suggests a focus on tool manufacture rather than core reduction.

The pattern of scars left by earlier removals on the dorsal surface of a flake can also help define reduction strategy. Since bifacial reduction removes flakes from opposite edges, some scars originate beyond the distal end of a flake and run toward its proximal end. These are opposing scars, and indicate reduction from opposite edges. Opposing dorsal scars are indicative of biface manufacture, but can also occur when cores are reduced bidirectionally (Laumbach 1980:858). Thus, this attribute is not directly indicative of tool production, but can help in defining the reduction strategy used.

The ratio of flakes to cores on a site is another potential indicator of reduction strategy. As the amount of tool manufacture increases, so does the ratio between flakes and cores. The opposite should be true of assemblages in which expedient core reduction dominated; in that case the ratio between flakes and cores should be relatively low. A potential problem, of course, is that cores were often carried to another location if still useable while debris from their reduction was left behind. This would inflate the ratio and suggest that tool manufacture rather than core reduction occurred. The systematic reduction of cores can also produce high flake to core ratios.

Few of the attributes examined by this study are accurate independent indicators of reduction strategy. However, when combined, they should allow us to fairly accurately determine how materials were reduced at a site. A purely efficient debitage assemblage should contain high percentages of noncortical debitage, biface flakes, modified platforms, manufacturing breaks, lipped platforms, and flakes with opposing dorsal scars, and should have high flake to angular debris and flake to core ratios. Purely expedient debitage assemblages should contain lower percentages of noncortical debitage and low percentages of biface flakes, modified platforms, manufacturing breaks, lipped platforms, and flakes with opposing dorsal scars. They should also have low flake to angular debris and flake to core ratios. Unfortunately, "pure" assemblages are rare, and most can be expected to combine tool manufacture and core reduction.

Dorsal Cortex and Reduction Stage. While cortex has been discussed in the context of material source, its relation to reduction stage remains to be considered. Cortex is the weathered outer rind on nodules, and is rarely suitable for flaking or tool use. Outer sections of nodules transported by water often contain microcracks created by cobbles striking against one another, producing a zone with unpredictable flaking characteristics. Chemical weathering at outcrops can change the structure of the outer surface, making it more brittle or powdery and unsuitable for flaking. Because of these factors, cortical zones are typically removed and discarded because they flake differently than nodule interiors and may be cracked and flawed. Flakes have progressively less dorsal cortex as reduction proceeds, so dorsal cortex data can be used to examine reduction stages. Early stages are characterized by high percentages of flakes with much dorsal cortex, while the opposite suggests the later stages.

Reduction can be divided into two basic stages: core reduction and tool manufacture. Flakes are removed for use or modification during core reduction. Primary core reduction includes initial core platform preparation and removal of the cortical surface. Secondary core reduction entails removal of flakes from core interiors. This difference is rarely as obvious as these definitions make it seem. Both processes often occur simultaneously and rarely is all cortex removed before secondary reduction begins. They represent opposite ends of a continuum, and it is difficult to determine where one stops and the other begins. In this analysis, primary core flakes have 50 percent or more of their dorsal surfaces covered by cortex, and secondary core flakes have less than 50 percent dorsal cortex. This distinction can provide data on the condition of cores used at a site. For example, a lack of primary flakes suggests that initial reduction occurred elsewhere, while the presence of few secondary flakes may indicate that cores were carried off for further reduction. Primary core flakes represent the early stage of reduction, while secondary core flakes and biface flakes represent the later stages.

Table 7.4 shows percentages of dorsal cortex on flakes from both sites. Only flakes are used in this analysis because they are purposeful removals rather than unintentional by-products. Percentage of dorsal cortex on flakes tells us something about

TABLE 7.4. DORSAL CORTEX CATEGORIES FOR LA 115550/AR-03-02-07-528 AND THE SAMPLE FROM LA 115544/AR-03-02-07-523; FREQUENCIES AND ROW PERCENTAGES

SITE AND ASSEMBLAGE	DORSAL CORTEX (percent)		
	0	*1 - 49*	*50 - 100*
LA 115544 (sample)	354	16	18
	91.2	4.1	4.6
LA 115550	226	10	15
	90.0	4.0	6.0
Total	580	26	33
	90.8	4.1	5.2

TABLE 7.5. PERCENTAGES OF CORTICAL FLAKES AND ANGULAR DEBRIS FROM BOTH SITES

SITE AND ASSEMBLAGE	FLAKES	ANGULAR DEBRIS	OVERALL
LA 115544 (sample)	8.7	17.7	12.4
LA 115550	10.0	13.4	11.5

where a flake came from in a core. The same is not true of angular debris. Both assemblages are dominated by noncortical flakes and contain rather small percentages of primary and secondary cortical flakes. Chi-square analysis rather strongly suggests that both assemblages may belong to the same population for this attribute (chi-square=.559, df=2, significance=.756, phi=.03). The resemblance is even stronger when only andesites are considered (chi-square=.34, df=2, significance=.844, phi= .023). There is only one example of a cortical flake that is not andesite, and it is an obsidian flake from the LA 115544/AR-03-02-07-523 sample. Thus, andesites appear to have been reduced similarly at both sites.

The very small percentages of cortical andesite flakes were unexpected. There should be significantly higher percentages of cortical flakes at quarry sites, providing that materials were simply being obtained there, with some initial preparation also occurring. These percentages suggest that cores were significantly reduced at these loci, with mostly interior flakes being removed. Table 7.5 shows percentages of cortical flakes and angular debris for each site. While there is a higher percentage of cortical angular debris than flakes in both cases, the overall percentage of cortical debitage is still low for both sites. These percentages are comparable to those at the San Ildefonso Springs site (LA 65006), a multicomponent locale near San Ildefonso Pueblo (Moore n.d.b). At least three Late Archaic components were identified at that site. The manufacture of large bifaces was the main focus of each use, especially in Component 1, which contained the largest number of artifacts and features. Noncortical flakes comprise 93.1 percent of that assemblage, and 82 to 88.1 percent of the others. Thus, percentages of noncortical flakes in both of our assemblages are comparable to those from Archaic workshops where large biface manufacture occurred. Further analysis should show whether there are any other similarities between these sites.

Flake Platforms. Platforms are remnants of core or tool edges that were struck to remove flakes. Various types of platforms can be distinguished, providing information about the condition of the artifact from which a flake was removed as well as reduction technology. Cortical platforms are usually evidence of early stage core reduction, especially when dorsal cortex is also present. Single-facet platforms can occur at any time during reduction, but are most often associated with flakes removed from cores. Multifacet platforms are evidence of previous removals along an edge; they occur on both core and biface flakes, and suggest that the parent artifact was subjected to a considerable amount of earlier reduction.

Platforms were often modified to facilitate flake removal. Two types of modification were used–retouch and abrasion. While abrasion occurs on all types of platforms (except cortical), retouch is a distinct platform type. Both modifications result from rubbing an abrader across an edge–movement perpendicular to the edge removes microflakes and retouches it, while parallel movement causes abrasion. These processes increase the exterior angle of the platform, strengthening it and reducing the risk of shatter. Stronger platforms also increase control over the shape and length of flakes.

Platform types could not be defined in many instances. The most common reason was breakage, with the proximal fragment being absent. Two other processes also obscure platforms during reduction.

An unmodified or poorly prepared platform will sometimes crush when force is applied. Though the impact point may still be visible on a crushed platform, its original configuration is impossible to determine. Platforms can also collapse when force is applied, detaching separately and leaving a scar on the dorsal or ventral surface. Part of the platform is sometimes preserved on one or both sides of the scar. While these remnants are usually too small to allow identification of the original platform, they show where impact occurred and indicate that even though the platform is missing, flake dimensions may be complete. Platforms that were damaged by use or impact from natural processes were recorded as obscured.

The distribution of platform types by materials for each assemblage is shown in Table 7.6. Cortical platforms occur only on andesite, and for the most part on flakes that lack dorsal cortex. For the sample from LA 115544/AR-03-02-07-523, 82.6 percent of the andesite and both of the coarse andesite flakes with cortical platforms lack dorsal cortex, while 81.3 percent of those in the LA 115550/AR-03-02-07-528 assemblage also fall into this category. These are flakes removed from the interior of a core, with a cortical surface used as a striking platform. Of the andesite flakes that retain identifiable platforms, single-facet platforms are the dominant type for both sites, followed by multifacet. Large percentages of andesite flakes have missing or damaged platforms, and comparatively few have modified platforms.

This distribution contrasts with that of the other material types identified in the sample from LA 115544/AR-03-02-07-523. Of those flakes that retain identifiable platforms, multifacet platforms are the dominant type, and modified platforms are fairly common. Table 7.7 shows percentages of unmodified, modified, and missing/damaged platforms for all material types in these assemblages.

TABLE 7.6. DISTRIBUTION OF PLATFORM TYPES BY MATERIALS ON FLAKES FROM LA 115550/AR-03-02-07-523 AND THE SAMPLE FROM LA 115544/AR-03-02-07-528; FREQUENCIES AND COLUMN PERCENTS

PLATFORM TYPE	SITE AND ASSEMBLAGE				
	LA 115544 (sample)				LA 115550
	Cherts	Obsidians	Andesite	Coarse andesite	Andesite
Cortical	0	0	23	2	16
	0.0	0.0	6.4	22.0	6.4
Single facet	0	1	90	1	60
	0.0	6.3	25.0	11.1	23.9
Single facet and abraded	0	1	0	0	0
	0.0	6.3	0.0	0.0	0.0
Multifacet	2	3	69	4	30
	40.0	18.8	19.3	44.4	12.0
Multifacet and abraded	0	1	1	0	0
	0.0	6.3	0.3	0.0	0.0
Abraded	0	0	0	0	1
	0.0	0.0	0.0	0.0	0.4
Retouched	0	1	1	0	0
	0.0	6.3	0.3	0.0	0.0
Collapsed	0	5	81	1	68
	0.0	31.3	22.6	11.1	27.1
Crushed	0	1	2	0	1
	0.0	6.3	0.6	0.0	0.4
Absent (snap)	1	2	60	1	49
	20.0	12.5	16.8	11.1	19.5
Absent (manufacture)	2	1	29	0	26
	40.0	6.3	8.1	0.0	10.4
Obscured	0	0	2	0	0
	0.0	0.0	0.6	0.0	0.0
Total	5	16	358	9	251
Row percent	1.3	4.1	92.3	2.3	100.0

TABLE 7.7. PLATFORM CATEGORIES BY MATERIAL TYPE FOR LA 115550/AR-03-02-07-528 AND THE SAMPLE FROM LA 115544/AR-03-02-07-523; COLUMN PERCENTAGES

PLATFORM CATEGORY	SITE AND ASSEMBLAGE				
	LA 115544 (sample)				LA 115550
	Cherts	Obsidians	Andesite	Coarse Andesite	Andesite
Unmodified	40.0 (100.0)	25.0 (57.1)	50.8 (98.9)	77.8 (100.0)	42.2 (99.1)
Modified	0.0 (0.0)	18.8 (42.9)	0.6 (1.1)	0.0 (0.0)	0.4 (0.9)
Missing/damaged	60.0	56.3	48.6	22.2	57.4

Percentages with missing/damaged platforms deleted in parentheses.

Except for coarse andesite in the LA 115544/AR-03-02-07-523 sample, missing/damaged platforms comprise nearly half or more of each material type. By eliminating this category we can get a better idea of the contrast between modified and unmodified platforms. These values are shown in parentheses in Table 7.7. Except for the obsidians in the LA 115544/AR-03-02-07-523 sample, the amount of platform modification is low to nonexistent. This is especially true of andesite in both assemblages, with only about 1 percent exhibiting any form of modification.

Platform data contrast strongly with the conclusions drawn from examination of dorsal cortex. While the latter suggested that large biface manufacture might have been an important activity at these sites, platform data indicate the opposite. There seems to have been little reduction performed at these locales that required platform modification. Thus, it would appear that the manufacture of large bifaces from andesite was not an important activity in these components.

Debitage Type and Condition. The distribution of debitage types is shown in Table 7.8. This is one of the attributes for which we have data from the entire assemblage from LA 115544/AR-03-02-07-523. Over half of each assemblage is comprised of core flakes, with angular debris making up most of the remaining debitage. Bipolar flakes are rare, but occur in all three assemblages, and a few biface flakes were identified in both assemblages from LA 115544/AR-03-02-07-523. While all bipolar flakes are andesite, biface flakes of this material are rare. The only examples identified were in the rough sort from LA 115544/AR-03-02-07-523, one of which appears to be a small notching flake.

The sample from LA 115544/AR-03-02-07-523 contains a slightly higher percentage of angular debris and a correspondingly lower percentage of core flakes than was derived for the entire assemblage. Percentages of biface flakes are similar, while a single bipolar flake was identified in both assemblages. Nearly equivalent percentages of chert angular debris and core flakes may indicate that some of this material was reduced at LA 115544/AR-03-02-07-523. Similarly, the amount of obsidian debitage suggests that it was also flaked at the site, but the veritable lack of obsidian angular debris may indicate that existing cores, biface cores, or tools were transported here for limited reduction. A few pieces of Pedernal chert debitage were identified in the rough sort assemblage, but are missing from the sample. It is feasible that these specimens were reduced elsewhere and transported to the site as debitage. The same is likely for the single quartzite flake identified in the rough sort.

The presence of a single piece of undifferentiated igneous angular debris at LA 115550/AR-03-02-07-528 is suspicious. The likelihood that this type of artifact would be transported from one site to another is low, so it may not actually be an artifact. Similar conclusions can be drawn about the two pieces of siltstone angular debris identified in the rough sort for LA 115544/AR-03-02-07-523. These specimens may not actually be artifacts.

The ratio between flakes and angular debris can be a good indicator of reduction strategy. All three assemblages have low flake to angular debris ratios–1.61:1 for the rough sort from LA 115544/AR-03-02-07-523, 1.50:1 for the LA 115544/AR-03-02-07-523 sample, and 1.29:1 for the LA 115550/AR-03-02-07-528 assemblage. These ratios are very low when compared with other sites around the state. Vierra (1990:67) pro-

TABLE 7.8. DEBITAGE TYPES BY MATERIAL TYPES FOR EACH ASSEMBLAGE; FREQUENCIES AND ROW PERCENTAGES

MATERIAL TYPE	SITE AND ASSEMBLAGE										
	LA 115544 (whole assemblage)				*LA 115544 (sample)*				*LA 115550*		
	Angular Dbris	Core Flakes	Bipolar Flakes	Biface Flakes	Angular Debris	Core Flakes	Bipolar Flakes	Biface Flakes	Angular Debris	Core Flakes	Bipolar Flakes
Chert	9	10	0	1	3	3	0	1	0	0	0
	45.0	50.0	0.0	5.0	42.9	42.9	0.0	14.3	0.0	0.0	0.0
Pedernal chert	1	3	0	0	0	0	0	0	0	0	0
	25.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alibates chert	0	0	0	1	0	0	0	1	0	0	0
	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Obsidians	9	59	0	4	5	15	0	1	0	0	0
	12.5	81.9	0.0	5.6	23.8	71.4	0.0	4.8	0.0	0.0	0.0
Undifferentiated igneous	0	0	0	0	0	0	0	0	1	0	0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0
Andesite	1,098	1,777	1	2	244	357	1	0	193	247	4
	38.2	61.7	0.04	0.07	40.5	59.3	0.2	0.0	43.5	55.6	0.9
Coarse andesite	56	34	0	0	7	9	0	0	0	0	0
	62.2	37.8	0.0	0.0	43.8	56.2	0.0	0.0	0.0	0.0	0.0
Siltstone	2	0	0	0	0	0	0	0	0	0	0
	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Quartzite	0	1	0	0	0	0	0	0	0	0	0
	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	1,175	1,884	1	8	259	384	1	3	194	247	4
	38.3	61.4	0.03	0.3	40.0	59.4	0.2	0.5	43.6	55.5	0.9

vides flake to angular debris ratios from sites in northwest New Mexico, where the average ratio for Archaic sites is 4.34:1; Puebloan residential sites have a ratio of 2.52:1, while Puebloan limited-use locales have a mean ratio of 3.40:1. Ratios of 2.42:1 and 3.12:1 were derived for Valdez phase residential sites near Pot Creek Pueblo (Moore 1994), and are similar to those presented by Vierra. A study of assemblages from 25 Archaic through late Pueblo sites near Luna and Reserve in the highland Mogollon region provided flake to angular debris ratios of 4.71:1 for the late Archaic, a range of 3.35:1 to 3.78:1 for the early Pithouse through early Pueblo periods, and 1.40:1 for the late Pueblo period (Moore 2000). Our ratios are similar to that for the late Pueblo period in the Luna study, but when a very brittle material (Luna Blue agate) was removed from consideration, the late Pueblo period ratio was 2.78:1, more in line with those from Puebloan sites in other areas. Flake to angular debris ratios for late Archaic components at the San Ildefonso Springs site range from 6.68:1 to 14.55:1 (Moore 2001). Clearly, flake to angular debris ratios are very low at LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528, considerably lower than expected for a prehistoric Puebloan occupation, much less for Archaic use.

Are the low flake to angular debris ratios at these sites a result of the type of material being flaked or is some other process at work? Three glassy black andesite nodules from Cerro Negro were reduced to examine this question. All three were reduced by hard-hammer percussion using Thunderbird rhyolite and quartzite hammerstones. Two nodules were flaked using strong support on the flintknapper's thigh, the third was flaked with minimal support in a hand. Not unexpectedly, the latter produced the most angular debris. Several observations of interest were made during the experiment, but were not quantified. Andesite is a fairly brittle material, and usually fractures conchoidally. Flakes often broke during reduction, and many were split by the force applied. Multiple flakes were sometimes removed by a single blow.

Debitage from reduction of each nodule was collected and passed through a ¼-inch mesh hardware cloth to replicate field recovery methods. The small fraction that went through the screen was discarded and the remaining debitage was rough-sorted into flake (whole and fragments) and angular debris categories. In all, the experiment produced three cores, 379 flakes, and 153 pieces of angular debris for a total of 535 artifacts. Flake to angular debris ratios were 2.42:1 and 3.80:1 for the nodules reduced with strong support, and 1.89:1 for the weakly supported nodule. This provides an average ratio of 2.48:1. Considering that prehistoric flintknappers were more skilled at reduction and more familiar with the material, this ratio probably represents a minimum. Thus, experimental results suggest that flake to angular debris ratios for our assemblages are very low, especially for LA 115550/AR-03-02-07-528, and that a process other than reduction may be responsible for these values.

Table 7.9 provides flake to angular debris ratios by material type for each assemblage. In this case differences between the whole and sample assemblages from LA 115544/AR-03-02-07-523

TABLE 7.9. FLAKE TO ANGULAR DEBRIS RATIOS BY MATERIAL TYPES FOR EACH ASSEMBLAGE

MATERIAL TYPE	SITE AND ASSEMBLAGE		
	LA 115544		LA 115550
	Sample	Whole Assemblage	
Chert	1.33:1	1.33:1	-
Pedernal chert	-	3.00:1	-
Obsidian	1.50:1	7.50:1	-
Polvadera Peak obsidian	10.0:1	6.00:1	-
Andesite	1.47:1	1.62:1	1.30:1
Coarse andesite	1.21:1	0.61:1	-

are sometimes significant. The generic chert ratio is very low, but this may be deceptive. Few pieces of chert debitage were identified in either assemblage, and at least two varieties are present. Similarly, the moderate ratio for Pedernal chert may be misleading, since only four artifacts of this material were recovered. Generic obsidian has a low ratio in the sample assemblage, but a fairly high ratio for the entire assemblage. Polvedera Peak obsidian has a fairly high ratio in both cases. The ratio for andesite is low in all three assemblages, but is somewhat lower for the sample from LA 115544/AR-03-02-07-523 than it is for the entire assemblage. Coarse andesite also has a low ratio at LA 115544/AR-03-02-07-523, but in this case it is higher for the sample than for the whole assemblage.

The cause for the low andesite flake to angular debris ratios is fairly clear–flakes of this material have probably been removed from the assemblages. A similar process may also be responsible for the low ratio derived for generic cherts. However, in that case so few pieces of debitage were recovered that this remains unclear. A minimal amount of reduction of Pedernal chert may have occurred, but once again the population size is so small that the actual cause is unclear. Both varieties of obsidian seem to have been fairly efficiently reduced at LA 115544/AR-03-02-07-523, though in the areas examined by excavation this may not be so. The low flake to angular debris ratio for coarse andesite may not be meaningful, since limited flaking of this material resulted in mostly angular debris. Thus, for coarse andesite the ratio may be a result of the type of material being reduced rather than some other process.

Core flake portions are shown for both sites in Table 7.10. Bipolar and biface flakes are not included because there are few specimens of either. None of the chert flakes is whole. A third of the obsidian flakes are complete, another third are proximal fragments, and over a quarter are lateral fragments. Surprisingly, there are no distal obsidian flake fragments; those fragments may have shattered or been too small for recovery. About a quarter of the andesite flakes in each assemblage are complete. Proximal fragments outnumber distal fragments nearly 3 to 1 in the LA 115544/AR-03-02-07-523 sample, but only 1.3 to 1 in the LA 115550/AR-03-02-07-528 assemblage. Similar percentages of proximal and distal fragments in the latter may be an indication of post-reduction breakage, which is unlikely for the andesite and obsidian core flake assemblages in the LA 115544/AR-03-02-07-523 sample.

The low percentages of whole andesite flakes are probably attributable to removal of an uncertain number of specimens from the site. The total lack of whole chert flakes at LA 115544/AR-03-02-07-523 may have been caused by the same process, but again the small number of specimens in this category renders this conclusion suspect. While obsidian is more fragile than either of these materials,

TABLE 7.10. CORE FLAKE PORTIONS BY MATERIAL TYPE FOR LA 115550/AR-03-02-07-528 AND THE LA 115544/AR-03-02-07-523 SAMPLE; FREQUENCIES AND COLUMN PERCENTAGES

FLAKE PORTION	SITE AND ASSEMBLAGE				
	LA 115544 (sample)				LA 115550
	Chert	Obsidian	Andesite	Coarse andesite	Andesite
Whole	0	5	92	3	65
	0.0	33.3	25.8	33.3	26.3
Proximal	1	5	110	5	51
	33.3	33.3	30.8	55.6	20.6
Medial	1	1	38	0	15
	33.3	6.7	10.6	0.0	6.1
Distal	1	0	36	1	39
	33.3	0.0	10.1	11.1	15.8
Lateral	0	4	81	0	77
	0.0	26.7	22.7	0.0	31.2

there was a higher percentage of whole obsidian flakes in the LA 115544/AR-03-02-07-523 sample. This is undoubtedly meaningful, and may indicate (mostly) whole flakes were removed from the LA 115544/AR-03-02-07-523 sample, affecting the distribution of flake portions.

Large percentages of andesite flake fragments were broken during removal–40.4 percent of the LA 115544/AR-03-02-07-523 sample and 43.4 percent for LA 115550/AR-03-02-07-528. The remainder from both assemblages exhibit snap fractures. A pilot study of flake breakage patterns found manufacturing breaks on 37.5 percent of flakes broken during experimental reduction of four obsidian cores (Moore 2001). Flakes broken during the manufacture of obsidian bifaces were also quantified in that experiment, with manufacturing breaks occurring on 73.2 percent of specimens. Though hardly scientific, these results suggest that there are quantifiable differences in breakage patterns between core and biface reduction.

Our percentages are close to those derived for core reduction, and are much smaller than those for biface reduction. Even accounting for differences in material type, breakage patterns are more indicative of core reduction than of tool manufacture. While similar percentages of proximal and distal fragments at LA 115550/AR-03-02-07-528 led us to suggest that post-reduction impact may have been responsible for breakage at that site, the relatively high percentage of manufacturing breaks argues against this. Chi-square analysis of this attribute strongly suggests that both assemblages may represent the same population (chi-square=.408, df=1, significance=.523, phi=.03). Thus, it is likely that the same process was responsible for most flake breakage in both cases. Considering the large amount of fracture during reduction seen in the experimental reduction of three andesite nodules, most breakage in the LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 assemblages probably occurred during removal from cores.

Platform Lipping and Dorsal Scar Orientation. These data are shown in Tables 7.11 and 7.12. Lipped platforms are common in both assemblages, and there is a fairly strong probability that they may represent the same population (chi-square=1.91, df=1, significance=.167, phi=.079). The LA 115544/AR-03-02-07-523 sample includes two biface flakes with platforms, both of which have lipped platforms. With those specimens eliminated from consideration, the resemblance between these assemblages is even greater (chi-square=1.606, df=1, significance=.205, phi=.072), and suggests that similar reduction techniques were used at both locales. While hard-hammer percussion appears to have been the main technique used, a significant percentage of both assemblages exhibits evidence of soft-hammer percussion. This is an important point, because soft-hammer percussion tends to cause less material shattering. Over a third of the platforms on andesite flakes in the LA 115544/AR-03-02-07-523 sample and over a quarter of those from LA 115550/AR-03-02-07-528 are lipped. This suggests that much of the reduction of these materials was accomplished with soft rather than hard hammers. If so, flake to angular debris ratios should

TABLE 7.11. PLATFORM LIPPING DATA FOR LA 115550/AR-03-02-07-528 AND THE SAMPLE FROM LA 115544/AR-03-02-07-523; FREQUENCIES AND COLUMN PERCENTAGES

LIPPING	SITE AND ASSEMBLAGE	
	LA 115544 (sample)	LA 115550
Present	70 34.8	29 27.1
Not present	131 65.2	78 67.9
Totals	201 100.0	107 100.0

TABLE 7.12. DORSAL SCAR DATA FOR LA 115550/AR-03-02-07-528 AND THE SAMPLE FROM LA 115544/AR-03-02-07-523; FREQUENCIES AND COLUMN PERCENTAGES

DORSAL SCARS	SITE AND ASSEMBLAGE	
	LA 115544 (sample)	LA 115550
Present	369 95.1	234 93.2
Not Present	19 4.9	17 6.8
Totals	388 100.0	251 100.0

have been even higher than those derived for the experimentally reduced nodules, and this could be indicative of an even larger amount of flake removal from the site.

Opposing dorsal scars are rare in both assemblages, and there is a strong probability that they may represent the same population (chi-square=1.01, df=1, significance=.315, phi=.04). This relationship holds up but is weaker when only whole flakes are considered (chi-square=2.066, df=1, significance=.151, phi=.111). Opposing dorsal scars represent earlier removals from platforms at the opposite edge of a core or biface from that used to remove the flake being examined. Some consider the presence of this type of scar indicative of biface manufacture. Only one of three biface flakes in the LA 115544/AR-03-02-07-523 sample exhibits opposing dorsal scars, as do four of five bipolar flakes. The predominance of opposing dorsal scars in the bipolar flake category was expected, since force was applied from two directions at once in the formation of these flakes. However, a larger proportion of biface flakes should also exhibit this attribute. The only biface flake with opposing dorsal scars is a distal fragment, while both specimens that lack opposing dorsal scars are proximal fragments. The latter may simply have not possessed enough dorsal surface for opposing scars to show. When biface and bipolar flakes are eliminated from consideration, there is a very strong probability that both assemblages may belong to the same population for this attribute (chi-square=.496, df=1, significance=.482, phi=.028).

It is possible that some flakes with lipped platforms or opposing dorsal scars that are identified as having been removed from cores are incorrectly categorized and instead represent atypical biface flakes. This could occur for several reasons. Flakes that are too fragmentary for positive assignment may be classified as core flakes by default. Debitage from early in the biface manufacturing process may be present but lacks some of the attributes needed for accurate inclusion with other biface flakes. By comparing several attributes it should be possible to reassess these specimens and determine whether their original morphological assignment was correct.

Only three core flakes from the LA 115544/AR-03-02-07-523 sample and two from LA 115550/AR-03-02-07-528 possess both lipped platforms and opposing dorsal scars. One core flake from the LA 115544/AR-03-02-07-523 sample possesses both a modified platform and opposing dorsal scars. No core flakes exhibit platform modification in association with lipping and opposing dorsal scars. While the specimens that exhibit lipped platforms and opposing dorsal scars may represent early stage biface flakes that were not identified by the polythetic set, this is by no means certain. The polythetic set appears to have correctly assigned most flakes to the proper category. Since some core flakes exhibit opposing dorsal scars or lipped platforms, it is possible that a few possess both attributes.

Flakes to Cores and Bifaces. Frequencies and percentages of flakes, cores, and bifaces are shown in Table 7.13. Only whole flakes and proximal fragments are considered, providing a minimum number of individual removals. No evidence of biface manufacture or use is visible in the LA 115550/AR-03-02-07-528 assemblage. While bifaces were used at LA 115544/AR-03-02-07-523, there is little evidence for their manufacture. Biface flakes in this assemblage include the proximal fragment of a chert flake, the distal fragment of an Alibates chert flake, and the proximal fragment of an obsidian flake; none have modified platforms. If flakes with modified platforms are included with this small assemblage, we can add three more obsidian flakes and three andesite flakes.

Obsidians and cherts also dominate the assemblage of bifaces recovered from LA 115544/AR-03-02-07-523. Five of seven obsidian bifaces are small projectile points, and the other two are fragments of small tools that could not be assigned a specific

TABLE 7.13. FLAKES (WHOLE AND PROXIMAL FRAGMENTS), CORES, AND BIFACES FOR EACH ASSEMBLAGE; FREQUENCIES AND ROW PERCENTAGES

SITE AND ASSEMBLAGE	ARTIFACT TYPE			
	Core Flakes	Biface Flakes	Bifaces	Cores
LA 115544 (sample)	222 93.7	2 0.8	9 3.8	4 1.7
LA 115550	119 94.4	0 0.0	0 0.0	7 5.6

function. Other bifaces include a Pedernal chert drill bit and the tip of a large andesite biface that was broken during manufacture. Four of the five points are broken; two were fractured during use, while the types of breaks on the others are nondiagnostic. When flakes with modified platforms are combined with biface flakes, the ratio of biface flakes to bifaces is only 1:1. Clearly, little biface reduction occurred in this part of the site. The only potential evidence for large bifaces are an andesite flake with a modified platform and the andesite biface tip. Most biface reduction was focused on obsidian. There is little evidence for the manufacture of andesite tools except for the biface tip that was broken during manufacture, implying that it was flaked, broken, and discarded here. No obsidian biface exhibits evidence of having been manufactured at LA 115544/AR-03-02-07-523, though the whole point may have been resharpened at this site.

It should be noted that only ¼-inch mesh hardware cloth was used for artifact recovery, and that size of mesh is often too large to recover debitage from the production of small bifaces. Materials from the manufacture of 3 large dart points and 27 small arrow points were quantified in an experiment. Debitage from these tool manufacturing episodes was run through ¼-inch mesh, 1/8-inch mesh, and window screen. When ¼-inch mesh was used, no debitage was recovered for 55.6 percent of the small points and only one flake was recovered for 22.2 percent. For the remaining small points, two, three, four, and five flakes were collected in one case apiece. This contrasts sharply with the large projectile points, for which 26, 30, and 68 flakes were recovered by ¼-inch mesh. When 1/8-inch mesh was used, the minimum number of debitage recovered from the small points was 40, ranging up to 290. Using window screen the minimum number of recovered debitage was 354, ranging up to 812.

Only ¼-inch mesh was used at our sites because we expected to find little evidence of small biface manufacture. The experimental data suggest that recovery of just a few small biface flakes in that size mesh could represent the manufacture of several small bifaces. Thus, the paucity of biface flakes in the LA 115544/AR-03-02-07-523 sample may be more indicative of recovery methods than the amount of small biface manufacture that occurred there. Indeed, comparisons with the experimental data suggest that one or more small obsidian bifaces may well have been made at this locale. Considering the types and conditions of small obsidian bifaces that were recovered, small projectile points were probably made or refurbished at LA 115544/AR-03-02-07-523.

The ratio of core flakes to cores seems very high for both assemblages, contrasting with the biface flake to biface ratios. There are 55.5 flakes for every core in the sample from LA 115544/AR-03-02-07-523, and 17.0 for every core from LA 115550/AR-03-02-07-528. This ratio can also be calculated for the rough sort assemblage from LA 115544/AR-03-02-07-523, and in that case it is also 55.5:1. The high ratio for LA 115544/AR-03-02-07-523 may be deceptive, since several quarried boulders were noted within and just outside project limits. By including the four quarried boulders that occur within project limits with the sample assemblage, the ratio is cut in half to 27.75:1. However, for the rough sort it only drops to 49.7:1, which is still very high. Cores were either extensively reduced at this location, or they were transported away for use elsewhere. Whichever is the case, it is certain that core reduction was the dominant activity involving chipped stone at both locales.

Considering the andesite nodules that were reduced in our experiment, these flake to core ratios do not seem all that large. In the experiment, we produced an average of 126.3 flakes per core–about 2.3 times more than the raw ratios for LA 115544/AR-03-02-07-523. What must be remembered is that we were aiming for the maximum number of flakes that could be removed from cores in the experiment, while this was probably rarely the goal of a prehistoric reduction episode. The only case in which this might occur is when flakes were produced for transport to another location. Of course, since this may have happened at both of our sites, we might view these ratios as smaller than expected.

Such a possibility may also be supported by the small percentages of cortical debitage recovered at our sites, 10 percent or less in both the LA 115544/AR-03-02-07-523 sample and the LA 115550/AR-03-02-07-528 assemblage. These percentages are very small when compared with our experimentally reduced nodules, from which percentages of cortical flakes averaged 35.6. Since most large flakes in our experiments possessed at least some dorsal cortex, this may suggest that larger flakes from LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 (i.e., those with a better chance of being cortical) were selected for transport elsewhere. Of course, this attribute could also indicate that they were flaking nodules quarried from outcrops rather than smaller weathered nodules like those that were used in our experiment. If so, very small percentages of cortical flakes might be expected. This possibility can be addressed by examining the cores recovered from our sites.

Cores

The types and conditions of cores can provide corroborative data concerning reduction strategy. Table 7.14 shows numbers of cores by morphology for each site. Tested cobbles are nodules with one or two flakes struck from them. Unidirectional cores had flakes removed from only one platform, bidirectional cores had removals from two opposing platforms, and multidirectional cores had removals from two (nonopposing) or more platforms. Pyramidal cores reflect systematic reduction and are similar to blade cores, but were not specially prepared to allow blades of a standard size and shape to be struck.

Multidirectional cores are the most common type in all three assemblages, followed by unidirectional, bidirectional, and tested cobbles. Pyramidal cores occur only in the LA 115544/AR-03-02-07-523 rough sort. Cores comprise very small percentages of each assemblage–0.01 percent of the LA 115544/AR-03-02-07-523 rough sort, 0.6 percent of the LA 115544/AR-03-02-07-523 sample, and 1.5 percent of the artifacts from LA 115550/AR-03-02-07-528.

Only four cores were identified in the sample from LA 115544/AR-03-02-07-523. Since the proportion of core flakes to cores is the same for both the rough sort and sample assemblages, the number of cores contained by the sample is representative of the assemblage as a whole. This extends to material type, since all cores in both assemblages are andesite. However, since only two of the five types of cores identified in the rough sort occur in the sample, the sample is not representative of the distribution of morphological types in the entire assemblage.

The cores from LA 115550/AR-03-02-07-528 are andesite (n=3), coarse andesite (n=1), undifferentiated igneous materials (n=2), and quartzite (n=1). These artifacts originated elsewhere and, except for glassy andesite, were discarded at LA 115550/AR-03-02-07-528 with little or no reduction of them occurring at the site. This is suggested

TABLE 7.14. TYPES AND CONDITIONS OF CORES FROM BOTH ASSEMBLAGES; FREQUENCIES AND COLUMN PERCENTAGES

CORE TYPE	SITE AND ASSEMBLAGE		
	LA 115544 (rough sort)	LA 115544 (sample)	LA 115550
Tested cobble	1 3.0	0 0.0	2 28.6
Unidirectional	7 21.2	1 25.0	2 28.6
Bidirectional	4 12.1	0 0.0	1 14.3
Multidirectional	19 57.6	3 75.0	5 45.5
Pyramidal	2 6.1	0 0.0	0 0.0
Total	33	4	7

by the absence of quartzite and coarse andesite debitage in the assemblage, and the presence of only one piece of undifferentiated igneous angular debris. That category is a catch-all that contains materials of igneous origin that could not be more specifically identified or were represented by single examples. Since this specimen is a completely different material than the undifferentiated igneous cores, there is no evidence that the cores were reduced at the site. Thus, four of seven cores from LA 115550/AR-03-02-07-528 were apparently never reduced there. This actually increases the flake to core ratio for that site from 17.0:1 to 83.7:1, much higher than the ratios for LA 115544/AR-03-02-07-523.

Because few cores are included in the detailed analysis, they are discussed as a single assemblage before being compared and contrasted by site. Core sizes represent estimates based on available measurements, and are expressed as volume. Andesite cores tend to be the smallest, with a mean volume of 130.07 cu cm. Coarse andesite has the second smallest mean at 177.97 cu cm, followed by quartzite (242.88 cu cm), and undifferentiated igneous (257.7 cu cm). Two of the three latter categories are represented by only a single example, so this comparison may not be particularly meaningful. When materials other than andesite are combined, however, the mean volume is 234.06 cu cm, considerably larger than the mean for andesite. Thus, either andesite cores were reduced to a greater extent than other materials, or they were initially smaller.

One means of examining this question is to compare amounts of cortical surface remaining on cores. Of course, considering that andesite outcrops in the area and that most cores of this material may be pieces that were knocked off of boulders rather than cobbles picked up from the surface, this measure may not be the most accurate. Examining cortical coverage on cores, we find that andesite cores average 7.1 percent cortical coverage, while other materials average 37.5 percent coverage. Coupled with the significantly smaller volume of andesite cores discussed above, this material seems to have been extensively reduced.

A discussion of cortical coverage for each material may provide other important data. Starting with nonandesite specimens from LA 115550/AR-03-02-07-528, the coarse andesite core is a tested cobble with 80 percent cortical coverage. This is by far the largest amount of cortex in the core assemblage, and probably indicates that, after a few flakes were removed, this nodule was determined to be unsuitable for use and discarded. The quartzite core has the third largest volume in this assemblage (242.88 cu cm), but only 10 percent cortical coverage. Despite the comparatively large size of this core, it was extensively reduced before arriving at LA 115550/AR-03-02-07-528. The smaller undifferentiated igneous core was extensively reduced, and at 92.12 cu cm, has only 20 percent cortical coverage. The larger specimen has a volume of 423.28 cu cm, and 40 percent cortical coverage. While these cores were not quite as extensively reduced as the quartzite specimen, each had quite a bit of material removed from it before arriving at the site. Thus, of the four nonandesite cores, one (coarse andesite) was probably procured nearby, tested, and discarded as unsuitable. The others (quartzite and undifferentiated igneous) were extensively reduced elsewhere, and were discarded at this site without being flaked.

The largest andesite core (749.7 cu cm) has the most cortical coverage (30 percent). Two specimens with 10 percent cortical coverage have a mean volume of 102.6 cu cm, while four cores with no cortex have a mean volume of 113.2 cu cm. The largest andesite core was recovered from LA 115544/AR-03-02-07-523, which is not surprising since that site is located at an outcrop. The other three cores from that assemblage have no cortical coverage, and average 89.2 cu cm in volume. In contrast, two of three andesite cores from LA 115550/AR-03-02-07-528 have 10 percent cortical coverage and the third has no cortical surface remaining. These cores average 130.1 cu cm in volume.

In general, the more platforms there are on a core, the more extensively it was reduced. Thus, multidirectional cores tend to have been reduced more extensively than bidirectional cores, which in turn have usually had more flakes removed from them than unidirectional cores. This is a relative measure of reduction extent, and does not necessarily hold true in all cases, though it is a convenient way of grouping cores.

All multidirectional cores in our assemblage are andesite, and 75 percent of those with no cortex also fall into this morphological category. Only one bidirectional core was recovered, and while it has more cortex than the three unidirectional cores, it has a volume of 92.12 cu cm as opposed to a mean of 161.8 cu cm for the latter. Considering that some of the andesite cores were probably broken off of boulders or outcrops and thus started with little cortical coverage, the bidirectional core may have been reduced more than the unidirectional cores, but given the small size of our assemblage, this conclusion is very weak.

Though comprising only a small percentage of both assemblages, the cores provide important data that can be used to interpret the functions of these localities. The undifferentiated igneous and quartzite cores from LA 115550/AR-03-02-07-528 were fairly extensively flaked, but the lack of corresponding debitage indicates that reduction took place elsewhere. Two of these cores were among the largest in the assemblage, yet they were not flaked at the site. Procurement of andesite may have made these cores unneeded. When they were replaced with a higher quality rock at LA 115550/AR-03-02-07-528 they were no longer needed as reserve material, and were discarded. Except for a single example from LA 115544/AR-03-02-07-523, the andesite cores tend to be comparatively small and extensively reduced. This suggests two possibilities. The occupants of LA 115550/AR-03-02-07-528 and the portion of LA 115544/AR-03-02-07-523 within project limits may have been producing debitage for use elsewhere, and so reduced their cores to the point of exhaustion. They may also represent cores that were used during the occupations of these sites and discarded because of their small size, or because they were judged unsuitable for transport elsewhere. Considering the experimental data discussed in the previous two sections, the former seems more likely–flakes seem to have been produced for transport elsewhere.

Tool Use

While some aspects of the tools have been discussed, their uses have not. An examination of this topic can provide important data on site function. Tool assemblages are broken into two categories–informal and formal. Informal tools are debitage displaying evidence of cultural edge damage but lacking purposeful modification of shape or edge angle. Very conservative standards were applied when defining edge damage as evidence of use because trampling and erosional movement can cause damage that may be mistaken for cultural wear, especially in a surface or near-surface assemblage. Only when scar patterns were consistent along an edge and the edge margin was regular was debitage categorized as an informal tool.

Formal tools are pieces of material whose shape was purposely altered to produce a specific shape or edge angle. Flaking patterns are unifacial or bifacial, and artifacts are classified as early-, middle-, and late-stage tools based on extent of flaking and edge condition. Early-stage tools have an irregular outline and widely and variably spaced flake scars that often do not extend across surfaces. Middle-stage tools have a semiregular outline and closely or semiregularly spaced scars that sometimes extend across surfaces. Late-stage tools have a regular outline and closely or regularly spaced scars that usually extend completely across surfaces. While these categories may reflect manufacturing stages, this is not always true. Flaking is often confined to margins on one or both surfaces of projectile points, suggesting the early or middle stage of tool manufacture even though they are finished tools. Thus, tools cannot be judged as finished or unfinished on the basis of morphology alone.

Informally Used Debitage

Table 7.15 illustrates wear patterns by material type for all informal tool edges. There are 12 utilized edges on 10 informal tools from LA 115544/AR-03-02-07-523, and six edges on six tools for LA 115550/AR-03-02-07-528. Andesite was by far the most commonly used material, comprising 93.8 percent of these tools. Obsidian was the only other material used informally, and makes up only 6.2 percent of this category. Core flakes were the most common morphological form used as informal tools (n=10; 62.5 percent), followed by angular debris (n=6; 37.5 percent). No biface flakes were used. Core flakes comprise 60.0 percent of the informal tools for LA 115544/AR-03-02-07-523, and 66.7 percent for LA 115550/AR-03-02-07-528.

Scars on utilized edges vary with the way tools

TABLE 7.15. OBSIDIAN AND ANDESITE WEAR PATTERNS BY MATERIAL TYPE FOR BOTH ASSEMBLAGES; FREQUENCIES AND COLUMN PERCENTAGES

WEAR PATTERN	SITE AND ASSEMBLAGE		
	LA 115544		LA 115550
	Obsidian	Andesite	Andesite
Unidirectional wear	0	2	0
	0.0	18.2	0.0
Bidirectional wear	1	1	2
	100.0	9.1	33.3
Unidirectional retouch	0	3	0
	0.0	25.0	0.0
Rounding	0	0	1
	0.0	0.0	16.7
Rounding and unidirectional wear	0	1	1
	0.0	9.1	16.7
Rounding and unidirectional retouch	0	1	0
	0.0	9.1	0.0
Unidirectional retouch and wear	0	1	0
	0.0	9.1	0.0
Unidirectional retouch and abrasion	0	0	1
	0.0	0.0	16.7
Serrated	0	2	1
	0.0	18.2	16.7
Total	1	11	6
Row percent	8.3	91.7	100.0

were used, the material they were used on, and the type of material from which they were made. In experiments by Vaughan (1985:20), cutting caused bidirectional scarring on 65 percent of his specimens, and unidirectional scarring on 17 percent. Scraping or whittling produced bidirectional scars on 46 percent of his specimens, and unidirectional scars on 54 percent. Thus, it is difficult to assign a specific function to either of these wear patterns since there is a significant overlap in the type of pattern produced.

Hardness of the object being processed is also an important factor in edge scarring. Vaughan's (1985:22) experiments showed that consistent scarring is almost always the result of contact with a hard material. However, nearly half the edges used on hard materials in his experiments and 80 percent of those used on medium-hard materials were not consistently scarred. These findings mirror experimental results reported by Schutt (1980b), who also found that consistent edge scarring only occurs when hard materials are contacted. Scarring also varies with the material being used. Fragile materials like obsidian scar more easily than tough materials like chert and basalt, and scarring is easier to define on glassy and fine-grained materials.

Another important factor in informal tool selection was material texture. Cutting and scraping require materials with sharp edges, and glassy and fine-grained materials usually produce the sharpest edges. In contrast, these textures are rarely suitable for pounding or chopping because of their fragility, while coarse-grained materials are tougher and more resistant to fracture damage (Cotterell and Kamminga 1990:129). Edges on coarse-grained materials will last longer and splinter less rapidly or often when used for pounding and chopping. Materials have different compressive strengths. The compressive strength of basalt, quartzite, and chert is high, while that of obsidian is very low because it lacks a crystalline structure (Hughs 1998:372). Materials also vary in toughness, or resistance to fracture. Andesite, basalt, tuff, rhyolite, and dacite are much tougher than chert and obsidian (Cotterell and Kamminga 1990:129).

Edge angle was another important factor in selecting informal tools for specific purposes. Most edges used in Schutt's (1980b) experiments measuring over 40 degrees were found to be poorly suited for cutting. Edge angles smaller than 40 degrees seem to have been best for that purpose, while those larger than 40 degrees were better for scraping.

Only one informal tool with a glassy texture was identified at LA 115544/AR-03-02-07-523. Most andesite informal tools are medium-grained (70 percent for LA 115544/AR-03-02-07-523 and 100 percent for LA 115550/AR-03-02-07-528), while two at LA 115544/AR-03-02-07-523 are fine-grained. Despite the predominance of tough medium-grained materials in these assemblages, none of the informal tools were used for chopping or pounding. Only five edges are less than 40 degrees, while 13 have angles greater than 40 degrees. There seems to be some comparability between edge angle and general wear pattern, though sample size is small and range of variation is large. Serrated edges (n=3) tend to have the smallest angles, with a mean of 44.3 degrees and a range of 31 to 65 degrees. Unidirectionally used edges (n=7) have a mean of 46.4 degrees and a range of 31 to 54 degrees, bidirectionally used edges (n=4) have a mean of 52.7 degrees and a range of 39 to 72 degrees, and rounded edges (n=4) have a mean of 55.5 degrees and a range of 47 to 61 degrees.

It is difficult to suggest functions for some categories based on these data. The exceptions are the serrated category, which are considered to be denticulates (saws), and the rounded category, which were probably used to work leather. Considering the experimental wear-pattern data cited earlier, unidirectional patterns are more common when debitage is used for scraping, while bidirectional patterns are more common when they are used for cutting. Yet mean edge angles are smaller for unidirectional use, which is opposite the expected pattern. All that these data allow us to say is that these informal tools were probably used for a variety of cutting and scraping tasks on medium to hard materials.

Formal Tools

Formal tools were only recovered from LA 115544/AR-03-02-07-523. All tools from that site are incorporated in this discussion and include nine bifaces, three unifaces, and one cobble tool. Several materials are represented in this small assemblage, including Pedernal chert, Alibates chert, Polvadera obsidian, undifferentiated obsidian, and both glassy and coarse andesite.

Five of the bifaces are projectile points; all are finished tools, but only one is whole. Another biface may represent part of a point, but this is uncertain. The definite points are small; four are corner-notched, while the notching style could not be defined for the last because it is only represented by a tip. Obsidian was the only material used for projectile points and came from Polvadera Peak in two cases, while sources for the others are undetermined but are probably from the Jemez Mountains. The only complete point was resharpened, and two specimens were broken during use. One of these is a midsection with a haft snap at its proximal end and an impact fracture at its distal end. This point was almost certainly returned to the site in a meat package and removed during processing. The second specimen is a base with a haft snap that was probably also broken during use and carried to the site for refurbishing. The two remaining fragments have snap fractures, the cause of which cannot be defined.

Three bifaces could not be assigned to specific functional categories. All three are broken–two are lateral fragments of obsidian tools, and the third is the distal end of an andesite tool. The break on the latter is a lateral snap, which indicates that it fractured during manufacture (Johnson 1979). The other specimens have nondiagnostic fractures, so we are uncertain how they broke. The last biface is the tip and part of the shaft of a Pedernal chert drill. Unifacial tools include a andesite end-side scraper, a probable obsidian scraper, and an Alibates chert tool of unknown function. The only cobble tool recovered from LA 115544/AR-03-02-07-523 is a coarse andesite chopper that does not appear to have been extensively used.

Summaries of Activities Reflected in the Assemblages

We can define the range of activities in each assemblage by combining data from the analysis of reduction debris and tools. Assemblages from both sites are dominated by debris from expedient core reduction. No evidence of efficient reduction or tool manufacture was recovered from LA 115550/AR-

03-02-07-528, and only limited evidence for these activities was found at LA 115544/AR-03-02-07-523.

Core reduction was the main activity reflected in debitage assemblages from both sites. Large percentages of noncortical flakes in both assemblages initially suggested that efficient reduction, presumably large biface manufacture, was also a major activity. However, analysis of debitage types, flake platform treatment, flake to angular debris ratios, and biface flake to biface ratios indicated that this assumption was wrong. While there was some evidence for small and large biface manufacture at LA 115544/AR-03-02-07-523, it was a very minor activity.

Numerous andesite cores were reduced at both sites, yet few cores were actually recovered. Flake to core ratios of 55.5:1 and 17.0:1 were derived for LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528, respectively. However, this did not take into account the presence of several nonandesite cores that were discarded and not reduced at LA 115550/AR-03-02-07-528. With these specimens removed from consideration, the revised flake to core ratio is 62.8:1, which is even higher than the ratio for LA 115544/AR-03-02-07-523.

We initially considered the flake to core ratios to be quite high, and possibly indicative of the preparation of cores for transport elsewhere. The very low flake to angular debris ratios were suspicious, but potentially could be used to support this possibility. However, very low percentages of cortical flakes tended to argue against initial core preparation unless mostly noncortical nodules were used. Too many questions were left open because we simply did not know enough about the byproducts of andesite core reduction. To fill this gap, three andesite cores were reduced, providing both quantified and anecdotal data about this material. Several important facts were gleaned from this experiment. Glassy andesite is a fairly brittle material, and hard hammer reduction produces quite a bit of angular debris. However, when flake to angular debris ratios were averaged for all three cores it began to look like there simply weren't enough flakes at either LA 115544/AR-03-02-07-523 or LA 115550/AR-03-02-07-528. Anecdotally, we noted that there was a high probability that large flakes in the experimental assemblages would possess cortical surfaces. Thus, removal of larger flakes from the LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 assemblages might account for both the low flake to angular debris ratios and the low percentages of cortical flakes.

However, the question of what kinds of nodules were reduced at these sites remains. If existing cobbles were reduced and selected flakes were carried off there should be a discrepancy between cortical flakes and angular debris. However, if nodules were knocked off boulders or outcrops, even if selected flakes were removed there might be no differences between percentages of cortical flakes and angular debris. To examine this possibility, we used the presence or absence of dorsal cortex on debitage to see whether the same or different populations were represented. Cortex occurs on 17.8 percent of the angular debris from LA 115544/AR-03-02-07-523, which is about double the percentage for flakes (8.8 percent). At the 95 percent confidence level, chi-square analysis suggests that different populations are represented (chi-square=11.605, df=1, significance=.0007, phi=.134). This may indicate that cortical flakes are missing from this assemblage, and that at least some existing cobbles were probably used as cores.

Different results were obtained for LA 115550/AR-03-02-07-528. In that case, percentages of cortical angular debris and flakes were similar (13.4 and 10.0, respectively). At the 95 percent confidence level, chi-square analysis rather strongly suggests that both debitage categories may belong to the same population (chi-square=1.278, df=1, significance=.258, phi=.054). The smaller percentage of cortical flakes could indicate that some were removed from the site, but this possibility was not supported by the analysis. In this case, we might conclude that noncortical or mostly noncortical fragments of boulders or outcrops were reduced at this location.

Flake to core ratios for the three experimentally reduced nodules were much higher than those derived for LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528. This could indicate that initial core preparation rather than extensive core reduction occurred at those locations. However, this brings up again the unresolved question of cortical flakes. There simply aren't enough, especially at LA 115544/AR-03-02-07-523, to account for this possibility. There is also the condition of the andesite cores recovered from these sites, which all appear to have been significantly reduced. Overall, flake to core ratios for the sites are lower than those derived from the experimental reduction of cores–89.5:1 for the LA 115544/AR-03-02-07-523 sample, 53.9:1 for the entire LA 115544/AR-03-02-07-523 assemblage, and 83.7:1 for LA 115550/AR-03-02-07-528. Thus, it is feasible that the andesite cores recovered from these sites were the sources of all debitage recovered there.

These data indicate that our identification of LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 as quarries is correct, though not in the way we originally thought. We felt that the data would reflect extraction of andesite and preparation of cores or bifaces for transport elsewhere. Instead, we seem to be seeing evidence for an extensive reduction of andesite cores and selection of debitage, mostly flakes, for transport elsewhere. This may be a reflection of the brittleness of andesite, which results in a large amount of wasted material during core reduction. Nearly a third of the debitage produced by our experiments was angular debris, and a very large percentage of the flakes was probably too small for use. By reducing cores at these locations and carrying off only selected debitage, site occupants were able to reduce the amount of wasted material that would otherwise have been transported. In effect, they were maximizing the utility of the materials they carried away with them.

However, neither site was a simple extractive location, and in both cases there was evidence for activities other than simple core reduction. Informal tools were identified at both sites, but only LA 115544/AR-03-02-07-523 yielded formal tools. The informal tool inventory for both sites includes denticulates and debitage with rounded edges. The former have at least one serrated edge, and are presumed to have been used as saws. Rounded edges may result from leather working, but this is uncertain. Other wear patterns are more difficult to assign to specific tasks, but are considered indicative of manufacturing or maintenance tasks that involved the scraping and cutting medium-hard to hard materials like wood and antler.

As discussed earlier, at least one projectile point fragment was brought to LA 115544/AR-03-02-07-523 in a meat package and removed during processing. A second fragment is a base that was probably removed and replaced during refurbishing of an arrow shaft. Thus, these two artifacts indicate that hunting, meat processing and consumption, and weapon refurbishment were among the tasks performed at LA 115544/AR-03-02-07-523. Like the denticulates, the presence of a drill shaft suggests that woodworking occurred there. The chopper may also have been used in that task, or for other jobs that required chopping vegetal materials. Two scrapers were also recovered, and, like the rounded informal tools, are probably indicative of hide preparation.

Conclusions

Analysis of the chipped stone assemblages has provided important information about LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528. Interestingly, LA 115550/AR-03-02-07-528 comes closest to the expected pattern for a simple quarry-reduction site. Glassy andesite nodules were probably obtained from the west flank of Cerro Negro and carried to this site for reduction. Cores were extensively reduced, and selected debitage (mostly flakes) appear to have been carried off for use elsewhere. Cores of less desirable materials that were carried to the site as part of the tool kit were discarded. Occupation of the main part of LA 115550/AR-03-02-07-528 on the west side of NM 522 was probably short term, and few tasks other than woodworking, hide processing, and core reduction occurred.

The chipped stone assemblage from LA 115544/AR-03-02-07-523 presents a more complex picture. Like LA 115550/AR-03-02-07-528, nodules of black glassy andesite were reduced at this site and selected debitage (again, probably mostly flakes) were carried off for use elsewhere. In addition to the procurement of andesite, activities reflected in this assemblage include limited manufacture of small and large bifaces, hunting, meat processing and consumption, wood working, hide preparation, and general tool manufacture-maintenance tasks.

LA 115544/AR-03-02-07-523 compares favorably with many other sites recorded or described in this region. A predominance of andesite in combination with minor amounts of obsidian and chert seems to be a common signature. However, the part of LA 115544/AR-03-02-07-523 that was examined is just one of a large number of artifact concentrations in a material source area that were combined to form this site. Our locality appears to have been a camp where quarried material was processed and a fairly wide array of activities was performed. Other clusters of chipped stone at the site may more closely resemble LA 115550/AR-03-02-07-528, and primarily represent andesite procurement and processing areas.

Tentative dates can be assigned to these sites based on chipped stone assemblages. Mobile forager assemblages are expected to reflect an efficient reduction strategy in which large bifaces were manufactured and used as general purpose tools, cores, and blanks. An expedient reduction strategy is expected if the sites were occupied by relatively sedentary peoples. In general, the assemblages from both sites fit the latter pattern, with only a little evidence for large biface manufacture occurring in the LA 115544/AR-03-02-07-523 sample, and none at LA 115550/AR-03-02-07-528. The only possible exception to this is an andesite flake with a modified platform from LA 115550/AR-03-02-07-528 that could have been removed from a large biface. However, this flake does not meet the criteria of the polythetic set, so its identification is questionable. The projectile points from LA 115544/AR-03-02-07-523 suggest a Puebloan period occupation, since the bow and arrow were introduced early in the Puebloan Developmental period.

Some characteristics of these sites are suspiciously similar to those of forager occupations. Pottery was absent from both sites, and none was observed in the part of LA 115544/AR-03-02-07-523 adjacent to project limits that was cursorily inspected during data recovery. At LA 115544/AR-03-02-07-523 especially, the range of activities reflected in the assemblage is indicative of a temporary camp. Evidence for a few activities other than core reduction at LA 115550/AR-03-02-07-528 also suggests a short-term camp function. However, the range of activities defined at both sites includes none that are clearly indicative of the presence of women. Indeed, the suite of tasks completed at LA 115544/AR-03-02-07-523 is primarily associated with the processing of chipped stone material, hunting, and weapons maintenance. Limited evidence for all three types of activities is also visible at LA 115550/AR-03-02-07-528, though to a much smaller extent.

Only small corner-notched projectile points consistent in size with those used as arrow tips were found at LA 115544/AR-03-02-07-523. While use of this type has been documented in Puebloan sites occupied as late as the seventeenth century (Moore n.d.a), in the Taos area they seem to have mostly fallen out of use by the Late Developmental period. Wetherington (1968:65) indicates that Valdez phase points at Pot Creek Pueblo are usually corner-notched, and only rarely are side-notched. However, excavation of two late Valdez phase pithouses near Pot Creek Pueblo (Moore 1994) yielded only side-notched points. Both of these sites were occupied during the twelfth century, and apparently by that time side-notched points had become the most popular form. Since corner-notched points were the only type found in the section of LA 115544/AR-03-02-07-523 examined by this study, occupation of the area probably occurred before the twelfth century, perhaps early in the Valdez phase or before.

The combination of an aceramic occupation with little evidence for the manufacture of large general purpose bifaces is intriguing. If these sites reflect occupation by late foragers we would expect to see a continuation of an Archaic pattern of tool use, except that large corner-notched dart points should have been replaced by small arrow points. This is not the case. The structure of these chipped stone assemblages seems more indicative of the acquisition of suitable debitage for transport elsewhere. This leaves two possibilities. The Early to Middle Developmental Period occupants of the Taos area may have been foragers that were no longer using an efficient reduction technology. Conversely, these sites might reflect material acquisition embedded in hunting expeditions originating at Valdez phase hamlets. The latter seems more likely at this point, and it is doubtful that the groups that used these locales came from nearby residential sites along the Rio Hondo, where glassy andesite outcrops also occur (see Chapter 9). Rather, they probably came from further south in the Taos Valley.

Andesite appears to have been a fairly common material at Pot Creek Pueblo (Wetherington

1968:65; Newman 1990). The rhyodacite mentioned by Newman (1990) is probably andesite. If this assumption is correct, andesite is one of a suite of materials that evidence greater use in the Valdez phase at Pot Creek Pueblo than during later periods of occupation (Wetherington 1968:65). Groups of men from the central and southern parts of the Taos Valley may have combined hunting in the northern valley with procurement of high-quality andesite for use at their homes. A small site like the western section of LA 115550/AR-03-02-07-528 may reflect a very short-term occupation where a few cores were reduced and a small amount of tool maintenance and hide-working occurred. The nonandesite cores probably represent materials brought along for use during the early part of the expedition, which were discarded when they were no longer needed. Indeed, the quartzite core may be evidence of a southerly origin for site occupants, since that material is available in the Picuris range (Herold 1968:29).

The portion of LA 115544/AR-03-02-07-523 examined by this study represents a somewhat longer and more intensively used camp. A considerable number of andesite cores seem to have been reduced at this location, possibly on more than one occasion. Hunting occurred at the same time, and the limited amount of faunal data available indicate that they were exploiting medium to large mammals. The range of materials carried to this site is more extensive than was the case for LA 115550/AR-03-02-07-528, and included obsidian and various cherts. Andesite augmented rather than replaced these materials in the tool kit. While glassy andesite is a fairly high quality material that breaks with a conchoidal fracture, obsidian and chert are of higher quality. Thus, the limited number of obsidian and chert debitage and formal tools found at the site represent materials that were discarded after use or when they were no longer usable. Any usable cores, debitage, or formal tools made from these materials that were transported to LA 115544/AR-03-02-07-523 seem to have been carried off again when the site was abandoned.

From the data that are currently available we conclude that both LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 represent sites used by early Valdez phase occupants of the Taos Valley whose main residences were located in the central or southern parts of the region. The lack of pottery is comparatively easy to explain. As noted in the data recovery plan, Western Apache men on hunting or similarly mobile excursions did not carry pottery because it was too much of an encumbrance. A similar tradition may explain why pottery is absent from our sites, and is rarely encountered on similar sites in the area. The region exploited by Puebloan people was much more extensive than simply their home village and fields. Expeditions to obtain natural resources or visit sacred areas were common and often covered long distances. By combining hunting with the acquisition of raw lithic materials the prehistoric

Puebloan residents of the Taos area were able to more efficiently exploit the landscape, essentially "killing two birds with one stone."

8

AN EXAMINATION OF SITE STRUCTURE

James L. Moore

An examination of the internal structure of LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528, as seen in the distributions of artifacts and materials, could aid in assessing the conclusions presented in Chapter 7. Since we lack both surface and subsurface data for all parts of these sites, this analysis will mainly focus on excavation areas. We will compare and contrast the three excavation areas at LA 115544/AR-03-02-07-523 to determine whether they reflect similar or different patterns of use. Our examination of LA 115550/AR-03-02-07-528 will look at remains from both sides of NM 522 to see if they reflect similar or different activities. We will also examine Excavation Area 3 from that site in detail.

LA 115544/AR-03-02-07-523

Using the distribution of surface materials we defined three clusters of chipped stone artifacts within project limits at LA 115544/AR-03-02-07-523, and all subsurface investigations focused on those areas. However, it must be remembered that this part of the site represents only a small portion of a large scatter that probably reflects multiple uses over a long period of time. Any conclusions concerning how this area functioned in prehistoric settlement and economic systems cannot be extended to the rest of the site because other parts have not been studied. Thus, when LA 115544/AR-03-02-07-523 is mentioned in the remainder of this discussion, we are referring to the area within project limits and not the entire site.

The goals of this analysis are threefold. First, we will look at distributions of certain classes of artifacts and material types to determine how many task locations are represented among our excavation units. We will then examine any task areas that are defined and interpret the pattern of use each exemplifies. With that analysis completed, we will look at the larger picture and determine whether this section of LA 115544/AR-03-02-07-523 represents a single occupation or a series of unrelated uses.

The surface distribution of formal and informal

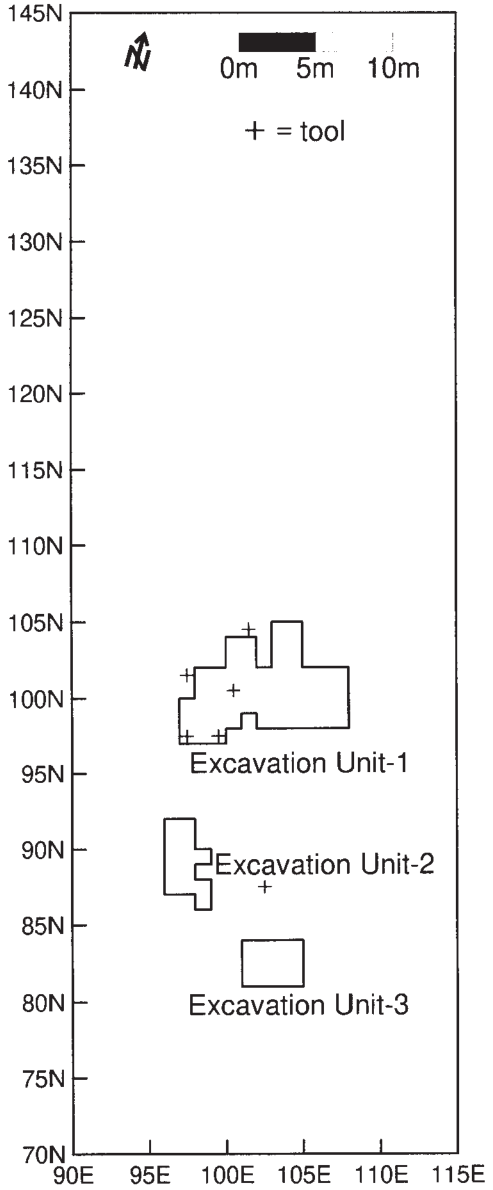

Figure 8.1. LA 115544/AR-03-02-07-523: surface distribution of tools.

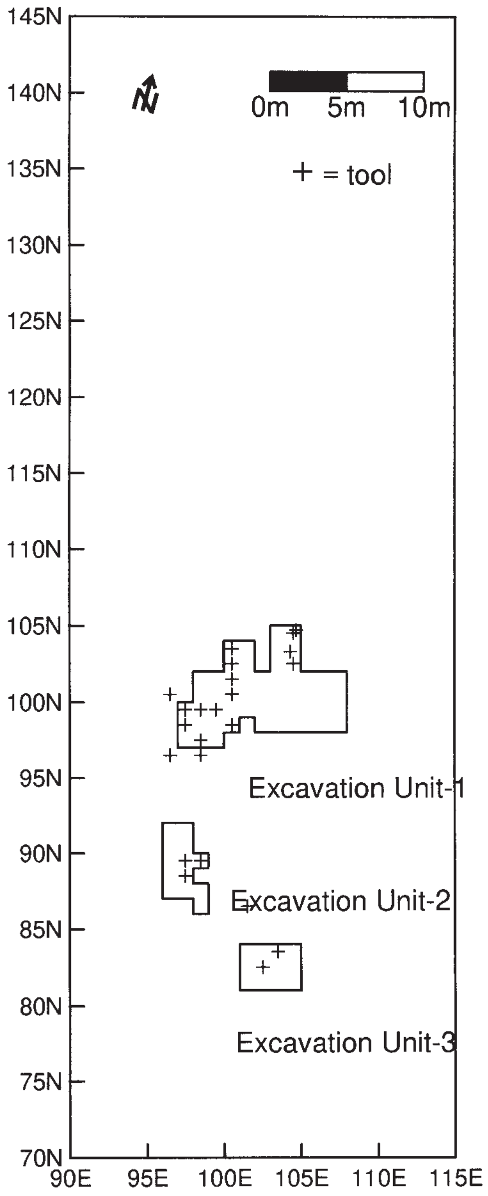

Figure 8.2. LA 115544/AR-03-02-07-523: distribution of all tools.

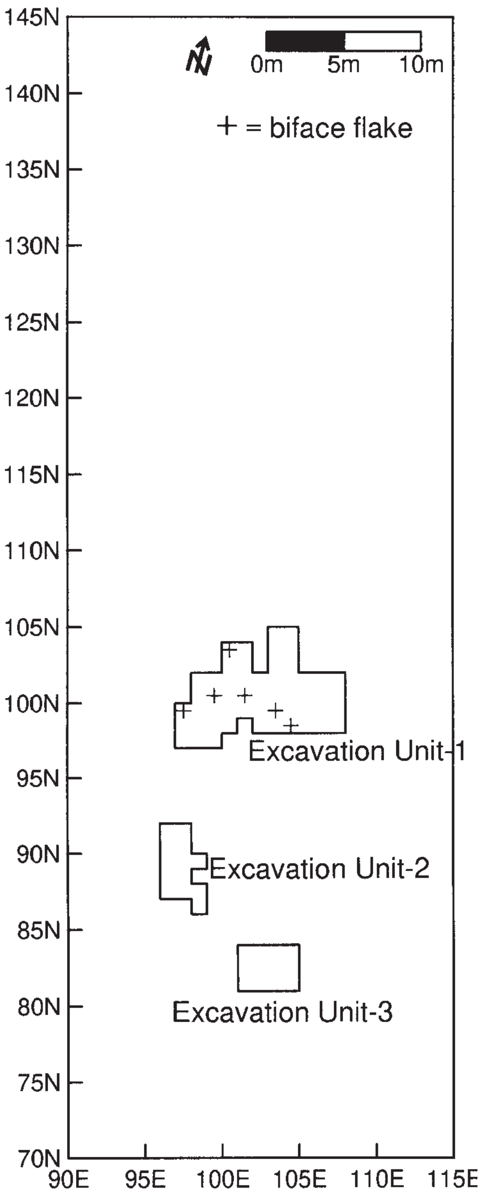

Figure 8.3. LA 115544/AR-03-02-07-523: distribution of biface flakes.

tools is shown in Figure 8.1. Five of six artifacts in this category were found in or immediately adjacent to EU-1, while the last was found between EU-2 and EU-3. This distribution suggests that EU-1 was the main tool-use locus. The virtual lack of tools elsewhere on the surface implies that our excavation units contained the main activity loci involving tool use. When subsurface tools are included (Fig. 8.2), EU-1 continues to contain most of the tools, though a few occur in other excavation units. All but one of the formal tools were found in or immediately adjacent to EU-1, suggesting that this area was the main locus of formal tool use. Only one formal tool was found in EU-2, but its presence in that area is very important because it is a projectile point similar to several found in EU-1. This may indicate a similar date for both excavation units, and could imply that they were used during the same occupation.

Though biface manufacture was a relatively minor activity at LA 115544/AR-03-02-07-523, analysis showed that both small and large specimens were made or resharpened at this site. Figure 8.3 shows the distribution of biface flakes (real and

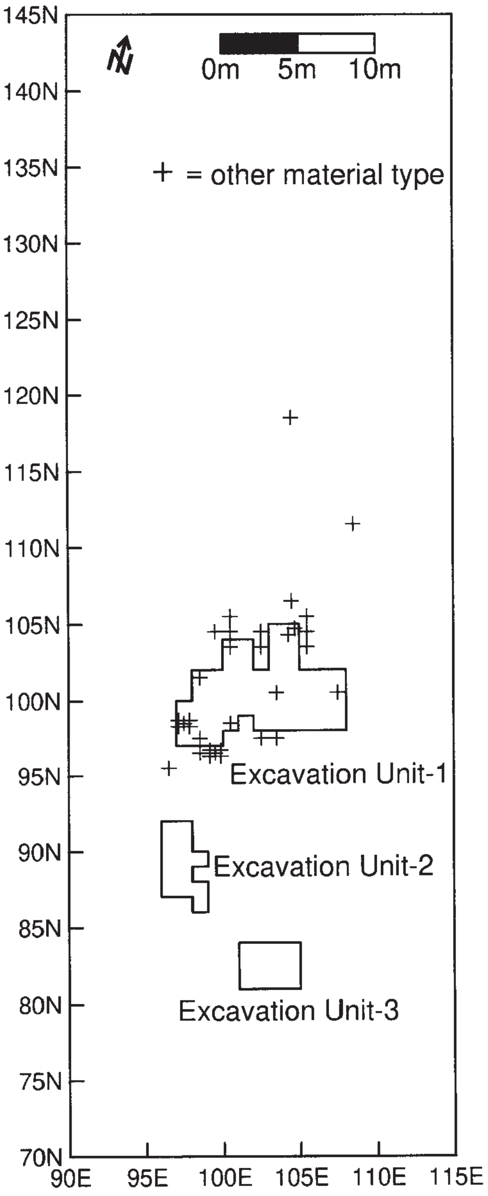

Figure 8.4. LA 115544/AR-03-02-07-523: distribution of surface materials other than andesite.

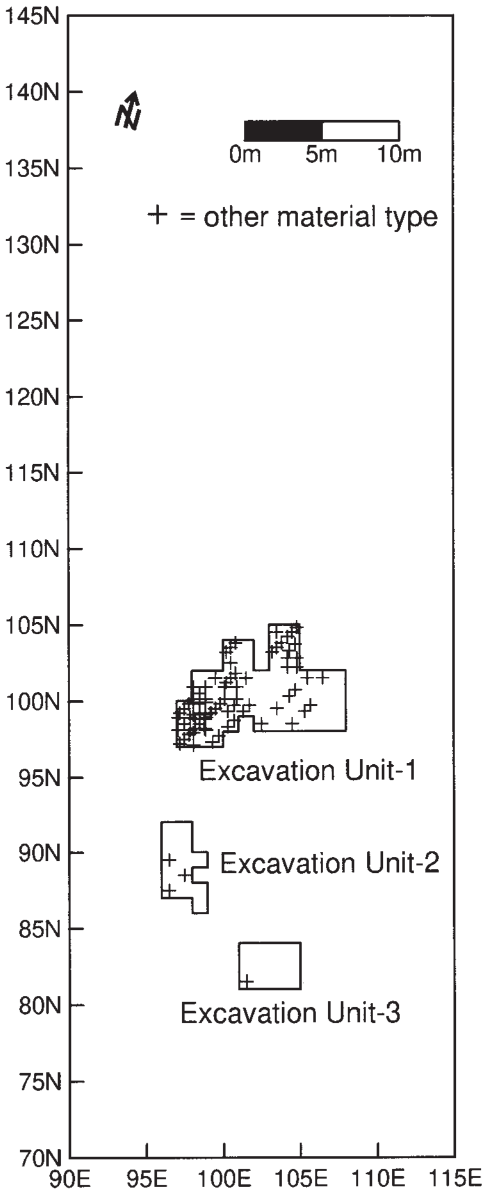

Figure 8.5. LA 115544/AR-03-02-070523: distribution of subsurface materials other than andesite.

possible), all of which were found in EU-1. Thus, this area also appears to have been the main locus for biface reduction.

While andesite was the main material used at LA 115544/AR-03-02-07-523, several varieties of cherts and obsidians also occur in the assemblage. The surface distribution of these materials is shown in Figure 8.4. Again, our initial perception of this distribution is that it centered on EU-1. The subsurface distribution of materials other than andesite is shown in Figure 8.5, and supports our conclusion based on surface materials. Few artifacts of materials other than andesite were found in either EU-2 or EU-3, and nearly all occur in and around EU-1. This is especially true of obsidian, which was the second most abundant material recovered in that area (4.4 percent of the subsurface and 2.6 percent of surface artifacts). Except for two specimens, all surface obsidian was found in and around EU-1. When subsurface artifacts are also considered, only three obsidian artifacts were found outside that area. Clearly, EU-1 was the main area where materials other than andesite were used.

Excavation Unit-1

As the preceeding discussion indicates, EU-1 contained most evidence for andesite tool manufacture/maintenance and use at LA 115544/AR-03-02-07-523, as well as materials other than andesite. EU-1 was also the only area that yielded faunal remains. Clearly, this excavation unit contained debris from most of the activities performed in this part of LA 115544/AR-03-02-07-523. But does the structure of these deposits reflect in situ performance of activities and, if so, how many such episodes are represented?

Figure 8.6 shows the distribution of andesite artifacts, locations of andesite outcrops, and the approximate positions of andesite cores in EU-1. The latter are estimated because those artifacts were recovered during excavation and their exact locations were not recorded. Two main clusters of andesite debitage are visible, one on the east side of EU-1 centered at 101N/106E (Cluster 1), and a second in the west half of EU-1 centered at 99N/99E (Cluster 2). Cluster 1 also has smaller peaks to the northwest and west, centered at 104N/104E and 102N/103E. The clusters are separated by a zone between the 102E and 103E grid lines where the number of artifacts drops significantly, with a low centered at 101N/103E.

Cluster 1 contains the densest concentration of andesite debris, and is next to two outcropping boulders of andesite, as shown in Figure 8.6. Four other outcropping boulders occur just east of EU-1, slightly outside project limits (see Fig. 6.1). One core was also recovered from this area. Cluster 2 contained a concentration of andesite debitage, with five associated cores but no outcrops. The last three cores occurred around the smaller peak in Cluster 1 that centers at 102N/103E.

Figure 8.7 shows the distribution of andesite core flakes in EU-1. While there are a few differences in structure between Figures 8.6 and 8.7, this distribution closely resembles that of the andesite assemblage as a whole, clustering in the same areas. Similarly, the distribution of andesite angular debris in Figure 8.8 follows the same general pattern as the core flakes and the assemblage in general. Thus, we seem to have evidence for two discrete episodes of andesite reduction in EU-1, each scattered over several square meters. The location of Cluster 1 next to several outcropping andesite boulders supports its definition as a reduction locus. Cursory examination of areas outside project limits showed that outcrops of glassy andesite are almost always accompanied by concentrations of reduction debris, which are undoubtedly indicative of in situ reduction.

By eliminating a 1-m-wide zone between the clusters where they appear to overlap, we should be able to compare and contrast them. Thus, materials between the 102E and 103E grid lines were dropped, leaving 778 artifacts in Cluster 1 and 1,069 in Cluster 2. The only evidence for andesite biface reduction was found in Cluster 2, and includes a biface tip that was broken in manufacture, a biface flake, and a notching flake.

Flake to angular debris ratios are 1.21:1 for Cluster 1 and 1.52:1 for Cluster 2, which are both low. The clusters contain, respectively, 351 and 421 pieces of angular debris and 425 and 640 core flakes. Analysis of debitage distributions weakly suggests that different populations of debitage are represented in these clusters (chi-square=5.671, df=1, significance=.017, phi=.056). This exhausts the ability of the rough sort data to provide information, and we must now turn to the full analysis sample.

Unfortunately, samples from the clusters are not completely representative of the entire assemblages. The samples contain 21.3 percent of the debitage from Cluster 1 and 19.1 percent from Cluster 2–fairly similar proportions. Flake to angular debris ratios are slightly higher for the samples than for the complete assemblages: 1.33:1 for Cluster 1 and 1.60:1 for Cluster 2. However, when debitage distributions are compared for the samples, there is a strong probability that they represent the same population (chi-square=.75, df=1, significance=.386, phi=.045), which was not the case when the distribution of debitage types in the entire assemblage was examined. Since the samples may not be completely representative of the assemblage as a whole, any further conclusions must be considered tentative.

When flakes are compared for presence and absence of dorsal cortex there is a strong probability that both clusters represent a single population (chi-square=.038, df=1, significance=.845, phi=.013). However, when presence or absence of cortex on angular debris is examined, the samples

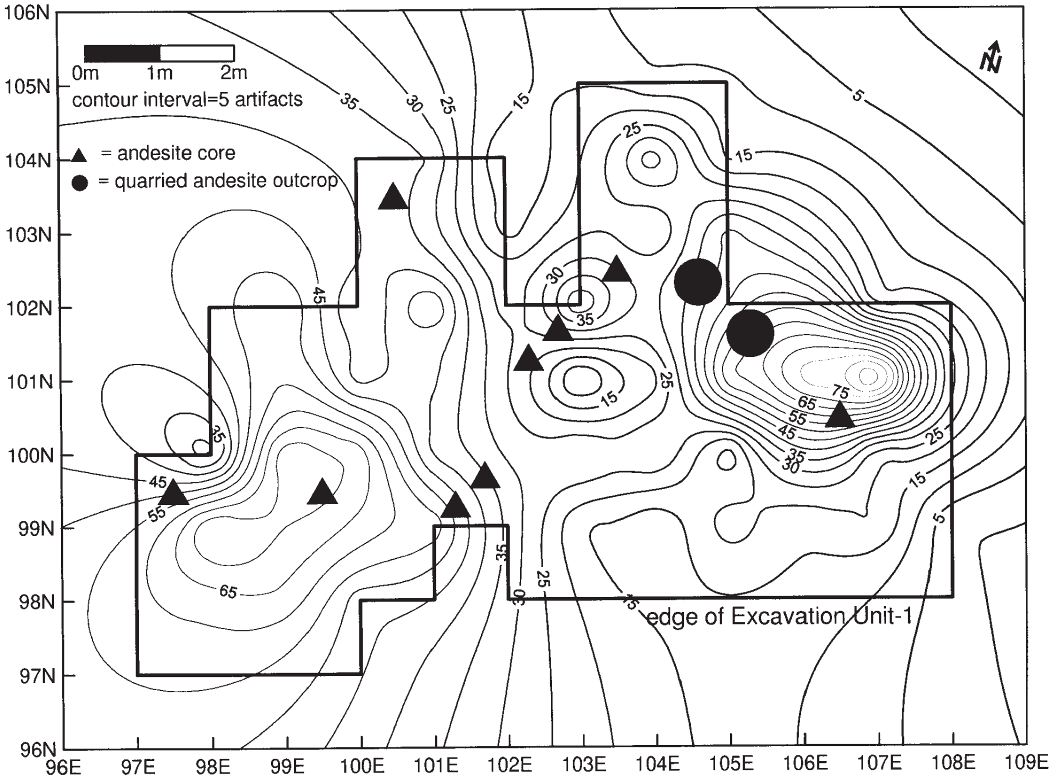

Figure 8.6. LA 115544/AR-03-02-07-523, EU-1: distribution of andesite debitage and cores.

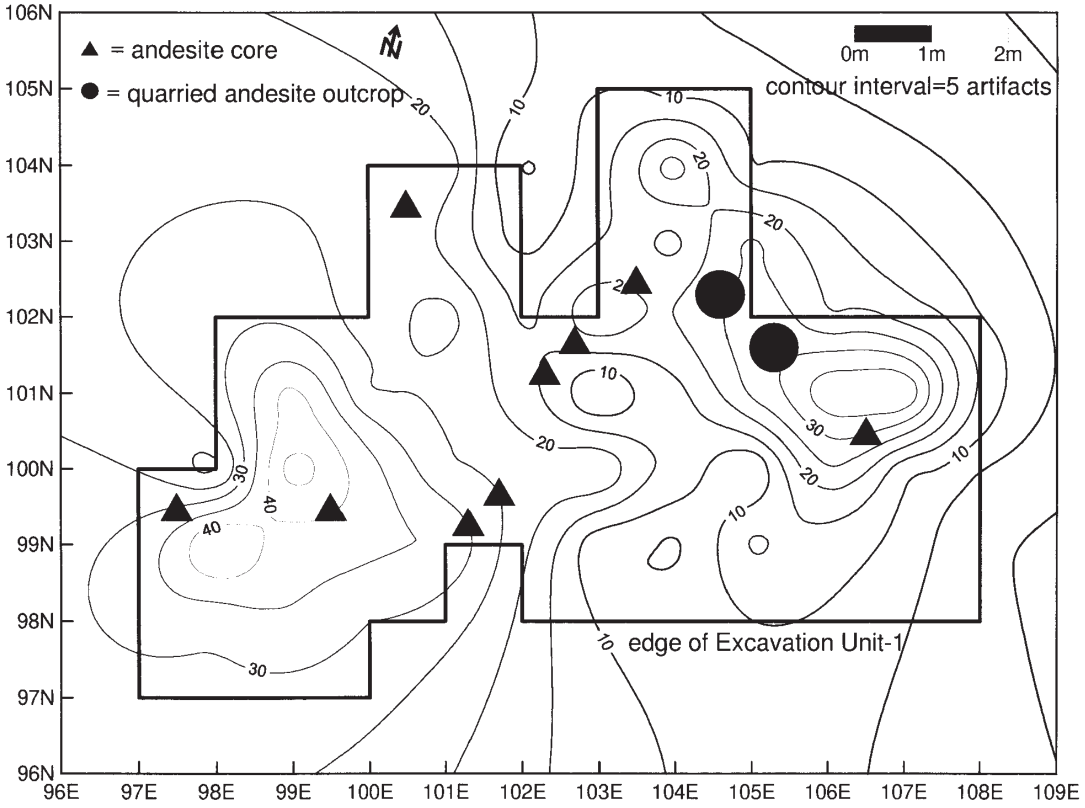

Figure 8.7. LA 115544/AR-03-02-07-523, EU-1: distribution of andesite core flakes.

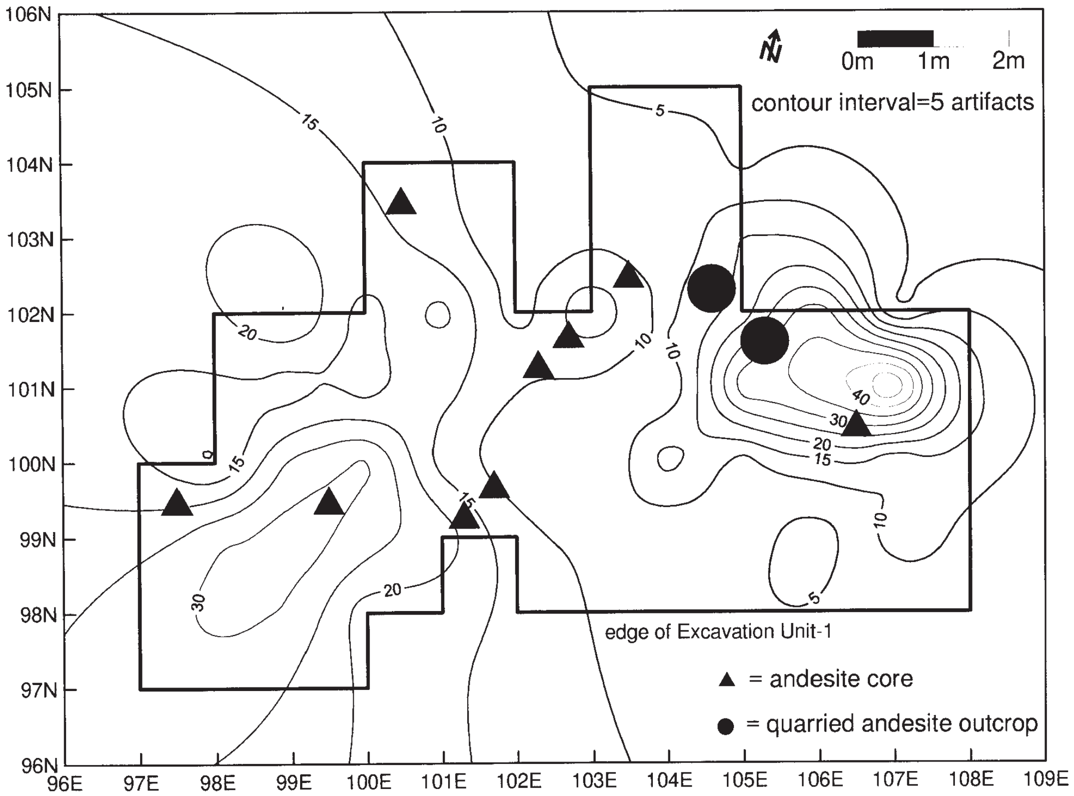

Figure 8.8. LA 115544/AR-03-02-07-523, EU-1: distribution of andesite angular debris.

from each cluster probably represent different populations (chi-square=6.223, df=1, significance=.013, phi=.204). As Table 8.1 shows, cortical flakes are relatively rare in both assemblages. There is a much higher percentage of cortical angular debris than core flakes from Cluster 1, and a slightly smaller percentage of cortical angular debris than core flakes from Cluster 2. Examination of the distribution of cortex on flakes and angular debris in Cluster 1 suggests that these debitage types represent different populations (chi-square=4.545, df=1, significance=.033, phi=.165). In contrast, in Cluster 2 they may represent the same population (chi-square=.617, df=1, significance=.432, phi=.055).

Platforms occur on slightly more than half of the whole and partial flakes in both assemblages, the rest are either missing their platforms or they are obscured. Modified platforms are rare in both clusters, with only a single example occurring in each. Unmodified platform types include cortical, single facet, and multifacet. Comparison of the distribution of unmodified, modified, and missing/obscured platforms strongly suggests that both clusters may represent a single population (chi-square=2.449, df=2, significance=.294, phi=.145).

Nearly a third of the flakes in Cluster 1 are whole, versus only about a quarter in Cluster 2. However, when distributions of flake portions are compared, a single population may be represented (chi-square=4.267, df=1, significance=.371, phi=.139). Nearly a third of the whole flakes and proximal fragments in both assemblages have lipped platforms (29.4 percent in Cluster 1 versus 34.8

TABLE 8.1. LA 115544/AR-03-02-07-523, EU-1: PERCENTAGES OF CORTICAL DATA FOR ANDESITE DEBITAGE

DEBITAGE TYPE	ARTIFACT CLUSTER			
	Cluster 1		Cluster 2	
	Core flakes	Angular debris	Core flakes	Angular debris
No cortex	92.7	81.9	92.0	94.9
Cortex present	7.3	18.1	8.0	5.1

TABLE 8.2. LA 115544/AR-03-02-07-523, EU-1: COMPARISON OF WHOLE ANDESITE FLAKE AND ANGULAR DEBRIS DIMENSIONS FOR CLUSTERS 1 AND 2

DEBITAGE TYPE	DIMENSION (MM)	ARTIFACT CLUSTER			
		Cluster 1		Cluster 2	
		Mean	SD	Mean	SD
Flakes	Length	22.4	15.8	26.8	19.5
	Width	21.1	19.3	20.4	10.7
	Thickness	5.6	4.4	7.0	4.6
Angular debris	Length	19.9	11.2	31.8	22.7
	Width	13.3	6.8	20.3	13.4
	Thickness	5.7	4.1	8.7	6.8

percent in Cluster 2). Analysis of this attribute also strongly suggests that both clusters may represent a single population (chi-square=.386, df=1, significance=.535, phi=.057).

Considering both whole and fragmentary flakes, there are few cortical specimens in either assemblage that are less than 20 mm long (4.8 percent for Cluster 1 and 3.2 percent for Cluster 2). Larger percentages of specimens longer than 20 mm are cortical (11.7 percent for Cluster 1 and 22.6 percent for Cluster 2). Thus, the longer a flake is, the better the chance it will retain some dorsal cortex. Nearly twice as many longer flakes are cortical in Cluster 2 than in Cluster 1, suggesting that fewer large primary and secondary flakes were removed from that assemblage. Whole flakes tend to be larger in Cluster 2 (Table 8.2). This may be an indication that most of the larger flakes from Cluster 1 were removed and transported elsewhere, while this is not the case for Cluster 2. However, since angular debris from Cluster 2 is also larger than that from Cluster 1, it is more likely that the nodules reduced in Cluster 2 were simply larger than those in Cluster 1.

Considering the results of experimental reduction of andesite nodules reported in Chapter 7, and remembering that the samples from each cluster may not be statistically representative of the complete assemblages, we can use these results to make several assertions concerning the reduction of andesite in EU-1. Low flake to angular debris ratios suggest that flakes may be missing from both clusters. Fairly low percentages of cortex suggest that nodules removed from andesite outcrops, rather than weathered cobbles, were used as cores. Attributes of flakes in samples from both clusters indicate that a similar reduction technology was used in both episodes. Few platforms were modified to expedite removal in either cluster, fairly large percentages of platforms are lipped in both, and the distributions of flake portions are very similar. The large percentages of lipped platforms suggests that soft-hammer percussion was an important part of the reduction strategy.

Similar types of nodules seem to have been reduced in much the same way in both clusters, though those used in Cluster 2 may have been larger than the ones that were flaked in Cluster 1. Differences in several attributes suggest that there was variation in the parameters used to select debitage for transport elsewhere. Significant differences in percentages of cortical flakes and angular debris in Cluster 1 combined with a low flake to angular debris ratio suggests that most of the cortical flakes from that cluster were among those that were removed. This type of variation is not visible in Cluster 2, and may indicate that fewer large flakes were taken from that area.

Obsidian was the second most abundant material used in EU-1, and its distribution is shown in Figure 8.9. The main concentration of obsidian debitage is in Cluster 2, with a low in Cluster 1. Five of seven obsidian tools were found in Cluster 2, as were all three potential biface flakes. The two remaining tools were found near Cluster 1. The main locus of obsidian reduction was clearly in Cluster 2. This material can be divided into clear (unsourced) and Polvadera Peak varieties. The distributions of these varieties are shown in Figures 8.10 and 8.11. As Figure 8.10 shows, the distribu-

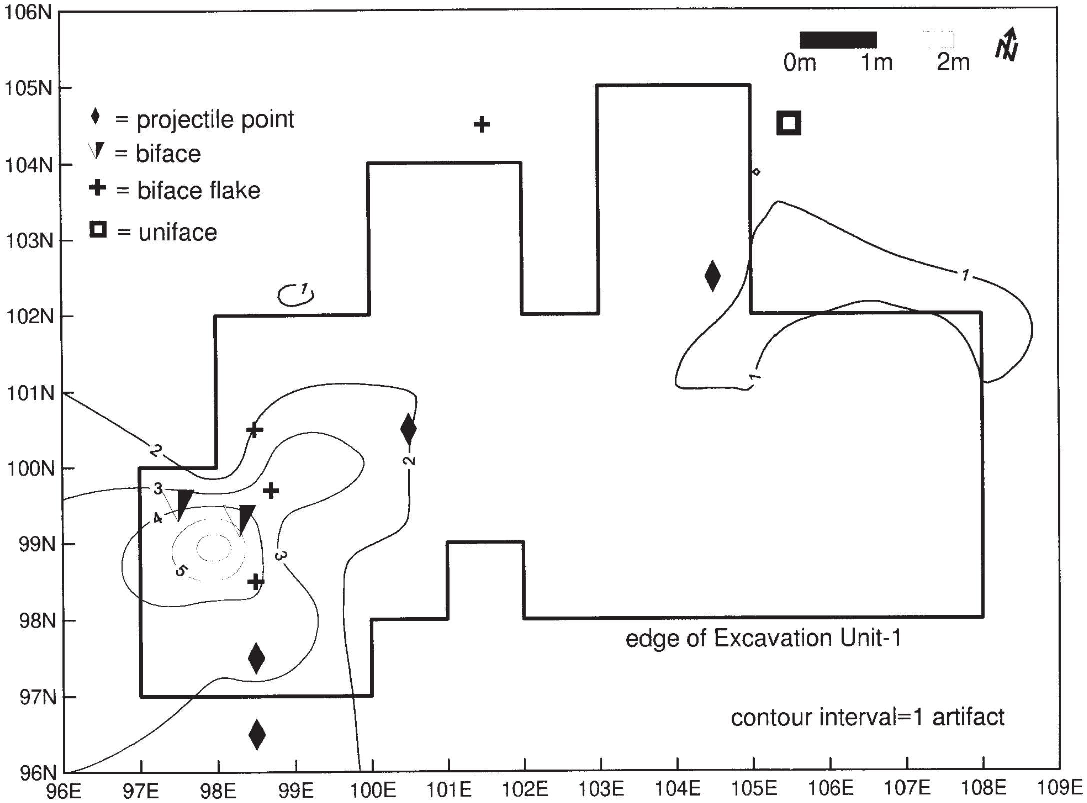

Figure 8.9. LA 115544/AR-03-02-07-523, EU-1: distribution of obsidian artifacts.

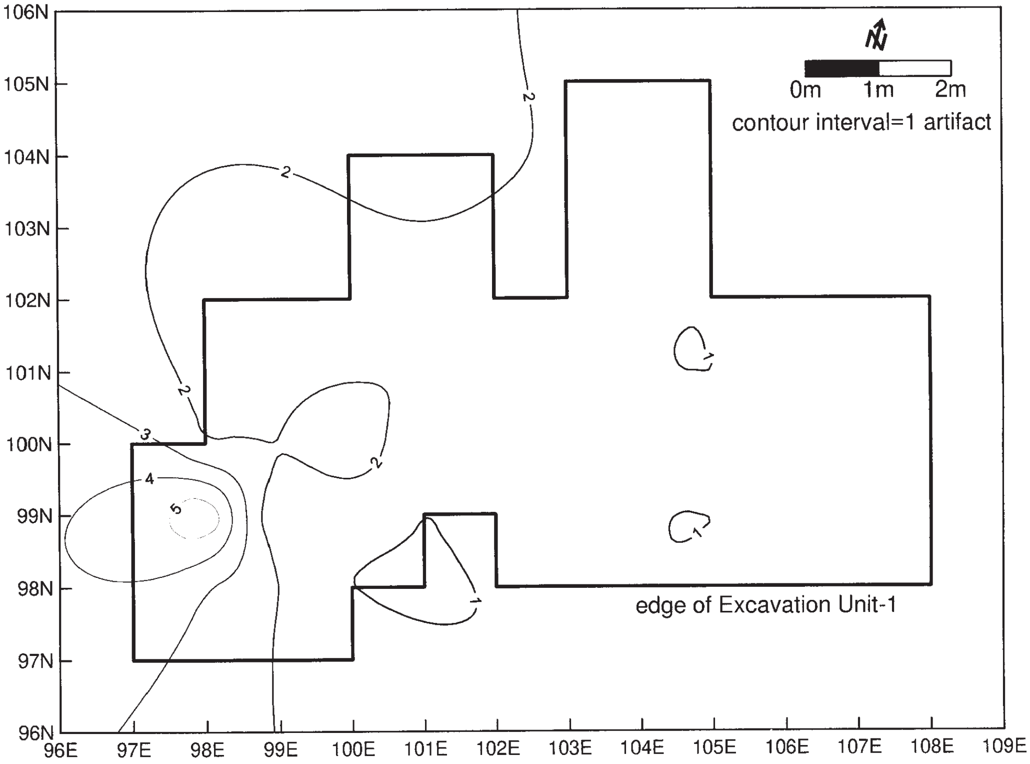

Figure 8.10. LA 115544/AR-03-02-07-523, EU-1: distribution of clear obsidian artifacts.

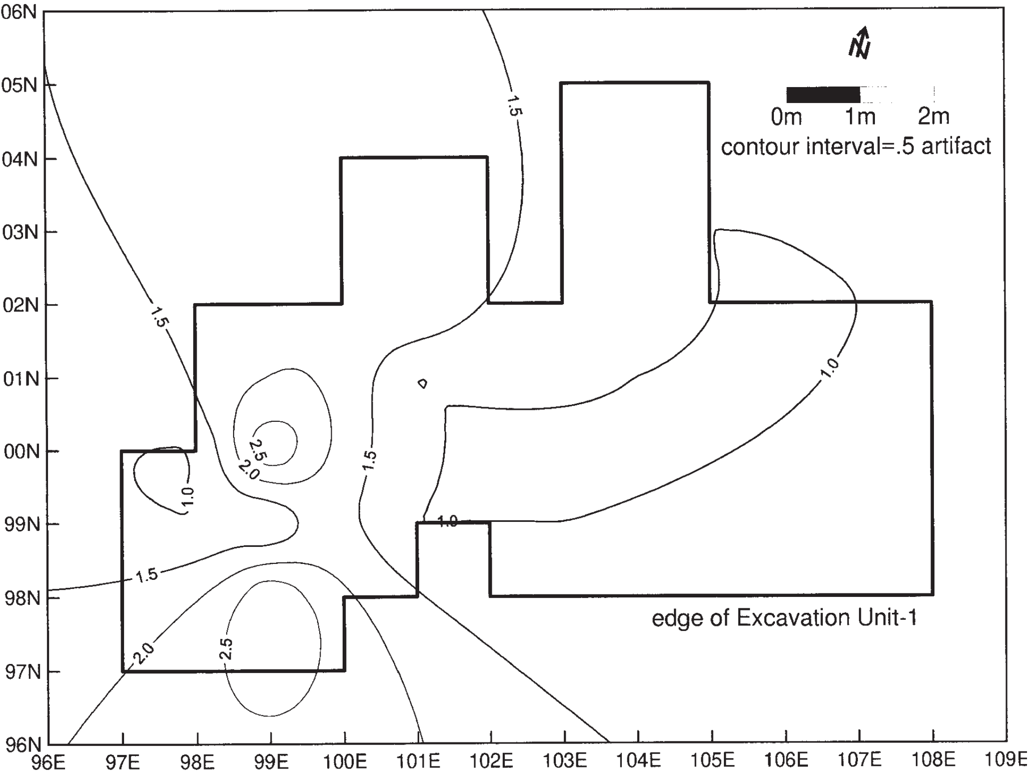

Figure 8.11. LA 115544/AR-03-02-07-523, EU-1: distribution of Polvadera obsidian.

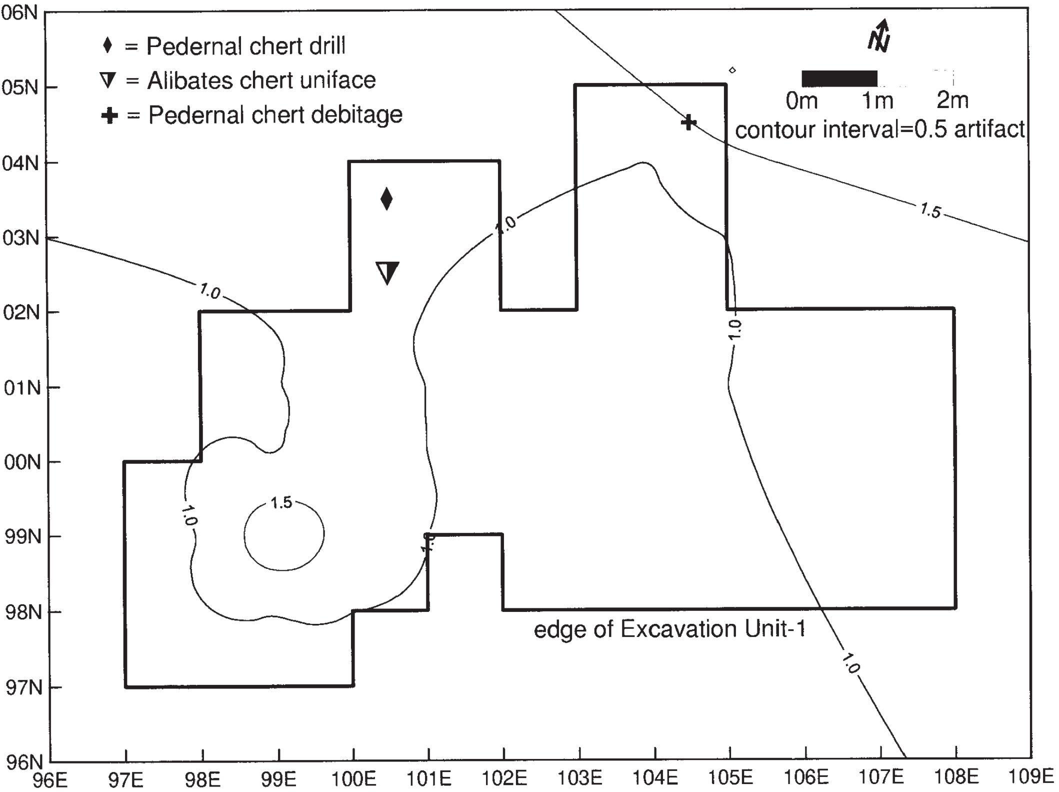

Figure 8.12. LA 115544/AR-03-02-07-523, EU-1: distribution of chert artifacts.

tion of clear obsidian closely resembles that of obsidian in general. This variety is concentrated in Cluster 2, with lows in and adjacent to Cluster 1. The distribution of Polvadera Peak obsidian is enhanced in Figure 8.11 to more clearly illustrate patterning. This variety also concentrates in Cluster 2, with peaks on the north and south edges of the andesite debitage concentration. Once again, there is a low in Cluster 1.

The last material to be examined is chert, the distribution of which which is shown in Figure 8.12, and is enhanced to more clearly show patterning. As was the case with obsidian, chert debitage concentrates in Cluster 2, with a low in the central part of EU-1 corresponding to the west half of Cluster 1; a few pieces of chert debitage were recovered from the east half of that cluster. Two chert tools and a piece of Pedernal chert debitage in EU-1 were found outside the small clusters of chert debris.

The distributions of obsidian and chert artifacts in EU-1 allow us to fine-tune our discussion of Clusters 1 and 2. Cluster 1 represents an andesite reduction area, with selected debitage (primarily flakes) apparently being removed for use elsewhere. While a few artifacts of other materials were also found in this cluster, they do not seem to represent in situ reduction episodes. An Alibates chert biface flake was recovered from Cluster 1, and an Alibates uniface was found at the north edge of Cluster 2. Visual comparison of these artifacts suggested that they may have come from the same core, but the flake was not struck from the uniface. Thus, at least one flake was removed from an Alibates chert biface, but the biface itself seems to have been carried off.

Other artifacts of note from Cluster 1 include a uniface, two pieces of utilized debitage (Polvadera Peak obsidian and andesite), and a andesite flake with a modified platform. The latter may have been removed from a biface, but this is unclear. The andesite flake with a modified platform came from the south edge of Cluster 1, while both formal tools were found along the north edge of the cluster. The informal tools came from a grid unit that is part of the small peak that occurs west of the main debitage concentration. The projectile point also came from near this peak. Thus, no tools were directly associated with the main concentration of andesite debitage, and the tools seem unrelated to the main episode of reduction in this area.

While most debris in Cluster 2 is derived from the reduction of one or more andesite cores, other reduction episodes are also visible. Both Polvadera Peak and clear obsidian were flaked in this area. Though all flakes of these materials found in Cluster 2 were categorized as core flakes, three have modified platforms that may be indicative of biface reduction. These flakes include one clear obsidian and two Polvadera Peak specimens. Several obsidian bifaces were found in Cluster 2, but all are small and none evidence manufacturing breaks. The possible obsidian biface flakes all seem too long to have come from these tools, and were probably removed from bifaces that were at least 20 mm wide. Though all obsidian bifaces from Cluster 2 are fragmentary, size projections suggest that none were that wide. Thus, the possible biface flakes flakes appear to derive from tools that were not discarded at this location.

The only definite biface flake recovered from Cluster 2 is chert, and does not match the Pedernal chert drill, which is the only chert tool recovered from LA 115544/AR-03-02-07-523. Two artifacts are potential evidence for the manufacture of at least one andesite biface in this area, including a large flake with a modified platform and the tip of a large biface that was broken during manufacture. These artifacts may reflect the same episode of tool production, but this is uncertain.

EU-1 appears to represent a palimpsest of reduction and tool-use events. Two major reduction episodes are represented by concentrations of andesite debitage and cores in Clusters 1 and 2. The two secondary peaks in Cluster 1 probably represent other minor andesite reduction episodes. Chert and obsidian artifacts are rare in Cluster 1 and are widely scattered across that area without occurring in concentrations. Formal and informal tools in Cluster 1 were found in and around the small secondary peaks that center at 102N/103E and 104N/104E. The former contains two informal tools and an obsidian projectile point base, and an obsidian uniface was found near the latter. Thus, the activities represented by these tools seem related to the minor reduction events rather than the main andesite reduction episode.

The situation is different in Cluster 2. While andesite reduction was also the main activity in this part of EU-1, other materials were also flaked there. Both clear and Polvadera Peak obsidian were reduced in Cluster 2, and, when their distributions are compared, at least three different episodes appear to be reflected. Polvadera obsidian was flaked on both the north and south edges of the main andesite reduction area, while clear obsidian was reduced along the west edge of that area. Flakes may have been removed from two different obsidian bifaces in this area, and at least two cores. The occurrence of a few potential biface flakes may be significant, as discussed in Chapter 7. Since ¼-inch mesh was used to screen these deposits, most debitage from small biface manufacture would not have been recovered.

While some cherts may also have been flaked in Cluster 2, the general paucity of this material category on the site and the fact that at least four types are represented among the nine chert artifacts in the EU-1 sample and 19 in the rough sort suggests that very little reduction of this material occurred in EU-1. Indeed, the chert debitage may actually have arrived at the site in that state rather than reflecting in situ core reduction. Chert also seems to have arrived at the site as large bifaces and formal tools. The distribution of chert debitage centers on Cluster 2, with a very thin scatter elsewhere.

Cluster 2 seems to have been more intensively used than Cluster 1. Several materials were reduced in Cluster 2, both as cores and bifaces. Tools were more abundant and include three bifaces, three projectile points, and three informally used pieces of debitage. Several activities are suggested by these artifacts, including biface manufacture (andesite biface tip broken in manufacture), weapon refurbishing (small corner-notched point base with haft snap), and woodworking (andesite denticulate and spokeshave).

Excavation Unit-2

The distribution of andesite debitage and cores in EU-2 is shown in Figure 8.13. This area contains two concentrations of debitage separated by a low area; Cluster 3 is centered at 91N/97E, while Cluster 4 is centered at 88N/98E. The distribution of andesite core flakes in EU-2 essentially replicates this pattern, and is shown in Figure 8.14. The main difference between patterning in Figures 8.13 and 8.14 is that the center of core flake distribution in Cluster 4 is a bit further north than is the center for andesite in general. However, the distribution of andesite angular debris in Figure 8.15 is patterned quite differently from that of the core flakes and debitage in general (Figs. 8.13 and 8.14). Two peaks are visible in Cluster 4, one of which centers at the same point as the debitage assemblage, and the second at 89N/97E. No peak occurs in Cluster 3 for andesite angular debris; indeed, there is a low centered at 90N/98E.

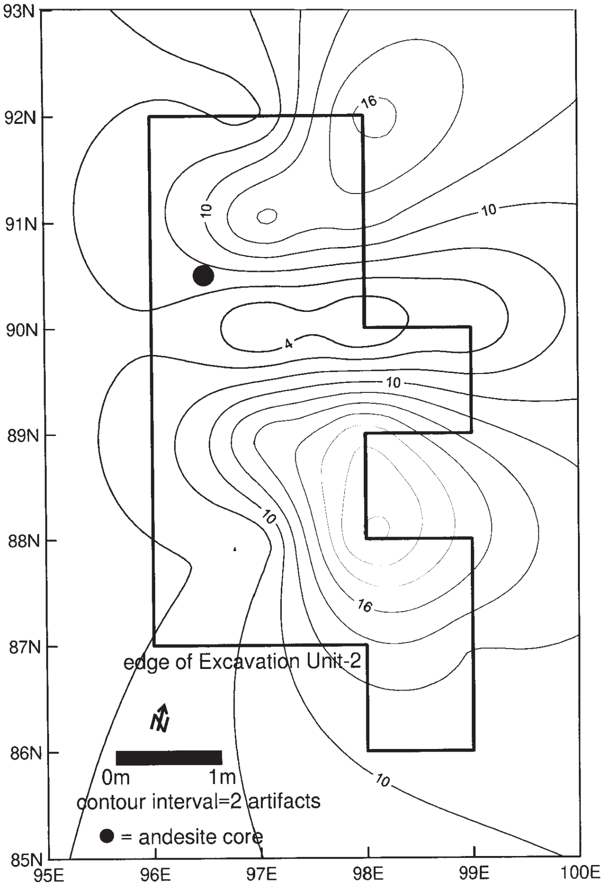

Figure 8.13. LA 115544/AR-03-02-07-523, EU-2: distribution of andesite debitage.

In order to compare Clusters 3 and 4, the EU-2 assemblage was split along the 90N grid line. Cluster 3 contains 50 pieces of andesite debitage, and Cluster 4 contains 99. Flake to angular debris ratios are 1.78:1 for Cluster 3 and 1.42:1 for Cluster 4, both fairly low. Though the flake to angular debris ratio is higher for Cluster 3 than for Cluster 4, a comparison of debitage type distributions

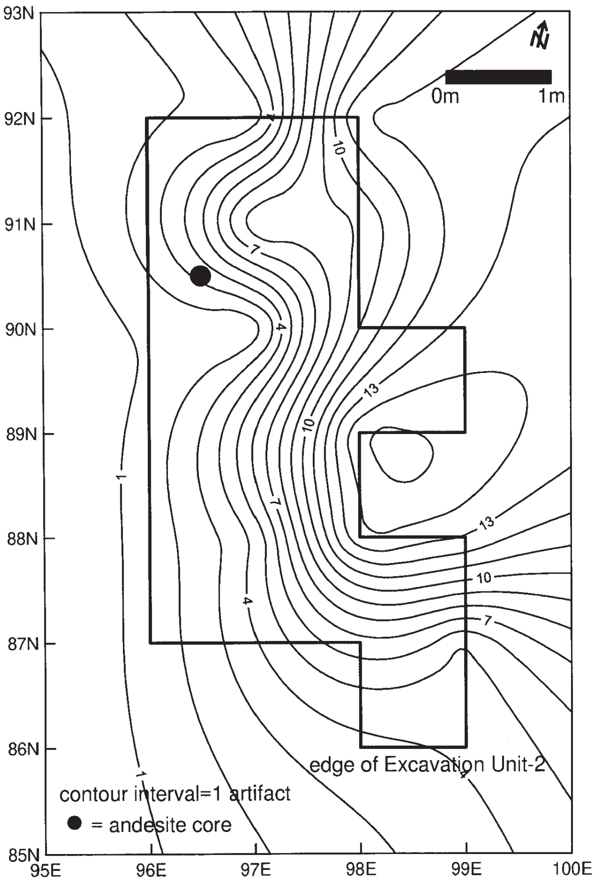

Figure 8.14. LA 115544/AR-03-02-07-523, EU-2: distribution of andesite core flakes.

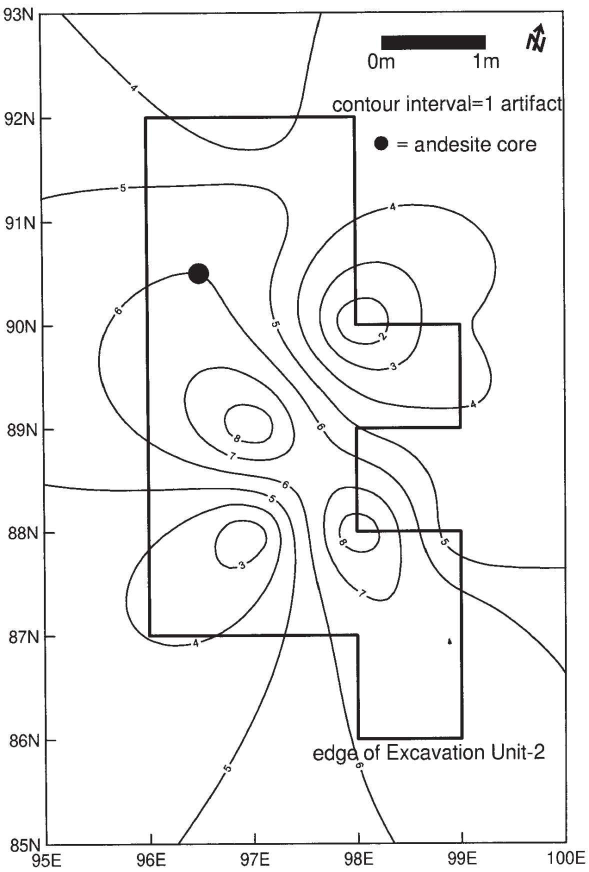

Figure 8.15. LA 115544/AR-03-02-07-523, EU-2: distribution of andesite angular debris.

between clusters strongly suggests that the same population may be represented (chi-square=.407, df=1, significance=.523, phi=.052). Conclusions made earlier concerning similar low flake to angular debris ratios also pertain here. Selected debitage, primarily flakes, may have been removed from these assemblages for transport elsewhere.

As with EU-1, this level of analysis essentially exhausts the information available from the rough sort, and we must turn to the sample for further data. The sample contains 30 pieces of andesite debitage from Cluster 3 (60 percent) and 35 from Cluster 4 (36 percent). Flake to angular debris ratios for the samples are 2.75:1 for Cluster 3 and 1.33:1 for Cluster 4. While the latter is close to that of the Cluster 4 assemblage as a whole, the former is much higher than that of the Cluster 3 assemblage as a whole. This suggests that the sample may be representative for Cluster 4, but not for Cluster 3. We must keep this in mind when drawing conclusions.

An examination of the distribution of platform types strongly suggests that a single population may be represented when missing and obscured platforms are combined in one category (chi-square=.573, df=3, significance=.903, phi=.117). Platform lipping is fairly common in both assemblages (46.2 percent for Cluster 3 and 18.2 percent for Cluster 4). Percentages of noncortical debitage are also similar for both assemblages (86.7 percent for Cluster 3 and 94.3 percent for Cluster 4). Unfortunately, there are too few examples in several categories for these attributes to allow dependable statistical examination.

Figure 8.16 shows how other materials are distributed in relation to the andesite debitage. Except that most of the coarse andesite artifacts are in Cluster 4, there is little correspondence between these categories. Cluster 3 contains a few coarse andesite and chert core flakes, while Cluster 2 con-

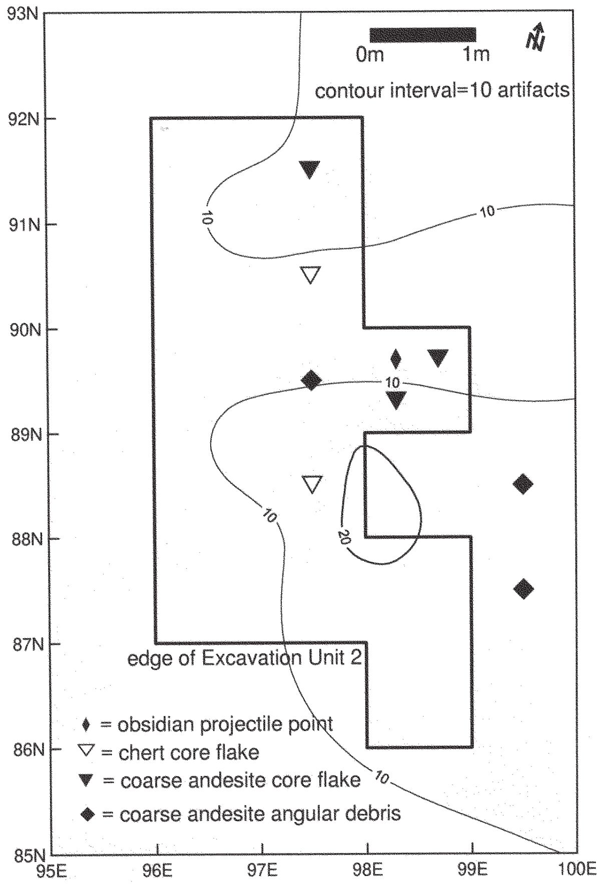

Figure 8.16. LA 115544/AR-03-02-07-523, EU-2: distribution of coarse andesite, chert, and obsidian artifacts in relation to andesite.

tains five pieces of coarse andesite debitage, a chert core flake, and an obsidian projectile point. All three tools found in EU-2 were in Cluster 4. They include the projectile point, which has a haft snap and impact fracture, and two pieces of utilized andesite debitage. Patterns of use on the latter are not diagnostic, so only general manufacture and maintenance tasks can be inferred from their presence.

This area contains far fewer artifacts than EU-1, and therefore cannot be examined at quite the same level of detail. Nonetheless, the distribution of artifacts suggests there were two discrete episodes of andesite reduction in EU-2. The close correspondence in distributions of platform types between the clusters suggests that similar reduction techniques were used. Much of the reduction in Cluster 3 and a fair amount of that in Cluster 4 was probably accomplished by soft-hammer percussion, judging from relatively high percentages of lipped platforms. Only core reduction appears to have been performed in this part of the site; there is no evidence for biface reduction in this area. Only three nonandesite artifacts were recovered from EU-2: two chert core flakes and an obsidian projectile point base. Since there is no good evidence for the production or use of these artifacts in EU-2, it is likely that they are unrelated to the reduction of andesite cores in this area, and instead reflect overlap with another occupation or suite of activities.

Excavation Unit-3

The distribution of andesite debitage and cores in EU-3 is shown in Figure 8.17, and comprises a single dense concentration (Cluster 5) centered at 83N/104E. A single andesite core is associated with this cluster. Distributions of andesite core flakes and angular debris are shown in Figures 8.18 and 8.19. The core flakes are distributed similarly to the debitage in general, and center at the same point. Angular debris are also patterned similarly, but center somewhat more to the west at 83N/103E. These materials probably represent one reduction event.

The flake to angular debris ratio for this cluster is 1.80:1, fairly low but among the highest for the site. The rest of this discussion is dependent on the sample, which comprises nearly 70 percent of the artifacts recovered from this area. The flake to angular debris ratio for the sample is only 1.33:1, so flakes may be underrepresented. When cortex is considered, flakes and angular debris seem to represent different populations (chi-square=7.230, df=1, significance=.017, phi=.211). Indeed, 30 percent of the angular debris is cortical, versus only 12.9 percent of the flakes. If percentages were originally more proportional, this may be an indication that larger cortical flakes were removed for transport elsewhere. However, since flakes are underrepresented in the sample, this difference may instead be due to sample error. Only core reduction is represented in the andesite assemblage from this area, with no biface flakes or modified platforms noted.

The distribution of materials other than andesite is shown in Figure 8.20. Eight of these nine artifacts are coarse andesite, mostly angular debris. The coarse andesite is distributed similarly to the glassy variety, suggesting that some of this material was reduced in the same area. The only other arti-

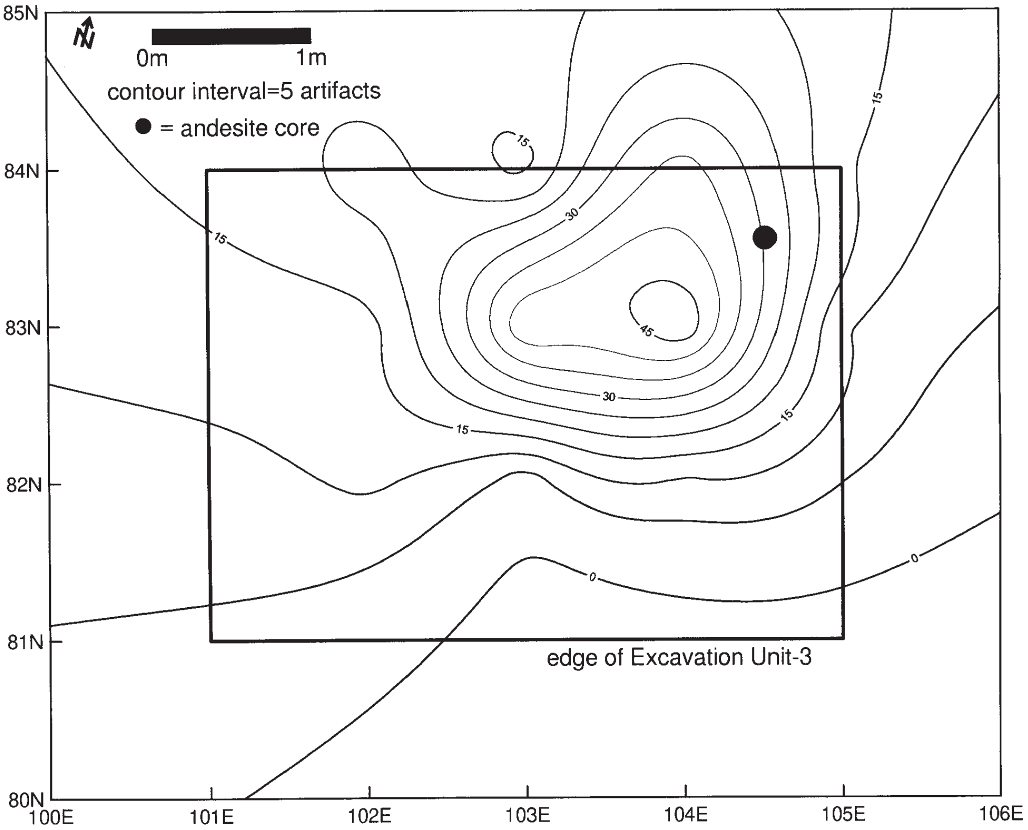

Figure 8.17. LA 115544/AR-03-02-07-523, EU-3: distribution of andesite debitage.

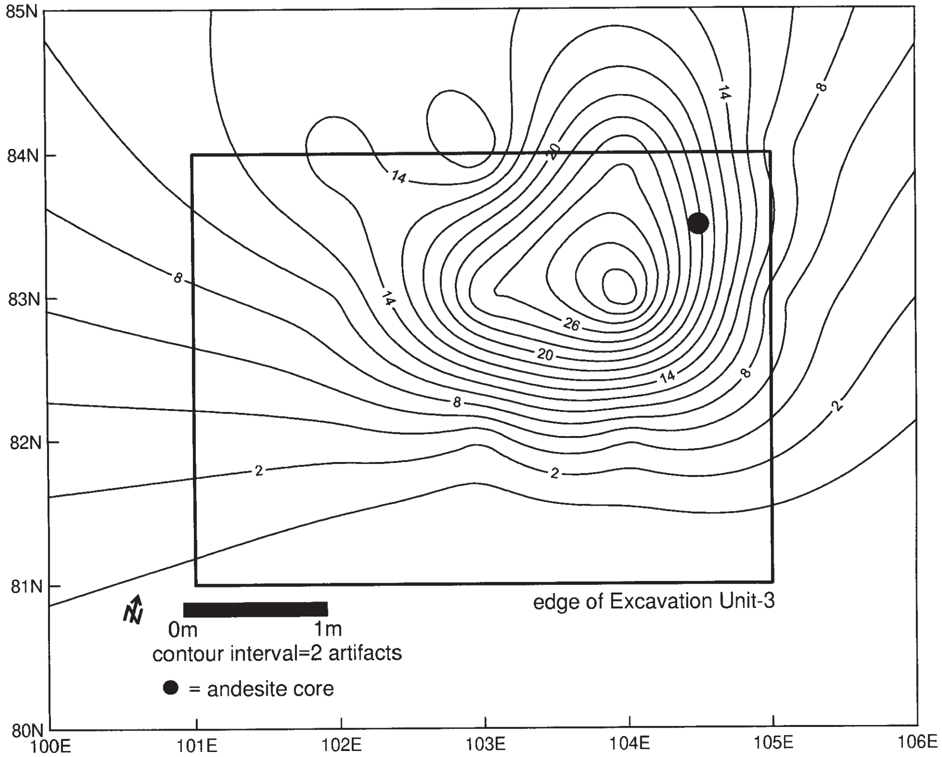

Figure 8.18. LA 115544/AR-03-02-07-523, EU-3: distribution of andesite core flakes.

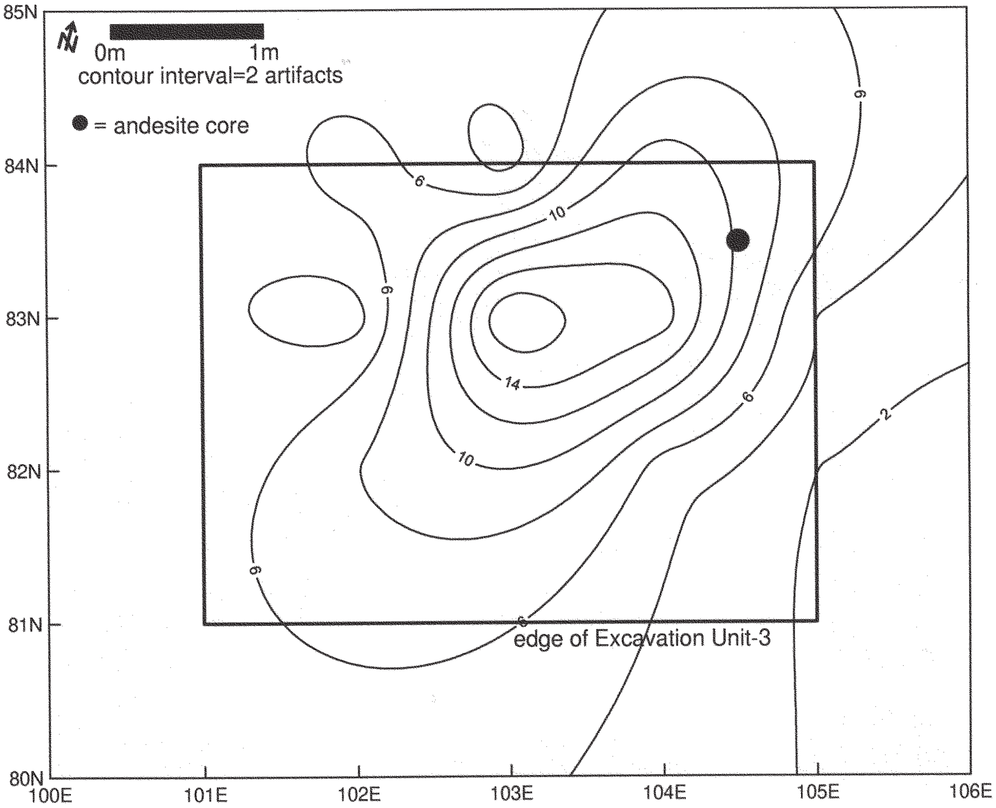

Figure 8.19. LA 115544/AR-03-02-07-523, EU-3: distribution of andesite angular debris.

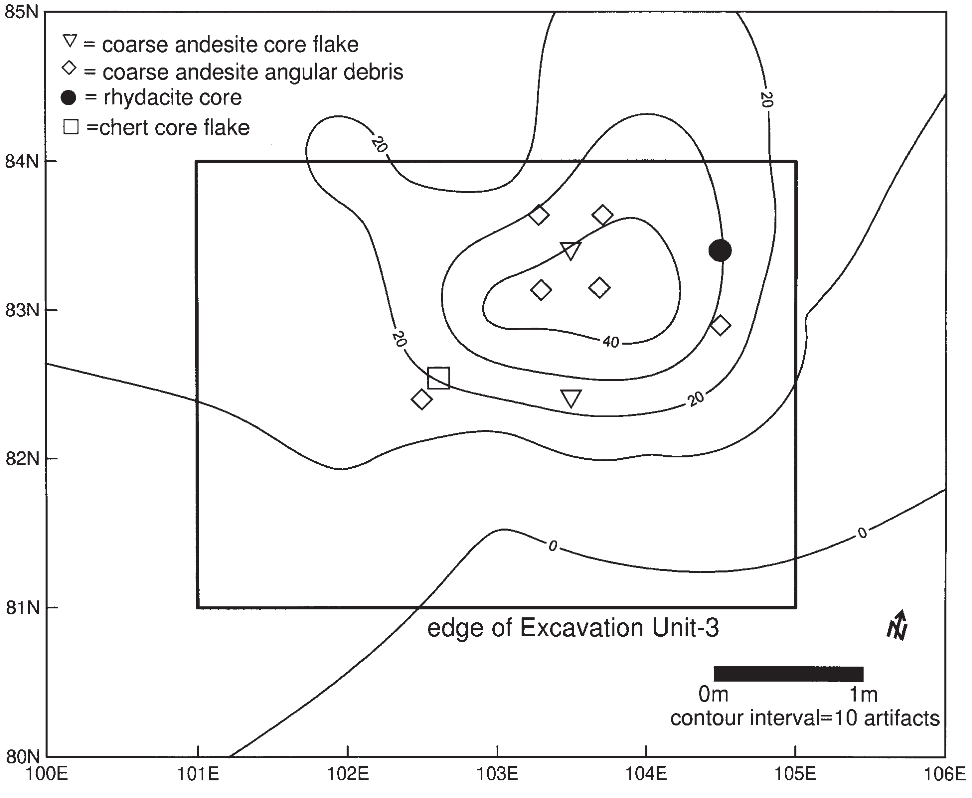

Figure 8.20. LA 115544/AR-03-02-07-523, EU-3: distribution of other materials in relation to andesite.

fact recovered from EU-3 is a chert core flake, which was certainly discarded here but may not have been struck from a core at this location. The only tools found in this area are andesite, and include a denticulate and a piece of utilized angular debris. Thus, the only task other than core reduction that can be suggested for this area is woodworking.

Comparison of Andesite Reduction Areas

Five discrete andesite reduction areas seem to be represented in the three excavation units at LA 115544/AR-03-02-07-523. While these clusters do not necessarily represent all of the flaking episodes that occurred in this area, they contain the densest concentrations of andesite and thus represent the most intensive episodes of core reduction. By comparing the clusters we may be able to determine whether they represent similar or disparate chipping events. In turn, this may allow us to suggest whether or not they represent similar occupations dating to the same general time period. As discussed above, Clusters 1 and 2 are in EU-1, Clusters 3 and 4 are in EU-2, and Cluster 5 is in EU-3. There will be differences between this analysis and the foregoing discussion because Clusters 1 and 2 have been refined to eliminate possibly nonrelated materials, especially the two secondary peaks in Cluster 1.

Comparing morphological distributions for all andesite core debitage in these clusters, the five assemblages seem to weakly represent different populations at the 95 percent confidence level (chi-square=15.188, df=4, significance=.0043, phi= .088). Standard residuals suggest that most of the variation is caused by the distribution in Cluster 1 (Table 8.3). With that cluster dropped from consideration there is a strong probability that the four remaining clusters may represent one population (chi-square=1.674, df=3, significance=.643, phi= .035). Thus, in terms of the distribution of morphological types, four of five clusters are similar. Cluster 1 contains an atypically small percentage of core flakes, as illustrated by the flake to angular debris ratios shown in Table 8.3.

When only the sampled assemblages are examined (Table 8.4), there is a strong probability that all five assemblages may represent the same population (chi-square=3.327, df=4, significance=.505, phi=.075). With Cluster 1 dropped from consideration the relationship remains the same, though the probability that a single population is represented is smaller (chi-square=3.130, df=3, significance=.372, phi=.085). Thus, once again we must note that the distribution of debitage types in the sample is not representative of the entire population. We can only hope that other attribute distributions are more representative of the whole assemblage, because these data are available only for the sample.

The distribution of cortex percentages is shown in Table 8.5. The amount of cortex was estimated in 10 percent increments, which created too many empty cells in a crosstabulation for dependable statistical analysis. Thus, cortex was reclassified as present or absent. Considering angular debris first, more than one population seems to be represented by these assemblages (chi-square=16.820, df=4, significance=.002, phi=.266), but since 30 percent of the cells contain five or fewer examples these results are suspect. Standard residuals suggest that Cluster 5 may be atypical, with a cortical percent-

TABLE 8.3. LA 115544/AR-03-02-07-523: COMPARISONS OF DEBITAGE DISTRIBUTIONS FOR THE FIVE ANDESITE REDUCTION AREAS; FREQUENCIES, COLUMN PERCENTAGES, AND STANDARD RESIDUALS

DEBITAGE TYPE	ARTIFACT CLUSTER				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 4
Angular debris	290	386	18	41	83
	47.9	39.8	36.0	41.4	35.8
	2.3	-1.0	-0.6	-0.1	-1.4
Core flakes	315	585	32	58	149
	52.1	60.2	64.0	58.6	64.2
	-2.0	0.8	0.5	0.1	1.2
Flake:angular debris	1.09:1	1.52:1	1.78:1	1.41:1	1.80:1

TABLE 8.4. LA 115544/AR-03-02-07-523: COMPARISONS OF DEBITAGE DISTRIBUTIONS FOR SAMPLES POPULATIONS FROM THE FIVE ANDESITE REDUCTION AREAS; FREQUENCIES AND COLUMN PERCENTAGES

DEBITAGE TYPE	ARTIFACT CLUSTER				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Angular debris	66 41.8	78 38.4	8 26.7	15 42.9	70 42.9
Core flakes	92 58.2	125 61.6	22 73.3	20 57.1	93 57.1

TABLE 8.5. LA 115544/AR-03-02-07-523: COMPARISONS OF CORTEX DISTRIBUTIONS ON DEBITAGE FOR THE SAMPLE POPULATIONS FROM THE FIVE ANDESITE REDUCTION AREAS; FREQUENCIES, COLUMN PERCENTAGES, AND STANDARD RESIDUALS

DEBITAGE TYPE	CORTEX	ARTIFACT CLUSTER				
		Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Angular debris	None	55 83.3 0.0	74 94.9 1.1	7 87.5 0.1	13 86.7 0.1	49 70.0 -1.2
	Present	11 16.7 0.0	4 5.1 1.1	1 12.5 -0.3	2 13.3 -0.3	21 30.0 2.8
Core flakes	None	86 93.5 0.2	115 92.0 0.1	19 86.4 -0.2	20 100.0 0.4	81 87.1 -0.4
	Present	6 6.5 -0.7	10 8.0 -0.3	3 13.6 0.8	0 0.0 -1.3	12 12.9 1.3

TABLE 8.6. LA 115544/AR-03-02-07-523: UNMODIFIED CORE PLATFORM TYPES ON FLAKES FROM THE FIVE ANDESITE CLUSTERS; FREQUENCIES AND COLUMN PERCENTAGES

PLATFORM TYPE	ARTIFACT CLUSTER				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Cortical	3 6.5	6 8.8	4 30.8	2 18.2	7 17.1
Single facet	18 39.1	37 54.4	4 30.8	4 36.4	25 61.0
Multifacet	25 54.3	25 36.8	5 38.5	5 45.5	9 22.0

age nearly double that of all the other clusters. Unfortunately, the remaining assemblages contain insufficient examples in too many cells for reliable statistical analysis.

Comparison of the presence and absence of cortex for flakes strongly suggests that a single population may be represented (chi-square=5.213, df=4, significance=.266, phi=.122). However, with 20 percent of the cells containing five or fewer examples, these results are also suspect (Table 8.5). All we can say from the cortical distributions is that very high percentages of both debitage categories lack cortex, with Cluster 5 being the only area with cortex on more than 14 percent of its debitage.

Examining striking platforms on flakes may help determine whether similar or different reduction techniques were used in the clusters. Only Clusters 1 and 2 contain modified platforms. In both cases only one example is present, either indicating that abrasion was rarely used to modify core platforms or that these examples represent early stage biface reduction. Platforms are either missing or obscured on 41 to 56 percent of the whole and fragmentary flakes in these assemblages. Unmodified platforms are illustrated in Table 8.6; because too many cells contain less than five examples, statistical examination of this distribution would be inconclusive. However, Clusters 1 and 2 have fairly small percentages of cortical platforms, while that category is considerably higher for Cluster 3 and moderately higher for Clusters 4 and 5.

Proportions of single facet and multifacet platforms vary considerably between assemblages. Fairly high percentages of multifacet platforms in Clusters 1 and 4 may indicate that cores were reduced to a greater extent in those areas than in the others. If so, whole flakes from these areas should be smaller than in the others. Mean whole flake dimensions for each cluster are shown in Table 8.7, and tend to support this prediction. Whole flakes with unmodified platforms in Clusters 1 and 4 are the smallest, overall. Of course, sample size is also very small, so it would probably be unwise to overly stress this correspondence.

Comparing proportions of cortical platforms in Table 8.6 to cortical flakes in Table 8.5, we find that the highest percentages of cortical platforms occur in assemblages with the highest percentages of cortical flakes (Clusters 3 and 5). The only exception to this is Cluster 4, which contained no cortical flakes but had over 18 percent cortical platforms. This is undoubtedly due to the small sample of flakes with platforms in that cluster, since only two flakes have cortical platforms.

Certain trends in these data suggest several similarities between andesite clusters. Low cortical debitage percentages imply that most of the nodules reduced at these locations were struck from nearby andesite outcrops and boulders, and therefore had little cortical coverage to begin with. This is especially true for Clusters 1, 2, and 4 where cortical debitage percentages are 6.5, 8.0, and 0.0, respectively. Percentages are somewhat higher for Clusters 3 and 5 (13.6 and 12.9 percent, respectively), and may be indicative of the use of some natural cobbles as well as those struck from outcrops.

Platforms tend to be simple types that lack modifications to facilitate removal. Though there are differences between clusters in percentages of cortical, single facet, and multifacet platforms, this variation is probably due to factors other than reduction technique. Higher percentages of cortical platforms occur in assemblages with larger proportions of cortical debitage. Multifacet platforms occur in assemblages in which cores may have been more extensively reduced, producing a smaller mean flake size. Percentages of lipped platforms are high, ranging from 18.2 percent in Cluster 4 to 46.2 percent in Cluster 3, and averaging 33.6 percent. While hard-hammer percussion was probably used for half or more of the reduction in each cluster, soft-hammer percussion also seems to have been an important component of the reduction strategy.

This analysis suggests that similar techniques were used to reduce cores in all five andesite clusters defined at LA 115544/AR-03-02-07-523. The high level of variability in some attributes is proba-

TABLE 8.7. LA 115544/AR-03-02-07-523: MEAN WHOLE FLAKE LENGTHS FOR ANDESITE FLAKES WITH UNMODIFIED PLATFORMS FROM THE FIVE CLUSTERS

DIMENSION	ARTIFACT CLUSTER				
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Length	21.3	28.0	50.7	13.3	21.5
Width	20.1	21.1	59.7	13.5	22.2
Thickness	5.7	7.1	14.0	4.3	6.1
No. of examples	18	22	3	4	15

bly due to differences in original nodule size, where the nodule was procured, presence and absence of flaws, skill of the flintknapper, and other factors. Even using the same reduction techniques, no two cores will produce the same amount of debitage, the same proportion of flakes to angular debris, or the same range and percentages of platform types. Some variation is undoubtedly due to differences in the number and types of debitage selected for transport elsewhere. As suggested in Chapter 7, rather than preparing cores for transport to residential sites, the people who used this part of LA 115544/AR-03-02-07-523 appear to have been reducing cores and selecting debitage that fit their parameters for usable informal tools. Those that fit were carried away, those that did not were left behind. Differences in individual tastes or needs probably caused some variation. Unfortunately, these are variables that cannot be quantified, though they may have extensively affected the various assemblages.

LA 115550/AR-03-02-07-528

Two proveniences were defined for LA 115550/AR-03-02-07-528, one on the east side of NM 522 and the other on the west side. Since these areas are now physically separated, there is no way to determine whether they represent a single occupation of this site or multiple uses, so they are discussed separately.

East Side of NM 522

Only 24 artifacts were recovered from the east side of NM 522. Most (n=22; 91.7 percent) are andesite, and include ten core flakes, nine pieces of angular debris, two bipolar flakes, and a multidirectional core. The two remaining artifacts are a bidirectional core and a piece of angular debris, both of undifferentiated igneous materials. While both of these artifacts were placed in the same material category, they do not have the same minerological content, and in reality are different materials, neither of which appear to have been reduced at this location. The core may have been discarded in favor of better quality andesite, while the piece of angular debris was probably brought to the site in its current state.

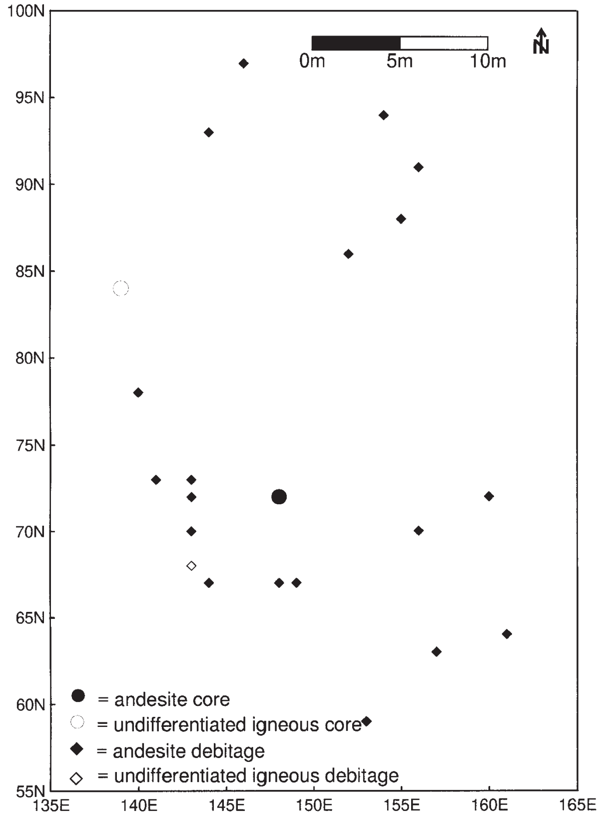

Figure 8.21. LA 115550/AR-03-02-07-528: distribution of artifacts on the east side of NM 522.

Not enough artifacts were found in this area for a detailed structural analysis. Figure 8.21 shows the distribution of artifacts on the east side of NM 522. Most andesite debitage cluster in the south part of the provenience, but the density of artifacts there is only .03 per sq m. This is extremely low, and is not indicative of reduction. Three of six informal andesite tools from LA 115550/AR-03-02-07-528 are from this provenience and include a core flake with bidirectional wear, a core flake with rounding, and a piece of angular debris with unidirectional retouch and abrasion. The relatively high percentage of utilized debitage in this provenience (14.3 percent) suggests that it may represent an activity area. The flake with rounding could have been used in hide preparation, while all we can say about the other two specimens is that they were used in tasks involving scraping or cutting medium-hard to hard materials.

A second possibility is suggested when dorsal cortex on andesite debitage from this area is considered. Cortex occurs on 55.6 percent of angular debris and 16.7 percent of core flakes. One of two core flakes with dorsal cortex is a primary flake with 100 percent dorsal coverage, the other is a secondary flake with 10 percent dorsal coverage. The former also has a cortical platform, as does a flake with no dorsal cortex. Considering the high percentage of cortical angular debris, we would have expected to see a much higher percentage of cortical flakes. The flake to angular debris ratio for andesite in this area is 1.1:1, which is also extremely low. Some of the flakes seem to be missing, and it is possible that they were carried off for use elsewhere, while some of those that remained in this area were used in various tasks. The comparatively high percentage of cortical angular debris suggests that one or more existing weathered cobbles were flaked in this area.

West Side of NM 522

Only Excavation Area 3 (EA-3) on the west side of NM 522 contains enough artifacts to allow detailed analysis; the other areas are discussed in a more cursory fashion. Only five andesite artifacts were recovered from EA-1, including three core flakes and two pieces of angular debris, none of which exhibited evidence of informal tool use. EA-2 yielded 18 artifacts, including 8 core flakes, a bipolar flake, and 9 pieces of angular debris; none was used as informal tools. These areas were selected for excavation because they contained slightly higher concentrations of surface artifacts than elsewhere. They may represent loci where cores were reduced, but the small size of each assemblage makes it impossible to determine whether this is correct.

A greater level of analysis is possible for EA-3 because it contains the most extensive concentration of chipped stone debris at the site. Indeed, EA-3 contains 82.5 percent of the artifacts found on the west side of NM 522, and 78.1 percent overall. Andesite comprises 99.7 percent of the artifacts in EA-3, the only exception being an undifferentiated igneous core. Since no debitage from the latter were recovered, we must conclude that it was reduced elsewhere before being transported to this location

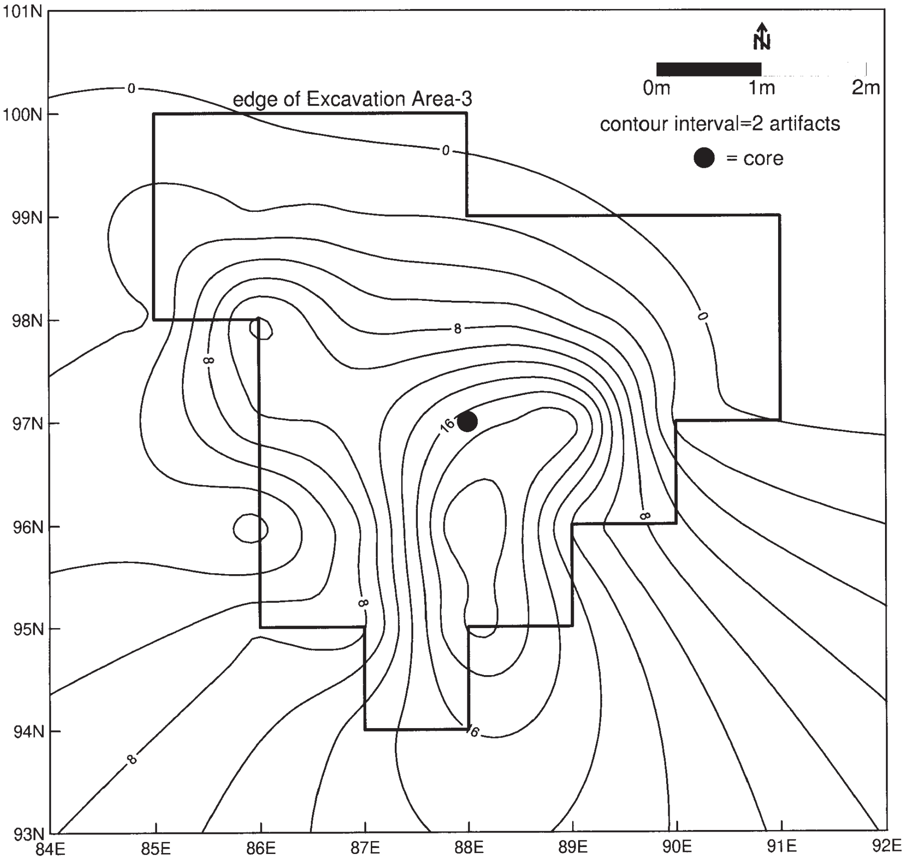

Figure 8.22. LA 115550/AR-03-02-07-528, EA-3: distribution of andesite flakes.

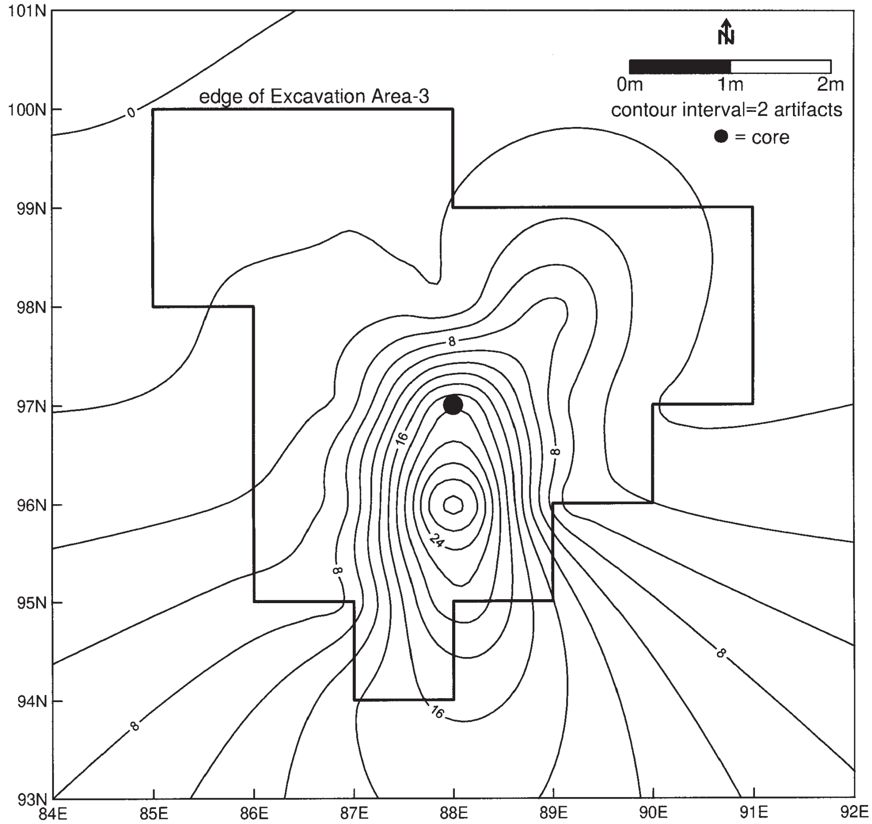

Figure 8.23. LA 115550/AR-03-02-07-528, EA-3: distribution of andesite angular debris.

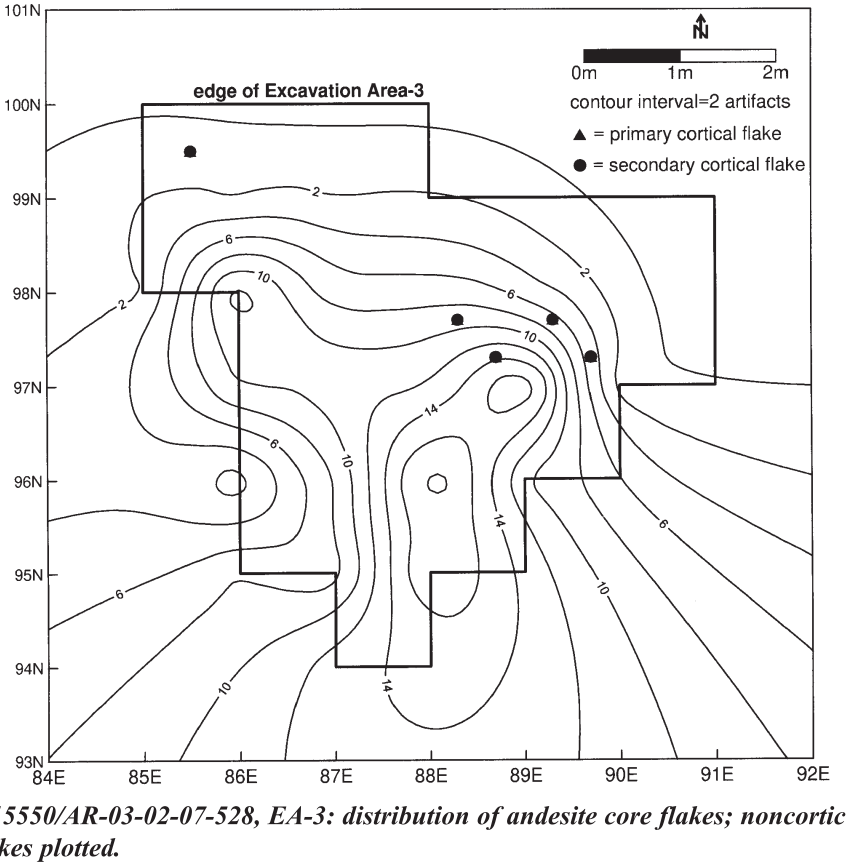

Figure 8.24. LA 115550/AR-03-02-07-528, EA-3: distribution of andesite core flakes; noncortical flakes contoured, cortical flakes plotted.

and discarded.

Figure 8.22 shows the distribution of andesite flakes in EA-3. This distribution is well structured and shows two peaks, one in the south-central part of the area (Cluster 1) and a second to the northwest (Cluster 2). The only andesite core recovered from EA-3 was in Cluster 1. The distribution of andesite angular debris in Figure 8.23 is quite interesting. Angular debris concentrates in Cluster 1, but drops off to nearly nothing in Cluster 2. The core is also associated with the main cluster of angular debris. Figure 8.24 shows the distribution of noncortical andesite core flakes, with the locations of primary and secondary core flakes plotted. With one exception, the cortical flakes group around Cluster 1.

Flakes in Cluster 2 have a slightly larger mean size and smaller standard deviations than do those in Cluster 1 (Table 8.8), so flake sizes are more tightly grouped in Cluster 2 than in Cluster 1. Added to the virtual lack of angular debris and cortical flakes, the nature of Cluster 2 is suspicious. Overall, the flake to angular debris ratio for EA-3 is 1.22:1, which is low. The same ratio for Cluster 1 is 1.08:1, which is even lower. However, the flake to angular debris ratio for Cluster 2 is 3.75:1, much higher than any other section of this site. The angular debris in Cluster 2 also tend to be larger than those in Cluster 1, averaging over 8 mm longer and nearly 5 mm wider.

The andesite debitage in Cluster 2 is different from that in Cluster 1. On average they are larger in size, and fewer pieces have cortical surfaces. Only 1 flake out of 38 pieces of debitage in Cluster 2 has a cortical surface, with 10 percent of its dorsal surface covered with cortex. In contrast, 9.6 percent of debitage in Cluster 1 is cortical, and 6.1 percent has cortical coverage of 50 percent or more.

TABLE 8.8. LA 115550/AR-03-02-07-528, EA-3: MEAN SIZES AND STANDARD DEVIATIONS IN MM FOR FLAKES IN THE TWO CLUSTERS; STANDARD DEVIATIONS IN PARENTHESES

DIMENSION	ARTIFACT CLUSTER	
	Cluster 1	Cluster 2
Length	17.2 (9.44)	18.9 (9.65)
Width	16.3 (9.65)	17.4 (5.78)
Thickness	5.63 (3.82)	6.17 (3.54)

Considering the results of experimental reduction of andesite nodules presented in Chapter 7, we can suggest what these patterns might mean. Cluster 1 looks like an area where one or more andesite cores were reduced and from which selected debitage were removed for transport elsewhere. Reduction in this area is suggested by the clustering of both core flakes and angular debris, and by the presence of a andesite core (Figs. 8.22 and 8.23). While cortex is comparatively rare on debitage from EA-3, the way in which cortical flakes are distributed in Cluster 1 (Fig. 8.24) also supports the contention that that it represents a reduction area. Evidence for the removal of selected debitage (mostly flakes) from this area is found in the very low flake to angular debris ratio. As we found in our reduction experiment, this ratio should be higher if all the debris resulting from reduction were left in this area.

The nodule(s) reduced in Cluster 1 appear to have had few cortical surfaces, as suggested by the rather small percentage of cortical debitage that was recovered. Only 9.2 percent of the flakes and 10.0 percent of the angular debris from this area have cortical surfaces. These percentages are very similar, despite the fact that flakes seem to have been removed from this area. Indeed, chi-square analysis strongly suggests that a single population may be represented when cortical and noncortical percentages of flakes and angular debris are compared (chi-square=.057, df=1, significance=.811, phi=.014). Despite the probable removal of selected flakes from this area, these similarities suggest that only a few cortical flakes were actually removed. Thus, the original nodule(s) probably had limited cortical coverage. Either a nodule was prepared elsewhere, removing most of the cortical surface, or it came with little cortex. The latter is most likely, and this suggests that one or more nodules were struck from outcrops in this area and reduced at LA 115550/AR-03-02-07-528.

Cluster 2 seems to be where selected debitage was placed for possible use or transport elsewhere. Both flakes and angular debris in this area tend to be larger than those in Cluster 1, only one cortical specimen was recovered, and there are no associated cores. Of course, since the flake to angular debris ratio for this area is similar to the mean derived experimentally, this could be a location where a core was reduced and all debitage were left behind. This seems unlikely considering the apparent function of LA 115550/AR-03-02-07-528 as a workshop where flakes were produced for transport elsewhere, especially considering the close proximity of Cluster 1. The larger mean size of debitage in this area, the virtual lack of cortical debitage, and the comparatively high flake to angular debris ratio all suggest that this is the area where acceptable debitage was placed during a reduction episode, most of which was subsequently collected for transport elsewhere. Either it was decided not to carry the debitage off, or the pieces represent specimens that were rejected on a second pass through the collection.

Summary and Discussion

While the paucity of available data for LA 115550/AR-03-02-07-528 has limited our analysis of site structure, we were able to draw some conclusions concerning certain parts of that site. There are distinct differences in how the scatters on the east and west sides of NM 522 functioned. The area on the east side of the highway saw limited reduction of andesite and some informal tool use. Anomalous artifacts in this area include a core and a piece of angular debris that are of distinctly different materials, and are not andesite. The core appears to have been discarded without being reduced at this site, suggesting that it was replaced by an andesite core or debitage. The nature of the piece of angular debris is suspect, and it may not actually be an artifact.

Most of the information available for the scatter on the west side of the highway comes from analysis of EA-3. One or more andesite cores were reduced in that area, and debitage suitable for use elsewhere may have been separated out and placed to one side. Most of the stockpiled debitage seems to have been transported away from the site, though some were left behind, possibly because a second pass through the pile found them to be unsuitable for use.

There is only limited evidence for activities using informal tools on the west side of the highway. Three informal tools were found in that area, the same number as on the east side, but they represent a much smaller percentage of that assemblage (0.07 percent versus 14.3 percent on the east side). One tool from the west side of the highway may have been used for leather working, while the others functioned in general manufacture-maintenance tasks. Two cores of materials foreign to the general site area–quartzite and undifferentiated igneous–were discarded on the west side of the highway, and do not appear to have been reduced at LA 115550/AR-03-02-07-528. A third core is a tested coarse andesite cobble. While the latter was probably flaked on-site, no associated debitage was recovered.

The main activity performed in both proveniences was the reduction of glassy andesite to obtain debitage for transport elsewhere. This was accompanied by limited informal tool use, and discard of cores of less desirable materials when andesite became available. Both proveniences evidence a dual use as resource procurement areas and short-term camps in which some manufacture-maintenance of tools and perhaps hide processing was accomplished. This was essentially the function that was suggested by the detailed analysis of the entire chipped stone assemblage in the last chapter. While the limited amount of site structure analysis that could be performed has added little to those conclusions, it has confirmed that these activities occurred in both proveniences. If LA 115550/AR-03-02-07-528 represents more than one occupational episode, it was used in essentially the same way during each occupation. If a single occupation is represented, we may be missing the main part of the site, which would have been in the area of the existing highway. However, sufficient data remain to show that both parts of LA 115550/AR-03-02-07-528 functioned very similarly to LA 115544/AR-03-02-07-523 in the prehistoric settlement and economic system.

DISCUSSION

Analysis of the structure of excavated remains at LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 did not yield the types of data that would allow us to conclude whether or not the various analytical units were used contemporaneously. We are uncertain whether artifacts on the east and west sides of NM 522 at LA 115550/AR-03-02-07-

528 represent different activity areas related to the same occupation. Similarly, we do not know whether the five andesite reduction areas defined for LA 115544/AR-03-02-07-523 all relate to the same occupational episode or are indicative of more than one use of this area. However, there are enough data to allow us to suggest interpretation of the patterns of deposits on these sites.

Dating the Sites

The same techniques seem to have been used to reduce andesite in all five clusters defined at LA 115544/AR-03-02-07-523. Both hard- and soft-hammer percussion were used to remove flakes from cores, with little evidence of platform modification. This is also the case for the assemblage from the west side of NM 522 at LA 115550/AR-03-02-07-528, especially EA-3. Only one flake from that area has a modified platform. A fairly high percentage of platform lipping was also noted for this part of LA 115550/AR-03-02-07-528 (29.6 percent overall, 34.2 percent for EA-3). However, the assemblage from the east side of NM 522 differs in that no platform lipping was noted, suggesting that only hard-hammer reduction was used to remove the flakes recovered from that area.

The similarities in reduction techniques noted in Clusters 1 through 5 at LA 115544/AR-03-02-07-523 and EA-3 at LA 115550/AR-03-02-07-528 suggests that they may date to the same general time period. This may be supported by similarities in the structure of these areas, which suggest reduction of glassy andesite nodules that were struck from outcrops and removal of selected debitage for transport elsewhere. Rather than testing and preparing cores for use elsewhere, glassy andesite was reduced and suitable debitage was apparently selected for transport to residential sites. Flaking characteristics of the glassy andesite were probably responsible for this. Experiments showed that this material is brittle and prone to much shattering and flake breakage. By returning only selected debitage to residential sites, prehistoric peoples were able to reduce wastage and thus the weight of useless material that had to be transported.

Large biface manufacture was either a minor aspect of reduction activities (Clusters 1 and 2 at LA 115544/AR-03-02-07-523), or did not occur at all (Clusters 3 through 5 at LA 115544/AR-03-02-07-523; east and west sides of NM 522 at LA 115550/AR-03-02-07-528). This would tend to argue against an Archaic date for these deposits, since bifacial tools made from andesite tend to be fairly common on sites dating to that period. Dependence on expedient reduction, sometimes with more limited use of large general purpose bifaces, is usually considered indicative of a relatively sedentary lifestyle. For the Taos area, this suggests that these deposits reflect quarrying activities dating after about A.D. 1050 or 1100. This is partly supported by the occurrence of several small corner-notched projectile points on LA 115544/AR-03-02-07-523, which may be indicative of use fairly close to these dates rather than later in the Coalition or Classic periods, though this remains uncertain.

Pattern of Use

Determining whether the clusters on these sites represent single or multiple episodes of use is a difficult proposition. However, data presented in this chapter can be used to suggest which of these possibilities might reflect the actual pattern of use. The key to determining how the part of LA 115544/AR-03-02-07-523 within project limits was used may lie in our analysis of Cluster 2 in EU-1. That concentration of chipped stone seems to reflect several discrete yet overlapping reduction events involving glassy andesite and at least two varieties of obsidian. Because of the way they cluster, these reduction episodes probably reflect a single use of the area. While obsidian is also mixed with glassy andesite in Cluster 1, it occurs in no definable pattern. This suggests that it may have been deposited at a different time.

The unpatterned overlay of obsidian, chert, and tools in Cluster 1 may indicate more than one use of that area. This possibility is strengthened by the distribution of glassy andesite, which forms a main peak and two minor ones, suggesting that Cluster 1 may actually represent three discrete uses of this area. Little tool use was documented for Cluster 1. The only tool in the main cluster of glassy andesite is a small, corner-notched, projectile point of Polvadera Peak obsidian that has been resharpened. While this point could be related to the activity that produced the cluster of glassy andesite debitage, this is by no means certain. It is equally possible that it represents a discard from another use of the site. The remaining tools from this part of EU-1 are associated with the minor peak northwest of the main concentration in Cluster 1. That area contains two pieces of retouched debitage and a uniface. No tools were indentified in the second minor peak to the west of the main andesite concentration.

Cluster 2 seems to represent a single-use episode involving the reduction of glassy andesite, and at least two varieties of obsidian. This area also contains most of the tools recovered from LA 115544/AR-03-02-07-523 including a piece of retouched debitage, a spokeshave, a denticulate, three bifaces, and two projectile points. Most of the fragments of bone recovered during excavation also occurred along the east side of this artifact concentration. A drill and a uniface were recovered from just north of this cluster, and may also have been associated with it. Activities that appear to have occurred during this use of the site include andesite core and biface reduction, core and probably biface reduction of at least two varieties of obsidian, wood working, hide preparation, hunting, and meat processing-consumption. While the tools may have been discarded where they were used or replaced (in the case of the projectile points), the bone fragments may represent trash that was merely tossed out of the living zone, indicating that its direct association with Cluster 2 is questionable. However, since most of the bone occurs directly adjacent to Cluster 2, such an assumption is not unwarranted.

Though Clusters 3 and 4 in EU-2 are near EU-1, they seem to represent one or more separate uses of the area. Rather than representing two discrete chipping events, Clusters 3 and 4 might actually be a single, rather dispersed, reduction zone, based on differences in the distributions of glassy andesite flakes and angular debris. While two andesite chipping areas seem visible in Figure 8.13, there is no good correspondence between distributions of flakes and angular debris in Figures 8.14 and 8.15. Thus, the existence of two separate reduction areas is questionable. Two informally used pieces of debitage and an obsidian projectile point fragment were recovered from Cluster 4. The informal tools can only be assigned to a general manufacture or maintenance function. A haft snap and impact fracture are combined on the point, indicating that it shattered during use and was probably returned to the site in a meat package. If so, hunting may be added to the array of tasks accomplished during use of this area. However, the only faunal remains were found in EU-1, slightly to the north of EU-2. Thus, this point fragment could have originated during use of that area and may have simply been discarded in EU-2. Unfortunately, there is no way to determine which of these possibilities (if either) is correct.

The distribution of artifacts in Cluster 5 is much clearer. This area mainly represents a single glassy andesite reduction episode, with some chipping of coarse andesite. The only tools recovered from this area were an informally used piece of debitage and a denticulate, both of glassy andesite.

The pattern of use in this part of LA 115544/AR-03-02-07-523 is fairly clear. Reduction of glassy andesite to obtain usable debitage for transport elsewhere was the main task performed in each use area. In most cases, there is an overlay of tool-using activities, the most intensive of which is in Cluster 2. Otherwise, there is evidence for some manufacture or maintenance of tools made from perishable materials in most clusters, but little else. This is similar to the pattern seen in EA-3 on the west side of NM 522 at LA 115550/AR-03-02-07-528. There is evidence for the production of andesite debitage for transport elsewhere in that area, and for limited tool use. A different pattern of use was visible on the east side of NM 522 at LA 115550/AR-03-02-07-528. There is limited evidence for andesite reduction in that area, but much more informal tool use (on the average).

Evidence for five to seven relatively repetitive episodes of glassy andesite reduction at LA 115544/AR-03-02-07-523, usually with a limited amount of tool use in association, tends to argue for multiple use events. This is fairly clear in EU-1, where Cluster 2 seems to postdate deposition of the main concentration of andesite in Cluster 1. Indeed, both minor andesite peaks in Cluster 1 may also postdate deposition of the main concentration of that material. Cluster 3/4 in EU-2 and Cluster 5 in EU-3 probably also represent discrete use episodes, and it is unlikely that they are directly related to the other use episodes defined in this part of the site. Thus, at least four discrete episodes of use appear to be represented in the part of LA 115544/AR-03-02-

07-523 within project limits. Three of these uses were fairly minor, and primarily involved the acquisition of andesite debitage and a minor amount of tool manufacture or repair (and probably the latter). Cluster 2 represents the most intensive use of this area, and provides the best evidence for the pattern of use posited in Chapter 7. In this case, at least, procurement of glassy andesite debitage appears to have been embedded in a hunting trip.

Differences in patterns of use exhibited between proveniences on the east and west sides of NM 522 at LA 115550/AR-03-02-07-528 suggest that at least two discrete episodes of use are represented. The structure of deposits on the west side of the highway closely resemble the pattern defined at LA 115544/AR-03-02-07-523, and could feasibly be indicative of use during the same general period. However, the pattern defined for materials on the east side of NM 522 is quite different from the west side pattern, and may be indicative of use during another period.

Summary and Conclusions

Analysis of the structure of cultural materials at LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 has provided data that are useful in further exploring site function. In the initial analysis of chipped stone from these sites, the assemblages were essentially viewed as representing single components. This discussion suggests that they were not. Multiple components appear to be represented at both sites. A minimum of four uses are suggested for the part of LA 115544/AR-03-02-07-523 within project limits, and two seem to be represented in the sections of LA 115550/AR-03-02-07-528 that were available for examination.

Most episodes of use follow a similar pattern of reduction of glassy andesite nodules and removal of selected debitage, presumably for transport to residential sites for future use. In association with these episodes of material acquisition, there is limited evidence for the performance of tasks involving the manufacture or maintenance of tools made from perishable materials. The exception to this was Cluster 2 at LA 115544/AR-03-02-07-523, where a much more intensive use was represented. The latter almost certainly was embedded in a hunting expedition, and comparable uses at LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 were probably also embedded in similar tasks.

Circumstantial evidence presented in this and the preceding chapter suggests that most, if not all, of these episodes of use occurred after the Taos area was settled by relatively sedentary farmers around A.D. 1050 to 1100. While these quarry/camp sites could have been used at any time after that date, we feel that use during the early part of the Puebloan occupation of the region is most likely. This is based on the types of projectile points found at LA 115544/AR-03-02-07-523, and the common use of what appears to be andesite at Pot Creek Pueblo during the Valdez phase. The sole exception to these conclusions is the area on the east side of NM 522 at LA 115550/AR-03-02-07-528, which may represent a different pattern of use. Unfortunately, the central section of LA 115550/AR-03-02-07-528 was removed during earlier road construction activities, so we do not know whether this area represents a discrete activity zone, or is simply the outer edge of a much larger occupation area. Tentatively, we may suggest that differences observed in the patterning of remains in this part of LA 115550/AR-03-02-07-528 are significant when compared with the remainder of that site and LA 115544/AR-03-02-07-523, and represent a different pattern of use that may also reflect variation in the period of use. However, this remains tenuous owing to the lack of data, as discussed earlier.

Despite the fact that these sites are simple scatters of chipped stone artifacts devoid of both pottery and cultural features, analysis has shown that quite a bit of information was available from them. This discussion and the preceding chapter have shown that such sites can yield important temporal and behavioral information when studied in detail. Such information can be critical when examining the use of a landscape by a particular group of people, rather than simply looking at residential sites in isolation.

9

VOLCANIC CHIPPED STONE QUARRIES: A PRELIMINARY INVESTIGATION OF MAJOR MATERIAL SOURCES ON THE TAOS PLATEAU

Jeffrey L. Boyer, James L. Moore, and Lisa A. Ooten

Many archaeological projects have examined sites on the northern Taos Plateau, and most note that chipped stone assemblages are dominated by a dark gray to black volcanic rock that is variably labeled basalt, rhyolite, glassy andesite, or simply "black stone" (Bryan and Butler 1940; Renaud 1942, 1946; Rule 1973; Seaman 1983, 1987; Seaman and Chapman 1993). Visually this material resembles basalt or glassy andesite, and some mineralogical studies suggest that it is rhyodacite (Lipman and Mehnert 1979; Newman and Nielsen 1985). As we discuss in this chapter, our mineralogical studies using x-ray fluourescence (XRF) have identified most of these materials as high potassium andesite (hereafter referred to as andesite) or high potassium dacite (hereafter referred to as dacite) (see Dungan et al. 1984). In order to understand this material and its distribution on the Taos Plateau, we discuss volcanism in the area, the formation of andesite and dacite, and the known distribution of quarries that exploited this material.

VOLCANISM ON THE TAOS PLATEAU

Volcanism in the study area is discussed by Lipman and Mehnert (1979), who serve as the main source for information in this section. The Taos Plateau contains 35 to 50 volcanic shields and cones in a 1,500-sq-km area. The composition of materials derived from these volcanos ranges from basalt to silicic rhyolite. Though compositionally diverse, this suite of rocks is basically basaltic in nature, and was erupted nearly contemporaneously. As Lipman and Mehnert (1979:307) note:

> The volcanic vents also display a crude, concentric zonation, with the volumetrically dominant Servilleta shields central within the field, shields of olivine andesite at intermediate distances, and andesite cones farther out. Except for the Servilleta Basalt, the different compositional types also tend to define continuous variation series in major-element compositions. These age, distribution, and compositional relations all suggest that the diverse Taos Plateau volcanics are closely related genetically.

Materials found in these volcanic deposits originated as magmas from different parts of the earth's mantle, erupting in a series of related events. The amount of silica in extruded materials increases as one moves out from the center of the field, and the volume of material decreases. Thus, the more silica-rich rocks are less common. This type of volcanic field is considered a fractionated basaltic suite, and is typical of one type of basaltic volcanism (Lipman and Mehnert 1979:296).

Three major types of basalt have been defined in this volcanic field. The most common is Servilleta basalt, which formed shield volcanos near the center of the field and flowed across most of the Taos Plateau. Servilleta basalt contains the smallest percentage of silica in this suite of volcanic rocks, and appears to have erupted from five shield volcanos, including La Segita Peaks and Cerro Mojino. Silicic alkalic basalts are dominant east and west of the Taos Plateau, but are fairly uncommon in the study area. Small cinder cones of this type occur in the central part of the volcanic field around Cerros de los Taoses, at Red Mountain, and on the south flank of Ute Mountain (Lipman and Mehnert 1979:302). The third major basaltic rock is xenocrystic basaltic andesite, and is concentrated in the central and northern parts of the field.

Several volcanos near the center of the field are comprised of olivine andesite, and include Cerro de la Olla, Cerro Montoso, and Cerro del Aire. This material has a higher silica content that the Servilleta and silicic alkalic basalts, and a slightly higher content than the xenocratic basaltic andesite. Flows of andesite are scattered around the margins of the volcanic field at San Antonio Mountain, Ute Mountain, Guadalupe Mountain, Cerro Negro, Tres Orejas, and a deposit east of Cerro Montoso that we have, in this report, named the Cerro Sin Nombre. This material is found in relatively uniform phenocryst-poor flows, which in places contain black glassy zones, and it has a significantly higher silica content than the olivine andesite (Lipman and Mehnert 1979:305). Although this material is identified as rhyodacite by Lipman and Mehnert (1979) and Newman and Nielsen (1985), our analyses of samples from Cerro Negro, Guadalupe Mountain, Cerro Montoso, and Cerro Sin Nombre indicate that these deposits, at least, are actually composed of high potassium andesite and dacite.

Deposits of quartz latite occur on Cerro Chiflo, and are intermediate in silica content between dacite and rhyolite. The condition of this feature and a potassium-argon date of 10.2 million years suggest that this flow represents a significantly older event than the main period of volcanism on the Taos Plateau, which occurred between 2 and 4 million years ago.

Rhyolite is the most silica-rich material in the suite, and is restricted to four lava domes at No Agua Peaks. At its margins the rhyolite is perlitic and contains small obsidian nodules a few centimeters in diameter (Lipman and Mehnert 1979:306; see Michels 1985). Analysis of rhyolite and obsidian from this source showed that they are nearly chemically identical. Not only is this rhyolite the most silica-rich material in the Taos Plateau volcanic field, it has one of the highest silica contents in the southern Rocky Mountains (Lipman and Mehnert 1979:306).

ANDESITE AND DACITE SOURCES

Rather than basalt, as was suggested by earlier descriptions of LA 115544/AR-03-02-07-523 and LA 115550/AR-03-02-07-528 (Levine and Boyer 1998; Boyer 1997b), Newman and Nielsen (1985) have identified the material that was quarried and used at these sites as rhyodacite. As they note, this material usually resembles a siliceous glassy basalt that contains few phenocrysts (Newman and Nielsen 1985:263), indicating that without mineralogical characterization it is easily misidentified. Dungan et al. (1984:161) argue that this material should be referred to as andesite or low SiO_2 (< 64 percent) or high SiO_2 (> 64 percent) dacite.

Newman and Nielsen (1985:263) identified six discrete sources of this material on the Taos Plateau, which correspond to those listed by Lipman and Mehnert (1979:305). Newman and Nielsen (1985:263) list four sources that provide a very fine-grained and phenocryst-poor, black to very dark gray "rhyodacite," including Cerro Negro, Cerro Montoso, San Antonio Mountain, and Ute Mountain; coarser-grained material is available from Tres Orejas and Guadalupe Mountain. They tentatively use the name Cerro Montoso to refer to an unnamed deposit that is actually east of Cerro Montoso, which is potentially confusing since they are different and separate features:

> A vent located west of the Red River gorge and east of Cerro Montoso (UCEM–unnamed cerrito east of Cerro Montoso) is the source of a single large dacite flow which outcrops at or near the top of the west wall of the gorge for a length of 12 km. (Dungan et al. 1984:164)

We have chosen to call that source Cerro Sin Nombre to prevent confusion.

Preliminary results of x-ray fluorescence analysis indicates that the various sources are chemically distinguishable (Newman and Nielsen 1985). Surface examination of sources suggested that these materials tend to be restricted to flows and adjacent slopes, and that fluvial and erosional movement should be negligible (Newman and Nielsen 1985:264). However, Dungan et al. (1984:164) indicate that the Cerro Negro lavas flowed west and are exposed in the Rio Grande Gorge, as are the Cerro Sin Nombre lavas. Thus, material from these sources (at least) may have much larger areal distributions than presumed by Newman and Nielsen (1985).

ANDESITE AND DACITE QUARRIES

One of the earliest discussions of prehistoric use of andesite in the Taos area is by Bryan and Butler (1940), who examined outcrops at San Antonio Mountain. They initially (and correctly, as it turns out) defined this material as a glassy andesite with a high silica content and very small phenocrysts (Bryan and Butler 1940:28). High quality andesite comprises only a small part of the volcanic flows exposed in that area, but was determined to have been a fair material for chipped stone reduction (Bryan and Butler 1940). Artifacts made from andesite were subsequently found on several sites along the west edge of the Taos Plateau (Bryan and Butler 1940).

Several probable andesite quarries were recorded by Renaud (1942, 1946) during his investigations of the upper Rio Grande Valley. He refers to this material as "black stone," and indicates that it was variably known as basalt, diorite, and rhyolite (Renaud 1946:34). From his description of the material and the locations of quarries he visited, it is almost certainly andesite. Sites that he defined as "workshops" fit a modern definition of quarries:

> *Workshops* were located where flakeable material was furnished by nature in the form of outcrops of the black stone common in the volcanic area, or of blocks of the same rock broken down from cliffs and boulders. (Renaud 1946:31)

Thus, he identified quarries on the north and west flanks of San Antonio Mountain and the north side of Guadalupe Mountain (Renaud 1942, 1946). Though Renaud recorded a few small probable campsites on the north and south edges of Cerro Negro, he failed to locate any of the quarries used to exploit that source.

Renaud (1946:12) also found a quarry on the south side of Cerro Montoso, noting the presence of several outcrops of a very good and hard black stone, which he considered to be the same material identified at sites previously visited in the area. As noted earlier, Cerro Montoso is an olivine andesite volcano, so this leaves us in a quandry. If the location given by Renaud is correct, this is either a source of high potassium andesite that has not subsequently been identified or the material from this source is so similar in appearance to andesite that Renaud could not distinguish between the two. Thus, while Renaud discusses numerous sites in the area that contain the "black stone," we can not always assume that he is referring to high potassium andesite. Indeed, while andesite appears to have been considered an excellent material for use, it almost certainly was not the only local volcanic rock used for flintknapping.

It would be similarly erroneous to assume that all reports that mention basalt in this area actually refer to high potassium andesite. As Lipman and Mehnert (1979) indicate, basalts dominate in the Taos Plateau volcanic field, and along with basaltic andesite comprise a very large percentage of available materials. Only when sites are located on or directly adjacent to known high potassium andesite sources can we tentatively consider materials classified as basalt to be andesite. Thus, we can now turn to other likely andesite quarries examined at known sources, noting that the material being procured at those locations is usually labeled basalt.

Seaman (1983:3) defined a number of quarries in a saddle between the north and south peaks of Guadalupe Mountain. Of eleven sites located by his survey, evidence of quarrying was found at six. The five remaining sites appear to represent short-term residential camps, and in most cases they also functioned as production areas for tools perhaps made from locally quarried materials. Residential activities also seem to have occurred at several of the quarries. For example, LA 38422 is located at the transition between valley bottom sediments and talus (Seaman 1983:11). Hearths and residential areas occur below the talus, while quarrying debris occurs above. LA 38424 is an even more intriguing site. Preliminary data recovery efforts defined three zones of use: a mesa top quarry area, a saddle containing a mixture of quarry and tool manufacture debris, and ridge-valley margin zone used as a residential locale (Seaman 1987; see Seaman and Chapman [1993] for discussions of similar activities at other Guadalupe Mountain sites).

Several studies have examined the area south of Guadalupe Mountain. Hume (1973, 1974, 1975) investigated an area on Garrapata Ridge, identifying numerous sites. Preliminary results of this study suggested that older sites (Archaic) occur at the west end of the ridge, while younger sites (post A.D. 600) mostly cluster at the east end (Hume 1974:4). No quarries were identified in this area (Hume 1975), which is not surprising given the alluvial nature of Garrapata Ridge and Cebolla Mesa. Several fuel wood sale surveys conducted by Carson National Forest have recorded sites at the north end of Cebolla Mesa just south of Guadalupe Mountain (Hobbs 1989; Leven 1995b, 1996; Westbury 1989). These surveys recorded numerous sites, all aceramic scatters that mostly appear to represent short-term camps. While assemblages are dominated by andesite debitage and tools, other materials also occur on most sites, the most common of which is obsidian. Diagnostic projectile points were found on about 34 percent of these sites, and suggest that most of those containing datable artifacts (56 percent) were occupied during the Late Archaic period. Another 20 percent were occupied during the Late Archaic or Developmental period, and 12 percent reflect only Developmental period use. One site (4 percent) contained points diagnostic of use during both the Late Archaic and Pueblo periods, and the last site (4 percent) may be indicative of a historic Apache occupation.

Hume (1973, 1974, 1975) also surveyed a parcel between Arroyo Hondo and Valdez on the south and San Cristobal on the north, which contains our study area. The section of this parcel that lies south of the Carson National Forest contains numerous andesite quarries. Hume (1974:8) notes that every outcrop in this area is accompanied by a workshop, with those along the 2,256 m (7,400 ft) contour primarily dating to the Archaic period, and those along the 2,195 m (7,200 ft) contour to the ceramic period. One of the latter sites was examined in more detail by Rule (1973), who notes that several outcrops used as material sources are visible from the site. Andesite was available in a thick outcrop and as boulders and cobbles at this site; quarrying scars were frequently noted on both (Rule 1973:5). Only local materials were found at this site. A survey conducted by the Carson National Forest to allow road closures recorded 36 prehistoric sites in the same general area (McCrary 1988b). Andesite is the dominant material, though obsidian is apparently also fairly common.

What this brief overview shows is that most (if not all) of the known andesite sources in the Taos Plateau volcanic field were quarried by prehistoric residents of the area. In addition to quarries, there is considerable evidence for residential camps near or directly adjacent to andesite outcrops. Therefore, we cannot assume that a site was only used to procure andesite when it is located directly adjacent to outcrops of this material. Evidence suggests that the prehistoric population often used quarry locations as workshops for the manufacture of tools, and sometimes they also served as short-term residential camps. Sites located near but not at andesite outcrops appear to have primarily functioned as workshops, but often there is some evidence of a short-term residential function as well.

Site Selection for XRF Analyses

As we noted in Chapter 4, we used NMCRIS site record files to identify archaeological sites that have been described as quarries, or that have quarry components recorded in their site descriptions. This is an important difference between this project and the work of Newman and Nielsen (1985). Newman and Nielsen (1985:263-264) identified "rhyodacite" sources from the survey of regional volcanic features by Lipman and Mehnert (1979). At each source, they collected 20 "in situ source samples" from flows and slopes, so as to minimize or eliminate the possibility for deposit mixing and consequent misidentification of materials. Regarding quarries, Newman and Nielsen (1985:264) state, "Rhyodacite quarries and workshops were noted during sample collection at the rhyodacite deposit east of Cerro Montoso, Cerro Negro, and San Antonio Mountain," but, "(n)o quarries or workshops have yet been located for the Ute Mountain, Tres Orejas Mountain, or Guadalupe Mountain sources." We see, then, that they collected raw materials from volcanic sources, but not necessarily from quarry locations, and, in three cases, from sources without recorded quarries (Newman and Nielsen 1985:273; they appear to have been unfamiliar with the work of Seaman [1983, 1987] at Guadalupe Mountain; see also Seaman and Chapman 1993).

Our contention is that unless materials are collected and analyzed from known quarry locations, we cannot begin to track human use of materials across space or through time. For instance, Newman and Nielsen (1985:270) observe that no artifacts identifiable as coming from Tres Orejas or Guadalupe Mountain were present in their analyzed assemblages from three sites in the southern Taos Valley. They ascribe this absence to the texture of the materials from these sources: "Tres Orejas Mountain and Guadalupe Mountain appear to have been avoided due to the relatively coarse texture of their respective deposits" (Newman and Nielsen 1985:270). Similarly, they conclude that San Antonio Mountain and Ute Mountain materials were not represented because of distance from the sites under investigation. However, because the materials they collected and analyzed were not, with one exception, from locations that were actually exploited as quarries, they cannot know, with certainty, that absence of materials in artifact assemblages reflects texture and suitability for tool manufacture, or distance.

With that in mind, we began this portion of the project by using NMCRIS site record files to identify archaeological sites in the Taos Valley that are recorded as quarries or that have components recorded as quarries. Twenty sites were defined in this manner. Four of those sites were not, in fact, quarry locations and were eliminated from the sample. Two other sites, LA 114104 and 114106, are located on the eastern slope of Cerro Montoso and are recorded as quarries. However, our inspection of those sites did not reveal quarry locations. In one case, LA 114104, we determined that the outcrops that appeared to have been quarried had actually been subjected to natural erosive processes, primarily freeze-thaw action, that resulted in considerable quantities of debris resembling quarrying and reduction debris. We collected raw materials from these two sites for XRF analysis, nonetheless, and the results of these analyses are presented in this report. Our concern in doing so is principally to differentiate between those materials, which actually came from Cerro Montoso, and materials collected from the actual quarries at the source we have named Cerro Sin Nombre, which seems to be the material identified by Newman and Nielsen (1985) by the name Cerro Montoso.

There are other quarries in the Taos Valley, as we noted earlier, reported by Renaud (1942, 1946) and Hume (1974). Because these sites are not recorded in the NMCRIS files and their locations are not securely identified, we did not attempt to relocate them or collect material from them for analysis. Relocation of those sites should be a focus of future research that has already begun to grow from this project.

The 14 sites selected for this project are shown in Figure 9.1 and are listed in Table 9.1 by source groups. At this point, we have defined source groups by the volcanic feature with which they are associated, with the exception of Cerro Negro, for which we defined two source groups. In large part, this is because quarries have been recorded on the northwest (this project) and southeast flanks of Cerro Negro, allowing us to examine materials from those areas for similarities and differences. In addition to relocating quarries known but not recorded in NMCRIS files, future research should also focus on locating and recording more quarries, both at those volcanic features where quarries are already known, and at those where quarries have not been reported. Additional data from additional quarries will allow increased discrimination between materials from the different features (Latham et al. 1992:82). Increasingly fine-tuned discrimination of materials will, in turn, allow better definition and characterization of the cultural landscapes of which the volcanic features were clearly significant parts.

TABLE 9.1. VOLCANIC CHIPPED STONE MATERIAL SOURCES GROUPS AND QUARRY SITES

Cerro Negro NW Group
LA 115543
LA 115544
LA 115545
LA 115546
Cerro Negro SE Group
LA 49586 (Rule's Site)
LA 75751 (Turley Mill Site)
Guadalupe Mountain Group
LA 38422
LA 38424
LA 38427
LA 38429
Cerro Montoso Group
LA 114104
LA 114106
Cerro Sin Nombre Group
LA 114108
LA 114109

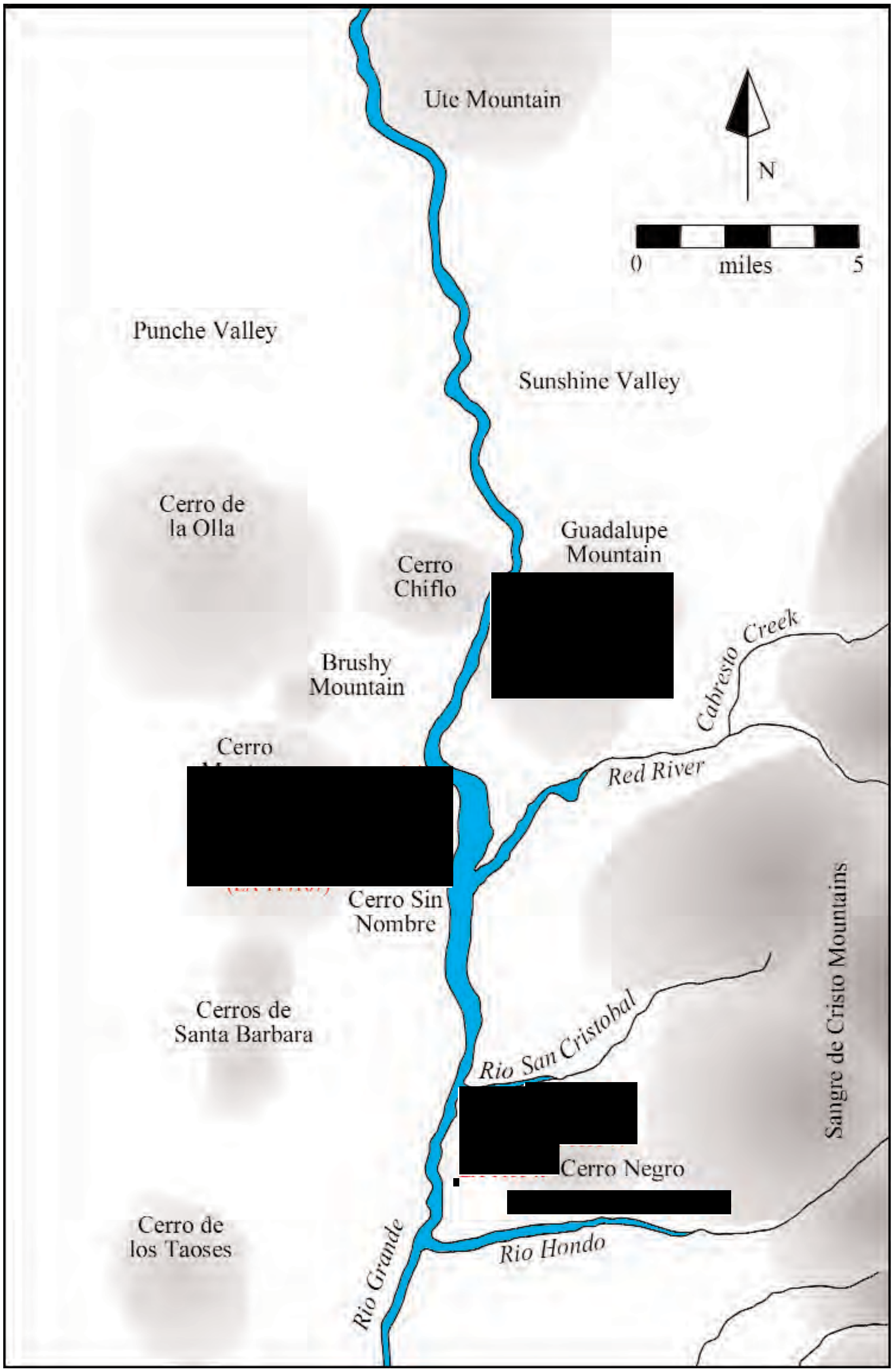

Figure 9.1. Quarry/collection locations.

RESULTS OF XRF ANALYSES

Identification of Quarried Materials

Following Lipman and Mehnert (1979), Newman and Nielsen (1985) identify materials included in their analyses as rhyodacite, a material intermediate between and with characteristics of both dacite and rhyolite. Distinguishing between different volcanic rocks is based primarily on the amount of silicate (SiO_2) present, and Lipman and Mehnert (1979) define rhyodacite as having 62 to 64 percent silicate. According to standards established by Peccerillo and Taylor (1976) and commonly used by geochemists (Warner Cribb, pers. comm. 2000), the transition between dacite and rhyolite occurs at about 68 percent silicate, with dacite below that figure and rhyolite above it. Newman and Nielsen (1985:263) state that the materials they examined contained between 62 and 65 percent silicate, although they do not provide actual silicate amounts for their samples (Newman and Nielsen 1985:265). Materials in this range are andesites (< 63 percent silicate) and dacites (> 63 percent silicate), according to the Peccerillo and Taylor standards. Dungan et al. (1984:161) state "Application of the name rhyodacite to rocks with less than 65% SiO2 would be contradictory to the current usage of this term . . ." and, "We have chosen to apply the term dacite to the entire spectrum of pyroxene-phyric rocks ranging from 60 to 67.5% SiO_2 . . ." Although use of the term dacite to refer to rocks having less than 63 percent silicate is not in keeping with the standards set by Peccerillo and Taylor (1976), the point is that use of the term rhyodacite is inappropriate for rocks with silicate composition in the 62 to 65 percent range indicated by Newman and Nielsen (1985).

Figure 9.2 shows the silicate composition of the materials analyzed during this project. We calculated mean figures for the samples for each site and for each source group (Table 9.2); it is those mean figures that are presented in Figure 9.2. As seen in Figure 9.2, the samples from the Cerro Sin Nombre source are low-silicate dacite, while the samples from the other sources are high-silicate andesite. The exceptions are the samples from the Cerro Montoso sites, which are high-silicate basaltic andesite. Additionally, as seen in Figure 9.2, the samples are high in potassium. Figure 9.3 shows the site and source group silicate and potassium figures at a scale that allows us to more clearly see the different groups and their relationships to each other. The results of these analyses correspond to those of Dungan et al. (1984), who identify the materials from the same volcanic features as dacite (60–67.5 percent SiO_2 in their analysis).

Identifying Source Groups

Newman and Nielsen (1985) assert that three trace elements provide the strongest evidence for discriminating between different materials: barium, strontium, and zirconium. They do not, however, state why these elements are most significant. Our analyses show that these three elements have the highest concentrations in each sample (Table 9.2); this may explain their apparent discriminatory power. We have chosen another approach to determining which elements may be most useful for discriminating between materials and sources. Having calculated the mean values and standard deviations for each trace element in the samples from each site and each source group (Table 9.2), we determined which of those elements showed the least and most variation about their respective means by dividing the single standard deviation values by the mean values (sd/mean). Those elements that show the least variation about the mean have sd/mean values less than 0.01 in four of the five source groups. In these cases, the standard deviation values are equal or less than 1 percent of the mean values. Those that show the most variation have sd/mean values greater than 0.10 in four of the five source groups; their standard deviation values are equal to or greater than 10 percent of their mean values.

Our rationale for this procedure is that those elements that show the least variation about their means, that have the smallest ranges of values, are most closely correlated with the materials in which they are found. That is, those elements should most closely identify and differentiate materials. At the same time, because the least-variation values are very similar between samples, we also consider those elements with moderate and largest ranges of values. These elements and the degrees to which their wider ranges of values overlap between materials reflect compositional similarities. If differ-

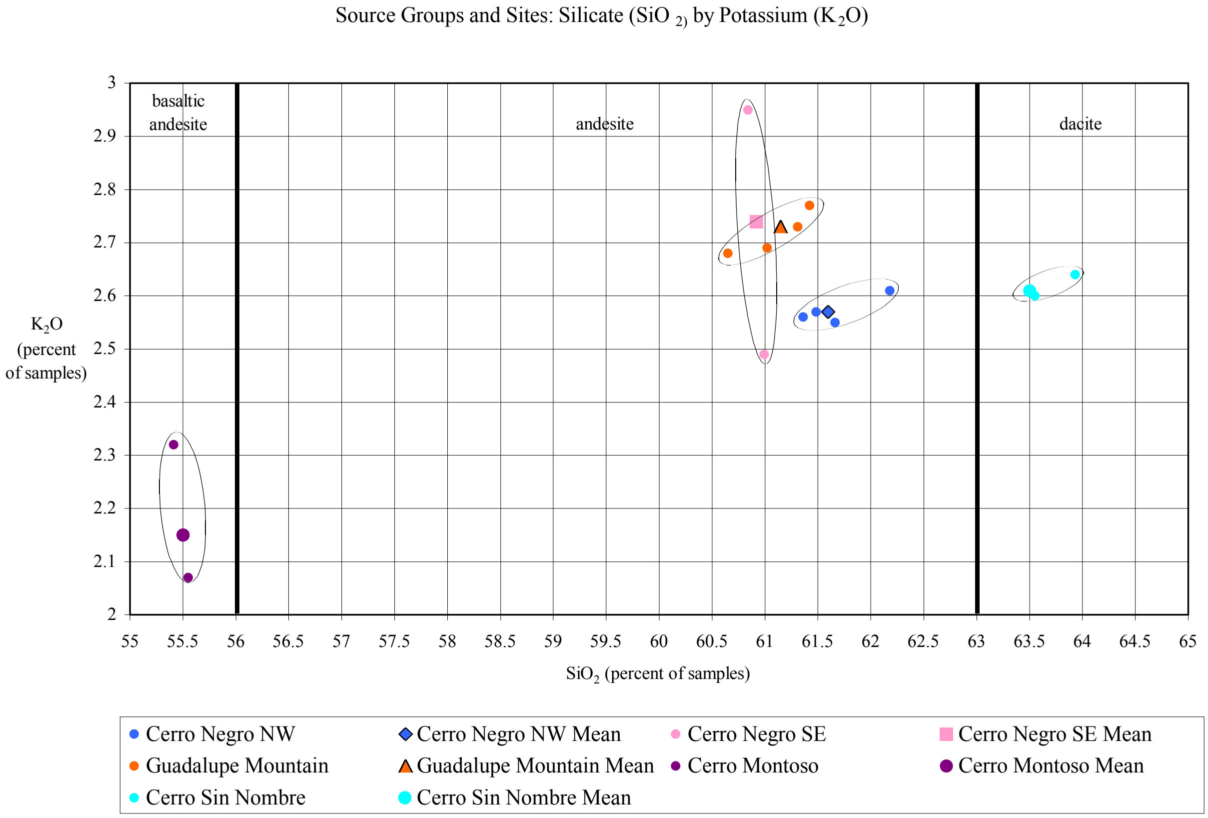

Figure 9.2. Source groups and sites: silicate (SiO_2) by potassium (K_20).

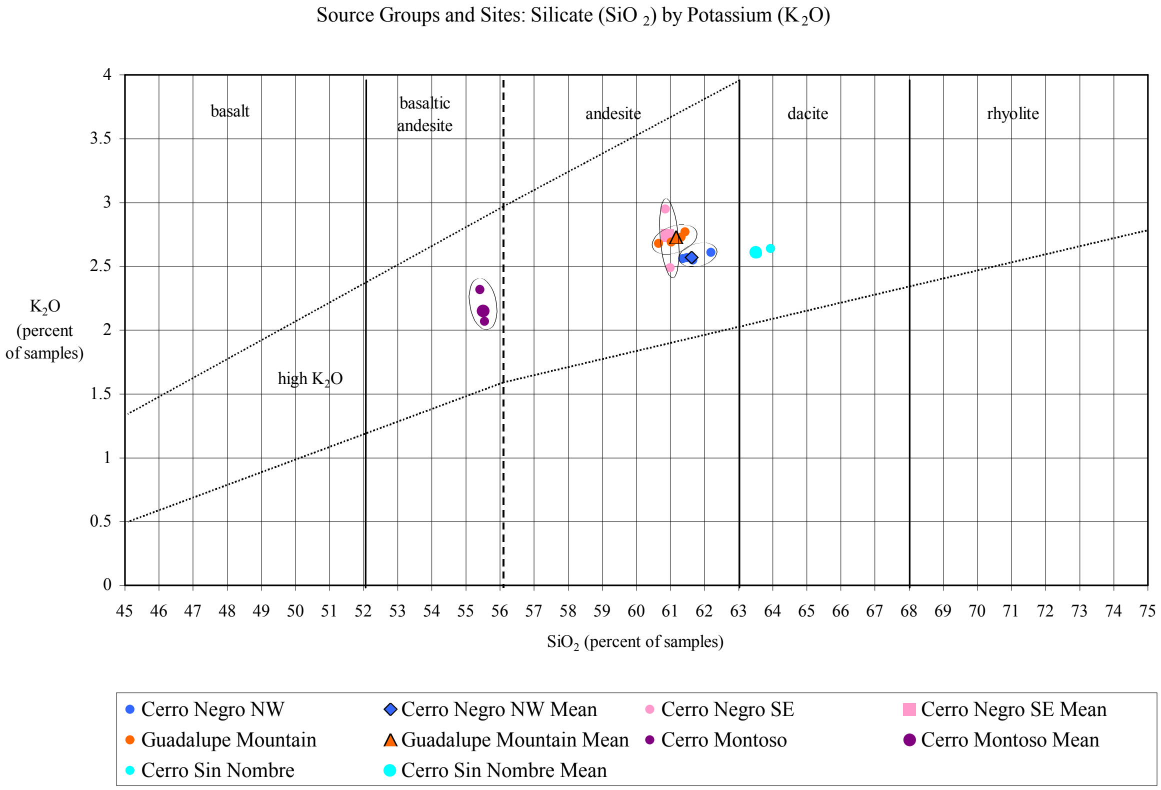

Figure 9.3. Source groups and sites: silicate by potassium.

TABLE 9.2. X-RAY FLUORESCENCE DATA: MAJOR ELEMENTAL COMPOUNDS AND TRACE ELEMENTS BY SOURCE GROUPS AND SITE NUMBERS

SOURCE GROUP AND SITE NUMBER	SAMPLE NO.	ELEMENTAL COMPOUNDS (percent of weight; numbers in parentheses are one standard deviation)											TRACE ELEMENTS (parts per million; numbers in parentheses are one standard deviation)							
		SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	K_2O	MgO	TiO_2	P_2O_5	MnO	*Total*	*Ba*	*Sr*	*Zr*	*Zn*	*Rb*	*Y*	*Cu*	*Nb*
Cerro Negro NW Group																				
LA 115543	43-A	62.10	16.88	5.34	4.68	4.29	2.62	1.84	0.73	0.33	0.09	98.90	1491.40	762.00	352.40	112.00	54.40	31.30	30.30	24.20
	43-A-2	62.25	16.76	5.30	4.67	4.28	2.60	1.84	0.73	0.33	0.09	98.85	1489.00	758.20	344.90	111.40	54.60	28.20	29.00	25.30
	Mean	62.18	16.82	5.32	4.68	4.29	2.61	1.84	0.73	0.33	0.09	98.88	1490.20	760.10	348.65	111.70	54.50	29.75	29.65	24.75
LA 115544	44-OA	61.84	16.48	5.51	4.78	4.15	2.54	2.00	0.76	0.34	0.09	98.49	1485.20	752.80	359.00	112.60	54.30	24.10	26.00	25.00
	44-OB	61.98	16.73	5.34	4.68	4.27	2.62	1.88	0.74	0.33	0.09	98.66	1493.50	755.10	317.50	114.50	54.50	19.30	31.60	25.50
	44-A	60.80	15.75	5.24	4.72	4.03	2.51	1.83	0.72	0.33	0.09	96.02	1495.30	749.00	305.90	107.00	54.40	23.20	31.00	23.40
	44-A-2	61.59	16.03	5.31	4.80	4.09	2.54	1.89	0.73	0.34	0.09	97.41	1496.20	754.10	298.60	113.60	54.20	29.30	28.20	24.10
	44-B	61.22	16.54	5.30	4.74	4.23	2.54	1.81	0.74	0.32	0.09	97.53	1480.60	769.10	287.30	110.30	54.30	27.00	35.50	26.90
	44-C	61.52	16.72	5.35	4.79	4.26	2.55	1.91	0.73	0.32	0.09	98.24	1482.50	767.60	290.20	109.00	54.20	26.40	36.40	27.50
	44-D	61.30	16.46	5.34	4.81	4.22	2.58	1.89	0.75	0.33	0.09	97.77	1490.70	774.30	287.70	115.40	54.30	22.30	37.50	26.90
	44-E	61.30	15.97	5.27	4.71	4.08	2.49	1.81	0.74	0.33	0.08	96.78	1494.90	755.30	288.50	110.70	54.40	25.20	30.10	25.80
	44-E-2	60.66	16.50	5.74	4.96	4.12	2.69	2.46	0.82	0.28	0.09	98.32	1452.00	795.00	336.40	110.70	56.10	26.40	35.80	27.00
	Mean	61.36 (0.41)	16.35 (0.33)	5.38 (0.15)	4.78 (0.08)	4.16 (0.08	2.56 (0.06)	1.94 (0.19)	0.75 (0.03)	0.32 (0.02)	0.09 (0)	97.69 (0.82)	1485.66 (13.10)	763.59 (13.78)	307.90 (23.87)	111.53 (2.56)	54.52 (0.57)	24.80 (2.79)	31.34 (4.19)	25.79 (1.34)
LA 115545	45-A	61.71	16.78	5.36	4.74	4.28	2.59	1.89	0.73	0.33	0.09	98.50	1482.20	767.60	293.20	108.80	54.40	20.60	33.30	26.80
	45-C-2	61.24	16.13	5.35	4.77	4.14	2.55	2.07	0.72	0.33	0.09	97.39	1494.90	756.40	282.50	112.70	54.60	26.20	35.50	26.50
	45-D	61.55	16.11	5.31	4.41	4.08	2.45	1.93	0.72	0.34	0.08	97.28	1500.70	746.60	284.80	113.10	54.40	18.00	27.10	25.90
	45-E	61.56	16.54	5.33	4.78	4.23	2.58	2.03	0.73	0.32	0.09	98.19	1489.30	764.80	286.40	118.00	54.40	21.30	34.10	26.40
	45-F	61.33	16.04	5.27	4.65	4.14	2.51	1.99	0.73	0.32	0.09	97.07	1492.10	752.80	285.20	112.30	54.70	23.30	36.10	25.90
	45-G	61.77	16.31	5.30	4.66	4.16	2.53	2.11	0.73	0.32	0.09	97.98	1489.00	771.70	290.80	110.00	54.50	21.30	31.40	25.70
	45-O	61.61	16.30	5.32	4.68	4.17	2.58	1.98	0.72	0.32	0.09	97.77	1490.80	753.10	335.90	113.90	54.40	24.20	35.00	26.40
	45-OA	62.09	16.51	5.30	4.68	4.22	2.57	2.02	0.07	0.32	0.09	97.87	1494.80	754.80	329.60	112.50	54.30	26.50	31.70	24.30
	45-OA-2	62.06	16.66	5.35	4.72	4.25	2.59	2.05	0.72	0.32	0.09	98.81	1488.90	765.40	340.40	113.90	54.40	30.20	34.60	26.00
	Mean	61.66 (0.27)	16.38 (0.25)	5.32 (0.03)	4.71 (0.04)	4.19 (0.06)	2.55 (0.04)	2.01 (0.07)	0.73 (0)	0.32 (0)	0.09 (0)	98.15 (1.23)	1491.40 (4.86)	759.24 (7.89)	303.20 (23.04)	112.80 (2.44)	54.46 (0.12)	23.51 (3.50)	33.20 (2.63)	26.00 (0.68)
LA 115546	46-A	61.17	16.13	5.36	4.70	4.13	2.53	1.97	0.74	0.33	0.09	97.15	1487.80	761.70	295.10	118.50	54.40	22.90	33.30	24.70
	46-C	61.26	16.27	5.33	4.68	4.18	2.56	1.90	0.73	0.32	0.09	97.32	1493.70	767.20	293.90	110.50	54.30	27.60	30.10	27.60
	46-D	61.72	16.54	5.38	4.72	4.25	2.60	1.97	0.74	0.33	0.09	98.34	1488.30	752.30	295.60	116.90	54.60	31.10	37.70	25.70
	46-E	61.75	16.38	5.36	4.72	4.20	2.57	1.94	0.73	0.33	0.09	98.07	1492.10	761.50	289.50	110.30	54.60	32.30	37.30	25.60
	Mean	61.48 (0.26)	16.33 (0.15)	5.36 (0.02)	4.71 (0.02)	4.19 (0.04)	2.57 (0.03)	1.95 (0.03)	0.74 (0)	0.33 (0)	0.09 (0)	98.07 (1.14)	1490.98 (2.50)	760.68 (5.35)	293.53 (2.40)	114.05 (3.69)	54.48 (0.13)	28.48 (3.65)	34.60 (3.12)	25.90 (1.06)
Cerro Negro NW Group	Mean	61.56 (0.39)	16.39 (0.28)	5.33 (0.05)	4.72 (0.09)	4.19 (0.07)	2.56 (0.05)	1.96 (0.13)	0.74 (0.02)	0.33 (0.01)	0.09 (0)	97.86 (0.71)	1489.00 (9.01)	761.18 (10.16)	307.14 (24.40)	112.44 (2.80)	54.49 (0.36)	25.34 (3.81)	32.86 (3.34)	25.80 (1.08)

TABLE 9.2.CONTINUED.

SOURCE GROUP/ SITE NUMBER	SAMPLE NO.	ELEMENTAL COMPOUNDS (percent of weight; numbers in parentheses are one standard deviation)											TRACE ELEMENTS (parts per million; numbers in parentheses are one standard deviation)							
		SiO_2	*Al_2O_3*	*Fe_2O_3*	*CaO*	*Na_2O*	*K_2O*	*MgO*	*TiO_2*	*P_2O_5*	*MnO*	*Total*	*Ba*	*Sr*	*Zr*	*Zn*	*Rb*	*Y*	*Cu*	*Nb*
Cerro Negro SE Group																				
LA 49586	86-A	61.14	16.84	5.66	4.98	4.25	2.48	2.25	0.78	0.31	0.09	98.78	1473.20	788.20	287.00	111.00	54.10	21.50	39.40	26.30
	86-B	60.44	16.55	5.59	4.94	4.21	2.44	2.17	0.77	0.31	0.09	97.51	1470.40	790.50	287.10	113.10	54.00	23.20	38.00	26.60
	86-C	60.86	16.93	5.68	4.98	4.26	2.48	2.17	0.79	0.31	0.10	98.56	1470.30	792.20	286.70	111.00	54.00	21.80	37.00	24.40
	86-D	60.86	16.61	5.68	4.97	4.21	2.46	2.25	0.79	0.31	0.09	98.23	1464.30	776.40	280.80	115.30	54.00	28.20	36.10	24.00
	86-E	60.86	16.57	5.59	4.96	4.23	2.45	2.15	0.78	0.30	0.09	97.98	1464.80	782.40	283.50	119.40	54.00	24.60	41.00	25.40
	86-SA	61.43	15.98	5.85	4.74	3.79	2.58	1.85	0.79	0.38	0.07	97.46	1146.80	764.30	252.70	109.60	54.20	27.50	45.00	26.50
	86-SB	61.37	15.94	5.87	4.92	3.83	2.54	1.87	0.81	0.40	0.07	97.62	1466.70	774.00	254.20	108.40	54.20	20.60	48.00	25.90
	Mean	60.99	16.49	5.70	4.93	4.11	2.49	2.10	0.79	0.33	0.09	98.02	1468.28	781.14	276.00	112.54	54.07	23.91	40.64	25.59
		(0.32)	(0.36)	(0.11)	(0.08)	(0.19)	(0.05)	(0.16)	(0.01)	(0.04)	(0.01)	(0.49)	(3.25)	(9.40)	(14.42)	(3.50)	(0.09)	(2.76)	(4.07)	(0.96)
LA 75751	51-A	61.00	16.67	5.64	4.99	4.22	2.44	2.27	0.79	0.31	0.09	98.42	1466.40	788.30	301.20	110.40	54.10	25.40	32.30	26.30
	51-B	60.71	16.72	5.66	5.00	4.24	2.42	2.28	0.79	0.33	0.09	98.24	1472.70	784.70	283.60	109.40	54.10	21.50	44.50	26.00
	51-C	60.74	16.46	5.67	4.99	4.21	2.43	2.33	0.78	0.31	0.09	98.01	1475.90	779.30	293.80	107.30	54.00	29.30	38.80	26.90
	51-D	60.64	16.54	5.70	4.98	4.19	4.43	2.32	0.78	0.35	0.09	100.02	1460.80	786.10	277.10	118.10	54.10	20.40	33.80	25.50
	51-E	60.12	16.26	5.65	4.97	4.14	4.43	2.19	0.79	0.30	0.09	98.94	1472.60	780.70	288.70	113.80	54.10	31.30	34.00	24.60
	51-F	60.76	16.58	5.62	4.96	4.20	2.44	2.21	0.78	0.31	0.09	97.95	1472.70	785.30	274.60	111.80	54.00	23.50	41.00	25.50
	51-SA	61.59	15.93	5.74	4.98	3.86	2.54	2.15	0.79	0.39	0.08	98.05	1453.80	770.70	247.50	109.90	54.00	28.30	40.10	25.50
	51-SB	61.27	15.59	5.70	4.88	3.83	2.50	2.06	0.79	0.38	0.08	97.08	1458.40	771.40	254.50	107.30	54.20	26.00	42.40	24.50
	Mean	60.84	16.34	5.67	4.97	4.11	2.95	2.23	0.79	0.34	0.09	98.34	1466.66	780.81	277.63	111.00	54.08	25.71	38.36	25.60
		(0.41)	(0.37)	(0.04)	(0.04)	(0.16)	(0.85)	(0.09)	(0)	(0.03)	(0)	(0.80)	(7.60)	(6.25)	(17.42)	(3.36)	(0.07)	(3.57)	(4.19)	(0.76)
Cerro Negro SE Group	Mean	60.92	16.41	5.69	4.95	4.11	2.74	2.17	0.79	0.33	0.09	98.19	1467.36	780.97	276.87	111.72	54.07	24.87	39.43	25.59
		(0.38)	(0.37)	(0.08)	(0.06)	(0.17)	(0.67)	(0.14)	(0)	(0.03)	(0)	(0.69)	(6.18)	(7.88)	(16.11)	(3.51)	(0.08)	(3.34)	(4.29)	(0.86)
Guadalupe Mountain Group																				
LA 38422	22-B	61.02	16.68	5.78	5.19	4.00	2.69	2.33	0.84	0.30	0.10	98.93	1437.80	777.70	275.80	106.50	55.10	29.20	27.80	27.70
LA 38424	24-A	61.61	17.01	5.37	4.81	4.27	2.78	2.11	0.78	0.27	0.09	99.10	1468.50	785.80	298.80	106.50	55.90	23.20	35.30	29.50
	24-B	61.61	17.02	5.36	4.76	4.25	2.76	2.10	0.77	0.26	0.09	98.98	1467.20	787.00	310.60	113.10	56.30	26.50	35.30	28.30
	24-C	61.12	16.60	5.37	4.82	4.21	2.76	2.14	0.78	0.27	0.09	98.16	1466.10	781.40	308.50	108.30	56.00	26.70	40.40	27.00
	24-D	61.35	16.71	5.29	4.73	4.23	2.76	2.05	0.78	0.26	0.09	98.25	1468.80	788.30	325.00	101.70	56.10	27.70	35.80	26.70
	Mean	61.42	16.84	5.35	4.78	4.24	2.77	2.10	0.78	0.27	0.09	98.62	1467.65	785.63	310.73	107.40	56.08	26.03	36.70	27.88
		(0.20)	(0.18)	(0.03)	(0.04)	(0.02)	(0)	(0.03)	(0)	(0)	(0)	(0.42)	(1.08)	(2.60)	(9.37)	(4.08)	(0.15)	(1.69)	(2.15)	(1.11)
LA 38427	27-A-2	60.03	16.16	5.72	4.96	4.06	2.69	2.41	0.81	0.27	0.10	97.21	1453.10	793.70	333.80	106.70	55.90	25.60	35.00	28.70
	27-B	60.77	16.53	5.61	4.84	4.41	2.68	2.35	0.80	0.26	0.09	98.07	1465.80	779.60	290.90	117.40	55.80	20.50	36.20	29.20
	27-C	61.19	16.77	5.47	4.83	4.20	2.70	2.26	0.80	0.26	0.09	98.57	1463.70	766.10	302.80	102.20	55.90	18.30	32.90	27.40
	27-D	60.59	16.31	5.57	4.80	4.08	2.66	2.37	0.79	0.26	0.09	97.52	1464.30	777.90	314.10	109.50	56.10	19.10	38.90	29.50
	Mean	60.65	16.44	5.59	4.86	4.12	2.68	2.35	0.80	0.26	0.09	97.84	1461.73	779.33	310.40	108.95	55.93	20.86	35.75	28.70
		(0.42)	(0.23)	(0.09)	(0.06)	(0.06)	(0.02)	(0.05)	(0)	(0)	(0)	(0.52)	(5.04)	(9.79)	(15.81)	(5.53)	(0.11)	(2.84)	(2.17)	(0.80)
LA 38429	29-A	61.88	16.66	5.46	4.80	4.07	2.72	2.27	0.80	0.03	0.09	99.05	1459.00	779.70	273.90	107.80	55.20	24.70	26.90	26.60
	29-B	61.59	16.75	5.54	4.94	4.08	2.74	2.27	0.81	0.31	0.10	99.13	1458.50	780.30	275.30	101.70	55.10	23.20	26.10	26.80
	29-1A	61.94	16.62	5.49	4.81	4.01	283	2.14	0.80	0.28	0.09	99.01	1464.20	770.30	279.10	104.70	55.60	25.60	35.40	28.10
	29-2A	60.54	16.38	5.47	4.85	4.14	2.70	2.15	0.79	0.26	0.09	97.37	1458.90	788.20	279.10	109.30	56.10	27.10	39.00	27.60
	29-3A	61.17	16.91	5.47	4.81	4.20	2.69	2.25	0.79	0.26	0.09	98.64	1464.20	780.20	289.90	105.80	55.70	27.80	32.30	26.70

TABLE 9.2. CONTINUED.

SOURCE GROUP AND SITE NUMBER	SAMPLE NO.	ELEMENTAL COMPOUNDS (percent of weight; numbers in parentheses are one standard deviation)											TRACE ELEMENTS (parts per million; numbers in parentheses are one standard deviation)							
		SiO_2	*Al_2O_3*	*Fe_2O_3*	*CaO*	*Na_2O*	*K_2O*	*MgO*	*TiO_2*	*P_2O_5*	*MnO*	*Total*	*Ba*	*Sr*	*Zr*	*Zn*	*Rb*	*Y*	*Cu*	*Nb*
LA 38429	29-2B	60.74	16.56	5.44	4.81	4.16	2.71	2.17	0.80	0.26	0.09	97.74	1466.20	776.70	307.70	104.60	56.20	31.80	40.70	29.50
	Mean	61.31	16.65	5.48	4.84	4.11	2.73	2.21	0.80	0.28	0.09	98.49	1461.83	779.23	287.48	105.65	55.63	26.70	33.40	27.55
		(0.54)	(0.16)	(0.03)	(0.05)	(0.06)	(0.05)	(0.06)	(0)	(0.02)	(0)	(0.69)	(3.11)	(5.31)	(12.56)	(2.44)	(0.39)	(2.73)	(5.56)	(1.02)
Guadalupe Mountain Group	Mean	61.14	16.65	5.49	4.85	4.14	2.73	2.22	0.80	0.27	0.10	98.38	1461.75	780.82	299.01	107.05	55.79	25.13	34.53	27.95
		(0.52)	(0.23)	(0.13)	(0.11)	(0.08)	(0.04)	(0.11)	(0.02)	(0.02)	(0)	(0.65)	(7.65)	(6.88)	(17.71)	(4.10)	(0.37)	(3.61)	(4.48)	(1.07)
Cerro Montoso Group																				
LA 114104	04-A	55.82	16.36	7.61	6.21	3.59	2.08	3.79	1.20	0.41	0.13	97.20	1289.90	887.60	285.70	114.40	53.40	25.70	35.60	29.40
	41-A-2	55.27	16.67	7.59	6.59	3.65	2.06	3.73	1.16	0.43	0.13	97.28	1270.90	904.00	275.50	109.30	53.30	32.90	39.90	29.60
	Mean	55.55	16.52	7.60	6.40	3.62	2.07	3.76	1.18	0.42	0.13	97.20	1280.40	895.80	280.60	111.85	53.35	29.30	37.75	29.50
LA 114106	06-A-2	55.41	16.56	7.51	6.54	3.57	2.32	3.78	1.16	0.46	0.12	97.43	1311.60	894.50	262.00	109.10	53.30	23.90	39.70	29.20
Cerro Montoso Group	Mean	55.50	16.53	7.57	6.45	3.60	2.15	3.77	1.17	0.43	0.13	97.30	1290.80	895.37	274.40	110.93	53.33	27.50	38.24	29.40
		(0.23)	(0.13)	(0.04)	(0.17)	(0.03)	(0.12)	(0.03)	(0.02)	(0.02)	(0)	(0.10)	(16.63)	(6.72)	(9.71)	(2.45)	(0.05)	(3.89)	(2.04)	(0.16)
Cerro Sin Nombre Group																				
LA 114108	08-B	63.93	14.69	5.83	4.31	3.61	2.64	2.09	0.77	0.08	0.10	98.05	1530.10	212.10	170.00	77.30	58.90	20.60	45.70	18.10
LA 114109	09-A-2	63.40	14.68	6.08	4.55	3.63	2.58	2.26	0.84	0.08	0.11	98.21	1508.40	22.430	173.90	96.90	58.10	15.40	36.60	16.20
	09-B	63.70	14.70	5.89	4.40	3.61	2.58	2.10	0.82	0.08	0.11	97.99	1508.70	226.50	171.60	81.80	58.80	24.40	46.60	19.70
	09-C-2	63.26	14.47	5.98	4.49	3.59	2.62	2.17	0.84	0.08	0.11	97.61	1498.00	227.80	172.50	77.30	58.10	27.70	48.60	18.30
	09-D	63.83	14.54	5.82	4.32	3.63	2.62	2.08	0.81	0.08	0.11	97.84	1512.70	222.40	150.50	87.50	58.40	24.00	36.60	18.70
	Mean	63.55	14.60	5.94	4.44	3.62	2.60	2.15	0.83	0.08	0.11	97.91	1506.95	225.25	167.13	85.88	58.35	22.88	42.10	18.23
		(0.23)	(0.10)	(0.10)	(0.09)	(0.02)	(0.02)	(0.07)	(0.01)	(0)	(0)	(0.22)	(5.44)	(2.07)	(9.63)	(7.32)	(0.29)	(4.55)	(5.55)	(1.28)
Cerro Sin Nombre Group	Mean	63.50	14.62	5.92	4.41	3.61	2.61	2.14	0.82	0.08	0.11	97.94	1511.58	222.62	167.70	84.16	58.46	22.42	42.82	18.20
		(0.23)	(0.09)	(0.10)	(0.09)	(0.02)	(0.02)	(0.07)	(0.03)	(0)	(0)	(0.20)	(10.46)	(5.58)	(8.69)	(7.39)	(0.34)	(4.17)	(5.17)	(1.14)

ences seen in those elements with the least variation about their mean are also evident in those elements with more variation, they are more likely to be real differences that can be used to distinguish the materials.

Three trace elements fall in the category showing least variation about their mean values (sd/mean 0.01): barium (Ba), rubidium (Rb), and strontium (Sr). Two elements fall in the category showing the most variation about their means (sd/mean 0.10): copper (Cu) and yttrium (Y). Three elements fall between these categories, with standard deviation values between 1 and 10 percent of mean values (sd/mean > 0.01 and < 0.10): niobium (Nb), zinc (Zn), and zirconium (Zr).

We plotted the values of the elements in these categories against each other in scatter plots (Ba by Rb, Rb by Sr, Ba by Sr; Nb by Zn, Zn by Zr, Nb by Zr; Cu by Y; Figs. 9.2 through 9.10), in order to determine whether groups or clusters of materials could be visually distinguished. We chose not to perform statistical tests of groups or clusters to determine the degree to which they are statistically valid. Because of the preliminary nature of these analyses and because subsequent re-analysis of some samples resulted in different values, as we discuss later, we feel that statistical examination of patterns observed in these data is premature and should await collection and analysis of materials from additional quarry sites. Further, the different source groups examined in this study are represented by differing numbers of sites and differing numbers of samples from each site. For these reasons, statistical examination will follow standardization of collection and analysis procedures.

Low-Variation Trace Elements. Figures 9.4, 9.5, and 9.6 are scatter plots of mean barium, rubidium, and strontium values. Five different clusters of values are evident in Figure 9.4, which plots barium against rubidium. The clusters correspond to the five source locations and site groups identified during this project. Note that the Cerro Negro SE values are so tightly clustered that the site values are indistinguishable from the group mean values. Note also that the Cerro Montoso samples (which, as we discussed earlier, are not from quarry locations) are considerably different from the other source groups in the presence of barium. Finally, note that the Cerro Negro NW, Cerro Negro SE, and Guadalupe Mountain samples are most similar.

The same five clusters of values are evident in Figure 9.5, which plots strontium against rubidium. The Cerro Negro SE and Cerro Montoso values are so tightly clustered that the site values are indistinguishable from the group mean values, and the Cerro Negro NW values are nearly so. In this case, the Cerro Sin Nombre samples are very different from the other sample groups. However, the Cerro Negro NW, Cerro Negro SE, and Guadalupe Mountain samples are still most similar.

Four distinct clusters are apparent in Figure 9.6, which plots barium against strontium. Again, the Cerro Negro SE site values are not distinguishable from the group mean values. However, in this case, the Cerro Negro SE values are also virtually identical to those of the Guadalupe Mountain samples.

The scatter plots of the three trace elements showing the least variation in compositional variation indicate that four, and perhaps five, groups of material samples can be distinguished. The groups correspond to the source locations and their associated quarry sites identified during this project. The three source locations on the east side of the Rio Grande are most similar to each other, but appear to be distinct except when barium is plotted against strontium. In that case, the Cerro Negro SE and Guadalupe Mountain materials appear to be nearly identical. Rubidium may be the trace element that most readily differentiates materials from the different sources, since it is the common factor in Figures 9.4 and 9.5, where five clusters of values are most evident.

Moderate-Variation Trace Elements. Figures 9.7, 9.8, and 9.9 are scatter plots of niobium, zirconium, and zinc values. The moderate-variation trace elements present patterns that are similar to those revealed by the low-variation elements.

Five distinct clusters of values are evident in Figure 9.7, which plots niobium against zirconium. Again, the five clusters correspond to our five source locations and site groups. As seen in Figures 9.4, 9.5, and 9.6, the Cerro Negro SE site and group values are so tightly clustered that they are indistinguishable.

Four clusters of niobium and zinc values are shown in Figure 9.8. The Cerro Negro NW and Cerro Negro SE samples appear to be identical, pointing to expectable compositional similarity between these source groups from the same volcanic feature. Four clusters of zinc and zirconium values are also evident in Figure 9.9. In this case, the Cerro Negro SE and Cerro Montoso samples are nearly identical.

High-Variation Trace Elements. Figure 9.10 is a scatter plot of copper and yttrium values. Three clusters of samples are apparent, one of which is the Cerro Sin Nombre group. The Cerro Negro SE and Cerro Montoso samples comprise a second distinct cluster, and the Cerro Negro NW and Guadalupe Mountain samples comprise a third. The samples making up the third group show the greatest range of values.

Discussion. XRF studies examine compositional similarities and differences between samples, groups of samples, and source localities. Comparison of trace elemental values allows investigation of the degrees and extents to which samples and source locations are similar in composition and may be securely distinguished. Similarities in trace elemental composition are expectable in our assemblage given that the volcanic features involved are part of the same volcanic field. So, considering the expectable similarities, the questions to be asked become what kinds of similarities are present and what degree of compositional overlap is represented? Assessing the similarities should allow us to determine whether they are so pervasive as to preclude differentiation or they can be accommodated while allowing differentiation.

Three scatter plots, Figures 9.4, 9.5, and 9.7, show five clusters of site and group mean values; two of those plots are for the low-variation trace elements rubidium, strontium, and barium, and suggest that rubidium may be the trace element with the greatest capacity to be used for differentiating sample groups. The third plot is for two of the moderate-variation elements, niobium and zirconium. The five clusters of sample values correspond to the five source and site groups defined archaeologically during this project.

Three trace element scatter plots, Figures 9.6, 9.8, and 9.9, point to four clusters of site and group mean values. One of these plots is for two of the low-variation elements, barium and strontium. Two plots are for the moderate-variation elements niobium, zinc, and zirconium. One sample group, Cerro Negro SE, is not distinct in these plots. In Figure 9.5 (barium and strontium), the Cerro Negro SE samples are most similar to those from Guadalupe Mountain, a situation also seen in Figures 9.2 and 9.3 (silicate and potassium). In Figure 9.8 (niobium and zinc), the Cerro Negro SE samples are most similar to the Cerro Negro NW samples. Finally, the Cerro Negro SE samples are most similar to those from Cerro Montoso when comparing zinc and zirconium (Fig. 9.9).

One scatter plot, Figure 9.7, points to three clusters of site and group mean values, when comparing copper and yttium, the two high-variation trace elements. In this situation, the Cerro Negro SE and Cerro Montoso samples are most similar, as are the Cerro Negro NW and Guadalupe Mountain samples. This is the only plot in which the Cerro Negro NW and Guadalupe Mountain samples are indistinguishable.

Two observations can be made from the results of XRF analyses of the collected samples. First, the Cerro Negro SE materials may be the most difficult to distinguish consistently. Depending on which trace elements are monitored, the Cerro Negro SE materials may be largely indistinguishable from materials from the Cerro Negro NW, Guadalupe Mountain, or Cerro Montoso source locations. However, it is probably important to note that confusion between Cerro Negro SE and Cerro Negro NW materials, which may be expectable since the two groups are from the same volcanic feature, is only seen when we compare barium and rubidium and when we determine the amount of silicate present in the samples. In the other plots for the low-variation, moderate-variation, and high-variation trace elements, the two groups of materials from Cerro Negro are distinct.

Confusion between Cerro Negro SE and Guadalupe Mountain materials is only seen when we compare niobium and zinc, two of the moderate-variation elements. Similarly, confusion between Cerro Negro SE and Cerro Montoso materials (remember that the latter were not collected from quarry locations) is seen only when we compare zinc and zirconium (moderate-variation elements) and copper and yttrium (high-variation). Otherwise, the Cerro Negro SE materials are consistently different from the Guadalupe Mountain and Cerro Montoso materials.

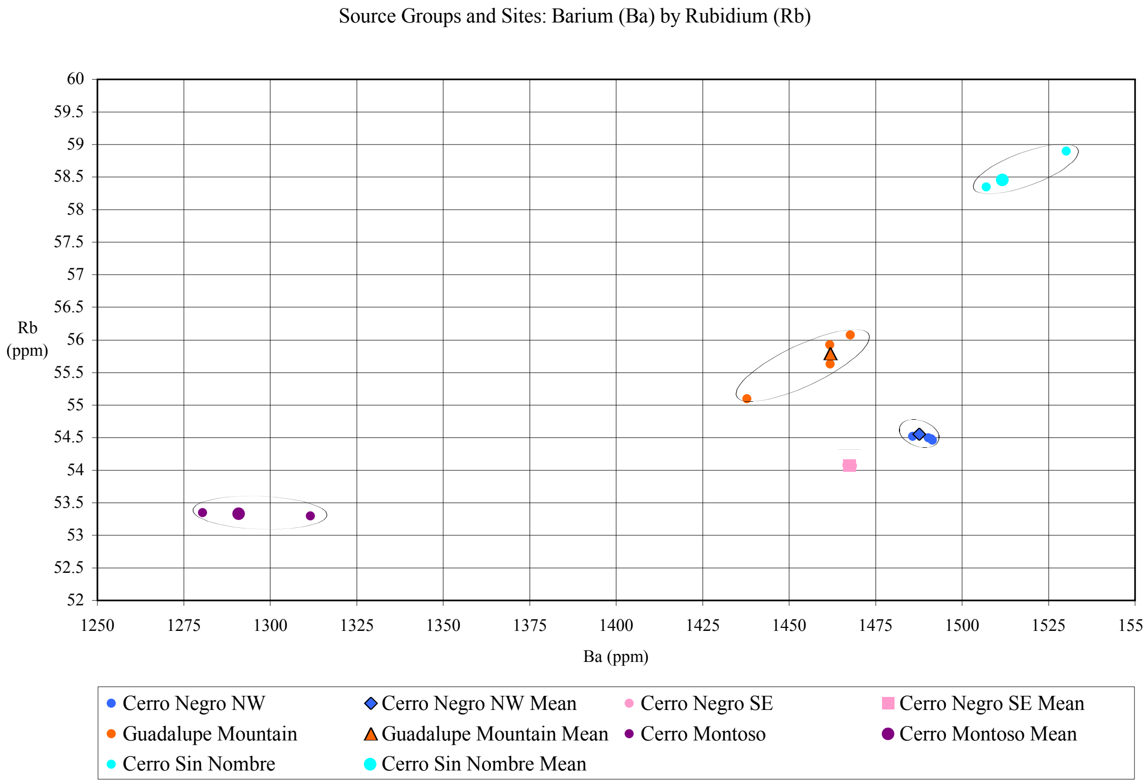

Figure 9.4.Source groups and sites: barium (Ba) by rubidium (Rb).

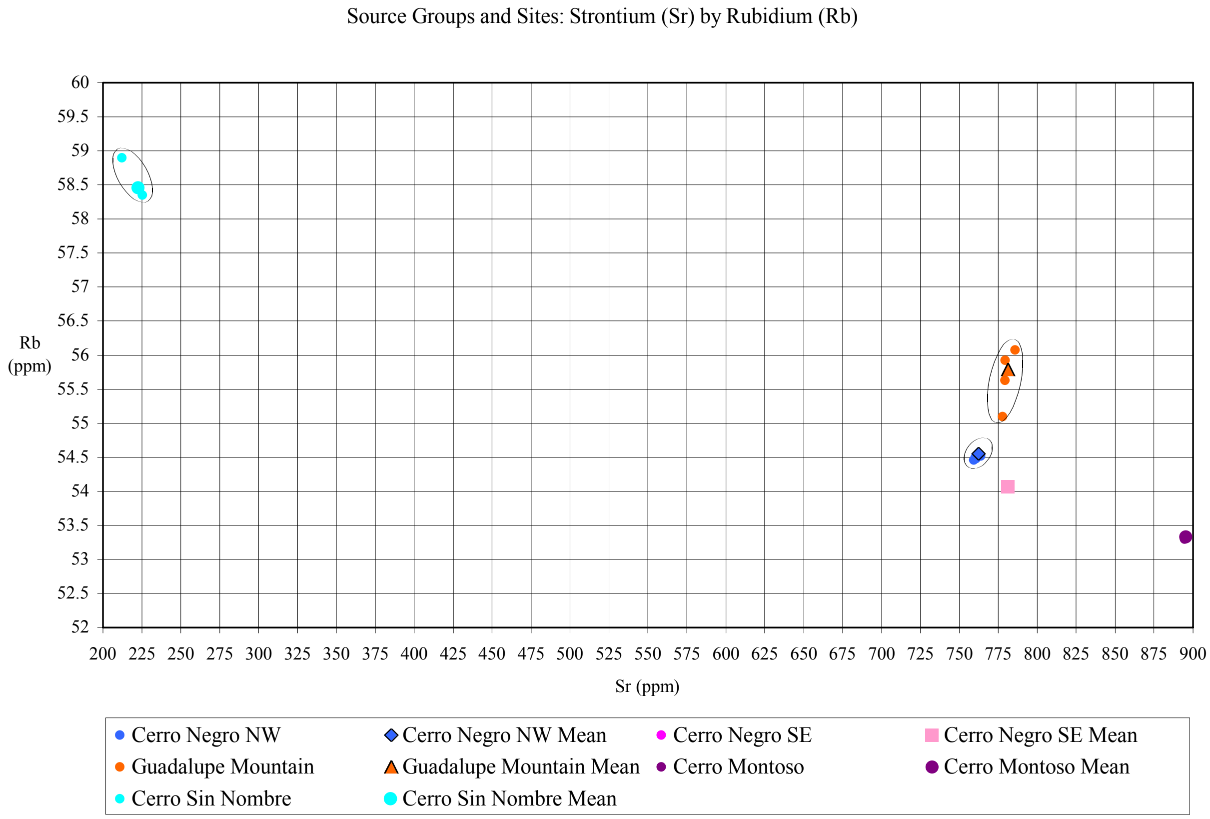

Figure 9.5. Source groups and sites: strontium (Sr) by rubidium (Rb).

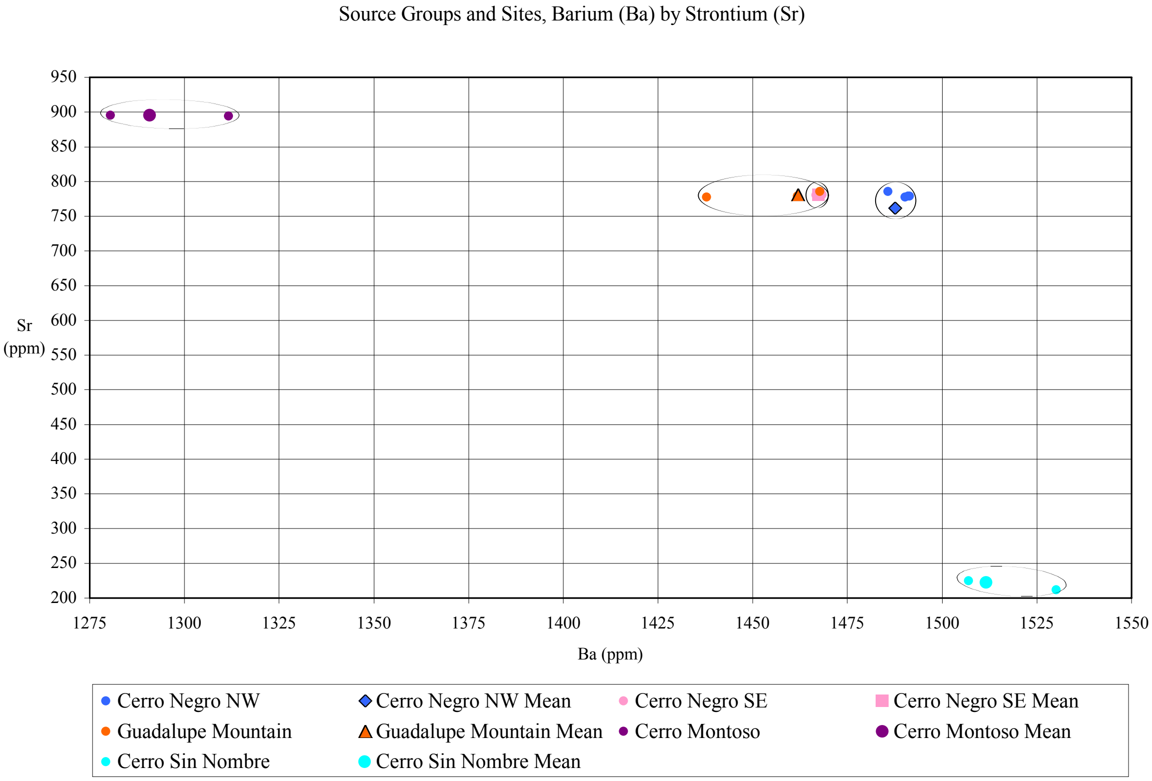

Figure 9.6. Source groups and sites: barium (Ba) by strontium (Sr).

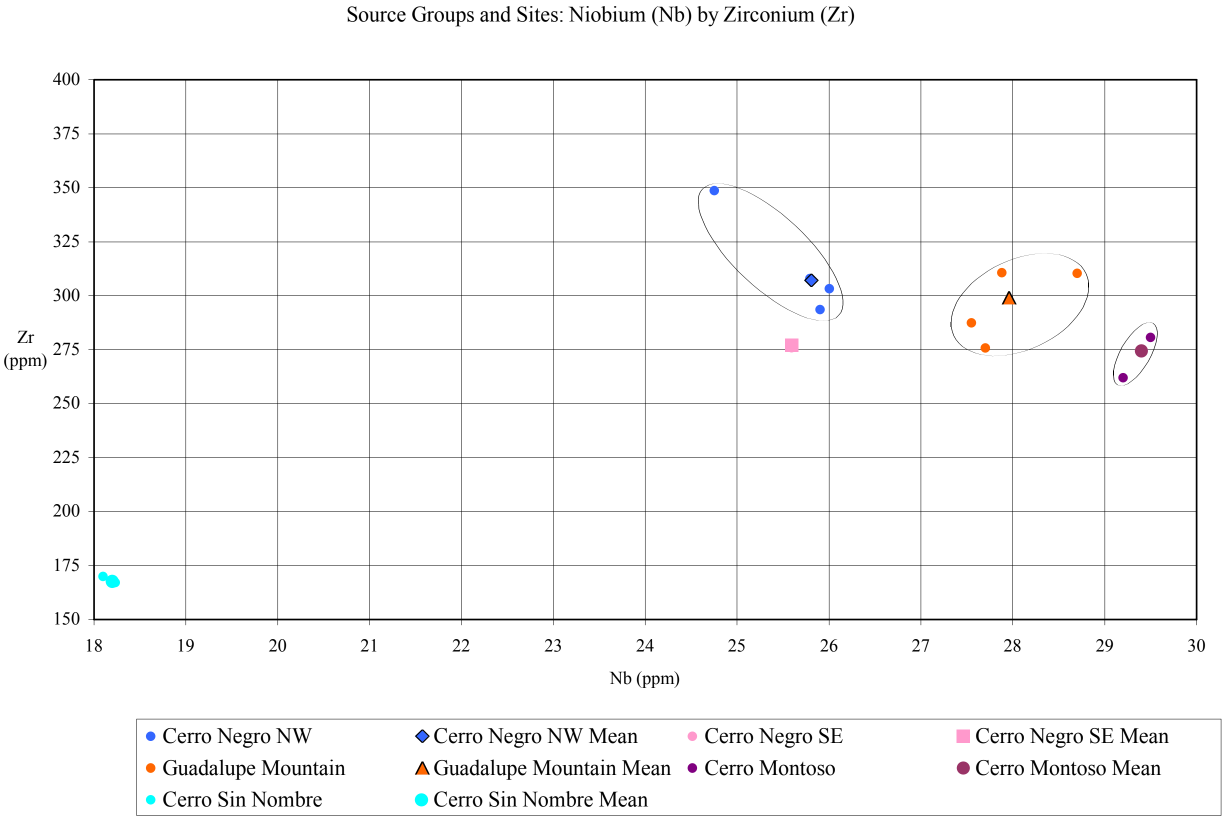

Figure 9.7. Source groups and sites: niobium (Nb) by zirconium (Zr).

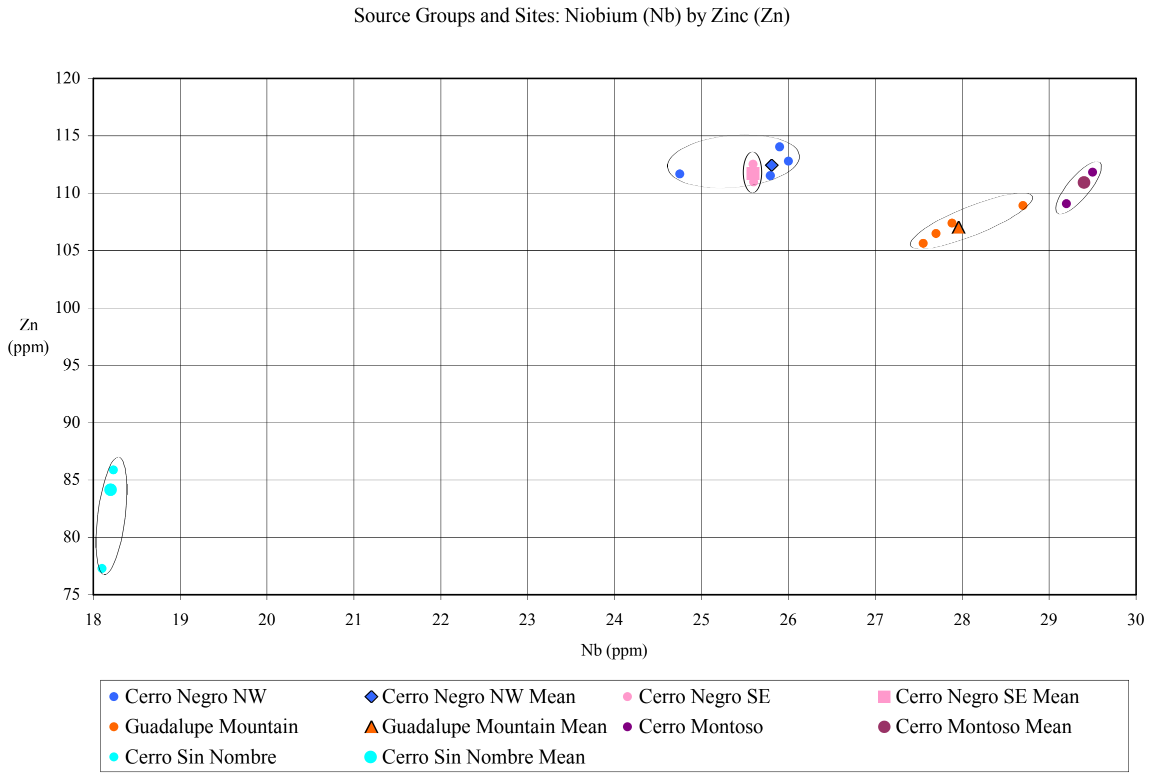

Figure 9.8. Source groups and sites: niobium (Nb) by Zinc (Zn).

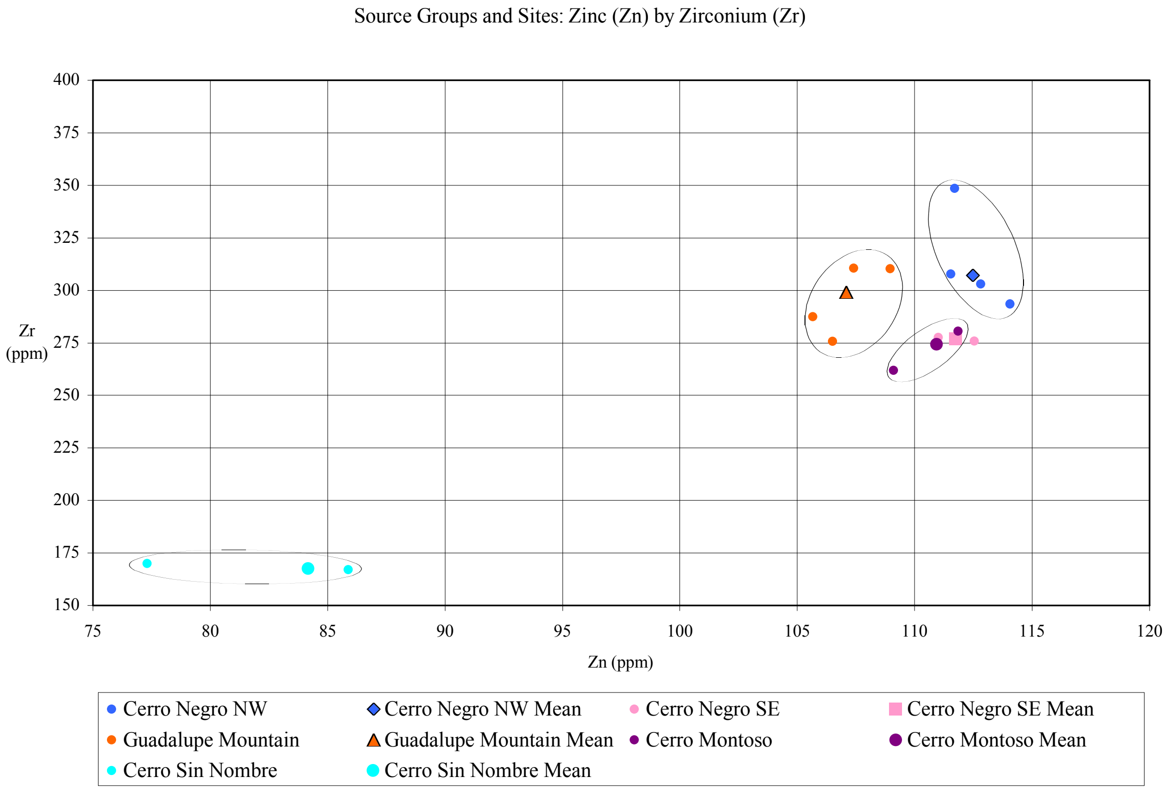

Figure 9.9. Source groups and sites: zinc (Zn) by Zirconium (Zr).

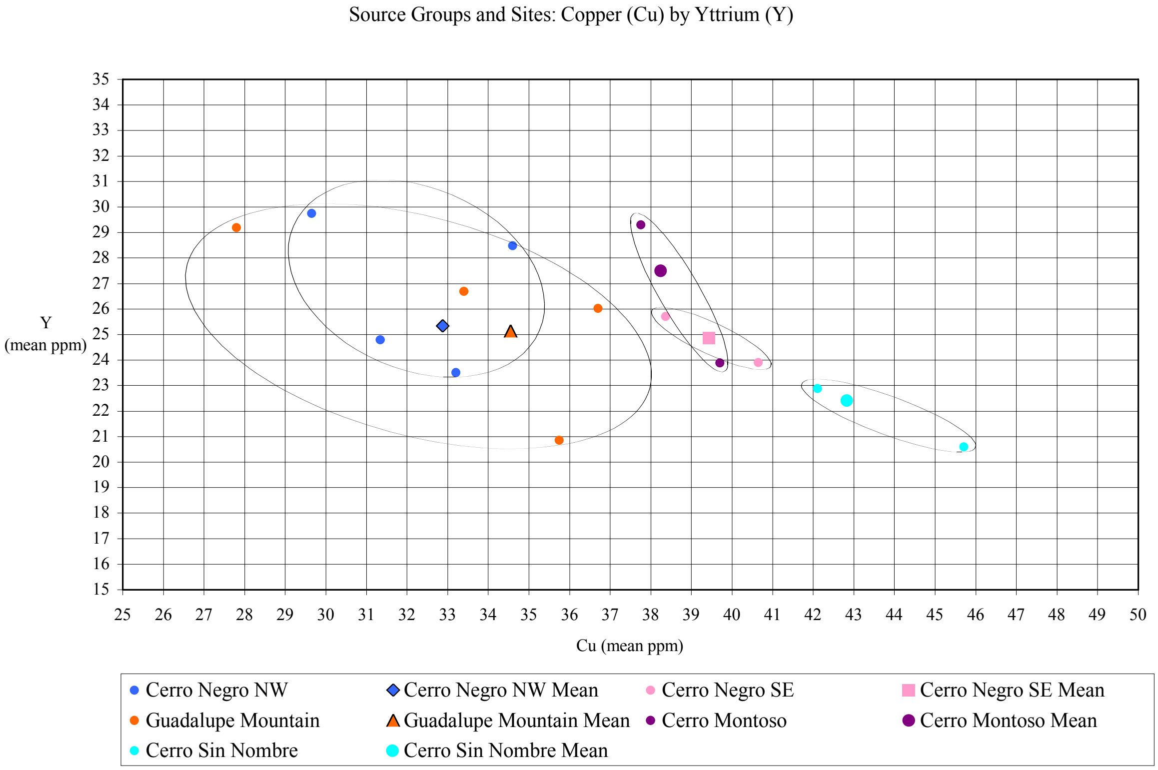

Figure 9.10. Source groups and sites: copper (Cu) by Yttrium (Y).

Given these circumstances, it is likely that the Cerro Negro SE materials are, in fact, distinct and consistently distinguishable, although analyses of additional samples from additional quarry locations on the southeast side of Cerro Negro are needed to adequately test and confirm or deny this conclusion. The results of these preliminary analyses suggest that the Cerro Negro SE materials are most easily confused with materials from other sources when comparing moderate- and high-variation trace elements. Further, even in those circumstances, Cerro Negro SE materials are not consistently similar to those from the same other sources; depending on which elements are monitored, they may be confused with materials the Cerro Negro NW, Guadalupe Mountain, or Cerro Montoso sources. These observations suggest that accurate identification of Cerro Negro SE materials should not be appreciably more difficult than identification of materials from other sources.

The second observation is that the Cerro Sin Nombre material is the easiest to recognize of the materials examined during this project. It is compositionally unlike any of the other materials tested and is distinct in every scatter plot. This should make artifacts made from Cerro Sin Nombe dacite easily identifiable using geochemical analyses.

Identification of Artifact Materials

As an initial test of the utility of geochemical characterization to reveal the sources of artifacts made from regional andesite and dacite sources, we submitted six artifacts from LA 115544/AR-03-02-07-523 for XRF. Between the XRF analyses of the source materials presented above and the analysis of the artifacts, the spectrometer was recalibrated following analyses of materials from another project. Consequently, compositional figures for some major elemental compounds and trace elements are considerably different than those obtained from the earlier analyses. Initially, we thought that the differences indicated that the artifacts were made from materials obtained from a source other than LA 115544/AR-03-02-07-523, and that the source was probably the Cerro Sin Nombre, since barium (Ba) values are much lower than those originally obtained from the LA 115544/AR-03-02-07-523 source. The results of the newer analyses, listed in Table 9.3, show that some elemental compound and

TABLE 9.3. LA 115544/AR-03-02-07-523 REVISED X-RAY FLUORESCENCE DATA : MAJOR ELEMENTAL COMPOUNDS AND TRACE ELEMENTS

SAMPLE NUMBER	ELEMENTAL COMPOUNDS (percent of weight; numbers in parentheses are one standard deviation)											TRACE ELEMENTS (parts per million; numbers in parentheses are one standard deviation)							
	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	K_2O	MgO	TiO_2	P_2O_5	MnO	Total	Ba	Sr	Zr	Zn	Rb	Y	Cu	Nb
44-OA	62.19	15.11	5.92	4.64	4.02	2.48	3.31	0.79	0.33	0.10	98.89	1130.20	823.30	425.80	88.30	61.20	17.00	26.20	9.30
44-OB	61.83	14.98	5.71	4.51	4.03	2.56	2.92	0.76	0.31	0.10	97.71	1160.00	817.90	397.00	91.10	63.90	16.20	40.00	7.90
44-A-2	61.65	14.84	5.68	4.60	3.96	2.48	3.15	0.76	0.32	0.10	97.10	1126.60	824.30	373.50	81.30	61.70	17.20	29.10	9.90
44-B	61.41	15.06	5.72	4.64	4.05	2.50	2.84	0.77	0.31	0.10	97.40	1150.70	832.80	358.10	80.60	61.60	17.70	31.40	11.00
44-C	61.51	15.07	5.74	4.62	4.05	2.49	2.99	0.77	0.30	0.10	97.64	1126.90	827.50	338.20	87.30	61.20	19.20	37.40	14.60
44-D	60.87	14.87	5.73	4.65	4.03	2.53	2.84	0.77	0.31	0.10	96.70	1145.90	826.00	364.40	84.10	62.90	16.40	35.20	7.70
44-E	61.41	14.73	5.68	4.58	3.85	2.44	2.89	0.76	0.32	0.10	96.76	1144.60	827.50	380.90	76.20	61.40	17.20	26.70	10.70
44-E-2	60.55	15.13	6.06	4.67	3.95	2.72	4.12	0.83	0.25	0.10	98.38	1167.70	819.40	402.10	82.70	71.20	18.50	30.70	15.50
Mean	61.43 (0.49)	14.97 (0.14	5.78 (0.13)	4.61 (0.05)	3.99 (0.07)	2.53 (0.08)	3.13 (0.40)	0.78 (0.02)	0.31 (0.02)	0.10 (0)	97.57 (0.72)	1144.08 (14.37)	824.84 (4.46)	380.00 (25.95)	83.95 (4.44)	63.14 (3.17)	17.43 (0.95)	32.09 (4.68)	10.83 (2.69)

TABLE 9.4. LA 115544/AR-03-02-07-523 REVISED X-RAY FLUORESCENCE DATA : MAJOR ELEMENTAL COMPOUNDS , SHOWING MEAN VALUES AND TWO -STANDARD-DEVIATION VALUE RANGES

ELEMENTAL COMPOUNDS (percent of weight; parts per million; numbers each cell are mean values, two standard deviation values of means, and value ranges)									
SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O	K_2O	MgO	TiO_2	P_2O_5	MnO
61.43	14.97	5.78	4.61	3.99	2.53	3.13	0.78	0.31	0.10
0.98	0.28	0.26	0.10	0.14	0.16	0.80	0.04	0.04	0
60.45 – 62.41	14.69 – 15.25	5.52 – 6.04	4.51 – 4.71	3.85 – 4.13	2.37 – 2.69	2.33 – 3.93	0.74 – 0.82	0.27 – 0.35	

TABLE 9.5. LA 115544/AR-03-02-07-523 REVISED X-RAY FLUORESCENCE DATA: TRACE ELEMENTS, SHOWING MEAN VALUES AND TWO-STANDARD-DEVIATION VALUE RANGES

TRACE ELEMENTS (parts per million; numbers each cell are mean values, two standard deviation values of means, and value ranges)							
Ba	*Sr*	*Zr*	*Zn*	*Rb*	*Y*	*Cu*	*Nb*
1144.08	824.84	380.00	83.95	63.14	17.43	32.09	10.83
28.74	8.92	51.90	8.98	6.34	1.90	9.36	5.45
1115.34 – 1172.82	815.92 – 833.76	328.10 – 431.90	74.97 – 92.93	56.80 – 69.48	15.53 – 19.33	22.73 – 41.45	5.38 – 16.28

TABLE 9.6. LA 115544/AR-03-02-07-523 ARTIFACT X-RAY FLUORESCENCE DATA: MAJOR ELEMENTAL COMPOUNDS AND TRACE ELEMENTS. TRACE ELEMENT VALUES IN **BOLD ITALICS** TYPE ARE OUTSIDE TWO-STANDARD-DEVIATION RANGES FOR EACH ELEMENT

FS NO.	PROVENIENCE	ELEMENTAL COMPOUNDS (percent of weight)											TRACE ELEMENTS (parts per million)							
		SiO_2	*Al_2O_3*	*Fe_2O_3*	*CaO*	*Na_2O*	*K_2O*	*MgO*	*TiO_2*	*P_2O_5*	*MnO*	*Total*	*Ba*	*Sr*	*Zr*	*Zn*	*Rb*	*Y*	*Cu*	*Nb*
215	78N/98E, surface	62.93	15.59	5.85	5.54	4.17	2.53	2.67	0.78	0.31	0.10	100.47	1140.70	824.20	***552.40***	84.10	61.20	19.20	36.70	14.10
230	75N/102E, surface	63.00	15.52	5.92	4.57	4.11	2.52	3.03	0.79	0.31	0.10	99.87	1148.80	820.30	***720.20***	92.40	61.50	16.40	33.60	8.10
390	98N/102E, level 1	63.27	15.67	5.84	4.59	4.31	2.54	2.88	0.79	0.31	0.10	100.30	***1179.50***	824.30	***666.80***	81.70	60.30	***14.40***	32.20	3.90
391	102N/100E, level 1	61.89	15.23	5.78	4.63	4.04	2.52	2.81	0.78	0.31	0.10	98.09	1126.90	831.40	385.80	80.90	62.30	17.70	36.20	9.70
352	101N/100E, strat. 1	62.52	15.46	5.78	4.60	4.15	2.62	2.66	0.78	0.31	0.10	98.98	1145.30	826.30	***554.60***	92.00	61.60	16.40	31.20	6.90
388	101N/101E, strat. 1	62.38	15.31	5.97	4.59	4.04	2.50	3.44	0.77	0.30	0.10	99.40	***1110.50***	***807.70***	***472.20***	93.30	61.40	***19.70***	36.70	16.00

trace element values changed after recalibration of the spectrometer (compare Tables 9.2 and 9.3). In particular, among the elemental compounds, Al2O3 and MgO values changed, and, among the trace elements, Ba, Sr, Zr, Zn, Rb, Y, and Nb values changed considerably, so that their original and revised two standard-deviation ranges do not overlap. The project schedule precluded reanalysis of all raw material samples collected from all sources, so we present in Table 9.3 only the revised values for LA 115544/AR-03-02-07-523 material samples. Tables 9.4 and 9.5 present mean values and two standard-deviation ranges for the LA 115544/AR-03-02-07-523 material elemental compounds and trace elements.

Table 9.6 presents elemental compound and trace element values for the six artifacts from LA 115544/AR-03-02-07-523. In Table 9.6, those values in bold, italic type are outside the two standard-deviation ranges for the respective trace elements. Note that five artifacts have higher than expected zirconium values. Since zirconium was not identified as one of the low-variation elements, considered most likely to be diagnostic of source differences, the artifact zirconium values probably indicate that there is more variation in zirconium values than shown by the LA 115544/AR-03-02-07-523 source materials.

Of the three low-variation trace elements, barium, strontium, and rubidium, one artifact has a higher-than-expected barium value (FS 390), and one has a lower-than-expected barium value (FS 388) (Table 9.6). All artifacts have strontium and rubidium values within expected value ranges.

Artifacts FS 388 and FS 390 have higher- and lower-than-expected yttrium values, respectively, and FS 390 has a lower-than-expected niobium value. Niobium is a moderate-variation trace element, while yttrium is a high-variation trace element.

Taken together, these data indicate that all six artifacts submitted for XRF analysis were made from raw material available at LA 115544/AR-03-02-07-523. Two artifacts present trace element values outside expected value ranges. However, with the exception of barium, the elements involved are moderate- and high-variation elements and are probably not diagnostic of differences in material sources. Although these two artifact present more variation in trace element values than is suggested by data in Tables 9.3, 9.4, and 9.5, most of that variation is not found in elements most likely to point to source differences. We conclude, therefore, that the artifacts reflect variation in trace element values that is not reflected in analyzed, on-site, material samples. The artifacts probably do not represent off-site materials.

10

Conclusions

Jeffrey L. Boyer

In other projects in the Taos Valley, we have looked at the region as a Puebloan frontier and examined the implications of frontier development for examining, describing, and understanding the prehistoric Puebloan occupation of the valley (Boyer et al. 1994; Boyer 1995, 1997a; Moore 1995). Although the research design for this project did not specifically address frontier issues, the project results are important for regional frontier studies for several reasons.

First, the two sites investigated during this project probably date to the early Puebloan occupation of the region (early Valdez phase; Chapter 7). Consequently, since nonresidential Valdez phase sites have not been investigated (see Moore 1995), the NM 522 sites provide a first look at nonresidential Puebloan use of the regional natural and cultural landscape, the embedding of quarrying and material reduction for transport during foraging land use (or, perhaps, vice versa), and the transportation, use, and discard of exotic materials (obsidians, Pedernal and Alibates cherts) during foraging-quarrying-reduction trips made by early inhabitants of the Puebloan frontier. In so doing, the sites point out how rapidly frontier inhabitants mapped onto the landscape and its resources, for, if Moore's conclusions in Chapter 7 regarding site dating are accurate, Puebloan frontier settlers had identified these resources relatively soon after occupying the valley.

Second, the sites provide a look at Puebloan use of nonresidential sites (which is not the same as looking at nonresidential Puebloan land use). In so doing, the sites provide preliminary data that may be of use in comparing the structures of Puebloan and non-Puebloan sites. In Chapter 4, we suggested that quarry sites could be expected to fit into Puebloan and non-Puebloan economic, settlement, and land-use strategies in different ways. One difference could be structural in nature, based on how long and for what reasons people were on-site, the strategies with which they quarried and reduced on-site and exotic materials, and what other activities were performed there. Although it is well beyond the scope of this project to make these sorts of comparisons, the project has produced site structural data that may be useful in this regard.

Finally, with the geochemical characterization of quarried sources, we can begin to look at how and where those materials that were mapped onto in the frontier landscape were selected, quarried, transported, used, and discarded as the frontier expanded and became established. As we gather more data on the distribution of quarried materials and sources, we will obtain a more accurate view of the frontier than is available by only looking at residential sites. And, we'll begin to see how, as the Puebloan frontier became more firmly established through time, the development of communities and supra-communities impacted access to and use of natural resources, providing us with better understanding of interaction and integration within and between community and supra-community groups.

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