UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

BLACK ROCKS IN THE BORDERLANDS: OBSIDIAN PROCUREMENT IN SOUTHWESTERN NEW MEXICO AND NORTHWESTERN CHIHUAHUA, MEXICO, A.D. 1000 TO 1450

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

By

SEAN G. DOLAN
Norman, Oklahoma
2016

BLACK ROCKS IN THE BORDERLANDS: OBSIDIAN PROCUREMENT IN SOUTHWESTERN NEW MEXICO AND NORTHWESTERN CHIHUAHUA, MEXICO, A.D. 1000 TO 1450

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF ANTHROPOLOGY

BY

____
Dr. Bonnie L. Pitblado, Chair

____
Dr. Patricia A. Gilman

____
Dr. Paul E. Minnis

____
Dr. Samuel Duwe

____
Dr. Sean O’Neill

____
Dr. Neil H. Suneson

For my parents, Tom and Cathy Dolan

Acknowledgments

Many people have helped me get to this point. I first thank my professors at Pennsylvania State University where I received my undergraduate education. Dean Snow, Claire McHale-Milner, George Milner, and Heath Anderson introduced me to archaeology, and Alan Walker introduced me to human evolution and paleoanthropology. They encouraged me to continue in anthropology after graduating from Happy Valley.

I was fortunate enough to do fieldwork in Koobi Fora, Kenya with professors Jack Harris and Carolyn Dillian, amongst others in 2008. Northern Kenya is a beautiful place and participating in fieldwork there was an amazing experience. Being there gave me research opportunities that I completed for my Master's thesis at New Mexico State University. Carolyn deserves a special acknowledgement because she taught me about the interesting questions that can be asked with sourcing obsidian artifacts.

I thank my professors and friends at New Mexico State University, particularly my advisers Monte McCrossin and Brenda Benefit. I also thank Bill Walker who introduced me to archaeology in the hot stinking desert of Deming, New Mexico.

I was lucky to be a part of Crow Canyon Archaeological Center in 2011. It is one of the best places in the world to study and learn about archaeology, and I was fortunate to learn from Shanna Diederichs, Steve Copeland, Caitlin Sommer, Mark Varien, Susan Ryan, Paul Ermigiotti, Kristin Kuckelman, Scott Ortman, Rebecca Hammond, and Grant Coffee. They showed me a brand new part of the Southwest and got me out of the hot stinking desert, at least for a little bit. I don't know what I would have done without Allison Hill, Sarah Johnson, and Jessa Fowler who were my fellow

Crow Canyon interns. Allison deserves special thanks because she has become one of my best friends after leaving Cortez.

I’m grateful for my time in Norman, Oklahoma because it is one of the best universities to study anthropology and archaeology. I was fortunate to work at the Oklahoma Archeological Survey with Bob Brooks and Marjy Duncan in 2012 when I first arrived. The archaeology faculty always gave me advice and encouragement when it was needed. Thank you to Patrick Livingood, Asa Randall, Marc Levine, Susan Vehik, and Don Wyckoff.

I must thank my fellow grad students when I lived in Norman. Thanks to Sonya Beach, Juliet Morgan, Stephanie Stutts, Bill Ankele, Anne Kroeger, Nicole Umayam, Caroline Fernald, and Alesha Marcum-Heiman. Ali Livesay, Shawn Lambert, and Andrew Ozga deserves special thanks because they were always there when I needed revisions or to join me for happy hour.

This dissertation would not have been completed without the encouragement of Jen Payne and LeAnn Purtzer from Los Alamos National Laboratory. I also thank my coworkers Alan Madsen, Gerald Martinez, Kari Garcia, Ellen McGehee, Amanda Cvinar, Sandi Copeland, David Holtkamp, and Jeremy Brunette for putting up with me when I point out every piece of obsidian I see on an archaeological site.

Data collection, travel, and analysis for this dissertation were funded by the University of Oklahoma’s Department of Anthropology, Graduate Student Senate, Arts and Sciences, as well as the Arizona Archaeological and Historical Society. I would like to thank Julia Clifton and Rachel Johnson at the Laboratory of Anthropology/Center for New Mexico Archaeology/Museum of Indian Arts and Culture in Santa Fe, as well as

Luis Tena from INAH in Chihuahua. A tremendous thank you and acknowledgement must be given to Michael Whalen for helping me get the obsidian artifacts from Casas Grandes, and letting me borrow pants, shorts, and socks after I lost my clothes in Chihuahua.

I thank my fellow archaeologist who I've shared meals, drinks, car rides, and classrooms with. You have meant a lot to my development as a scholar, archaeologist, and a person in general. Conversations with other grad students, faculty, and researchers at many universities, institutions, and CRM companies have greatly improved this research. In alphabetical order, thank you: Neil Ackerly, Fumi Arakawa, Katie Baustian, Nick Beale, Judy Berryman, Kyle Bocinsky, Christopher Caseldine, Robin Cordero, Kristin Corl, Bob DeBry, Lauren Falvey, Jeff Ferguson, Andrew Fernandez, John Fitch, Brian Halstead, Thomas Holcomb, Eric Kahldal, David Kirkpatrick, Karl Laumbach, Steve Lekson, Lonnie Ludeman, Myles Miller, John Taylor-Montoya, Sarah Nichols, Anna Osterholtz, Matt Peeples, Barb Roth, Mike Searcy, Mark Sechrist, Jakob Sedig, Kari Schleher, Chris Schwartz, Fabiola Silva, Caitlin Stewart, Bob Stokes, Matt Taliaferro, Elizabeth Toney, John Ware, Aaron Woods, and Kristina Wyckoff.

Two people in particular deserve special acknowledgment. First I thank Steve Shackley. He is one of the reasons why I moved to northern New Mexico after leaving Oklahoma. His home and XRF lab is less than an hour away from me, and I am thankful for him and family for being so helpful and allowing me to spend time with them. This study would not have been possible without his help and expertise. Katy Putsavage has been a big sister to me during this process. She was instrumental in keeping me sane and I greatly appreciate our weekly and sometimes daily phone calls. I think we both learned a great deal from them.

Finally, I thank my dissertation committee. Pat Gilman, Paul Minnis, Bonnie Pitblado, Sean O'Neill, Sam Duwe, and Neil Suneson have helped me with this research from the start. Pat and Paul are the reason why I went to Oklahoma. I knew I wanted to study with them during our first meeting at the Frontier Restaurant in Albuquerque before the 2012 Southwest Symposium. They provided me with the tools to succeed and the right connections to study Mimbres and Casas Grandes archaeology. They are also great land lords. Bonnie deserves a special acknowledgment because she stepped in when Pat and Paul retired. I greatly appreciate the time and conversations I had with her, especially the adventure in Corales, New Mexico seeing artifacts in a private collection that archaeologists dream of seeing. Prehistoric diapers, really?! I'm very happy Sam joined the faculty at Oklahoma. I know he and his future students will contribute immensely to the archaeology of northern New Mexico. I also thank Neil and Sean who I had very engaging conversations with about obsidian in all parts of the world.

Table of Contents

List of Tables

List of Figures

Abstract

Over the past 50 years, geochemical characterization studies of obsidian artifacts from archaeological sites around the world have become an important way to examine long- and short-distance social interactions and procurement practices through time and across space. This is certainly the case for the North American Southwest and Mexican Northwest as there are approximately 40 to 50 known geochemically distinct obsidian sources on the landscape. As a result, precise identification of which sources people used is invaluable information to archaeologists interested in studying regional and temporal patterns of obsidian procurement.

In this dissertation, I establish the first regional context for obsidian procurement in southwestern New Mexico and northwestern Chihuahua, Mexico from A.D. 1000 to 1450. I accomplish this by discussing the results of an energy-dispersive X-ray fluorescence (EDXRF) analysis of over 1,000 obsidian artifacts from 26 archaeological sites. I supplement previous studies of obsidian procurement in southwestern New Mexico, by incorporating data from new sites and adding to the database of sourced obsidian artifacts. I also present the first well documented EDXRF study of obsidian procurement in the Casas Grandes region of northwestern Chihuahua during the Medio period.

The goal of this dissertation study is to examine variability in obsidian procurement through time and across space. Did people only use one or two types of obsidian, or was procurement more diverse which suggests that people extended their social networks to obtain different types of obsidian? The sourcing results demonstrate there are clear regional dissimilarities between the Mimbres Valley, the Deming basin and range, the Uvas Valley, the Animas Valley, and the Casas Grandes Valley from A.D. 1000 to 1450.

My research shows there are diverse strategies of obsidian procurement. People from some regions never changed their procurement tradition. On the other hand, some obsidian traditions fluctuated through time and people in the same geographic region used multiple sources of obsidian. By discussing the homogeneity and heterogeneity in obsidian procurement in the five culturally and environmentally diverse regions over a long period of time, I expose diverse social histories regarding obsidian procurement traditions at the temporal, regional, and site levels. By doing so, I have moved toward a more dynamic understanding of the mutually constitutive relationships that linked groups of people who shared a tradition of obsidian procurement in southwestern New Mexico and northwestern Chihuahua.

Chapter 1: Introduction

The archaeological record shows that where obsidian is available either by obtaining it directly at the source or by other social means like trade, people made stone tools with of this volcanic glass. The use of obsidian to make stone tools extends back to our earliest bipedal hominin ancestors in Africa during the Oldowan period, over two million years ago (Ambrose 2012; Piperno et al. 2009) and continued through the earliest Spanish occupation of the Americas (Saunders 2001; Silliman 2003, 2005). Obsidian is extremely sharp, easily flaked, and in some parts of the world has been imbued with ceremonial meaning and cosmological properties (Dillian 2002; Levine and Carballo 2014; Saunders 2001). It was very much a high valued lithic material through time and across space, and as a result, archaeologists using geochemical sourcing methods have documented the long-distance movement of obsidian objects across vast geographic and cultural regions in parts of North America (Barker et al. 2002; Boulanger et al. 2007; Dillian et al. 2010; Griffin et al. 1969; Hammerstedt et al. 2008; Hatch et al. 1990; Steffen and LeTourneau 2007).

The North American Southwest and Mexican Northwest (hereafter the Southwest/Northwest [SW/NW], Figure 1.1) have seen a tremendous interest from the archaeological community in the study of obsidian procurement. Archaeologists throughout the world, including the SW/NW, are able to study obsidian in more dynamic ways than other lithic raw materials because the trace elements of this volcanic glass can be accurately and reliably characterized to determine the source outcrop (Glascock 2002; Glascock et al. 1998; Shackley 1988, 1995, 2005, 2008). The geochemical composition or ‘fingerprint’ within an individual obsidian source is homogenous, but the geochemical differences among outcrops on the landscape are statistically significant (Glascock 2002:2; Hughes and Smith 1993). The geochemical fingerprint of each obsidian source in the SW/NW for which the location is known is understood based on sourcing results from a host of geochemical sourcing techniques including energy-dispersive X-ray fluorescence (EDXRF) spectrometry (Glascock 2011; Shackley 2005, 2011a).

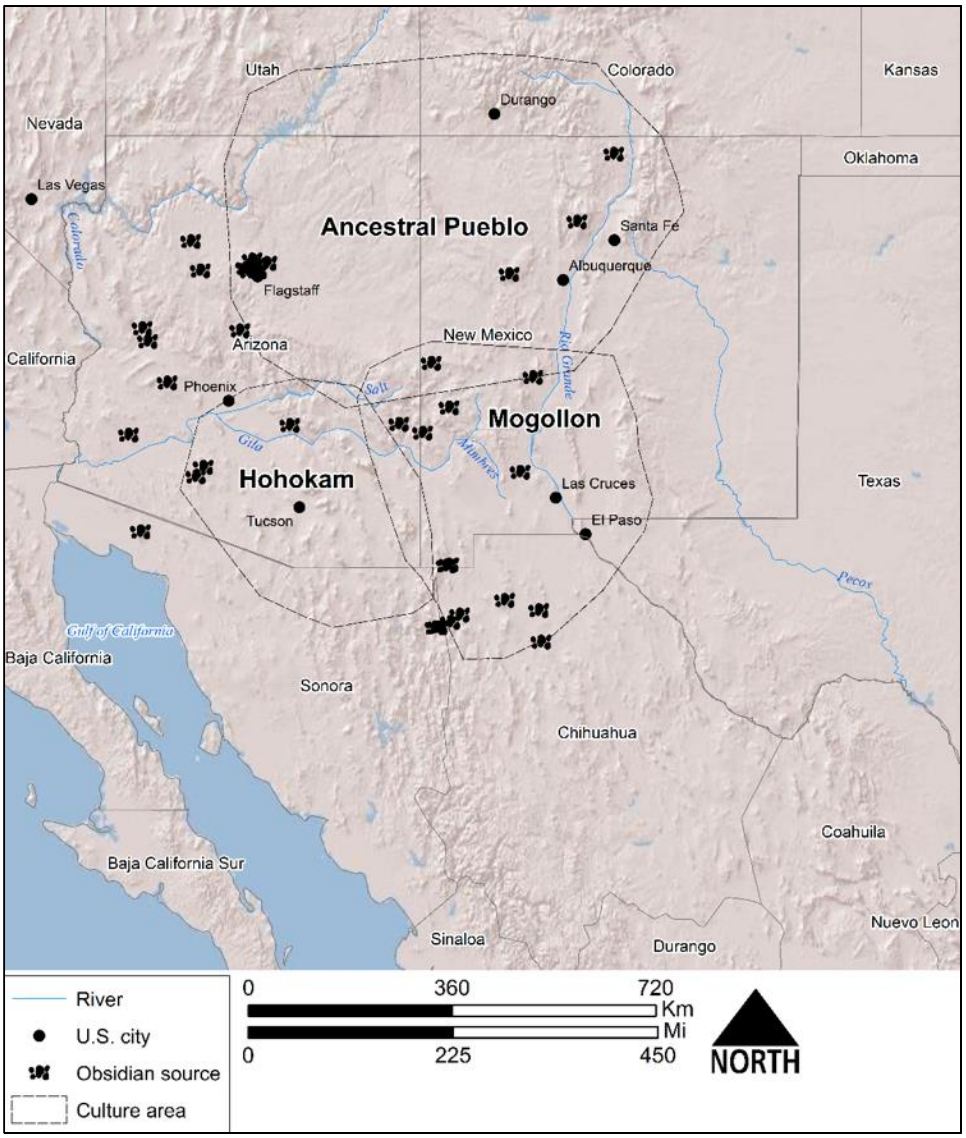

Figure 1.1. The North American Southwest and Mexican Northwest.

Although obsidian provenance studies in the SW/NW has lagged behind other regions of the western United States like California and the Great Basin, as well as Mesoamerica (Clark 2003; Hughes 1984, 1986), archaeologists in the past decade have begun to examine a host of issues related to trade, exchange, economy, and long-distance social interaction using the source provenance data from obsidian projectile points and chipped stone debitage recovered from archaeological contexts in the SW/NW (Arakawa et al. 2011; Duff et al. 2012; Ferguson et al. 2016; Fertelmes et al. 2012; Graves 2005; Mills et al. 2013; Kibler et al. 2014; Loendorf 2010; Putsavage 2015; Shackley 2005; Taliaferro 2004, 2014; Taliaferro et al. 2010; Vierra 2005). Sourcing data are critical for answering questions related to the social mechanisms behind how people moved obsidian across the landscape. In this dissertation, I discuss the regional and temporal patterns of obsidian procurement in the SW/NW that have not been previously investigated. As a result of this outcome, in this study, I establish a regional and temporal context for obsidian procurement in southwestern New Mexico and northwestern Chihuahua, Mexico (Figure 1.2) from A.D. 1000 to 1450.

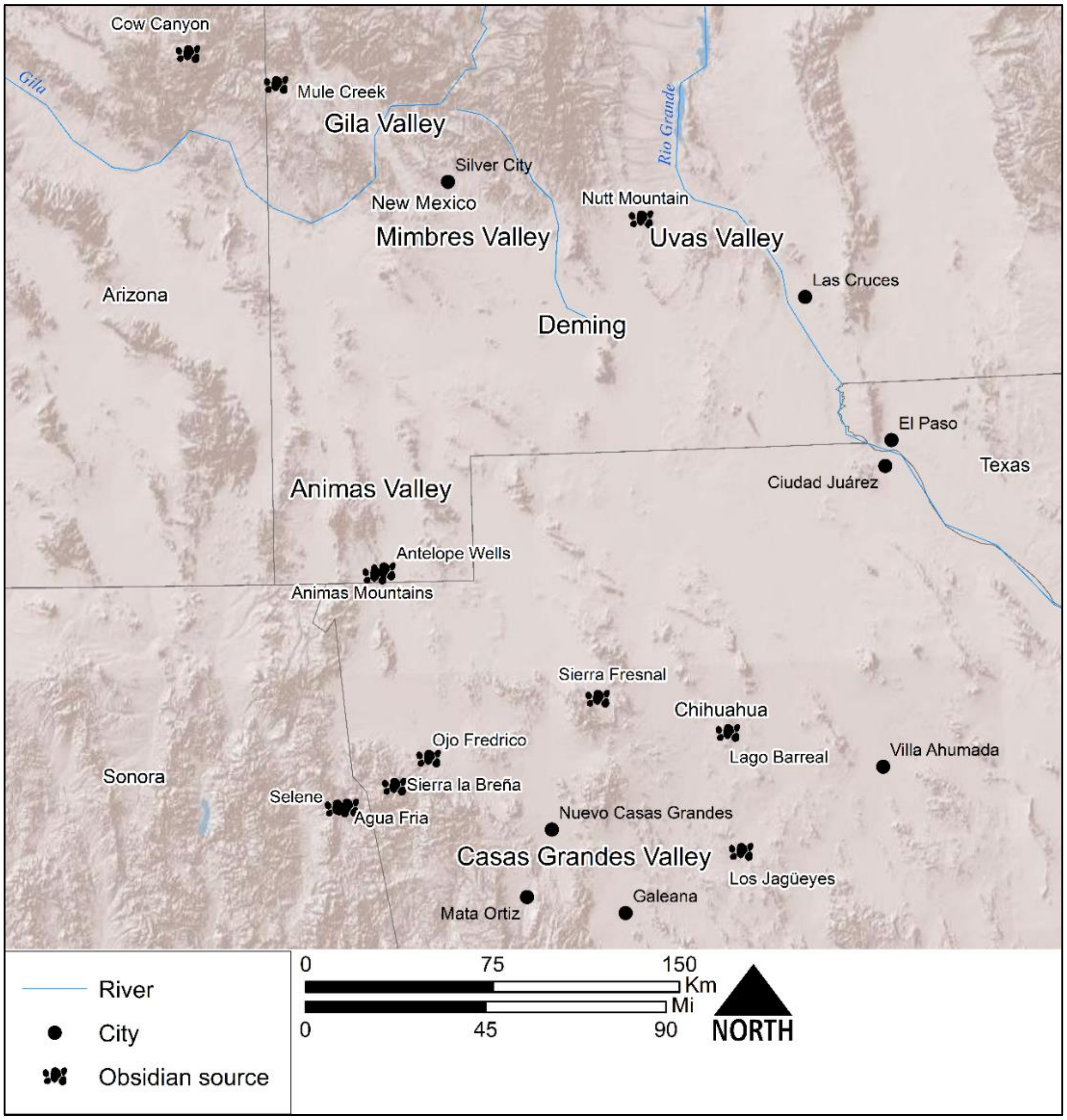

Figure 1.2. Southwestern New Mexico and northwestern Chihuahua, Mexico.

People living in southwestern New Mexico and northwestern Chihuahua could choose from many high-quality obsidian sources in Arizona, New Mexico, Sonora, and Chihuahua to manufacture stone tools (Figure 1.3). Shackley (1988, 1992, 1995, 1998a, 2005) and other archaeologists and researchers have sourced thousands of obsidian artifacts and geologic samples in the SW/NW to understand the geochemical signature for each one of these sources (Glascock et al. 1999; Kibler et al. 2014; Martynec et al.

2011). Their results demonstrate that there are approximately 40 to 50 geochemically known obsidian sources in the SW/NW, but there are also some sources for which the primary and secondary source deposits are geographically unknown even though geochemically they can be distinguished from one another (Shackley 2005).

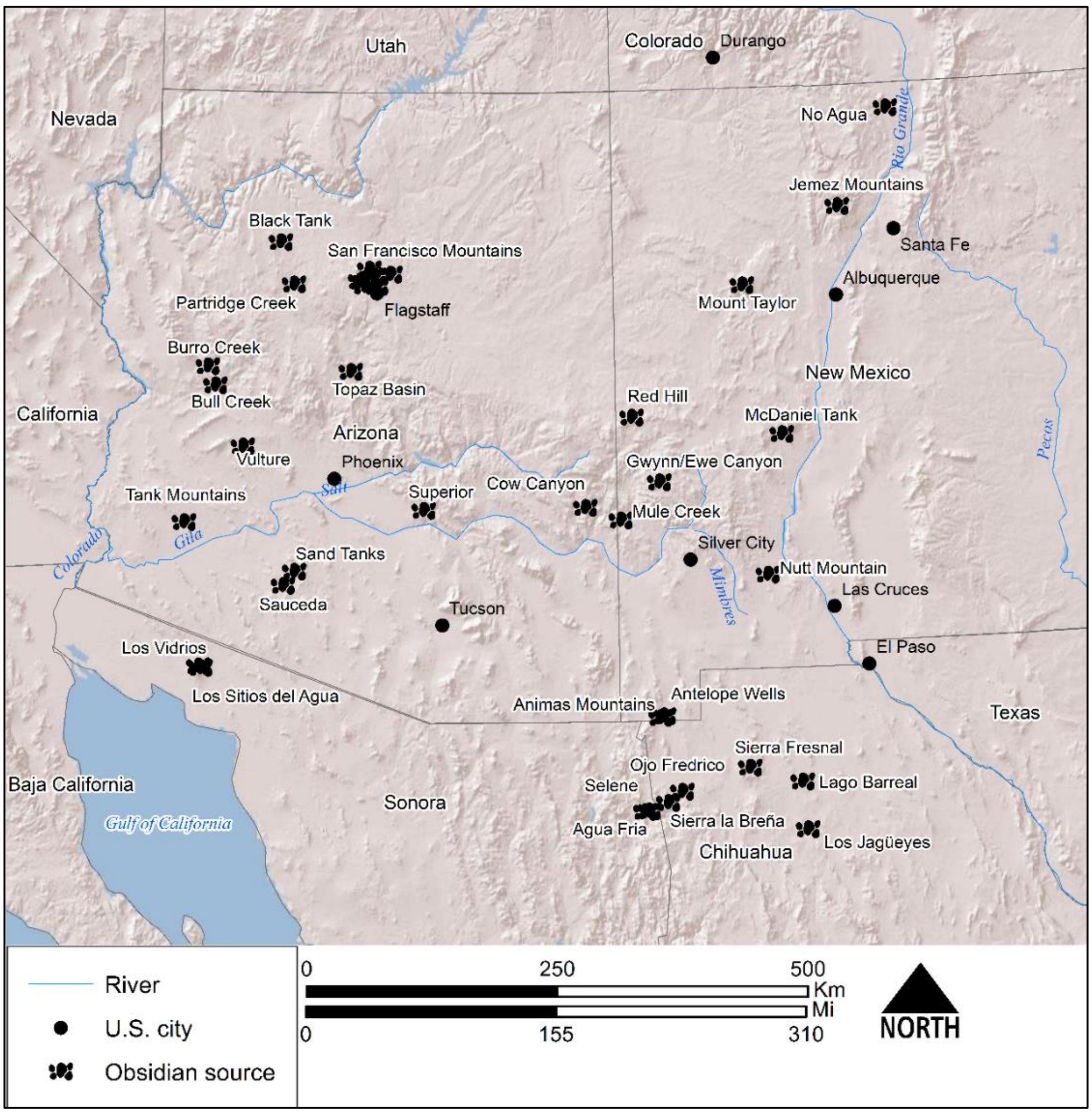

Figure 1.3. Known obsidian sources in the North American Southwest and Mexican Northwest.

Using the geochemical provenance data obtained through EDXRF spectrometry, I examine which obsidian sources people in the Mimbres Valley, the Deming basin and range, the Uvas Valley, the Animas Valley, and the Casas Grandes Valley (Figure 1.2) used to make stone tools during the eleventh through mid-fifteenth centuries A.D. I take a diachronic and multiscalar approach to discuss procurement homogeneity and/or heterogeneity in a dynamic SW/NW landscape. Southwestern New Mexico and northwestern Chihuahua during the eleventh through mid-fifteenth centuries A.D. are an exceptional laboratory to study obsidian procurement because of the many sources spaced throughout the region. As well, archaeologists understand the time-space systematics of the Mimbres Valley, the Deming basin and range, the Uvas Valley, the Animas Valley, and the Casas Grandes Valley (Anyon et al. 1981; Dean and Ravesloot 1993; Di Peso 1974; Di Peso et al. 1974; Hegmon et al. 1999; LeBlanc 1983, 1989; LeBlanc and Whalen 1980; Lekson 1996, 2006, 2009; Lekson et al. 2004; Phillips 1989; Stuart and Gauthier 1981:175-258; Whalen and Minnis 2001a, 2009a; Wilcox et al. 2008) (Table 1.1)

Table 1.1. Select Chronology in Southwestern New Mexico and Northwestern Chihuahua.

Region	Period/Phase	Date (A.D.)
Mimbres-Deming-Uvas	Mimbres Classic	1000-1130
	Black Mountain	1130-1300
	Cliff	1300-1450
Animas	Animas	1200-1450
Casas Grandes	Medio	1200-1450

Note: Dating is based on dendrochronology, radiocarbon, and ceramic cross-dating (Anyon et al. 1981; Dean and Ravesloot 1993; Hegmon et al. 1999; Whalen and Minnis 2009a:41-70, 2012).

Avocational, university, and cultural resource management (CRM) archaeologists have worked in the Mimbres Valley of southwestern New Mexico for many decades. Research has focused on how people lived in this region by examining chronology, subsistence strategies, architecture, long-distance interaction, burial practices, and other forms of material culture (Anyon et al. 1981; Anyon and LeBlanc 1980, 1984; Blake et al. 1986; Cosgrove and Cosgrove 1932; Creel 1989, 1999, 2006a; Creel and Anyon 2003; Diehl and LeBlanc 2001; Fewkes 1914, 1923, 1924; Gilman 1987, 1990, 2006; Gilman and Stone 2013; Gilman et al. 2014; Haury 1936a, 1936b; Hegmon 2002a; Hegmon et al. 1999; LeBlanc 1980a, 1983, 1986, 1989, 2006; LeBlanc and Whalen 1980; Lekson 1988, 2002, 2006; Minnis 1985; Nelson and LeBlanc 1986; Nelson 1999; Putsavage 2015; Roth and Baustian 2015; Roth and Stokes 2007; Sedig 2015; Shafer 1995, 1999, 2003, 2006; Taliaferro 2014). The other two areas of southwestern New Mexico that I examine in this study, the Deming basin and range and the Uvas Valley, have seen less archaeological investigation than the more researched Mimbres Valley, but archaeologists apply the same cultural time-space systematics as the Mimbres Valley to these areas (Anyon et al. 1981; Hegmon et al. 1999).

The Animas Valley in extreme southwestern New Mexico in the boot heel is historically linked to the Casas Grandes regional system more so than the Mimbres Valley, Deming, and the Uvas Valley. Because of this, archaeologists early on have investigated sites in southern Hidalgo County like Joyce Well, Box Canyon, Clanton Draw, and Pendleton Ruin (Kidder et al. 1949; McCluney 1965a, 1965b; Skibo et al. 2002; see also DeAtley and Findlow 1982; Findlow and DeAtley 1974). Unlike southwestern New Mexico, the Casas Grandes region in northwestern Chihuahua has had less excavation and survey work, but archaeologists still have large datasets with which to work because of Di Peso's Joint Casas Grandes Expedition (JCGE) at and near the site of Paquimé (Di Peso 1974; Di Peso et al. 1974). Other more recent projects in northwestern Chihuahua have expanded our knowledge of chronology, settlement patterns, and material culture (Antillón et al. 2004; Dean and Ravesloot 1993; Douglas and Quijada 2004, 2005; Kelley et al. 2012; Minnis and Whalen 2015b; Pitezel and Searcy 2013; Rakita 2009; Ravesloot 1988; Schaafsma and Riley 1999; VanPool and Leonard 2002; VanPool et al. 2000; Whalen and Minnis 2001a, 2001b, 2009a, 2012).

Research Goals and Measures

I have three research goals for this dissertation study. Using the source provenance information provided by EDXRF spectrometry, the first goal is to determine the source locations of 1,132 obsidian artifacts from 26 archaeological sites dating from A.D. 1000 to 1450 in southwestern New Mexico and northwestern Chihuahua. In other words, of the many geochemically distinct obsidian sources present in the SW/NW, which ones did people in the Mimbres Valley, the Deming basin and range, the Uvas Valley, the Animas Valley, and the Casas Grandes Valley use through time?

This dissertation research builds on previous obsidian sourcing projects (Dolan 2012; Dolan and Livesay 2015; Dolan and Putsavage 2012, 2013; Kenmotsu et al. 2014; Putsavage 2015; Taliaferro 2004, 2014; Taliaferro et al. 2010; VanPool et al. 2013), and I add new sourcing data to time periods and regions that have not been previously investigated. For example, Taliaferro (2004, 2014; Taliaferro et al. 2010), Putsavage (2015), and VanPool et al. (2013) have presented source provenance results in the Mimbres Valley and the Deming basin and range through time, but the source provenance of obsidian artifacts in the Uvas Valley, the Animas Valley, and the Casas Grandes Valley have not been fully documented or discussed until now. With this new information, I offer interpretations about prehispanic obsidian procurement and the extent of obsidian social networks between and among people in southwestern New Mexico and northwestern Chihuahua.

The second goal of this study is to take the sourcing results and separate the data into macro-, meso-, and microscales of analyses. Recently, Mills et al. (2015) took this multiscalar approach to examine how people's social networks changed through time and across space in southern Arizona. By taking this approach, I discuss obsidian procurement at various levels to illuminate spatial and temporal patterns that are sometimes overlooked in the archaeological record. Each one of the three scales of analysis yields different results and I am able to discuss broad and overarching patterns of obsidian procurement, as well as more refined patterns at the temporal, spatial, and site level. This helps to examine how people living in various regions and time periods may have used different sources based on a host of historical factors including transformations in social systems that occurred in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450.

The final goal is to take these interpretations and contextualize all results into the broader picture of the SW/NW archaeological record. By taking a diachronic and multiscalar approach, I examine whether obsidian procurement changed through time and across space as a result of changing social situations. The eleventh through mid-fifteenth centuries A.D. are the most dynamic time period in the entire SW/NW (Adams and Duff 2004; Adler 1996; Lekson 2009). Many transformations occurred affecting population movement, religious practices, ceramic iconography, architecture, and social interaction (Crown 1994; Hegmon 2002; Hill et al. 2010; Lekson 2009; Mills et al. 2013). As people moved across the landscape in response to drought, social and religious unrest, and violence, the knowledge of where the best quality or closest obsidian may have been lost or forgotten. Movement is an important cultural process in Pueblo life, and archaeologists typically use painted ceramics and architecture to document when and where people moved (Cameron 2013; Clark 2001; Haury 1958; Naranjo 1995; Ortman 2012). However, as the database of sourced obsidian artifacts continues to grow, archaeologists are now more than ever able to use sourcing information to better examine the movement of people through time and across space in the SW/NW (Arakawa et al. 2011; Shackley 2005).

In terms of measures, I use a dataset of sourced obsidian artifacts from sites dating to A.D. 1000 to 1450 in southwestern New Mexico and northwestern Chihuahua. This 450-year time span encompasses the Mimbres Classic period, the Black Mountain phase, and the Cliff phase in the Mimbres region of southwestern New Mexico including the Deming basin and range and the Uvas Valley; the Animas phase in southern Hidalgo County, New Mexico in the Animas Valley; and the Medio period in the Casas Grandes region of northwestern Chihuahua (Table 1.1). My data include previously collected and published obsidian sourcing results (Dolan 2012; Dolan and Livesay 2015; Dolan and Putsavage 2012, 2013; Kenmotsu et al. 2014; Putsavage 2015; Taliaferro 2004, 2014; Taliaferro et al. 2010; VanPool et al. 2013), as well as new results collected specifically for this dissertation. All of the artifacts collected specifically for this dissertation were sent to Shackley at the Geoarchaeological XRF Laboratory in Albuquerque, New Mexico for EDXRF analysis. Shackley sourced many of the other obsdiain artifacts investigated in this study (e.g., Kenmotsu et al. 2014; Taliaferro et al. 2010), but artifacts from some sites (e.g., Putsavage 2015; VanPool et al. 2013) the artifacts were sourced by the University of Missouri Research Reactor (MURR) using the same method.

Dissertation Organization

I organize this dissertation into seven topically specifically chapters that I briefly summarize below.

Chapter 2

Chapter 2 is a brief culture history of southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. This discussion is important to help understand why some people, as a result of their historical developments, may have used one obsidian source through time, while other groups used many. Many cultural developments occurred in this 450-year time span including changes in architecture, ceramic styles, demography, and religious movements. Because many transformations occurred, obsidian procurement may have changed as a result of the movement of people throughout the SW/NW.

Chapter 3

In Chapter 3, I present a review of the archaeology, geology, and geochemistry associated with the known obsidian sources in the SW/NW. I briefly discuss the formation and geochemistry of obsidian, as well as the XRF method. I also describe the primary and secondary sources people used in New Mexico, Chihuahua, Arizona, and Sonora. I do not discuss all individual sources in these states because people living in southwestern New Mexico and northwestern Chihuahua did not use all sources. Finally, in this chapter, I review pertinent obsidian sourcing studies that archaeologists have conducted in southern New Mexico and northwestern Chihuahua.

Chapter 4

Chapter 4 is the materials and methods portion of this dissertation. I discuss the research measures and expectations and describe the 26 archaeological sites investigated and the obsidian artifacts from each site. The sites were chosen because either archaeologists have previously soured obsidian artifacts from them, or I was able to access artifacts myself and then had Shackley source them. I discuss the sample collection process that include which sites and sourcing results derived from published materials and which were collected specifically for this study.

Chapter 5

The obsidian sourcing results at the macro- and mesoscale are discussed in Chapter 5. These data are presented in multiple tables listing the sourcing results, as well as figures showing where specific sites are located in the study region.

Chapter 6

The obsidian sourcing results at the microscale level are discussed in Chapter 6. Similar to the macro- and mesoscale data, I provide the microscale results in multiple tables. Because I investigate 26 archaeological sites in this study, I separated the results into two chapters so a more thorough discussion can be included in Chapter 6, exploring if people used the closest available source to them or if they used sometimes or always used obsidian from further away.

Chapter 7

Finally, in Chapter 7, I summarize and conclude my findings. I then briefly discuss the contributions and anthropological significance I make in this dissertation, and I end with comments on how to improve this study and recommendations for future work that should be considered regarding obsidian provenance studies in the SW/NW and elsewhere.

Chapter 2: Southwestern New Mexico and Northwestern Chihuahua, A.D. 1000 to 1450

In this chapter, I am concerned with events that occurred in the Mimbres Valley, the Deming basin and range, the Uvas Valley, and the Animas Valley of southwestern New Mexico, and the Casas Grandes Valley of northwestern Chihuahua from A.D. 1000 to 1450. I give a culture history account of how people in these areas lived and created their own unique traditions and practices, which may have influenced the source procurement of obsidian.

The eleventh through mid-fifteenth centuries A.D. represent the most dynamic 450 year time span in the history of the SW/NW. Many demographic and reorganizational shifts occurred throughout this time frame because of environmental instability, violence, and social and religious transformations (Adams and Duff 2004; Adler 1996; Hill et al. 2010; Lekson 2009). As a result, this is an excellent time to study which obsidian sources people used because as populations increased or decreased through time and space, people possibly changed the sources they used as interactions with other groups near and afar changed. People did not procure obsidian in a social vacuum, and if the use of one particular obsidian source changes through time, most likely this was a result of larger socio-economic issues related to changes in demography.

I first discuss the archaeology of southwestern New Mexico from A.D. 1000 to 1450. I include a discussion of what happened in the Mimbres Valley, the Deming basin and range, and the Uvas Valley including the significant cultural changes through time. I then discuss the archaeology of northwestern Chihuahua in the Casas Grandes region during the Medio period from A.D. 1200 to 1450. I discuss the significant cultural developments associated with the site of Paquimé and the larger Casas Grandes regional system. I also discuss the Animas Valley in this section because many archaeologists see architectural and ceramic similarities between Animas and Casas Grandes settlements.

Southwestern New Mexico, A.D. 1000 to 1450

In this section, I discuss what happened from the Mimbres Classic period through the Cliff phase (A.D. 1000-1450) in southwestern New Mexico (Table 2.1). The Mimbres Mogollon chronological sequence also contains Pithouse period components, but because I do not integrate sourcing data from sites before the eleventh century A.D., I do not describe what happened during the Early or Late Pithouse periods, except when necessary.

Table 2.1. Mimbres Mogollon Chronological Sequence.

Period	Phase	Date (A.D.)
Early Pithouse	Cumbre	200-550
Late Pithouse	Georgetown	550-650
	San Francisco	650-750
	Three Circle	750-1000
Mimbres Classic		1000-1130
Terminal/Postclassic/Reorganization	Black Mountain	1130/1150-1250/1300
	Cliff	1300-1450

Note: Dating is based on dendrochronology, radiocarbon, and ceramic cross-dating (Anyon et al. 1981; Hegmon 2002a; Hegmon et al. 1999; LeBlanc 1983; Lekson 2006; Shafer 2003; Shafer and Brewington 1995).

The culture history presented in this chapter derives largely from survey, excavation, and artifact and architectural analyses from archaeological sites in the Mimbres Valley of southwestern New Mexico (Figure 1.2). This is because archaeologists have focused primarily on this region and have partially neglected field work in the Deming basin and range, the Uvas Valley, and the Animas Valley. However, Deming and the Uvas Valley share the same time-space systematics with the Mimbres Valley (Anyon et al. 1981; Hegmon et al. 1999). The Animas Valley is located in extreme southwestern New Mexico in the “boot heel” of Hidalgo County, and this region has its own cultural sequence and is tied more closely to Casas Grandes (Carpenter 2002; DeAtley 1980; DeAtley and Findlow 1982; Douglas 1995; Kidder et al. 1949). I do not discuss what happened in the Animas Valley in this section, but I describe it later in this chapter within the cultural context of Casas Grandes.

I first briefly discuss the Mimbres Mogollon in southwestern New Mexico. I focus on the Mimbres branch of the Mogollon because that is the most pertinent to this obsidian sourcing study. I do not integrate any sourcing data from sites within the other Mogollon branches. I take a chronological approach and start with the Mimbres Classic period followed by a discussion on the Black Mountain phase and Cliff phase. These time periods/phases are represented by distinct material culture traits like pottery style, architecture, social organization, and settlement patterns that archaeologists can distinguish (Anyon et al. 1981; Hegmon 2002a; Hegmon et al. 1999; LeBlanc 1983; Putsavage 2015; Taliaferro 2014; Shafer 2003; Shafer and Brewington 1995).

The Mimbres Mogollon

After excavating Mogollon village and Harris village, Haury (1936a) defined the Mogollon as a separate cultural tradition from the Anasazi (now called the Ancestral Pueblo) who lived in the northern North American Southwest and the Hohokam in southern Arizona (Figure 1.1). Haury (1936a, 1936b) demonstrated the differences in the timing and structure of Mogollon society through the use of pithouse and pueblo architecture, dating methods, and artifact analyses, especially painted and textured designs on pottery. Mogollon pottery was a brown ware compared to the gray ware of the Ancestral Pueblo and buff ware of the Hohokam.

After Haury's work, archaeologists identified seven cultural branches in the Mogollon culture area based on differences in cultural and environmental adaptations in parts of New Mexico, eastern Arizona, west Texas, and northern Mexico (Haury 1936a, 1985; Lehmer 1948; Martin 1943, 1979; Wheat 1955; also see Diehl 2007). The seven branches include Mimbres, Jornada, Cibola, San Simon, Black River, Forestdale, and Eastern Periphery (Figure 2.1). The Mimbres is the most well-known and studied Mogollon branch largely due to the remarkable black-on-white made during the Mimbres Classic period from A.D. 1000 to 1130 (Brody 2004; Brody et al. 1983; LeBlanc 1983).

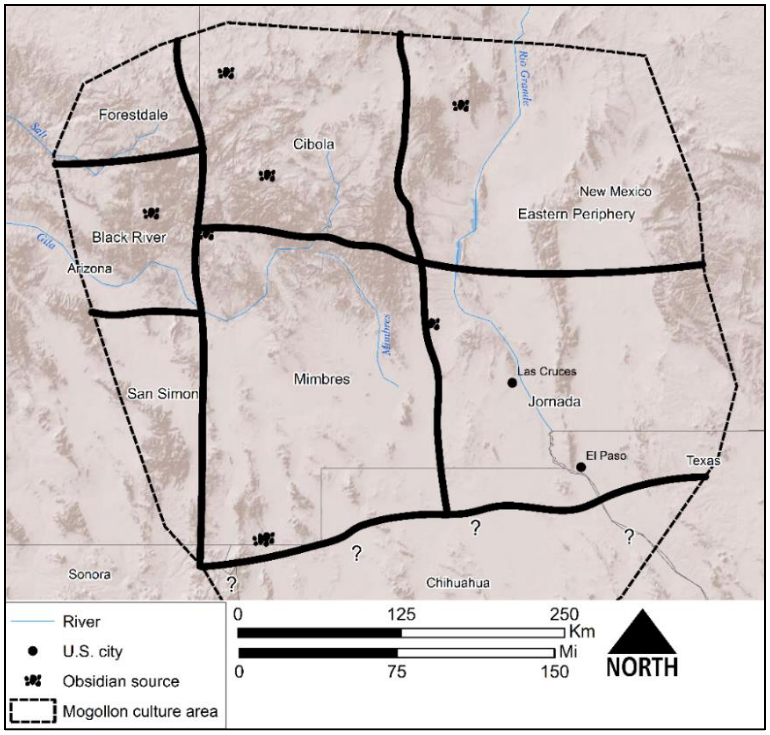

Figure 2.1. Location of Mogollon branches.
Note: Based on Martin (1979:Figure 1; see also Wilcox and Gregory 2007:Figure 1.2).

The Mimbres Classic Period

Archaeologists define the Mimbres Classic period (A.D. 1000-1130) by the transition from subterranean pithouse structures to surface masonry pueblos, along with the manufacture of fine-line Mimbres Classic Black-on-white with geometric and naturalistic images, increased population aggregation, and an intensification of maize agriculture (Anyon and LeBlanc 1984; Anyon et al. 1981; Gilman 1987; Hegmon 2002; Lekson 2006; Minnis 1985; Shafer 2003). These material culture features, especially the pottery, are predominantly found in the Mimbres Valley, which is why archaeologists call it the Mimbres heartland or Mimbres core. This is not to say that these Mimbres Classic period features do not appear elsewhere in the SW/NW, because Mimbres painted pottery is present in the Jornada Mogollon region, as well as in southeastern

Arizona, and northern Chihuahua (Creel 2014; Di Peso 1974; Di Peso et al. 1974; Gilman 2011; Kelley and Searcy 2015; Lekson 2009; Nelson 1999).

The two cultural manifestations of the Mimbres Classic period visible in the archaeological record and that differentiate this period from the earlier Late Pithouse period and Three Circle phase (A.D. 750-1000) (Table 2.1) is the stone masonry pueblo architecture and a specific type of painted pottery. People lived in semisubterannean pithouses in southwestern New Mexico in the Early and Late Pithouse periods (Anyon et al. 1981; Gilman 1987, 2010; Hegmon 2002a; LeBlanc 1983; LeBlanc and Diehl 2001; Lekson 2006), but starting around the eleventh century A.D., there was a conscious decision to start living in aboveground pueblos made of locally available river cobbles (Anyon and LeBlanc 1984; Anyon et al. 1981; Gilman 1980, 1987; LeBlanc 1983).

Shafer (1995:23) suggests the change from living below the ground in pithouses to living above the ground in pueblos "may be linked to symbolic expressions of the multi-layered universe and passage to the Otherworld" based on the adoption of ceiling hatchways, slab-lined hearths, and sub-floor burials with ceramic vessels that were "killed" over the deceased individual's face. Anyon et al. (1981:219) proposed the pithouse-to-pueblo transition was a "major organizational change within the local population, presumably as a result of local pressures." This pressure was likely a result of the increase in population starting around A.D. 1000 (Blake et al. 1986), in the Mimbres Valley. Duff (1998:Figure 2.4) suggests the Mimbres Valley was one of the more densely populated regions in the SW/NW in the eleventh century A.D.

Archaeologists have differing views on population size during the Mimbres Classic period. The lowest estimates suggest 600 people lived in the Mimbres Valley, whereas the largest estimates include 5,000 people (Blake et al. 1986; Gilman 1989; Lekson 2006; Minnis 1985). No matter how many people lived in this region from A.D. 1000 to 1130, there were 10 to 12 large pueblos like Galaz, Swarts, Mattocks, and Old Town with as many as 100 surface rooms on the upper, middle, and lower Mimbres River (Anyon and LeBlanc 1984; Creel 2006a; Gilman 2006; Gilman and LeBlanc 2015; LeBlanc 1983; Shafer 2003).

Transformations in the use and construction of ritual structures in the Mimbres Valley also changed dramatically around A.D. 1000 (Anyon and LeBlanc 1980; Creel and Anyon 2003, 2010; Gilman and Stone 2013; Gilman et al. 2014). During the Late Pithouse period, people constructed and performed communal rituals in Great Kivas. Great Kivas are large semisubterranean structures similar to pithouses, but unlike habitation pithouses, Great Kivas have a much larger surface floor area of up to 175 meters^2, and often have floor features not commonly found in pithouses (Anyon and LeBlanc 1984; Creel and Anyon 2003). People in the Mimbres Valley ritually burned Great Kivas and built new ones (Creel and Anyon 2003, 2010), but in the early to middle A.D. 900s, "people very intensely burned a number of the extant Great Kivas in the Mimbres region" (Creel and Anyon 2003:69, 78-79). After these events, Great Kivas were no longer built, and Gilman et al. (2014:94) write, "Not replacing the Great Kivas suggests a major change in the structure of religious spaces." People in the A.D. 1000s most likely used open spaces in the form of plazas to hold communal ceremonies and activities.

Archaeologists and art historians have intensively studied the black-on-white painted pottery that was manufactured during the Mimbres Classic period (Brody 2004; Brody et al. 1983; Gruber 2007, 2015; Moulard 1984; LeBlanc 2004, 2006; Munson 2000, 2006). Many of the bowls depict naturalistic images with animals like scarlet macaws, turtles, bears, fish and rabbits; men, women, and children doing things; and anthropomorphic creatures. Researchers have argued that some of the animals depicted on pottery, like scarlet macaws and fish derive from distances far to the south and west, including Mesoamerica and the Gulf of California (Gilman et al. 2014; Jett and Moyle 1986; Moulard 1984), and that some of the scenes depicting animals, people, and anthropomorphs represent oral traditions and stories from Mesoamerica (Gilman et al. 2014).

Objects, ideas, and living things that derive from far away are present in the Mimbres Valley during the Mimbres Classic period. Scarlet macaws, military macaws, and thick-billed parrot remains have been found, and their images are depicted on ceramic vessels (Gilman et al. 2014; Hargrave 1970; Vokes and Gregory 2007; Wyckoff 2009). Other objects like many species of marine shell from the Gulf of California (Anyon et al. 1984; Vokes and Gregory 2007); copper bells inferred to have come from West Mexico (Vargas 1995; Vokes and Gregory 2007), and cacao from Mesoamerica (Crown et al. 2015) also occur at some Mimbres Classic period sites. There is also evidence for gene flow between Mimbres and Mesoamerican populations (Snow et al. 2011; Turner 1999), and possible Hohokam individuals cremated at Late Pithouse and Mimbres Classic period sites (Anyon and LeBlanc 1984; Creel 1989, 2014; Shafer 2003).

Despite the presence of exotic and non-local objects, raw materials, ideas, and living things in the Mimbres Valley during the Mimbres Classic period, archaeologists suggest economic and social networks were largely insular (Hegmon 2002a; Minnis 1985). According to Creel and Anyon (2010), the beginning of an insular and inward-focused Mimbres society started with the burning of existing Great Kivas and cessation of additional Great Kiva construction. Another reason why Mimbres archaeologists believe people in this region were insular is due to pottery manufacture and obsidian tool procurement. Mimbres painted and non-painted pottery wares were made at the household level at many sites (Creel and Speakman 2012; Gilman et al. 1994; James et al. 1995; Speakman 2013), and very few, if any, sherds of non-local painted wares from the Hohokam or Chaco Canyon region occur at Mimbres Classic period sites in dateable contexts (Lekson 2009).

Regarding obsidian, there are no artifacts made of extremely non-local obsidian sources, for example, from elsewhere in the western United States or sources that the Maya or Aztecs used, found at sites in the Mimbres Valley. Obsidian sourcing data from many of the Mimbres sites that have exotic and non-local objects and raw materials listed above are included in this dissertation study. Despite this, however, currently there is no published geochemical sourcing data that demonstrate obsidian from non-SW/NW sources is present at Mimbres Classic period sites. In fact, Taliaferro et al. (2010) show that obsidian procurement in the Mimbres Valley is homogenous, and almost all obsidian artifacts are made of the Antelope Creek subsource of Mule Creek.

The material culture patterns archaeologists define as quintessential Mimbres Classic in southwestern New Mexico were no longer used or made after A.D. 1130. As a result, the Mimbres Classic period ends in the Mimbres Valley, the Deming basin and range, and the Uvas region slightly before the mid-twelfth century A.D. (Anyon et al. 1981; Hegmon 2002; Hegmon et al. 1999). People stopped making the intricate fine-line Mimbres Classic painted pottery and cobblestone masonry pueblos in southwestern New Mexico, although some Mimbres traditions like black-on-white painted pottery and cobblestone masonry continued east near the Rio Grande (Hegmon et al. 1999; Nelson 1999).

The events that happened in the approximately five generations (A.D. 1000-1130) of the Mimbres Classic period likely reverberated throughout the SW/NW long afterwards (Lekson 1999, 2009, 2015). The early twelfth century is about the same time that Chaco Canyon loses influence and changes in Hohokam society (Lekson 2009). This time period is marked in the Mimbres Valley by environmental instability and social stress as many years of drought caused hardships for Mimbres farmers (Minnis 1985). A likely combination of social and environmental reasons caused large population dispersal out of the Mimbres Valley at about A.D. 1130. People in the Mimbres Valley and Deming regions did not fully abandon the area nor did a full collapse of Mimbres society occur. Excavation, survey, ceramic analyses, architectural, and dating demonstrate people continued to live in the Mimbres Valley and in Deming (Creel 1999; Hegmon 2002; Hegmon et al. 1998, 1999; Nelson 1999, 2010; Nelson and Hegmon 2001; Nelson and Schachner 2002; Nelson et al. 2006, 2012; Putsavage 2015; Taliaferro 2014).

The Black Mountain Phase

The Black Mountain phase (A.D. 1130-1300) is the Mimbres Valley and Deming basin and range expression of the early Medio period (A.D. 1200-1450) in Chihuahua and the early part of the Animas phase (A.D. 1200-1450) in the New Mexico boot heel (DeAtley 1980; LeBlanc 1980:280; Lekson 2006:8, 2009, 2015; Putsavage 2015; Taliaferro 2014). It is critical to understand how people lived after the Mimbres Classic period and before and during the Medio period fluorescence in northwestern Chihuahua. Unfortunately, few Black Mountain phase sites have been excavated or studied (Putsavage 2015; Ravesloot 1979; Taliaferro 2014:Appendix A). Relatively little research has been completed on Black Mountain phase occupations, but archaeologists do know a major demographic shift occurred in southwestern New Mexico during the Mimbres Classic period to Black Mountain phase transition. Despite the decrease in population size, pottery and architectural evidence suggests new groups of people moved into the region bringing their material cultural practices and traditions with them.

People built pueblos using large river cobbles during the Mimbres Classic period, but starting in the Black Mountain phase in southwestern New Mexico, people constructed pueblos from puddled adobe. Mimbres Classic period Black-on-white pottery was no longer manufactured in this region after A.D. 1130. New pottery types like Chupadero Black-on-white, Playas Red Incised, El Paso Polychrome, Salado Polychrome (Roosevelt Red Wares), and Chihuahuan polychromes appear at Black Mountain phase sites in the Mimbres Valley and Deming basin and range (Creel 1999;

Blake et al. 1986; Hegmon 2002a; Hegmon et al. 1999; LeBlanc 1980a, 1989; Shafer 1999; Putsavage 2015; Taliaferro 2014).

Recent research by Taliaferro (2014) and Putsavage (2015) has increased our knowledge of how the Black Mountain phase fits in the broader picture of SW/NW history. They used new radiocarbon and tree-ring dates, architecture, and geochemical sourcing analysis of ceramics and obsidian to see if there is continuity or discontinuity in certain material cultural practices from the earlier Mimbres Classic period. Taliaferro (2014) studied the Black Mountain phase occupation at Old Town, which is located on the lower Mimbres River (see also Creel 2006a), and Putsavage (2015) excavated at the Black Mountain site (LA 49) close to Deming. Sourced obsidian artifacts from these sites are used in this dissertation study.

Black Mountain is the type site for the Black Mountain phase and is the largest known site in the Mimbres region after A.D. 1130 with an estimated 200 rooms (Putsavage 2015). Black Mountain phase occupations at this site, along with those at Old Town (Creel 2006a; Taliaferro 2014), NAN Ranch (Shafer 2003), Galaz (Anyon and LeBlanc 1984), and Montoya and Walsh (Ravesloot 1979) demonstrate that the region was not abandoned after the Mimbres Classic period. However, due to the increase in new pottery types and different pueblo construction techniques, archaeologists suggest a population replacement and an immigration of new people in to the Mimbres region sometime after A.D. 1130 (Anyon et al. 1981; Shafer 1999, 2003).

Although there are many cultural differences between the Mimbres Classic period and the Black Mountain phase (see above), archaeologists also suggest there are some continuities between the two periods (Creel 1999; LeBlanc 1977; Putsavage 2015;

Taliaferro 2014). For example, the mortuary practice of placing a "killed" Mimbres Classic Black-on-white bowl over the head of a deceased individual is common during the Mimbres Classic period. Evidence shows the continuation of this tradition into the Black Mountain phase but using other pottery types (Creel 1999:110; LeBlanc 1977:16).

Because so few Black Mountain phase sites have been excavated or thoroughly studied, information on chipped stone raw material procurement and lithic technology is scant (Creel 1999:114). With research by Taliaferro (2014) and Putsavage (2015) that integrates obsidian sourcing from Black Mountain phase sites, however, more data are available to compare and contrast the similarities and differences in obsidian procurement between the Mimbres Classic period and the Black Mountain phase.

The Cliff Phase

The transition from the Black Mountain phase to the Cliff phase around A.D. 1300 is not as dramatic as the previous Mimbres Classic period to Black Mountain phase transition, but changes in pottery and social interaction with other groups increases. The Cliff phase (A.D. 1300-1450) is southwestern New Mexico's equivalent of the Salado phenomenon farther west (LeBlanc 1980a; Lekson 2000, 2002, 2006, 2009; Nelson and LeBlanc 1986). Salado is not a time period but is instead a ceramic horizon that connected migrant groups of local and non-local origin in southern Arizona and southwestern New Mexico under a unified ideology that included religiously charged iconography like horned serpents on polychrome wares like Gila, Tonto, and Pinto Polychrome (Crown 1994; Dean 2000; Haury 1976; Lekson 2000, 2002; Lyons and Clark 2012; Lyons and Lindsay 2006; Nelson and LeBlanc 1986; VanPool et al. 2006).

Two major migrations occurred in the northern North American Southwest during the mid to late thirteenth and early fourteenth centuries. The first involved people who left the Mesa Verde region in southwestern Colorado and moved into the northern Rio Grande of New Mexico (Cordell 1995; Kohler et al. 2010; Lipe 1995; Ortman 2012; Stone and Lipe 2011; Wendorf and Reed 1955). This movement did not have a direct impact on the populations in southwestern New Mexico or northwestern Chihuahua, however. The other large migration was that of people from the Kayenta region of northeastern Arizona into southern Arizona in the Hohokam region (Clark 2001; Gladwin and Gladwin 1935; Haury 1958; Lincoln 2000; Stark et al. 1998; Stone 2015; Stone and Lipe 2011). This migration did impact southwestern New Mexico and northwestern Chihuahua in the A.D. 1300s, because research indicates the movement of Kayenta people is closely linked to the spread of Salado Polychromes (Maverick Mountain Polychrome and Roosevelt Red Wares) across the southern North American Southwest including Casas Grandes (Crown 1994; Dean 2000; Lekson 2002, 2009).

With the movement of people throughout southwestern New Mexico during the Cliff phase, do archaeologists see changes in obsidian procurement? Mills et al.'s (2013) social network analysis of ceramic wares and obsidian sourcing data from sites west of the Continental Divide in parts of Arizona and New Mexico suggest a dramatic change there in obsidian procurement after A.D. 1300. Before A.D. 1300 obsidian procurement from sources from far away was rare at sites. When nonlocal sources were present, however, the artifact was usually a finished tool and not debitage. After A.D.

1300, debitage from sources further away increased tenfold. Their research shows that, in sites in which Mule Creek and Cow Canyon obsidian were overrepresented, Salado polychromes dominated ceramic assemblages. However, Mills et al. (2013) did not study obsidian procurement in the five regions that I examine in this dissertation. Therefore, I present new temporal and regional obsidian procurement information that expands on Mills et al.'s (2013) analysis, although I do not integrate social network analysis.

There is evidence to support some social interaction and exchange between people in the Casas Grandes region and the Salado phenomenon because Gila Polychrome ceramics are present at Paquimé (Di Peso et al. 1974:6; Lekson 2000, 2002; Nelson and LeBlanc 1986; Rakita and Raymond 2003). Therefore, if there is a connection between Salado ceramics, Mule Creek and Cow Canyon obsidian, and Casas Grandes – does that mean artifacts made of Mule Creek and Cow Canyon obsidian are present at Medio period sites in Chihuahua?

Northwestern Chihuahua, A.D. 1200-1450

In this section, I discuss what happened during the Medio period (A.D. 1200-1450) in northwestern Chihuahua (Table 2.2). The Medio period ends around A.D. 1450, but few archaeological sites date to this time period. The end of Paquimé is one of the more pressing research issues in SW/NW archaeology (Lekson 2015; Minnis and Whalen 2015:15; Phillips and Gamboa 2015). As shown in Table 2.2, the Casas Grandes chronological sequence also contains occupations before and after the Medio period (the Viejo and Tardio). Few Viejo period sites and even fewer Tardio period sites have been excavated in northwestern Chihuahua because the archaeological visibility of these occupations is low due to the high presence of Medio period pueblos (but see Di Peso 1974:1, 3; Kelley and Searcy 2015; Pitezel and Searcy 2013; Stewart et al. 2005).

Table 2.2 Casas Grandes Chronology.

Period	Phase	Di Peso	Dean and Ravesloot
Viejo	Convento	700-900	600-1200
	Pilon	900-950	
	Perros Bravos	950-1060	
Medio	Buena Fé	1060-1205	1200-1450
	Paquimé	1205-1261	
	Diablo	1261-1340	
Tardio	Robles	1340-1519	1450-1550

Note: All dates are A.D. Dating is based on dendrochronology, radiocarbon, and ceramic cross-dating (Dean and Ravesloot 1993; Di Peso et al. 1974:4; Lekson 2002; Whalen and Minnis 2009a:41-70, 2012).

The culture history description of the Casas Grandes region is important because I present the first thorough study of obsidian procurement during the Medio period using EDXRF analysis. The research presented in this chapter derives largely from survey, excavation, and artifact and architectural analysis from the center of the Casas Grandes world at Paquimé and other neighboring Medio period sites in the Casas Grandes region (Di Peso 1974; Di Peso et al. 1974; Whalen and Minnis 2001a, 2009a). I also describe the connections between Casas Grandes and the Animas phase in this section because occupations in the Animas Valley of the New Mexico boot heel have more in common with Casas Grandes than with Black Mountain or Cliff phase settlements in southwestern New Mexico.

The Medio period fluorescence is described as resulting from either external or internal cultural stimuli (Di Peso 1968, 1974; Di Peso et al. 1974; Lekson 1999, 2009, 2015; Whalen and Minnis 2001a, 2003, 2009a). Therefore, whether people from further south in Mexico or a more local population founded Paquimé could have influenced obsidian procurement. If the Casas Grandes regional system was more local, then perhaps people obtained obsidian locally as well, whereas if people from outside the area built Paquimé as Di Peso (1968, 1974; Di Peso et al. 1974) proposed, then perhaps artifacts made from obsidian sources elsewhere in Mesoamerica might be present.

After a discussion of local or non-local development for the Casas Grandes regional system, I describe the relationship between Animas phase settlements in the boot heel of New Mexico with Casas Grandes. I do this because there are varying opinions on the scope and scale of interconnectedness or lack of regarding people at sites like Pendleton, Joyce Well, Box Canyon, and Clanton Draw in the boot heel and with Paquimé. I use obsidian sourcing data from Animas phase sites in the boot heel to compare and contrast the obsidian procurement between the two regions.

For clarification, because archaeologists use Paquimé and Casas Grandes interchangeably (Minnis and Whalen 2015a:16), in this dissertation, when I use Paquimé I refer to the site, but when I use Casas Grandes, I refer to the general region of northwestern Chihuahua and the regional system during the Medio period.

Medio Period Paquimé and the Casas Grandes Regional System

Di Peso dated the Medio period to A.D. 1060 to 1340, but revisions by Dean and Ravesloot (1993) now put the Medio period from about A.D. 1200 to 1450 (see also Whalen and Minnis 2009a:41-70, 2012) (Table 3.2). The site most associated with the Medio period is Paquimé in northwestern Chihuahua, approximately 200 linear kilometers south of Deming. Paquimé was excavated from 1958-1961, and after field work and over a decade of artifact analysis and writing, Di Peso (1974) and colleagues

(Di Peso et al. 1974) published *Casas Grandes: A Fallen Trading Center of the Gran Chichimeca*.

In his eight-volume Paquimé site report, Di Peso (1974; Di Peso et al. 1974) demonstrated Paquimé was the largest political, social, economic, and ceremonial center in northern Mexico and possibly in the North American Southwest at its height during the Medio period. Paquimé has an estimated 2,000 rooms and the architects of this large complex needed to build adobe walls a meter-thick to withstand the weight of the multi-story room blocks. Paquimé still stands and is recognized as a UNESCO World Heritage Site. Other important features at the site include a water distribution system, many public ritual structures including I- and T-shaped ball courts, platform effigy mounds, and large feasting ovens throughout the Casas Grandes region (Di Peso 1974; Di Peso et al. 1974; Minnis and Whalen 2015b; Whalen and Minnis 1996, 2001a, 2001b, 2003, 2009a). In the few centuries that Paquimé existed, this site and the associated Casas Grandes regional system had an influence of over 750,000 m^2 and population estimates suggest several thousand people lived close to and around the Río Casas Grandes (Rakita 2009; Whalen and Minnis 2001a, 2009a). However, Cordell (2015:199) argued that Paquimé is not so unique when viewed in context with the rest of the SW/NW, pueblos along the central and southern Rio Grande during the fifteenth and sixteenth centuries were much bigger (see also Duwe et al. 2016).

Internal or External Start for Paquimé

One of the long-standing research questions concerning Paquimé and the Casas Grandes regional system is how it started. Di Peso (1968, 1974; Di Peso et al. 1974) was adamant that a traveling merchant class of *pochteca* from an unnamed

Mesoamerican state founded Paquimé to obtain exotic goods like turquoise and other raw materials for Mesoamerican elites and to collect tribute as agents of Mesoamerican expansion. He thought this because excavations revealed material culture like architecture, scarlet macaws, and copper bells derived from West Mexico and further south in Mesoamerica. Therefore, in Di Peso's view, people from outside the SW/NW built Paquimé and started the Casas Grandes regional system, rather than people already living in the SW/NW. Di Peso was influenced by Wallerstein's (1974) economic world systems theory because he thought *pochteca* built Paquimé as a northern trading outpost for Mesoamerica to increase the power, wealth, control, and circulation of goods and services like exotic minerals like turquoise. There is no doubt Paquimé had powerful leaders as elite individuals and families likely controlled the distribution of goods, services, and ceremonial activities (Lekson 2005; Rakita 2009; Ravesloot 1988; Whalen and Minnis 2000). But did the elites controlling Paquimé originally come from Mesoamerica or elsewhere (Lekson 1999, 2015)?

Excavations at Paquimé revealed numerous objects and raw materials that are not local in the SW/NW but are associated with Mesoamerica. These include hundreds of scarlet macaws, copper artifacts, multiple species of shell, horned serpent iconography, colonnades, and ball courts. Other non-local raw materials and pottery types included serpentine from the Redrock region of west-central New Mexico and pottery from southern New Mexico and west Texas (Di Peso 1974; Di Peso et al. 1974; Lekson 2000, 2009). Obsidian chipped stone debitage and projectile points were found at Paquimé, but obsidian artifacts commonly found at Mesoamerican sites like prismatic blades or anthropomorphic eccentrics (Hirth 2003, 2006) were not present.

No geochemical sourcing analyses were performed on obsidian recovered from Paquimé, but based on visually sourcing the artifacts, Di Peso et al. (1974:8:189) believed some obsidian came into the site from sources in Jalisco and Durango (see also Darling 1998 in Chapter 3). In fact, few geochemical and trace-element compositional analyses have been performed on any artifact type from Paquimé or other Medio period sites (Minnis and Whalen 2015:15). This is despite the fact that these analyses could refute or corroborate many of the arguments made by Di Peso about the internal or external founding of the site.

Di Peso (1974; Di Peso et al. 1974) presents his argument for an external stimulus for the rise of Paquimé, but recent excavation, survey, and settlement pattern analysis refute most of his claims. Whalen, Minnis, and their colleagues argue that Paquimé began internally in the Casas Grandes Valley during the Viejo period (Table 2.1) and not as a "trading center of the Gran Chichimeca" from an unnamed Mesoamerican state from the south (Douglas and MacWilliams 2015; Minnis 1984, 1988, 1989; Whalen and Minnis 1996, 1999, 2000, 2001a, 2001b, 2003, 2004, 2009, 2012; Whalen and Pitezel 2015; Whalen et al. 2010). Whalen and Minnis (2001a, 2009a) acknowledge, however, that the archaeological visibility of Viejo period pithouse occupation is low in northwestern Chihuahua. They argue that pithouses are located underneath Medio period pueblos.

To help illustrate differences through time and space, archaeologists have adopted the concept of regional system instead of using the static culture area. It is important to briefly discuss what a regional system is and how SW/NW archaeologists have used it throughout the years. A regional system approach "expects that diversity will exist among societal members as a result of their differential participation in the society's various components" (Neitzel 2000:26). Wilcox (1979, 1980) first applied the regional system approach to the Hohokam, but archaeologists in the past few decades have used it for Chaco Canyon and Casas Grandes. Archaeologists needed a way to describe the cultural homogeneity they saw in the archaeological record other than using the static culture area approach. Culture areas imply culturally homogenous groups in one particular geographic location, but in this dissertation, I emphasize that "cultural heterogeneity is the rule rather than the exception" (Pauketat 2001b:5).

The Core Zone, Middle Zone, and Outer Zone in Casas Grandes

By examining regional differences in pottery distribution and ceremonial and public architecture, archaeologists have applied the use of a regional system to Casas Grandes (Kelley and Villalpando 1996; McGuire 1993; Whalen and Minnis 2001b). A regional system approach is helpful because archaeologists are able to examine the extent and scale of the distance that certain artifact types and features are moved in a given geographic region. One way to start a discussion of the Casas Grandes regional system is to examine the role of individual leaders or elite families at Paquimé. Did important people have control over others and natural and cultural resources throughout parts of the Casas Grandes regional system in northwestern Chihuahua? Similarly, did the regional system extend beyond Chihuahua and into parts of present-day Sonora, Arizona, and New Mexico?

Elites at Paquimé did have control over others throughout parts of the Casas Grandes regional system, but research indicates that the control did not include the same square mileage first proposed by Di Peso (1974; Di Peso et al. 1974; Minnis 1984;

Whalen and Minnis 1999, 2001a, 2001b, 2003). Paquimé is most definitely an anomaly similar to Pueblo Bonito at Chaco Canyon. If Chacoan archaeologists only studied Great Houses and not how other people lived in the region, archaeological research within Chaco Canyon would only know about large sites with extravagant architecture and exotic objects. Di Peso (1974; Di Peso et al. 1974) focused primarily on Paquimé, but he understood there were many hundreds or thousands of Medio period settlements throughout northwestern Chihuahua (Brand 1933, 1943; Sayles 1936; Lister 1946; Lumholtz 1902). For many decades after the excavation of Paquimé, archaeologists did not know how other people lived close to and further away from Paquimé because no other Medio period sites were intensively excavated until 1989 when Whalen and Minnis began a survey and excavation project to examine the Casas Grandes regional system.

Through excavation, survey, and analysis of settlement patterns and the presence and absence of certain artifact types, architecture, and other features, Whalen and Minnis (1999, 2001a, 2001b, 2003, 2009a; Whalen and Pitezel 2015) concluded there were varying levels of interaction and control throughout much of northwestern Chihuahua during the Medio period (Figure 2.2). Elites had less control over others as the distance from Paquimé increased, and Minnis (1984; Whalen and Minnis 2001a:82) argued that the regional system did not extend much beyond 130 linear kilometers north of Paquimé. This estimation is the equivalent of the Chaco and Hohokam regional systems (Crown and Judge 1991), and so Paquimé is more on the scale of other SW/NW societies than what Di Peso (1974; Di Peso et al. 1974) suggested.

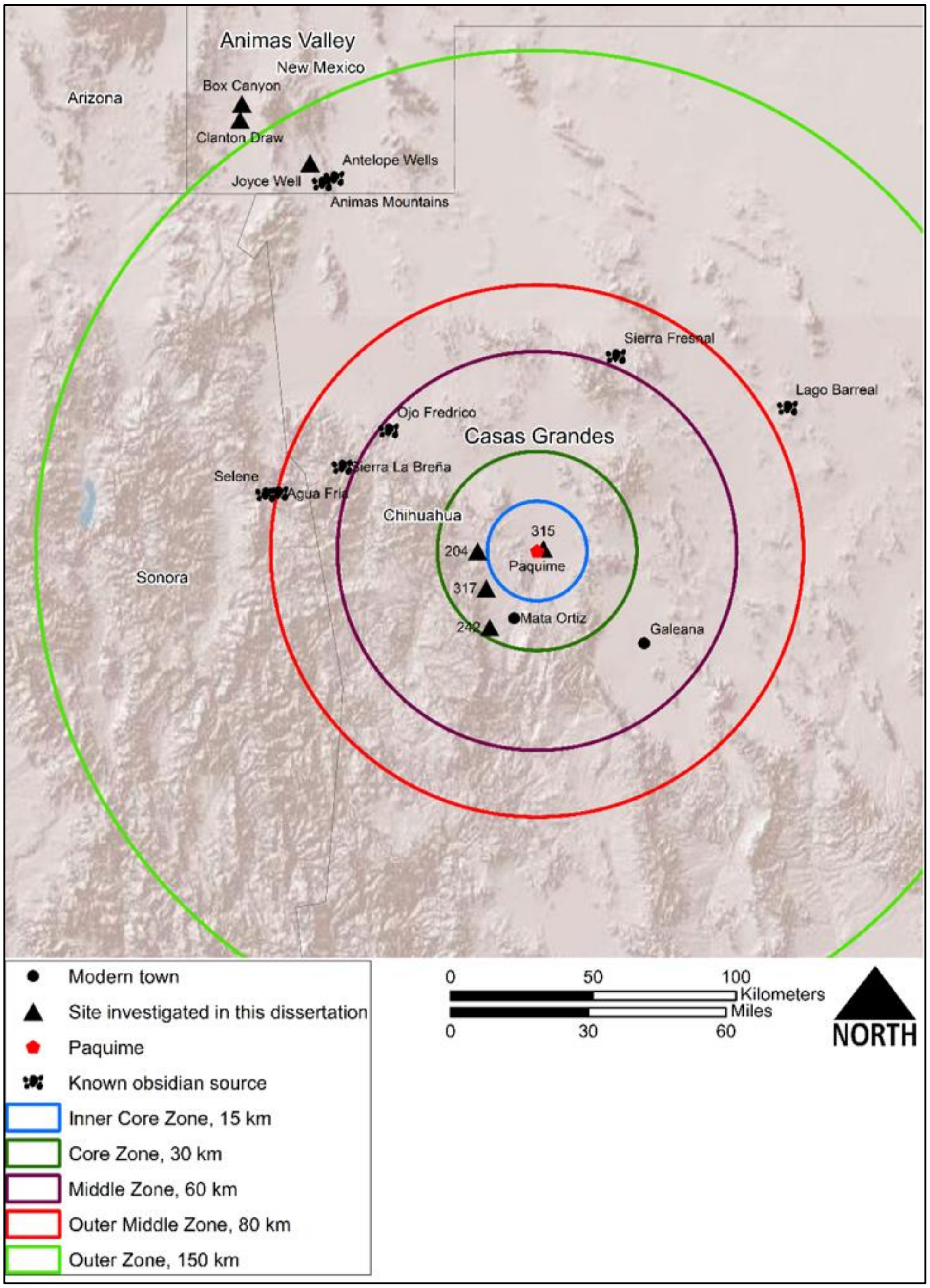

Figure 2.2. The Core Zone, Middle Zone, and Outer Zone in the Casas Grandes region.

Elites had less control as the distance from Paquimé increased, and Paquimé exerted the strongest control over neighboring sites in the Core Zone, an area within a

30 kilometer radius (Figure 2.2). More precisely, sites within 10 to 15 kilometers of Paquimé are referred to as the Inner Core Zone (Whalen and Pitezel 2015). Sites in this zone have a close link to Paquimé with the existence of similar architectural features, the presence of exotic objects, and the production of certain goods like Type 1A metates (Rakita and Cruz 2015; VanPool and Leonard 2002; Whalen and Minnis, 2009a; Whalen and Pitezel, 2015). The Outer Core Zone is 15 to 30 kilometers away from Paquimé. The Middle Zone is within 60 to 80 kilometers and sites have similar architectural features and ceramics as the Core Zone but other features are rare or absent (Whalen and Minnis, 2009a). This suggests that although elites monopolized the political, economic, and ceremonial functions there are higher levels of autonomy beyond this distance that posits a lack of centralized control (see Bayman and Shackley (1999) for similar arguments for the Classic Hohokam). Finally, the Outer Zone lies near the international border. Archaeologists have noted ceramic, architectural, and other features linking Casas Grandes with contemporaneous Animas phase sites like Joyce Well in the New Mexico boot heel of this Outer Zone (Fish and Fish, 1999; Lekson et al., 2004; Skibo et al., 2002).

Figure 2.2 illustrates the location of Paquimé at the center, along with four Medio period sites Whalen and Minnis excavated (2001a, 2001b, 2009a, 2009b) and the known obsidian sources nearby. I use obsidian sourcing data from sites 204, 242, 315, and 317 in this dissertation to examine the nature of obsidian procurement in northwestern Chihuahua. As Figure 2.2 shows, sites 204, 242, and 317 are slightly within the Core Zone, and site 315 is within the Inner Core Zone at just two kilometers from Paquimé. The known obsidian sources, however, are all outside of the Core Zone and many like Sierra Fresnal are in the Outer Middle Zone. The Antelope Wells obsidian source is within the Outer Zone. Although no large sourcing study has been conducted on obsidian from Paquimé. Based on the sourcing data from these four Medio period sites that I discuss in Chapter 4, I examine whether people at Paquimé controlled the distribution and circulation of obsidian during this time period.

Animas and Casas Grandes

Archaeologists refer to Animas as both a place and an archaeological phase. The Animas Valley is located in the extreme southwestern part of New Mexico in the boot heel of Hidalgo County. Kidder et al. (1949) defined the Animas phase (A.D. 1200-1450) after excavating Pendleton ruin. Subsequent excavation, survey, and artifact analyses at other Animas phase sites in New Mexico and southeastern Arizona ensued (DeAtley 1980; DeAtley and Findlow 1982; Douglas 1995, 1996, 2007; Findlow and DeAtley 1974; McCluney 1965a, 1965b; Skibo et al. 2002). Compared to the Mimbres Valley in southwestern New Mexico, however, the Animas region has seen little investigation and excavation. As a result, chronology and settlement patterns are difficult to assess (LeBlanc 1980a). From these few investigations, archaeologists debate the scope and scale of social interaction between Animas phase settlements in the boot heel and the larger Casas Grandes regional system to the southeast in northwestern Chihuahua.

In the thirteenth through mid-fifteenth centuries A.D., the Animas region is sometimes described as a cultural hinterland to the larger and more populated Casas Grandes region (Carpenter 2002, Douglas 1995, 2007; Walker and Skibo 2002; Walker et al. 2002) (see Figure 2.2). According to Di Peso (1974:2:331-332, 1974:3:778), Animas phase sites like Joyce Well were satellite communities to Paquimé that were established to provide resources including obsidian raw materials for craft production (see also Fish and Fish 1999:38). Antelope Wells is the closest available obsidian source to Joyce Well at four kilometers away, and people at Joyce Well may have played an important part in the circulation of Antelope Wells obsidian to Paquimé and the rest of the Casas Grandes regional system. Because of this possible connection, I sourced obsidian artifacts from Joyce Well and two other Animas phase sites nearby for this dissertation (Chapters 4 and 5).

There are similarities between Animas phase sites and Medio period sites (Table 2.3). Some Chihuahuan ceramics were imported from Casas Grandes to sites in the New Mexico boot heel, but ceramics with Casas Grandes iconography were also locally made in the boot heel (Carpenter 2002; McCluney 2002:39; Woosley and Olinger 1993). The Animas phase site of Joyce Well has many architectural features that link it to the Casas Grandes regional system (Fish and Fish 1999; McCluney 1965b; Skibo et. 2002). People in the boot heel constructed large, coursed-adobe pueblos and compounds and lived in room blocks that were built around plazas. Joyce Well also has T-shaped doors, raised and scalloped hearths, and collared postholes that are reminiscent of Paquimé (Fish and Fish 1999:38; Skibo et al. 2002). A key architectural feature connecting Animas phase sites like Joyce Well to the Casas Grandes regional system is the presence of ball courts (Fish and Fish 1999; Lekson 2000:292; Skibo and Walker 2002).

Table 2.3. Select Characteristics of Paquimé and Animas Phase Sites.

	Paquimé	Animas Phase Sites
Number of Rooms	2,300 rooms	Up to 400 rooms
Construction	Massive puddled adobe, multistoried	Thin adobe lower walls, single storied
Doorway Type	T-shaped doors common	T-shaped doors rare
Mortuary Treatment	Plaza and subfloor burials with goods highly variable but sometimes rich	Subfloor and extramural burials rare with limited grave goods
Metates	Closed trough	Shallow scooped or open trough
Hearths	Raised platform hearths frequent	Floor-level round fire pits but raised hearths at Joyce Well
Utility Pottery	Casas Grandes Plain (scored, incised, corrugated), Playas Red, Ramos Black	Casas Grandes Plain, Cloverdale Corrugated, incised wares, core-marked wares
Painted Pottery	Chihuahuan Polychromes, Salado Polychromes, El Paso Polychrome, wide variety of nonlocal wares	Chihuahuan Polychromes, Salado Polychromes, variety of nonlocal wares
Scarlet Macaws/Parrots	Over 300	Not present
Ball courts	Present	Present at Joyce Well and LA 54049
Obsidian	Antelope Wells (?), sources in Durango (?)	Antelope Wells

Note: Table modified from Douglas (1995:Table 1).

Even though there are similarities between Animas and Casas Grandes, archaeologists have recently argued that there is no evidence to support the claim that people at Paquimé controlled ceremonial activities and other social processes farther north in the Animas Valley (DeAtley 1980; DeAtley and Findlow 1982; Douglas and MacWilliams 2015; Minnis 1984; Whalen and Minnis 2003). Not all Animas phase sites had Casas Grandes-like architecture (Kidder et al. 1949). Whereas Paquimé and other sites in Chihuahua have highly exotic objects, Animas phase sites lack scarlet macaws, copper bells, and elite burials. Known leaders or elite families who held authority are missing from the archaeological record at Animas phase sites, but present at Paquimé (Rakita 2009; Whalen and Minnis 2000). There is more heterogeneity than homogeneity between Animas phase and Medio period settlements, and archaeologists suggest a loose integration between the two regions because Animas sites are on the far northern periphery of the Casas Grandes regional system (Figure 2.2) and were not likely economically or ceremonially dependent on Paquimé (Douglas 1995; Douglas and MacWilliams 2015; Whalen and Minnis 1996:743). Perhaps Animas phase sites like Joyce Well were not dependent on Paquimé for certain items because Chihuahuan polychrome types like Ramos Polychrome could be and were locally made in the boot heel (Carpenter 2002; Woosley and Olinger 1993), but maybe Di Peso was correct in that Paquimé and the Casas Grandes regional system were dependent on some the resources in the New Mexican boot heel like Antelope Wells obsidian.

Future Directions in Casas Grandes Archaeology

Archaeological fieldwork at Paquimé and the surrounding Casas Grandes region by Di Peso ended in 1961. Research was limited in the following decades until Whalen and Minnis began a field project in 1989 that lasted for over three decades (Minnis and Whalen 2015a; Whalen and Minnis 1999, 2001a, 2004, 2009a). Their work has contributed immensely to the understanding of core and periphery models of how non-elites lived in the region as well as variation in architecture, artifact distribution, and settlement patterns throughout northwestern Chihuahua (Minnis and Whalen 2004, 2015a; Whalen and Minnis 1996, 1999, 2000, 2001a, 2001b, 2003, 2009a, 2012; Whalen and Pitezel 2015; Whalen et al. 2010).

During an Amerind Foundation symposium (Minnis and Whalen 2015b), Casas Grandes scholars suggested that future archaeological research in Casas Grandes should focus on six issues. The six issues are listed in Minnis and Whalen (2015a:15) and include (1) a better understanding of the Viejo period and the Viejo-to-Medio period transition; (2) improvements in Casas Grandes chronology; (3) additional fieldwork, survey, and excavation throughout much of northern Chihuahua; (4) what happened at the end of Paquimé; (5) increased knowledge of exchange patterns using ceramic sourcing; and (6), settlement patterns with regional comparisons. Another key issue that is not included in the top six, but that is similar to number five and mentioned in Minnis and Whalen (2015a:15) is to study extant artifact collections using methods not available at the time of Di Peso's project. In this dissertation, I do so by examining the source provenance of obsidian artifacts from Medio period sites. Geochemical sourcing methods for obsidian were present during Di Peso's examination of Paquimé, and colleagues recommended that Di Peso geochemically source the obsidian artifacts for more accurate source characterization (Di Peso et al. 1974:8:189).

Chapter 2 Summary

In this chapter, I have described the cultural developments in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. Many critical events happened including the pithouse-to-pueblo transition, the development and end of Mimbres Classic Black-on-white pottery, transformations in demography as people moved out of the Mimbres region and new people came in, the rise of the Casas Grandes regional system, and changes in social networks. However, did these transformations affect where people obtained their obsidian? I examine these questions in the research presented Chapters 5 and 6.

Chapter 3: Obsidian Geology and Archaeology in the North American Southwest and Mexican Northwest

Here, I present background information on how obsidian forms, the XRF method, and how archaeologists have used obsidian sourcing data to expand our knowledge of the SW/NW archaeological record. This chapter is separated into four sections. In the first section of this chapter, I present the basics behind obsidian formation along with its geochemistry. I include how obsidian is created and the chemical properties that make it a chipped stone raw material amenable for sourcing analysis. I also discuss concepts and terms that geologists and archaeologists use when discussing provenance studies. For a more in-depth discussion of obsidian geology and geochemistry, see Hughes and Smith (1993) and Shackley (2005). In section two, I summarize the energy-dispersive XRF (EDXRF) method because this is the technique I used to source the obsidian artifacts to understand temporal and regional procurement patterns in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450.

In section three, I describe the known obsidian sources in New Mexico, Arizona, Chihuahua, and Sonora that pertain to this study. I do not discuss all available known and unknown sources that people could use in the SW/NW, but instead I focus only on the sources people in southwestern New Mexico and northwestern Chihuahua frequently used. For each source I include where the primary and secondary source deposits are located, along with nodule/cobble size, color, and material quality. Unfortunately, not all obsidian sources in the SW/NW are well documented, so some sources have more information than others. I refer readers to Shackley (2005) for information pertaining to sources not discussed in this chapter.

To contextualize the importance of a broad understanding of obsidian procurement in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450, in the last section of this chapter, I briefly review some of the most current archaeological research that discusses obsidian procurement. I include two studies from the Jornada Mogollon region (Figure 3.1), two studies in the Mimbres region, and two studies from the Casas Grandes region. I demonstrate what research questions have been asked, and how have archaeologists used sourcing data to examine a host of issues.

Obsidian Formation

Obsidian is a silica-rich volcanic glass that is typically of rhyolitic composition. It forms when magma from a volcanic source extrudes to the Earth's surface and supercools into glass when the magma contacts with air (Blatt and Tracy 1996; Hughes and Smith 1993; Shackley 2005). Geologists understand the chemical composition of obsidian. It is composed of 70 to 75 percent silicon dioxide (SiO_2), 10 to 15 percent aluminum oxide (Al_2O_3), three to five percent sodium oxide (Na_2O), two to five percent potassium oxide (K_2O), three to five percent iron oxide (FeO and Fe_2O_3), and 0.2 to 0.5 percent water (H_2O) (Glascock et al. 1998). The lava flow that forms obsidian has an elemental composition including chromium (Cr), cobalt (Co), and nickel (Ni), as well as rubidium (Rb), strontium (Sr), cesium (Cs), barium (Ba), and zirconium (Zr) (Shackley 2005).

The formation of obsidian is rare in Earth's history and outcrops are restricted to places of the world that experienced volcanism at the start of the Tertiary period 65 million years ago and continuing today in parts of the Americas, Africa, Japan, and the Mediterranean. Obsidian does not occur naturally in the eastern part of the United States, and instead outcrops are only located in western states including Washington, Oregon, California, Nevada, Idaho, Montana, Wyoming, Utah, South Dakota, Colorado, Arizona, and New Mexico in the United States, and in northern Mexico (Baugh and Nelson 1987; Ferguson and Skinner 2003; Hughes 1984, 1986; Kibler et al. 2014; Martynec et al. 2011; Nelson and Holmes 1979; Shackley 2005).

Obsidian absorbs water through cracks in obsidian flows, and as this process occurs, obsidian becomes perlite which is another form of hydrated glass (Hughes and Smith 1993). Perlite has relatively high water content and is not adequate for manufacturing sharp stone tools like obsidian can. Because of this, artifacts made from obsidian generally come from relatively younger geologic formations because the older the formation, the more time the obsidian outcrop could turn into perlite.

Using the proportions of the above mentioned elements, geochemists can obtain the geochemical characterization of each obsidian source on the landscape using a host of sourcing methods like XRF, neutron activation analysis (NAA), and indicatively-coupled plasma mass-spectrometry (ICP-MS) (Glascock 2011; Shackley 2005, 2011a). For the purpose of this dissertation, I only discuss the XRF method, and more specifically energy-dispersive XRF (EDXRF). Some archaeologists, however, have used the visual appearances and qualitative characteristics of obsidian including color, texture, and opaqueness to tell one source from another because obsidian can come in an assortment of colors including black, gray, reddish-black, reddish-brown (mahogany), and green (Bettinger et al 1984; Fuller 1927; Moholy-Nagy and Nelson 1990; Vierra and Dilley 2008). However, determining one source over another using this technique is ill-advised for most parts of the world and for most sources, especially in the SW/NW because various degrees of banding, mottling, and color can occur within a single obsidian deposit (Glascock et al. 1998; Shackley 2005). For example, LeTourneau and Steffen (2002) report on a semi-translucent mahogany variety of Cerro del Medio obsidian from the Valles Caldera, northern New Mexico that has the same geochemical signature as the translucent gray variety from the same source in the Jemez Mountains. Therefore, a geochemical method like XRF is the only reliable and accurate way to determine the source outcrop.

As for material quality, obsidian is by far the most preferred when needing a sharp stone tool compared to other chipped stone raw materials around the world that are not as sharp. The atomic structure of obsidian is disordered and the glass has no "preferred" direction of fracture and is completely isotropic. This makes obsidian an extremely sharp volcanic glass. As a result, obsidian was the steel of New World prehistory (Cobean et al. 1971:666) because before the Spanish arrived in the Americas in the fifteenth century A.D., people in the Americas used obsidian as one of the primary materials to make weapons for warfare and hunting. In fact, obsidian blades are sharper than steel blades used for modern day surgery because this volcanic glass cuts between cells rather than tear the cells as steel does (Buck 1982; Disa et al. 1993; Scott and Scott 1982). Even medicine men in the past (Clark 1989) used obsidian blades to make incisions because it results in quicker healing and smaller scars than modern day steel scalpels. Obsidian is extremely sharp, but because it is very brittle it may not be the best chipped stone raw material to manufacture certain types of tools like scrapers. The knapper will need to rejuvenate the bifacial edge on a more regular basis because of the brittleness than harder materials like basalt or chert.

Terms and Concepts

Archaeologists and geologists sometimes use different terminology and are at times interested in different issues (Hughes and Smith 1993). Because some archaeologists have experience with geochemistry like Shackley (2005) and others (Hughes 1998; Hughes and Smith 1993), and some geologists are interested in archaeology and how people in the past used stone tools, the cross-disciplinary collaboration between archaeology and geology has been productive but not without challenges (Martinón-Torres and Killick 2015; Pollard and Bray 2007). I attempt to circumvent such challenges in this dissertation by briefly addressing some key terms and concepts that both archaeologists and geologists use, and that pertain to this research.

It is important to note the term *source* because it is critical in sourcing analysis, but it can also be confusing and differentially or misused at times. Harbottle (1982:15) who is a geochemist but has contributed immensely to the integration of material science and archaeology notes about the term "source,"

> In point of fact, with a very few exceptions, you cannot unequivocally source anything. What you can do is characterize the object, or better, groups of similar objects found in a site or archaeological zone by mineralogical, thermoluminescent, density, hardness, chemical, and other tests, and also characterize the equivalent source materials, if they are available, and look for similarities to generate attributions. A careful job of chemical characterization, plus a little numerical taxonomy and some auxiliary archaeological and/or stylistic information, will often do something almost as useful: It will produce

> groupings of artifacts that make archaeological sense. This, rather than absolute proof of origin, will often necessarily be the goal.

Archaeologists throughout the world can better assess trade and exchange of obsidian artifacts using geochemical source provenance methods because "sourcing is possible as long as there exists some qualitative or quantitative chemical or mineralogical difference between natural sources that exceeds the qualitative or quantitative variation within each source" (Neff 2001:107-108). However, it is important to emphasize that for some researchers this is not the case, as sourcing "implies that whatever is submitted to the archaeometrist will return with a bona fide and certified source provenance that is not probabilistic at all, but confidently determined" (Shackley 2008:196).

There is also a difference between a primary lithic source and a secondary source, archaeologically speaking. Sourcing methods like EDXRF identifies the primary geological source of obsidian artifacts recovered from archaeological sites. Primary sources consist mainly of various flows that are in the immediate vicinity of the vent where the magma was extruded, even though the flow can extend some distance from the actual vent (Hughes 1998). Once obsidian or any other lithic material erodes from a primary source and enters a river system like the Rio Grande in New Mexico, the material is no longer considered to be a nodule but rather a cobble because it is not associated with the primary obsidian flow. Cobbles are then considered to be at a secondary source location. Because of this, in this dissertation, when I use the term nodule I refer to obsidian at the primary source, whereas I use cobble when the obsidian is subjected to stream erosion and is further away from the primary source. However, even though obsidian cobbles can travel hundreds of kilometers from the primary source, it will still have the same geochemical composition. For example, obsidian from the Jemez Mountains eroded into the Rio Grande one million years ago and cobbles are now in southern New Mexico, some 400 kilometers south of the primary source (Church 2000; Shackley 2005, 2013) (Figure 3.1).

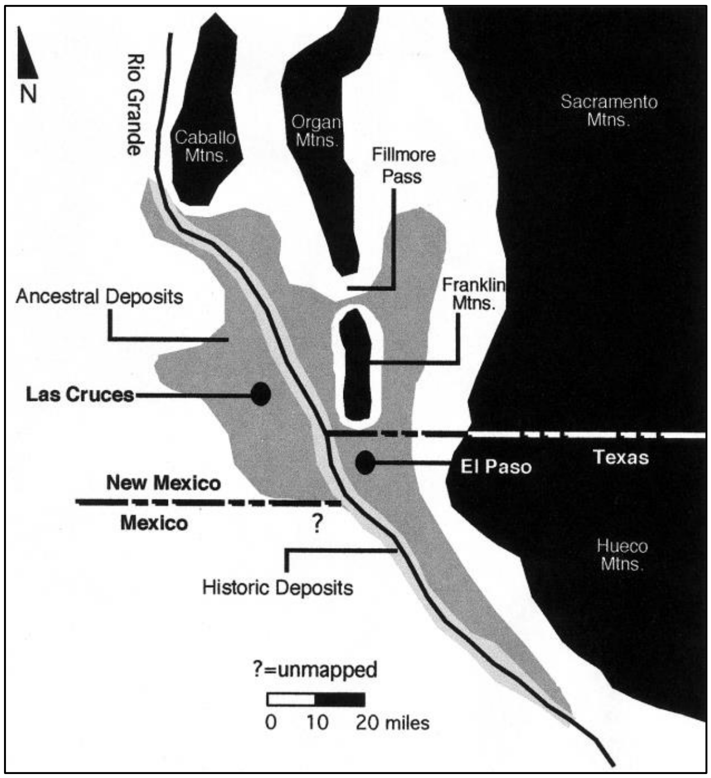

Figure 3.1. The distribution of ancestral and historic Rio Grande Quaternary alluvium gravels (Rio Grande gravels).
Note: Figure from Hawley et al. (1969) and Church (2000:Figure 2).

Of the five geochemically distinct obsidian sources in the Jemez Mountains of north-central New Mexico - Cerro Toledo, El Rechuelos, Cerro del Medio, Bear Springs, and Bearhead Rhyolite, only Cerro del Medio does not enter the Rio Grande. The other four can and did travel further south in ancestral Rio Grande Quaternary alluvium gravels as pictured in Figure 3.1 (Baugh and Nelson 1987; Church 2000;

Glascock et al. 1999; Shackley 2005, 2012b, 2013b; Shackley et al. 2016). If an archaeologist finds two obsidian projectile points at a site in El Paso and one can be chemically associated with Cerro Toledo and the other to Cerro del Medio, an archaeologist cannot necessarily determine if someone picked up a Cerro Toledo cobble from the Rio Grande and knapped it at the site, or if that point was made near the primary source in the Jemez Mountains and was moved to the site in El Paso. However, Cerro del Medio glass does not erode into the Rio Grande, the nodule from which the projectile point was made could not have been picked up in the alluvium. Therefore, there is evidence of human involvement in its movement.

When obsidian cobbles have been redeposited from primary outcrops into streams and flow into river gravels, such as in the Rio Grande of New Mexico, this presents archaeologists with a difficult task in determining whether the obsidian artifact was made from cobbles procured from gravel deposits or further away at the primary source. Also, obsidian cobbles from gravel alluvium that was redeposited is essentially the primary and secondary source in a geochemical sense (Hughes 1998:105). Archaeologists must keep secondary sources in mind because this process has profound impacts on how archaeologists interpret trade and how an obsidian artifact got to an archaeological site (Shackley 2002:56-59). Because it is very difficult to determine if someone obtained a nodule from the primary source as opposed to cobbles from a secondary source, Frahm (2012) uses the term, collection area. A collection area is "a place, of any scale, that the specimen's original collector considered to be a single area where obsidian occurs. It is not necessarily equal to either a geographically defined source or a chemical type of obsidian" (Frahm 2012:24).

Sometimes in one obsidian source, there are multiple related but geochemically discrete signatures that can be called subsources (Eerkens and Rosenthal 2004:21; Hughes 1994; Shackley 1994). The Mule Creek obsidian source is an example. Later in this chapter I describe Mule Creek obsidian and note that there are four geochemically distinct subsources associated with it. Antelope Creek, Mule Mountains, North Sawmill Creek, and San Francisco/Blue River are the individual subsources (Shackley 1992, 2005). Archaeologists should note which Mule Creek subsource people in the past used because if an archaeologist were to lump all Mule Creek obsidian into one general category during a sourcing project, procurement patterns to differentiate between one subsource and another would not be as effective to answer archaeological questions. It is therefore critical to distinguish among subsources because it may prove essential in understanding differences in procurement patterns across space or through time (Eerkens and Rosenthal 2004), because there may be differences in material quality, color, and other features between each subsource even though nodules/cobbles from different subsources may be located closer together. The Antelope Creek subsource of Mule Creek was used much more extensively than the North Sawmill Creek subsource, and material quality differs between the Mule Creek sources (Shackley 2005; Taliaferro et al. 2010).

EDXRF Spectrometry

Before a projectile point is made, or even before the first flake from a core is removed, someone procured the lithic raw material to manufacture an object. Procurement is the most important step because it is the initial step in the knapping process. Deciding to use one raw material over another directly influences the steps of the manufacture process, and shapes the chipped stone lithic assemblages that people in the past deposited into the current archaeological record. For the archaeologists, knowing which obsidian source(s) people in a given time or place used to manufacture stone tools is invaluable information, because models of trade, exchange, and social interaction can be investigated. Before interpretations about past human behavior can be inferred about obsidian procurement, the researcher must decide which geochemical technique to use.

For this dissertation study, I chose EDXRF because it is the most popular method for to characterize the trace elements of obsidian in the SW/NW for a host of reasons which I discuss later in this section. EDXRF spectrometry measures the amount of energy given off from a sample, like an obsidian artifact, that has been irradiated with X-rays. After the artifact is placed inside a chamber it is irradiated with a beam of primary high-energy X-rays that excite the electrons. The electrons are then displaced from their orbits and return to the orbits to emit secondary X-rays. The secondary X-rays are known as fluorescence X-rays, the reason for the name “X-ray fluorescence.” The fluorescence X-rays are important because they have wavelengths that are diagnostic of the element being emitted. By measuring the intensity of the wavelengths for each element emitted, the concentrations of elements from the artifact can be collected (Pollard et al. 2007:101-109; Shackley 2011a; Verma 2007:1-90).

To distinguish between one obsidian source over another, the most commonly used elements geochemists examine in parts per million (ppm) are rubidium (Rb), strontium (Sr), zirconium (Zr), niobium (Nb), barium (Ba), yttrium (Y), titanium (Ti), manganese (Mn), sodium (Na), potassium (K), and iron (Fe) (Shackley 2005). These elements fall within the energy ranges that are easily detectable using EDXRF and other sourcing methods like NAA. The artifacts sourced specifically for this dissertation were analyzed by at the Geoarchaeological XRF Laboratory in Albuquerque, New Mexico using EDXRF spectrometry. Trace elemental analyses were conducted on a ThermoScientific *Quant*'X EDXRF spectrometer for the mid-Z elements Ti, Mn, Fe, Zn, Rb, Sr, Y, Zr, and Nb, and the high-Z element Ba. The instrumental protocol and settings for this analysis are outlined in Shackley (2005, 2011a), and online at http://www.swxrflab.net/anlysis.htm. For an example, Figure 3.2 demonstrates the differences in Nb versus Y for the various geochemically distinct obsidian sources found at archaeological sites in southwestern New Mexico (Dolan and Gilman 2015; Shackley 2013a).

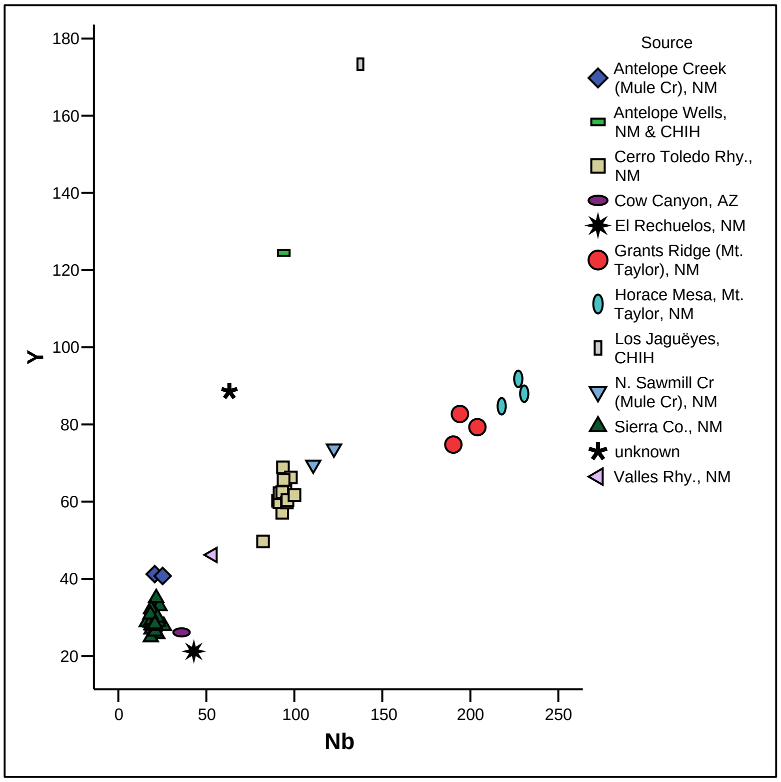

Figure 3.2. Bivariate plot of Nb versus Y for the compositional groups in parts of New Mexico, Arizona, and Chihuahua.
Note: Each symbol represents one obsidian artifact that geochemically characterizes to a specific obsidian source.

There are several advantages for using EDXRF spectrometry (Table 3.1), because of its overall speed, accuracy and precision, availability, and low cost compared to other sourcing methods. As Glascock (2011:Table 8.1, reproduced in Table 3.1 here) notes, EDXRF is non-destructive and requires very little if any sample preparation unlike wavelength-dispersive XRF (WDXRF) and NAA. Secondly, analysts can analyze many artifacts at once and results can be obtained within several minutes. EDXRF machines are also more widely available around the world because minimal training is required, unlike NAA which requires a nuclear reactor. The price of EDXRF is relatively low cost with an average cost per sample between $20.00 and $45.00, but usually it is on the lower end.

Table 3.1. EDXRF Characteristics.

Availability	Many lab- and university-based XRF facilities are located in the United States, Canada, and Europe. Minimal training is required to operate.
Sample requirements	Sample preparation is minimal to none. Optimal artifact size is >10 mm in smallest dimension and >2 mm thick (Davis et al.1998). EDXRF is a non-destructive technique as the artifact is analyzed whole.
Analysis	Between 10 and 15 trace elements analyzed. Rapid turnaround for analysis. Accuracy and precision is good enough to distinguish between one source and another.
Interlaboratory comparison	Depends on equipment and calibration methods but good to excellent.
Approximate cost per sample	Depends on lab but standard rates range between $20 and $45/sample.

Note: Table modified from Glascock (2011:Table 8.1).

EDXRF analysis has limitations, however. Whether an obsidian artifact is large or small can determine whether analysts should use EDXRF or another method like WDXRF or NAA. Davis et al. (1998, 2011) demonstrated that the optimal size for obsidian artifacts or geologic samples to be analyzed using EDXRF is greater than 10 millimeters in smallest dimension and greater than two millimeters thick. For research questions concerning Paleoindian and Archaic period hunter-gatherer mobility and long-distance procurement of obsidian chipped stone debitage, especially microflakes, the size limitation for EDXRF may be problematic. This is particularly true given that Eerkens et al. (2007) have shown that microflakes have greater source diversity and derive from further distances in hunter-gatherer obsidian assemblages than larger flakes.

Microflakes are usually smaller than the EDXRF analytical threshold, and so WDXRF or NAA may then be used, because there is no size limitation for these methods, unfortunately because both are destructive. Moreover NAA is expensive and requires more training, and few laboratories and universities are capable of this method because it requires a nuclear reactor and that means to store radioactive samples until they “cool” (Glascock 2011). The Missouri University Research Reactor (MURR), Columbia, Missouri can perform NAA and XRF analyses on artifacts (Glascock et al. 2007).

Obsidian Source Descriptions

There are many known obsidian sources in Arizona, New Mexico, Chihuahua, and Sonora (Figure 1.3). Here I only describe those most applicable to this dissertation study, because they are the ones people used in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. Some source descriptions are longer and contain more detail than others because information regarding the extent of primary and secondary deposits, nodule/cobble size, and material quality varies. For the location of all known sources, I refer readers to Figure 1.3, although in some cases I provide more specific maps. For a list of all sources in the SW/NW including but not limited to those discussed here, see Shackley (2005).

Antelope Wells Obsidian

The Antelope Wells obsidian source is located in southern Hidalgo County, New Mexico, and nodules extend at least 15 to 20 kilometers south into Chihuahua where it is known as El Berrendo obsidian. The term Antelope Wells will be used rather than El Barrendo in this dissertation because Antelope Wells is more common in the archaeological literature (Findlow and Bolognese 1980, 1982a, 1982b; Shackley 2005:57). Nodules are generally five to 10 centimeters in diameter but can be smaller. People who used Antelope Wells obsidian to manufacture tools needed to use bipolar percussion technology to knap nodules due to the size limitations (Andrefsky 1994, 2001:28). Knappers use bipolar technology to maximize the use of a limited or scarce raw material like obsidian in most parts of the SW/NW, and if nodule size is relatively small. Antelope Wells obsidian can vary in color and thin flakes are often opaque, but some can be green with transmitted light. Other variations include translucent brownish-green, dark gray, green/brown banded, and opaque black (Findlow and Bolognese 1980; Shackley 2005).

Mule Creek Obsidian

The Mule Creek obsidian source is located in west-central New Mexico in Grant County. Nodules erode into the Gila and San Francisco river systems and can Mule Creek obsidian cobbles can be collected along river beds as far south as southeastern Arizona (Shackley 2005:53-55). There are four geochemically distinct subsources belonging to the Mule Creek group: Antelope Creek, Mule Mountains, North Sawmill Creek, and San Francisco/Blue River. Primary source localities for Antelope Creek, Mule Mountains, and North Sawmill Creek obsidian have been found (Figure 3.3). San Francisco/Blue River has not been identified in primary contexts, but cobbles occur somewhere west of Blue River and north and west of the San Francisco River (Shackley 2005:53).

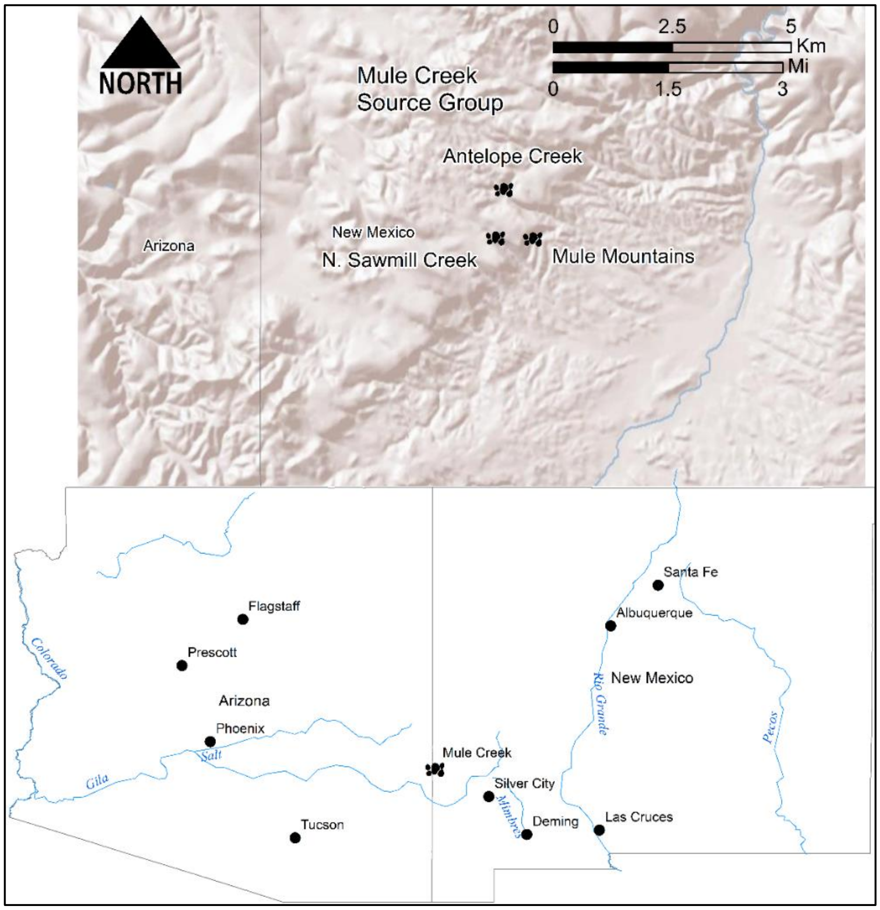

Figure 3.3. Location of three of the four Mule Creek subsources in New Mexico.
Note: See also Shackley (2005:Figure 3.5)

Of the four Mule Creek subsources, Antelope Creek obsidian is the most popular medium for obsidian toolstone production in the Mimbres Valley (Taliaferro et al. 2010). For this reason, I discuss Antelope Creek in more depth than the other Mule Creek sources. In general, nodule size vary is from 10 to 15 centimeters in diameter, but most are under 10 centimeters. Color ranges from opaque black to translucent smoky gray with some banding, and even mahogany-brown and black-banded occurs (Shackley 2005:55).

Even though most obsidian projectile points dating to later periods are made of Antelope Creek obsidian in southwestern New Mexico (Taliaferro 2004), Shackley (2005:55) had doubts about the material quality of Antelope Creek and suggested the Mule Mountain subsource was higher-quality. In 2013, Shackley and members of Archaeology Southwest's Mule Creek Preservation field school discovered a previously unknown locality of high-quality Antelope Creek glass west of the known source (Shackley personal communication, 2013). Antelope Creek material was thought to be of less quality than Mule Mountains for knapping as some Antelope Creek nodules would shatter on impact. The new western locality, however, exhibits much higher quality nodules than the previously known eastern locality. Because of this discovery, it is now thought that people used the western source area rather than the eastern. Both Antelope Creek localities have the same geochemical signature.

Jemez Mountain Obsidian

The Jemez Mountains are located in north-central New Mexico in Sandoval and Rio Arriba Counties. Geologists have surveyed this area for quite some time, and much is known about the Jemez Mountains (Kues et al. 2007). There are five geochemically distinct obsidian sources in the Jemez region including Cerro Toledo, El Rechuelos, Cerro del Medio, Bear Springs, and Bearhead Rhyolite (formerly known as Paliza Canyon obsidian) (Baugh and Nelson 1987; Glascock et al. 1999; Shackley 2005, 2013; Shackley et al. 2016). The latter two are located in the southern part of the Jemez Mountains, and were seldom used to manufacture obsidian tools in southwestern New Mexico because of small nodule/cobble size less than two centimeters in diameter due to their Tertiary age of approximately eight million years. Therefore, I do not describe

Bear Springs and Bearhead Rhyolite in this chapter (but see Shackley 2005, 2013, 2014a; Shackley et al. 2016 for a discussion). I do however, discuss Cerro Toledo, El Rechuelos, and Cerro del Medio obsidian because they were used regularly in prehistory.

Other than the Southwest, Jemez obsidian, in particular, Cerro Toledo, El Rechuelos, and Cerro del Medio (Figure 3.4) have also been found at sites in the Great Plains, Rocky Mountains, and elsewhere. They are a popular medium for toolstone production because of the large nodule sizes at the primary source and high-quality knapping glass (Baugh and Nelson 1987; Baugh and Terrell 1982; Brooks et al. 2014; Brosowske 2004; Dillian et al. 2007; Steffen and LeTourneau 2007). Paleoindian and Archaic groups in New Mexico preferred to use all three sources as opposed to other sources in New Mexico because Cerro Toledo, El Rechuelos, and Cerro del Medio obsidian size was greater, and as a result, there were fewer limits on bifacial reduction for production of large spear points as compared to Mule Creek, Antelope Wells, and Gwynn/Ewe Canyon (Dolan et al. 2016; Huckell et al. 2011; LeTourneau and Shackley 2009; Vierra et al. 2012).

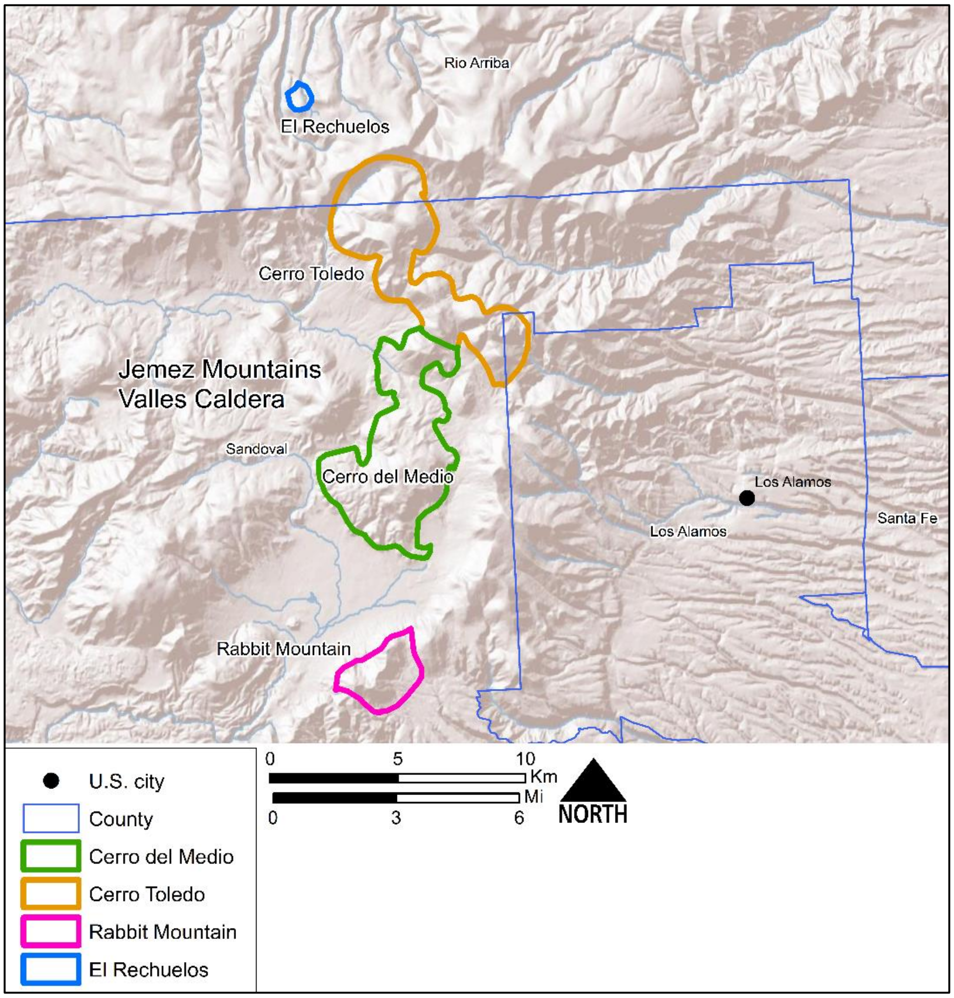

Figure 3.4. Location of Jemez Mountain obsidian.

Cerro Toledo Obsidian. Cerro Toledo obsidian is also known in the archaeological literature as Obsidian Ridge obsidian or Rabbit Mountain obsidian (Shackley 2013b). It is difficult, if not impossible, to determine whether people obtained Cerro Toledo nodules from Cerro Toledo or Rabbit Mountain because both localities have the same trace element signature (Figure 4.4). Cerro Toledo glass is the most volumetrically available obsidian from the Jemez Mountains, but material quality varies greatly (Shackley 2013b:22). Due to the variability, there is evidence from waste flakes close to the primary source that people knapped to test material quality before transporting back to site (Shackley 2005, 2013; Vierra and Dilley 2008).

Cerro Toledo is the most widespread of the Jemez sources because nodules that weather out of a hydrating obsidian outcrop erode into the Rio Grande and cobbles travel hundreds of kilometers south to the Las Cruces and El Paso areas (Baugh and Nelson 1987; Church 2000; Glascock et al. 1999; Shackley 2005, 2013; Steffen 2005; Stevenson and McCurry 1990). People in the Mimbres and Jornada Mogollon regions could have collected obsidian cobbles that eroded and transported further away from the primary source that has the same geochemical composition as Cerro Toledo from the Quaternary alluvium in the Rio Grande drainages rather than obtaining them through trade or direct procurement in the Jemez Mountains (Dolan et al. 2015; Church 2000; Taliaferro et al. 2010).

El Rechuelos Obsidian. El Rechuelos obsidian is also known in the archaeological literature as Polvadera Peak. This is the northernmost obsidian source in the Jemez Mountains (Baugh and Nelson 1987; Glascock et al. 1999; Shackley 2005, 2013:19-20) (Figure 3.4). It is an excellent medium for toolstone production because nodules generally lack the spherulites that decrease knapping quality. As noted in Shackley (2005:69, 2013:20) and Vierra and Dilley (2008:334-335), El Rechuelos glass is megascopically distinctive from Cerro Toledo and Cerro del Medio. El Rechuelos glass is uniformly granular possibly a result of ash in the El Rechuelos matrix, whereas the other two are instead more vitreous. The geographic extent of El Rechuelos is not as great as Cerro Toledo because it has a smaller primary source. Nodules up to 15 centimeters in diameter exist, but most nodules are between one and five centimeters.

Obsidian cobbles that are one to five centimeters in diameter are found further south in New Mexico in the Rio Grande alluvium (Church 2000; Shackley 2005, 2013).

Cerro del Medio Obsidian. Cerro del Medio obsidian is also known as Valle Grande obsidian or Valles Rhyolite in the archaeological literature. Cerro del Medio obsidian nodules can be up to 30-40 centimeters in diameter, and material quality is intermediate between Cerro Toledo and El Rechuelos (Shackley 2005:71, 2013:23). It is the only source in the Jemez Mountains that does not erode into the Rio Grande in any appreciable quantity. This is because of the relatively late eruption of Cerro del Medio and the limited stream power of the Jemez river and other streams that drain into the Valles Caldera (Church 2000; Shackley 2005:74, 2013:22-23; Steffen and Letourneau 2007).

If artifacts produced from Cerro del Medio obsidian are found at sites further south in southern New Mexico, social mechanisms like down-the-line exchange or direct/embedded procurement from the Valles Caldera were used. In other words, people could not collect Cerro del Medio obsidian along the Rio Grande alluvium south of the caldera to produce adequate sized projectile points or flaked tools. Because of this, Cerro del Medio artifacts are rare at Mimbres and Jornada Mogollon sites, but they do occur (Dolan et al. 2015; Miller and Shackley 1998; Taliaferro et al. 2010). For example, a late Paleoindian Eden point made Cerro del Medio obsidian was found at a site in northern Sierra County, New Mexico on White Sands Missile Range (Dolan et al. 2016).

Mount Taylor Obsidian

There are two geochemically distinct obsidian sources in the Mount Taylor Volcanic Field in northern Cibola County, New Mexico (Shackley 1998a, 2005:58-64): Grants Ridge and Horace Mesa. Similar to obsidian in the Jemez Mountains, both Grants Ridge and Horace Mesa glass erode into the Rio Grande Quaternary alluvium, and cobbles are found in southern New Mexico (Church 2000; Shackley 2005). Mimbres and Jornada groups could have collected Grants Ridge and Horace Mesa cobbles from riverbeds to make tools.

Grants Ridge Obsidian. Grants Ridge obsidian nodules can be up to 15 centimeters in diameter, but most are five to 10 centimeters or less. Grants Ridge has more obsidian than Horace Mesa, but nodules contain sanidine phenocrysts, which hamper toolstone production.

Horace Mesa Obsidian. Obsidian from Horace Mesa is located to the east of Grants Ridge. This glass does not have phenocrysts that hinder tool production, unlike Grants Ridge. The raw material is superior for pressure flaking and general knapping, but the vast majority of nodules are three to four centimeters in diameter, making glass at Horace Mesa smaller than Grants Ridge (Shackley 2005:63). Because of the smaller size, fewer Horace Mesa cobbles are found in the Rio Grande alluvium because they do not make it all the way into southern New Mexico as small cobbles break into pieces (Church 2000; Shackley 2005:63). If artifacts made from Horace Mesa material are found at sites further south, there might be a greater possibility that people collected the glass from the primary source or obtained it through down-the-line trade rather than collecting it from Rio Grande gravels.

Gwynn/Ewe Canyon Obsidian

The Gwynn/Ewe Canyon obsidian source is located in southern Catron County, New Mexico. Nodules can be up to five centimeters in diameter, but more are less than three centimeters in diameter. Gwynn/Ewe Canyon nodules erode into the Gwynn Canyon system and possibly into the upper San Francisco River in New Mexico (Shackley 2005:56).

Nutt Mountain Obsidian

The primary source of Nutt Mountain obsidian is unknown at this time, but Shackley (2013a) suggests it is in Sierra County, New Mexico. Nutt Mountain obsidian ranges in size from pea size up to five centimeters in diameter. This source is similar in trace element composition to the Gwynn/Ewe Canyon and Antelope Creek and Mule Mountain sources because all four likely have a common origin in the Mogollon-Datil rhyolites of west-central New Mexico (Shackley 2013a). Field observations suggest nodules derive from a vent other than the Nutt Mountain Rhyolite center, but the location of the eruptive center is unknown (Shackley personal communication, 2013). More fieldwork is needed to determine the primary and secondary distribution of this obsidian.

Cow Canyon Obsidian

The Cow Canyon obsidian source is located in east-central Arizona in Greenlee County (Shackley 2005:51-53). This is the only source in Arizona that I describe because Cow Canyon glass occasionally shows up on archaeological assemblages in southwestern New Mexico (Taliaferro et al. 2010). Cow Canyon obsidian does erode from the primary outcrop and cobbles are transported east into the Blue River, south into the San Francisco River, and west into the Gila River in parts of Arizona and New Mexico. Five centimeters in diameter is the maximum size for Cow Canyon obsidian, and most are less than five centimeters. The color is a near transparent brown-green, but it sometimes can be an opaque gray-green banded color (Shackley 2005:52).

Sierra Fresnal Obsidian

The Sierra Fresnal obsidian source is located in northern Chihuahua (Shackley 2005:83). It is the only known primary source in northern Chihuahua, but cobbles are found along secondary stream deposits in all directions. Sierra Fresnal obsidian erode north, and they have been collected from the Arroyo Casas Grandes alluvium 70 kilometers north of Sierra Fresnal and east toward Lago Fresnal and Lago Guzman. Because Sierra Fresnal glass can be collected in many different places, it is impossible to determine whether it was procured at the primary source or in secondary deposits near the border.

Los Jagüeyes Obsidian

The Los Jagüeyes obsidian source is located in northern Chihuahua near a tributary of the Rio Santa Maria (Shackley 2005:82-83). More field investigation is needed to determine the extent of primary and secondary source distribution of this glass, but Shackley (2005:82-83) notes that there are two source groups based on elemental composition belonging to Los Jagüeyes. One source group appears to be the Sierra Fresnal primary source which is located approximately 60 kilometers north of Los Jagüeyes. Nodules are five centimeters in diameter.

Selene Obsidian

The Selene obsidian source is located in the upper Rio Bavispe basin in northeastern Sonora (Kibler et al. 2014). This source was previously known as Sonora Unknown B, but Kibler et al. (2014) recently published a description of it. Nodules can be up to eight centimeters in diameter, but most are five centimeters in diameter. Color is mostly black, and black banded and shades of reddish brown occur rarely. Some nodules shatter on impact, but others are very hard and brittle. Overall, Selene obsidian is good quality knapping material.

Agua Fria Obsidian

The Agua Fria obsidian source is located in northeastern Sonora approximately 50 kilometers south of the Arizona border (Shackley 2005:79-80). Nodule size is five centimeters in diameter. Color is black to brown-black, some with banding, and most are opaque.

Archaeological Obsidian Studies in Southern New Mexico and Northwestern Mexico

The primary reason why archaeologists integrate sourcing techniques on obsidian artifacts is to assess the economic and social factors that underlie the movement of people and obsidian across the landscape. In the last part of this chapter, I review obsidian sourcing studies from southern New Mexico and northwestern Mexico, since these are the most relevant to my research. First, I discuss two studies in the Jornada region, and then I briefly mention what archaeologists have said about obsidian procurement in the Mimbres region. I do not provide an intensive synthesis for the Mimbres because many of the studies in this region have been integrated into my dataset (see Chapters 5 and 6). I then discuss three obsidian sourcing studies in northwestern Mexico, including two from Chihuahua and one in Sonora.

Obsidian Procurement in the Jornada Mogollon Region

Unlike other parts of the SW/NW, like the Hohokam region, there are few published studies concerning obsidian procurement in the Jornada Mogollon region. In this section, however, I discuss two Jornada Mogollon obsidian studies that were presented at conferences. In the first study, Miller and Shackley (1998) developed the initial discussion of sourcing data for the Jornada region by integrating a sample size close to 2,000 artifacts dating from Paleoindian, Archaic, Pueblo, and historic contexts. In the second study, in an attempt to provide an updated account of source procurement in the region, Dolan et al. (2015) added to the original Miller and Shackley (1998) database to examine whether there were more local or non-local sources present at two large occupied El Paso phase (A.D. 1200-1450) sites.

Miller and Shackley (1998). Miller and Shackley (1998) sought to examine whether all obsidian from sites and isolated occurrences in southern New Mexico and west Texas sources to Cerro Toledo, El Rechuelos, Bear Springs, Grants Ridge, and Horace Mesa, because there was an assumption by most archaeologists that the Jornada Mogollon and earlier Paleoindian and Archaic groups collected obsidian from the Rio Grande alluvium near Las Cruces and El Paso. If some artifacts derived from other sources including Mule Creek, Antelope Wells, or Cerro del Medio, for example, this would have important ramifications for prehispanic movement, trade, and interaction between Jornada groups and others in the SW/NW. Their results demonstrate that 90 percent of the artifacts characterize to sources that can be collected along the Rio

Grande, but a small proportion is from nonlocal sources. Most of the nonlocal obsidian derived from northern Chihuahua, including Sierra Fresnal (Miller and Shackley 1998). Temporal patterns also were present. Nonlocal sources like Cerro del Medio and Sierra Fresnal obsidian are present in Archaic assemblages suggesting a north-to-south procurement pattern, but this changed during the Pueblo period when Mule Creek and Cow Canyon obsidian were used, suggesting an east-to-west pattern.

Dolan et al. (2015). The obsidian sourcing data from two recently excavated El Paso phase pueblos, Cottonwood Spring (LA 175) and Madera Quemada (LA 91220), were added to Miller and Shackley's (1998) original database. Because ceramic evidence indicates that people living at these sites interacted with other groups to the west and south, Dolan et al. (2015) sought to examine whether there were more local or nonlocal obsidian sources present. The sourcing results indicate most of the obsidian artifacts geochemically source to locally available Rio Grande gravels like Cerro Toledo, Bear Springs, El Rechuelos, Grants Ridge, and Horace Mesa, but non-local sources are present like Antelope Creek, Cow Canyon, Red Hill, Nutt Mountain, Cerro del Medio, and Sierra Fresnal.

Jornada archaeologists should not assume that all obsidian artifacts were procured from Rio Grande gravels, especially projectile points. Fifty percent of the obsidian projectile points from Cottonwood Spring are from Mule Creek (Antelope Creek) or Sierra Fresnal. It is quite possible that Jemez and Mount Taylor obsidian were obtained through down-the-line exchange. Using chipped stone attribute analysis including nodule/cobble size, percentage of dorsal cortex, and geochemical source, future studies should ask whether people were directly procuring Jemez and Mount

Taylor obsidian from the primary source, or whether cobbles were obtained more locally close to the Rio Grande.

Obsidian Procurement in the Mimbres Region

Mimbres archaeologists have integrated obsidian sourcing into their projects to answer questions about trade, exchange, and social interaction (Dolan 2012; Dolan and Ferguson 2012; Dolan and Livesay 2015; Dolan and Putsavage 2012; Kenmotsu et al. 2014; Putsavage 2015; Sedig 2015; Taliaferro 2004, 2014; Taliaferro et al. 2010; VanPool et al. 2013). Here, I overview two obsidian sourcing studies from the Mimbres region, but I do not provide an in-depth discussion, because some of the obsidian sourcing data published in Taliaferro et al. (2010) and Putsavage (2015) are integrated into my dataset in Chapter 6.

Taliaferro et al. (2010). Taliaferro et al.'s (2010) accomplishes three research objectives in their Mimbres obsidian research. First, they sourced a large sample size of artifacts from many sites in southwestern New Mexico dating from the Late Archaic until the Mimbres Classic period; second, they integrated GIS least cost pathway analysis to examine how many round-trip hours it takes to get from site to source; and third, they constructed a baseline understanding of which obsidian sources people throughout southwestern New Mexico used through time. Obsidian sourcing data from seven Mimbres Classic period sites that Taliaferro et al. (2010) published are used in this dissertation. These seven sites are used because they are located in southwestern New Mexico, and they have a good sample size except for one site.

Taliaferro et al. (2010) sourced 923 obsidian artifacts from over 80 sites in the Luna/Reserve area, the Black Range, the Burro Mountain Range/Gila Mountains, the

Mimbres River Valley, the eastern Mimbres, the Cookes Range, the Cedar Mountains, the Pyramid/Peloncillo Mountains, and the Florida Mountains of southwestern New Mexico. Their results suggest people participated in either a northern or southern obsidian source network. People associated with the northern network used Mule Creek, Cow Canyon, Gwynn Canyon, and Red Hill, and people associated with the southern networked used Antelope Wells, Sierra Fresnal, and Los Jagüeyes. Northern sources like Mule Creek, however, are still common in the south. The Antelope Creek subsource of Mule Creek was the preferred choice in the region as a whole, even if it was not the optimal or closest source. Using GIS least cost analysis, Taliaferro et al. (2010) estimated the round-trip travel time from site to obsidian source and back in hours. At Galaz, it would take people approximately 100 hours round-trip to obtain obsidian at Mule Creek, whereas it would only take half the time for Sierra Fresnal. Interestingly no Sierra Fresnal obsidian occurs at Galaz.

Putsavage (2015). For her dissertation, Putsavage (2015) excavated the Late Pithouse, Black Mountain, and Cliff phase components of the Black Mountain site (LA 49) located near Deming. She sourced obsidian artifacts from LA 49 and other Black Mountain and Cliff phase sites in the Mimbres Valley proper and Deming basin and range to better understand the transition between the Mimbres Classic period, the Black Mountain phase, and the Cliff phase in southwestern New Mexico. Little obsidian sourcing data from Black Mountain and Cliff phase sites have been thoroughly investigated in the Mimbres Valley and Deming basin and range, so in this dissertation, I integrate sourcing data from six Black Mountain and Cliff phase sites discussed in Putsavage (2015). As a result, I do not give an exhaustive discussion of her results here.

According to Putsavage (2015; see also Dolan and Putsavage 2012), people at the Black Mountain site used slightly different obsidian procurement practices in the Mimbres Valley and Deming basin and range during the Black Mountain and Cliff phases. Artifacts made from Antelope Creek obsidian increased from the Black Mountain phase to the Cliff phase possibly because to the spread and influence of Kayenta people coming in from northeastern Arizona and moving into southern Arizona and into southwestern New Mexico. Mills et al. (2013) also see a correlation between Mule Creek (Antelope Creek) obsidian and Salado Polychromes in this region.

Obsidian Procurement in Northwestern Mexico

Unlike the North American Southwest and Mesoamerica where obsidian sourcing studies are common, such investigations have been limited for the northernmost Mexican states of Chihuahua and Sonora. In this section, I discuss three obsidian sourcing studies from northwestern Mexico. I do this because I sourced obsidian artifacts from Medio period sites in northwestern Chihuahua, and a discussion of what archaeologists have found prior to this dissertation is significant. First is Darling’s (1998) analysis of a small sample size from Paquimé. Second is Vierra’s (2005) analysis of obsidian artifacts from the Late Archaic site of Cerro Juanaqueña in northern western Chihuahua. Finally, I synthesize Kibler et al.’s (2014) recent publication on the Selene obsidian source in northeastern Sonora and discuss what their findings mean for obsidian in the Casas Grandes region. These three studies are included because they represent the only scholarship available on obsidian sourcing in this region.

Darling (1998). Darling's (1998) dissertation examined obsidian procurement in the northern frontier of Mesoamerica including Zacatecas and Chalchihuities. As a minor component to his study, however, he sourced 12 obsidian artifacts from Paquimé. He did this to "test observations by Di Peso et al. (1974) concerning the occurrence of obsidian at the site from source areas in Jalisco and Durango potentially linking the Mesoamerican north-central frontier area with the Greater Southwest" (Darling 1998:24). Therefore, the results and discussion from his study are pertinent to this dissertation.

If people at Paquimé used obsidian sources that people further south in Mesoamerica or in West Mexico used, it would have bolstered Di Peso's claims that Paquimé was the northernmost Mesoamerican outpost. Based on color and megascopic visual sourcing, Di Peso suggested the obsidian Paquiméans used came from Durango approximately 750 kilometers to the south because some of the obsidian artifacts they collected contained a gray and gold-tinged black and peculiar opaque green color. Di Peso et al. (1974:8:189) wrote,

> Throughout history and over the world, such men as the Sumerians, Assyrians, and Teotihuacans have used obsidian as a primary commodity (Child, 1951, p. 92). The Medio Period Paquimian also manipulated this material as both an import and export. Two Casas Grandes specimens were identified as a variety A mined export from a vicinity located just west of Durango City. One gold-tinged black piece [CG(o)/19C] was found in the collapse of Room 14-13, and a second sample [CG(o)/83C] was taken from the floor of Room 30-16. This was a translucent gray specimen. A third Casas flake (CG/5953) was a Type XIB knife found subfloor of Plaza 6-14 and was made of type K obsidian also mined in the vicinity of Durango City. All three came from mines worked from the Canutillo through the Calera phases, i.e. from A.D. 100 to A.D. 1350, with a production peak during the Ayala and Calera phases, A.D. 500 to A.D. 1350 (Spence, Personal communication, February 3, 1968; Spence and Weigand, 1968). These items then were apparent Paquimé imports trafficked 750 km. north from the Chalchihuites

> district, which, interestingly enough was the approximate distance that separated the alibates quarries of Texas and from Casas Grandes. Hard by and to the west of the southwestern corner of the Casas Grandes province, there are several surface concentrations of obsidian nodules. These include those described by Bandelier (1892, pp. 515-516) as the Tahuaro, Huepari Mesa, and Tesorobabi locations. Another such deposit is actually situated within the southwestern provincial border of Casas near present-day Tres Rios on the Gavilan drainage, some 25 km. (15 mi.) west of the Mormon colony of Pacheco (Lumholtz 1902, Vol. 1, pp. 56-57). A peculiar opaque green obsidian [CG(o)/92], found on the floor of Room 42-8, compared with specimens found by Weigand at Etzatlán in Jalisco, and was believed to have come from the above-mentioned Paquimé source, suggesting that there may have been a two-way trade in obsidian between these two areas (Spence, Personal communication, February 3, 1968).

Unfortunately, no geochemical sourcing analyses were performed on the Paquimé obsidian during Di Peso's analysis. Instead, Spence visually sourced some of the obsidian and concluded that no green obsidian from central Mexico was present in the Paquimé assemblage (Spence-Di Peso, correspondence, 1967-1968, photocopies on file, University of Michigan, Ann Arbor; Di Peso et al. 1974:8:189; Spence 1978:186, 269 fn. 25).

Darling (1998) sent 12 obsidian artifacts from Paquimé to Shackley for XRF analysis, and the artifacts were then sent to Missouri University Research Reactor (MURR) for NAA. The artifacts were from the University of Michigan, Museum of Anthropology collections because they were initially studied by Pires-Ferreira in the early 1970s (Darling 1998). Pires-Ferreira concluded all 12 artifacts were unlike any of the comparative material from Durango or Jalisco with which she was familiar (Darling 1998:267). The geochemical sourcing of the 12 artifacts revealed that one artifact characterized to Cow Canyon and the other 11 characterized to either two unknown chemical groups (Darling 1998:Table 5.5). These results contradict earlier thoughts and observations made by Di Peso (1974; Di Peso et al. 1974), in that no obsidian from

Paquimé came from Durango, Jalisco, or any other Mesoamerican state. However, Darling only examined 12 artifacts of the 443 obsidian items recovered at Paquimé (VanPool et al. 2000:Table 8). All but one of the artifacts could be attributed to a known source, and so there is a possibility that the 11 other artifacts source to an unknown source somewhere other than Arizona, New Mexico, Sonora, or Chihuahua. A larger sample size must be examined to fully rule out Mesoamerican obsidian. When Darling conducted his study in the 1990s, very few obsidian sources in northern Mexico were known, but currently there are more than half a dozen documented in Sonora and Chihuahua (Kibler et al. 2014; Martynec et al. 2011; Shackley 2005).

Vierra (2005). Vierra (2005) reports on the provenance data obsidian artifacts from the Late Archaic/Early Agricultural *cerros de trincheras* site of Cerro Juanaqueña in northwestern Chihuahua, located approximately eight kilometers east of the modern town of Janos and 60 kilometers north of Paquimé. Although this site is much earlier than the Medio period, dated to 1250 B.C. (Hard and Roney 1999, 2007), Vierra's (2005) discussion of obsidian from the site provides the first thorough obsidian sourcing study in northwestern Chihuahua (see also Shackley 1999).

Vierra's (2005) study contributes to the understanding of obsidian procurement in northwestern Chihuahua. The results demonstrate that people at Cerro Juanaqueña used a variety of obsidian sources from northern Chihuahua and southern New Mexico. The most commonly used source is Chihuahua Unknown A, but unfortunately, archaeologists do not know where the primary or secondary sources are located. Other sources include the more extensively studied Antelope Wells in southern Hidalgo County, New Mexico, and Sierra Fresnal and Los Jagüeyes in northern Chihuahua.

Groups occupying southern New Mexico use all three of these sources (Dolan 2012; Putsavage 2015; Taliaferro et al. 2010). Artifacts made from Lago Fredrico obsidian are rare in archaeological assemblages and this source likely did not play an important role in the lithic manufacture, unlike the other sources represented.

Kibler et al. (2014). Kibler et al. (2014:184) provided an important discussion on the use of Selene obsidian in a broader context of Medio period archaeology.

> The Selene obsidian source is located in the far eastern parts of the Rio Sonora culture area, near its boundary with the Casas Grandes culture area. While the principal Casas Grandes site of Paquimé is only ca. 120 km east-northeast of the Selene source, provenance studies of obsidian artifacts from Paquimé show that the materials come from local sources and the Antelope Wells source in southwestern New Mexico (Shackley 2005:81; Shackley in Fish and Fish 1999:40). This suggests that Casas Grandes peoples did not have access to the Selene source, either through direct procurement or trade, nor did they need access given the presence of local sources and access to the Antelope Wells source.

More investigation is required regarding the distribution of Selene obsidian through time and space, but Kibler et al. (2014) demonstrate the use of this obsidian source is rare in obsidian assemblages at sites in southern Arizona, northern Sonora, northern Chihuahua, and southern New Mexico. In the above quote from Kibler et al. (2014:184), they state that obsidian at Paquimé came from local sources and Antelope Wells. The sources closest to Paquimé are Lago Fredrico (Ojo Fredrico) 56 kilometers north, Sierra Fresnal at 73 kilometers northeast, Sierra la Breña at 74 kilometers northwest, Agua Fria 92 kilometers northwest, Los Jagüeyes at 92 kilometers east, and Lago Barreal at 101 kilometers northeast. According to Kibler et al. (2014:184), Selene is 120 kilometers away from Paquimé. Archaeologists know there are other obsidian sources present in northern Chihuahua based on geochemistry, but the geographic location of the primary and secondary source distribution is unknown (Shackley 2005).

For instance, Chihuahua Unknown A and B may be closer to Paquimé. More fieldwork in northwestern Mexico is needed to determine the extent of primary and secondary deposits since lithic materials erode into river systems and could be collected closer to sites, and as such, comparisons of the distances between sites and obsidian sources could possibly be meaningless.

Chapter 3 Summary

In this chapter I discussed generally how obsidian is formed, terms and concepts archaeologists and geologists use when using sourcing studies, as well as the EDXRF method, and archaeological research concerning the provenance of obsidian artifacts in the SW/NW. There are so few obsidian sources on the SW/NW landscape compared to other chipped stone raw material outcrops, but because each obsidian source has a relatively homogenous geochemical signature but each are statistically different from other sources for source provenance testing, obsidian is the chipped stone material most helpful in reconstructing regional and macroregional patterns of lithic production, exchange, and consumption. As a result, in the next chapter, I discuss the research measures and expectations, as well as give a brief description of the 26 archaeological sites used in this study.

Chapter 4: Methodology

I explains the methodology and measures used for this dissertation study here in Chapter 4. This includes a discussion of which sources people used in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. I take a multiscalar approach with the data, and I discuss the differences among macro-, meso-, and microscale. I also include how these data were collected and the archaeological sites used in this study.

Research Methods

In this section, I explain the research methods used for this study. First, I briefly describe the obsidian samples I used during data collection, as well as my sampling strategy. I then discuss the 26 archaeological sites I used for this study and clarify/identify the number of sourced obsidian artifacts from each site. I also enumerate the reasons why each site was selected. Finally, I discuss how the sourcing results are interpreted using a multiscalar perspective.

The Obsidian Sample, Data Collection, and Archaeological Sites

The obsidian artifacts used in this dissertation came from 26 archaeological sites in southwestern New Mexico and northwestern Chihuahua that were collected either on the surface or subsurface during excavation and/or survey (Table 4.1). I chose the sites to maximize the potential for identifying differences in procurement strategies among people through time and space, as well as intervillage social dynamics reflected in obsidian procurement from A.D. 1000 to 1450. I also chose the sites based on the number of obsidian artifacts available or the sample size of already sourced artifacts. Most of the 26 archaeological sites examined here are not located close to any one particular obsidian source, except for the sites in the Animas Valley. This lays the groundwork for a source provenance study that is likely to yield many different obsidian sources among the sites, because people had different social relationships with others in the SW/NW and obsidian could be obtained from sources in most directions.

Because archaeologists working in southwestern New Mexico have recently sourced many obsidian artifacts, myriad data are available in publications, dissertations, and conference proceedings (Putsavage 2015; Kenmotsu et al. 2014; Taliaferro 2004, 2014; Taliaferro et al. 2010; VanPool et al. 2013). I also sourced obsidian artifacts specifically for this dissertation study from sites previously not investigated in the Animas Valley, the Uvas Valley, and the Casas Grandes Valley, as well as data that I have previously collected and or obtained through collaboration with other archaeologists (Dolan 2012; Dolan and Ferguson 2012; Dolan and Livesay 2015; Dolan and Putsavage 2012) (Table 4.1).

Table 4.1 Archaeological Sites Used in This Study.

Region	Site Name/Number	Letter Code	Period/Phase	Artifact Count	Obsidian Reference
Mimbres	Badger Ruin (LA 111395)	A	Mimbres Classic	17	Taliaferro et al. 2010
	Disert (LA 15021)	B	Cliff	36	Putsavage 2015; Taliaferro et al. 2010
	Galaz (LA 635)	C	Late Pithouse/Mimbres Classic	90	Taliaferro et al. 2010
	Jackson Fraction Ruin (LA 111413)	D	Mimbres Classic	21	Taliaferro et al. 2010
	Janss (LA 12077)	E	Cliff	27	Putsavage 2015
	Montoya (LA 15075)	F	Black Mountain	14	Putsavage 2015;
	Old Town (LA 1113)	G	Late Pithouse/Mimbres Classic/Black Mountain	174	Taliaferro 2004; Taliaferro et al. 2010
		G	Black Mountain	14	Taliaferro 2014
	Stailey (LA 18939)	H	Cliff	35	Putsavage 2015
	Swarts (LA 1691)	I	Late Pithouse/ Mimbres Classic	24	Taliaferro et al. 2010
	Walsh (LA 15044)	J	Black Mountain	26	Putsavage 2015
	Lake Roberts (LA 47821)	K	Mimbres Classic	44	This dissertation
Deming	Black Mountain (LA 49)	L	Black Mountain	111	Dolan and Putsavage 2012; Putsavage 2015
		L	Cliff	76	
		L	Unknown	34	
	Columbus Pueblo (LA 85774)	M	Mimbres Classic	10	Griffith et al. 2012; Kenmotsu et al. 2014
	Kipp Ruin (LA 153465)	N	Cliff	48	Dolan 2012; Dolan and Ferguson 2012
	Red Mountain (LA 19188)	O	Late Pithouse/ Mimbres Classic	1	Taliaferro et al. 2010

Region	**Site Name/Number**	**Letter Code**	**Period/Phase**	**Artifact Count**	**Obsidian Reference**
Deming	76 Draw (LA 156980)	P	Cliff	131	VanPool et al. 2013
Uvas Valley	Amelia's Site (LA 176740)	Q	Mimbres Classic	19	This dissertation
	LA 173885	R	Mimbres Classic	22	This dissertation
Animas Valley	Box Canyon (LA 4980)	S	Animas	1	This dissertation
	Cabin Wells (LA 89227)	T	Mimbres Classic	5	This dissertation
	Clanton Draw (LA 4979)	U	Animas	1	This dissertation
	Joyce Well (LA 11823)	V	Animas	34	This dissertation
Casas Grandes	Site 204	W	Medio	37	This dissertation
	Site 242	X	Medio	8	This dissertation
	Site 315	Y	Medio	65	This dissertation
	Site 317	Z	Medio	6	This dissertation

Note: Each archaeological site has a designated letter (A through Z). This helps to format Table 5.1 in Chapter 5.

I sent all obsidian artifacts collected specifically for this dissertation to Shackley at the Geoarchaeological XRF Laboratory in Albuquerque, New Mexico for EDXRF analysis (see Table 4.1). Although there are other archaeological laboratories in the United States that can perform XRF analysis, like at the Missouri University Research Reactor (MURR), the Geochemical Research Laboratory, and the Northwest Research Obsidian Studies Laboratory, Shackley has an intimate knowledge of the geology, archaeology, and geochemistry of obsidian in the SW/NW as evidenced by his many publications on these topics. XRF was chosen as the sourcing method rather than neutron activation analysis (NAA), or other sourcing techniques because, as I discussed earlier in Chapter 3 (Table 3.1), the EDXRF version of XRF is non-destructive, and cost-efficient, and the results are obtained quickly. Many museums do not allow destructive analyses to be performed on the artifacts, and so because the artifacts specifically chosen for this dissertation were curated in museums, EDXRF analysis was chosen.

After EDXRF sourcing analysis was complete, I compiled all data into Excel spreadsheets. Each sheet contained the archaeological site and Laboratory of Anthropology number (if the site was in New Mexico), the time period of the site, the number of sourced artifacts, the publication reference, and site location information (county, zone, UTM coordinates). Coordinates were obtained with permission from the New Mexico Archaeological Records Management Section (ARMS). Archaeological site locations are sensitive information that is not for public use, and exact UTM coordinates are not disclosed in this dissertation. Only the general location of each site is illustrated in figures.

Because some data were compiled from previously sourced artifacts that archaeologists submitted to various laboratories, some source names may not be consistent. For instance, MURR calls Cerro Toledo by its other name of Obsidian Ridge, and El Rechuelos can be found as Polvadera Peak. I use Shackley’s (2005, 2013) nomenclature for source names, because he performed the EDXRF analysis on artifacts collected for this dissertation. Importantly, however, even though source names may be inconsistent across projects or laboratories, the geochemical characterizations are consistent. For example, Putsavage (2012, 2015:244) sent 47 obsidian artifacts from the Black Mountain site to MURR and to Shackley’s Geoarchaeological XRF Lab for EDXRF comparison, and the results demonstrated both labs are comparable.

It is also important to keep in mind that some archaeologists may neglect to specify which subsource was identified. For instance, Mule Creek or Mount Taylor may be given, whereas the subsources of Mule Creek or Mount Taylor (e.g., Antelope Creek and Horace Mesa, respectively) are not.

Archaeologists should note which subsource people used because if an archaeologist were to lump all Mule Creek obsidian into one general category during a sourcing project, procurement patterns to differentiate between one subsource and another would not be as effective for addressing archaeological questions. It is therefore important to distinguish among subsources because it may prove essential in understanding differences in procurement (Eerkens and Rosenthal 2004). Because of this, I do differentiate between subsources when possible.

I briefly discuss below the archaeological sites used in this study (Figure 4.1). I do not give an in-depth analysis of each site, but I do cite pertinent information including background, location, time period, and how many obsidian artifacts each contributed to the study. I use a database of sourced obsidian artifacts from 26 sites dating to the Mimbres Classic period and Black Mountain and Cliff phases in the Mimbres region of southwestern New Mexico, the Animas phase in southern Hidalgo County, New Mexico, and the Medio period in the Casas Grandes region of northwestern Chihuahua (Table 4.1). Although the Deming basin and range is just south of the Mimbres Valley, I differentiate between the two regions with all sites north of and including the Old Town site as part of the Mimbres Valley and all sites south of Old Town as part of the Deming region. I do this because the Deming basin and range is at a lower elevation and has a more desert scrub environment as compared to the Mimbres

Valley, which at a higher elevation and has more rainfall (Brown 1994; Minnis 1985:70-98).

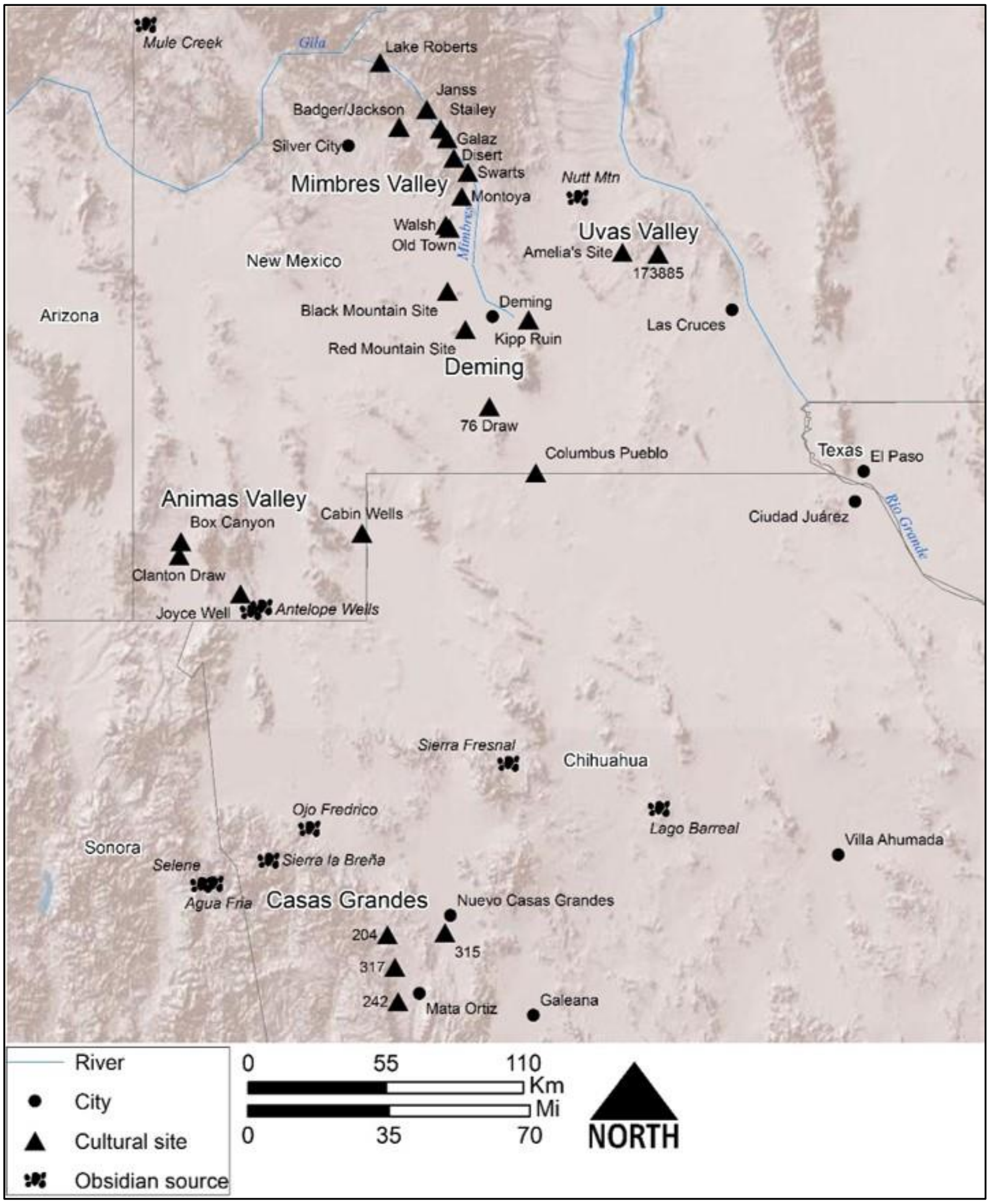

Figure 4.1. Location of archaeological sites in southwestern New Mexico and Northwestern Chihuahua used in this study.

Mimbres Valley Sites. Eleven sites used in this study are located in the Mimbres Valley or close to it in southwestern New Mexico. Thanks in part to the Mimbres Foundation's excavations and surveys in the 1970s and other long-term projects in this region, many of the sites shown in Figure 4.1 have been thoroughly investigated. These include Swarts (Cosgrove and Cosgrove 1932), Galaz (Anyon and LeBlanc 1984), Old Town (Creel 2006a), Disert, Stailey, and Janss (Nelson and LeBlanc 1986), and Walsh and Montoya (Ravesloot 1979). Other sites like Jackson Fraction, Badger Ruin, and Lake Roberts (Brown 1999a, 1999b; Chapman 2011) are relatively less known and are located to the west and north of the Mimbres Valley proper, but are included as part of it because of proximity and the similarity in environment

The Mimbres Classic period (A.D. 1000-1130) sites of Badger Ruin and Jackson Fraction are located in the Gila Valley (Brown 1999a, 1999b). Seventeen obsidian artifacts were sourced at Badger Ruin, and 21 were sourced at Jackson Fraction (Taliaferro et al. 2010).

Disert, Stailey, and Janss date to the Cliff phase (Nelson and LeBlanc 1986). Janss and Stailey are located in the upper Mimbres River, and Disert is further down the river closer to Swarts. Thirty-six obsidian artifacts were sourced from Disert (Taliaferro et al. 2010; Putsavage 2015). Twenty-seven obsidian artifacts from Janss (Putsavage 2015), and 35 obsidian artifacts were sourced from Stailey (Putsavage 2015).

Galaz is one of the most discussed sites in the Mimbres Valley because of the extensive excavation project by the Mimbres Foundation although the site was also excavated in the early 1930s (Anyon and LeBlanc 1984; Creel and Anyon 2003; Hegmon 2002). The site has a long occupation starting with the presence of

Georgetown phase pithouses all the way through Terminal Classic period pueblo occupations. Galaz has the two largest Great Kivas located in the Mimbres region, and so the site most likely was a ritual and ceremonial center for people living in the region (Creel and Anyon 2003). Taliaferro et al. (2010) sourced 90 obsidian artifacts from Galaz.

Swarts is located along the middle Mimbres River, and the Cosgroves excavated the site in the early twentieth century (Cosgrove and Cosgrove 1932). The site has a long occupation with at least Late Pithouse and Mimbres Classic period components. Taliaferro et al. (2010) sourced 24 obsidian artifacts from Swarts.

Old Town is another important ceremonial Mimbres Classic period site similar to Galaz, and it is located on the middle-lower part of the Mimbres River. Excavations have revealed a long occupation including pithouse architecture dating to the end of the Early Pithouse period all the way through Black Mountain phase components. Although much looting has occurred at Old Town, intensive excavations by professional archaeologists have given new insights into Mimbres community organization during the Late Pithouse period and Mimbres Classic period (Creel 2006a, 2006b; Creel and Anyon 2003). One hundred seventy-four obsidian artifacts from Late Pithouse/Mimbres Classic period contexts were sourced, and 14 obsidian artifacts were sourced from Black Mountain phase components at Old Town (Taliaferro 2004, 2014; Taliaferro et al. 2010).

Montoya and Walsh date to the Black Mountain phase (Ravesloot 1979). They were recently discussed in Taliaferro (2014) and Putsavage (2015). Montoya has 14 sourced obsidian artifacts (Putsavage 2015), and Walsh has 26 (Putsavage 2015).

The Lake Roberts site dates to the Mimbres Classic period. It was recently excavated by the Office of Contract Archeology, University of New Mexico (Chapman 2011). Shackley (2014a) sourced 44 obsidian artifacts from the site for my research

Deming Sites. Obsidian sourcing data from five sites in Deming were used in this study, including Black Mountain, Columbus Pueblo, Kipp Ruin, Red Mountain, and 76 Draw. Black Mountain is the type site for the Black Mountain phase (A.D. 1150-1300), and it is one of the largest sites in the Deming region with an estimated 300 rooms (Lekson 2006; Putsavage 2012, 2015). The Mimbres Foundation mapped the site (Minnis and LeBlanc 1979; Ravesloot and Minnis 1976), and then Putsavage excavated it for her dissertation (Putsavage 2012, 2015; Putsavage and Lekson 2010).

The Black Mountain site also has a Late Pithouse period and Cliff phase components to it. Putsavage (2015:255) reports that obsidian represents only five percent of the total Black Mountain site flaked stone assemblage, but this is the largest sourced obsidian sample dating to the Black Mountain phase. Seven additional pieces of obsidian were sourced from the site but are in the Late Pithouse component, which I did not use in this research. The Late Pithouse assemblage is discussed elsewhere (Dolan 2012; Dolan and Ferguson 2012; Dolan and Putsavage 2012; Putsavage 2015). The Black Mountain phase component of the site has a total of 111 sourced artifacts, and the Cliff phase has 76.

Columbus Pueblo is located near the New Mexico and Chihuahua border. Excavated by Geo-Marine, the site dates to the Mimbres Classic period (Griffith et al. 2012; Kenmotsu et al. 2010, 2014). Ten obsidian artifacts were sourced (Shackley 2010).

Kipp Ruin was excavated as part of a New Mexico State University field school led by William Walker. The area around Kipp Ruin, along the lower Mimbres River near Deming, was first described in the early twentieth century by some of the pioneering southwestern archaeologists, but it was known at the time as the Byron Ranch Ruin (Duff 1902:399; Fewkes 1914:12; Hough 1907:88). No peer-reviewed publications exist describing the site, but New Mexico State University graduate students have written Master's theses on the animal bones and ceramics (DeBry 2012; Kroulek 2011; see also Swanson et al. 2012: Figure 7.1). Obsidian artifacts from Late Pithouse and Cliff phase contexts were sourced from Kipp Ruin (Dolan 2012). Forty-eight obsidian artifacts including chipped stone debitage and projectile points were sourced from the Cliff phase component of Kipp Ruin. The Late Pithouse results are not discussed in this dissertation because the time period dates before A.D. 1000.

The Red Mountain site is located approximately 17 kilometers southeast of the Black Mountain site near Deming. The Mimbres Foundation recorded the site and gave it the site number Z:13:21. It is dated to the Mimbres Classic period. Only one obsidian artifact was sourced from this site, but it is included in this study because few obsidian artifacts have been sourced near Deming (Taliaferro et al. 2010).

The 76 Draw site is located approximately 35 kilometers south of Deming. The site has been excavated recently as a field school by the University of Missouri and University of North Florida (Rakita et al. 2011). Due to the presence of Chihuahuan ceramics, the site dates to the Cliff phase. A total of 131 obsidian artifacts were sourced (VanPool et al. 2013).

Uvas Valley Sites. Two sites in the Uvas Valley are used in this study. Both sites are discussed in Dolan and Gilman (2015). Amelia's site dates to the Mimbres Classic period based on surface ceramics. Nineteen obsidian artifacts were sourced. The other site, LA 173885, was recorded as part of a mitigation project by Mark Sechrist at Full Circle Heritage Services after the Las Cruces BLM Field Office observed looting there. LA 173885 is a large site that has a Classic Mimbres period components to it. As part of the 2013 Southern Mimbres Archaeological Project by Dolan and Gilman (2015), 22 obsidian artifacts were collected from the surface of LA 173885 and Shackley (2013b) sourced them.

Animas Valley Sites. Four sites were investigated in Hidalgo County, New Mexico in the Animas Valley. Three of the sites are associated with the Animas phase (Box Canyon, Clanton Draw, and Joyce Well), and there is one Mimbres Classic period site (Cabin Wells).

McCluney (1962, 1965) excavated all three Animas phase sites used in this study including Joyce Well which was later re-excavated in the 1990s by Skibo et al. (2002). Excavations revealed the sites have ceramic and architectural features connecting them to the Casas Grandes regional system (Carpenter 2002; Fish and Fish 1999). Thirty-four obsidian artifacts were sourced from Joyce Well and Box Canyon and Clanton Draw each had one artifact sourced.

The only Mimbres Classic period site in the Animas Valley used in this study, Cabin Wells, was not excavated, but it was re-recorded as part of a Southern Mimbres Archaeological Project survey in 2012 by University of Oklahoma and the Las Cruces Bureau of Land Management (BLM) Field Office (Livesay et al. 2015). Cabin Wells is multi-component including Early Pithouse, Late Pithouse, and Mimbres Classic period components. The Mimbres Classic component seems to consist of a large room block area that runs west-east on the east side of the site. The pueblo part of the site is unfortunately bulldozed. Five obsidian artifacts were sourced as part of the 2012 SMAP survey (Livesay et al. 2015).

Casas Grandes Sites. Shackley (2014b) sourced obsidian artifacts from four Medio period sites in northwestern Chihuahua for this dissertation study. This dissertation represents the first thorough study of Medio period obsidian procurement using geochemical sourcing methods. Whalen and Minnis (2001a, 2009a, 2009b) excavated sites 204, 242, 315, and 317, and I discuss the sourcing results from 116 obsidian artifacts from those sites. Site 204, also known as La Tinaja, is one of the largest Outer Core Zone sites. It is located 17 kilometers west of Paquimé (Whalen and Minnis 2009a:12-25). The site has a long occupation with pithouse structures underneath the Medio period pueblo, but the latter is the major period of use (mid-twelfth century to the early fourteenth century). There is a small data set from the early Medio period (about A.D. 1150-1300), and there is a substantial increase in the quantity of ritual paraphernalia during the late Medio period (about A.D. 1300-1400) occupation of the site. Obsidian was more common in the early part of the occupation (Whalen and Minnis 2009a:186, 214). I sourced 37 obsidian artifacts, of which 34 were flakes and three were projectile points.

Site 242 is the southernmost site used in this study, and it is located 27 kilometers southwest of Paquimé in the most distant part of the Outer Core Zone (Whalen and Minnis 2009a:33-40). This site is a small Medio period community with about 20 rooms, a large I-shaped ball court, and architectural elaboration similar to Paquimé but on a much smaller scale. Because of these features, Whalen and Minnis (2009a:33-40) suggest site 242 is a special administrative satellite of Paquimé with close contacts to the center. I sourced eight obsidian flakes from the site.

The medium-sized residential site of 315 is only two kilometers from Paquimé and on the Rio Casas Grandes. Elites likely lived there as evidenced by the many exotic artifacts looted there in the past (by local report) and found during excavations (Whalen and Minnis 2009b). I sourced 65 obsidian artifacts from site 315.

Site 317 is located in the middle of the broad piedmont slope above the confluence of the Piedras Verdes and Palanganas Rivers, approximately 19 kilometers west of Paquimé on the periphery of the Outer Core Zone (Whalen and Minnis 2009a:25-32). This is the smallest of the four sites investigated here, and it consists of a cluster of three small room block mounds with two large earthen ovens. The site dates to the late thirteenth century and has evidence for occupation continuing until the early sixteenth century. I sourced six obsidian artifacts from the site.

The Multiscalar Perspective

I interpret all results using a multiscalar perspective similar to that of Mills et al. (2015). Examining the data at macro-, meso-, and microscales of analysis is a way to tack back and forth between broad and overarching patterns of obsidian procurement versus finer-grained temporal, geographic, and site level interpretations through time (Table 4.2). This approach helps to illustrate whether obsidian procurement was homogenous or heterogeneous in a particular time period or region. Each scale of analysis yields different interpretations of the sources that people used.

Table 4.2. Explanation of Macro-, Meso-, and Microscales.

Macroscale	All obsidian data are combined to observe broad patterns of obsidian procurement.
Mesoscale	Obsidian sourcing data are separated into time periods/phases and geographic regions to discern temporal and regional patterns of obsidian procurement.
Microscale	Temporal and spatial data are examined at the site level to investigate whether there are differences or similarities among sites in the same region and time period.

The macroscale is the most general form of analysis. The temporal and spatial data are not separated, but instead, all source provenance analyses are combined to obtain broad overarching patterns of obsidian source use. No differentiation is given between regions or time periods/phases in the macroscale analysis. This analysis provides a broad view of obsidian procurement in all times and all places.

The mesoscale analysis does separate the temporal and regional patterns to obtain finer-grained resolution. At this level of analysis, temporal and regional procurement practices can be seen in the archaeological record. This part includes two sections. The first section involves a discussion of the obsidian sourcing data from each time period/phase. For example, I combine all sourcing data from sites that date to the Mimbres Classic period no matter from what region. The second section takes all the obsidian sourcing data from each region (e.g., Deming basin and range) no matter what time period.

Finally, at the microscale, the details of specific obsidian procurement practices are at the individual site level. Individual sites are assessed to elucidate regional and temporal differences in more detail as opposed to the macro- and mesoscale discussions.

Chapter 4 Summary

In this chapter, I defined the methodology and measures used for this dissertation. I described how the obsidian data were assemblage and provided a brief description of the archaeological sites the obsidian artifacts came from. In total, I used sourcing data from 1,132 obsidian artifacts from 26 archaeological sites dating from A.D. 1000 to 1450 located in southwestern New Mexico and northwestern Chihuahua. The 26 sites were divided into five geographic regions including the Mimbres Valley, the Deming basin and range, the Uvas Valley, the Animas Valley, and the Casas Grandes Valley. I did this to study obsidian procurement homogeneity and/or heterogeneity at the temporal and regional level. I also explained the multiscalar approach to examine obsidian sourcing data at the macro-, meso-, and microscale as a means to understand obsidian procurement through time and across space.

Chapter 5: Macroscale and Mesoscale Results

I present the results (Table 5.1) and a discussion of the EDXRF analysis on 1,132 obsidian artifacts from 26 archaeological sites in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450 in this chapter. In Table 5.1, the numbers along the horizontal axes are obsidian sources. Each of the 26 archaeological sites used in this study has a letter, and each of the 22 geochemically distinct obsidian sources present in my sample has a number listed in Table 5.2. The letters and numbers are only used in Tables 5.1 and 5.2 to help with formatting (see also Table 4.1). Elsewhere in this chapter, I do not use the letters or numbers. Instead, I use the archaeological sites name or State of New Mexico's Laboratory of Anthropology (LA) number when there is not a site name, and I use the obsidian source names or their abbreviation.

As mentioned in Chapter 4, I take these data and use a multiscalar approach to discuss the results. I compare and contrast the data using macro-, meso-, and microscales of analysis (Table 4.2). Each scale of analysis yields different results, and I provide a discussion of what each means for the archaeological record of southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. I first present the sourcing results for the macroscale, then the temporal and regional mesoscales in this chapter. I discuss the obsidian procurement patterns at each of the 26 archaeological sites investigated in this study at the microscale in the next chapter

Table 5.1. Sourcing Results from All Sites.

Site	Period/Phase	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
A	Mimbres Classic	-	-	-	13	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	17
B	Cliff	-	-	-	33	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	36
C	Late Pithouse/Mimbres Classic	2	1	-	74	-	5	7	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	90
D	Mimbres Classic	-	-	-	16	-	-	2	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	21
E	Cliff	-	-	-	24	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	27
F	Black Mountain	-	-	-	7	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	14
G	Mimbres Classic	4	1	-	109	-	1	48	-	-	8	-	-	-	3	-	-	-	-	-	-	-	-	174
G	Black Mountain	-	-	-	10	-	-	-	-	-	2	1	-	-	1	-	-	-	-	-	-	-	-	14
H	Cliff	-	-	-	30	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35
I	Late Pithouse/Mimbres Classic	-	-	-	21	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24
J	Black Mountain	-	-	-	17	-	-	-	-	-	-	3	4	1	1	-	-	-	-	-	-	-	-	26
K	Mimbres Classic	-	-	-	39	2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	44
L	Black Mountain	-	2	2	48	-	2	-	-	-	-	36	3	-	8	-	-	-	-	-	-	9	2	112
L	Cliff	-	-	-	44	-	1	-	-	-	-	21	1	1	3	-	-	-	-	-	-	5	-	76
L	Unknown	-	-	-	15	-	-	-	-	-	-	12	-	-	7	-	-	-	-	-	-	-	-	34
M	Mimbres Classic	1	-	-	1	-	-	-	-	-	-	1	-	-	7	-	-	-	-	-	-	-	-	10
N	Cliff	-	3	7	17	2	-	-	-	-	-	3	1	1	8	5	-	-	-	-	-	-	1	48
O	Late Pithouse/ Mimbres Classic	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1
P	Cliff	6	1	1	39	-	1	-	-	-	-	11	-	-	65	3	-	-	-	-	-	4	-	131
Q	Mimbres Classic	-	-	-	-	-	-	-	1	-	-	-	18	-	-	-	-	-	-	-	-	-	-	19
R	Mimbres Classic	10	2	-	1	-	-	-	2	3	-	-	4	-	-	-	-	-	-	-	-	-	-	22
S	Animas	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
T	Mimbres Classic	-	-	-	-	-	-	-	-	-	-	3	-	-	2	-	-	-	-	-	-	-	-	5
U	Animas	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
V	Animas	-	-	-	-	-	-	-	-	-	-	34	-	-	-	-	-	-	-	-	-	-	-	34
W	Medio	-	-	-	-	-	-	-	-	-	-	6	-	-	1	5	4	4	-	11	5	1	-	37
X	Medio	-	-	-	1	-	-	-	-	-	-	6	-	-	-	-	1	-	-	-	-	-	-	8
Y	Medio	-	-	-	-	-	-	-	-	-	-	16	-	-	25	2	5	3	1	5	6	2	-	65
Z	Medio	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	4	-	-	1	-	-	-	6
	Total	23	10	10	559	9	15	63	3	3	16	154	40	4	133	15	14	7	1	17	11	22	3	1.132

Table 5.2. Coding Sheet for Interpreting Table 5.1.

Archaeological Site	Letter	Obsidian Source	Number
Badger	A	Cerro Toledo (CT)	1
Disert	B	Cerro del Medio (CDM)	2
Galaz	C	El Rechuelos (ER)	3
Jackson	D	Antelope Creek (AC)	4
Janss	E	Mule Mountains (MM)	5
Montoya	F	North Sawmill Creek (NSM)	6
Old Town	G	SF/Blue River (SFB)	7
Stailey	H	Grants Ridge (GR)	8
Swarts	I	Horace Mesa (HM)	9
Walsh	J	Gwynn/Ewe (GWE)	10
LA 47821	K	Antelope Wells (AW)	11
Black Mountain	L	Nutt Mountain (NT)	12
Columbus Pueblo	M	Cow Canyon (CC)	13
Kipp	N	Sierra Fresnal (SF)	14
Red Mountain	O	Los Jagüeyes (LJ)	15
76 Draw	P	Agua Fria (AF)	16
Amelia's Site	Q	Selene (SEL)	17
LA 173885	R	Animas Mountains (AM)	18
Box Canyon	S	Chihuahua Unknown A (CHA)	19
Cabin Wells	T	Chihuahua Unknown B (CHB)	20
Clanton Draw	U	Unknown (UNK)	21
Joyce Well	V	Mount Taylor (MT)	22
Site 204	W	-	-
Site 242	X	-	-
Site 315	Y	-	-
Site 317	X	-	-

Macroscale Results

The macroscale analysis is the first level of discussion. Here, I present the sourcing results for all 1,132 obsidian artifacts from all sites (Table 5.3). The results indicate that 22 geochemically distinct obsidian sources from New Mexico, Arizona, Chihuahua, and Sonora are present in the assemblage. Of the 22 sources, 19 are geographically known, but three are geographically unknown (Chihuahua Unknown A, Chihuahua Unknown B, and one unknown). The unknowns are most likely near the international four corners in northern Sonora or Chihuahua.

Table 5.3. Macroscale Results.

Obsidian Source/Group	Number of Artifacts	Percent
Antelope Creek (Mule Creek)	559	49
Antelope Wells	154	14
Sierra Fresnal	133	12
SF/Blue (Mule Creek)	63	6
Nutt Mountain	40	4
Cerro Toledo (Jemez)	23	2
Unknown	22	2
Chihuahua Unknown A	17	2
Gwynn/Ewe Canyon	16	1
North Sawmill (Mule Creek)	15	1
Los Jagüeyes	15	1
Agua Fria	14	1
Chihuahua Unknown B	11	1
Cerro del Medio (Jemez)	10	1
El Rechuelos (Jemez)	10	1
Mule Mountain (Mule Creek)	9	1
Selene	7	1
Cow Canyon	4	< 1
Grants Ridge (Mount Taylor)	3	< 1
Horace Mesa (Mount Taylor)	3	< 1
Mount Taylor	3	< 1
Animas Mountains	1	< 1
Total	1,132	

The macroscale analysis demonstrates people primarily used three obsidian sources in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. People primarily made obsidian artifacts from Antelope Creek (n=559, 49 percent), Antelope Wells (n=154, 14 percent), and Sierra Fresnal (n=133, 12 percent). It is difficult to fully understand why Antelope Creek is the most dominant obsidian source at the macroscale level because the level of analysis is so broad. However, more in-depth interpretations behind these results can be given at the meso- and microscales.

Other than the three most commonly used sources, there are 19 other sources present in the macroscale assemblage, but because they consist of 25 percent of the assemblage, I do not discuss them in this section. Many of these 19 sources could be considered as outliers in the obsidian assemblage, for example obsidian from Mount Taylor, Cerro del Medio, and Cow Canyon. Outliers are certainly interesting and noteworthy because if people primarily used one or two obsidian sources, how did one piece from an uncommon source get to the site? This is one question that garners future attention.

Some of the obsidian sources are part of larger geochemical obsidian groups. There are four subsources of Mule Creek, three for the Jemez Mountains, and two for Mount Taylor. I combine all subgroups into their larger group (e.g., Antelope Creek into Mule Creek and El Rechuelos into Jemez) (Table 5.4). Cerro del Medio obsidian does not erode into the Rio Grande as the other Jemez sources do, and so I separate Cerro del Medio from the other Jemez sources.

Table 5.4. Macroscale Results Combining Source Groups.

Obsidian Group/Source	Number of Artifacts	Percentage
Mule Creek	646	57
Antelope Wells	154	14
Sierra Fresnal	133	12
Nutt Mountain	40	4
Jemez	33	3
Unknown	22	2
Chihuahua Unknown A	17	2
Gwynn/Ewe Canyon	16	1
Los Jagüeyes	15	1
Agua Fria	14	1
Chihuahua Unknown B	11	1
Cerro del Medio	10	1
Mount Taylor	9	1
Selene	7	1
Cow Canyon	4	< 1
Animas Mountains	1	< 1
Total	1,132	

The results presented in Table 5.4 do not change the overall macroscale patterns. Mule Creek, which includes the Antelope Creek, Mule Mountains, North Sawmill Creek, and San Francisco/Blue River subsources, still dominates the obsidian assemblage. Antelope Wells and Sierra Fresnal are still the second and third most used sources respectively. There are no changes in the lesser used sources.

The purpose of the macroscale analysis is to present a big and broad picture of obsidian procurement in the study area. There are general trends that can be elucidated from these results. The first trend is the significant use of Antelope Creek, Antelope Wells, and Sierra Fresnal glass. I discuss the procurement of each of these three sources below. I do not discuss the others because the 19 other sources present account for only 25 percent of the assemblage.

People in this study region made tools of Antelope Creek obsidian more than any other obsidian source. This is not surprising, however, as archaeologists have already established that Mule Creek was a very important toolstone source for people in southwestern New Mexico, starting in the Early Pithouse period and continuing through time (Mills et al. 2013; Putsavage 2015; Taliaferro 2004, 2014; Taliaferro et al. 2010). Why is the Antelope Creek material more often used than the other Mule Creek subsources like San Francisco/Blue River (n=63, 6 percent), North Sawmill Creek (n=15, 1 percent), and Mule Mountains (n=9, 1 percent)? There are three possible reasons for this. First, Antelope Creek is the most volumetrically available Mule Creek subsource because of secondary movement of cobbles through the Gila River alluvium in west-central New Mexico and as far west as Safford in southeastern Arizona (Shackley 1992, 1995, 2005). More collection areas of Antelope Creek were available on the landscape than the other Mule Creek sources.

The second possible reason why Antelope Creek is used more than the other Mule Creek sources is due to material quality. According to Shackley (personal communication, 2013), the western locality of Antelope Creek contains fairly large nodules that are high-quality material similar to Mule Mountain glass, although an eastern locality has Antelope Creek glass that is of lesser quality since some nodules explode upon impact (Chapter 3).

The third reason is a combination of the first and second. Because Antelope Creek cobbles can be collected near the many river beds in southwestern New Mexico and southeastern Arizona and because at least some cobbles are high-quality, people used Antelope Creek glass through time, and it eventually became part of one of their toolstone traditions. Rather than using other obsidian sources in the SW/NW, knappers used Antelope Creek glass because they were most familiar with it, and they were knowledgeable about where to find it on the landscape.

The second most used obsidian source is Antelope Wells with 14 percent of the total assemblage. This source is located near the border between New Mexico and Chihuahua in southern Hidalgo County, New Mexico, and cobbles erode 20 kilometers south into Chihuahua. It is difficult to ascertain why Antelope Wells obsidian is the second most popular media for obsidian toolstone production in this macroscale analysis, but a GIS least cost pathway analysis by Taliaferro et al. (2010) shows that Antelope Wells is the closest obsidian source in round-trip travel time from site to source for people living in parts of southwestern New Mexico. Despite this, however, artifacts made from Antelope Wells obsidian were rare in Taliaferro et al.'s (2010) study assemblage. Therefore, this dissertation study increases the archaeological visibility of Antelope Wells glass as it was a fairly popular toolstone material from A.D. 1000 to 1450. Also, more people may have incorporated Antelope Wells obsidian into their procurement strategy because of the rise of the Casas Grandes regional system starting in the thirteenth century A.D. Di Peso (1974:2:331-332, 1974:3:778) suggested Antelope Wells obsidian may have been an economic resource for Paquimé because Joyce Well and other Animas phase sites were located close to the source (Fish and Fish 1999:39-40). However, the comparison between obsidian procurement within the Casas Grandes region and in the Animas Valley cannot be completed at the macroscale level.

The third most used source is Sierra Fresnal at 12 percent of the total assemblage. The primary Sierra Fresnal source is located in northern Chihuahua approximately 100 linear kilometers south of the New Mexico border. Cobbles can be collected closer to the border because of streams moving them north (Shackley 2005). If artifacts produced from Sierra Fresnal glass are found at sites in southern New Mexico or even in west Texas, people could have collected the cobbles closer than the source, and so they might not have procured them directly from the source further south. This availability is most likely the reason why Sierra Fresnal obsidian is the third most used source in this assemblage. Also, many of the sites investigated in this study are located in southwestern New Mexico in the Mimbres Valley. Taliaferro et al. (2010) demonstrate that from the Mimbres Valley at Galaz, for example, Sierra Fresnal was the second closest source in round-trip travel time at 60 hours. Antelope Wells was the closest at 50 hours.

Summary of Macroscale Analysis

The purpose of a macroscale analysis is to give a broad and overarching picture of obsidian procurement from all sites and all time periods. Trends can be observed, but few patterns can be elucidated because all sourcing data are combined together. However, this is not to say that no patterns emerged. There are three obsidian sources located in different geographic and cultural regions that were primarily used. These include the Antelope Creek subsource of Mule Creek in west-central New Mexico, Antelope Wells in the New Mexico boot heel, and Sierra Fresnal in northern Chihuahua. Although these three sources were popular media for obsidian toolstone production, there is a tremendous difference between the extent of Antelope Creek, which is the overwhelmingly dominant source used and the second and third most used, which are Antelope Wells and Sierra Fresnal respectively. Antelope Creek, Antelope

Wells, and Sierra Fresnal make up 75 percent of the macroscale assemblage, whereas the remaining 25 percent consist of 19 other geochemically distinct sources.

What does this say about obsidian procurement at the macroscale level in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450? Many obsidian sources generally went unused, and Antelope Creek seems to be the one dominant source used by people in this study region, but Antelope Wells and Sierra Fresnal are also present. It is important to keep in mind this is only at the macroscale level. These results may change as a result of the analysis becoming more refined during the meso- and microscale. To investigate this, I present the results of the temporal mesoscale analysis in the next section.

Temporal Mesoscale Analysis

For the mesoscale analysis, I examine procurement patterns during the Mimbres Classic period, the Black Mountain phase, the Cliff phase, the Animas phase, and the Medio period. Unlike the regional mesoscale analysis that I discuss later in this chapter, I do not differentiate among regions in this analysis. In Table 5.5, I present the number and percent of sourced artifacts per time period. The most sourced artifacts derive from the Mimbres Classic period (n= 427) and the Cliff phase (n=353), followed by the Black Mountain phase (n=166) and the Medio period (n=116). The Animas phase obsidian assemblage has the lowest sample size of known temporal context with 36 artifacts. I include 34 artifacts that were sourced but come from unknown temporal contexts. I present the results below of each time period or phase in chronological order. First, I discuss artifacts dating to the Mimbres Classic period followed by the Black Mountain phase, the Animas phase, the Medio period, and finally the Cliff phase. I do not discuss artifacts from unknown temporal contexts, other than the artifacts derive from the Black Mountain site. Only three sources were characterized from this unknown context, Antelope Creek (n=15), Antelope Wells (n=12), and Sierra Fresnal (n=7).

Table 5.5. Number and Percent of Sourced Artifacts by Time Period/Phase.

Period/Phase	Number of Artifacts	Percentage of Assemblage
Mimbres Classic	427	38
Black Mountain	166	15
Animas	36	3
Medio	116	10
Cliff	353	31
Unknown	34	3
Total	1,132	

Mimbres Classic Period Obsidian

A total of 427 obsidian artifacts from 11 sites (Figure 5.1) dating to the Mimbres Classic period are used in this study. It should be noted that some artifacts from Galaz and Swarts possibly come from Late Pithouse period contexts but most are probably from Mimbres Classic period contexts (Taliaferro et al. 2010). The sourcing results (Table 5.6) indicate that 14 geochemically distinct sources are present in the 427 artifacts.

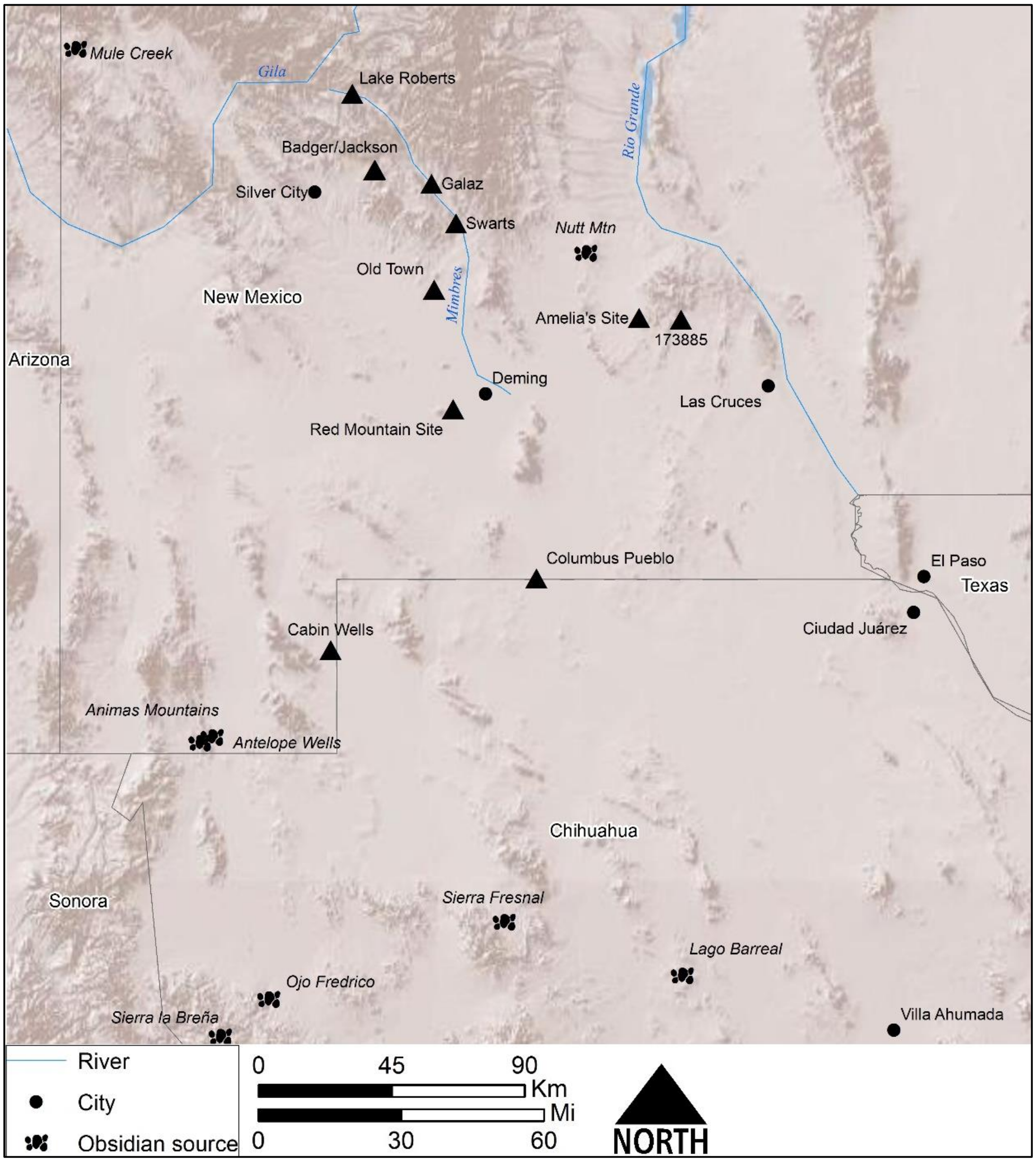

Figure 5.1. Location of Mimbres Classic period sites used in this study.
Note: Badger Ruin and Jackson Ruin are located 20 meters apart, and one triangle is used for both.

Table 5.6. Mimbres Classic Period Mesoscale Sourcing Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Creek	274	64
San Francisco/Blue	63	15
Nutt Mountain	22	5
Cerro Toledo	17	4
Gwynn/Ewe	14	3
Sierra Fresnal	13	3
North Sawmill	6	1
Cerro del Medio	4	1
Antelope Wells	4	1
Grants Ridge	3	1
Horace Mesa	3	1
Mule Mountains	2	< 1
Cow Canyon	1	< 1
Unknown	1	< 1
Total	427	

During the Mimbres Classic period, people made obsidian tools of Antelope Creek glass more than any other source (n=274, 65 percent). There is a difference between the use of Antelope Creek and the second most popular glass, which is another subsource of Mule Creek, San Francisco/Blue River (n=63, 15 percent). Artifacts made from Nutt Mountain (n=22, 5 percent), Cerro Toledo (n=17, 4 percent), Gwynn/Ewe Canyon (n=14, 3 percent), and Sierra Fresnal (n=13, 3 percent) are also present. Eight other sources occur, but each is one percent or less of the total assemblage.

In Table 5.7, I combine the subsources together into their larger source groups. The results demonstrate that Mule Creek is clearly the most dominant source used by people during the Mimbres Classic period. Nutt Mountain, which is third in the uncombined results, becomes the second most used source, although there is a drastic difference between the popularity of Mule Creek and the manufacture of Nutt Mountain obsidian artifacts. There is a small presence of Jemez Mountain obsidian that includes Cerro Toledo. El Rechuelos glass is also part of the Jemez Mountains, but no El

Rechuelos artifacts are present in this analysis. People most likely collected Cerro Toledo obsidian from the Rio Grande alluvium as it erodes into the Rio Grande and moves as far south as Las Cruces and El Paso (Church 2000; Shackley 2005, 2013). This is the same for the Mount Taylor artifacts.

Table 5.7. Mimbres Classic Period Mesoscale Sourcing Results with Subsources Combined.

Obsidian Group/Source	Number of Artifacts	Percent
Mule Creek	345	81
Nutt Mountain	22	5
Jemez (Cerro Toledo)	17	4
Gwyn/Ewe Canyon	14	3
Sierra Fresnal	13	3
Mount Taylor	6	1
Cerro del Medio	4	1
Antelope Wells	4	1
Unknown	1	< 1
Cow Canyon	1	< 1
Total	427	

There are differences in results when comparing the Mimbres Classic period data with those of the macroscale analysis. Although Antelope Creek (Mule Creek) has the highest number of sourced obsidian artifacts in both, the use of Antelope Wells and Sierra Fresnal are very low during the Mimbres Classic period when compared to the macroscale analysis.

The sourcing results show that people may have ventured in all directions to collect obsidian from other sources including east to the Rio Grande (Cerro Toledo) and Nutt Mountain, northwest to Cow Canyon, north to Gwynn/Ewe Canyon, Mount Taylor, and Cerro del Medio, and south for Antelope Wells and Sierra Fresnal, but these sources do not account for a high percentage in the Mimbres Classic period assemblage.

What then accounts for the small percentages of artifacts made from sources not from Mule Creek during the Mimbres Classic period? Most likely people obtained obsidian from these other sources via trade and exchange. During the Mimbres Classic period, archaeologists do see a substantial increase from the earlier Late Pithouse period in the amount of exotic objects like marine shell, scarlet macaws, and copper bells. The shell comes from the Hohokam region to the west, scarlet macaws come from further south in Mesoamerica, and copper bells likely are from West Mexico (Gilman et al. 2014; Vargas 1995; Vokes and Gregory 2007; Wyckoff 2009). However, obsidian from west Mexico, Mesoamerica, or elsewhere where shell, macaws, and copper bells derive from are not found at archaeological sites in southwestern New Mexico or northwestern Chihuahua.

The same trade or procurement networks by which people received Antelope Wells and Sierra Fresnal obsidian could have been the same ones connected to acquiring other exotica from the south. Another point to make is that there is obsidian in the Hohokam region, but sources the Hohokam mostly used like Vulture and Sauceda (Fertelmes et al. 2012) do not appear in southwestern New Mexico or northwestern Chihuahua from A.D. 1000 to 1450. However, Mule Creek is very common during the Mimbres Classic period, and some Mule Creek artifacts are present at Hohokam sites (Fertelmes et al. 2012; Peterson et al. 1997). There are two ways Hohokam groups could have obtained Mule Creek obsidian. First, they could have obtained it fairly close by because Mule Creek obsidian does enter stream beds that flow into southeastern Arizona closer to Hohokam settlements (Shackley 1992, 2005). They could also have obtained Mule Creek obsidian because there are strong connections between Hohokam and Mimbres groups during the Late Pithouse period and early in the Mimbres Classic period (Creel 1989, 2014; Hegmon and Nelson 2007; Lekson 1993, 2006, 2009). Mimbres groups could have ventured into the Hohokam region bringing with them Mule Creek obsidian, or Hohokam groups could have brought back Mule Creek obsidian while visiting groups in southwestern New Mexico. However, it should be emphasized that the obsidian sources typically used by Hohokam groups in the Phoenix and Tucson Basins like Sauceda, Vulture, and Superior are not found in this dissertation obsidian assemblage.

Obsidian sourcing data from these 11 Mimbres Classic period sites (Figure 5.1) suggest Antelope Creek obsidian was the only procurement tradition that existed. People rarely used glass from other sources, even though there were many from which to choose. Also, Taliaferro et al. (2010) demonstrate that Mule Creek was not the closest available source. Instead, it would have taken people less time to obtain Sierra Fresnal or Antelope Wells obsidian directly at the source. Because there is so much obsidian source homogeneity during the Mimbres Classic period, this partly corroborates Hegmon's (2002:339) postulation that Mimbres groups during the Classic period were "somewhat inward focused and isolated" (see also Minnis 1985). If the percentages of non-Mule Creek obsidian like Sierra Fresnal, Antelope Wells, or Mount Taylor were higher during the Mimbres Classic period, then people would have had obsidian social networks that connected them to a broader range of sources throughout the SW/NW.

Black Mountain Phase Obsidian

A total of 166 obsidian artifacts from four sites (Figure 5.2) dating to the Black Mountain phase are used in this study. The sourcing results (Table 5.8) indicate that 11 geochemically distinct sources are present. Ten of the sources are known geographically, but nine artifacts are from an unknown source.

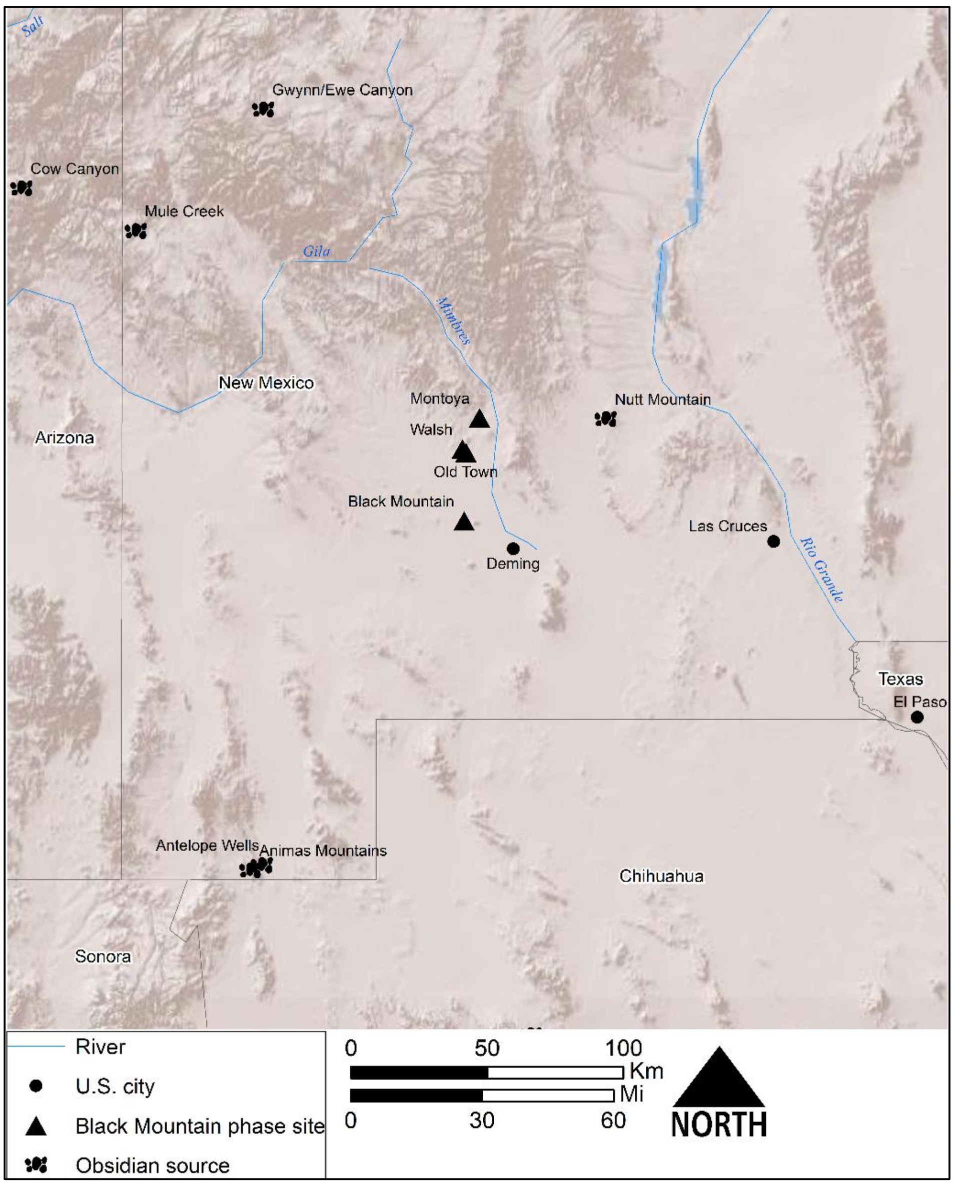

Figure 5.2. Location of Black Mountain phase sites used in this study.

Table 5.8. Black Mountain Phase Mesoscale Obsidian Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Creek	82	49
Antelope Wells	40	24
Nutt Mountain	14	8
Sierra Fresnal	10	6
Unknown	9	5
Cerro del Medio	2	1
Mount Taylor	2	1
El Rechuelos	2	1
North Sawmill	2	1
Gwynn/Ewe Canyon	2	1
Cow Canyon	1	1
Total	166	

Similar to the Mimbres Classic period assemblage discussed above, the Black Mountain phase assemblage consists primarily of artifacts produced from the Antelope Creek source (n=82, 49 percent) but in a much lower percent. There is a drastic increase in the use of Antelope Wells glass compared to the earlier Mimbres Classic period. Forty artifacts or 24 percent of the Black Mountain phase assemblage source to Antelope Wells, as opposed to four artifacts or about one percent of the Mimbres Classic period assemblage. This is the most significant difference between the two periods.

Nutt Mountain obsidian is the third most used source, and the use of this source increases through time (six percent in Black Mountain versus three percent in Mimbres Classic). Artifacts made from Sierra Fresnal obsidian are also present (n=10, six percent), as well as unknown source (n=9, 5 percent) during the Black Mountain phase. There are six other sources present, but they are rarely used.

In Table 5.9, I combine the subsources together into their larger source groups. The results demonstrate that Mule Creek is the most dominant source used by people during the Black Mountain phase (n=84, 51 percent). Unlike the Mimbres Classic period in which all four Mule Creek subsources are present, during the Black Mountain phase only the Antelope Creek and North Sawmill Creek subsources are present. Table 5.9 presents virtually the same results as shown in Table 5.8 because the obsidian sources with subsources (Jemez, Mule Creek, and Mount Taylor) only have one or two of their subsources.

Table 5.9. Black Mountain Phase Mesoscale Results with Subsources Combined.

Obsidian Group/Source	Number of Artifacts	Percent
Mule Creek	84	51
Antelope Wells	40	24
Nutt Mountain	14	8
Sierra Fresnal	10	6
Unknown	9	5
Jemez	2	1
Gwyn/Ewe Canyon	2	1
Mount Taylor	2	1
Cerro del Medio	2	1
Cow Canyon	1	1
Total	166	

Even though there were major changes in demography, social structure, and ceramic manufacture during the Mimbres Classic-to-Black Mountain phase transition around the mid twelfth century A.D. (Chapter 2), people continued their Antelope Creek obsidian tradition after A.D. 1130. Creel (1999), Taliaferro (2014), and Putsavage (2015) argue for continuity in some material culture practices during this transition (but see Shafer 1999), and the continued use of Antelope Creek also argues for continuity.

While people continued to use Antelope Creek glass through time, why did people increase the use of Antelope Wells, Sierra Fresnal, and Nutt Mountain glass during the Black Mountain phase when these sources were uncommon in Mimbres Classic period assemblages? As new populations moved into southwestern New Mexico after the end of the Mimbres Classic period around A.D. 1130, people brought in new ceramic types, ways of constructing pueblos, and perhaps knowledge of other obsidian source locations in the SW/NW. Therefore, it is possible that people from the south who were more familiar with the Antelope Wells and Sierra Fresnal sources moved into southwestern New Mexico during the Black Mountain phase.

Animas Phase Obsidian

A total of 36 obsidian artifacts from three sites (Figure 5.3) dating to the Animas phase are used in this study. The sourcing results (Table 5.10) indicate that two geochemically distinct sources are present from the 36 artifacts. This is the smallest sample size for both artifacts and sites in this dissertation, and so the results may be biased against rare sources.

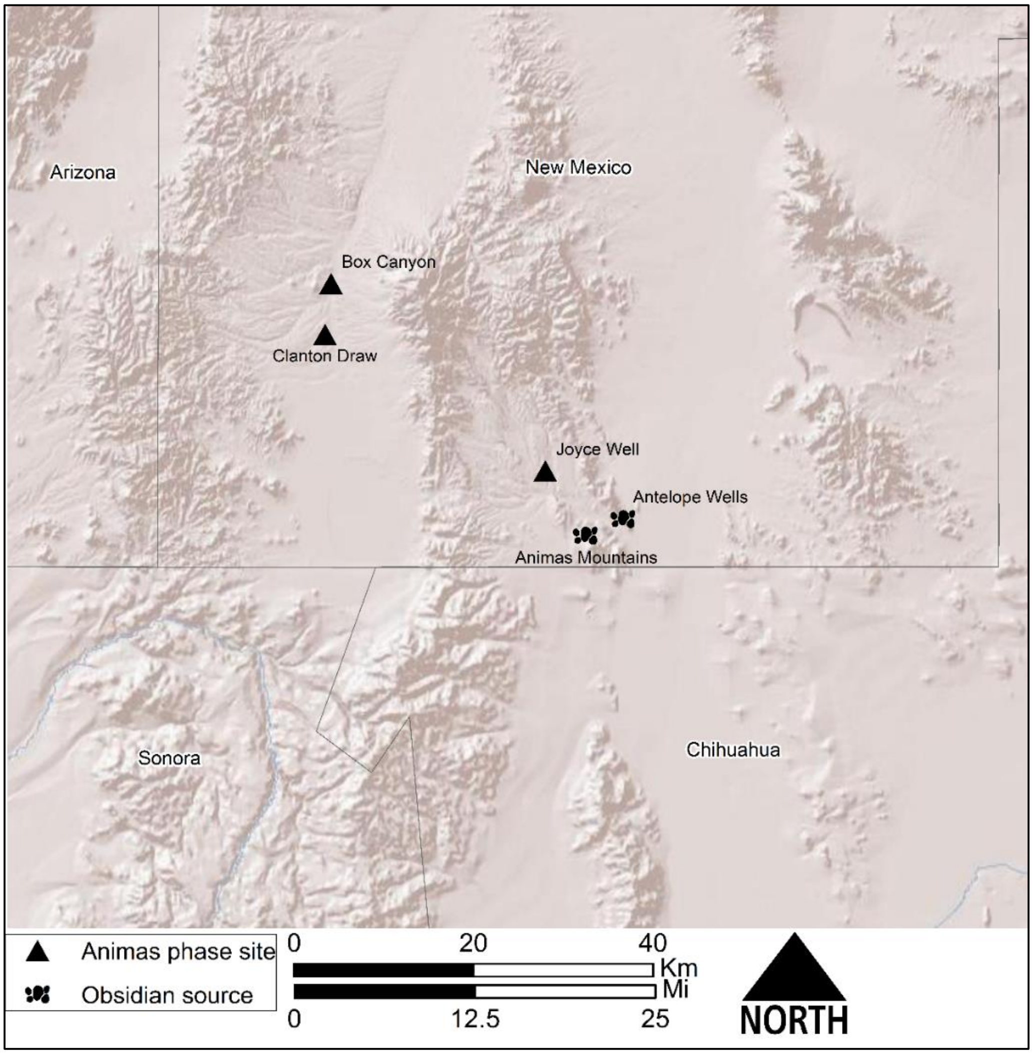

Figure 5.3. Location of Animas phase sites used in this study.

Table 5.10. Animas Phase Mesoscale Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Wells	35	97
North Sawmill Creek	1	3
Total	36	

The results suggest that people preferred Antelope Wells glass almost solely for obsidian stone tool manufacture. The preference for this glass is not surprising as the three sites investigated in this dissertation are located near Antelope Wells. However, people did not use Animas Mountains obsidian, which is almost equally close. If Animas Mountains obsidian is close to Antelope Wells, and close to Animas phase sites, why did people use Antelope Wells and not Animas Mountains? Perhaps the material quality of Animas Mountains is not as good as Antelope Wells, and the nodules may be smaller. Shackley (2014b) recently discovered Animas Mountains as a geochemically distinct obsidian source, and more work needs to be conducted to examine the primary and secondary deposits of this obsidian.

The one artifact from the Animas phase sites that characterizes to anything but the Antelope Wells source is a projectile point from the North Sawmill Creek subsource of Mule Creek. Mule Creek is over 200 linear kilometers north of the Animas Valley. Other artifacts included in this Animas phase assemblage consist of projectile points, but they source to Antelope Wells. Even though the Antelope Wells and Animas Mountains sources are next to these Animas phase sites, people used at least one other source for a projectile point. Due to the small sample size, however, it is difficult to assess if this North Sawmill Creek projectile point came into the site as a finished projectile point. Because no manufacturing debris from North Sawmill Creek was found, this point could have come into the site as a finished tool. More sourcing analysis is needed on Animas phase sites throughout the New Mexico boot heel to examine whether procurement practices expanded beyond these two sources.

Medio Period Obsidian

A total of 116 obsidian artifacts from four sites (Figure 5.4) dating to the Medio period are used in this study. The sourcing results (Table 5.11) indicate that 10 geochemically distinct sources are present from the 116 artifacts. Seven of the sources are known geographically, but three are unknown. This dissertation research is the first intensive study of Medio period obsidian procurement, and so it sets the baseline for future sourcing studies in northwestern Chihuahua during this time period. Because of this, I discuss the Medio period mesoscale data in more detail than the other time periods examined in this dissertation.

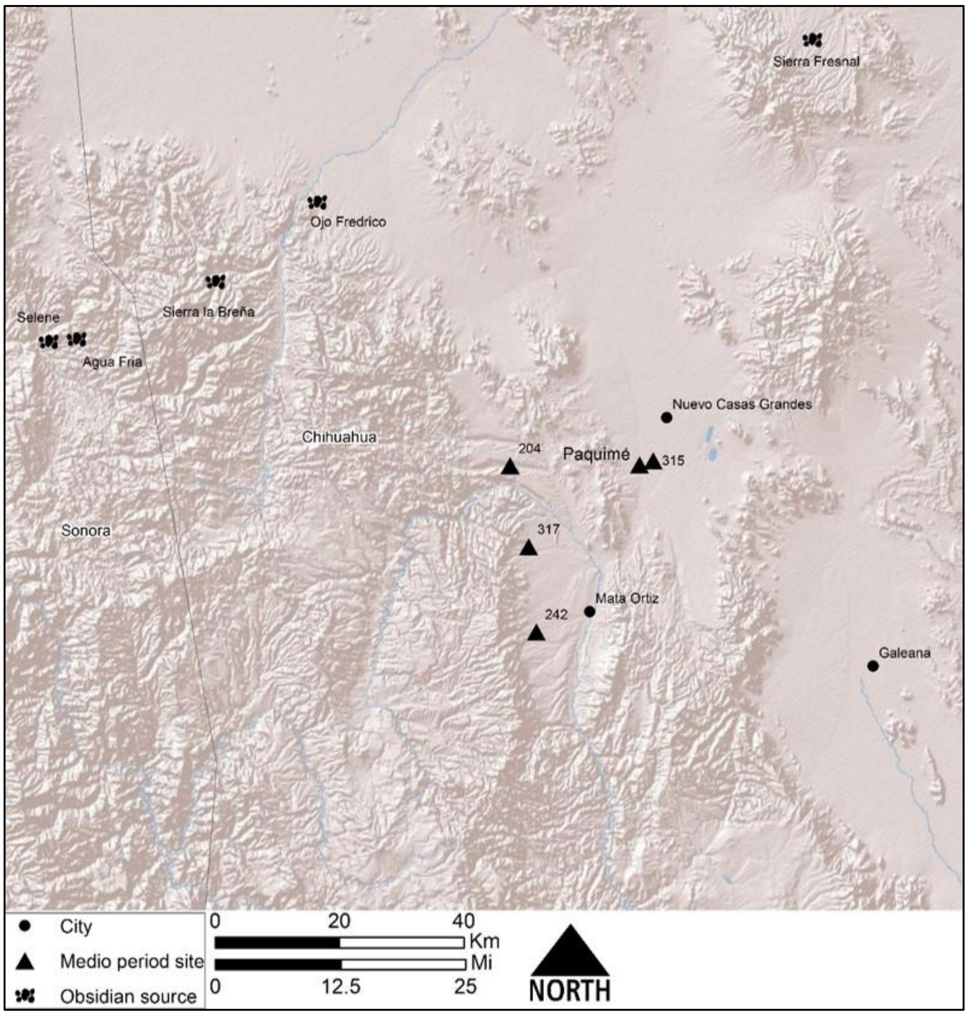

Figure 5.4. Location of Medio period sites used in this study.
Note: The site of Paquimé is included only to show its location in relationship to the other Medio period sites for which I have obsidian sourcing data.

Table 5.11. Medio Period Mesoscale Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Wells	28	24
Sierra Fresnal	27	23
Chihuahua Unknown A	17	15
Agua Fria	14	12
Chihuahua Unknown B	11	9
Los Jagüeyes	7	6
Selene	7	6
Unknown	3	3
Animas Mountains	1	1
Antelope Creek	1	1
Total	116	

The two most used sources during the Medio period are Antelope Wells (n=28, 24 percent) and Sierra Fresnal (n=27, 23 percent). Both are nearly equally represented in the assemblage. Antelope Wells and Sierra Fresnal occur at Mimbres Classic, Black Mountain, and Animas phase sites (and Cliff but see below), but the sourcing results indicate that obsidian procurement is more even among several sources during the Medio period compared to the other time periods. This is very different from the Mimbres Classic period, Black Mountain phase, and Cliff phase during which the second most used source is not close in percentage to the most used. The most used source during the Mimbres Classic period and Black Mountain phase is Antelope Creek, but Antelope Creek or any other Mule Creek subsources are not used during the Medio period to the same degree. Only one flake of Antelope Creek is present from the Medio period assemblage. However, this one flake derives from over 300 kilometers away. This is the “most exotic” piece of obsidian from the Medio period sites investigated here.

Other than Antelope Wells and Sierra Fresnal, the other obsidian sources present in the Medio period assemblage rarely occur at Mimbres Classic, Black Mountain phase, or Animas phase sites except for Sierra Fresnal, Los Jagüeyes, and an unknown source. Even still, these three sources are uncommon in southwestern New Mexico. Artifacts made of Chihuahua Unknown A, Agua Fria, Chihuahua Unknown B, Selene, and Animas Mountains obsidian only occur during the Medio period. These sources are located in Sonora or Chihuahua, but Animas Mountains is near Antelope Wells in the extreme boot heel of New Mexico close to the international border.

People during the Medio period used obsidian sources located primarily in Chihuahua and Sonora with the exception of Antelope Wells, although Antelope Wells obsidian erodes into Chihuahua. However, not all of the obsdiian sources from Chihuahua or Sonora are used. People did not use obsidian from Sierra la Breña, Ojo (Lago) Fredrico, and Lago Barreal (Figure 1.3). Sierra la Breña and Lago Barreal are discussed in Shackley (2005:80-82) and are artifact quality obsidian, whereas Shackley does not discuss the material quality of Ojo (Lago) Fredrico obsidian. These sources are also not reported in Darling (1993, 1998) or Fralick et al.'s (1998) work even though they focused on obsidian procurement in southern Chihuahua or in west Mexico. These three sources are rarely used at all, but Vierra (2005) does report the use of Lago Fredrico at Cerro Juanaqueña (see Vierra 2005 in Chapter 3).

The Antelope Wells source is located at least 100 linear kilometers northwest of Paquimé and is certainly not the closest available obsidian source, but it is difficult to determine the closest source because more fieldwork needs to be conducted to map primary and secondary obsidian source locations in northwestern Mexico. There are many sources present around the Casas Grandes region, and obsidian from all sources including Sierra Fresnal, Los Jagüeyes, and Chihuahua Unknown A, for example, could enter stream systems and travel closer to archaeological sites for easier procurement. A rough estimation of the primary Sierra Fresnal source is approximately 62 linear kilometers southwest of Paquimé, and this is possibly the closest available source. However, obsidian nodules are located along the Sierra Madre Occidental (Darling 1993; Fralick et al. 1998) straight west of Paquimé and would possibly be easier to obtain than Antelope Wells and Sierra Fresnal glass.

The Medio period obsidian results refute Di Peso's (1974; Di Peso et al. 1974) suggestion that people in the Casas Grandes region used obsidian sources from Durango or elsewhere further south in Mexico (see also Darling 1998 in Chapter 3). Although Di Peso was specifically discussing Paquimé, I suggest, based on my analysis, that artifacts produced from Mesoamerican obsidian sources are not present in the Casas Grandes region. On the other hand, I note that Paquimé is certainly an anomaly, like Pueblo Bonito, in the SW/NW in that both are the largest and likely most complex sites and centers of their regional systems. No other site in northwestern Chihuahua has as many scarlet macaws, marine shell, or copper artifacts. There is still a possibility that Mesoamerican obsidian could be present at Paquimé but most likely not. Obsidian artifacts from Di Peso's excavation of Paquimé are curated in Casas Grandes close to the site, but I did not have access to these artifacts at the time of this dissertations completion (see Chapter 7).

The obsidian data support archaeologists who suggest economic ties between Animas phase sites and Medio period sites (e.g., Di Peso 1974:2:331-332, 1974:3:778;

Douglas 1995). Ceramics, architecture, and other features that are fairly common in Casas Grandes also appear at some Animas phase sites like Joyce Well. All sourced obsidian from Joyce Well characterizes to Antelope Wells, which is the most used medium for obsidian toolstone manufacture at Medio period sites. Even though there is evidence to support the idea that Animas phase sites were too far north to be dependent on the Casas Grandes regional system and that Paquimé did not control ceremonial activities and other social processes in the Animas Valley (DeAtley 1980; DeAtley and Findlow 1982; Douglas 1995; Douglas and MacWilliams 2015; Minnis 1984; Whalen and Minnis 2003, 1996:743), the EDXRF results demonstrate that the Antelope Wells source played an important role in toolstone economics during the Medio period. However, Sierra Fresnal obsidian is located closer to Medio period settlements and is also highly used. If people in northwestern Chihuahua were economically dependent on Antelope Wells glass, then there would be less of other obsidian sources present in the Medio period assemblage. This does not negate, however, the importance of Antelope Wells obsidian to Medio period settlements.

Cliff Phase Obsidian

A total of 353 obsidian artifacts from six sites (Figure 5.5) dating to the Cliff phase are used in this study. The sourcing results (Table 5.12) indicate 13 geochemically distinct sources are present from the 353 artifacts. Twelve of the sources are known geographically, but nine artifacts are from an unknown source.

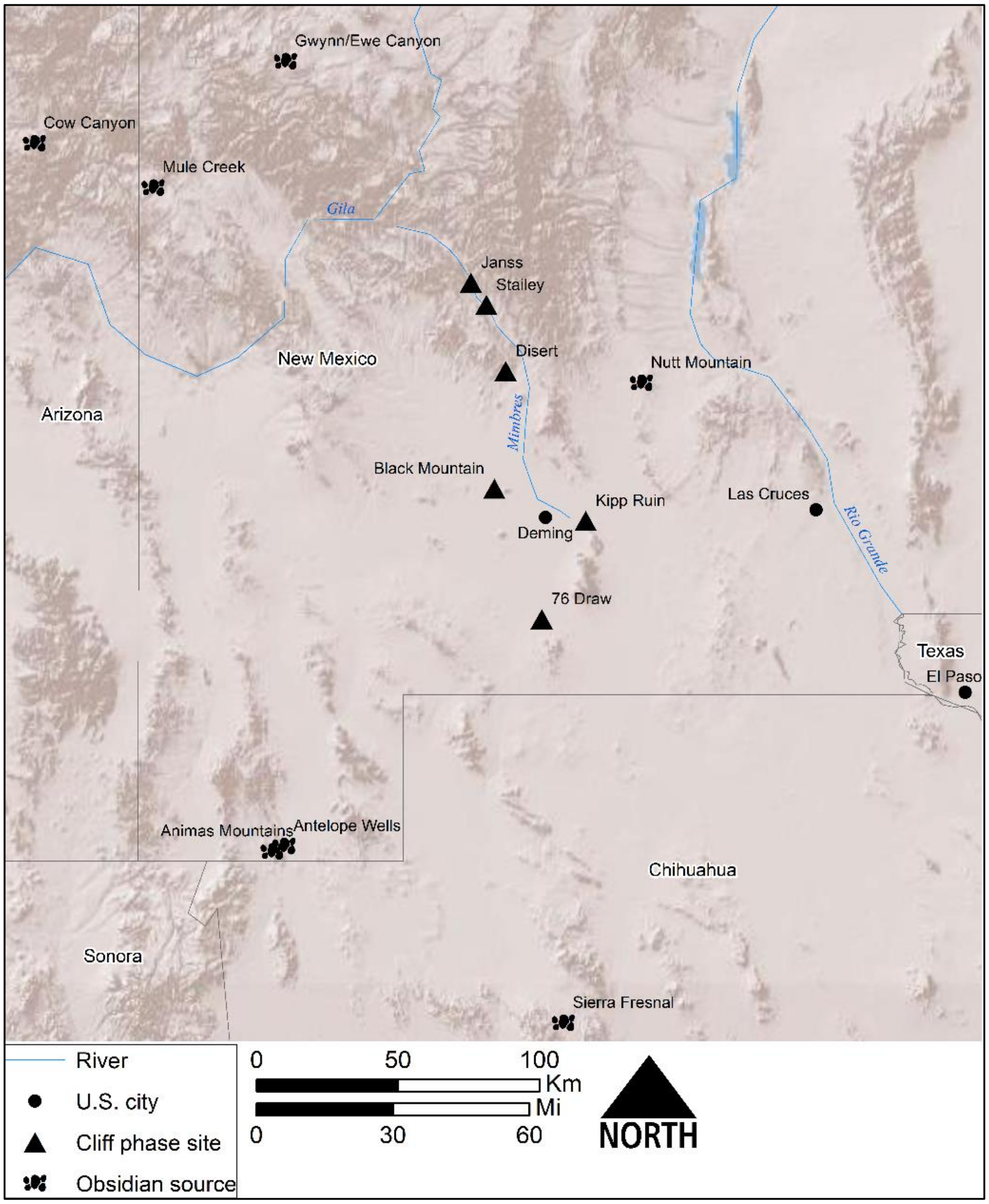

Figure 5.5. Location of Cliff phase sites used in this study.

Table 5.12. Cliff Phase Mesoscale Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Creek	187	53
Sierra Fresnal	76	22
Antelope Wells	35	10
Unknown	9	3
El Rechuelos	8	2
Los Jagüeyes	8	2
Mule Mountains	7	2
Cerro Toledo	6	2
North Sawmill	6	2
Cerro del Medio	4	1
Nutt Mountain	4	1
Cow Canyon	2	1
Mount Taylor	1	< 1
Total	353	

The results indicate that, similar to the Mimbres Classic period and Black Mountain phase assemblages, Antelope Creek is the preferred choice for obsidian manufacture during the Cliff phase (n=187, 53 percent). However, the use of Antelope Creek obsidian during the Cliff phase is lower than the Mimbres Classic period (64 percent), but the use of Antelope Creek is higher during the Cliff phase than the Black Mountain phase (49 percent). Unlike the earlier Black Mountain phase, Antelope Wells is not the second most used source during the Cliff phase. Instead, people increased their use of Sierra Fresnal glass (n=76, 22 percent). In other words, there is a switch from Antelope Wells obsidian to Sierra Fresnal obsidian during the Black Mountain-to-Cliff phase transition. The use of Nutt Mountain glass decreases through time as well. Nutt Mountain is five percent of the Mimbres Classic and eight percent of the Black Mountain assemblage, whereas it consists of only one percent during the Cliff phase.

In Table 5.13, I combine the subsources together into their larger source groups. Mule Creek is the most dominant source used by people during the Cliff phase (n=200, 57 percent), and Sierra Fresnal and Antelope Wells are still the second and third most used respectively. Four percent of the assemblage consists of sources from the Jemez Mountains (n=14), but most likely people obtained El Rechuelos and Cerro Toledo obsidian cobbles from closer near the Rio Grande and not directly at the primary source in the Jemez. Interestingly, people during the Mimbres Classic period used Jemez obsidian the same amount as during the Cliff phase (four percent), and people during the Black Mountain phase used it less (one percent).

Table 5.13. Cliff Phase Mesoscale Results with Subsources Combined.

Obsidian Group/Source	**Number of Artifacts**	**Percent**
Mule Creek	200	57
Sierra Fresnal	76	22
Antelope Wells	35	10
Jemez	14	4
Unknown	9	3
Los Jagüeyes	8	2
Nutt Mountain	4	1
Cerro del Medio	4	1
Cow Canyon	2	1
Mount Taylor	1	< 1
Total	353	

I suggest that, during the Cliff phase, people participated in the same obsidian social networks that occurred previously during the Mimbres Classic period and Black Mountain phase. People associated themselves by practicing either the Antelope Creek or Mule Creek tradition of obsidian procurement. However, the Cliff phase results are more similar to the Black Mountain phase results in that there is a slight increase in the use of Antelope Creek obsidian from the earlier Black Mountain phase but a fairly substantial decrease in the use of Antelope Wells. The decrease in Antelope Wells may be related to the increased use of the Sierra Fresnal obsidian source in northern Chihuahua during the Cliff phase.

Summary of Temporal Mesoscale Analysis

The above discussion entailed analyzing the obsidian sourcing results from artifacts dating to the Mimbres Classic period, the Black Mountain phase, the Animas phase, the Medio period, and the Cliff phase. There are clear trends through time with the increase and decrease of some sources, and I summarize the procurement patterns in Table 5.14.

Table 5.14. Temporal Mesoscale Procurement Patterns through Time.

Obsidian Source	Mimbres Classic %	Black Mountain %	Animas %	Medio %	Cliff %
Cerro Toledo	4	-	-	-	2
Cerro del Medio	1	1	-	-	1
El Rechuelos	-	1	-	-	2
Antelope Creek	64	49	-	1	53
Mule Mountains	< 1	-	-	-	2
North Sawmill Creek	1	1	3	-	2
SF/Blue River	15	-	-	-	-
Grants Ridge	1	-	-	-	-
Horace Mesa	1	-	-	-	-
Gwynn/Ewe	-	1	-	-	-
Antelope Wells	1	24	97	24	10
Nutt Mountain	5	8	-	-	1
Cow Canyon	< 1	1	-	-	1
Sierra Fresnal	3	6	-	23	22
Los Jagüeyes	-	-	-	6	2
Agua Fria	-	-	-	12	-
Selene	-	-	-	6	-
Animas Mountains	-	-	-	1	-
Chihuahua Unknown A	-	-	-	15	-
Chihuahua Unknown B	-	-	-	9	-
Unknown	< 1	5	-	3	3
Mount Taylor	-	1	-	-	< 1

Eleven Mimbres Classic period sites were used in this analysis and a total of 427 sourced obsidian artifacts. During this time period, people used the Antelope Creek subsource of Mule Creek the most with 64 percent of the total assemblage. The second most used source during this period is another subsource of Mule Creek, San Francisco/Blue River (15 percent). The Mimbres Classic period is the only time when people used San Francisco/Blue River obsidian as it does not appear in later time periods, while the other Mule Creek subsources continue to be used but infrequently. Interestingly, the third and fourth most used sources during the Mimbres Classic period are sources east of Mule Creek, Nutt Mountain at five percent and Cerro Toledo at four percent.

Four Black Mountain phase sites with a total of 166 sourced artifacts were used in this study. The obsidian sourcing results from this phase suggest that people continued to use the Antelope Creek subsource of Mule Creek after the transition between the Mimbres Classic period to the Black Mountain phase starting in the mid-twelfth century. Antelope Creek is the most preferred choice for obsidian toolstone manufacture at 49 percent of the total assemblage of 166 artifacts. The other 51 percent belong to 10 sources.

Obsidian procurement does change somwhat from the Mimbres Classic to the Black Mountain phase. The one major difference between the Black Mountain phase and Mimbres Classic period assemblage is the increase in Antelope Wells obsidian through time. Antelope Wells is present in 24 percent of the Black Mountain phase assemblage whereas it was present in only one percent during the Mimbres Classic period. Black Mountain phase architecture and ceramics are very different than the

Mimbres Classic (Chapter 2), and it seems that as there also differences in obsidian procurement. People continued to use Antelope Creek, but the increase in Antelope Wells obsidian suggests that people from the south who knew about Antelope Wells may have replaced some groups who left the Mimbres Valley, or at least people had different social networks connected to the Antelope Wells source.

Three sites dating to the Animas phase were used in this study with a total of 36 sourced artifacts. This is the lowest sample size of the five time periods/phases. Of the 36 artifacts, only one did not source to Antelope Wells. The use of Antelope Wells obsidian increases from the Mimbres Classic period to the Black Mountain phase, and this apparently continues into the Animas phase in the boot heel of New Mexico. However, the Antelope Wells source is the closest known obsidian source to Animas settlements in the international four corners. Obsidian from Animas Mountains is not used during the Mimbres Classic, Black Mountain, or Animas phase even though it is located near Antelope Wells. Only one piece of Animas Mountains obsidian was found at a Medio period site.

Four sites dating to the Medio period were used in this study with a total of 116 sourced artifacts. The temporal mesoscale analysis indicates Antelope Wells and Sierra Fresnal obsidian are nearly identical in use. The trend of Antelope Wells obsidian increasing through time continues into the Medio period, even though part of the Medio period is contemporaneous with the Black Mountain and Animas phases (Table 1.1). Artifacts made from Sierra Fresnal obsidian are prevalent in the Medio period assemblage, but the use of it is uncommon during the Mimbres Classic period, Black Mountain phase, and Animas phase.

Six Cliff phase sites with 353 sourced obsidian artifacts were used in this study. Similar to the Mimbres Classic period and Black Mountain phase, people during the Cliff phase used Antelope Creek obsidian the most. However, the sourcing results show there are significant differences in obsidian procurement during the Cliff phase versus the other time periods investigated, most notably the Black Mountain phase. There is a four percent increase in Antelope Creek obsidian from the earlier Black Mountain phase, a 16 percent increase in Sierra Fresnal use from the earlier Black Mountain phase, but a 14 percent decrease in Antelope Wells obsidian, and a seven percent decrease in Nutt Mountain.

From the discussion of obsidian procurement during the Mimbres Classic period, Black Mountain phase, Animas phase, Medio period, and Cliff phase at the temporal mesoscale level (Table 5.14), there are significant differences from the macroscale analysis (Table 5.3). Antelope Creek is not the most dominant source, as there is also a tradition of using Antelope Wells obsidian during the Animas phase and Medio period.

Geographic Mesoscale Analysis

There are five geographically and environmentally distinct regions that are of interest to this study: the Mimbres Valley in southwestern New Mexico, the Deming basin and range in the low elevation of the Chihuahuan desert, the Uvas Valley to the northeast of Deming, the Animas Valley in the New Mexico boot heel, and Casas Grandes in northwestern Chihuahua. Time is not an issue with this analysis. Instead, I highlight obsidian procurement in these five specific regions. Table 5.15 shows the number of sourced artifacts in each region. The Mimbres Valley and Deming have the most, while Casas Grandes has a sample size large enough that interpretations can be made. The Animas and Uvas valleys have the lowest numbers.

Table 5.15. Number of Sourced Artifacts in Each Region.

Region	Number of Artifacts	Percentage of Assemblage
Mimbres Valley	522	46
Deming	412	36
Uvas Valley	41	4
Animas	41	4
Casas Grandes	116	10
Total	1,132	

Mimbres Valley Obsidian

A total of 522 obsidian artifacts from 11 sites located in the Mimbres Valley are used in this study (Figure 5.1 and Table 5.2). The sourcing results (Table 5.16) indicate 12 geochemically distinct sources are present.

Table 5.16. Mimbres Valley Mesoscale Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Creek	393	75
San Francisco/Blue	63	12
Gwynn/Ewe Canyon	16	3
Nutt Mountain	13	2
North Sawmill Creek	10	2
Mule Mountain	7	1
Cerro Toledo	6	1
Sierra Fresnal	5	1
Antelope Wells	4	1
Cow Canyon	2	< 1
Cerro del Medio	2	< 1
Unknown	1	< 1
Total	522	

The Mimbres Valley mesoscale analysis demonstrates that Antelope Creek is the most used medium for obsidian toolstone manufacture with 75 percent of the assemblage (n=393). Artifacts made from San Francisco/Blue River are also present but in a much smaller proportion (n=63, 12 percent). The third most used source is Gwynn/Ewe Canyon at an even smaller percentage (3 percent). In Table 5.17 below, I combine the subsources together into their larger source groups. Mule Creek overwhelmingly dominates the assemblage at 91 percent, making the Mimbres Valley quite homogeneous in terms of the obsidian sources from which the vast majority of the obsidian came. Artifacts made from other sources are present like Gwynn/Ewe Canyon (n=16, 3 percent) and Nutt Mountain (n=13, 2 percent), along with others, but they consist of small percentages.

Table 5.17. Mimbres Valley Mesoscale Results with Subsources Combined.

Obsidian Source	Number of Artifacts	Percent
Mule Creek	473	91
Gwynn/Ewe Canyon	16	3
Nutt Mountain	13	2
Jemez	6	1
Sierra Fresnal	5	1
Antelope Wells	4	1
Cow Canyon	2	< 1
Cerro del Medio	2	< 1
Unknown	1	< 1
Total	522	

People in the Mimbres Valley clearly associated themselves by using Antelope Creek/Mule Creek obsidian. Taliaferro et al. (2010:546) report this pattern as well as they state,

> At this point, we cannot explain why it is that the Mule Creek sources and the communities near it became the focus of the network over other potential sources in the region. Drawing on Shafer's (2003, 2006) vision of Mimbres society, we suspect the explanation is a shared worldview and related socio-ideological practices that materialized this worldview among people in the region. Therefore, the preference for the Mule Creek sources might signify that this source or its geographic setting had significance within this worldview.

The obsidian sourcing results demonstrate that Mule Creek was an important lithic resource to people in the Mimbres Valley. However, Taliaferro et al.'s (2010) research indicates Mule Creek was not the closest available obsidian source. They integrated GIS least cost pathway analysis and found that the Antelope Wells source would have taken less travel time than Mule Creek. This is interesting because Taliaferro et al. (2010) found that Antelope Wells obsidian is not used in any significant quantity in the Mimbres Valley, whereas Mule Creek is.

The regional knowledge of Mule Creek obsidian, and in particular Antelope Creek, was manifest in homogeneity of obsidian procurement. Mimbres groups knew where Mule Creek was and where along various river beds in west-central New Mexico this high-quality glass could be collected. This is not to say that these same groups did not know where other obsidian sources were located because chipped stone debitage and formal tools made from other sources are present, but the Mimbres Valley at least during the Mimbres Classic period is thought to be relatively homogenous and somewhat "inward focused and isolated" (Hegmon 2002:339, see also Minnis 1985), and everyone used Mule Creek glass. The use of Antelope Creek became tradition in that these data suggest all groups in the Mimbres Valley participated in the overwhelming procurement of this obsidian. This is despite the fact that Mule Creek was not the closest source at which to obtain obsidian (Taliaferro et al. 2010).

Deming Obsidian

A total of 412 obsidian artifacts from five sites located in the Deming basin and range are used in this study (Figure 5.1 and Table 5.2). The sourcing results (Table 5.18) indicate 12 geochemically distinct sources are present.

Table 5.18. Deming Mesoscale Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Creek	164	40
Sierra Fresnal	99	24
Antelope Wells	84	20
Unknown	18	4
El Rechuelos	10	2
Los Jagüeyes	8	2
Cerro Toledo	7	2
Cerro del Medio	6	1
Nutt Mountain	5	1
North Sawmill Creek	4	1
Mount Taylor	3	1
Cow Canyon	2	< 1
Mule Mountains	2	< 1
Total	412	

Mimbres archaeologists generally consider the Deming basin and range part of the greater Mimbres Valley, but importantly here is that there is evidence suggesting differential procurement of obsidian for groups living in the Mimbres Valley versus the Deming region. Taliaferro et al.'s (2010) analysis focused primarily on obsidian procurement during the Mimbres Classic period in the Mimbres Valley heartland, but they did include data from other regions (see my Taliaferro et al. 2010 discussion in Chapter 4). They noted that more sourcing analysis needs to be done south of the Mimbres Valley as they have low sample sizes from the Deming region. They had 45 obsidian artifacts from five sites, and the Florida Mountain site (LA 18839) (Minnis and Wormser 1984; Searcy et al. 2016), a Late Pithouse period site had the most sourced artifacts (n=39). Although not the main temporal focus of this dissertation, during the Late Pithouse period in Deming, people used more Sierra Fresnal obsidian than Mule Creek. This is evident at Florida Mountain site (Taliaferro et al. 2010) and at the Late Pithouse period occupation at Kipp Ruin (Dolan 2012; Dolan and Ferguson 2012;

Dolan and Putsavage 2012). Therefore, this dissertation (see also Putsavage 2015) helps to elucidate obsidian procurement patterns in the Deming region by increasing the sample size of sourced obsidian artifacts for sites dating during and after the Mimbres Classic period. Also, comparing the Late Pithouse period obsidian data from sites in Deming to later time periods, there is a change in procurement patterns from Sierra Fresnal to Mule Creek (Antelope Creek) through time (Dolan 2012; Dolan and Ferguson 2012; Dolan and Putsavage 2012).

The Deming mesoscale analysis demonstrates that Antelope Creek is the most popular medium for obsidian toolstone manufacture with 40 percent of the assemblage (n=164). Artifacts made from Sierra Fresnal glass are also present (n=99, 24 percent), and the third most used source is Antelope Wells (n=84, 20 percent). In Table 5.19 below, I combine the subsources together into their larger source groups. Mule Creek obsidian is the preferred choice at 42 percent.

Table 5.19. Deming Mesoscale Results with Subsources Combined.

Obsidian Source	Number of Artifacts	Percent
Mule Creek	170	42
Sierra Fresnal	99	24
Antelope Wells	84	20
Unknown	18	4
Jemez (ER, CT)	17	4
Los Jagüeyes	8	2
Cerro del Medio	6	1
Nutt Mountain	5	1
Mount Taylor	3	1
Cow Canyon	2	< 1
Total	412	

There are significant differences in obsidian procurement between the Mimbres Valley and Deming. The source heterogeneity is about the same between the two regions, but the proportions of Mule Creek (Antelope Creek), Antelope Wells, and Sierra Fresnal are quite different. Artifacts made from Antelope Creek still dominate the assemblage (n=164, 40 percent) but that is a dramatic decrease from the Mimbres Valley mesoscale analysis results (n=393, n=75 percent). Not only did people use Antelope Creek, but artifacts made from Sierra Fresnal (n=99, 24 percent) and Antelope Wells (n=84, 20 percent) obsidian are also relatively frequent in the Deming assemblage. Other sources with more than one percent of the assemblage include an unknown source (n=18, 4 percent), El Rechuelos (n=10, 2 percent), Los Jagüeyes (n=8, 2 percent), and Cerro Toledo (n=7, 2 percent). Cerro Toledo is used in the Mimbres Valley, but Los Jagüeyes and El Rechuelos are not. Nutt Mountain is present in the Mimbres Valley obsidian assemblage.

Obsidian procurement in the Deming region is more heterogeneous than the Mimbres Valley as there is an increase in the use of Antelope Wells and Sierra Fresnal, Procurement in the Mimbres Valley is essentially homogenous in that people overwhelmingly used Antelope Creek glass, and Antelope Wells, Sierra Fresnal, and other sources are uncommon. What accounts for the difference in proportions between Antelope Creek, Antelope Wells, and Sierra Fresnal in the Mimbres Valley and Deming? One possible explanation is that people were more mobile in the basin and range, and they obtained more nodules from different sources as a result. However, people were full-time farmers from A.D. 1000 to 1450 and were primarily tethered to their land and agricultural fields. Because of this, mobile hunting and gathering activities were somewhat limited, and the scale of hunting and gathering was not the same as it was before the intensification of agriculture in southwestern New Mexico.

This is not to say that people did not travel long distances to visit kin, perform at dances, attend feasts, and search for marriage partners. Roth (2000) suggests that during the Middle and Late Archaic/Early Agricultural periods in the Tucson Basin, the diversity of obsidian sources at a site is dependent on the range of its inhabitants. The further people traveled during seasonal rounds, the greater variety of obsidians they collected. It is possible that people living in the Deming basin and range area south of the Mimbres Valley proper interacted with groups who lived closer to Antelope Wells and Sierra Fresnal because it would take less travel time to obtain obsidian from these sources.

Uvas Valley Obsidian

A total of 41 obsidian artifacts from two sites located in the Uvas Valley are used in this study. The sourcing results (Table 5.20) indicate that seven geochemically distinct sources are present from the 41 artifacts.

Table 5.20. Uvas Valley Mesoscale Results.

Obsidian Source	Number of Artifacts	Percent
Nutt Mountain	22	54
Cerro Toledo	10	24
Horace Mesa	3	7
Grants Ridge	3	7
Antelope Creek	1	2
El Rechuelos	1	2
Cerro del Medio	1	2
Total	41	

The Uvas Valley mesoscale analysis demonstrates that Nutt Mountain is the most popular medium for obsidian toolstone manufacture with 54 percent of the assemblage (n=22). Artifacts made from Cerro Toledo obsidian are also present but in smaller proportion (n=10, 24 percent). The third most used source is Horace Mesa and Horace Mesa (both part of the larger Mount Taylor Volcanic Field) at an even smaller percentage (three percent). In Table 5.21 below, I combine the subsources together into their larger source groups. Nutt Mountain is still the preferred choice, but the second most used are obsidian from the Jemez Mountains (n=11, 27 percent). Obsidian from Mount Taylor is the third most used (n=6, 15 percent).

Table 5.21. Uvas Valley Mesoscale Results with Subsources Combined.

Obsidian Source	Number of Artifacts	Percent
Nutt Mountain	22	54
Jemez	11	27
Mount Taylor	6	15
Antelope Creek	1	2
Cerro del Medio	1	2
Total	41	

Nutt Mountain consists of over half of the Uvas Valley assemblage. Obsidian procurement in the Uvas Valley is much different than that in the Mimbres Valley and Deming, because people living in the Uvas Valley used the two closest available sources which are Nutt Mountain obsidian and obsidian cobbles from the Rio Grande gravels. This is the opposite approach to that of people in the Mimbres Valley who did not use the closest sources. Although artifacts made from Nutt Mountain obsidian are present at sites in the Mimbres Valley but not Deming, the use of it in the Mimbres Valley is low (n=13, 2 percent).

The Uvas results demonstrate that in this area Antelope Creek or any other Mule Creek subsource is not used to any extent. Only one Antelope Creek obsidian artifact is present in the Uvas Valley assemblage. Instead, Nutt Mountain and Jemez and Mount

Taylor obsidian that can be collected from the Rio Grande Quaternary alluvium closer to the Uvas Valley are the most used. Rio Grande gravels include Cerro Toledo and El Rechuelos from the Jemez, and Horace Mesa and Grants Ridge from Mount Taylor (Church 2000; Shackley 1998a, 2005, 2013; Stevenson and McCurry 1990). There is also a much higher percentage of Jemez Mountain (Rio Grande gravels) obsidian use in the Uvas than in the Mimbres Valley or Deming assemblages because of the proximity of the Uvas Valley sites to the Rio Grande.

Animas Valley Obsidian

A total of 41 obsidian artifacts from four sites located in the boot heel of New Mexico are used in this study. The sourcing results (Table 5.22) indicate three geochemically distinct sources are present.

Table 5.22. Animas Valley Mesoscale Results.

Obsidian Source	Number of Artifacts	Percent
Antelope Wells	38	93
Sierra Fresnal	2	4
North Sawmill Creek	1	2
Total	41	

The obsidian sourcing results indicate that Antelope Wells was the preferred choice for obsidian stone tool manufacture in the boot heel of New Mexico (n=38, 93 percent). This is not surprising because the Antelope Wells source is located in southern Hidalgo County, New Mexico. The lack of heterogeneity in the Animas Valley obsidian suggests that people directed their obsidian procurement close by towards the Antelope Wells source. Animas Mountains obsidian (Shackley 2014b) is also located nearby, but no pieces of this glass were used to make artifacts in this assemblage. Two other obsidian sources are also present, including Sierra Fresnal and the North Sawmill Creek subsource of Mule Creek. A larger sample size might contain obsidian from more sources.

Casas Grandes Obsidian

The results of the Casas Grandes mesoscale analysis is the same as that presented in the Medio period mesoscale analysis (Table 5.11). This is because only Medio period sites are located in the Casas Grandes region. To reiterate the results, there are 10 geochemically distinct sources present in the 116 samples sourced. There is source heterogeneity in this region compared to the Mimbres Valley, Deming, Animas, and Uvas valleys. Antelope Wells is present in 24 percent of the assemblage and Sierra Fresnal in 23 percent. Interestingly, obsidian from other sources including Chihuahua Unknown A (15 percent), Agua Fria (12 percent), Chihuahua Unknown B (9 percent), Selene (6 percent) and Animas Mountains (1 percent) only occurs in this region. One artifact characterized to Antelope Creek. Mule Creek is approximately 400 linear kilometers north of Casas Grandes. This is the first documented case of obsidian from this source being found in the Casas Grandes region.

Summary of Geographic Mesoscale Analysis

The above discussion entailed looking at the obsidian sourcing results from artifacts from the Mimbres Valley, Deming basin and range, Uvas Valley, Animas Valley, and Casas Grandes. I summarize the procurement patterns in Table 5.23.

Table 5.23. Summary of Geographic Mesoscale Results.

Obsidian Source	Mimbres %	Deming %	Uvas %	Animas %	Casas Grandes %
Cerro Toledo (CT)	1	2	24	-	-
Cerro del Medio (CDM)	< 1	1	2	-	-
El Rechuelos (ER)	-	2	2	-	-
Antelope Creek (AC)	75	40	2	-	1
Mule Mountains (MM)	1	< 1	-	-	-
North Sawmill Creek (NSM)	2	1	-	2	-
SF/Blue River (SFB)	12	-	-	-	-
Grants Ridge (GR)	-	-	7	-	-
Horace Mesa (HM)	-	-	7	-	-
Gwynn/Ewe (GWE)	3	-	-	-	-
Antelope Wells (AW)	1	20	-	93	24
Nutt Mountain (NT)	2	1	54	-	-
Cow Canyon (CC)	< 1	< 1	-	-	-
Sierra Fresnal (SF)	1	24	-	4	23
Los Jagüeyes (LJ)	-	2	-	-	6
Agua Fria (AF)	-	-	-	-	12
Selene (SEL)	-	-	-	-	6
Animas Mountains (AM)	-	-	-	-	1
Chihuahua Unknown A (CHA)	-	-	-	-	15
Chihuahua Unknown B (CHB)	-	-	-	-	9
Unknown (UNK)	< 1	4	-	-	3
Mount Taylor (MT)	-	1	-	-	-

The geographic mesoscale obsidian sourcing results from artifacts in the Mimbres Valley demonstrate people overwhelmingly used Antelope Creek obsidian. Seventy-five percent of the assemblage is from this source, and the other 25 percent consists of 11 other geochemically distinct sources. The second most used source is the San Francisco/Blue River subsource of Mule Creek (12 percent), and the Gwynn/Ewe Canyon source (three percent) was the third most used in the Mimbres Valley. The use of Antelope Creek obsidian in this region is not surprising given that Taliaferro et al.

(2010) provided earlier evidence to support the idea that this region was quite homogenous regarding obsidian procurement.

Antelope Creek obsidian or Mule Creek in general are not the closest obsidian sources to the Mimbres Valley, however. Instead Antelope Wells in the boot heel and Sierra Fresnal in northern Chihuahua are more cost efficient in round trip hours from site to source (Taliaferro et al. 2010). Antelope Wells and Sierra Fresnal obsidian are artifact quality glass that people used as I have shown earlier in this chapter, but people in the Mimbres Valley did not use them to any degree as they combine for only two percent of the assemblage (Table 5.23).

Mule Creek was a very important toolstone resource to the inhabitants of the Mimbres Valley through time. They used this obsidian source more than other obsidian sources in the SW/NW even though it was not the closest to obtain directly (Taliaferro et al. 2010). The Mule Creek obsidian source is located near the Gila Mountains in west-central New Mexico, but nodules of Antelope Creek, North Sawmill Creek, Mule Mountains, and San Francisco/Blue River glass have a wide distribution into parts of Arizona and New Mexico as nodules enter river systems (Shackley 1992, 2005). Cow Canyon is located directly west of Mule Creek, but artifacts from this source represent less than one percent of the Mimbres Valley assemblage.

The geographic mesoscale obsidian sourcing results from artifacts in Deming demonstrate 40 percent of the assemblage is from Antelope Creek, but 12 other geochemically distinct sources are present. Sierra Fresnal obsidian is the second most used (24 percent), and Antelope Wells is the third most used (20 percent). Other than these three sources, the remaining 16 percent of the assemblage consist of 10 other sources. Obsidian procurement in the Deming region is much different than the Mimbres Valley. Although people still used Antelope Creek obsidian the most, the second and third most used sources are proportionally larger than the second and third most used in the Mimbres Valley. As a result, these data suggest people in the Deming region were either more mobile or traveled widely throughout the SW/NW, or people had more diverse social networks that connected to a variety of sources, especially Antelope Wells and Sierra Fresnal to the south.

Other than Antelope Creek, the Mule Creek sources do not play a role in obsidian procurement in the Deming region. All four Mule Creek subsources combine for 90 percent of the total Mimbres Valley assemblage, whereas they combine for 42 percent of the Deming assemblage. The decrease in overall Mule Creek obsidian procurement in Deming is likely related to the increase in Sierra Fresnal and Antelope Wells glass. Both of these sources are closer to the Deming region than to Mule Creek, but people still preferred Mule Creek glass even though it was not the most efficient choice.

The geographic mesoscale obsidian sourcing results from artifacts in the Uvas Valley demonstrate people used Nutt Mountain obsidian the most. Fifty-four percent of the assemblage is from this source, but six other geochemically distinct sources are present. Cerro Toledo is the second most used (24 percent), and the two sources from the Mount Taylor Volcanic Field (Grants Ridge and Horace Mesa, seven percent) are the third most used. This dissertation study is the first to examine obsidian procurement in the Uvas Valley because few archaeological investigations have occurred in this region (Dolan and Gilman 2015). Obsidian artifacts from two sites were sourced for this dissertation, and so it is difficult to get an overall sense of obsidian procurement in the Uvas Valley. However, the sourcing results I present here are very different from the Mimbres Valley and Deming.

People in the Uvas Valley used the closest available obsidian, which was Nutt Mountain, along with cobbles most likely collected along the Rio Grande to the east that geochemically source to Cerro Toledo and subsources belonging to Mount Taylor. People in the Mimbres Valley, on the other hand, did not use the closest available source which was Mule Creek. This is also true for the Deming region, but artifacts made from the closest sources (Antelope Wells and Sierra Fresnal) combine for 44 percent of the Deming assemblage.

The geographic mesoscale obsidian sourcing results from artifacts in the Animas Valley in the boot heel of New Mexico demonstrate people used Antelope Wells obsidian the most with 93 percent of the assemblage. The remaining seven percent consists of Sierra Fresnal and North Sawmill Creek artifacts. Due to the low artifact count from this region, similar to the Uvas Valley, it is difficult to provide more discussion, but Antelope Wells is clearly the most preferred choice for obsidian toolstone manufacture.

The Animas Valley presents an interesting case study because the Antelope Wells obsidian source is located close to the sites in the region. In fact, this source is only four kilometers from Joyce Well, a very prominent Animas phase site with architecture and ceramics similar to Medio period sites in the Casas Grandes region (Skibo et al. 2002). Despite the close proximity of site to the Antelope Wells source in the Animas Valley, there is evidence other sources were used. Sierra Fresnal obsidian is located to the southeast and the North Sawmill Creek subsource of Mule Creek directly to the north (Figure 1.3). Even though an archaeological site is located close to a high-quality obsidian source, archaeologists should not assume that *all* of the obsidian will geochemically characterize to that source.

This dissertation research is the largest obsidian sourcing study in the Casas Grandes Valley to date. This is despite the many decades of archaeological excavation and survey work in northwestern Chihuahua and the many opportunities to examine the source procurement of obsidian (e.g., Di Peso 1974; Di Peso et al. 1974; Whalen and Minnis 2001a, 2009a; see also Vierra 2005). As a result, this research sets the baseline for understanding obsidian procurement in this region.

The geographic mesoscale obsidian sourcing results from artifacts in the Casas Grandes Valley demonstrate 24 percent of the assemblage is from Antelope Wells, and 23 percent is from Sierra Fresnal. The third most used source is Chihuahua Unknown A at 15 percent. The remaining 38 percent consists of seven other geochemically distinct sources. People did use Antelope Wells and Sierra Fresnal in the Deming region and the Animas Valley, but Chihuahua Unknown A is not used anywhere else but Casas Grandes. As a result, the Chihuahua Unknown A source is likely located somewhere in northern Chihuahua. People in the Casas Grandes Valley during the Medio period share a similar obsidian procurement strategy with people in the Animas Valley because of the high use of Antelope Wells obsidian. However, did people from the Casas Grandes region travel north to directly procure Antelope Wells obsidian, or did people near the Antelope Wells source at sites like Joyce Well travel south to visit people near Paquimé?

Chapter 6: Microscale Analysis

In this chapter, I discuss the obsidian sourcing results for all 26 archaeological sites used in this study. I differentiate between each time period instead of geographic region at the microscale because I ask the question, did people living at different sites during the same time period in the same general region use the same obsidian source to manufacture stone tools, or did people use different sources because of their own autonomy?

In each of the data tables below, I give an approximate linear kilometer distance to the obsidian source from each site. I used the measuring tool in ArcMap to do this. When there are two distances given, the first is site to approximate primary source, and the distance in parentheses is the distance from site to its likely secondary collection area along the Rio Grande in New Mexico. I do this to examine whether people at each site used the closest available obsidian source. I discuss this further after all sourcing results are given.

Mimbres Classic Period Microscale Analysis

Eleven sites date to the Mimbres Classic period with a total of 427 obsidian artifacts. The sites are located in southwestern New Mexico including six in the Mimbres Valley, two in Deming, two in the Uvas Valley, and one in the Animas Valley (Figure 6.1). The results will be similar to the Mimbres Classic period mesoscale analysis discussed in Chapter 5, but instead of grouping all the data together, here I discuss the data at the site level.

Galaz. The Galaz site is one of the most intensively studied Late Pithouse and Mimbres Classic period sites in the Mimbres Valley heartland (Anyon and LeBlanc 1984; LeBlanc 1983). It is one of the largest sites in the region, and likely many people who practiced Mimbres traditions visited this place to attend ceremonies (Clayton 2006; Creel and Anyon 2003). The Galaz obsidian sourcing data are published in Taliaferro et al. (2010) and are presented in Table 6.1. The results indicate six geochemically distinct sources present from 90 artifacts. The three most commonly used sources belong to Mule Creek.

Table 6.1. Galaz Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Antelope Creek	74	82	107
SF/Blue River	7	7	107
North Sawmill Creek	5	5	107
Cerro Toledo	2	2	369 (74)
Cerro del Medio	1	1	369
Gwynn/Ewe Canyon	1	1	84
Total	90		

Note: Data first published in Taliaferro et al. (2010).

The three Mule Creek subsources represent the majority of obsidian at Galaz. Antelope Creek is used the most (n=74, 82 percent) followed by the San Francisco/Blue River (n=7, 7 percent) and North Sawmill Creek (n=5, 5 percent). Artifacts produced from Cerro Toledo, Cerro del Medio, and Gwynn/Ewe Canyon are also present but with a combined four artifacts in total. Previously discussed in the Mimbres Valley mesoscale analysis above, inhabitants of the Mimbres Valley did not use the closest obsidian sources which were Antelope Wells and Sierra Fresnal (Taliaferro et al. 2010). According to Taliaferro et al.'s (2010) GIS least cost pathway analysis, the closest obsidian source that is actually used at Galaz is Mule Creek and Gwynn/Ewe Canyon. Travel to and from Mule Creek would take approximately 100 hours round-trip. Non-Mule Creek glass is rare at sites in the Mimbres Valley, including at Galaz. One piece of Cerro del Medio glass is present at Galaz, but unlike the other Jemez Mountain sources like Cerro Toledo and El Rechuelos that were available in the Rio Grande gravels, Cerro del Medio does not erode into the Rio Grande and move south, and so procurement of that piece would have been from the Jemez Mountains.

These results suggest that people at Galaz rarely ventured to the east to the Rio Grande or northwest to Gwynn/Ewe Canyon. If they did, they did not collect obsidian and return. Knappers were connected to social networks and trading groups in the Mule Creek area, or they ventured northwest of the site approximately 107 linear kilometers or around 100 round-trip hours to directly procure Mule Creek obsidian.

Swarts. The Cosgroves (Cosgrove and Cosgrove 1932) excavated the Late Pithouse and Mimbres Classic period site of Swarts in the early twentieth century. Twenty-four obsidian artifacts from the site were sourced (Taliaferro et al. 2010), and the results are shown in Table 6.2.

Table 6.2. Swarts Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Antelope Creek	21	88	118
SF/Blue River	3	13	118
Total	24		

Note: Data first published in Taliaferro et al. (2010).

Based on this small sample size, people at Swarts used two geochemically distinct obsidian sources, both part of the larger Mule Creek group. Similar to Galaz, people at Swarts preferred Antelope Creek (n=21, 88 percent) the most and San Francisco/Blue River glass the second most (n=3, 13 percent). Swarts is slightly further away from Mule Creek than Galaz at 118 linear kilometers. There is more source homogeneity at Swarts than Galaz as only Mule Creek glass is present whereas people at Galaz at least had obsidian from other sources in New Mexico. Source homogeneity could be a result of the smaller sample size at Swarts, or people from longer distances visited Galaz for ritual or feasting events.

Old Town. Old Town is located on the mid-lower Mimbres River, and like Galaz, Old Town was one of the more important ritual sites in the Mimbres Valley (Clayton 2006; Creel 2006a, 2006b; Creel and Anyon 2003). The site had a long occupation including Late Pithouse, Mimbres Classic, and Black Mountain phase contexts (Creel 2006a; Taliaferro 2004, 2014). The Old Town obsidian sourcing data are published in Taliaferro et al. (2010) and presented in Table 6.3 (see also Taliaferro 2004, 2014). The results indicate seven geochemically distinct sources present from 174 artifacts. Three of the sources belong to Mule Creek.

Table 6.3. Old Town Mimbres Classic Period Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Antelope Creek	109	63	122
SF/Blue River	48	28	122
Gwynn/Ewe Canyon	8	5	122
Cerro Toledo	4	2	395 (93)
Sierra Fresnal	3	2	182
Cerro del Medio	1	1	395
North Sawmill Creek	1	1	122
Total	174		

Note: Data first published in Taliaferro et al. (2010).

The obsidian sourcing results at Old Town more closely resemble Galaz than Swarts because of the heterogeneity in sources present, probably because of the larger sample size. Antelope Creek (n=109, 63 percent) is the primary media for obsidian toolstone manufacture, but glass from two other Mule Creek subsources (San Francisco/Blue and North Sawmill Creek), Gwynn/Ewe Canyon, Cerro Toledo, Sierra Fresnal, and Cerro del Medio is also in the assemblage. It is clear that people at Old Town during the Mimbres Classic period preferred Antelope Creek obsidian although in a slightly different proportion than at Galaz (63 percent versus 82 percent at Galaz). Old Town is closer to the Deming basin and range than is the Mimbres Valley heartland. The location of the site may account for the increased use of Sierra Fresnal glass, although only three artifacts characterize to this source in northern Chihuahua. Sierra Fresnal is not present at Galaz or Swarts (Taliaferro et al. 2010).

Badger Ruin. Brown (1999a) recorded Badger Ruin, and the obsidian data are included in Taliaferro et al. (2010). Seventeen artifacts were sourced (Table 6.4), and the data indicate three geochemically distinct sources. One piece of Cow Canyon glass is present, and this represents the most distant obsidian source at the site. Cow Canyon is infrequently used in the Mimbres Valley, and according to Taliaferro et al. (2010) it would take people 170 round-trip hours to directly procure glass from Cow Canyon, whereas it would take 90 hours to Mule Creek. Antelope Wells is the closest source to the site at 50 round-trip hours away, but there is no evidence for Antelope Wells obsidian at Badger Ruin.

Table 6.4. Badger Ruin Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Antelope Creek	13	76	105
SF/Blue River	3	18	105
Cow Canyon	1	6	150
Total	17		

Note: Data first published in Taliaferro et al. (2010).

Jackson Fraction/Ruin. Like Badger Ruin, Brown (1999b) also recorded Jackson Fraction/Ruin. The sourcing data for 21 artifacts are in Taliaferro et al. (2010). The obsidian sourcing data (Table 6.5) at Jackson Fraction are similar to Badger Ruin, most likely because these two sites are near each other (Figure 5.1). Both sites have 76 percent of their assemblage from Antelope Creek, and have artifacts made from San Francisco/Blue River obsidian. However instead of the use of Cow Canyon obsidian at Badger Ruin, people at Jackson Fraction used Gwynn/Ewe Canyon. Jackson Fraction is 110 round-trip hours from Gwynn/Ewe Canyon and 90 round-trip hours from Mule Creek (Taliaferro et al. 2010).

Table 6.5. Jackson Fraction/Ruin Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Antelope Creek	16	76	105
Gwynn/Ewe Canyon	3	14	100
SF/Blue River	2	10	105
Total	21		

Note: Data first published in Taliaferro et al. (2010).

The Jackson Fraction/Ruin data demonstrate similar procurement patterns as the rest of the Mimbres Valley during the Mimbres Classic period, but there is some variability with the presence of three Gwynn/Ewe Canyon artifacts. San Francisco/Blue River glass was also used, but that is part of the Mule Creek tradition.

Lake Roberts Site. The University of New Mexico, Office of Contract Archeology excavated the Lake Roberts Site (Chapman 2011). This is the northernmost site used in this dissertation research as it is in the Sapillo Valley, which drains into the Gila River. Shackley (2014a) sourced 44 obsidian artifacts from the site for this dissertation (Table 6.6).

Table 6.6. Lake Roberts Site Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Antelope Creek	39	89	94
Mule Mountains	2	5	94
Gwynn/Ewe Canyon	2	5	75
Unknown	1	2	-
Total	44		

People at this site used Antelope Creek obsidian the most with 89 percent of the assemblage (n=39). Other sources include Mule Mountains (n=2, 5 percent), Gwynn/Ewe Canyon (n=2, 5 percent), and an unknown source (n=1, 2 percent). Mule Creek is approximately 94 linear kilometers west of the site, and Gwynn/Ewe Canyon is 75 linear kilometers northwest. The Mule Creek and Gwynn/Ewe Canyon obsidian sources are closer to the Lake Roberts site because it is located north of the Mimbres Valley. People at Galaz, Swarts, and Old Town in the Mimbres Valley have to travel through the Gila Forest and mountain ranges, whereas people at Lake Roberts Site are already located there.

Cabin Wells. Cabin Wells is the only Mimbres Classic period site in this study located in the boot heel of New Mexico (Figure 5.1). The site was mapped, and surface obsidian artifacts were collected as part of the 2012 Southern Mimbres Archaeological Project survey (Livesay et al. 2015). Five obsidian artifacts were sourced (Table 6.7). Two geochemically distinct sources are present, Antelope Wells (n=3, 60 percent) and Sierra Fresnal (n=2, 40 percent).

Table 6.7. Cabin Wells Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Antelope Wells	3	60	42
Sierra Fresnal	2	40	92
Total	5		

Note: Data first published in Livesay et al. (2015). See also Dolan and Livesay (2015).

People at Cabin Wells did use the closest available obsidian as Antelope Wells is approximately 42 linear kilometers to the southwest and Sierra Fresnal nodules are located approximately 92 linear kilometers southeast. But because Antelope Wells is closer than Sierra Fresnal, I suggest that if more obsidian artifacts from Cabin Wells were sourced, then a high proportion of Antelope Wells obsidian would be present. Most Mimbres Classic period sites in southwestern New Mexico have Mule Creek obsidian. Cabin Wells has a very small sample size, but no Mule Creek obsidian was found. This is not to say, however, that people at Cabin Wells did not use Mule Creek as more sourcing needs to be conducted.

LA 173885. Shackley (2013b) sourced 22 obsidian artifacts from LA 173885, and the results are discussed in Dolan and Gilman (2015) and Dolan and Livesay (2015) (Table 6.8).

Table 6.8. LA 173885 Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Cerro Toledo	10	45	387 (28)
Nutt Mountain	4	18	32
Horace Mesa	3	14	310 (28)
Grants Ridge	2	9	310 (28)
Cerro del Medio	2	9	387
Antelope Creek	1	5	188
Total	22		

Note: Data first published in Dolan and Gilman (2015). See also Dolan and Livesay (2015).

The EDXRF results indicate six geochemically distinct sources are present at LA 173885. The most common source found was Cerro Toledo obsidian (n=10, 45 percent), the second most was Nutt Mountain (n=4, 18 percent), and the third most was Horace Mesa (n=3, 14 percent). These results suggest that people at the site obtained most of their obsidian (n=15, 68 percent) from the Rio Grande Quaternary alluvium, approximately 28 kilometers to the east. Cerro Toledo obsidian, Horace Mesa obsidian, and Grants Ridge obsidian nodules all enter the Rio Grande and cobbles can be found as far south as Las Cruces (Church 2000; Shackley 1998b, 2005, 2012b, 2013a). Therefore, people at the site used the closest available sources like Nutt Mountain and Rio Grande gravels.

Amelia's Site. This site is approximately 14 linear kilometers west of LA 173885. The site was recorded, and surface artifacts were collected as part of the 2013 SMAP survey (Dolan and Gilman 2015). Shackley (2013b) sourced 19 obsidian flakes from the site, and the results are in Table 6.9.

Table 6.9. Amelia's Site Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Nutt Mountain	18	95	23
Grants Ridge	1	5	309 (44)
Total	19		

Note: Data first published in Dolan and Gilman (2015). See also Dolan and Livesay (2015).

The sourcing results indicate two geochemically distinct sources are present. People at the site overwhelmingly preferred Nutt Mountain obsidian (n=18, 95 percent). Nutt Mountain is the closest source to the site at approximately 23 linear kilometers northwest of the site. One piece of Grants Ridge glass was found, but it was likely collected from the Rio Grande alluvium. No Mule Creek artifacts were present at Amelia’s site. People at Amelia’s Site used locally available obsidian from Nutt Mountain, and people close by during the same general time period at LA 173885 used Rio Grande gravels. Therefore, it seems that there is some heterogeneity in obsidian procurement during the Mimbres Classic period in the Uvas Valley, but the Uvas Valley obsidian sample is small, and more sourcing analysis is needed to corroborate this suggestion.

Red Mountain. Red Mountain is located approximately 16 linear kilometers south of the Black Mountain site near Deming. Only one artifact was sourced, and it is reported in Taliaferro et al. (2010). Despite this, Red Mountain was used in this dissertation because sourcing data in the Deming region for the Mimbres Classic period is fairly scant. The one artifact is from Sierra Fresnal, which is approximately 148 linear kilometers south of Red Mountain. Nutt Mountain is the closest source to the Deming region at approximately 70 linear kilometers northeast of Red Mountain.

Columbus Pueblo. Kenmotsu et al. (2010, 2014) excavated Columbus Pueblo, and they (2010:10-63) state that nine pieces of obsidian and one sample of rhyolite were submitted for sourcing (Kenmotsu et al. 2010:10-63; Shackley 2010). The one piece of rhyolite is actually obsidian, and it sources to Cerro Toledo in the Jemez Mountains. Therefore 10 obsidian artifacts were sourced, not nine. Table 6.10 shows the four geochemically distinct sources present at Columbus Pueblo.

Table 6.10. Columbus Pueblo Obsidian Results.

Source	Number of Artifacts	Percentage	Distance to Source (km)
Sierra Fresnal	7	70	100
Cerro Toledo	1	10	467 (94)
Antelope Creek	1	10	200
Antelope Wells	1	10	103
Total	10		

Note: Data first published in Kenmotsu et al. (2010, 2014; Griffith et al. 2012).

Although Columbus Pueblo has a small sample size of sourced artifacts, the results suggest that Sierra Fresnal (n=7, 70 percent) is the most used source. However, as mentioned in Chapter 3, Sierra Fresnal obsidian nodules can enter stream systems and travel north, so that Sierra Fresnal cobbles can be found closer to the border rather than obtaining nodules directly at the primary Sierra Fresnal source in northern Chihuahua (Shackley 2005). Because Sierra Fresnal obsidian can be found naturally closer to the international border, this is likely the reason why it is the most frequently used source at Columbus Pueblo. Artifacts made from Cerro Toledo, Antelope Creek, and Antelope Wells are also present. The one piece of Cerro Toledo was likely collected from the Rio Grande as this is the closest area from which to obtain that obsidian. People at Columbus Pueblo did not integrate much Antelope Creek obsidian into their obsidian toolstone tradition. Mule Creek is located approximately 200 linear kilometers northwest of the site, and so that is most likely the reason why people did not use it.

Summary of Mimbres Classic Period Microscale Analysis

The Mimbres Classic period obsidian microscale dataset included 427 sourced artifacts from 11 sites throughout southwestern New Mexico including the Mimbres Valley, Deming, the Uvas Valley, and the Animas Valley. People throughout southwestern New Mexico during the Mimbres Classic period used a diversity of sources depending on the geographic location. People at Galaz, Swarts, Old Town, Badger Ruin, Jackson Fraction/Ruin, and the Lake Roberts site in and north of the Mimbres Valley overwhelmingly used Antelope Creek (Mule Creek) obsidian (Table 6.11), even though Mule Creek is not the closest source to these sites. Instead, Antelope Wells and Sierra Fresnal are the closest sources in terms of travel time to sites in the Mimbres Valley according to Taliaferro et al.'s (2010) GIS least cost pathway analysis. Antelope Wells and Sierra Fresnal obsidian artifacts do not occur in any appreciable quantity at Mimbres Valley sites.

Table 6.11. Most Used Obsidian Sources during the Mimbres Classic Period.

Site	Most Used Sourced	Second Most Used Source	Third Most Used Source
Galaz	Antelope Creek (82%)	San Francisco/Blue (7%)	North Sawmill Creek (5%)
Swarts	Antelope Creek (88%)	San Francisco/Blue (13%)	-
Old Town	Antelope Creek (63%)	San Francisco/Blue (28%)	Gwynn/Ewe Canyon (5%)
Badger Ruin	Antelope Creek (76%)	San Francisco/Blue (18%)	Cow Canyon (6%)
Jackson Fraction/Ruin	Antelope Creek (76%)	Gwynn/Ewe Canyon (14%)	San Francisco/Blue (10%)
Lake Roberts	Antelope Creek (89%)	Mule Mountains, Gwynn/Ewe Canyon (5%)	Unknown (2%)
Cabin Wells	Antelope Wells (60%)	Sierra Fresnal (40%)	-
LA 173885	Cerro Toledo (45%)	Nutt Mountain (18%)	Horace Mesa (14%)
Amelia's Site	Nutt Mountain (95%)	Grants Ridge (5%)	
Red Mountain	Sierra Fresnal (100%)	-	-
Columbus Pueblo	Sierra Fresnal (70%)	Cerro Toledo, Antelope Creek, Antelope Wells (10%)	-

The five remaining sites, Cabin Wells in the Animas region, LA 173885 and Amelia's site in the Uvas, and Red Mountain and Columbus Pueblo in Deming have different obsidian assemblages compared to sites in the Mimbres Valley. The non-Mimbres Valley sites unfortunately have low sample sizes. Despite this, however, people living in different regions had diverse obsidian procurement strategies, and Antelope Creek was not the preferred choice for obsidian and generally not the second or third choice either. Instead, for example, people in the Uvas Valley used the closest available obsidian sources; Cerro Toledo glass from the Rio Grande at LA 173885, and Nutt Mountain at Amelia's Site.

It is important to emphasize that obsidian procurement during the Mimbres Classic period is very different the further away sites are outside the Mimbres Valley. Taliaferro et al. (2010) demonstrated that Antelope Creek is the overwhelming choice for obsidian in the Mimbres Valley during the Mimbres Classic period even despite it is not the most economical to use because of the distance. People away from the Mimbres Valley who still practiced Mimbres Classic period traditions including using and manufacturing Mimbres Classic Black-on-white pottery and pueblo architecture did not participate or have access to Mule Creek obsidian social networks or trading relationships, however. Instead, people used other sources closer to them including Nutt Mountain, Sierra Fresnal, or obsidian cobbles near the Rio Grande that characterize to Jemez sources.

Black Mountain Phase Microscale Analysis

Four sites date to the Black Mountain phase, and 166 obsidian artifacts were used in this analysis. The sites are located in southwestern New Mexico including three in the Mimbres Valley and one in Deming (Figure 5.2). The results will be similar to the Black Mountain phase mesoscale analysis discussed in Chapter 5, but instead of grouping all the data together, here I discuss the data at the site level.

Montoya. The Montoya site is located along the middle portion of the Mimbres River approximately nine linear kilometers south of Swarts (LeBlanc 1977; Ravesloot 1979). Montoya contains a room block with approximately 30-40 rooms (Ravesloot

1979). As part of Putsavage's (2015) research, 14 obsidian artifacts from Montoya were sourced (Table 6.12).

Table 6.12. Montoya Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	7	50	120
Nutt Mountain	7	50	39
Total	14		

Note: Data first published in Putsavage (2015).

People at Montoya used two geochemically distinct obsidian sources. Seven artifacts were from Antelope Creek which is approximately 120 linear kilometers northwest of the site, and seven were from Nutt Mountain is which closer at 39 linear kilometers east of the site. The Montoya results are interesting because the site is located in the Mimbres Valley heartland, but Nutt Mountain consists of 50 percent of the obsidian assemblage. The use of Nutt Mountain in the heartland is rare because people overwhelmingly preferred Antelope Creek glass through time (Putsavage 2015; Taliaferro 2014; Taliaferro et al. 2010). These results point to the fact that, during the Black Mountain phase in the Mimbres Valley, at least at Montoya, people extended their procurement range to obtain not only Antelope Creek glass which was the norm, but also to Nutt Mountain which is closer than Mule Creek.

Walsh. The Walsh site is located approximately 13 linear kilometers south of Montoya and two linear kilometers north of Old Town on the Mimbres River (LeBlanc 1977; Ravesloot 1979). The site consists of three room blocks with 125 rooms total

(Ravesloot 1979). As part of Putsavage's (2015) research, 26 obsidian artifacts from Montoya were sourced (Table 6.13).

Table 6.13. Walsh Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	17	65	122
Nutt Mountain	4	15	45
Antelope Wells	3	12	143
Cow Canyon	1	4	157
Sierra Fresnal	1	4	183
Total	26		

Note: Data first published in Putsavage (2015).

Five geochemically distinct sources at Walsh compared to two at Montoya. Even though there is more obsidian source heterogeneity at the site, people during the Black Mountain phase at Walsh primarily used Antelope Creek obsidian similar to the rest of the Mimbres Valley through time. Sixty-five percent of the assemblage is from this source, but artifacts made from Nutt Mountain (n=4, 15 percent), Antelope Wells (n=3, 12 percent), Cow Canyon (n=1, 4 percent), and Sierra Fresnal (n=1, 4 percent) are also present.

Antelope Wells, Cow Canyon, and Sierra Fresnal are rare in Mimbres Valley obsidian assemblages even though, according to Taliaferro et al. (2010), Antelope Wells and Sierra Fresnal are the closest in round-trip hours, but not in distance. Cow Canyon in east-central Arizona is 150 round-trip hours from Old Town and Mule Creek is 80 round-trip hours away. Both Walsh and Montoya are towards the southern end of the Mimbres Valley and suggest obsidian source use heterogeneity from other Mimbres Valley sites further north like Galaz, Swarts, and Badger Ruin, but the latter also date to the earlier Mimbres Classic period. These results show that people at Walsh used the closest source available, which was Nutt Mountain, but they still mostly participated in the Mule Creek tradition even though that obsidian was fairly costly to acquire directly.

Old Town. People occupied Old Town for several hundred years as there is evidence for Late Pithouse, Mimbres Classic, and Black Mountain phase occupations (Creel 2006a; Taliaferro 2014). Earlier, I presented the Mimbres Classic period obsidian data from Old Town. This site is a good case study because a diachronic approach can be used. The Old Town Black Mountain phase data come from Taliaferro (2014) (Table 6.14).

Table 6.14. Old Town Black Mountain Phase Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	10	71	122
Gwynn/Ewe Canyon	2	14	122
Antelope Wells	1	7	143
Sierra Fresnal	1	7	182
Total	14		

Note: Data first published in Taliaferro (2014).

Fourteen Black Mountain phase obsidian artifacts were sourced, and the artifacts derive from four geochemically distinct sources. Much like the Mimbres Classic component, people preferred Antelope Creek the most (n=10, 71 percent), but other sources including Gwynn/Ewe Canyon (n=2, 14 percent), Antelope Wells (n=1, 7 percent), and Sierra Fresnal (n=1, 7 percent) are present.

The one drawback with looking at the Old Town obsidian sourcing data through time is the difference in sample size. Taliaferro et al. (2010) sourced 174 obsidian artifacts from the Mimbres Classic period component, whereas Taliaferro (2014) sourced 14 pieces from the Black Mountain phase component at Old Town (Table 6.15).

Table 6.15. Old Town Obsidian Results Through Time.

Source	Mimbres Classic	Black Mountain
Antelope Creek	109 (63%)	10 (71%)
San Francisco/Blue	48 (28%)	-
Gwynn/Ewe Canyon	8 (5%)	2 (14%)
Cerro Toledo	4 (2%)	-
Sierra Fresnal	3 (2%)	1 (7%)
Antelope Wells	-	1 (7%)
Cerro del Medio	1 (1%)	-
North Sawmill Creek	1 (1%)	-
Total	174	14

Old Town is the only site used in this dissertation with a significant proportion of San Francisco/Blue River obsidian. Twenty-eight percent of the Mimbres Classic period Old Town assemblage consists of this source, but it seems that people did not use glass from this source during the Black Mountain phase. There are also smaller adjustments in procurement through time, like no artifacts made from Antelope Wells in the Mimbres Classic period contexts, but there was only one during the Black Mountain phase. Cerro Toledo glass is also not present in the Black Mountain phase component. Antelope Creek, Gwynn/Ewe Canyon, and Sierra Fresnal are present in both time periods which could suggest that people continued the tradition of using these sources through time, but due to the smaller Black Mountain phase sample, it is difficult to make firm arguments about the increase in these three sources through time.

Black Mountain. The Black Mountain site is multi-component and has Late Pithouse, Black Mountain phase, and Cliff phase obsidian data. However, in this dissertation I only use data from the Black Mountain and Cliff phases. Putsavage (2015) sourced 112 obsidian artifacts from the Black Mountain phase component of the site, and nine geochemically distinct sources are present (Table 6.16).

Table 6.16. Black Mountain Site Black Mountain Phase Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	48	43	134
Antelope Wells	36	32	124
Unknown	9	8	-
Sierra Fresnal	8	7	161
Nutt Mountain	3	3	54
Cerro del Medio	2	2	415
El Rechuelos	2	2	415 (120)
North Sawmill Creek	2	2	134
Mount Taylor	2	2	321 (120)
Total	112		

Note: Data first published in Putsavage (2015). See also Dolan and Putsavage (2012).

Occupants at the site during the Black Mountain phase preferred Antelope Creek glass the most (n=48, 43 percent), but artifacts produced from Antelope Wells glass are well represented in the assemblage (n=36, 32 percent). Other sources including an unknown source, Sierra Fresnal, Nutt Mountain, Cerro del Medio, El Rechuelos, North Sawmill Creek, and Mount Taylor are also present but in small proportions. Unlike the other three Black Mountain phase sites discussed above, people at the Black Mountain site used obsidian from sources that are uncommonly used elsewhere in southwestern New Mexico. This could be the result of the site being the furthest south Black Mountain phase occupation investigated here and so part of the greater source diversity in the Deming region compared to the Mimbres Valley.

As for the distance from site to source, Antelope Wells and Sierra Fresnal are the closest sources to the Black Mountain site according to Taliaferro et al.'s (2010) GIS analysis, and the distance from site to source in linear kilometers is about the same. Taliaferro et al.'s (2010) GIS analysis did not incorporate Nutt Mountain which could be closer. However, people during the Black Mountain phase at the site did not use Nutt Mountain as much as Antelope Creek, Antelope Wells, an unknown source, and Sierra Fresnal.

Summary of Black Mountain Phase Microscale Analysis

The Black Mountain phase obsidian microscale dataset included 166 sourced artifacts from four sites in southwestern New Mexico. People at all four sites primarily used Antelope Creek obsidian, especially at the three sites in the Mimbres Valley (Table 6.17). The Black Mountain site is the only Black Mountain phase site investigated here in the Deming region. Although people at this site used Antelope Creek obsidian the most, they also integrated other sources into their procurement strategy to a greater degree.

Table 6.17. Most Used Sources during the Black Mountain Phase.

Site	Most Used Sourced	Second Most Used Source	Third Most Used Source
Montoya	Antelope Creek (50%) Nutt Mountain (50%)	-	-
Walsh	Antelope Creek (65%)	Nutt Mountain (15%)	Antelope Wells (12%)
Old Town	Antelope Creek (71%)	Gwynn/Ewe Canyon (14%)	Antelope Wells (7%)
Black Mountain	Antelope Creek (43%)	Antelope Wells (32%)	Unknown (8%)

Because Antelope Creek was the preferred choice for obsidian stone tool manufacture during the Black Mountain phase, people possibly went out of their way to obtain it. This practice also occurred during the earlier Mimbres Classic period, especially in the Mimbres Valley. One drawback with comparing the Mimbres Classic period obsidian data with Black Mountain phase data is that there are seven fewer Black Mountain phase sites investigated and in a more restricted geographic region. Therefore, more work needs to be done on Black Mountain phase sites in all regions covered by this dissertation research, even though few sites that date to this time period have been excavated (Putsavage 2015; Taliaferro 2014).

Cliff Phase Microscale Analysis

Six sites date to the Cliff phase, and 353 obsidian artifacts were used in this analysis. The sites are located in southwestern New Mexico including three in the Mimbres Valley and three in Deming (Figure 5.3). The results will be similar to the Cliff phase mesoscale analysis discussed in Chapter 5, but instead of grouping all the data together, here I discuss the data at the site level.

Disert. The Disert site is located along the middle Mimbres River approximately seven linear kilometers north of Swarts. According to the site's excavators (Nelson and LeBlanc 1986), Disert has an estimated 70 rooms. Putsavage (2015) sourced 36 obsidian artifacts from Disert (Table 6.18). Three geochemically distinct sources are present from the 36 artifacts.

Table 6.18. Disert Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	33	91	117
North Sawmill Creek	2	5	117
Nutt Mountain	1	2	40
Total	36		

Note: Data first published in Putsavage (2015).

The sourcing results from Disert indicate Antelope Creek glass was by far the most preferred media for obsidian toolstone manufacture (n=33, 91 percent). Two artifacts from the North Sawmill Creek subsource of Mule Creek and one artifact characterized to Nutt Mountain are also present, however. As for distance from site to source, Disert shows the same pattern as the rest of the Mimbres Valley sites. According to Taliaferro et al.'s (2010) GIS least cost pathway analysis, it would take people at Swarts, which is seven kilometers from Disert, approximately 90 hours round-trip travel time to Mule Creek which is an estimated 117 linear kilometers one-way. Nutt Mountain glass which is present in the assemblage would take a much shorter time, as would the use of Antelope Wells and Sierra Fresnal, but the latter two sources are not present in this small sample.

Janss. Janss is located on the upper Mimbres River approximately nine linear kilometers north of the Cliff phase Stailey site and 14 linear kilometers north of the Mimbres Classic period site of Galaz. According to the site's excavators (Nelson and LeBlanc 1986), the site has about 30 rooms. Putsavage (2015) sourced 27 artifacts from Janss for her dissertation research (Table 6.19).

Table 6.19. Janss Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	24	89	98
Mule Mountains	2	7	98
Nutt Mountain	1	4	59
Total	27		

Note: Data first published in Putsavage (2015).

The Janss sourcing results indicate three geochemically distinct sources present from the 27 artifacts. Antelope Creek is the preferred choice with 89 percent of the assemblage (n=24), but Mule Mountains (n=2, 7 percent) and Nutt Mountain (n=1, 4 percent) artifacts are also present. People at Janss participated in a similar obsidian procurement pattern to fellow Cliff phase occupants at Disert by both integrating Mule Creek and Nutt Mountain glass into their lithic raw material use. In this small sample, Mule Mountains was present instead of North Sawmill Creek obsidian, which was present at Disert.

Stailey. Stailey is located on the upper Mimbres River and is nine linear kilometers south of Janss and five linear kilometers north of Galaz. According to the site's excavators (Nelson and LeBlanc 1986), the site has about 15 rooms. Putsavage (2015) sourced 35 artifacts from Stailey for her dissertation research (Table 6.20).

Table 6.20. Stailey Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	30	86	105
Mule Mountains	3	9	105
North Sawmill Creek	2	6	105
Total	35		

Note: Data first published in Putsavage (2015).

Obsidian from Stailey comes from three geochemically distinct sources, all of which belong to the larger Mule Creek group. Antelope Creek obsidian is the preferred (n=30, 86 percent), and smaller amounts of Mule Mountains (n=3, 9 percent) and North Sawmill Creek (n=3, 6 percent) are present. People at Stailey had a similar obsidian tradition to Janss and Disert.

Black Mountain. The Black Mountain site has multiple occupations including a Cliff phase component. The Black Mountain phase obsidian data are presented earlier in this chapter, and the Cliff phase data from Putsavage (2015) are presented below (Table 6.21). The results indicate people used Antelope Creek glass the most (n=44, 58 percent), but Antelope Wells has a fairly high percentage (n=21, 28 percent). There is a major decrease between the second most used source and third which is an unknown source (n=5, 7 percent). More geochemically distinct obsidian sources are present at Black Mountain compared to Disert, Janss, and Stailey. However, Black Mountain also has a larger sample size which could skew the results.

Table 6.21. Black Mountain Site Cliff Phase Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	44	58	134
Antelope Wells	21	28	124
Unknown	5	7	-
Sierra Fresnal	3	4	161
Cow Canyon	1	1	170
North Sawmill Creek	1	1	134
Nutt Mountain	1	1	54
Total	76		

Note: Data first published in Putsavage (2015). See also Dolan and Putsavage (2012).

The Black Mountain site has Black Mountain and Cliff phase components. Table 6.22 shows there are differences through time in obsidian procurement at the Black Mountain site. Antelope Creek and Antelope Wells are the preferred choices during both periods. There is an increase in Antelope Creek and Cow Canyon and decrease in Antelope Wells, Nutt Mountain, unknown, El Rechuelos, Sierra Fresnal, Mount Taylor, Cerro del Medio, and North Sawmill Creek through time.

Table 6.22. Black Mountain Site Obsidian Results Through Time.

Source	Black Mountain	Cliff
Antelope Creek	48 (43%)	44 (58%)
Antelope Wells	36 (32%)	21 (28%)
Unknown	9 (8%)	5 (7%)
Sierra Fresnal	8 (7%)	3 (4%)
Nutt Mountain	3 (3%)	1 (1%)
El Rechuelos	2 (2%)	-
Cow Canyon	-	1 (1%)
Mount Taylor	2 (2%)	-
Cerro del Medio	2 (2%)	-
North Sawmill Creek	2 (2%)	1 (1%)
Total	n=112	n=76

Kipp Ruin. Kipp Ruin is a multi-component site located on the lower Mimbres River near Deming. It is approximately 34 linear kilometers east of the Black Mountain site and 25 linear kilometers east Red Mountain site. Obsidian artifacts from Late Pithouse and Cliff phase components were sourced (Dolan 2012; Dolan and Ferguson 2012; Dolan and Putsavage 2012; Putsavage 2015). Here, I discuss the Cliff phase results (Table 6.23).

Table 6.23. Kipp Ruin Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Creek	17	35	162
Sierra Fresnal	8	17	150
El Rechuelos	7	15	417 (75)
Los Jagüeyes	5	10	219
Antelope Wells	3	6	132
Cerro del Medio	3	6	417
Mule Mountains	2	4	162
Nutt Mountain	1	2	45
Cow Canyon	1	2	198
Mount Taylor	1	2	330 (75)
Total	48		

Note: Data first published in Dolan (2012; see also Dolan and Ferguson 2012; Dolan and Livesay 2015; Dolan and Putsavage 2012).

Obsidian artifacts from Kipp Ruin were sourced by Shackley as well as MURR using EDXRF spectrometry. Forty-eight obsidian artifacts were sourced from the Cliff phase component at Kipp Ruin, and the sourcing results indicate 10 geochemically sources present. People at the site used Antelope Creek obsidian the most (n=17, 35 percent), they also used other sources like Sierra Fresnal (n=8, 17 percent) and El Rechuelos (n=7, 15 percent). This is the only site investigated in this dissertation with a high proportion of artifacts made from El Rechuelos obsidian. People at Kipp Ruin likely obtained El Rechuelos cobbles to the east of the site near the Rio Grande, but it is also possible for connections between people at Kipp Ruin and those near the primary El Rechuelos source in the Jemez Mountains. More investigation is needed, however.

The trend of using Antelope Creek obsidian during the Cliff phase continues at Kipp Ruin, but unlike Disert, Janss, Stailey, and Black Mountain, people at Kipp Ruin used El Rechuelos obsidian the second most compared to either one of the Mule Creek subsources (Disert, Janss, and Stailey) or Antelope Wells (Black Mountain). Kipp Ruin is approximately 34 kilometers east of Black Mountain, and because Kipp Ruin is closer to the Rio Grande than Black Mountain, people integrated more Rio Grande gravel obsidian. This is represented in the obsidian assemblage as Kipp Ruin has the highest amount of El Rechuelos obsidian than any other site investigated here. However, the absence of Cerro Toledo obsidian at Kipp Ruin during the Cliff phase is noteworthy. Obsidian cobbles that geochemically source to Cerro Toledo from the Jemez Mountains are typically found in archaeological contexts in southern New Mexico, especially at Jornada Mogollon sites (Dolan et al. 2015; Miller and Shackley 1998). If people at Kipp Ruin are going east to get obsidian near the Rio Grande, why are there no pieces of Cerro Toledo obsidian in the assemblage? This merits future investigation.

76 Draw. The site of 76 Draw, which dates to the Cliff phase (Rakita et al. 2011), is located approximately 38 linear kilometers south of Kipp Ruin and approximately 32 linear kilometers northwest of Columbus Pueblo. Because of the location of this site south of Deming, as well as south of the Mimbres River, 76 Draw offers a unique opportunity to compare and contrast obsidian procurement in the borderlands. VanPool et al. (2013) sourced 131 obsidian artifacts, and the results are presented below (Table 6.24).

Table 6.24. 76 Draw Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Sierra Fresnal	65	50	121
Antelope Creek	39	30	173
Antelope Wells	11	8	103
Cerro Toledo	6	5	449 (94)
Unknown	4	3	-
Los Jagüeyes	3	2	194
North Sawmill Creek	1	1	173
El Rechuelos	1	1	449 (94)
Cerro del Medio	1	1	449
Total	131		

Note: Data first published in VanPool et al. (2013).

A total of nine geochemically distinct sources are present from the 131 artifacts sourced. The results indicate that half of the assemblage is from Sierra Fresnal (n=65, 50 percent) which is approximately 121 linear kilometers south of the site. The use of Antelope Creek obsidian is also high at 76 Draw as it consists of 30 percent of the assemblage (n=39). Other sources including Antelope Wells, Cerro Toledo, unknown, Los Jagüeyes, North Sawmill Creek, El Rechuelos, and Cerro del Medio are also present but in smaller amounts.

The obsidian sourcing results at 76 Draw suggest that people living at this Cliff phase site preferred Sierra Fresnal glass the most, but they also used Antelope Creek as well. The high use of Sierra Fresnal at 76 Draw is interesting because people preferred it here more than Antelope Creek which is the preferred choice at the other Deming Cliff phase sites, Black Mountain and Kipp Ruin, investigated in this study. These sites are located further north of 76 Draw making Antelope Creek glass closer. The closest obsidian source to 76 Draw could be Sierra Fresnal in northern Chihuahua, but obsidian can be collected closer to the New Mexico border (Shackley 2005).

Antelope Wells is the third most-used obsidian source at 8 percent of the total assemblage. The Antelope Wells obsidian source is approximately 103 linear kilometers west of the site, but there is a very low percentage of Antelope Wells glass. The Antelope Wells source is generally closer in linear kilometer distance from 76 Draw opposed to Sierra Fresnal and Mule Creek. This is interesting because VanPool et al. (2013) expected the people at 76 Draw to use more Antelope Wells obsidian. This is because of the connection between the Casas Grandes regional system and inhabitants at 76 Draw due to the high presence of Ramos Polychrome and the possible connection between Casas Grandes and the Antelope Wells obsidian source.

Summary of Cliff Phase Microscale Analysis

The Cliff phase obsidian microscale dataset included 353 sourced artifacts from six sites in southwestern New Mexico including the Mimbres Valley and Deming. From these six sites investigated, people primarily used Antelope Creek obsidian, except those at 76 Draw who used Sierra Fresnal the most (Table 6.25).

Table 6.25. Most Used Sources during the Cliff Phase.

Site	Most Used Sourced	Second Most Used Source	Third Most Used Source
Disert	Antelope Creek (91%)	North Sawmill Creek (5%)	Nutt Mountain (2%)
Janss	Antelope Creek (89%)	Mule Mountains (7%)	Nutt Mountain (4%)
Stailey	Antelope Creek (86%)	Mule Mountains (9%)	North Sawmill Creek (6%)
Black Mountain	Antelope Creek (58%)	Antelope Wells (28%)	Unknown (7%)
Kipp Ruin	Antelope Creek (35%)	Sierra Fresnal (17%)	El Rechuelos (15%)
76 Draw	Sierra Fresnal (50%)	Antelope Creek (30%)	Antelope Wells (8%)

Disert, Janss, and Stailey are located in the Mimbres Valley, and all have the first and second most used sources as Mule Creek. The second most used source is much lower than the first used. In fact, the third most used source at Stailey is also a subsource of Mule Creek, while the sourcing results at Disert and Janss's showed that Nutt Mountain is the third most used source. Therefore, people at these sites had a very similar obsidian procurement practice. However, the other Cliff phase sites, Black Mountain, Kipp Ruin, and 76 Draw offer a different perspective for obsidian procurement in southwestern New Mexico. These sites are located further south near Deming, and the obsidian data are different from each other in terms of source percentages. People at Black Mountain and Kipp Ruin mostly used Antelope Creek, but the sourcing results show that people at Kipp Ruin used 23 percent less Antelope Creek obsidian as people at Black Mountain during the Cliff phase. 76 Draw is the only site that does not have the most obsidian from Antelope Creek. Rather it is the second most used source, and Sierra Fresnal is the first.

Animas Phase Microscale Analysis

In this study, I sourced 36 obsidian artifacts from three Animas phase sites in the boot heel of New Mexico (Figure 5.4). The sourcing results are similar to the Animas phase mesoscale analysis discussed in Chapter 5, but instead of grouping all the data together, here I discuss the data at the site level to help understand obsidian procurement practices more locally during this time.

Joyce Well. Joyce Well is approximately four linear kilometers northwest of the Antelope Wells and Animas Mountain obsidian sources (Carpenter 2002:155-156). I submitted 34 artifacts from Joyce Well to Shackley (2011b) for analysis (Table 6.26). All 34 obsidian artifacts derived from Antelope Wells, and interestingly no Animas Mountains glass was present in the assemblage.

Table 6.26. Joyce Well Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Wells	34	100	4
Total	34		

Box Canyon. Box Canyon is located approximately 30 linear kilometers northwest of Joyce Well. I could only send Shackley one piece of obsidian from the site to be sourced because it was the only one available in the Box Canyon collections at the Museum of Indian Arts and Culture/Center for New Mexico Archaeology in Santa Fe. The flake sourced to Antelope Wells which is approximately 34 linear kilometers from the site (Table 6.27).

Table 6.27. Box Canyon Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Wells	1	100	34
Total	1		

Clanton Draw. Clanton Draw is approximately five linear kilometers south of Box Canyon. As with Box Canyon, I could only send Shackley one piece of obsidian from the site to be sourced because it was the only one available in the Clanton Draw collections at the Museum of Indian Arts and Culture/Center for New Mexico Archaeology in Santa Fe. The artifact, which was a projectile point, sourced to the North Sawmill Creek subsource of Mule Creek (Table 6.28). Clanton Draw is approximately 210 linear kilometers south of Mule Creek. Therefore, there is evidence of long-distance obsidian trade or procurement at Clanton Draw, but this is based on only one artifact.

Table 6.28. Clanton Draw Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
North Sawmill Creek	1	100	210
Total	1		

Summary of Animas Phase Microscale Analysis

The Animas phase obsidian microscale dataset included 36 sourced artifacts from three sites in the Animas Valley. The overall results shown in Table 6.29 indicate two geochemically distinct sources present.

Table 6.29. Most Used Obsidian Sources during the Animas Phase.

Site	Most Used Sourced	Second Most Used Source	Third Most Used Source
Joyce Well	Antelope Wells (100%)	-	-
Clanton Draw	North Sawmill Creek (100%)	-	-
Box Canyon	Antelope Wells (100%)	-	-

It is a fairly secure assumption that there was a tradition of using Antelope Wells glass in the region, based on the obsidian sourcing data. However, although the site does not date to the Animas phase, the Mimbres Classic period site of Cabin Wells located 54 linear kilometers east of Joyce Well and 72 linear kilometers east of Box Canyon has evidence that people used both Antelope Wells (n=3) and Sierra Fresnal (n=2) obsidian. No Sierra Fresnal obsidian was found at Box Canyon, Clanton Draw, or Joyce Well, but more sourcing projects need to be conducted in the New Mexico boot heel to document the amount of source heterogeneity present.

Medio Period Microscale Analysis

I sent 116 obsidian artifacts from four Medio period sites in northwestern Chihuahua to Shackley (2014b) for EDXRF analysis. The sites are located in and near the Casas Grandes Valley in northwestern Chihuahua (Figure 5.5). The results are similar to the Medio period mesoscale analysis discussed in Chapter 5, but instead of grouping all the data together, here I discuss the data at the site level to help understand obsidian procurement practices more locally during this time.

Site 204. Also known as the Tinaja site, site 204 is approximately 15 linear kilometers west of Paquimé at the base of the Sierra Madres. Excavations revealed it is one of the largest Medio period sites in the Casas Grandes Core Zone as it has an estimated 290 rooms, a ball court, two feasting ovens, and a midden (Whalen and Minnis 2009a:12-25; Whalen and Pitezel 2015:113). I sent Shackley (2014b) 37 obsidian artifacts from the site to be sourced (Table 6.30).

Table 6.30. Site 204 Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Chihuahua Unknown A	11	30	-
Antelope Wells	6	16	119
Chihuahua Unknown B	5	14	-
Los Jagüeyes	5	14	98
Agua Fria	4	11	62
Selene	4	11	66
Sierra Fresnal	1	3	72
Unknown	1	3	-
Total	37		

The sourcing results indicate eight geochemically distinct sources present at site 204. Chihuahua Unknown A glass is the most preferred (n=11, 30 percent), but artifacts made from Antelope Wells, Chihuahua Unknown B, Los Jagüeyes, Agua Fria, Selene, Sierra Fresnal, and an unknown source are also present. Seven sources are located either in Sonora, Chihuahua, or in the boot heel of New Mexico near the international border. The unknown source is geographically unknown, but geochemically it can be distinguished from other known sources.

Chihuahua Unknown A is the most used source at site 204 (n=11, 30 percent), but there are also relatively high percentages of Antelope Wells (16 percent), Chihuahua Unknown B (14 percent) and Los Jagüeyes (14 percent) obsidian. The site 204 sourcing results suggest that people at this large Medio period site preferred Chihuahua Unknown A obsidian the most but also used other sources from Chihuahua and New Mexico. Chihuahua Unknown A is likely located in Chihuahua based on the trace elements, but more field work is needed to determine its exact primary and secondary locations (Shackley 2014b). It is not possible to assess which direction or how far away this source is from site 204. The same is true for Chihuahua Unknown B and the unknown source.

Antelope Wells glass is the second most used source, and it is the most distant source used at the site at approximately 119 linear kilometers north. Even though Chihuahua Unknown A was used the most, people did have connections to Animas phase occupants in the boot heel of New Mexico due to the presence of Antelope Wells obsidian at site 204.

Site 242. Site 242 is approximately 30 linear kilometers southwest of Paquimé and a few kilometers west of the modern town of Mata Ortiz (Minnis and Whalen 2015a:52-53; Whalen and Minnis 2009a:33-40). This site is a secondary administrative and ceremonial center that had similar architecture to Paquimé including a very large ball court and a platform mound (Whalen and Minnis 2009a:33-40). There is also evidence for large-scale food preparation and possible feasting events (Minnis and Whalen 2015a:53).

Eight obsidian flakes were sourced from site 242 (Table 6.31). Shackley (2014b) determined a total of three geochemically distinct sources were present. People from site 242 preferred to use Antelope Wells obsidian the most (n=6, 75 percent), but Agua Fria and Antelope Creek artifacts are also present. Antelope Wells is approximately 142 linear kilometers north, Agua Fria is approximately 75 linear kilometers west in Sonora, and interestingly enough Antelope Creek is over 340 linear kilometers north of site 242. Mule Creek obsidian has not been found at any other site in northwestern Chihuahua to date. Because site 242 is a special administrative center, people from further north may have come for feasting events and brought the Antelope Creek flake.

Table 6.31. Site 242 Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Antelope Wells	6	75	142
Agua Fria	1	13	75
Antelope Creek	1	13	341
Total	8		

Site 315. At only two kilometers east, 315 is the closest site to Paquimé used in this study. Shackley (2014b) sourced 65 obsidian artifacts using EDXRF analysis (Table 6.32).

Table 6.32. Site 315 Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Sierra Fresnal	25	38	62
Antelope Wells	16	25	127
Chihuahua Unknown B	6	9	-
Agua Fria	5	8	81
Chihuahua Unknown A	5	8	-
Selene	3	5	85
Los Jagüeyes	2	3	78
Unknown	2	3	-
Animas Mountains	1	2	128
Total	65		

The sourcing results indicate nine geochemically distinct obsidian sources present at site 315. People preferred Sierra Fresnal glass the most (n=25, 38 percent). Artifacts made from Antelope Wells, Chihuahua Unknown B, Agua Fria, Chihuahua Unknown A, Selene, Los Jagüeyes, an unknown source, and Animas Mountains are also present. The single flake from Animas Mountains is the only artifact that characterizes to this source in this dissertation research. The high use of Sierra Fresnal and Antelope Wells obsidian at site 315 resembles Cliff phase sites in Deming. Although there is a high percentage of Antelope Wells obsidian at Black Mountain, Kipp Ruin, and 76 Draw, people at those sites also integrated Sierra Fresnal and Antelope Wells obsidian.

Site 317. Site 317 is a small village with three small room block mounds and two large ovens located approximately 19 kilometers southwest of Paquimé (Whalen and Minnis 2009a:25-31). The site has the smallest sourced obsidian sample size for the Medio period with only six flakes (Table 6.33).

Table 6.33. Site 317 Obsidian Data.

Obsidian Source	Number of Artifacts	Percent	Distance to Source (km)
Agua Fria	4	67	68
Sierra Fresnal	1	17	80
Chihuahua Unknown A	1	17	-
Total	6		

Shackley (2014b) found three geochemically distinct sources present including Agua Fria (n=4, 67 percent, Sierra Fresnal (n=1, 17 percent), and Chihuahua Unknown A (n=1, 17 percent). Because of the low sample size at site 317, it is difficult to fully discuss obsidian procurement at this site, but the results point to the preferred use of Agua Fria obsidian. Artifacts made from Agua Fria also occur at the other three Medio period sites investigated here but this source is not the preferred obsidian at the other sites.

Summary of Medio Period Microscale Analysis

The Medio period obsidian microscale dataset included 116 sourced artifacts from four sites in the Casas Grandes region. This is the largest obsidian sourcing study for Medio period sites in northwestern Chihuahua. People preferred Chihuahua Unknown A at site 204, Antelope Wells at site 242, Sierra Fresnal at site 315, and Agua Fria at site 317 (Table 6.34).

Table 6.34. Most Used Obsidian Sources during the Medio Period.

Site	Most Used Source	Second Most Used Source	Third Most Used Source
204	Chihuahua Unknown A (30%)	Antelope Wells (16%)	Chihuahua Unknown B, Los Jagüeyes (14%)
242	Antelope Wells (75%)	Agua Fria, Antelope Creek (13%)	-
315	Sierra Fresnal (38%)	Antelope Wells (25%)	Chihuahua Unknown B (9%)
317	Agua Fria (67%)	Sierra Fresnal, Chihuahua Unknown A (17%)	-

People at each Medio period site investigated here had their own tradition of obsidian procurement which makes it more unique than the other sites investigated in this dissertation. I acknowledge, however, that the sourced obsidian sample sizes for sites 242 and 317 are low, which could skew the results. More obsidian artifacts from Medio period sites in and around Paquimé, as well as at Paquimé must be sourced to examine more in-depth questions (see Chapter 6). The obsidian sourcing results at these four sites are very different than those from the Mimbres Classic, Black Mountain, Cliff, and Animas occupations in southwestern New Mexico. I argue this has profound implications for raw material stone tool economy and community organization in northwestern Chihuahua.

Obsidian procurement in the Casas Grandes region was most likely at the household level as people had autonomy and made their own decisions on which sources to use, not an unusual pattern in the North American Southwest (Bayman and Shackley 1999; Duff et al. 2012; Fertelmes et al. 2012; Mills et al. 2013; Shackley 2005). As I discussed in Chapter 2, Di Peso (Di Peso 1974; Di Peso et al. 1974) suggested that elites at Paquimé controlled many aspects of life in the Casas Grandes region. However, research demonstrates variation in material culture during the Medio period (Whalen and Minnis 2001a, 2001b, 2009, 2012; Whalen and Pitezel 2015), and obsidian procurement is no different.

Summary of Microscale Analysis

The microscale level examines the obsidian sourcing results at each individual site, which more accurately addresses which obsidian sources people used at the site level. I combine the microscale summary data into Table 6.35.

Table 6.35. Summary of Microscale Results.

Time Period	Site	Most Used	Second Most Used	Third Most Used
Mimbres Classic	Galaz	Antelope Creek (82%)	San Francisco/Blue (7%)	North Sawmill Creek (5%)
	Swarts	Antelope Creek (88%)	San Francisco/Blue (13%)	-
	Old Town	Antelope Creek (63%)	San Francisco/Blue (28%)	Gwynn/Ewe Canyon (5%)
	Badger Ruin	Antelope Creek (76%)	San Francisco/Blue (18%)	Cow Canyon (6%)
	Jackson Ruin	Antelope Creek (76%)	Gwynn/Ewe Canyon (14%)	San Francisco/Blue (10%)
Mimbres Classic	Lake Roberts	Antelope Creek (89%)	Mule Mountains (5) Gwynn/Ewe Canyon (5%)	Unknown (2%)
	Cabin Wells	Antelope Wells (60%)	Sierra Fresnal (40%)	-
Mimbres Classic	Amelia's Site	Nutt Mountain (95%)	Grants Ridge (5%)	-
	Red Mountain	Sierra Fresnal (100%)	-	-
	Columbus Pueblo	Sierra Fresnal (70%)	Cerro Toledo (10%), Antelope Creek (10%), Antelope Wells (10%)	-
Black Mountain	Montoya	Antelope Creek (50%) Nutt Mountain (50%)	-	-
	Walsh	Antelope Creek (65%)	Nutt Mountain (15%)	Antelope Wells (12%)
	Old Town	Antelope Creek (71%)	Gwynn/Ewe Canyon (14%)	Antelope Wells (7%)
Black Mountain	Black Mountain	Antelope Creek (43%)	Antelope Wells (32%)	Unknown (8%)
Animas	Joyce Well	Antelope Wells (100%)	-	-
	Clanton Draw	North Sawmill Creek (100%)	-	-
	Box Canyon	Antelope Wells (100%)	-	-
Medio	204	Chihuahua Unknown A (30%)	Antelope Wells (16%)	Chihuahua Unknown B, Los Jagüeyes (14%)
	242	Antelope Wells (75%)	Agua Fria, Antelope Creek (13%)	-
Medio	315	Sierra Fresnal (38%)	Antelope Wells (25%)	Chihuahua Unknown B (9%)
	317	Agua Fria (67%)	Sierra Fresnal, Chihuahua Unknown A (17%)	-
Cliff	Disert	Antelope Creek (91%)	North Sawmill Creek (5%)	Nutt Mountain (2%)
	Janss	Antelope Creek (89%)	Mule Mountains (7%)	Nutt Mountain (4%)
	Stailey	Antelope Creek (86%)	Mule Mountains (9%)	North Sawmill Creek (6%)

Time Period	Site	Most Used	Second Most Used	Third Most Used
Cliff	Black Mountain	Antelope Creek (58%)	Antelope Wells (28%)	Unknown (7%)
	Kipp Ruin	Antelope Creek (35%)	Sierra Fresnal (17%)	El Rechuelos (15%)
	76 Draw	Sierra Fresnal (50%)	Antelope Creek (30%)	Antelope Wells (8%)

In general, people during the Mimbres Classic period in the Mimbres Valley at Galaz, Swarts, Old Town, Badger Ruin, Jackson Ruin, and Lake Roberts primarily used Antelope Creek obsidian. Other sources were used, but for the majority of the sites people used other Mule Creek sources. Gwynn/Ewe Canyon, Cow Canyon, and an unknown source are also present but in low percentages. There are differences in procurement traditions during the Mimbres Classic period, however. For example, people in the Deming region during this time preferred to use Sierra Fresnal, but the sample size for Mimbres Classic period sourced artifacts in Deming are low (n=11). The same is true for the Uvas Valley during the Mimbres Classic period. I sourced artifacts from two sites, and people at each site had a different preference for obsidian. Cerro Toledo was used at LA 173885 and Nutt Mountain at Amelia’s Site. Only one Mimbres Classic period site was investigated in the Animas Valley, and the sample size is low (n=5), but people at Cabin Wells used Antelope Wells (n=3) and Sierra Fresnal (n=2).

People continued to use Antelope Creek obsidian the majority of the time during the Black Mountain phase in the Mimbres Valley at Montoya, Walsh, and Old Town. During this time, people were no longer using the other Mule Creek subsources to the same extent as they were in the Mimbres Classic period. Instead, people increased their use of Nutt Mountain, Gwynn/Ewe Canyon, Antelope Wells, and an unknown source.

The Black Mountain site is the only Black Mountain phase investigated in the Deming basin and range. People there also used Antelope Creek the most (43 percent), but the use of Antelope Wells glass is nearly a third of the obsidian assemblage (32 percent).

During the Animas phase in the boot heel of New Mexico, people overwhelmingly used Antelope Wells obsidian. Unfortunately, only three sites were investigated in this study that date to this time period, and only 36 artifacts were sourced. Although this is a small sample size, but because Joyce Well, Clanton Draw, and Box Canyon are located in close proximity to the Antelope Wells source and 97 percent of the assemblage sources to Antelope Wells, then I make the argument that this source was very important to Animas phase settlements, especially Joyce Well.

The Medio period obsidian sourcing results are the most interesting in this study. Similar to the Uvas Valley during the Mimbres Classic period, there are people at sites in the same region at the same time period preferring to use one obsidian source over another; Chihuahua Unknown A at site 204; Antelope Wells at site 242; Sierra Fresnal at site 315; and Agua Fria at site 317.

76 Draw is the one site during the Cliff phase that does not have its highest percentage of obsidian as Antelope Creek. Instead, 50 percent is from Sierra Fresnal, while 30 percent is from Antelope Creek. Three of the sites (Disert, Janss, and Stailey) are in the Mimbres Valley, and all have at least 86 percent Antelope Creek, with the second most used being another Mule Creek subsource. The other three Cliff phase sites are in Deming, and these results show people at Black Mountain and Kipp Ruin used Antelope Creek obsidian the most, but people at 76 Draw used Sierra Fresnal the most.

Discussion

In this section, I briefly investigate whether people at each of the 26 sites investigated in this study used the closest available obsidian source (Table 6.36). It is generally considered that any lithic material found within a 10 kilometer radius from a site is local, whereas anything beyond that is nonlocal (Binford 1982). Obsidian in the SW/NW is a small percentage of most lithic assemblages (Dockall 1991; Nelson 1981, 1984, 1986; Schriever et al. 2011; Taliaferro 2004), but often it is the most exotic chipped stone material at the site. If people did not use the closest available obsidian source, what does that mean for procurement patterns and larger questions about human behavior in the SW/NW?

Table 6.36. Most Used Obsidian Source and the Use of Closest Source to Site.

Time Period	Site	Most Used Source and Distance Away (km)	Use the Closest Obsidian Source to Site
Mimbres Classic	Galaz	Antelope Creek (82%), 107	No
	Swarts	Antelope Creek (88%), 88	No
	Old Town	Antelope Creek (63%), 122	No
	Badger Ruin	Antelope Creek (76%), 105	No
	Jackson Fraction/Ruin	Antelope Creek (76%), 105	No
	Lake Roberts	Antelope Creek (89%), 94	No
	Cabin Wells	Antelope Wells (60%), 42	Likely
	LA 173885	Cerro Toledo (45%), 387 or 28	Likely
	Amelia’s Site	Nutt Mountain (95%), 23	Likely
	Red Mountain	Sierra Fresnal (100%), +100	Likely
	Columbus Pueblo	Sierra Fresnal (70%), 100	Likely
Black Mountain	Montoya	Antelope Creek (50%), 120 Nutt Mountain (50%), 39	No
	Walsh	Antelope Creek (65%), 122	No
	Old Town	Antelope Creek (71%), 122	No
	Black Mountain	Antelope Creek (43%), 134	No
Cliff	Disert	Antelope Creek (91%), 117	No
	Janss	Antelope Creek (89%), 98	No
	Stailey	Antelope Creek (86%), 105	No
	Black Mountain	Antelope Creek (58%), 134	No
	Kipp Ruin	Antelope Creek (35%), 162	No
	76 Draw	Sierra Fresnal (50%), 121	Likely

Time Period	Site	Most Used Source and Distance Away (km)	Use the Closest Obsidian Source to Site
Animas	Joyce Well	Antelope Wells (100%), 4	Yes
	Clanton Draw	North Sawmill Creek (100%), 210	No
	Box Canyon	Antelope Wells (100%), 34	Yes
Medio	Site 204	Chihuahua Unknown A (30%),?	Unknown
	Site 242	Antelope Wells (75%), 142	No
	Site 315	Sierra Fresnal (38%), 62	Likely
	Site 317	Agua Fria (67%), 68	No

When an archaeological site is more distant from an obsidian source or any other raw material, in general, that site will have fewer artifacts from that particular obsidian source. On the other hand, when a site was close to a lithic outcrop, people likely used that source frequently, and a high percentage of that material will be recovered from archaeological contexts (Brantingham 2003). Using this rational, all of the obsidian found at the archaeological sites investigated in this study is considered nonlocal, except at Joyce Well because it is less than 10 kilometers from the Antelope Wells source. I caution about the use of distance from site to obsidian source in northwestern Mexico to make interpretations because we do not yet know the extent of primary and secondary deposits. Lithic materials erode into river systems and can be carried closer to the site than the primary source, such that a comparison of site to primary obsidian source can be meaningless (Shackley 2005:80). The distance from site to source can still be used heuristically to examine possible procurement strategies and to see if the highest proportion of obsidian is from the most economical, highest quality, and closest *known* obsidian source.

Taliaferro et al. (2010) demonstrated that people in the Mimbres Valley did not use the closest available source, and this trend continues elsewhere in southwestern

New Mexico and northwestern Chihuahua. The results from Table 6.36 indicate that people at 16 (Old Town and Black Mountain are multi-component) of the sites did not use the closest available obsidian source. Joyce Well and Box Canyon had obsidian from the closest source, and people from seven of the sites likely used the closest source. I say likely because the primary and secondary source locations like Nutt Mountain and most of the sources in northern Mexico are unknown, people could have collected cobbles that eroded further away from the primary source. People at site 204 used Chihuahua Unknown A the most, and this source is not known geographically. It could be in Chihuahua, but it could also be in Sonora or elsewhere.

There are two scenarios that likely occurred in southwestern New Mexico and northwestern Chihuahua to obtain obsidian. Because obsidian is not locally available to people at most of the sites investigated in this study, except at Joyce Well, people either had to directly procure obsidian or acquire it through some form of trade and exchange. To examine this question further, I suggest a research project incorporating either a formal or mass analysis (Ahler 1989; Shott 1994; Sullivan and Rozen 1985) on all obsidian artifact types including unretouched flakes, formal tools, and cores. With this information along with the source provenance of each individual artifact, archaeologists will be better to address the distance from site to source and at least help to elucidate if there are differences in procurement or trade practices within a particular obsidian source. In other words, for example – is there evidence to suggest people acquired Mule Creek obsidian through trade, whereas people directly procured obsidian from Antelope Wells (e.g., Morrow and Jefferies 1989)?

Chapter 6 Summary

In this chapter, I discussed the source provenance results for each of the 26 archaeological sites. This was the microscale analysis and it differs from the approach I took in Chapter 5 because I discussed what sources people used at the sites rather than only focusing on temporal and regional patterns of obsidian procurement, although I did discuss temporal or regional patterns in this chapter.

The results show that people in the same region during the same time period used different obsidian sources. For example, people at the two sites investigated in the Uvas Valley during the Mimbres Classic period used different obsidian sources, and this trend also occurs at sites in the Deming basin and range during the Cliff phase, the Animas Valley during the Animas phase, and the Casas Grandes Valley during the Medio period. Therefore, this research demonstrates variation in obsidian procurement in southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. I also discussed whether people at each site used the closest available obsidian. I concluded that many people did *not* integrate the closest available source into their obsidian raw material repertoire. Explaining this phenomenon, however, is difficult, and it requires future examination using a more in-depth discussion on the material culture of each site including the presence or absence of formal trading networks or embedded/direct procurement of obsidian.

Chapter 7: Summary and Conclusions

Questions about prehispanic trade, distribution, circulation, and procurement are tied to studies of obsidian sourcing. This is because obsidians from different geologic outcrops are geochemically distinct in their minor or trace elements, and each source on the landscape can be characterized using a host of geochemical sourcing methods like EDXRF. With this information, archaeologists can then ask large-scale questions about past human behavior using chipped stone debitage and formal tools made from this volcanic glass.

Studies of obsidian source procurement have increased in recent years in the SW/NW, and this knowledge has expanded our view of long- and short-distance obsidian procurement practices, and what groups possibly interacted with others near sources of this volcanic glass. Archaeologists will continue to source obsidian projectile points and flaked stone debitage because sourcing methods like EDXRF are more available than ever, and they provide fast and reliable results. EDXRF is a low-cost alternative to other methods, as well as being a non-destructive technique.

The goal of this dissertation study was to identify obsidian procurement patterns through time and across space in five culturally and environmentally distinct regions of southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450. I accomplished this by analyzing a dataset of over 1,000 sourced obsidian artifacts from 26 archaeological sites. Before this study, obsidian procurement in the Animas Valley of extreme southwestern New Mexico in southern Hidalgo County, the Uvas Valley in southwestern New Mexico, and the Casas Grandes Valley in northwestern Chihuahua from A.D. 1000 to 1450 were only poorly/rudimentarily understood. This is especially true for obsidian procurement in northwestern Chihuahua; in fact, this study is the first to fully examine procurement patterns during the Medio period. With these new data available to the archaeological community, coupled with how I integrated previously sourced obsidian artifacts into this dissertation dataset from research projects conducted by other archaeologists, this study provides the first regional context for obsidian procurement in southwestern New Mexico and northwestern Chihuahua, Mexico from A.D. 1000 to 1450. As a result, this dissertation makes large amounts of sourcing data available to those interested in obsidian procurement in these regions.

In most regions that I investigated in this study, the data are not consistent with the presence of a static, monolithic obsidian exchange system that worked the same way everywhere in the study region. Instead, there are variations through time and across space. The one anomaly is the Mimbres Valley from A.D. 1000 to 1450 (see Taliaferro et al. 2010 for the Mimbres Classic period). The sourcing results there indicate that people in this region through time did practice a consistent procurement system associated with the Mule Creek source group, and more specifically the Antelope Creek subsource. The polar opposite scenario occurred later in time during the Medio period, and further south in the Casas Grandes Valley. In that case, people did not primarily use only one source, but instead their procurement practices included a diversity of obsidian sources located in northern Chihuahua, northern Sonora, and southern New Mexico.

Research Contributions and Broader Impacts

Generally speaking, I have contributed to the archaeological record of southwestern New Mexico and northwestern Chihuahua from A.D. 1000 to 1450 by collating and analyzing which obsidian sources people used through time and across space. Moreover, before this study, archaeologists did not have a strong working knowledge of which sources people used in the Animas Valley, the Uvas Valley, and the Casas Grandes Valley. Arguably, the most important research contribution of this dissertation, is that it is the first geochemical provenance study to address the distribution and use of obsidian during the Medio period within the Casas Grandes regional system. Although Darling (1998) did source artifacts from Paquimé, the results were largely inconclusive, and the sample size was small (n=12).

Archaeologists can now compare and contrast obsidian procurement in most regions of the SW/NW, because northwestern Chihuahua is one of the last areas that had received little attention. In contrast, the Mimbres Valley, Chaco Canyon, Mesa Verde, Hohokam, Rio Grande, and other regions are fairly well understood (Arakawa et al. 2011; Bayman and Shackley 1999; Duff et al. 2012; Church 2000; Ferguson et al. 2016; Fertelmes et al. 2012; Graves 2005; Gilman 2011; Mills et al. 2013; Peterson et al. 1997; Putsavage 2015; Shackley 2005; Taliaferro 2004, 2014; Taliaferro et al. 2010).

Future Research

Archaeologists know more about obsidian procurement through time and across space in the SW/NW today than they did a decade or even five years ago. This is a result of wanting to ask more profound questions about the human past using obsidian sourcing data and the increase of cultural resource management archaeology needing to know more about trade, exchange, and long-distance interaction on low project budgets. However, there is still much to know about how people used obsidian in the SW/NW. In this section, I offer four suggestions for future research.

Unknown Obsidian Sources

One avenue for future study is the unknown obsidian sources in the SW/NW. Although artifacts made from these unknown sources were not regularly used by people in the SW/NW, they still present an anomaly and outlier when found in lithic assemblages. Throughout the years, however, research has improved our understandings of certain geochemically and geographically unknown sources on the landscape (Baugh and Nelson 1987; Church 2000; Glascock et al. 1999; Kibler et al. 2014; Martynec et al. 2011; Shackley 1988, 1995, 2005; Shackley et al. 2016). There are presently only a handful of unknown sources for which we do not know the location of the primary or secondary distributions, and I imagine that within the next decade there will be fewer still. Pedestrian survey and geoarchaeological fieldwork will remedy this.

Obsidian and Ceramic Sourcing

Very few, if any, SW/NW archaeologists have combined large datasets of sourced obsidian artifacts from multiple sites and time periods with large datasets of sourced ceramic sherds and whole vessels to look at the circulation and distribution of two of the most commonly studied artifact types (but see Mills et al. 2013). Ongoing work by Creel and Speakman (2012; Speakman 2013:197-198) to source whole vessels and large sherds will hopefully offer new insights into ceramic sourcing in southwestern New Mexico. These data could be compared to obsidian sourcing data from the same or similar archaeological sites. In fact, future studies that combine obsidian and ceramic sourcing analyses will most likely demonstrate differences in circulation patterns and exchange social networks between obsidian and ceramics.

The Performance Characteristics of Obsidian

Future studies focused on assessing obsidian material quality in the SW/NW should be conducted. This is a viable research goal for archaeologists that will shed light on performance characteristics. Below, I briefly discuss two methods used to determine the material quality of chipped stone materials. Natural performance characteristics of obsidian include the material quality, either high- or low-quality, or nodule/cobble size. For most parts of the SW/NW, archaeologists classify stone tools made from any raw material as mundane utilitarian artifacts that people procured or exchanged. Shackley (2005:26) has even stated that, "prehistoric knappers did not care – indeed no one cared – where they collected their raw material." However, early in American archaeology, Goodman (1944:416) thought to investigate the question of lithic technological choice. She said "the choice of certain materials may be purely a matter of tradition and may even be inconsistent with purely utilitarian considerations."

The material quality, availability, and nodule/cobble size of obsidian can impose technological constraints on fracture mechanics, production, and consumption (Andrefsky 1994; Crabtree 1967; Goodman 1944). Toolstone material is classified as either high- or low-quality, but these are poor dichotomies when discussing the effects of quality upon technological practice (Andrefsky 1994). Material qualities are usually qualitatively defined, but it is necessary to develop quantitative methods to better describe raw material in a controlled setting, although quantifying remains complex (Braun et al. 2009).

Archaeologists have attempted to quantitatively and qualitatively assess material quality by examining the mechanical properties of each individual obsidian source using modulus and hardness values obtained through engineering tests similar to those discussed in Husien (2010) and Meesala (2014). Braun et al. (2009) quantified the durability and hardness of different types of chert, quartzite, rhyolite, and basalt from East Africa by investigating fracture predictability using the Schmidt Hammer mechanical test (Katz et al. 2000) on multiple raw materials. Although obsidian was not part of their sample, Braun et al. (2009) demonstrated Oldowan hominins selected raw material based on durability more than fracture predictability. Similarly, Nelson et al. (2012) examined the material quality of different Idaho obsidian sources, testing whether lower variability in fracture patterns corresponded to increased distribution in the region.

Using the Shore Schleroscope, Nelson et al. (2012) prepared thin sections of geochemically distinct obsidian sources to determine if performance characteristics like flakeability can explain the variation in selection and procurement in Idaho. They measured the length between the inner and outer impact fractures made by the Shore Schleroscope, using the images produced from a scanning electron microscope. Their results demonstrate variation among the different obsidian sources. The inverse coefficient of variation between the inner and outer fracture diameters indicate that Bear Gulch obsidian was among the most predictable for flaking, followed by Cedar Butte and Packsaddle glass. Malad and Brown's Bench obsidian had significantly lower values, which suggests less predictable flaking patterns, but in fact these two are the most widely distributed and used obsidian sources throughout Idaho. Nelson et al. (2012) concluded that other factors such as subjective appraisal of color, luster, or other estimates of workability, visibility, and the accessibility of obsidian sources influenced the distribution. There thus seem to be cultural factors affecting the choice of obsidian procurement in Idaho. Using this same method on multiple types of obsidian from known geologic outcrops, SW/NW archaeologists could examine a host of issues related to the procurement of obsidian.

Obsidian Procurement in Casas Grandes and at Paquimé

I am particularly interested in sourcing obsidian artifacts from Viejo period sites in the Casas Grandes region. Archaeologists know very little about the Viejo period in general compared to the Medio period, and even less about chipped stone raw material procurement. A sourcing project focused on Viejo period obsidian assemblages will either show continuity or discontinuity with Medio period procurement patterns. With this information, larger questions can be addressed including the possible relationship between people living in the Casas Grandes region and those is southwestern New Mexico in the Mimbres Valley during the Late Pithouse and Mimbres Classic periods and people to the south during the same time. Mimbres Classic Black-on-white pottery was present in the Casas Grandes region during the eleventh century, and so obsidian sourcing data may reveal artifacts made from sources used by Mimbres groups in southwestern New Mexico.

Although I tried for this research, I could not get approximately 130 pieces of obsidian debitage from Paquimé (see Figures 7.1 and 7.2 below) and approximately 30 projectile points, debitage, and cores from site 315 out of Chihuahua for EDXRF analysis before the completion of this dissertation. However, this will occur in the near future. The source provenance of obsidian from Paquimé remains unknown, but this dissertation sets the baseline for understanding obsidian procurement during the Medio period. Even though Darling's (1998) dissertation sourced 12 pieces from Paquimé, the results were rather inconclusive because 11 of them were from an unknown source, and one was from Cow Canyon (Chapter 3). However, with new and advanced sourcing methods, the unknowns from Paquimé may be better understood today.

The sourcing results from sites 204, 242, 315, and 317 demonstrate that people used sources from Chihuahua, Sonora, and New Mexico. I therefore suggest it is highly unlikely that there is obsidian in the Casas Grandes region derived from sources in West Mexico or Mesoamerica as Di Peso (Di Peso et al. 1974:7:337) suggested. However, because Paquimé is unique in northwestern Chihuahua given its very large number of exotic and non-local objects, raw materials, and architecture, there is still a chance that Mesoamerican obsidian is present at Paquimé. Pieces of Pachuca obsidian from the Mexican state of Hidalgo are present in Spanish and Coronado-era sites in northern New Mexico (Lekson and Cameron 2016) and at Spiro in eastern Oklahoma (Barker et al. 2002). Therefore, it is not out of the realm of possibility for Mesoamerican obsidian to be at a very large and important site closer to Mesoamerica than most other sites in the SW/NW. More investigation and sourcing are needed at Paquimé and other Medio period sites.

Some obsidian debitage at Paquimé has a bluish-gray color with gray banding (Figures 7.1 and 7.2). Di Peso (1974:7:337) also noticed the unique banding of some of the obsidian flakes from Paquimé, similar to those in Figure 7.1.

> The differences in color and banding of the chert and obsidian, in particular, indicated that they were derived from several sources, including at least one W of Durango City (see Vol. 8, p. 189, for discussion). The obsidian appeared to be of several varieties, each with some range in color. There was, for example, a series

of black obsidian with a very glassy texture, the variations of which may or may not be related. Some of this material was quite translucent, even in quite thick pieces, and actually gray in this form, while at the other end of the spectrum was obsidian that was opaque and very black. Somewhere between these two extremes was a specimen that was streaked with a very light gray color, which in comparison to the black of the mass, looked white. A variation noted in the opaque black obsidian was a grainier texture and a very dark gray color. One of the types of translucent black obsidian had a tinge of gold when held to a light. At least some of this latter material, as well as some of the translucent gray and opaque black, appeared to have had their source W of Durango City (Spence, Personal communication, February 3, 1968). Another series of opaque obsidian ranged from a clear light-to-medium gray to a dark gray on the bluish side, including specimens barely to more heavily streaked in lighter and darker shades of bluish-gray. These may have been related to an interesting series with a greenish cast. Some of the material, an opaque medium gray with a greenish cast, could be matched on the Munsell Soil Colors charts as FY 3/2. A particularly interesting flake was a darker medium gray streaked with green which, in turn, was finely streaked with a brownish-gray. Similar to this was a flake of the same shade of green streaked with a lighter medium gray; it, too, was opaque. Another variant of this material was an opaque obsidian of the same medium green, but without streaking.

Figure 7.1. One obsidian flake from Paquimé showing the unique bluish-gray/green color and banding.
Note: Measurements are listed for this artifact (CG/1871T) in Di Peso et al. (1974:7:381). Photo taken by Dolan in July 2014 in Casas Grandes, Chihuahua.

Figure 7.2. Obsidian chipped stone debitage from Paquimé.
Note: Photo taken by Dolan in July 2014 in Casas Grandes, Chihuahua.

In the above quote, Di Peso (1974:7:337) notes that obsidian from Paquimé is from multiple sources including one from Durango City based on differences in color, transparency, and opaqueness. Although he is correct, variations in these attributes do not necessarily mean nodules derived from different geochemically distinct obsidian sources. For instance, there is a mahogany version of Cerro del Medio from the Valles Caldera (Chapter 3; LeTourneau and Steffen 2002).

After a visual inspection of all obsidian artifacts from sites 204, 242, 315, and 317 after sourcing analysis was completed, I noticed some Sierra Fresnal and Los Jagüeyes flakes have a similar color to those depicted in Figures 7.2 and 7.2. Unfortunately, the Sierra Fresnal and Los Jagüeyes flakes were not as big as those shown in Figure 7.2, and so a comparison of color is difficult to assess at this point.

While determining the provenance of obsidian using megascopic visual techniques is ill-advised because there can be variation within and between obsidian sources throughout the world, I tentatively hypothesize that people at Paquimé used Sierra Fresnal the most for obsidian manufacture. This hypothesis is strengthened by the fact that people at site 315 used Sierra Fresnal more than other sources, and this site is two kilometers from Paquimé (Whalen and Minnis 2009b).

Taking a More Theoretical Approach

One way to move archaeological method and theory forward using sourcing methods is to integrate higher levels of anthropological theory with obsidian provenance datasets. In other words, geochemically characterizing the trace elements of obsidian and describing what sources people used need to be a means to an end (Freund 2013). This is similar to what Dillian (2002:2) has argued in that most obsidian and lithic quarry studies have focused on "here's-what-they-made and here's-where-it-came-from." It is one thing to document and describe the sources of raw materials using geochemical sourcing methods to first understand baseline patterns, but without placing the results into a broader picture of human action, behavior, and practice, the data can only tell us so much.

There is more to be accomplished anthropologically with obsidian in the twenty-first century. The study of obsidian procurement within the SW/NW demands a reevaluation of the role that agents and communities of practice played within society. This requires archaeologists to think about people, places, and things using a practice-centered approach. One way to do this in the future is to take an object life history, object itinerary, or chaîne opératoire approach to examine the intricacies of human behavior associated with the procurement, use, and discard of objects made of obsidian.

As an example, in certain parts of the western United States like in California and Arizona, people made certain projectile point styles and stone tool styles of certain types of obsidian. In other words, people used one source to manufacture one style or tool, while another source would be used to manufacture another (Dillian 2002; Hoffman 1997; Jackson 1989; Shackley 2005:147-171). Dolan and Putsavage (2013) examined this question for obsidian projectile points in southwestern New Mexico that date to A.D. 1000 to 1450. The results, however, showed that based on a small sample size of sourced obsidian projectile points (n=46) from three sites (Old Town, Black Mountain, and Kipp Ruin), the different projectile point types did not derive from different obsidian sources, but rather most characterized to Antelope Creek. This is not to say that this research question is not a fruitful one in other areas or time periods of the SW/NW. Dolan and Putsavage (2013) did show, however, that people in southwestern New Mexico during the eleventh through mid-fifteenth centuries primarily made projectile points from Antelope Creek obsidian, even at sites with evidence of Antelope Wells and Sierra Fresnal use (see Taliaferro 2004 for Mimbres Classic period obsidian projectile points sourcing results). If most obsidian projectile points in southwestern New Mexico are made of Antelope Creek obsidian, why do some sites near Deming have a high percentage of flaked chipped stone debitage made from Sierra Fresnal and Antelope Wells when these two sources are infrequently used to manufacture formal tools like projectile points?

I suggest that by further examining all stages of obsidian lithic procurement, manufacture, distribution, and discard in the archaeological record, archaeologists may be able to examine what Lave and Wenger (1991; Wenger 1998) call a community of practice. A community of practice is a network of shared relations among people and objects that is mediated by actions and performances that participants of the community conduct. Ceramicists have already examined potting communities of practice in the SW/NW (Cordell and Habicht-Mauche 2012; Duwe 2005; Eckert et al. 2015; Huntley 2008; Stark 2006), and their results reveal fascinating insights into how people identified with themselves and within their own communities, given the type of temper, the glaze recipe they used during vessel manufacture, and the painting style they used.

Finally, archaeologists and other scientists who are trained in geochemical analyses have used such analytical techniques from the natural sciences to gather information about the artifacts we find in the archaeological record (Shackley 2008). A twenty-first century archaeologist should use all available tools in a laboratory setting, but it is now even most important to take that information and apply anthropological theory (Jones 2002; Joyce 2011; Pollard and Bray 2007) because studies of obsidian are increasingly present in the archaeological literature.

References Cited

Adams, E. Charles, and Andrew I. Duff (editors)
2004 *The Protohistoric Pueblo World, A.D. 1275-1500*. University of Arizona Press, Tucson.

Adler, Michael A. (editor)
1996 *The Prehistoric Pueblo World, A.D. 1150-1350*. University of Arizona Press, Tucson.

Ahler, Stanley A.
1989 Mass Analysis of Flaking Debris: Studying the Forest Rather than the Tree. In *Alternative Approaches to Lithic Analysis*, edited by Donald O. Henry and George H. Odell, pp. 85-118. Archaeological Paper No. 1. American Anthropological Association, Arlington, Virginia.

Ambrose, Stanley H.
2012 Obsidian Dating and Source Exploitation Studies in Africa: Implications for the Evolution of Human Behavior. In *Obsidian and Ancient Manufactured Glasses*, edited by Ioannis Liritzis and Christopher M. Stevenson, pp. 56-72. University of New Mexico Press, Albuquerque.

Andrefsky Jr., William
1994 Raw-Material Availability and the Organization of Technology. *American Antiquity* 59:21-34.

2001 *Lithics: Macroscopic Approaches to Analysis*. Cambridge Manuals in Archaeology. Cambridge University Press, Cambridge.

Antillón, Rafael Cruz, Robert D. Leonard, Timothy D. Maxwell, Todd L. VanPool, Marcel J. Harmon, Christine S. VanPool, David A. Hyndman, and Sidney S. Brandwein
2004 Galeana, Villa Ahumada, and Casa Chica: Diverse Sites in the Casas Grandes Region. In *Surveying the Archaeology of Northwest Mexico*, edited by Gillian E. Newell and Emiliano Gallaga, pp. 149-175. University of Utah Press, Salt Lake City.

Anyon, Roger, Patricia A. Gilman, and Steven A. LeBlanc
1981 A Reevaluation of the Mogollon-Mimbres Archaeological Sequence. *Kiva* 46:209-225.

Anyon, Roger, and Steven A. LeBlanc
1980 The Architectural Evolution of Mogollon-Mimbres Communal Structures. *Kiva* 45:253-277.

1984 *The Galaz Ruin: A Prehistoric Mimbres Village in Southwestern New Mexico*. Maxwell Museum of Anthropology and University of New Mexico Press, Albuquerque.

Arakawa, Fumiyasu, Scott G. Ortman, M. Steven Shackley, and Andrew I. Duff
2011 Obsidian Evidence of Interaction and Migration from the Mesa Verde Region, Southwest Colorado. *American Antiquity* 76:773-795.

Barker, Alex W., Craig E. Skinner, M. Steven Shackley, Michael D. Glascock, and J. Daniel Rogers
2002 Mesoamerican Origin for an Obsidian Scraper from the Precolumbian Southeastern United States. *American Antiquity* 67:103-108.

Baugh, Timothy G., and Fred W. Nelson
1987 New Mexico Obsidian Sources and Exchange on the Southern Plains. *Journal of Field Archaeology* 14:313-329.

Baugh, Timothy G., and Charles W. Terrell
1982 An Analysis of Obsidian Debitage and Protohistoric Exchange Systems in the Southern Plains as Viewed from the Edwards I Site (34BK2). *Plains Anthropologist* 27:1-17.

Bayman, James M., and M. Steven Shackley
1999 Dynamics of Hohokam Obsidian Circulation in the North American Southwest. *Antiquity* 73:836-845.

Bettinger, Robert L., Michael G. Delacores, and Robert J. Jackson
1984 Visual Sourcing of Central Eastern California Obsidians. In *Obsidian Studies in the Great Basin*, edited by Richard E. Hughes, pp. 63-78. Contributions of the University of California Archaeological Research Facility 45.

Binford, Lewis R.
1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1:5-31.

Blake, Michael, Steven A. LeBlanc, and Paul E. Minnis
1986 Changing Settlement and Population in the Mimbres Valley, SW New Mexico. *Journal of Field Archaeology* 13:439-464.

Blatt, Harvey, and Robert J. Tracy
1996 *Petrology*. W.H. Freeman and Company, New York.

Boulanger, Matthew T., Thomas R. Jamison, Craig E. Skinner, and Michael D. Glascock

2007 Analysis of an Obsidian Biface Reportedly Found in the Connecticut River Valley of Vermont. *Archaeology of Eastern North America* 35:81-92.

Brand, Donald D.

1933 *The Historical Geography of Northwestern Chihuahua*. Unpublished Ph.D. dissertation, University of California, Berkeley, California.

1943 The Chihuahua Culture Area. *New Mexico Anthropologist* 6-8:115-158.

Brantingham, P. Jeffrey

2003 A Neutral Model of Stone Raw Material Procurement. *American Antiquity* 68:487-509.

Braun, David R., Thomas Plummer, Joseph V. Ferrarro, Peter Ditchfield, and Laura C. Bishop

2009 Raw Material Quality and Oldowan Hominin Toolstone Preferences: Evidence from Kanjera South, Kenya. *Journal of Archaeological Science* 36:1605-1614.

Brody, J. J.

2004 *Mimbres Painted Pottery*. School of American Research Press, Santa Fe.

Brody, J.J., Catherine J. Scott, and Steven A. LeBlanc

1983 *Mimbres Pottery: Ancient Art of the American Southwest*. Hudson Hills Press, New York.

Brooks, Robert L., Christopher Lintz, and Timothy G. Baugh

2014 If It's Bright and Shiny: An Assessment of Sites with Obsidian in Oklahoma. Paper presented at the 72nd Annual Plains Anthropological Society meeting, Fayetteville, AR.

Brosowske, Scott D.

2004 Obsidian Procurement and Distribution during the Middle Ceramic Period of the Southern High Plains: Evidence for the Emergence of Regional Trade Centers. *Council of Texas Archaeologists Newsletter* 28:16-28.

Brown, David E.

1994 Chihuahuan Desertscrub. In *Biotic Communities: Southwestern United States and Northwestern Mexico*, edited by David E. Brown, pp. 169-179. University of Utah Press, Salt Lake City.

Brown, Gary M.

1999a Data Recovery at LA 111395, Badger Ruin. In *South West Rock Expansion: Archaeological Data Recovery in the Buckhorn Gulch Area at the Continental Mine, Grant County, New Mexico*, edited by Gary M. Brown, pp. 45-106. Western Cultural Resource Management, Farmington, New Mexico.

1999b Data Recovery at LA 111413, Jackson Fraction. In *South West Rock Expansion: Archaeological Data Recovery in the Buckhorn Gulch Area at the Continental Mine, Grant County, New Mexico*, edited by Gary M. Brown, pp. 151-257. Western Cultural Resource Management, Farmington, New Mexico.

Buck, Bruce A.

1982 Ancient Technology in Contemporary Surgery. *Western Journal of Medicine* 136:265-269.

Burgett, Jessica P.

2006 *El Paso Polychrome in the Casas Grandes Region, Chihuahua, Mexico: Ceramic Exchange between Paquimé and the Jornada Mogollon*. Unpublished Ph.D. dissertation, Pennsylvania State University, University Park.

Cameron, Catherine M.

2013 How People Moved among Ancient Societies: Broadening the View. *American Anthropologist* 115:218-231.

Carpenter, John P.

2002 The Animas Phase and Paquimé Regional Differentiation and Integration at Joyce Well. In *The Joyce Well Site: On the Frontier of the Casas Grandes World*, edited by James M. Skibo, Eugene B. McCluney, and William H. Walker, pp. 149-166. University of Utah Press, Salt Lake City.

Chapman, Richard

2011 Research Design and Data Recovery Plan for LA 47821, LA 127051, and LA 157279 near Lake Roberts, Grant County, New Mexico. Prepared for New Mexico Department of Game and Fish, Office of Contract Archeology OCA/UNM Project No. 185-1082, Albuquerque.

Church, Tim

2000 Distribution and Sources of Obsidian in the Rio Grande Gravels of New Mexico. *Geoarchaeology* 15:649-678.

Clark, Jeffrey J.

2001 *Tracking Prehistoric Migrations: Pueblo Settlers among the Tonto Basin Hohokam*. Anthropological Papers 65. University of Arizona Press, Tucson.

Clark, John E.
2003 A Review of Twentieth-Century Mesoamerican Obsidian Studies. In *Mesoamerican Lithic Technology: Experimentation and Interpretation*, edited by Kenneth G. Hirth, pp. 15-54. University of Utah Press, Salt Lake City.

Clayton, Sarah C.
2006 Ritual and Residence: The Social Implications of Classic Mimbres Ceremonial Spaces. *Kiva* 72:71-92.

Cordell, Linda S.
2015 Ancient Paquimé: A View from the North. In *Ancient Paquimé and the Casas Grandes World*, edited by Paul E. Minnis and Michael E. Whalen, pp. 192-207. University of Arizona Press, Tucson.

Cordell, Linda S., and Judith A. Habicht-Mauche (editors)
2012 *Potters and Communities of Practice: Glaze Paint and Polychrome Pottery in the American Southwest, A.D. 1250-1700*. Anthropological Papers of the University of Arizona 75. University of Arizona Press, Tucson.

Cosgrove, Harriet B., and Cornelius B. Cosgrove
1932 *The Swarts Ruin: A Typical Mimbres Site in Southwestern New Mexico*. Papers of the Peabody Museum of American Archaeology and Ethnology No. 15. Harvard University, Cambridge, Massachusetts.

Crabtree, Don E.
1967 Notes on Experiments in Flintknapping 3: The Flintknapper's Raw Materials. *Tebiwa* 10:8-24.

Creel, Darrel
1989 A Primary Cremation at the NAN Ruin, with Comparative Data on Other Cremations in the Mimbres Area, New Mexico. *Journal of Field Archaeology* 16:309-329.

1999 The Black Mountain Phase in the Mimbres Area. In *The Casas Grandes World*, edited by Curtis F. Schaafsma and Carroll L. Riley, pp. 197-120. University of Utah Press, Salt Lake City.

2006a *Excavations at the Old Town Ruin, Luna County, New Mexico, 1989-2003, Vol. 1.* U.S. Bureau of Land Management, New Mexico State Office, Santa Fe.

2006b Evidence for Mimbres Social Differentiation at the Old Town Site. In *Mimbres Society*, edited by Valli S. Powell-Martí and Patricia A. Gilman, pp. 32-44. University of Arizona Press, Tucson.

2014 The Hohokam, the Mimbres, and the Land Between: A Mimbres Perspective. In *Between Mimbres and Hohokam: Exploring the Archaeology and History of Southeastern Arizona and Southwestern New Mexico*, edited by Henry D. Wallace, pp. 535-549. Anthropological Papers No. 52, Archaeology Southwest, Tucson.

Creel, Darrel, and Roger Anyon
2003 New Interpretations of Mimbres Public Architecture and Space: Implications for Cultural Change. *American Antiquity* 68:67-92.

2010 Burning Down the House: Ritual Architecture of the Mimbres Late Pithouse Period. In *Mimbres Lives and Landscapes*, edited by Margaret C. Nelson and Michelle Hegmon, pp. 29-37. SAR Press, Santa Fe.

Creel, Darrel, and Robert Speakman
2012 The Mimbres Vessel Project: An Update to the Neutron Activation Analysis Effort. Paper presented at the 17th Biennial Mogollon Conference, Silver City.

Crown, Patricia L.
1994 *Ceramics and Ideology: Salado Polychrome Pottery*. University of New Mexico Press, Albuquerque.

Crown, Patricia L., Jiyan Gu, W. Jeffrey Hurst, Timothy J. Ward, Ardith D. Bravenec, Syed Ali, Laura Kebert, Marlaina Berch, Erin Redman, Patrick D. Lyons, Jamie Merewether, David A. Phillips, Lori S. Reed, and Kyle Woodson
2015 Ritual Drinks in the Pre-Hispanic US Southwest and Mexican Northwest. *Proceedings of the National Academy of Sciences* 112:11436-11442.

Crown, Patricia L., and W. James Judge
1991 Synthesis and Conclusions. In *Chaco and Hohokam: Prehistoric Regional Systems in the American Southwest*, edited by Patricia L. Crown and W. James Judge, pp. 293-308. School of American Research Press, Santa Fe, New Mexico.

Darling, J. Andrew
1993 Notes on Obsidian Sources of the Southern Sierra Madre Occidental. *Ancient Mesoamerica* 4:245-253.

1998 *Obsidian Distribution and Exchange in the North-Central Frontier of Mesoamerica*. Unpublished Ph.D. dissertation, University of Michigan.

Davis, M. Kathleen, Thomas L. Jackson, M. Steven Shackley, Timothy Teague, and Joachim H. Hampel

1998 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *Archaeological Obsidian Studies: Method and Theory*, edited by M. Steven Shackley, pp. 159-180. Plenum Press, New York.

2011 Factors Affecting the Energy-Dispersive X-Ray Fluorescence (EDXRF) Analysis of Archaeological Obsidian. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M. Steven Shackley, pp. 45-63. Springer, New York.

DeAtley, Suzanne P.

1980 *Regional Integration on the Northern Casas Grandes Frontier*. Unpublished Ph.D. dissertation, University of California, Los Angeles.

DeAtley, Suzanne P., and Frank J. Findlow

1982 Regional Integration of the Northern Casas Grandes Frontier. In *Mogollon Archaeology: Proceedings of the 1980 Mogollon Conference*, edited by Pat H. Beckett, pp. 263-277. Acoma Books, Ramona, California.

DeBry Robert V.

2012 *A Diachronic Analysis of Zooarchaeological Remains at Kipp Ruin (LA 153465), Luna County, New Mexico*. Unpublished Master's thesis, New Mexico State University, Las Cruces.

Dean, Jeffrey S.

2000 Introduction. In *Salado*, edited by Jeffrey S. Dean, pp. 3-25 University of New Mexico Press, Albuquerque.

Dean, Jeffrey S., and John C. Ravesloot

1993 The Chronology of Cultural Interaction in the Gran Chichimeca. In *Culture and Contact: Charles C. Di Peso's Gran Chichimeca*, edited by Anne I. Woosley and John C. Ravesloot, pp. 83-103. Amerind Foundation, Dragoon, Arizona and University of New Mexico Press, Albuquerque.

Diehl, Michael W.

2007 Mogollon Trajectories and Divergences. In *Zuni Origins: Toward a New Synthesis of Southwestern Archaeology*, edited by David A. Gregory and David R. Wilcox, pp. 146-162. University of Arizona Press, Tucson.

Diehl, Michael W., and Steven A. LeBlanc

2001 *Early Pithouse Villages of the Mimbres Valley and Beyond: The McAnally and Thompson Sites in their Cultural and Ecological Contexts*. Papers of the Peabody Museum of Archaeology and Ethnology, vol. 83. Harvard University Press, Cambridge.

Dillian, Carolyn D.
2002 *More than Toolstone: Differential Utilization of Glass Mountain Obsidian*. Unpublished Ph.D. Dissertation, Department of Anthropology, University of California, Berkeley.

Dillian, Carolyn D., Charles A. Bellow, and M. Steven Shackley
2010 Long-Distance Exchange of Obsidian in the mid-Atlantic United States. In *Trade and Exchange: Archaeological Studies from History and Prehistory*, edited by Carolyn D. Dillian and Carolyn L. White, pp. 17-35. Springer, New York.

Di Peso, Charles C.
1968 Casas Grandes and the Gran Chichimeca. *El Palacio* 75:45-61.

1974 *Casas Grandes: A Fallen Trading Center of the Gran Chichimeca,* Vols. 1-3. Amerind Foundation, Dragoon, Arizona; and Northland Press, Flagstaff.

Di Peso, Charles C., John B. Rinaldo, and Gloria Fenner
1974 *Casas Grandes: A Fallen Trading Center of the Gran Chichimeca,* Vols. 4-8. Amerind Foundation, Dragoon, Arizona; and Northland Press, Flagstaff.

Disa, Joseph J., Jafar Vossoughi, and Nelson H. Goldberg
1993 A Comparison of Obsidian and Surgical Steel Scalpel Wound Healing in Rats. *Plastic and Reconstructive Surgery* 92:884-887.

Dockall, John E.
1991 *Chipped Stone Technology at Nan Ruin, Grant County, New Mexico*. Unpublished M.A. Thesis. Texas A&M University, College Station.

Dolan, Sean G.
2012 Source Provenance Analysis of Archaeological Obsidian from Kipp Ruin (LA 153465), Luna County, New Mexico. In *Collected Papers from the 16th Biennial Mogollon Archaeology Conference*, edited by Lonnie C. Ludeman, pp. 17-28. Friends of Mogollon Archaeology, Las Cruces, New Mexico.

Dolan, Sean G., Judy Berryman, and M. Steven Shackley
2016 The Source Provenance of an Obsidian Eden Point from Sierra County, New Mexico. *PaleoAmerica* 2:48-51.

Dolan, Sean G., and Jeffrey R. Ferguson
2012 Diachronic Investigations of Obsidian along the Lower Mimbres River. Paper presented at the 77th Annual Meeting of the Society for American Archaeology, Memphis.

Dolan, Sean G., and Patricia A. Gilman
2015 *Southern Mimbres Archaeological Project, Summer 2013, Cultural Resource Inventory Report*. Prepared for and on file at the Bureau of Land Management, Las Cruces Field Office, Las Cruces, NM.

Dolan, Sean G., and Alison K. Livesay
2015 Mimbres Traditions and Practices past the Mimbres Valley: Results and Investigations from Six Field Seasons of the Southern Mimbres Archaeological Project. In *Collected Papers from the 18th Biennial Mogollon Archaeology Conference*, edited by Lonnie C. Ludeman, pp. 11-20. Friends of Mogollon Archaeology, Las Cruces, New Mexico.

Dolan, Sean G., Myles R. Miller, M. Steven Shackley, and Jeffrey R. Ferguson
2015 *An Update and New Insights into Obsidian Procurement in the Jornada Region*. Paper presented at the 17th biennial Jornada Mogollon Conference, El Paso, Texas.

Dolan, Sean G., and Kathryn J. Putsavage
2012 *Black Rocks at Black Mountain: Obsidian Sourcing Results from LA 49*. Paper presented at the 2012 Mogollon Archaeology Conference, Silver City, New Mexico.

2013 *Obsidian Sources, Projectile Point Typologies, and Questions of Continuity in the Mimbres Valley, New Mexico, A.D. 1000-1450*. Poster presented at the 78th Annual Meeting of the Society for American Archaeology, Honolulu, Hawaii.

Douglas, John E.
1995 Autonomy and Regional Systems in the Late Prehistoric Southwest. *American Antiquity* 60:240-257.

1996 Distinguishing Change during the Animas Phase (A.D. 1150-1450) at the Boss Ranch Site, Southeastern Arizona. *North American Archaeologist* 17:183-202.

2007 Making and Breaking Boundaries in the Hinterlands: The Social and Settlement Dynamics of Far Southwestern Arizona and Southwestern New Mexico. In *Hinterlands and Regional Dynamics in Ancient Southwest*, edited by Alan P. Sullivan and James M. Bayman, pp. 97-108. University of Arizona Press, Tucson.

Douglas, John E., and A.C. MacWilliams
2015 Society and Polity in the Wider Casas Grandes Region. In *Ancient Paquimé and the Casas Grandes World*, edited by Paul E. Minnis and Michael E. Whalen, pp. 126-147. University of Arizona Press, Tucson.

Douglas, John E., and César A. Quijada
2004 Between the Casas Grandes and the Rio Sonora Valleys: Chronology and Settlement in the Upper Bavispe Drainage. In *Surveying the Archaeology of Northwest Mexico*, edited by Gillian E. Newell and Emiliano Galalga, pp. 93-109. University of Utah Press, Salt Lake City.

2005 Di Peso's Concept of the Northern Sierra: Evidence from the Upper Bavispe Valley, Sonora, Mexico. *Latin American Antiquity* 16:275-291.

Duff, Andrew I., Jeremy M. Moss, Thomas C. Windes, John Kantner, and M. Steven Shackley
2012 Patterning in Procurement of Obsidian in Chaco Canyon and in Chaco-Era Communities in New Mexico as Revealed by X-ray Fluorescence. *Journal of Archaeological Science* 39:2995-3007.

Duff, U. Francis
1902 The Ruins of the Mimbres Valley. *The American Antiquarian and Oriental Journal* 24:397-400.

Duwe, Samuel
2005 *Communities of Practice and Ancient Apprenticeship in the American Southwest: Pigment Analyses of Pueblo IV Period Ceramics from Bailey Ruin, East-Central Arizona*. Unpublished Master's thesis, University of Arizona, Tucson.

Duwe, Samuel, B. Sunday Eiselt, J. Andrew Darling, Mark D. Willis, and Chester Walker
2016 The Pueblo Decomposition Model: A Method for Quantifying Architectural Rubble to Estimate Population Size. *Journal of Archaeological Science* 65:20-31.

Eckert, Suzanne L., Kari L. Schleher, and William D. James
2015 Communities of Identity, Communities of Practice: Understanding Santa Fe Black-on-White Pottery in the Española Basin of New Mexico. *Journal of Archaeological Science* 63:1-12.

Eerkens, Jelmer W., Jeffrey R. Ferguson, Michael D. Glascock, Craig E. Skinner, and Sharon A. Waechter
2007 Reduction Strategies and Geochemical Characterization of Lithic Assemblages: A Comparison of Three Case Studies from Western North America. *American Antiquity* 72:585-597.

Eerkens, Jelmer W., and Jeffrey S. Rosenthal
2004 Are Obsidian Subsources Meaningful Units of Analysis? Temporal and Spatial Patterning of Subsources in the Coso Volcanic Field, Southeastern California. *Journal of Archaeological Science* 31:21-29.

Ferguson, Jeffrey R., Karl W. Laumbach, Toni S. Laumbach, Virginia T. McLemore, and Stephen H. Lekson

2016 You Get It Here, I'll Get It There: Examining the Movement of Objects, People, and Ideas throughout the Pithouse and Pueblo Occupation of the Cañada Alamos. In *Exploring Cause and Explanation: Historical Ecology, Demography, and Movement in the American Southwest*, edited by Cynthia L. Herhan and Ann F. Ramenofsky, pp. 231-256. University Press of Colorado, Boulder.

Ferguson, Jeffrey R., and Craig E. Skinner

2003 Colorado Obsidian? Preliminary Results of a Statewide Database of Trace Element Analysis. *Southwestern Lore* 69:35-50.

Fertelmes, Craig M., David R. Abbott, and M. Steven Shackley

2012 Obsidian Source Characterization at Las Colinas: Shifting Exchange Patterns during the Hohokam Sedentary to Classic Transition. *Kiva* 77:281-311.

Fewkes, Jesse Walter

1914 Archaeology of the Lower Mimbres Valley, New Mexico. *Smithsonian Miscellaneous Collections* 63:1-53. Washington, D.C.

1923 Designs on Prehistoric Pottery from the Mimbres Valley, New Mexico. *Smithsonian Miscellaneous Collections* 74:1-47. Washington, D.C.

1924 Additional Designs on Prehistoric Mimbres Pottery. *Smithsonian Miscellaneous Collections* 76:1-46. Washington, D.C.

Findlow, Frank J., and Marisa Bolognese

1980 An Initial Examination of Prehistoric Obsidian Exchange in Hidalgo County New Mexico. *Kiva* 45:227-251.

1982a Regional Modeling of Obsidian Procurement in the Southwest. In *Contexts for Prehistoric Exchange,* edited by Jonathon Ericson and Timothy Earle, pp. 53-81. Academic Press, New York.

1982b A Preliminary Analysis of Prehistoric Obsidian Use within the Mogollon Area. In *Mogollon Archaeology: Proceedings of the 1980 Mogollon Conference*, edited by Patrick H. Beckett, p. 297-316. Acoma Books, Ramona, California.

Findlow, Frank J., and Suzanne P. DeAtley

1974 Prehistoric Land Use Patterns in the Animas Valley: A First Approximation. *Anthropology UCLA* 6:1-57.

Fish, Paul R., and Susanne K. Fish
1999 Reflections on the Casas Grandes Regional System from the Northwestern Periphery. In *The Casas Grandes World*, edited by Curtis F. Schaafsma, and Carroll L. Riley, pp. 27-42. University of Utah Press, Salt Lake City.

Frahm, Ellery
2012 What Constitutes an Obsidian "Source"? Landscape and Geochemical Considerations and their Archaeological Implications. *International Association for Obsidian Studies Bulletin* 46:16-28.

Fralick, Phillip W., Joe D. Stewart, and A.C. MacWilliams
1998 Geochemistry of West-central Chihuahua Obsidian Nodules and Implications for the Derivation of Obsidian Artefacts. *Journal of Archaeological Science* 25:1023-1038.

Freund, Kyle P.
2013 An Assessment of the Current Applications and Future Directions of Obsidian Sourcing Studies in Archaeological Research. *Archaeometry* 55:779-793.

Fuller, Richard E.
1927 The Mode of Origin of the Color of Certain Varicolored Obsidians. *Journal of Geology* 35:570-573.

Gilman, Patricia A.
1987 Architecture as Artifact: Pit Structures and Pueblos in the American Southwest. *American Antiquity* 52:538-564.

1989 Households, Communities, and Painted Pottery int eh Mimbres Region of Southwestern New Mexico. In *Households and Communities*, edited by Scott MacEachern, David J. W. Archer, and Richard D. Garvin, pp. 218-226. The Archaeological Association of the University of Calgary, Calgary.

1990 Social Organization and Classic Mimbres Period Burials in the SW United States. *Journal of Field Archaeology* 17:457-469.

2006 Social Differences at the Classic Period Mattocks Site in the Mimbres Valley. In *Mimbres Society*, edited by Valli S. Powell-Martí and Patricia A. Gilman, pp. 66-81. University of Arizona Press, Tucson.

2011 Between Mimbres and Hohokam: The San Simon Basin during the Pit Structure Period. *Kiva* 76:277-295.

Gilman, Patricia A., Veletta Canouts, and Ronald Bishop
1994 The Production and Distribution of Classic Mimbres Black-on-white Pottery. *American Antiquity* 69:695-709.

Gilman, Patricia A., and Tammy Stone
2013 The Role of Ritual Variability in Social Negotiations of Early Communities: Great Kiva Homogeneity and Heterogeneity in the Mogollon Region of the North American Southwest. *American Antiquity* 78:607-623.

Gilman, Patricia A., Marc Thompson, and Kristina C. Wyckoff
2014 Ritual Change and the Distant: Mesoamerican Iconography, Scarlet Macaws, and Great Kivas in the Mimbres Region of Southwestern New Mexico. *American Antiquity* 79:90-107.

Glascock, Michael D.
2002 Introduction: Geochemical Evidence for Long-Distance Exchange. In *Geochemical Evidence for Long-Distance Exchange*, edited by Michael D. Glascock, pp. 1-11. Bergin and Garvey, Westport, Connecticut.

2011 Comparison and Contrast between XRF and NAA: Used for Characterization of Obsidian Sources in Central Mexico. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M. Steven Shackley, pp. 161-192. Springer, New York.

Glascock, Michael D., Geoffrey E. Braswell, and Robert H. Cobean
1998 A Systematic Approach to Obsidian Source Characterization. In *Archaeological Obsidian Studies: Method and Theory*, pp. 15-66, edited by M. Steven Shackley. Plenum Press, New York.

Glascock, Michael D., Speakman, Robert J., and Hector Neff
2007 Archaeometry at the University of Missouri Research Reactor and the Provenance of Obsidian Artefacts of North America. *Archaeometry* 49:343-359.

Glascock, Michael D., Raymond Kunselman, and Daniel Wolfman
1999 Intrasource Chemical Differentiation of Obsidian in the Jemez Mountains and Taos Plateau, New Mexico. *Journal of Archaeological Science* 26:861-868.

Goodman, Mary Ellen
1944 The Physical Properties of Stone Tool Materials. *American Antiquity* 4:415-433.

Graves, William M.
2005 Obsidian Procurement among the Jumanos Pueblos, New Mexico, A.D. 1300-1670s. *Kiva* 71:7-35.

Griffin, James B., Adon A. Gordus, and Gary A. Wright
1969 Identification of the Sources of Hopewellian Obsidian in the Middle West. *American Antiquity* 34:1-14.

Griffith, Tabitha L., Nancy A. Kenmotsu, William Russell, and Myles Miller
2012 Exploring Southern Mimbres Settlement: Excavations at LA 85774, Southern Luna County, New Mexico. In *Collected Papers from the 16th Biennial Mogollon Archaeology Conference*, edited by Lonnie C. Ludeman, pp. 41-51. Friends of Mogollon Archaeology, Las Cruces, New Mexico.

Gruber, Thomas E.
2007 *The Regional Diversity of Mimbres Boldface (Style 1) Bowl Designs*. Unpublished Master's thesis, University of Oklahoma, Norman.

2015 *Social Boundaries between Ceramic Design Production Groups at Classic Mimbres Sites, Southwestern New Mexico, A.D. 1000-1130*. Unpublished Ph.D. dissertation, University of Oklahoma, Norman.

Hammerstedt, Scott W., Michael D. Glascock, and Craig E. Skinner
2008 Obsidian Artifacts from Moundville. *Journal of Alabama Archaeology* 54:53-56.

Harbottle, Garman
1982 Chemical Characterization in Archaeology. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 13-51. Academic Press, New York.

Hard, Robert J., and John R. Roney
1999 *An Archaeological Investigation of Late Archaic Cerros de Trincheras Sites in Chihuahua, Mexico: Results of the 1998 Investigations. Report to Consejo de Arquelogi'a, Instituto Nacional de Antropologi'a e Historia*. Center for Archaeological Research, University of Texas at San Antonio Special Report, No. 25. San Antonio, Texas.

2007 Cerros de Trincheras in Northwestern Chihuahua: The Arguments for Defense. In *Trincheras Sites in Time, Space, and* Society, edited by Suzanne K. Fish, Paul R. Fish, and M. Elisa Villalpando, pp. 11-34. University of Arizona Press, Tucson.

Hatch, James W., Joseph W. Michels, Christopher M. Stevenson, Barry E. Scheetz, and Richard A. Geidel
1990 Hopewell Obsidian Studies: Behavioral Implications of Recent Sourcing and Dating Research. *American Antiquity* 55:461-479.

Haury, Emil W.

1936a *The Mogollon Culture of Southwestern New Mexico*. Medallion Papers 20. Gila Pueblo, Globe, Arizona.

1936b *Some Southwestern Pottery Types (Series IV)*. Medallion Papers No. 19. Gila Pueblo, Globe, Arizona.

1958 Evidence at Point of Pines for a Prehistoric Migration from Northern Arizona. In *Migrations in New World Culture History*, edited by Raymond H. Thompson. University of Arizona Bulletin 29 Social Science Bulletin 27:1-8.

1976 Salado: The View from Point of Pines. *Kiva* 42:81-84.

1985 *Mogollon Culture in the Forestdale Valley, East-Central Arizona*. University of Arizona Press, Tucson.

Hawley, John, Frank E. Kottlowski, W. R. Seager, William E. King, William S. Strain, and David V. LeMone

1969 The Santa Fe Group in the South-Central New Mexico Border Region. In *Border Stratigraphy Symposium*, edited by Frank E. Kottlowski and David V. LeMone, pp. 52-76. New Mexico Bureau of Mines and Mineral Resources.

Hegmon, Michelle

2002 Recent Issues in Archaeology of the Mimbres Region of the North American Southwest. *Journal of Archaeological Research* 10:307-357.

Hegmon, Michelle, Margaret C. Nelson, Roger Anyon, Darrell Creel, Steven A. LeBlanc, and Harry J. Shafer

1999 Scale and Time-Space Systematics in the Post-A.D. 1100 Mimbres Region of the North American Southwest. *Kiva* 65:143-166.

Hegmon, Michelle, and Margaret C. Nelson

2007 In Sync, but Barely in Touch: Relations between the Mimbres Region and the Hohokam Regional System. In *Hinterlands and Regional Dynamics in the Ancient Southwest*, edited by Alan P. Sullivan and James M. Bayman, pp. 70-96. University of Arizona Press, Tucson.

Hegmon, Michelle, Margaret C. Nelson, and Susan Ruth

1998 Abandonment, Reorganization, and Social Change: Analysis of Pottery and Architecture from the Mimbres Region of the American Southwest. *American Anthropologist* 100:148-162.

Hill, J. Brett, Jeffrey J. Clark, William H. Doelle, and Patrick D. Lyons

2010 Depopulation of the Northern Southwest: A Macroregional Perspective. In *Leaving Mesa Verde: Peril and Change in the Thirteenth-Century Southwest*, edited by Timothy A. Kohler, Mark D. Varien, and Aaron M. Wright, pp. 34-52. University of Arizona Press, Tucson.

Hirth, Kenneth G. (editor)

2003 *Mesoamerican Lithic Technology: Experimentation and Interpretation*. University of Utah Press, Salt Lake City.

2006 *Obsidian Craft Production in Ancient Central Mexico: Archaeological Research at Xochicalco*. University of Utah Press, Salt Lake City.

Hoffman, Charles M.

1997 *Alliance Formation and Social Interaction during the Sedentary Period: A Stylistic Analysis of Hohokam Arrowpoints*. Unpublished Ph.D. Dissertation, Arizona State University.

Hough, Walter

1907 *Antiquities of the Upper Gila and Salt River Valley in Arizona and New Mexico*. Bureau of American Ethnology, Bulletin 35, Washington D.C.

Huckell, Bruce B., M. Steven Shackley, Matthew J. O'Brien, and Christopher W. Merriman

2011 Folsom Obsidian Procurement and Use at the Boca Negra Wash Site, New Mexico. *Current Research in the Pleistocene* 28:49-52.

Hughes, Richard E.

1986 *Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon*. University of California Publications in Anthropology, Vol. 17. University of California Press, Berkeley.

1994 Intrasource Chemical Variability of Artefact-Quality Obsidians from the Casas Diablo Area, California. *Journal of Archaeological Science* 21:263-271.

1998 On Reliability, Validity, and Scale in Obsidian Sourcing Research. In *Unit Issues in Archaeology: Measuring Time, Space, and Material*, edited by Ann F. Ramenofsky and Anna Steffen, pp. 103-114. University of Utah Press, Salt Lake City.

Hughes, Richard E., and Robert L. Smith

1993 Archaeology, Geology, and Geochemistry in Obsidian Provenance Studies. *Geological Society of America Special Paper 283*. Geological Society of America.

Hughes, Richard E. (editor)
1984 *Obsidian Studies in the Great Basin*. Contributions of the University of California Archaeological Research Facility No. 45. Archaeological Research Facility, University of California, Berkeley, California.

Huntley, Deborah L.
2008 *Ancestral Zuni Glaze-Decorated Pottery: Viewing Pueblo IV Regional Organization through Ceramic Production and Exchange*. University of Arizona Anthropological Papers 72. University of Arizona Press, Tucson.

Husien, Mohammed S.
2010 *Fracture Behavior and Mechanical Characterization of Obsidian: Naturally Occurring Glass*. Unpublished Master's thesis, Oklahoma State University, Stillwater.

Jackson, Thomas L.
1989 Late Prehistoric Obsidian Production and Exchange in the North Coast Ranges, California. In *Current Directions in California Obsidian Studies*, edited by Richard E. Hughes, pp. 79-94. Contributions of the University of California Archaeological Research Facility 48, Berkeley, California.

Jett, Stephen C., and Peter B. Moyle
1986 The Exotic Origins of Fishes Depicted on Prehistoric Mimbres Pottery from New Mexico. *American Antiquity* 51:688-720.

Jones, Andrew
2002 *Archaeological Theory and Scientific Practice*. Cambridge University Press, Cambridge.

Joyce, Rosemary A.
2011 Is There a Future for XRF in Twenty-First Century Archaeology? In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M. Steven Shackley, pp. 193-202. Springer, New York.

Katz, O., Z. Reches, and J.C. Roegiers
2000 Evaluation of Mechanical Rock Properties Using a Schmidt Hammer. *International Journal of Rock Mechanics and Mining Sciences* 37:723-728.

Kelley, Jane H., and M. Elisa Villalpando
1996 An Overview of the Mexican Northwest. In *Interpreting Southwestern Diversity: Underlying Principles and Overarching Patterns,* edited by Paul R. Fish and J. Jefferson Reid, pp. 69-77. Anthropological Research Papers No. 48. Arizona State University, Tempe.

Kelley, Jane H., A.C. MacWilliams, Joe D. Stewart, Karen R. Adams, Jerimy J. Cunningham, Richard D. Garvin, J. M. Maillol, Paul J. Reimer, and Danny Zborover
2012 The View from the Edge: The Proyecto Arqueológico Chihuahua (PAC): 1990 to 2010: An Overview. *Canadian Journal of Archaeology* 36:82-107.

Kelley, Jane H., and Michael T. Searcy
2015 Beginnings: The Viejo Period. In *Ancient Paquimé and the Casas Grandes World,* edited by Paul E. Minnis and Michael E. Whalen, pp. 17-40. University of Arizona Press, Tucson.

Kenmotsu, Nancy A., Tabitha G. Burgess, Lora Jackson Legare, and Myles R. Miller
2014 Maintaining Ties, Seeking Opportunities: Excavations at Columbus Pueblo (LA 85774), Luna County, New Mexico. *Bulletin of the Texas Archaeological Society* 85:183-203.

Kenmotsu, Nancy A., Tabitha L. Griffith, Lora Jackson Legare, William Russell, and Myles R. Miller
2010 *Archaeological Investigations at Columbus Pueblo (LA 85774), a Southern Mimbres Occupation in Luna County, New Mexico*. Prepared for the U.S. Army Corps of Engineers, Fort Worth District. Geo-Marine Inc, El Paso, Texas.

Kibler, Karl W., Héctor R. Hinojosa-Prieto, M. Steven Shackley, Héctor J. Hinojosa-García
2014 The Selene Obsidian Source (Formerly Sonora Unknown B) of the Upper Río Bavispe Basin, Sonora, Mexico. *Kiva* 80:168-192.

Kidder, Alfred V., Harriet S. Cosgrove and C. Burt Cosgrove
1949 *The Pendleton Ruin, Hidalgo County, New Mexico*. Contributions to American Anthropology and History, Vol. 10, No. 50. Carnegie Institution, Washington, D. C.

Kroulek, Orion
2011 *A Temporal Component Analysis of Kipp Ruin (LA 153645)*. Unpublished Master's thesis, New Mexico State University, Las Cruces.

Kues, Barry S., Shari A. Kelley, and Virgil W. Lueth (editors)
2007 *Geology of the Jemez Region II*. New Mexico Geological Society 58th Annual Field Conference. New Mexico Geological Society, Socorro.

Lave, Jean, and Etienne Wenger
1991 *Situated Learning: Legitimate Peripheral Participation*. University of Cambridge Press, Cambridge.

LeBlanc, Steven A.
1977 The 1976 Field Season of the Mimbres Foundation in Southwestern New Mexico. *Journal of New World Archaeology* 2:1-24.

1980 The Post Mogollon Periods in Southwestern New Mexico: The Animas/Black Mountain Phase and the Salado Period. In *An Archaeological Synthesis of Southcentral and Southwestern New Mexico*, edited by Steven A. LeBlanc and Michael E. Whalen, pp. 271-316. Office of Contract Archeology, University of New Mexico, Albuquerque.

1983 *The Mimbres People: Ancient Painters of the American Southwest*. Thames and Hudson, London.

1986 Development of Archaeological Thought on the Mimbres Mogollon. In *Emil W. Haury's Prehistory of the American Southwest*, edited by J. Jefferson Reid and David E. Doyel, pp. 297-304. University of Arizona Press, Tucson.

1989 Cultural Dynamics in the Southern Mogollon Area. In *Dynamics of Southwestern Prehistory*, edited by Linda S. Cordell, and George J. Gumerman, pp. 179-209, Smithsonian Institution Press, Washington, D.C.

2004 *Painted by a Distant Hand: Mimbres Pottery from the American Southwest*. Peabody Museum Press, Harvard University, Cambridge, Massachusetts.

2006 Who Made the Mimbres Bowls? Implications of Recognizing Individual Artists for Craft Specialization and Social Networks. In *Mimbres Society*, edited by Valli S. Powell-Martí and Patricia A. Gilman, pp.109-150. University of Arizona Press, Tucson.

LeBlanc, Steven A., and Ben A. Nelson
1976 The Question of Salado in Southwestern New Mexico. *Kiva* 42:71-79.

LeBlanc, Steven A. and Michael E. Whalen (editors)
1980 *Archaeological Synthesis of South-Central and Southwestern New Mexico*. Office of Contract Archeology, University of New Mexico, Albuquerque.

Lehmer, Donald J.
1948 *The Jornada Branch of the Mogollon*, University of Arizona Social Science Bulletin No. 17, University of Arizona Press, Tucson.

Lekson, Stephen H.
1988 Regional Systematics in the Later Prehistory of Southern New Mexico. In *Fourth Jornada Mogollon Conference Collected Papers*, edited by Melia S. Duran and Karl W. Laumbach, pp. 1-37. Human Systems Research, Las Cruces.

1993 Chaco, Mimbres, and Hohokam: The 11th and 12th Centuries in the American Southwest. *Expedition* 35:44-52.

1996 Southwestern New Mexico and Southeastern Arizona, A.D. 900 to 1300. In *The Prehistoric Pueblo World A.D. 1150-1350*, edited by Michael A. Adler, pp. 170-176. University of Arizona Press, Tucson.

1999 *The Chaco Meridian: Centers of Political Power in the Ancient Southwest*. Altamira Press, Walnut Creek, CA.

2000 Salado in Chihuahua. In *Salado*, edited by Jeffrey S. Dean, pp. 275-294. University of New Mexico Press, Albuquerque.

2002 *Salado Archaeology of the Upper Gila, New Mexico*. Anthropological Papers 67. University of Arizona Press, Tucson.

2005 Chaco and Paquimé: Complexity, History, Landscape. In *North American Archaeology*, edited by Timothy R. Pauketat and Diana DiPaolo Loren, pp. 235-272. Blackwell Publishers, New York.

2006 *Archaeology of the Mimbres Region, Southwestern New Mexico, U.S.A.* British Archaeological Reports International Series 1466. Archaeopress, Oxford.

2009 *A History of the Ancient Southwest*. School of Advanced Research Press, Santa Fe, New Mexico.

2015 *The Chaco Meridian: One Thousand Years of Political and Religious Power in the Ancient Southwest*. Second Edition. Rowman and Littlefield, New York.

Lekson, Stephen H., Michael Bletzer, and A.C. MacWilliams
2004 Pueblo IV in the Chihuahuan Desert. In *The Protohistoric Pueblo World: A.D. 1275-1600*, edited by E. Charles Adams and Andrew I. Duff, pp. 53-61. University of Arizona Press, Tucson.

Lekson, Stephen H., and Catherine M. Cameron
2016 Obsidian in the Southwest. Paper presented at the 81st Annual Meeting of Society for American Archaeology, Orlando, Florida.

LeTourneau, Philippe D., and M. Steven Shackley
2009 Geochemistry of Paleoindian and Early-Archaic Obsidian Artifacts from New Mexico and Colorado. *Current Research in the Pleistocene* 26:81-84.

LeTourneau, Philippe D., and Anastasia Steffen
2002 Field Investigations at a Likely Source for New Mexico Obsidian Folsom Artifacts. *Current Research in the Pleistocene* 19:57-59.

Loendorf, Chris
2010 Regional and Temporal Variation in Obsidian Use within the Hohokam Region. *Journal of Arizona Archaeology* 1:47-59.

Lyons, Patrick D., and Alexander J. Lindsay Jr.
2006 Perforated Plates and the Salado Phenomenon. *Kiva* 72:5-54.

Martin, Paul S.
1979 Prehistory: Mogollon. In *Southwest*, edited by Alfonso Ortiz, pp. 61-74. *Handbook of North American Indians*, Vol. 9. Smithsonian Institution, Washington, D. C.

Martinón-Torres, Marcos, and David Killick
2015 Archaeological Theories and Archaeological Sciences. In *The Oxford Handbook of Archaeological Theory*, edited by Andrew Gardner, Mark Lake, and Ulrike Sommer. Oxford University Press, Oxford. DOI: 10.1093/oxfordhb/9780199567942.013.004

Martynec, Richard J., Rich Davis, and M. Steven Shackley
2011 The Los Sitios del Agua Obsidian Source (Formerly AZ Unknown A) and Recent Archaeological Investigations along the Rio Sonoyta, Northern Sonora. *Kiva* 76:413-429.

McCluney, Eugene B.
1965a *Clanton Draw and Box Canyon: An Interim Report on Two Prehistoric Sites in Hidalgo County, New Mexico, and Related Surveys*. School of American Research Monograph No. 26. Santa Fe, New Mexico.

1965b Excavation of the Joyce Well Site, Hidalgo County, New Mexico. Manuscript on file, School of American Research, Santa Fe, New Mexico

2002 The 1963 Excavation. In *The Joyce Well Site: On the Frontier of the Casas Grandes World*, edited by James M. Skibo, Eugene B. McCluney, and William H. Walker, pp. 11-96. University of Utah Press, Salt Lake City.

McGuire, Randall H.
1993 Charles Di Peso and the Mesoamerican Connection. In *Culture and Contact: Charles C. Di Peso's Gran Chichimeca*, edited by Anne I. Woosley and John C. Ravesloot, pp. 23-38. Amerind Foundation, Dragoon, Arizona and University of New Mexico Press, Albuquerque.

Meesala, Raghu V.
2014 *Role of Residual Stresses on Mechanical Properties of Obsidian: Naturally Occurring Glass*. Unpublished Master's thesis, Oklahoma State University, Stillwater.

Miller, Myles R., and M. Steven Shackley
1998 New Interpretations of Obsidian Procurement and Movement in the Jornada Mogollon Region of West Texas, Southern New Mexico and Northern Chihuahua. Paper presented at the Annual Meetings of the Texas Archaeological Society, Waco, Texas.

Mills, Barbara J., Jeffery J. Clark, Matthew A. Peeples, W. Randall Haas, Jr., John M. Roberts, Jr., J. Brett Hill, Deborah L. Huntley, Lewis Borck, Ronald L. Breiger, Aaron Clauset, and M. Steven Shackley
2013 Transformation of Social Networks in the Late Pre-Hispanic US Southwest. *Proceedings of the National Academy of Science* 110:5785-5790.

Mills, Barbara J., Matthew A. Peeples, W. Randall Haas, Jr., Lewis Borck, Jeffery J. Clark, and John M. Roberts, Jr.
2015 Multiscalar Perspectives on Social Networks in the Late Prehispanic Southwest. *American Antiquity* 80:3-24.

Minnis, Paul E.
1984 Peeking Under the Tortilla Curtain: Regional Interaction and Integration on the Northern Periphery of Casas Grandes. *American Archaeology* 4:181-193.

1985 *Social Adaptations to Food Stress: A Prehistoric Southwestern Example*. University of Chicago Press, Chicago.

1996 Notes on Economic Uncertainty and Human Behavior in the Prehistoric North American Southwest. In *Evolving Complexity and Environmental Risk in the Prehistoric Southwest*, edited by Joseph Tainter and Bonnie Bagley Tainter, pp. 57-78. Santa Fe Institute Studies in the Sciences of Complexity, Vol. 24. Addison Wesley, Boston.

Minnis, Paul E., and Michael E. Whalen
2015a Introduction: The Joint Casas Grandes Expedition in Historical Context. In *Ancient Paquimé and the Casas Grandes World*, edited by Paul E. Minnis and Michael E. Whalen, pp. 3-16. University of Arizona Press, Tucson.

Minnis, Paul E., and Michael E. Whalen (editors)
2015b *Ancient Paquimé and the Casas Grandes World*. University of Arizona Press, Tucson.

Minnis, Paul E., and Alan J. Wormser
1984 Late Pithouse Period Occupation in the Deming Region: Preliminary Report of Excavations at the Florida Mountain Site (LA 18839). In *Recent Research in Mogollon Archaeology*, edited by Fred Plog, David G. Batcho, Barbara E. Kauffman, and Steadman Upham, pp. 229-249. Occasional Papers No. 10. The University Museum, New Mexico State University, Las Cruces.

Moholy-Nagy, Hattula, and Fred W. Nelson
1990 New data on Sources of obsidian Artifacts from Tikal, Guatemala. *Ancient Mesoamerica* 1:71-80.

Morrow, Carol A., and Richard W. Jefferies
1989 Trade or Embedded Procurement: A Test Case from Southern Illinois. In *Time, Energy and Stone Tools*, edited by Robin Torrence, pp. 27-33. Cambridge University Press, Cambridge.

Moulard, Barbara L.
1984 *Within the Underworld Sky: Mimbres Ceramic Art in Context*. Twelvetrees, Pasadena, California.

Munson, Marit K.
2000 Sex, Gender, and Status: Human Images from the Classic Mimbres. *American Antiquity* 65:127-143.

2006 Picturing Differences: Gender, Ritual, and Power in Mimbres Imagery. In *Mimbres Society*, edited by Valli S. Powell-Martí and Patricia A. Gilman, pp. 85-108. University of Arizona Press, Tucson.

Naranjo, Tessie
1995 Thoughts on Migration by Santa Clara Pueblo. *Journal of Anthropological Archaeology* 14:247-250.

Neff, Hector
2001 Neutron Activation Analysis for Provenance Determination in Archaeology. In *Modern Analytical Methods in Art and Archaeology*, edited by Enrico Ciliberto and Guiseppe Spoto. Chemical Analysis Series, Vol. 155. John Wiley and Sons, New York.

Nelson, Ben A., and Steven A. LeBlanc
1986 *Short Term Sedentism in the American Southwest: The Mimbres Valley Salado*. Maxwell Museum of Anthropology and the University of New Mexico Press, Albuquerque.

Nelson, Aimee M., Dinesh Bastakoti, and John V. Dudgeon
2012 *Do Performance Characteristics Explain Variation in Archaeological Selection and Use of Snake River Obsidian?* Poster presented at the 77th Annual Meeting of Society for American Archaeology, Memphis, Tennessee.

Nelson, Fred W., and R. D. Holmes
1979 Trace Element Analysis of Obsidian Sources and Artifacts from Western Utah. Antiquities Section Selected Papers 15. Brigham Young University, Provo, Utah.

Nelson, Margaret C.

1981 *Chipped Stone Analysis in the Reconstruction of Prehistoric Subsistence Practices: An Example form Southwestern New Mexico*. Unpublished Ph.D. dissertation. Department of Anthropology, University of California, Santa Barbara.

1984 Food Selection at Galaz: Inferences from Chipped Stone Analysis. In *The Galaz Ruin: A Prehistoric Mimbres Village in Southwestern New Mexico* by Roger Anyon and Steven A. LeBlanc. Maxwell Museum of Anthropology and the University of New Mexico Press, Albuquerque.

1986 Chipped Stone Analysis: Food Selection and Hunting Behavior. In *Short Term Sedentism in the American Southwest: The Mimbres Valley Salado*, by Ben A. Nelson and Steven A. LeBlanc. Maxwell Museum of Anthropology and the University of New Mexico Press, Albuquerque.

1999 *Mimbres during the Twelfth Century*: *Abandonment, Continuity, and* Reorganization. University of Arizona Press, Tucson.

2010 Mimbres, the Mystery. In *Mimbres Lives and Landscapes*, edited by Margaret C. Nelson and Michelle Hegmon, pp. 99-103. School of Advanced Research Press, Santa Fe, New Mexico

Nelson, Margaret C., and Michelle Hegmon

2001 Abandonment Is Not As It Seems: An Approach to the Relationship between Site and Regional Abandonment. *American Antiquity* 66:213-235.

Nelson, Margaret C., and Gregson Schachner

2002 Understanding Abandonments in the North American Southwest. *Journal of Archaeological Research* 10:167-206.

Nelson, Margaret C., Michelle Hegmon, Stephanie Kulow, and Karen G. Schollmeyer

2006 Archaeological and Ecological Perspectives on Reorganization: A Case Study from the Mimbres Region of the US Southwest. *American Antiquity* 71:403-432.

Neitzel, Jill E.

2000 What is a Regional System? Issues of Scale and Interaction in the Prehistoric Southwest. In *The Archaeology of Regional Interaction: Proceedings of the 1996 Southwest Symposium*, edited by Michelle Hegmon, pp. 25-40. University Press of Colorado, Boulder.

Peterson, Jane D., Douglas R. Mitchell, and M. Steven Shackley

1997 The Social and Economic Contexts of Lithic Procurement: Obsidian from Classic-Period Hohokam Sites. *American Antiquity* 62:231-259.

Phillips, David A.
1989 The Prehistory of Chihuahua and Sonora. *Journal of World Archaeology* 3:373-401.

Phillips, David A., and Eduardo Gamboa
2015 The End of Paquimé and the Casas Grandes Culture. In *Ancient Paquimé and the Casas Grandes World*, edited by Paul E. Minnis and Michael E. Whalen, pp. 148-171. University of Arizona Press, Tucson.

Pollard, Mark, Catherine Batt, Ben Stern, and Suzanne M. M. Young
2007 *Analytical Chemistry in Archaeology*. University of Cambridge, Cambridge.

Pollard, Mark, and Bray, Peter
2007 A Bicycle Made for Two? The Integration of Scientific Techniques in Archaeological Interpretation. *Annual Review of Anthropology* 36:245-259.

Piperno, Marcello, Carmine Collina, Rosalia Galloti, Jean-Paul Raynal, Guy Kieffer, Francois-Xavier le Bourdonnec, Gerard Poupeau, and Denis Geraads
2009 Obsidian Exploitation and Utilization during the Oldowan at Melka Kunture (Ethiopia). In *Interdisciplinary Approaches to the Oldowan*, edited by David R. Braun and Erella Hovers, pp. 111-128. Springer, Berlin.

Pitezel, Todd, and Michael T. Searcy
2013 Understanding the Viejo Period: What are the Data? In *Collected Papers from the 17th Biennial Mogollon Archaeology Conference,* edited by Lonnie C. Ludeman, pp. 77-81. Friends of Mogollon Archaeology, Las Cruces, New Mexico.

Putsavage, Kathryn J.
2012 The Black Mountain Site (LA 49): A First Look. *Collected Papers from the 16th Biennial Mogollon Archaeology Conference*, edited by Lonnie C. Ludeman, pp. 71-84. Friends of Mogollon Archaeology, Las Cruces, New Mexico.

2015 *Social Reorganization in the Mimbres Region of Southwestern New Mexico: The Classic to Postclassic Mimbres Transition (A.D. 1150-1450)*. Unpublished Ph.D. dissertation, University of Colorado, Boulder.

Putsavage, Kathryn J., and Stephen H. Lekson
2010 *Preliminary Study of the Black Mountain Archaeological Site, LA 49*. Manuscript on file, New Mexico State Land Office, Santa Fe.

Rakita, Gordon F.M.
2009 *Ancestors and Elites: Emergent Complexity and Ritual Practices in the Casas Grandes Polity*. AltaMira Press, Lanham, Maryland.

Rakita, Gordon F.M., Christine S. VanPool, Todd L. VanPool, and Sarah Sterling
2011 An Introduction to the 76 Draw Site, Luna County, New Mexico. In *Patterns in Transition: Papers from the 16th Biennial Jornada Mogollon Conference*, edited by Melinda R. Landreth, pp. 296-64. El Paso Museum of Archaeology, El Paso, Texas.

Ravesloot, John C.
1979 *The Animas Phase: The Post Classic Mimbres Occupation of the Mimbres Valley, New Mexico*. Unpublished Master's thesis, Southern Illinois University, Carbondale.

1988 *Mortuary Practices and Social Differentiation at Casas Grandes, Chihuahua, Mexico*. Anthropological Papers of the University of Arizona No. 49. University of Arizona Press, Tucson.

Roth, Barbara J.
2000 Obsidian Source Characterization and Hunter-Gatherer Mobility: An Example from the Tucson Basin. *Journal of Archaeological Science* 27:305-314.

Roth, Barbara J., and Kathryn M. Baustian
2015 Kin Groups and Social Power at the Harris Site, Southwestern New Mexico. *American Antiquity* 80:451-471.

Roth, Barbara J., and Robert J. Stokes (editors)
2007 *Exploring Variability in Mogollon Pithouses*. Anthropological Research Papers No. 58. Arizona State University, Tempe.

Sayles, Eugene B.
1936 *An Archaeological Survey of Chihuahua*. Medallion Papers, No. 22. Gila Pueblo, Globe, Arizona

Schaafsma, Curtis F., and Carroll L. Riley (editors)
1999 *The Casas Grandes World*. University of Utah Press, Salt Lake City.

Schriever, Bernard A., Matthew Taliaferro, and Barbara J. Roth
2011 A Tale of Two Sites: Functional Site Differentiation and Lithic Technology during the Late Pithouse Period in the Mimbres Area of Southwestern New Mexico. *Journal of Anthropological Archaeology* 30:102-115.

Scott, Michael J., and Michael J. Scott Jr.
1982 Obsidian Surgical Blades: Modern Use of a Stone Age Implement. *The Journal of Dermatologic Surgery and Oncology* 8:1050-1052.

Searcy, Michael T., Bernard Schriever, and Matthew Taliaferro
2016 Early Mimbres Households: Exploring the Late Pithouse Period (550-1000 AD) at the Florida Mountain Site. *Journal of Anthropological Archaeology* 41:299-312.

Sedig, Jakob W.
2015 *The Mimbres Transitional Phase: Examining Social, Demographic, and Environmental Resilience and Vulnerability from A.D. 900-1000 in Southwest New Mexico*. Unpublished Ph.D. dissertation, University of Colorado, Boulder.

Shackley, M. Steven
1988 Sources of Archaeological Obsidian in the Southwest: An Archaeological, Petrological, and Geochemical Study. *American Antiquity* 53:752-772.

1992 The Upper Gila River Gravels as an Archaeological Obsidian Source Region: Implications for Models of Exchange and Interaction. *Geoarchaeology* 7:315-326.

1994 Intersource and Intrasource Geochemical Variability in Two Newly Discovered Archaeological Obsidian Sources in the Southern Great Basin. *Journal of California and Great Basin Anthropology* 16:118-129.

1995 Sources of Archaeological Obsidian in the Greater American Southwest: An Update and Quantitative Analysis. *American Antiquity* 60:531-551.

1998a Geochemical Differentiation and Prehistoric Procurement of Obsidian in the Mount Taylor Volcanic Field, Northwest New Mexico. *Journal of Archaeological Science* 25:1073-1082.

1998b Intrasource Chemical Variability and Secondary Depositional Processes in Sources of Archaeological Obsidian: Lessons from the American Southwest. In *Archaeological Obsidian Studies: Method and Theory,* edited by M. Steven Shackley, pp. 83-102. Advances in Archaeological and Museum Science 3. Kluwer Academic/Plenum Press, New York.

1999 Obsidian Sourcing. In *An Archaeological Investigation of Late Archaic Cerros de Trincheras Sites in Chihuahua, Mexico: Results of the 1998 Investigations. Report to Consejo de Arqueologi'a, Instituto Nacional de Antropologi'a e Historia*, edited by Robert J. Hard and John Roney, pp. 21-22. Center for Archaeological Research, University of Texas at San Antonio Special Report, No. 25. San Antonio, Texas

2005 *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.

2008 Archaeological Petrology and the Archaeometry of Lithic Materials. *Archaeometry* 50:194-215.

2010 X-Ray Fluorescence Analysis. In *Archaeological Investigations at Columbus Pueblo (LA 85774), a Southern Mimbres Occupation in Luna County, New* Mexico, by Nancy A. Kenmotsu, Tabitha L. Griffith, Lora Jackson Legare, William Russell, and Myles R. Miller, pp. E-1-E-10. GMI Report No. 783EP. Geo-Marine, Inc., El Paso, Texas.

2011a An Introduction to X-Ray Fluorescence (XRF) Analysis in Archaeology. In *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, edited by M. Steven Shackley, pp. 7-44. Springer, New York.

2011b Source Provenance of Obsidian Artifacts from Late Classic Contexts at Kipp Ruin (LA153465) and Joyce Well (LA11823), Southern New Mexico. Report prepared for Sean Dolan, Department of Anthropology, New Mexico State University, Las Cruces.

2013a Source Provenance of Obsidian Artifacts from Archaeological Sites in the University of Oklahoma's Southern Mimbres Archaeological Project, Southern New Mexico. Report prepared for Sean Dolan, Department of Anthropology, University of Oklahoma, Norman.

2013b The Geochemistry and Archaeological Petrology of Volcanic Raw Materials in Northern New Mexico: Obsidian and Dacite Sources in Upland and Lowland Contexts. In *From Mountain Top to Valley Bottom: Understanding Past Land Use in the Northern Rio Grande Valley, New Mexico*, edited by Bradley J. Vierra, pp. 17-32. University of Utah Press, Salt Lake City.

2014a Source Provenance of Obsidian Artifacts from Archaeological Sites near Lake Roberts, Southern New Mexico. Report prepared for Sean Dolan, Department of Anthropology, University of Oklahoma, Norman.

2014b Source Provenance of Obsidian Artifacts from the Casas Grandes Outlier Sites 204, 242, 315, and 317, Northern Chihuahua. Report prepared for Sean Dolan, Department of Anthropology, University of Oklahoma, Norman.

Shackley, M. Steven, Fraser Goff, and Sean G. Dolan

2016 Geologic Origin of the Source of Bearhead Rhyolite (Paliza Canyon) Obsidian, Jemez Mountains, Northern New Mexico. Submitted to *New Mexico Geology*.

Shafer, Harry J.

1995 Architecture and Symbolism in Transitional Pueblo Development in the Mimbres Valley, SW New Mexico. *Journal of Field Archaeology* 22:23-47.

1999 The Mimbres Classic and Postclassic: A Case for Discontinuity. In *The Casas Grandes World*, edited by Curtis F. Schaafsma, and Carroll L. Riley, pp. 121-133. University of Utah Press, Salt Lake City.

2003 *Mimbres Archaeology at the NAN Ranch Ruin*. University of New Mexico Press, Albuquerque.

2006 Extended Families to Corporate Groups: Pithouse to Pueblo Transformation of Mimbres Society. In *Mimbres Society*, edited by Valli S. Powell-Martí and Patricia A. Gilman, pp. 15-31. University of Arizona Press, Tucson.

Shafer, Harry J., and Robbie L. Brewington
1995 Microstylistic Changes in Mimbres Black-on-white Pottery: Examples from the NAN Ruin, Grant County, New Mexico. *Kiva* 61:5-29.

Shott, Michael J.
1994 Size and Form in the Analysis of Flake Debris: Review and Recent Approaches. *Journal of Archaeological Method and Theory* 1:69-110.

Silliman, Stephen W.
2003 Using a Rock in a Hard Place: Native American Lithic Practices in Colonial California. In *Stone Tool Traditions After Contact*, edited by Charles Cobb, pp. 127-150. University of Alabama Press, Tuscaloosa.

2005 Obsidian Studies and the Archaeology of 19th- Century California. *Journal of Field Archaeology* 75-94.

Skibo, James M., and William H. Walker
2002 Ball Courts and Ritual Performance. In *The Joyce Well Site: On the Frontier of the Casas Grandes World*, edited by James M. Skibo, Eugene B. McCluney, and William H. Walker, pp. 107-128. University of Utah Press, Salt Lake City.

Skibo, James M., Eugene B. McCluney, and William H. Walker (editors)
2002 *The Joyce Well Site: On the Frontier of the Casas Grandes World*. University of Utah Press, Salt Lake City.

Snow, Meradeth, Harry Shafer, and David Glenn Smith
2011 The Relationship of the Mimbres to Other Southwestern and Mexico Populations. *Journal of Archaeological Science* 38:3122-3133.

Speakman, Robert J.
2013 *Mimbres Pottery Production and Distribution*. Unpublished Ph.D. dissertation, Universitat de Barcelona, Barcelona.

Stark, Miriam T.
2006 Glaze Ware Technology, the Social Life of Pots, and Communities of Practice in the Late Prehistoric Southwest. In *The Social Life of Pots: Glaze Wares and Cultural Dynamics in the Southwest, A.D. 1250-1680*, edited by Judith A. Habicht-Mauche, Suzanne L. Eckert, and Deborah L. Huntley, pp. 17-33. University of Arizona Press, Tucson.

Steffen, Anastasia
2005 *The Dome Fire Obsidian Study: Investigating the Interaction of Heat, Hydration, and Glass Geochemistry*. Unpublished Ph.D. Dissertation, University of New Mexico, Albuquerque.

Steffen, Anastasia, and Philippe D. LeTourneau
2007 Sources in the Middle: The Jemez Mountains Obsidian Database Project. Paper presented at the 72nd Annual Meeting of the Society for American Archaeology, Austin, Texas.

Stevenson, Christopher M., and Michael O. McCurry
1990 Chemical Characterization and Hydration Rate Development for New Mexican Obsidian Sources. *Geoarchaeology* 5:149-170.

Stewart, Joe D., Jane H. Kelley, A. C. MacWilliams, and Paula J. Reimer
2005 The Viejo Period of Chihuahua Culture in Northwestern Mexico. *Latin American Antiquity* 16:169-192.

Stuart, David E., and Rory P. Gauthier
1981 *Prehistoric New Mexico: Background for Survey*. New Mexico Historic Preservation Bureau, Santa Fe.

Sullivan, Alan P., and Kenneth C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50:755-779.

Swanson, Steve, Roger Anyon, and Margaret C. Nelson
2012 Southern Mogollon Pithouse Period Settlement Dynamics, Land Use, and Community Development, AD 200-1000. In *Southwestern Pithouse Communities, AD 200-900*, edited by Lisa C. Young and Sarah A. Herr, pp. 95-109. University of Arizona Press, Tucson.

Taliaferro, Matthew S.
2004 *Technological Analysis of the Formal Chipped Stone Tool Assemblage from Old Town (LA1113) with Obsidian Provenance Studies from Selected Archaeological Sites Throughout the Mimbres Valley*. Unpublished Master's thesis, University of Texas, Austin.

2014 *The Black Mountain Phase Occupation at Old Town: An Examination of Social and Technological Organization in the Mimbres Valley of Southwestern New Mexico, ca. A.D. 1150-1300*. Unpublished Ph.D. dissertation, University of Texas, Austin.

Taliaferro, Matthew S., Bernard A. Schriever, and M. Steven Shackley
2010 Obsidian Procurement, Least Cost Path Analysis, and Social Interaction in the Mimbres Area of Southwestern New Mexico. *Journal of Archaeological Science* 37:536-548.

Turner, Christy G., II
1999 The Dentition of Casas Grandes with Suggestions on Epigenetic Relationships among Mexican and Southwestern U.S. Populations. In *The Casas Grandes World*, edited by Curtis F. Schaafsma and Carroll L. Riley, pp. 229-233. University Press of Utah, Salt Lake City.

VanPool, Todd L., and Robert D. Leonard
2002 Specialized Ground Stone Production in the Casas Grandes Region of Northern Chihuahua, Mexico. *American Antiquity* 64:710-730.

VanPool, Christine S., Todd L. VanPool, and David Phillips
2006 The Casas Grandes and Salado Phenomena: Evidence for a Religious Schism in the Greater Southwest. In *Religion in the Prehispanic Southwest*, edited by Christine S. VanPool, Todd L. VanPool, and David A. Phillips, Jr., pp. 17-30. Altamira Press, Lanham, Maryland.

VanPool, Todd L., Christine S. VanPool, Rafael Cruz Antillón, Robert D. Leonard and Marcel J. Harmon
2000 Flaked Stone and Social Interaction in the Casas Grandes Region, Chihuahua, Mexico. *Latin American Antiquity* 11:163-174.

VanPool, Todd L., Christopher M. Oswald, Jason A. Christy, Jeffrey R. Ferguson, Gordon F.M. Rakita, and Christine S. VanPool
2013 Provenance Studies of Obsidian at 76 Draw. In *Advances in Jornada Mogollon Archaeology: Proceedings from the 17th Jornada Mogollon Conference*, edited by Todd L. VanPool, Elizabeth M. McCarthy, and Christine S. VanPool, pp. 163-184. El Paso Museum of Archaeology, El Paso, Texas.

Vargas, Victoria D.
1995 *Copper Bell Trade Patterns in the Prehispanic US Southwest and Northwest Mexico*. Archaeological Series No. 187. Arizona State Museum, Tucson.

Verma, H. R.
2007 *Atomic and Nuclear Analytical Methods: XRF, Mössbauer, XPS, NAA and Ion-Beam Spectroscopic Techniques.* Springer, New York.

Vierra, Bradley J.
2005 Late Stone Tool Technology across the Borderlands. In *The Late Archaic across the Borderlands: From Foraging to Farming*, edited by Bradley J. Vierra, pp. 187-218. University of Texas Press, Austin.

Vierra, Bradley J., and Michael J. Dilley
2008 Coping with Changes: Stone Tool Technology on the Pajarito Plateau. In *The Land Conveyance and Transfer Data Recovery Project: 7000 Years of Land Use on the Pajarito Plateau, Vol. 3*, edited by Bradley J. Vierra and Kari M. Schmidt, pp. 307-386. LA-UR-07-6205. Los Alamos National Laboratory, Los Alamos, New Mexico.

Vierra, Bradley J., Margaret A. Jodry, M. Steven Shackley, and Michael J. Dilley.
2012 Late Paleoindian and Early Archaic Foragers in the Northern Southwest. In *From the Pleistocene to the Holocene: Human Occupation and Cultural Transformations in Prehistoric North America*, edited by C. Britt Bousman and Bradley J. Vierra, pp. 171-196. Texas A&M University Press, College Station, Texas.

Vokes, Arthur W., and David A. Gregory
2007 Exchange Networks for Exotic Goods in the Southwest and Zuni's Place in Them. In *Zuni Origins: Toward a New Synthesis of Southwestern Archaeology*, edited by David A. Gregory and David R. Wilcox, pp. 318-357. University of Arizona Press, Tucson.

Walker, William H., and James M. Skibo
2002 Joyce Well and the Casas Grandes Religious Interaction Sphere. In *The Joyce Well Site: On the Frontier of the Casas Grandes World*, edited by James M. Skibo, Eugene B. McCluney, and William H. Walker, pp. 167-175. University of Utah Press, Salt Lake City.

Walker, William H., James M. Skibo, and Eugene B. McCluney
2002 Joyce Well and the Casas Grandes World. In *The Joyce Well Site: On the Frontier of the Casas Grandes World*, edited by James M. Skibo, Eugene B. McCluney, and William H. Walker, pp. 1-10. University of Utah Press, Salt Lake City.

Wallerstein, Immanuel
1974 *The Modern World System*. Academic Press, New York.

Wenger, Etienne
1998 *Communities of Practice: Learning, Meaning, and Identity*. Cambridge University Press, Cambridge.

Whalen, Michael E., and Paul E. Minnis

1996 Ball Courts and Political Centralization in the Casas Grandes Region. *American Antiquity* 61:732-746.

1999 Investigating the Paquimé Regional System. In *The Casas Grandes World*, edited by Curtis F. Schaafsma and Carroll L. Riley, pp. 54-62. University of Utah Press, Salt Lake City.

2000 Leadership at Casas Grandes, Chihuahua, Mexico. In *Alternative Leadership Strategies in the Prehispanic Southwest*, edited by Barbara J. Mills, pp. 168-179. University of Arizona Press, Tucson.

2001a *Casas Grandes and Its Hinterland: Prehistoric Regional Organization in Northwest Mexico*. University of Arizona Press, Tucson.

2001b Architecture and Authority in the Casas Grandes Region, Chihuahua, Mexico. *American Antiquity* 66:651-699.

2003 The Local and the Distant in the Origin of Casas Grandes, Chihuahua, Mexico. *American Antiquity* 68:314-332.

2009a *The Neighbors of Casas Grandes: Excavating Medio Period Communities of Northwest Chihuahua, Mexico*. University of Arizona Press, Tucson.

2009b Excavaciones en el Sitio 315, Chihuahua. Primera Temporada. Technical report submitted to I.N.A.H., Mexico, D. F.

2012 Ceramics and Polity in the Casas Grandes Area, Chihuahua, Mexico. *American Antiquity* 77:403-424.

Whalen, Michael E., and Todd Pitezel

2015 Settlement Patterns of the Casas Grandes Area. In *Ancient Paquimé and the Casas Grandes World*, edited by Paul E. Minnis and Michael E. Whalen, pp. 103-125. University of Arizona Press, Tucson.

Wheat, Joe Ben

1955 *Mogollon Culture Prior to A.D. 1000*. American Anthropological Association Memoir 82. Society for American Archaeology Memoir 10.

Wilcox, David R.

1979 The Hohokam Regional System. In *An Archaeological Test of Sites in the Gila Butte-Santan Region*, edited by Glen E. Rice, David R. Wilcox, Kevin Rafferty, and James Schoenwetter, pp. 77-116. Anthropological Research Paper No. 18, Arizona State University, Tempe, Arizona.

1980 The Current Status of the Hohokam Concept. In *Current Issues in Hohokam Prehistory: Proceedings of a Symposium,* edited by David E. Doyel and Fred Plog, pp. 236-242. Arizona State University Anthropological Research Papers No. 23, Tempe, Arizona.

Wilcox, David R., and David A. Gregory
2007 Introduction: The Structure of Anthropological Inquiry into Zuni Origins. In *Zuni Origins: Toward a New Synthesis of Southwestern Archaeology*, edited by David A. Gregory and David R. Wilcox, pp. 3-13. University of Arizona Press, Tucson.

Wilcox, David R., Phil C. Wiegand, J. Scott Wood, and Jerry B. Howard
2008 Ancient Cultural Interplay of the American Southwest in the Mexican Northwest. *Journal of the Southwest* 50:103-206.

Woosley, Anne I., and Bart Olinger
1993 The Casas Grandes Ceramic Tradition: Production and Interregional Exchange of Ramos Polychrome. In *Culture and Contact: Charles C. Di Peso's Gran Chichimeca*, edited by Anne I. Woosley and John C. Ravesloot, pp. 105-132. University of New Mexico Press, Albuquerque.