PREHISTORIC OBSIDIAN PROCUREMENT AND EXCHANGE

IN WEST-CENTRAL ARIZONA

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ABSTRACT

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This research investigates prehistoric obsidian acquisition in the Northern and Southern Sinagua, Prescott, and Cohonina culture areas to elucidate obsidian foraging and exchange patterns among prehistoric groups that inhabited west-central Arizona. The spatial distribution of prehistoric features and elements of material culture lend themselves to archaeological study for the purpose of discerning the interactions between an area's population and neighboring people and cultures. I analyze obsidian artifacts, including debitage, at 608 prehistoric sites in west-central Arizona using a portable x-ray fluorescence (XRF) spectrometer, identify the obsidian source provenance based on microchemistry, and map potential exchange routes between obsidian source areas and points of deposition. I use human behavioral ecology and landscape archaeology theory to generate testable hypotheses regarding the distribution of obsidian artifacts, potential foraging or exchange routes, and the influence of landscape connectivity on these patterns. I infer plausible foraging and exchange routes based on the spatial distribution of obsidian artifacts and least-cost path modeling that integrates slope, proximity to water, and vegetation community type. This research provides compelling evidence of wide-ranging foraging and exchange interactions among prehistoric groups that inhabited west-central Arizona.

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Chapter One - Introduction

My thesis research focuses on obsidian acquisition in the Northern and Southern Sinagua, Cohonina, and Prescott culture areas in order to elucidate obsidian foraging and exchange patterns among precontact groups inhabiting west-central Arizona. This is important research, because interaction among Sinagua, Cohonina, and Prescott people groups has received very little archaeological study to date. The two major environmental regions that comprise my study area in west-central Arizona are the Colorado Plateau and the Central Mountains. The Mogollon Rim demarcates the transition between the Colorado Plateau to the north and the Central Mountains Region to the south (Reid and Whittlesey 1997). The Colorado Plateau is drained by the Colorado River and Little Colorado River. The Verde River and Agua Fria River drain the Central Mountains Region through the heart of my study area. The Verde River and Agua Fria River provide natural travel corridors that transect the Sinagua and Prescott culture areas.

Four previously defined principle culture areas intersect in west-central Arizona -- the ancestral Pueblo to the north, Mogollon to the east, Hohokam to the south, and Patayan to the west (Reid and Whittlesey 1997). Archaeologists have identified several ostensibly distinct precontact people groups associated with one or more of the four principal culture areas within west-central Arizona, including Sinagua, Cohonina, and Prescott, based on ceramics and other aspects of material culture (Barnett 2006; Cline and Cline 1983; Downum and Garcia 2012). The Prescott culture area is located at the intersection of the four principal culture areas identified in Arizona. Although there is substantial archaeological research describing the material culture and other aspects of the four principal culture areas and, to some extent, the Sinagua and Cohonina people groups, the Prescott culture area remains under-studied and enigmatic.

The juxtaposition of precontact culture areas presents a unique opportunity to study the extent and types of interactions among the Northern and Southern Sinagua, Cohonina, Prescott and other precontact people groups of west-central Arizona. The Agua Fria National Monument encompasses approximately 71,100 acres of public lands in the southeastern extent of my study area and includes at least 450 archeological sites dating between A.D. 1250 and 1450. Using the authority of Section 2 of the Antiquities Act of 1906, President William J. Clinton signed the proclamation creating the Agua Fria National Monument on January 11, 2000. According to the Agua Fria National Monument Proclamation (34 Stat. 225, 16 U.S.C. 431):

> The area's architectural features and artifacts are tangible objects that can help researchers reconstruct the human past. *Such objects and, more importantly, the spatial relationships among them, provide outstanding opportunities for archeologists to study the way humans interacted with one another, neighboring groups, and with the environment that sustained them in prehistoric times* (emphasis added).

The monument's founders recognized that the spatial distribution of archaeological features and elements of material culture lend themselves to archeological study for the purpose of discerning the interactions between the area's populations and neighboring people and cultures. My research elucidates patterns of social interaction among the precontact inhabitants of the Prescott culture area and surrounding parts of west-central Arizona based on archaeological evidence of obsidian acquisition through foraging and exchange.

Primary data sources for my research include obsidian microchemistry obtained through portable x-ray fluorescence (pXRF) spectrometry and archaeological site locations identified using aerial photography reconnaissance. Portable XRF spectroscopy provides accurate, repeatable, non-destructive analysis of elemental composition in the field, thus eliminating the need for artifact collection. My research entails using pXRF spectrometry to analyze thousands of obsidian artifacts, including debitage, at hundreds of widely distributed precontact sites throughout west-central Arizona. Based on pXRF-derived microchemistry, I assign each artifact to an obsidian source area and map potential obsidian exchange routes between source areas and points of deposition. Secondary data sources for my research include extant museum collections, topographic maps, and digital data representing elevation, vegetation, and surface water. I extensively use GIS for mapping and spatial analysis, because GIS provides tools for cost-surface analyses and has demonstrated capability to process landscape-scale data sets.

I developed three primary research questions to guide my research. 1) Which sources of obsidian are represented at archaeological sites in west-central Arizona? 2) Does the archaeological record provide evidence that precontact people groups in west-central Arizona acquired obsidian through exchange? 3) What aspects of precontact obsidian acquisition behaviors are discernable from the spatial distribution of obsidian artifacts? I use human behavioral ecology, landscape archaeology, and circuit theory to generate testable hypotheses regarding the distribution of obsidian artifacts, potential foraging or exchange routes, and the influence of landscape connectivity on these patterns. I infer plausible routes of travel or exchange based on the overall spatial distribution of obsidian artifacts, landscape connectivity, proximity to water, and other variables.

My research entails the application of proven methods including pXRF spectrometry and geospatial analyses to a poorly understood area of west-central Arizona. The research informs previously undescribed aspects of interactions among the inhabitants of the Prescott culture area and adjacent people groups. Information regarding the distribution of obsidian and relative utilization of obsidian from eight documented source areas contributes to the body of research on lithic material procurement and interactions among the prehistoric people groups of west-central Arizona. Research results supplement existing archaeological information in support of cultural resource managers on public lands managed by the Forest Service and Bureau of Land Management. The following six chapters present the theoretical framework, literature review, methodology, results, discussion, and conclusions of my research. The results of my research advance our understanding of foraging and exchange interactions among precontact groups that inhabited west-central Arizona.

Chapter Two – Theory

In this chapter, I outline the theoretical foundations for my thesis research on prehistoric obsidian acquisition in and around the Prescott culture area. The theoretical framework helps to frame my hypotheses and inform the methods I use for hypotheses testing. I borrow from several theoretical perspectives that primarily derive from the processual paradigm, including human behavioral ecology, circuit theory, and landscape archaeology. Portable XRF analysis has great potential to elucidate lithic foraging and exchange patterns among precontact groups that inhabited west-central Arizona.

The processual paradigm provides the primary theoretical basis for measuring the elemental composition of obsidian artifacts with portable x-ray fluorescence (pXRF) spectrometry and determining the sources of the obsidian via comparison with reference data collected from obsidian source areas. The processual paradigm in archaeology focuses on explaining the social and economic processes and adaptations of culture that contribute to the material record (Binford 1980). Pivotal to my research, processual archaeologists seek to understand past human behavior by investigating spatial and temporal patterns in cultural resource distribution (Binford 1980). The notion that aspects of culture are accessible through the material record is, by definition, logical positivism - a hallmark of the processual paradigm.

Processual theories, as represented by Binford (1967, 1982), are a departure from culture history or traditional archaeology, as represented by Hawkes (1954). Processual archaeology is more explicitly theoretical and focuses on explaining changes in social and economic aspects of culture based on evidence in the material record. Traditional archaeology focused on description, artifact typology and classification, chronologies and seriation, and compiling narrative contextual histories that frequently relied on imaginative reconstruction, appeals to authority, and hearsay (Salmon 1982:41). Processual archaeology is inherently positivist, believing that the past is understandable through the rigorous application of the scientific method to the material record and its contexts, whereas traditional archaeology maintained a more skeptical, even pessimistic perspective regarding what could be discerned from the archaeological record. The practice of processual archaeology emphasizes the hypothetico-deductive method, often in conjunction with statistical inference and predictions induced from hypotheses (Salmon 1982:40; Binford 1967), in contrast with traditional archaeology's use of "pure archaeological inference" inductively drawn from historical knowledge and notions of behavioral norms (Hawkes 1954). Processual archaeology also emphasizes the use of quantitative data and hypothesis testing (Binford 1967), while traditional archaeology often relied on qualitative data (Hawkes 1954). The processual research paradigm is the most appropriate framework for my obsidian provenance research and related data analysis, because I will infer aspects of obsidian acquisition in prehistoric cultures of west-central Arizona primarily based on patterns of geographic distribution and the elemental composition of obsidian found in archaeological contexts.

Although behavioral ecology is a theoretical perspective within the processual paradigm, behavioral ecology is distinctive and represents areas of divergence with the processual approach advocated by Binford (1967,1982). Archaeologists operating from the perspective of behavioral ecology primarily use historical and/or functional explanations to reconstruct human behavior (Bird and O'Connell 2006). Historical explanations typically differ from functional explanations "in emphasizing the unique characteristics of particular historical sequences and thus often reject the proposition that universal processes of any kind might be involved" (Bird and O'Connell 2006:145). In contrast, universal processes are one of the mainstays of processual archaeology.

Bird and O'Connell (2006:145) also noted that behavioral ecology may be used to "guide well-warranted speculation about aspects of past behavior that are unlikely to be represented archaeologically." This stands in stark contrast to the processual paradigm espoused by Binford (1967,1982), in which explanations are strictly derived through deduction and analogs from the material record. Unlike historical explanations, functional explanations based in behavioral ecology usually relate to universal processes, more typical of processual archaeology.

Archaeologists working from the perspective of behavioral ecology assume that decision making capacities of people past and present are adaptive and shaped by natural selection (Bird and Codding 2016:396; Taliaferro et al. 2010:537; Bird and O'Connell 2006:143). Based on this premise, archaeologists generate hypotheses regarding how prehistoric human behaviors might have varied in response to specific ecological settings and test those hypotheses against patterns observed in the material record. Questions regarding patterns of resource procurement and transport have been a particular focus of archaeologists using the behavioral ecology approach. While the majority of archaeological studies conducted within the human behavioral ecology (HBE) theoretical framework have focused on developing optimization models for subsistence procurement, HBE-based optimization models are also effective tools for investigating non-subsistence resource procurement (Taliaferro et al. 2010).

I use a version of the optimal foraging model, which is rooted in human behavioral ecology (Taliaferro et al. 2010:537), to develop hypotheses that obsidian artifact distribution is based on relative proximity or least-cost paths to the obsidian source areas. Human Behavioral Ecology is an application of evolutionary theory that investigates how the behavior of humans is adapted to their ecological context, and is particularly useful in developing hypotheses for archaeological research, as described by Beck (2008) and Bird and O'Connell (2006). As noted above, archaeologists operating from the human behavioral ecology theoretical framework primarily use historical and/or functional explanations to reconstruct human behavior. Accessing the nearest obsidian source would be adaptive because it is conservative, minimizing the time, energy expenditure, and exposure to risk during foraging. Other material acquisition strategies that could conserve time and energy, and minimize exposure to risk, include using least-cost paths and exchange through a social network.

Material acquisition through exchange requires some level of social interaction. For example, Findlow and Bolognese (1982) conclude that prehistoric obsidian exchange increased with social stratification in the vicinity of the Antelope Wells obsidian source in Hidalgo County, New Mexico. Based on analysis of projectile points from Hogup and Danger Caves in the eastern Great Basin, Hughes (2015) demonstrates that obsidian source materials shifted in conjunction with transitions in lithic technology that accompanied the adoption of archery. Hughes (2015) concludes that the introduction of the bow and arrow likely expanded social contacts, increased foraging distance and material acquisition opportunities, and contributed to the alteration of the social structure in the eastern Great Basin. Wilcox (1991b:115-124) inferred that the nascent market exchange system that developed throughout central Arizona in association with ballcourts during the Hohokam sedentary period supplemented preexisting kinship-based exchange.

Human behavioral ecology is concerned with human agency (individual interests and actions) – the choices, social interactions, and decision-making of prehistoric people (Bird and Codding 2016:397, Dobres and Robb 2000:8). Archaeological interpretations of precontact human behaviors and lifeways can be greatly enhanced by embracing the perspective that the archaeological record is the result of decisions made by social actors (Roth 2017:299). Obsidian transport presupposes human agency. Two alternative expressions of human agency in obsidian procurement are direct acquisition from the obsidian source areas via round trip foraging, and indirect acquisition through exchange. Aggregations of obsidian debitage and other artifacts from multiple obsidian sources may suggest exchange, but would not rule out direct acquisition through multiple foraging trips to different source areas. Microchemistry data from XRF spectrometry will identify the source of obsidian artifacts, but will not indicate whether the material was obtained directly from the source, or indirectly through exchange; nor will XRF spectrometry reveal the route of travel between the source area and the point of deposition. Therefore, I infer plausible routes of travel or exchange based on GIS analyses of the overall spatial distribution of obsidian artifacts, landscape connectivity, proximity to water, and other variables.

Archaeologists routinely use least-cost path (LCP) analysis to analyze the prehistoric movements of people (Howey 2011:2523). LCP analysis assumes that a traveler has complete familiarity with the modeled landscape and is both willing and able to select the least-cost path (Howey 2011:2524). Despite these basic assumptions, however, numerous factors, such as weather, water availability, or disputes, could lead prehistoric travelers to select alternate routes (Howey 2011:2524). Most LCP models are based on a single factor - usually slope. Unlike LCP modeling, landscapes modeled using circuit theory quantify connectivity as a function of both resistance and conductance of movement (Howey 2011:2524). Using circuit theory with LCP analysis enhances models of prehistoric movement by incorporating scenarios with multiple potential pathways while acknowledging optimized routes (Howey 2011:2523). I apply circuit theory by creating multi-criteria cost surfaces that incorporate slope, vegetation, and proximity to water to model potential obsidian acquisition routes.

Distinguishing between exchange and direct acquisition of obsidian presents a key challenge for this analysis. Kelly (2011:190) discusses the difficulty of distinguishing between trade and direct acquisition of materials in the archaeological record, noting that the distinction is "important because the difference between social and physical connections reflects important differences in how people coped with their natural environment." Kelly (2011) uses relative debitage frequency and weight analyses to ascertain whether obsidian in the Carson Desert arrived as raw material, cores, or bifaces. By comparing the distributions of prehistoric campsites, obsidian artifacts, and obsidian sources to the ethnographically documented foraging distances of mobile foragers in the Carson Desert, Kelly (2011) concludes that much of the obsidian was obtained through exchange. Brown (1991) examines the structure and content of lithic assemblages from Chavez Pass and a number of neighboring sites to define contrasting patterns of procurement and production, and distinguish between lithic resources obtained through 'embedded' procurement (encountered during subsistence activities) and lithic materials obtained by direct procurement and exchange. Brown's (1991) results suggest that trade routes in the eastern half of my study area may have extended through Anderson Mesa and Chavez Pass.

Maschner (1996) describes challenges in applying evolutionary ecology in general and optimal foraging theory in particular to human decision-making processes in societies intermediate between bands and states. To address these challenges, Maschner (1996) integrates evolutionary theory, field survey, GIS (viewshed), and multivariate statistics to explain prehistoric settlement patterns and settlement change among the Tlingit in Tebenkof Bay, Alaska. Miroslav (2015) uses GIS to model potential routes of Neolithic obsidian conveyance into the region of present-day Vrac (Balkans) from two sources located near the present-day border area between Hungary and Slovakia. The projected routes indicate the existence of a settlement patterning close to the modelled pathways. Miroslav's (2015) results suggest that trade routes in my study area may be spatially correlated with settlement patterning between the obsidian sources and points of deposition.

The distribution, accumulation, and composition of lithic assemblages are highly conducive to the study of cultural landscapes, and surface lithic scatters commonly comprise the majority of the data in landscape-scale analyses (Clarkson 2016:493). The lithic raw materials suitable for flaked-stone tool manufacturing derive from specific, distinctive, and unevenly distributed sources, thereby providing evidence of material selection and transport that connect individual choices, places, and artifacts with the movements and social contacts of people in the past (Clarkson 2016:490). Lithic assemblages, therefore, can provide valuable insights into the places in a landscape people visited, or the nature and direction of social networks that facilitated lithic procurement across regions (Clarkson 2016:491).

Surface lithic accumulations may have served a symbolic function by marking the history of places to people passing through or returning to an area (Clarkson 2016:492). The scope and content of lithic assemblages may have also connoted the suitability of a place for habitation or served as a reminder of locally available raw materials or the social contacts associated with non-local lithic sources (Clarkson 2016:492). Habitation features, especially those with multiple rooms and associated ceramic and lithic scatter likely indicate extended periods of occupation or repeated occupations. A majority of the obsidian debitage analyzed in my study is associated with stone-masonry or pithouse features that fit this general description. Some of the obsidian debitage and other artifacts in the study area, however, present as isolated occurrences, or in association with other artifacts that do not include any habitation features. For example, there is obsidian debitage in context with approximately 36 bedrock metates adjacent to an extensive walnut grove near Mescal Spring in Yavapai County, Arizona. I hypothesize that such isolated occurrences are the result of hunting and gathering behaviors that were not associated lithic foraging or exchange routes. Alternatively, they may represent waypoints where subsistence activities occurred in conjunction with a larger lithic foraging or exchange network.

Landscape archaeology is the study of cultural and environmental variables that influence the way humans interact with their surroundings, and the influence of the environment on human activities (Hu 2012). Landscapes are more than the geographical distributions of artifacts and sites (Roth 2017:299). Rather, a landscape is a culturally constructed setting where people "survive, cognise the world, act, and make meaning" (Roth 2017:299; Hu 2012). Landscape archaeology provides a theoretical framework for pairing quantitative spatial data with qualitative, conceptual, contextual, and dynamic attributes of human-landscape interactions and interpretation (Hu 2012). Landscape archaeology theory is well suited to my research, because it provides a framework for integrating Geographic Information Systems (GIS), remote-sensing, cartographic data, and XRF technology with ethnographic and historical information. The spatial distribution of prehistoric features and elements of material culture lend themselves to archeological study of interactions between the area's population, neighboring people and cultures, and the environment. Landscape archaeology, therefore, heavily relies on spatial analyses using GIS tools. The GIS applications most relevant to my research are mapping site and artifact distributions and cost surface analyses.

Earle (1982) argues the need for theoretical development in the subdiscipline of prehistoric economics focusing on exchange. Earle (1982) goes on to discuss the need to develop methods to describe the form and content of exchange from archaeological data, and explain exchange as conditioned by individual choice and cultural context. Using concepts from human behavioral ecology and landscape archaeology theory, I generate testable hypotheses regarding the spatial distribution of obsidian artifacts and the influence of potential foraging and exchange routes on these patterns. The empirical components of this research are grounded in the processual archaeology paradigm, involving the collection of quantitative data and application of the scientific method to test hypotheses.

Renfrew (1975:3) noted that trade has become a principal focus of archaeology because imperishable trade goods are detectable, recent analytical techniques are able to identify material sources, and patterns of distribution are assessable using quantitative methods in geography. Although Renfrew (1975) primarily addresses exchange within higher levels of social and political organization, the fundamental concepts are also relevant to incipient forms of exchange. The material aspects of human culture (e.g., subsistence, technology, and economy) and the social aspects of human culture (e.g., social relations, religion, knowledge of the world) are inextricably linked (Renfrew 1975:4). Trade requires social organization and commodity, and imply criteria of value and measure, thereby relating the material and social aspects of human culture (Renfrew 1975:4). Polanyi (1957:266) defined trade (synonymous with exchange) as "the mutual appropriative movement of goods between hands." The movement of goods (and information) associated with exchange may operate within social units or across cultural boundaries between social units (Renfrew 1975:4). The term "movement" in Polanyi's definition of trade generates the distributions of material culture and information. The phrase "between hands" in Polanyi's definition establishes trade as social interaction (Renfrew 1975:4). Trade implies social organization that regulates both procurement of goods (including raw materials) and the social relations involved in human encounters during the exchange of goods

(Renfrew 1975:4). When people habitually exchange commodities at a specific location, that location functions as a central place, and takes on particular significance for the cohesiveness of the group (Renfrew 1975:5). According to Renfrew (1975:8), "High population need not be permanently associated with a central place, and indeed at periodic central places there is frequently no population." The imperative for any early civilization to control the resources necessary for survival is axiomatic (Renfrew 1975:22). As specialization develops within human populations, centers become points of attraction for a larger territory, and become exchange centers for non-local goods (Renfrew 1975:27). When applied to my study area in west-central Arizona, Renfrew's (1975) theoretical perspective suggests that I may find evidence of commoditization of obsidian and other resources, control of commodity resources, sites of commodity specialization, intra- and intercultural exchange, and central places of exchange.

The theoretical framework for my thesis research integrates aspects of human behavioral ecology, circuit theory, and landscape archaeology to help me explore obsidian procurement by precontact people living in and around the Prescott culture area. This integrated theoretical structure informs both the development of my hypotheses and the methods I use for hypotheses testing. In successive chapters, I use an optimization model derived from human behavioral ecology and circuit theory to investigate spatial distributions of obsidian artifacts across the cultural and environmental landscape of west-central Arizona. My research elucidates lithic foraging and exchange patterns among precontact groups within and surrounding the Prescott culture area.

Chapter Three – Background

Archaeologists have conducted obsidian provenance studies in numerous contexts to discern the foraging and exchange patterns of prehistoric groups throughout much of the western U.S. Numerous obsidian sources surround the Prescott culture area in west-central Arizona. The relative importance of these obsidian sources and the means through which prehistoric people living in the Prescott culture area acquired obsidian, however, have yet to be described beyond site-specific contexts. To date, there have been no obsidian provenance studies specifically designed to describe obsidian acquisition and exchange by prehistoric people in the Prescott culture area and the related interactions with adjacent cultural groups of west-central Arizona.

Obsidian Sources in Northern and Central Arizona

Archaeologically important obsidian sources in north-central Arizona include Partridge Creek, Presley Wash and Black Tank in the Mt. Floyd Volcanic Field north of Ash Fork and Government Mountain and RS Hill in the San Francisco Mountains Volcanic Field northwest of Flagstaff (Figure 3.1). Although the locations of these primary obsidian source areas are critical to understanding prehistoric obsidian foraging patterns, secondary deposits resulting from fluvial transport are also important in understanding the spatial distribution of obsidian in the archaeological record (Shackley 2005:26).

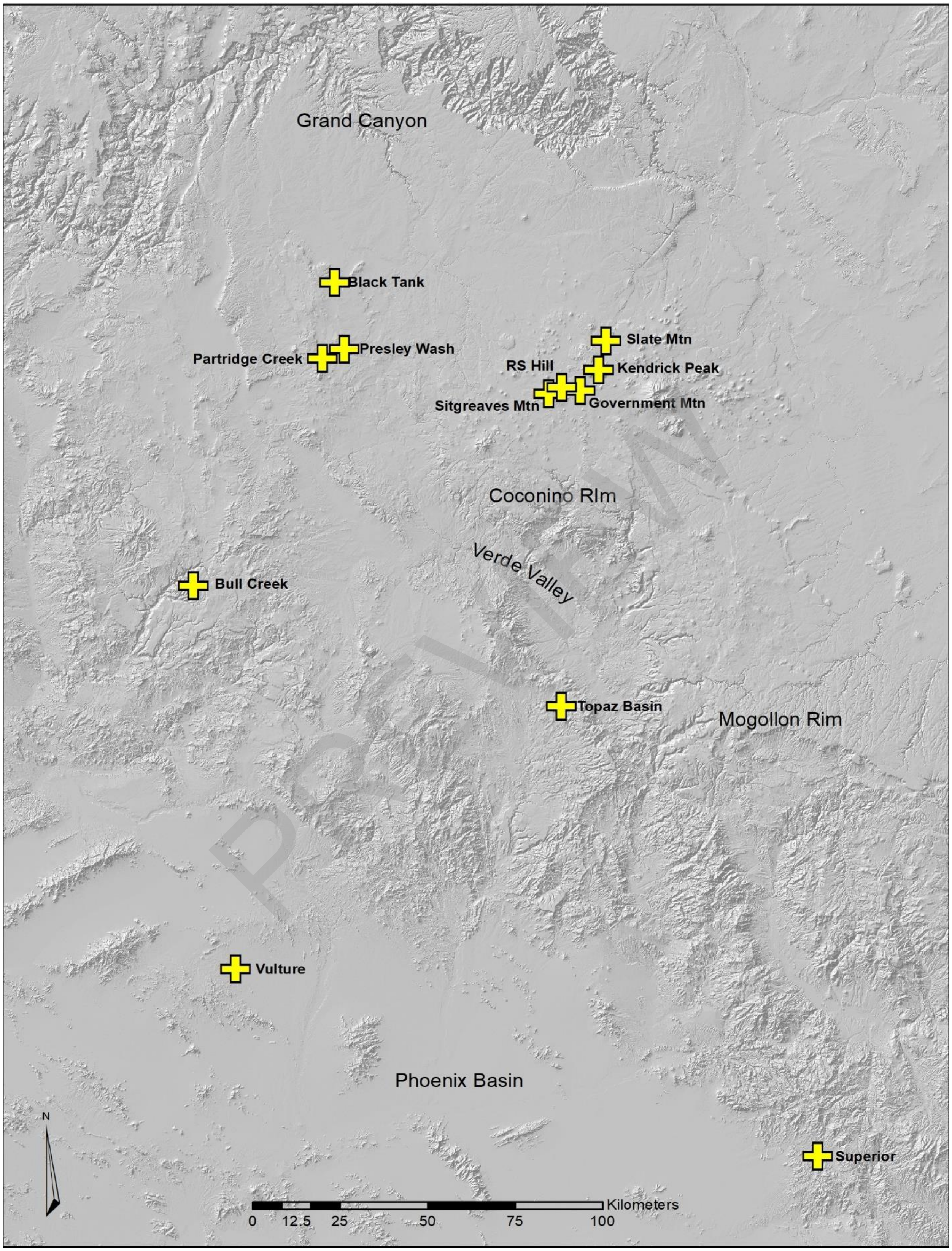

Figure 3.1. Obsidian sources in central Arizona.