LITHIC RAW MATERIAL PROCUREMENT AND THE SOCIAL LANDSCAPE IN THE CENTRAL MESA VERDE REGION, A.D. 600-1300

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of FUMIYASU ARAKAWA find it satisfactory and recommend that it be accepted.

Chair

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LITHIC RAW MATERIAL PROCUREMENT AND SOCIAL LANDSCAPE IN THE CENTRAL MESA VERDE REGION, A.D. 600-1300

Abstract

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This dissertation explores social interactions by investigating procurement patterns of lithic raw materials to make inferences concerning territoriality in the central Mesa Verde region. It investigates a central question: What do lithic raw material procurement patterns indicate about territoriality and interactions from A.D. 600 to 1280s?

In this research, the costs of traveling from each habitation to the nearest quarry to obtain the several raw materials used are summed in order to understand how inhabitants expended energy in procuring these raw materials across space and through time. I also examine the way in which the proportions of each material used relates to cost-distances for procurement, across space and through time. The results of these two analyses suggest that the ancestral Mesa Verde Puebloans probably developed restricted territories during the early Pueblo III period (A.D. 1140-1225).

The results of this analysis are also compared with expectations from three models – Dyson-Hudson and Smith's economic defensibility model; modified resource predictability and productivity model, controlling for population size; and the naïve-cultural evolutionary model. None of the three models fully explains the development of territoriality in this region over time seen in the lithic data. This research, however, suggests that considering socio-political organization is crucial for understanding behaviors of the ancestral Puebloans.

The central Mesa Verde population began to emigrate from the region to Rio Grande areas in New Mexico during the A.D. 1200s, possibly to reduce tensions in socio-political organization. Since the ancestral Puebloans diffused competitive modes through emigration, I claim that their emigration was not an indication of failure, but rather an adaptive success in human history. This research suggests that we can learn from how the ancestral Puebloans sustained and maintained their cultures and lifeways by investigating their histories.

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CHAPTER ONE

INTRODUCTION

Competing hypotheses for the major, still-unresolved questions concerning the Mesa Verde region's prehistory (the causes for aggregation, the nature of the local Chacoan great houses, the possibility of multiple ethnicities in this region, and the causes of the post-Pueblo I and post-Pueblo III depopulations) often depend on differing views of the social and spatial scales of conflict and cooperation (Adler 1996; Glowacki 2006; Johnson 2006; Kohler and van der Leeuw 2007; Lipe et al. 1999; Ortman et al. 2007; Varien 1999, 2000; Varien and Wilshusen 2002). This research assists in narrowing the range of possible models for these problem domains in the research area and elsewhere to the extent that this area serves as a "model" system for small-scale agricultural societies.

This research concentrates on toolstone procurement patterns in the central Mesa Verde region from A.D. 600 to 1300. The study of toolstone procurement patterns over time helps to develop a regional database for lithics, material that is greatly understudied in this region, and provides significant information about land use, territoriality, and interactions at four scales of analysis from the residential site to the community, locality, and region. The perspectives gained on the social dynamics of the region with this database can be greatly enhanced through this research and can contribute to ongoing and future studies in this region.

In this chapter, I first present the study area and time periods that are used for this research, construct a theoretical framework and identify models that can be applied, and finally consider how toolstone procurement patterns might reveal increasing territoriality and other cooperative or competitive modes in this study region over the 700-year period.

Study Area and Time Periods

This study focuses on those portions of the Mesa Verde region that include the Dolores Valley, Mesa Verde, Ute, and McElmo-Yellowjacket districts as defined by Varien and others (1996). Figure 1.1 shows district boundaries within the Mesa Verde region and to the west (Varien et al. 1996:86). My study area – outlined in the square towards the center of this figure – encompasses the research area of the "Village Ecodynamics Project" (Kohler and van der Leeuw 2007), as well as adjacent areas to the south and east whose addition almost triples the size of the village study area. I refer to this as the "central Mesa Verde region." The Village Project is examining the complexity of human social, spatial, and ecological relationships using both the archaeological record and agent-based modeling (Kohler et al. 2000). This research benefits from the database of sites compiled by that project but also adds new data on lithic material sources from within the "Village" area and nearby.

The geologic physiology of this area is diverse. The lithology of Ute Mountain is mostly igneous, while the central portions of the McElmo-Yellow Jacket district, including the Yellowjacket area, are composed of sedimentary and metamorphic rocks (Ekren and Houser 1965). Most lithic materials used prehistorically in this region were procured from sedimentary or metamorphic rocks from the southern portions of the central Mesa Verde region (Arakawa 2000).

This research encompasses four scales of analysis: sites, communities, localities, and the region (Varien 1999; Willey and Phillips 1958). Habitation sites – the Duckfoot site (5MT3868), Shields Pueblo (5MT3807), and Yellow Jacket Pueblo (5MT5) – are the

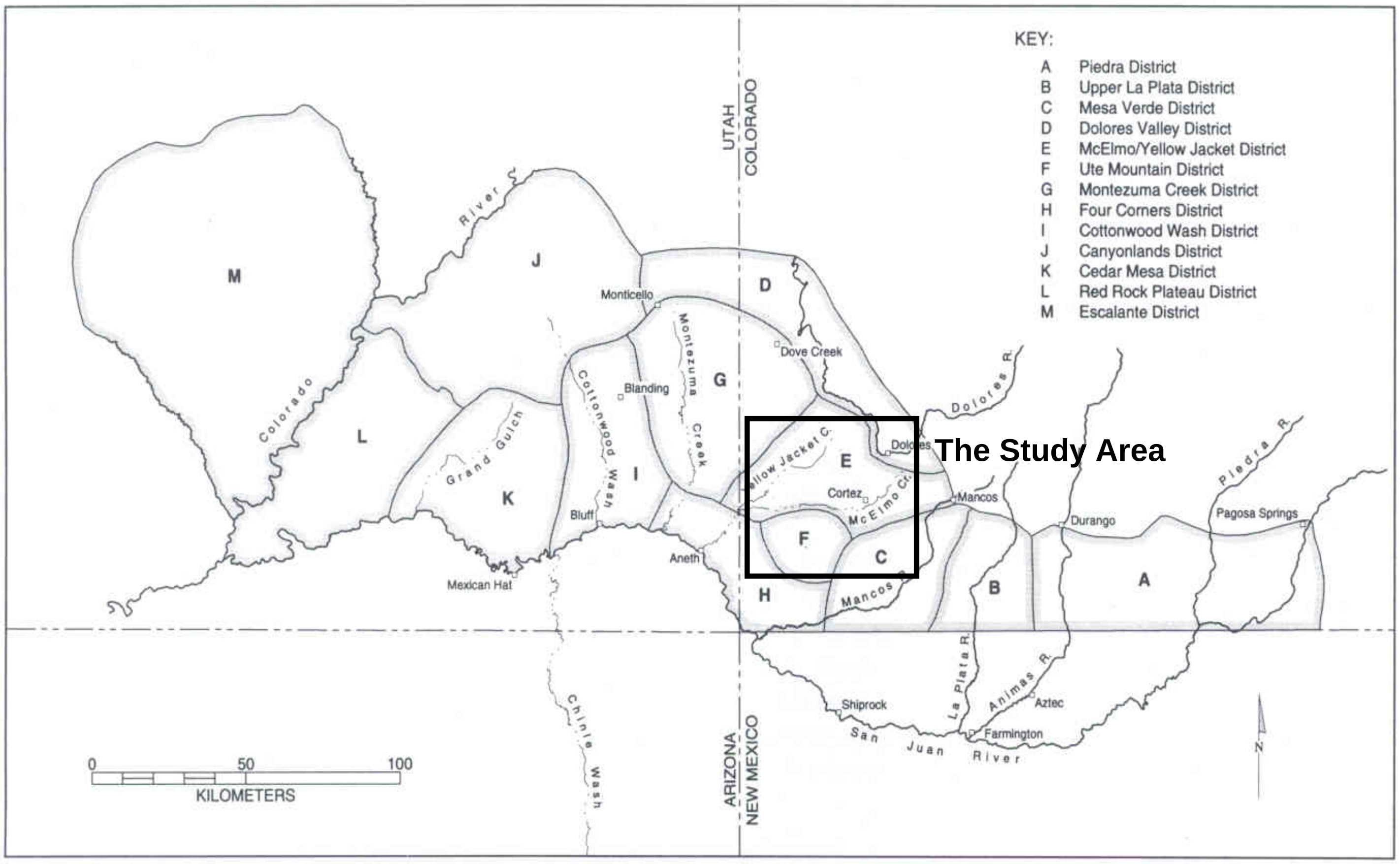


Figure 1.1. District boundaries in the Mesa Verde region, relative to the study area for this project (adopted from Varien et al. 1996).

smallest units of study. A community is defined as many households that regularly engage in face-to-face interaction and share social and natural resources; communities ordinarily include multiple sites (Kolb and Snead 1997; Murdock 1949; Varien 1999:19). For this study, community maps were generated from the settlement database (Crow Canyon Archaeological Center and Washington State University 2004) derived from the Village Ecodynamics Project. Polygon boundaries were implemented using GIS technology and friction surfaces or cost-weight analysis to identify each community boundary in the study area over time (Varien 1999). Lithic data from community centers of the late Pueblo periods were considered in order to understand and reconstruct territoriality and/or land-tenure systems. Six periods are used for this study (Table 1.1). Periods were chosen to be relatively homogenous internally with respect to obvious settlement processes, whereas breaks between periods coincide with discontinuities in settlement process (Ortman et al. 2007).

Table 1.1. Periods Used in This Study.

Traditional Periods	Dates Used in This Study	"Village" Periods[a]
Basketmaker III	A.D. 600-725	6
Pueblo I	A.D. 725-920	7-9
Early Pueblo II	A.D. 920-1060	10-13
Late Pueblo II	A.D. 1060-1140	14-15
Early Pueblo III	A.D. 1140-1225	16-17
Late Pueblo III	A.D. 1225-1280	18-19

[a] Periods used by the Village Ecodynamics Project (Ortman et al. 2007).

A locality is defined as an area larger than a community but smaller than a region (Varien 1999:23; Willey and Phillips 1958:18), and is generally identified by physical boundaries such as rivers, canyons, and mountains. The localities defined by canyon borders in this study area include the McElmo-Yellowjacket, Hovenweep, Dolores, Mesa

Verde, and Ute (Figure 1.2). The region for this study encompasses McElmo-Yellowjacket, Ute, Mesa Verde, Dolores Valley districts (Varien et al. 1996:86). The region is the largest scale used in this study, except in chapter 8, where I consider inter-regional exchange of obsidian and migration flows.

One aim of this research is to investigate the possible development of territoriality within this study area from A.D. 600 to 1280. In this chapter, I first define the term "territoriality," then discuss a theoretical approach drawn from human behavioral ecology (HBE), address how the study of territorial responses helps us understand the mechanisms for achieving cooperation or conflict, and introduce a theoretical framework of "power and scale" to understand social-political organization in the central Mesa Verde region over time.

Land-Tenure Systems and Territoriality

Some scholars have used the concepts of territoriality and land-tenure system interchangeably, but their definitions differ slightly (Netting 1982). Land-tenure systems are defined only for human societies. Adler (1996:338) defined land-tenure systems as "the systems of rights and privileges that human groups use to protect their resources and resource areas from outsiders." Study of the land-tenure systems generally focuses on how exploitive uses of local resources within a community are buffered from similar use by other communities, and in general, land-tenure systems become more salient when individuals encounter risky and uncertain situations, or when people settle and develop an aggregated community or village (Adler 1996; Kohler 1992; Smith 1988). Smith

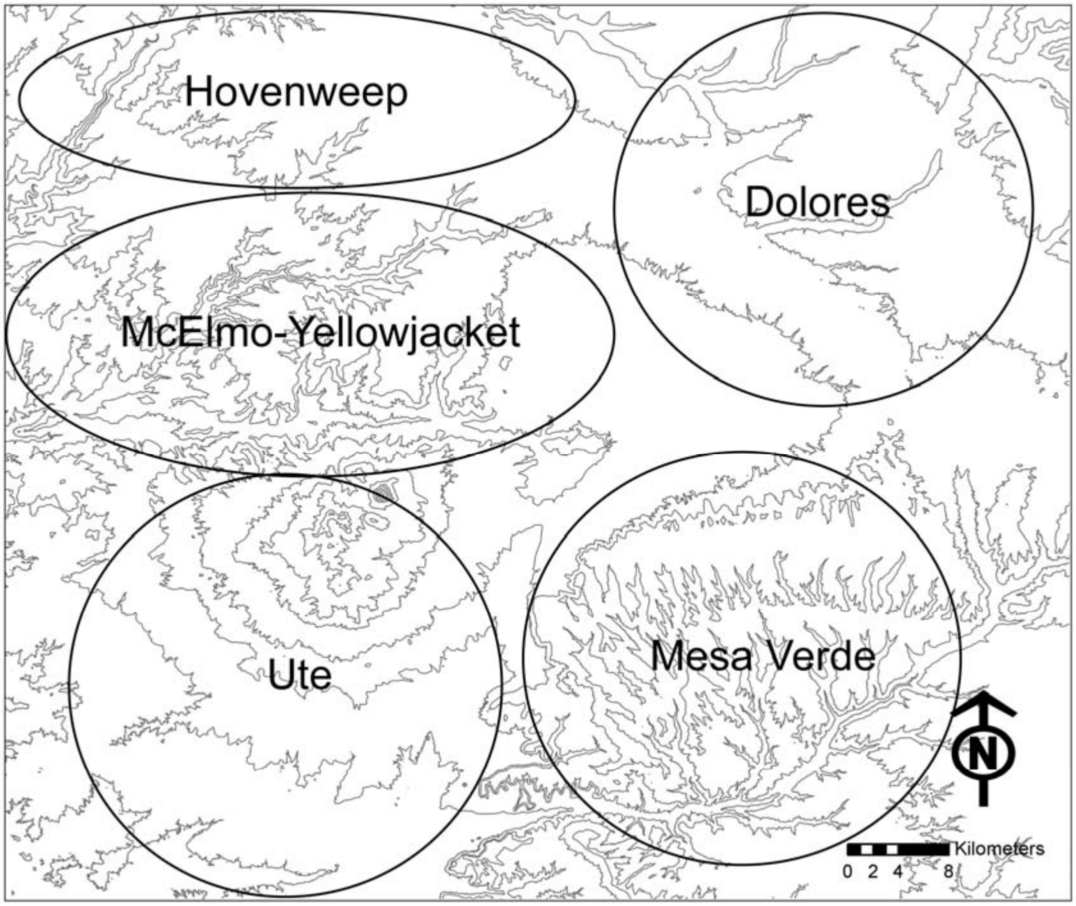


Figure 1.2. Localities in the study area.

(1988:244-245) outlined a continuum in the development of land-tenure systems among hunters-gatherer societies in which five states are particularly salient: 1) commons (common property), 2) reciprocal access (communal property), 3) territoriality (local-group ownership), 4) private property (kin-group ownership), and 5) private property (individual ownership). The first system does not involve strict enforcement in accessibility; people regularly develop permission by consensus allowing land use and access by others. The second system allows groups to reciprocally access land owned by another group. In this system groups can easily negotiate with each other to move in and/or access resources. The third system provides more strict controls on land access, limiting such access to local members. Systems four and five indicate a strong control of lands by private ownership, either by kin–group or by individuals. Although two different land-owning groups may negotiate reciprocal accesses, the chances of obtaining such access are reduced under these private-ownership arrangements. Smith (1988:245-246) recognized that societies might employ a mix of these systems for different resources.

Various kinds and degrees of territoriality are visible in the behavior of many organisms, including humans (Bohannan 1960). Humans generally mark and identify their lands, resources, and possessions (e.g., water resources and agricultural fields) in all levels of societies; bands, tribes, chiefdoms, and states. Anthropologists (Dyson-Hudson and Smith 1978; Gendel 1984; Higgs and Vita-Finzi 1972; Hoffman 1976; Netting 1982), geographers (Malmberg 1980; Sack 1983), and ethnologists (Brown 1964) have discussed territoriality from various perspectives. For instance, some sociobiologists focus on whether humans are aggressive by nature and develop territories more or less instinctually (Brown 1964). These scholars work from a theoretical framework in biology to explain the development of territoriality, and argue that aggressive behavior helps individuals to maximize their survival and reproduction, and natural selection generally favors the aggressor within a population when territory is easily reachable or accessible (Brown 1964:160).

In archaeology, territoriality is often defined simply through empirical observation of social, economic, or ecological restrictions on resource use imposed on individuals, human groups (such as lineage, clan, or moiety), or communities by other individuals or groups. Archaeologists have generally employed land-use and catchment patterns to understand and reconstruct territories in hunter-gatherer and agricultural societies (Bettinger 1989; Gendel 1984; Varien 1999). Study of land use focuses on the actual modification, manipulation, and utilization of ecofacts and artifacts, such as plants, fauna, soils, water, and lithics, in a large landscape. The study of catchment patterns concentrates on exploitation of resources from a central place (e.g., residential sites, community centers) and generally considers the distance and/or cost of procuring and transporting resources to understand logistic mobility or accessibility. Jarman and others (1982:38) rightly differentiate the catchment and the territory; they defined the former as "an empirical statement of observations concerning the geographical relationship between an archaeological site and its constituents, and whether these arrived there through geological, meteorological, human, or other biological agencies." On the other hand, territory is understood not only through empirical observation but also through more theoretical expressions of what we believe to be restrictions on access by individuals or groups under social, economic, or ecological factors (Jarman et al. 1982:38).

To build the theoretical expression of territories, Higgs and Jarman (1972) and Jarman et al. (1982) emphasized the importance of the time-distance factor. Jarman et al. (1982:32) estimated that when people walk about 5 and 10 km on flat terrain, they usually spend about 1 and 2 hours respectively. Use of travel time can also factor in a consideration of topography and geographical features, such as canyons and rivers, that impact people's movement.

In contrast, when we investigate catchment patterns, they are typically highly artificial radii of some set distance from a feature, such as a habitation site. It does not matter whether that radius is computed in terms of travel time or distance; thus, study of catchment patterns are generally implemented arbitrarily, distinct from territorial boundaries. Catchment analysis, thus, does not reflect anything actually known about human use of that landscape, although there may be some weak ethnographic records for choosing one radius size over another. The key concept about catchment analysis is that catchments are artificial circles (in a metric of either actual distance or travel time) imposed on a surface by some archaeologists or geographers.

Land-tenure systems are different from catchments but similar to territoriality. The key feature of land-tenure systems is that they are simply the human way of being territorial. Biologists and ecologists have investigated the relationship between spatial organization and ecological niche among animals, but they often use the term territory or home-range instead of land-tenure system to understand animal behaviors (e.g., Revilla and Palomares 2002). Additionally, ethnographers often use the concept of land-tenure systems to describe indigenous people's economic and socio-political organization within their territories (Cashdan 1983; Netting 1982). Thus, this supports that the concept of land-tenure system is presumably used for the human way of arranging and managing territories.

In this research, I implement the concept of territoriality using time-distance measures to investigate changes in socio-political organization in the central Mesa Verde region over a 700-year period, from A.D. 600 to 1280. To understand and reconstruct the complexity and variability of territories, I focus on the economic concept of territoriality derived from human behavioral ecology, particularly using an economic defensibility model (Dyson-Hudson and Smith 1978). Before I discuss this model, I outline the general theoretical orientation of human behavioral ecology and the implications of the approach for archaeological analysis and interpretation.

Human Behavioral Ecology (HBE)

Human behavioral ecologists (Bird and O'Connell 2006; Smith and Winterhalder 1992; Winterhalder and Smith 2000) assume that human behavior and decision making are strongly influenced by the natural and social environments including the predictability and abundance of resources; food, water, and mating partners. As Winterhalder and Smith (2000) suggest, "variation in social organization between and within species could be analyzed as evolutionary responses to local social and ecological conditions." HBE scholars have developed neo-Darwinian explanations to understand phenotypic traits using relatively simple mathematical models (particularly using optimization or game theory) to account for human organization and behavior. The neo-

Darwinian perspective emphasizes the role of natural selection as formative in organisms' survival and reproduction, leading over time to "adaptive designs" (Williams 1966). From this perspective, humans struggle for survival and reproduction, and compete for resources (Malthus 1803). Thomas Malthus (1803), who initially introduced conflict and competition theory, believed that increasing population density influences resource availability and opportunities for mobility. Increasing agricultural production cannot keep up with human population growth, and this causes humans to compete for resources. Following the Malthusian argument, some scholars (Boserup 1965; Brown and Podolefsky 1976; Dyson-Hudson and Smith 1978; Netting 1969) argued that the development of individual or communal territories is a typical response to such competition. These scholars developed cost-benefit estimates to understand the development and evolution of territoriality. Before discussing how HBE considers territoriality, I address how archaeologists use HBE theories to understand and reconstruct archaeological records.

Bird and O'Connell (2006) recently summarized applications of HBE to the archaeological record and identified five important steps archaeologists must make when using it to interpret their sequences in the systemic context. Specifically, they must identify: 1) the fitness-related *goal* of a behavior, 2) the *decision* variable associated with achieving the goal, 3) the *trade-offs* connected with the decision variable, 4) one or more *currencies* with which to evaluate those trade-offs, and 5) the *constraints* that define or limit the actor's situational response. In this research, the fitness-related goal of behavior is the procurement of toolstone and the establishment and defense of territories. To understand this goal, I consider not only whether the ancestral Puebloans had to make decisions regarding whether to travel a long or short distance to obtain raw materials or to exchange for those materials, but whether they also engaged in direct or indirect procurement (see Chapter 2). I also consider whether the proximate currency, such as the use of time, energy, and cost-distance of procuring raw materials, was a significant reflection of their behaviors. In other words, the development and defense of territories, which are presumably related to procurement of other resources – productive land, water, fuel, and hunting animals – are the constraints that define or limit actors' situational responses. Study of toolstone procurement patterns provides some insight into what the central Mesa Verde Puebloans may have experienced and how they may have behaved in this landscape. Bird and O'Connell (2006) assert that when we find mismatches between predicted and observed behaviors under those assumptions, we should reevaluate our models or assumptions.

When archaeologists use HBE to interpret their archaeological data, they use various theories, such as optimal foraging, patch choice, diet breadth, and central place foraging theories. To understand territoriality for this study, I consider the optimality, central place, and the economic defensibility theories.

Optimality/Optimization Theory. HBE focuses on optimality theory (particularly optimal foraging theory) using neo-Darwinian theory to understand the observable phenotypes of human behaviors (Emlen 1987:165). HBE scholars use time and energy as cost-benefit currencies and assume that organisms maximize their energy efficiency (the net acquisition rate) (Smith 1979:56) in each local niche or habitat. Those scholars argue that when available energy is limited, one should increase his/her energy efficiency in order to increase the total net energy captured; on the other hand, when energy is not limited, one should increase his/her energy efficiency in order to minimize the time for acquiring energy (Smith 1979:70). Based on these assumptions, Bird and O'Connell defined optimal foraging theory for hunter-gatherers as:

> …the assumption that maximizing the rate of nutrient acquisition enhances fitness, either by increasing nutrient intake or by reaching some intake threshold more quickly, thereby freeing time to pursue other fitness-related activities [2006:146].

We can further claim that in order to be energy efficient, natural selection favors behavior that maximizes the net acquisition rate and minimizes the cost of obtaining resources, or increases efficiency for traveling costs. I employ the term "cost" as synonymous with "time and energy" through the remainder of my discussion. Since HBE scholars use a neo-Darwinian approach and neoclassical economics (which uses cost-benefit analysis) for developing and testing their models, cost is a fundamental category in their analysis. For instance, based on considerations of time allocation, we expect that when people encounter an increase in time and energy expenditures required for specific activities (food production, feasting, and/or defense), they must reduce the time and energy spent in other activities (such as hunting, gathering, or procuring clay or lithic resources) to prevent overuse of their time and energy (Jeske 1992:469). Additionally, we assume that when individuals invest much time in obtaining a transportable quantity in a landscape, they may encounter scheduling conflicts with food-production tasks or tool-manufacturing (Jones and Madsen 1989:533). In short, the HBE scholars generally use time and energy as the major economic currency.

Minimizing Cost. Following the optimality theory dictum of maximizing the net acquisition rate and minimizing the time and energy expended in other activities, I further assume that humans tend to minimize the costs (time and energy) of traveling. I follow a simple statement by Jarman et al. (1982:26), “the more distant the resource to be exploited, the more expensive it is in energy costs, and the more its exploiter is exposed to predation and competition.” Many archaeologists have used the cost-minimization concept, particularly as measured by distance, in their research (Findlow and Bolognese 1980; Morrow and Jefferies 1989:30). Studies of demography and catchment pattern tend to support the idea that people minimize their travel cost, particularly in agricultural societies. When population density increases in a community or village, activities become more constrained by social, economic, and political involvements within the society. For instance, various archaeologists (Crown and Wills 1995; Jeske 1992; Parry and Kelly 1987) discuss how time–allocation interacts with degrees of sedentism. Agriculturalists tend to reduce their mobility, and when so doing, reduce their cost of traveling to procure resources on a daily basis.

Ethnographic studies of catchment patterns suggest that agriculturalists conduct most of their activities within a primary area where resources for most agricultural products necessary on a daily basis are found, such as water (1 km in Jarman et al. [1982] study and 2 km in Varien’s [1999] study) and a secondary area in an exploitative zone where most fuel and/or hunting animals are located (7 km in Arnold [1980], 5-10 km in Jarman et al. [1982], and 7 km in Varien [1999]). Finally, there is an area in a non-exploitative-zone where other materials, such as clay and lithic sources, may be located more than 10 km in Jarman and others (1982) and 18 km in Varien (1999). All of these studies suggest that agriculturalists concentrate their activities within the primary area, and their exploitation radius decreases with an increase in agricultural intensification. These studies of catchment pattern are therefore based on logic that is consonant with that of HBE, that humans minimize the costs of traveling to obtain their resources within their landscape.

Central Place Foraging Theory. Males tend to expend more energy to obtain resources, such as large animals, farther away from their residences than do women. In the HBE framework, central place foraging theory provides one plausible explanation for understanding these male vs. female resource-acquisition strategies. Bird and O'Connell note that "female reproductive success is constrained by access to resources critical for offspring survival. Male fitness, on the other hand, is limited by mating opportunities" (2006). Women in foraging societies tend to expend energy to acquire resources for maintaining their offspring and themselves on a daily basis, whereas males expend time and energy to obtain resources for the public, which eventually returns to the providers a good reputation and higher reproductive rates. Bird and O'Connell suggest that we can distinguish male and female activities in the archaeological record using these arguments. Women's activities and behaviors are tethered more closely to residential bases, while men's activities may be located farther away from residential bases where they are more likely to encounter animal prey (Binford 1980). The HBE scholars have applied this model mostly to hunter-gatherer societies (e.g., Kelly 2001). However, I argue that male's and female's different strategies with regard to travel distances are apparent in agricultural societies as well (Arakawa 2000). I believe that the central place foraging theory can provide plausible explanations for understanding high-quality versus low-quality procurement patterns by gender in the societies dealt with here.

Economic Defensibility Model. Dyson-Hudson and Smith (1978) investigated the relationships between human spatial organization and resource density and predictability.

They contrasted the conditions under which four spatial organizations should develop: 1) high mobility, information-sharing, spatio-temporal territories, 2) increased dispersion and mobility, 3) geographically stable territories, and 4) home-range systems (Figure 1.3; Dyson-Hudson and Smith 1978:26). We expect high mobility, information-sharing, spatio-temporal territories when resource density is high but resource predictability is low. When both resource density and predictability are low, we expect increased dispersion and mobility. In this circumstance, people frequently move to acquire resources. When resources are both plentiful and predictable, we expect geographically stable territories. When people have abundant and predictable resources, it is economically advantageous to spend more time and energy to defend their territories. Finally, we expect home-range systems when resource predictability is high but resource density is low. The mammalogist, Burt (1943), defines home-range as, "the area, usually around a home site, over which the animal normally travels in search of food. Territory is the protected part of the home range, be it the entire home range or only the nest." We can use this biological definition and distinction between home-range and territory to understand the economic defensibility model. For instance, suppose people from one community always found deer in the Dolores valley, but perhaps people from other communities in the central Mesa Verde region also went hunting in that area. Deer tend to be of fairly low density, even in good areas, and not very predictable in their distribution. Thus, although the Dolores inhabitants might have desired to control and restrict access to their territory by others, the size of the territory that would have to be defended was very large, and the costs of so doing might well have been greater than the benefits. In addition, while

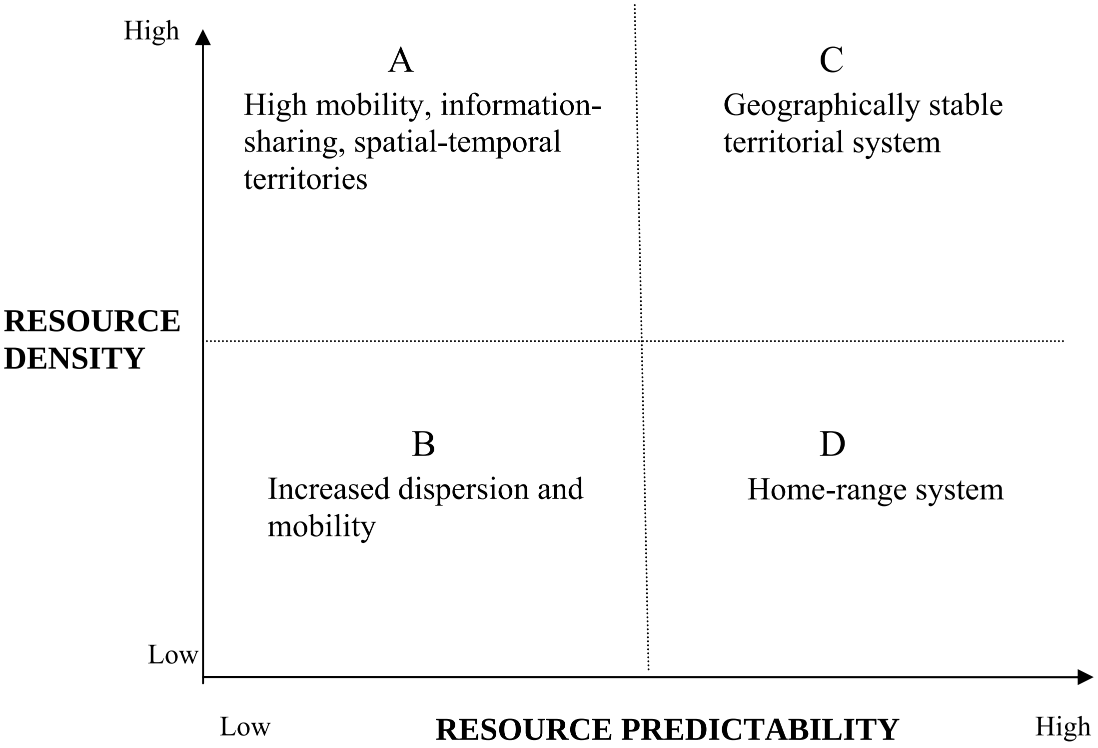


Figure 1.3. General predictions of the economic defensibility model for spatial organization (adapted from Dyson-Hudson and Smith 1978).

outsiders might have engaged in hunting, they generally would not have had extra energy to compete for other resources with local residents in the area.

Dyson-Hudson and Smith's economical defensibility model was developed for foraging societies but is applied to investigate an agricultural society here in the central Mesa Verde region. Through domestication, people produce resources that are more dense and more predictable than most food resources used by foragers. Agricultural systems, then, will tend to gravitate towards the upper right-hand corner of Dyson-Hudson and Smith's model – the geographically stable territorial systems. Additionally, not only was agricultural production increased with increasing population density through time, but the domestication of animal resources, particularly turkey in this region, also increased from the late Pueblo II period onward (Cowan et al. 2006). Linked with the increasing importance of domesticated agricultural and meat resources are the effects of population density on where people can be in the diagram. In agricultural societies, high population densities seem to always gravitate towards in systems of type C (geographically stable territories), both because of mobility restrictions imposed by population packing and because of the ecological structure of the landscape. Due to all these considerations, I argue that systems in compartment C might move slightly in one of the A, B, or D directions in an agricultural society, but circumstances do constrain the behaviors of the systems to be within or very near the heartland of compartment C.

Some ethnoarchaeological evidence supports such evolutionary ecological explanations for the evolution of territoriality. Since the early 1960s, anthropologists have studied territoriality and land-tenure systems, especially in Africa (Biebuyck 1960). Stone (1994), for instance, investigated the relationship between intensification and encroachment among the Kofyar in Nigeria. Stone noticed that increased intensification of agriculture, which was caused generally by increasing population density, led to the development of boundary protections. Netting (1982:475) employed historical and anthropological studies among the Ibo of eastern Nigeria (Brown and Podolefsky 1976) and the Kofyar in northern Nigeria (Netting 1969) to argue that the emergence of land-tenure systems is strongly tied to increasing population density and agricultural intensification. Netting stated, “as land becomes scarcer and competition for its products increases, it is obvious that groups with more limited membership and eventually individuals should claim more continuing rights to its use” (1982:464). These ethnographic accounts support the idea that the development of individual or communal territoriality and land-tenure systems generally occurs after an increase in population and in conjunction with agricultural intensification.

In the Mesa Verde region, Adler (1996), Kohler (1992), and Varien and Wilshusen (2002) have attempted to reconstruct territories and land-tenure systems through archaeological records. Kohler (1992) and Adler (1996) investigated the possible visibility and effects of land-tenure systems in the context of changing socio-political organizations in the central Mesa Verde region. Kohler (1992) used Hardin's famous concept of the tragedy of commons (1968) to understand the emergence of land-tenure systems among the Dolores Valley inhabitants between A.D. 600 and 850. He concluded that an earlier system of relatively open access to resources gave way during the population peak of the Pueblo I period to a competitive system in which superior agricultural land was claimed by particular social units (possibly lineages or clans); claims were "marked" by fieldhouses, populations clumped into villages, and villages were closed to new immigrants. Adler (1996), on the basis of both a worldwide and a southwestern cross-cultural sample, identified a general tendency for the size of the group with "primary access" to agricultural lands to increase from households to multihousehold units as agricultural intensity initially increased, and then to decrease again – to the level of the household – as the intensity of labor investment in agriculture increased still further (to levels possibly beyond those experienced in this study area). Neither study considered the possibility that communities might have attempted to exert control over other resources (such as lithic resources) within their catchments under such competitive conditions. Varien (1999, 2002) and Varien et al. (2000) argued specifically that exclusionary land-tenure systems might have played a substantial role in community organization and competition or conflict in the region.

As a group, these papers conclude that access to the best arable lands in the central Mesa Verde region became restricted during those portions of the late Pueblo II and III periods when populations peaked in size. This restricted access was presumably a source of inter-community conflict or at least competition in the central Mesa Verde region prior to abandonment. Exploitation territories have been reconstructed based on the location of community centers using spatial estimates of maize productivity sufficient to support the estimated community populations (Van West 1994; Varien et al. 2000).

One of the purposes of this dissertation is to explore the economic defensibility model using lithic data to understand how the Mesa Verde inhabitants developed and altered their territories from A.D. 600 to 1280. Within this landscape, ancestral Puebloans may have experienced social, economic, and political pressures from other groups that may have led them to develop more restricted territories over time. Exclusion or inclusion of individuals in such systems depends on patterns of interaction/alliance or conflict/competition. Thus, it is desirable to review the literature that addresses when and how individuals and groups establish either cooperative or competitive relationships with other individuals or groups.

Mechanisms for Achieving Cooperation or Conflict

Achieving cooperation or conflict is like a “coin flip,” meaning people can easily switch their attitudes either way, and it can be established on either a short-term or long-terms basis. Many potential mechanisms for achieving cooperation, such as genetic self-interest, reciprocal altruism, indirect reciprocity, reciprocity based on reputation, and costly signaling, have been studied (Gil-White and Richerson 2002). For example, on the individual level, whether or not one shares resources (e.g., meat) can be understood through the cost-benefit analysis of cooperative or competitive acts using the prisoner-dilemma game, which is a type of non-zero-sum game in which two players attempt to acquire rewards from a banker by cooperating with or betraying each other. Such game theory helps anthropologists and archaeologists to understand and analyze how individuals' decisions have filtered through and structured groups through time (Axelrod 1984; Kohler and Van West 1996; Smith 1988). The concept of territoriality (Bettinger 1989) and the economic utility model (Kohler and Van West 1996; Smith 1988) are also useful to a consideration of conflict and cooperation. Following these studies, I bring to bear three lines of argumentation, based on a population pressure and socioeconomic complexity model (Keeley 1988), a scalar threshold model (Kosse 1996), and a scale of power model (Bodley 2003, 2005) to understand and reconstruct cooperative or competitive acts in the central Mesa Verde region over 700 years.

Keeley (1988) investigated the correlation between population pressure and socioeconomic complexity among hunter and gatherer societies using cross-cultural records. He employed population density and resource productivity as the major factors for understanding population pressure in complex hunter-gather societies. Based on this study, Keeley concluded that there is a strong correlation between population pressure and socioeconomic complexity; in other words, when population density increases, socioeconomic structure also becomes more complex. This study provides some support for considering population density and resource productivity as the "prime" mover for the complexity. In my research, I employ population density to consider social, economic, and political changes as coincident with development of territoriality in the central Mesa Verde region over time.

Kosse (1996) investigated the relationship between population density and sociopolitical complexity using ethnographic and cross-cultural studies. She used several middle-range societies between the band and chiefdom levels of complexity from four different continents. She found that some societies containing more than 2,500-3,000 people have regionally organized polities, while populations below 2,500-3,000 have more variability in sociopolitical organization. Although this was a preliminary study, the scalar threshold number of 2,500-3,000 can be used to suggest whether polities by this definition emerge in the central Mesa Verde region. I will use this scalar threshold model as well as previous arguments made by archaeologists in this region (Lipe 2002, 2006) to help understand the scale of sociopolitical organization in the central Mesa Verde region.

I integrate all information, both demography and sociopolitical elements, and discuss how emigration occurred in the greater Southwest after the A.D. 1100s, drawing on the power and scale approach (Bodley 2003, 2005). In the next section, I explain what this approach is, and how it is helpful for understand issues of aggregation, competition/cooperation, and migration in the greater Southwest.

Power and Scale: Sociopolitical Complexity in the Central Mesa Verde Region

Bodley (2003, 2005) argues that when power concentration and scale increase in a society, the gap widens between powerful and subordinate individuals with each increase, and social, political, and economic advantages become pronounced among elites. Bodley (2005:19) defines power as "the ability of individuals to influence other people and events in order to maintain or improve their own and their children's material opportunities or life chances." Scale refers to the absolute size of populations, cities/villages, or anything that influences people. In the case of ancestral Puebloan societies, population density is a crucial element for understanding the scale of social-political organization. Bodley (2005) insists that small-scale societies provide us a "model" we can use to understand and solve present problems generated by the gap between the powerful and subordinate individuals, or the accumulation of socio-political power by elites. One of the mechanisms necessary to develop sustainable cultures or societies is what Bodley terms the "localization process" (2005:514), actions that distribute or diffuse social power within local communities to regulate growth and scale by giving priority to the maintenance and reproduction of healthy households. To Bodley, "localization" means that political and economic power is not only equally established within each local community, but decision making authority is democratic, the purview of individuals in a community.

Archaeologists have also noted distinct trajectories in social organization that either consolidate or distribute social power (Bernardini 1996; Blanton et al. 1996; Johnson 1989). Termed either network or corporate strategies, Feinman (2000:214) notes that corporate organizational strategies tend towards a more egalitarian system, characterized by equal distribution of wealth, shared power arrangements, with power embedded in the group. In contrast, network organizational strategies are more hierarchical, with concentrated wealth, individual positions of power, and ostentatious elite adornment.

In the central Mesa Verde region, Lipe (1995, 2002) argued that the ancestral Puebloans closely approached developing a complex socio-political organization (including a hierarchical system, as in a chiefdom) in the central Mesa Verde region during the thirteenth century. Considering the Pueblo world from the Chaco florescence through A.D. 1300, Lipe (2006:281) said:

> …the social, religious, and settlement systems that developed south of the San Juan in the 1200s and spread throughout the Pueblo world in the late 1200s and 1300s appear designed to emphasize community integration at the expense of household political autonomy and to prevent individuals or kin groups from gaining control of multiple reins of power.

I interpret his statement to indicate that although the late Pueblo III Pueblo people were trending more towards a network organizational strategy, they chose to diffuse the concentration of social power by the process of migration, embracing the corporate alternative more prominent in areas south of the central Mesa Verde region. These actions are analogous to what Bodley (2005) refers to as the "localization process" where groups consciously act to deter consolidations of power. This mobility strategy helped them to sustain a more egalitarian or corporate social and political organization after the turmoil in the central Mesa Verde region in the A.D. 1200s. This desire to avoid hierarchy was perhaps a reaction to the development and collapse of the Chaco polity in the eleventh and early twelfth centuries in the Southwest (Kohler and Turner 2006). In other words, the ancestral Puebloans most likely learned the drawbacks of stratified or network type socio-political organization (Feinman 2000) during the Chaco florescence and subsequent period, and this experience encouraged central Mesa Verde Pueblo peoples to migrate to actively reject this process in the thirteenth century. Toolstone procurement patterns are not only a way to understand and reconstruct the turmoil of the region, particularly the development of restricted territoriality from A.D. 600 to 1280s, but also to address the movement of ancestral Pueblo peoples from the northern San Juan to the south during the 1200s.

Toolstone Procurement Patterns

Toolstone procurement patterns reflect important aspects of territoriality by suggesting how far and how often the people inhabiting the central Mesa Verde traveled to obtain raw materials. Many archaeologists have focused on catchments and resource procurement to understand and reconstruct territoriality and accessibility in hunter-gatherer and agricultural societies (Arnold 1985; Bettinger 1982; Harro 1997; Walsh 1998). Arnold (1985), for example, analyzed ethnographic records to understand spatial acquisition patterns for various natural resources. He discovered that people in agricultural societies typically do not travel more than 7 km to exploit most resources related to ceramic production (Arnold 1985).

Bettinger (1982) used Steward's (1937) family-band model to argue that because people in Owens Valley frequently moved from place to place, they did not have a restricted territory. Using linear regression analysis of the distributions of obsidian frequency in the valley, Bettinger expected that the frequency of obsidian would be large close to a quarry and relatively low in more distant areas, if specific groups controlled or dominated that quarry. His regression analyses showed that obsidian frequencies above regression line were found mainly within 15 km of the source, while below regression line were mostly within 15-25 km. Bettinger also examined the spatial distributions of obsidian projectile points during three time periods in Owens Valley and discovered a major shift in the high frequency of this tool type within the fall-off zone (based on Renfrew's distance-decay model) during the late period (A.D. 1300-historic). He concluded that this change in toolstone procurement pattern for projectile points probably occurred because of trade. Bettinger's study of territoriality through lithic distributions suggested that there was a confined territorial boundary within the supply-zone (within 15 km) that impeded direct access to the source, whereas strong trading networks occurred within the fall-off zone (within 15-25 km) during the late period in Owens Valley. This study was innovative because it used distance-decay analysis to understand territoriality in hunter-gatherer societies.

To understand human behavior using lithic materials, Torrence compiled the volume *Time, Energy, and Stone Tools* (1989), which is written from a human behavioral ecological perspective. Many scholars in this volume use time and energy as proximate currencies for understanding human behavior using lithic data, starting from the assumption that humans have been shaped by natural selection to find more or less optimal solution to problems, including those posed by lithic technological organization. According to Jochim:

> The study of stone tools has entered an exciting stage because of theoretical developments linking technology to the overall organization of behavior within a framework of economics and evolutionary ecology [1989:111].

This research follows Jochim's lead, examining various factors such as settlement placement and use relative to patterns of resource productivity and population estimates within an HBE framework. Additionally, this research considers the concept of territoriality using the distance-decay model and cost-distances for obtaining toolstone as a proximate currency (an approach similar to that of Findlow and Bolognese 1983).

I expect that this study of lithics will provide clues to terrain accessibility and extent of territoriality through time. From the Basketmaker III to the early Pueblo II periods, mobility was probably relatively unrestricted due to low population density coupled with greater reliance on hunting, with the possible exception of the population peak achieved during the late Pueblo I aggregation (ca. A.D. 840-880; Wilshusen 1999b). In contrast, during the late Pueblo II and III periods, mobility may be more restricted and more well defined, and defended social boundaries or territories may have emerged in this region. I believe that varying proportions of debitage raw materials both reveal and reflect these different patterns of mobility and access. When logistic mobility was high and access relatively unrestricted, we might expect to see use of materials that are best suited to the performance requirements of particular tools or tasks, within additional constraints imposed primarily by cost-distance. When logistic mobility was restricted by access considerations, we might expect to see more use of local materials, with constraints imposed more by considerations of social access than by considerations of cost-distance. Therefore, considering the distance-decay model and making difference maps (using GIS technology) of changes in toolstone procurement of energy expenditure from one period to next using well-dated sites spread across the study area should help to document changes in the types and scales of territoriality during the prehispanic occupation of the central Mesa Verde region. Harro (1997) provides a general example of this methodology; see also Walsh (1998) on the development of social boundaries in the northern Rio Grande.

Summary

Unlike biotic resources, lithic materials were deposited in particular geological formations so that we can pinpoint these sources in this region (Ericson and Purdy 1983). Archaeologists in the Four Corners area have worked to identify raw material types and quarries for 20 years or more (e.g., Arakawa 2000; Cameron 2001; Gerhardt et al. 2005; Green 1985; Phagan 1988a, 1988b; Shackley 1996). Building on these studies and adding more lithic quarry surveys, it is possible to understand and reconstruct a relative "cost-distance" from a habitation to a quarry. Because the distance from a quarry to a site varies throughout the landscape, I measured the "cost" of distance by calculating the slope using the ArcGIS program (this calculation is discussed in Appendix A). These cost distances will be used instead of raw distances to examine how raw material patterns changed over time.

In the next chapter, I discuss how I collected the samples and analyzed the debitage, and explain how I applied the distance-decay model and calculated energy expenditure values in this research. In Chapter 3, I introduce typical raw material types and their quarries in the central Mesa Verde region. In Chapter 4 through 6, I discuss toolstone procurement patterns from Basketmaker III to late Pueblo III periods by investigating the distance-decay and energy expenditure models. In Chapter 7, I summarize toolstone procurement patterns through time and also compare three different models – the naïve-cultural evolutionary prediction model, Dyson-Hudson and Smith's model (1978), and Dyson-Hudson and Smith's model controlling for population size – with the results of lithic analyses. In Chapter 8, I discuss what kinds of relationships occurred between the central Mesa Verde inhabitants and residents who accepted them into Rio Grande by investing obsidian procurement through time. In Chapter 9, I provide a summary of what I accomplished and discovered from this research, and what kinds of questions or research we will be able to further explore in the future.

CHAPTER TWO

METHODS AND THEORIES

This chapter outlines the models and analytic procedures that guide the project's sampling design and analysis. In this research, I utilize three different approaches. In the first, I use a modified distance-decay model to determine which sites within a locality deviate from the predicted model, using linear regression, correlation coefficients, and residual analysis. In this analysis, I define the percentage of each raw material type across all sites as a dependent variable, and the cost-distance for that material from each site as the independent variable.

The second approach encompasses in-depth analyses of flake attributes from several excavated sites, emphasizing what can be learned from through-time and across-space comparisons of the energy-acquisition data for these materials. This provides high-resolution data from the best contexts available.

In the third approach, I build an energetic-expenditure map for the entire study area for the periods defined in Table 1.1, each of which displays the spatial distribution of energy expenditure for toolstone procurement in each time period. To the "high-resolution" data from the excavated sites, I add data that I coded from other sites designed to provide as even a spread of data points across the study area as possible for each period. These maps (which can be "differenced" to show the areas of largest change from one period to the next) are used to provide regional context for the high-resolution data described above, and may reveal regional patterns not obvious from the in-depth analyses.

The Distance-Decay Model

Since I implement a modification of Renfew's distance-decay model for this study, I discuss some differences between my cost-distance model and Renfrew's original formulation before I discuss the regression and correlation analysis. Renfrew (1969, 1972, 1977) employed the retail gravitation model of Reilly (1931) to understand the distribution of obsidian and early Bronze Age bowls (1972) in European prehistory. For instance, in his study of Bronze Age obsidian distribution in the Aegean, Renfrew (1969) discovered that a decline in frequency of obsidian occurred with an increase in the distance from the source. He called this pattern "Down-the-Line Exchange" (1972:465) or the "Distance-Decay Model" (1972), each of which contain two different "gravitational" zones – the contact and the fall-off zone (Figure 2.1). The first, which may encompass distance of up to 200 to 300 km from the source as well as the culture region or internal trade center (Renfrew 1972:465), generally shows a gradual decrease in percentage of materials over distance, but with still a large proportion of these materials even at its periphery. The fall-off zone by contrast encompasses a steep gradient with a relatively concave shape for the line.

Hodder (1974) and Hodder and Orton (1976) further explored Renfrew's distance-decay model by implementing Taylor's (1971) regression analysis of single and double log-transformations (Figure 2.1). Using the single-log transformation of distance, Hodder found that two different α values (the transformation of α to either .1 to .6 or .9 to 2.5) provide a good fit to the observed data, in two different situations. He expresses the single-log equation for regression analysis as:

$$\log I = a - b\,D^{\alpha} + e \qquad (1)$$

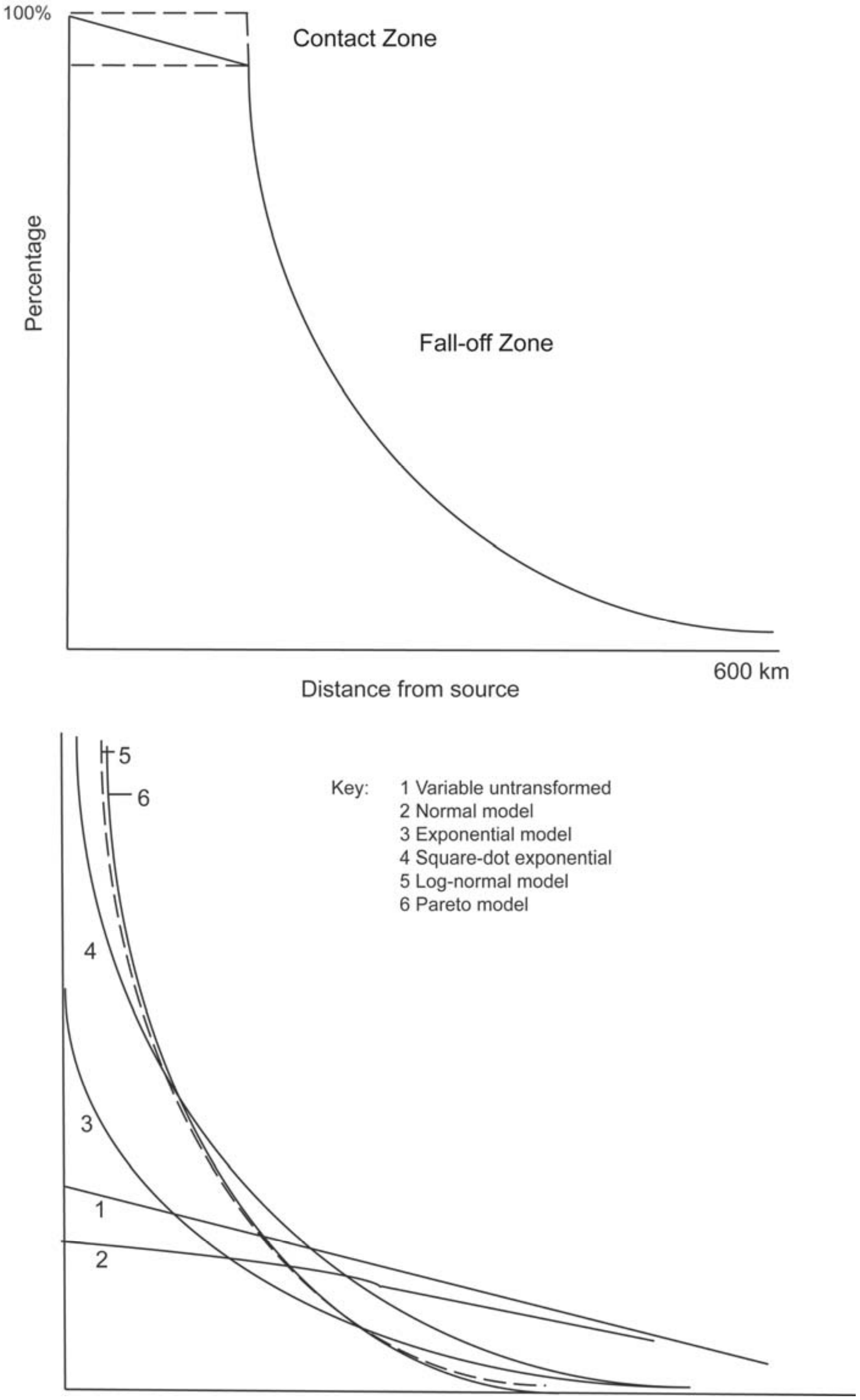


Figure 2.1. The above panel shows down-the-line exchange (adopted from Renfrew (1977:78, Figure 4a). The bottom panel shows the effects of different transformations of interaction and distance (adapted from Hodder 1974:173, Figure 15).

where I is distance, a (the intercept) is the amount of interaction irrespective of distance, b (the slope) is the rate of decrease in interaction with distance from the origin, and e is an error term expressing the deviation of each point from the regression line (Hodder 1974). When the best-fitting regressions employ α values ranging from .1 to .6, Hodder suggests the system is dominated by direct trade and/or represents a close-in contact zone within which movement was not costly. When the α value is greater than .9, this indicates an indirect, more costly, and random-walk process in an unrestricted environment. According to Hodder and Orton (1976:126), a random-walk process means "the distances and directions moved by points progressing from a source are chosen within specified limits, at random." They claimed that the latter α values are comparable with the down-the-line zone in Renfrew's model (1976).

Clark (1979) further examined Renfrew's and Hodder's models using more reliable and well-studied archaeological data. He considered Renfrew and Hodder's empirical data to be relatively weak because of small sample sizes, inconsistency of excavation methods, and poorly defined temporal periods from archaeological collections. Clark's restudy of coins at Dura Europus in Syria did not exactly fit with Renfew's and Hodder's down-the-line model, but he claimed that both provide a "plausible scheme" for understanding these distributions in terms of Reilly's (1931) retail gravitation model. Clark found that the curves were relatively convex to the origin and also discovered that using a double-log transformation provided better r^2 values for well behaved archaeological data. He realized that trading patterns may have been influenced by the case of elaborate items such as coins, and that degree of transportability of archaeological materials varies with changes in socio-political conditions.

Using a distance-decay analysis for lithic materials, Hess (1997) explored the relationship between some attributes of debitage, such as cortex amounts and dorsal flake scars, and distance. He differentiated procurement patterns for various toolstones in the Late Pre-Mazama (c. 8000 – c. 6850 B.P.) and the Late Prehistoric (2000 – 150 B.P.) periods, using debitage attributes as the dependent variable and distance as the independent variable. Using changes in the slope and correlation coefficients from the regressions, he concluded that inhabitants in the Late Pre-Mazama period probably engaged in more direct procurement than those in the Late Prehistoric period.

My approach to distance-decay analysis is similar to Renfrew's and Hodder's models, which attempted to fit the gravitational model of Reilly (1931), than it is to the approach used by Hess (1997). I use linear regression with an emphasis on interpreting the slope and Pearson's coefficient of determination (r^2) and residual analysis to understand interactions and territoriality in this study. My approaches differ in some way, however, I implement the above analysis with those of Renfrew (1969, 1977), Hodder and Orton (1976) and Clark (1979). First, this study focuses on "utilitarian" products – the percentage of debitage of various sorts across all sites – as the dependent variable. According to Clark, "objects such as coins, to which special limited values are attached by society, might move in very different ways than those which are traded on the basis of their utility alone" (1979:14). Unlike highly elaborate goods such as coins, debitage is ubiquitously distributed in almost all prehistoric sites, has been little disturbed (e.g., through pot-hunting), and was mostly used for everyday activities. Second, this study concentrates on the contact zone in Renfrew's model and not the fall-off zone because it encompasses a small portion of ancestral Puebloans' territories (the size of my study area is approximately 72.1 km [north-south] and 68.7 km [east-west]). As a result, I investigate mostly the results of localized interaction by pedestrian contacts. I display the percentage and cost-distance regression lines, then show residual plots on both a graph and a map. These analyses help to determine how and why certain sites deviate from the best-fit of regression analysis and warrant further explanations using socio-political and environmental factors.

Another major difference with these traditional approaches is that I use cost-distances rather than straight-line distances as the independent variable in my regressions (see the section data representation below). As discussed in the Chapter 1, the cost-distance offers a more humanly meaningful scale than does the straight-line distance, since this area contains significant and abrupt physiographic features. For instance, consider two quarries in a landscape one located on a mesa top about 1 km from a habitation site, the other situated on flat terrain approximately 5 km from the same site. Although the mesa top quarry is closer to a habitation site by a straight line, people may actually expend more energy in procuring this material than to obtain the materials that are 5-km distant along a flat surface.

Expectations of Linear Regression

All things being equal, I expect that people who live closer to a quarry to use a larger proportion of that raw material. Thus, a regression line with the proportion of that raw material on the y-axis and the distance on the x-axis should show a negative slope when these values are regressed for a number of sites. If this is not the case, then a high degree of trade, interactions, or frequent mobility must be inferred. This further raises the possibility of spatial biases due to strong alliances with other communities within the region.

Second, as Neily (1983) argued, I expect that inhabitants of the central Mesa Verde region gradually relied more on materials closer to their habitation sites (such as Morrison materials generally are) through time if the population increase that coincided with aggregation led to the development of more restricted territoriality over time. If this is not true (that is, there is no change over time or that people living farther away from a quarry had a larger proportion of certain raw material types), this suggests that some people had more open and/or unrestricted mobility and territory, or had more access to trade, than did others. Another explanation for the unexpected result would be a dramatic change in subsistence patterns. For instance, if ancestral Puebloans were forced to reduce their hunting distances because of territorial considerations (Cowan et al. 2006; Driver 2002; Muir and Driver 2002), then they could not embed procurement of high-quality materials in their long-distance hunts. Instead, they may have relied more on agricultural products, procuring and utilizing local materials, for example, building houses, cultivation, and clearing land.

Third, the analyses of slopes and r^2 values demonstrate how the ancestral Puebloans used their landscapes over time. When there is a strong negative slope, this means that people have a strong tendency to use material that is close to their habitations; it means further that they are very "sensitive" to the cost-distance relationship for that material. People might appear to be "cost-sensitive" because they actually were, because they were quite confined to their local areas by population packing, or because they could obtain everything they needed locally (e.g., they lived in an area in which game was not depleted). When trade occurred among some groups, it would probably lead to relatively shallow negative slopes or even positive slopes in the cost-distance relationship.

The size of the r^2 values indicates the variability in procurement patterns across the landscape. When everyone is similarly sensitive to the cost-distance relationship, the r^2 values tend to be high, and the relationship is significant because all sites fall near the regression line. If inhabitants in some sites are exchanging and others are not, the cost-distance relationship is weak (e.g., r^2 values will be low).

In general, I expect that the slopes of these linear regressions should become steeper, and the correlation coefficients stronger, if the ancestral Mesa Verde Puebloans experienced more restricted territories and employed less logistic mobility (Binford 1978) over time. Such conditions might be accompanied by a less-even distribution of social power within this region (Lipe 2002). On the other hand, more shallow slopes might indicate frequent logistic mobility, unrestricted territories, and/or more exchange. In chapters 4 through 6, I investigate those expectations for the relationship between the proportion by weight of raw material types and the cost-distance from a residence to a quarry, using linear regression.

Three Raw Material Categories

High-Quality Materials. Three raw material types – chalcedony, Cretaceous Dakota/Burro Canyon quartzite (Kdbq), and Cretaceous Burro Canyon chert (Kbc) (see Chapter 3) – may be especially sensitive to changes in access that might accompany growing community territoriality. These are high-quality materials used in making formal tools, and their quarries are well-known, recorded, and relatively ubiquitous in this study area. Their quarries fall within 18 km of most villages in the central Mesa Verde region (Arakawa 2000). For instance, Shields Pueblo is approximately 3 km from the nearest Kdbq quarry, while the nearest quarry for this material is approximately 12 km from Yellow Jacket Pueblo (Arakawa and Duff 2002). Because these materials are frequent choices for manufacturing formal tools, and since projectile points and bifacial tools are most likely associated with probably male activities such as deer hunting, changes in the proportions of these materials through time might indicate, in part, changes in male hunting territories.

Low-Quality Materials. Morrison materials are another interesting medium for investigating changes in toolstone procurement patterns. As mentioned previously, Neily (1983) and Arakawa and Duff (2002) recognized that the central Mesa Verde residents used of a larger proportion of these low-quality materials during the later Pueblo periods. If, as population increased and communities became more and more aggregated and communities exercised greater control over their immediate territories, making it more difficult for others to freely collect raw materials, then most Puebloans would have come to rely more on resources near their communities. Accessibility may also have been reduced by hostilities between communities or by other pressures not to encroach on other groups' territories. In general, as population increases, people would try to expand their territories to procure their resources. However, both the Neily (1983) and Arakawa and Duff (2002) suggest that this phenomenon did not take place among the ancestral Puebloans in the central Mesa Verde region. Given this unusual situation, I further investigate the proportion of Morrison materials to determine whether increased use occurred in all of the communities and/or localities through time.

Jurassic Morrison Brushy Basin chert (Jmbc) and Igneous Materials (Ign). Both Jmbc and igneous materials are interesting materials for this study because the sources of both of these medium-quality materials can be pinpointed (see Chapter 3). The sources of Jmbc are mostly in the southwestern portion of our region, while igneous materials are in the southern portions of the study area. If lithic data reveal spatial patterns in the frequencies of these materials that are unrelated to distance to quarries, further consideration must be given to supra-community scales. For example, it may be that some households or communities in the study area have relatively high frequencies of Jmbc and igneous materials although they are relatively distant from these quarries, possibly signaling a strong alliance with other communities close to the quarries. Using such logic, I will make some suggestions about possible alliances among households and/or communities based on these materials.

Energy-Expenditure Model

To help understand changes in toolstone procurement patterns through time from another angle, I calculated an estimate of the expenditure of energy for obtaining raw materials for each site in each period. The energy-expenditure model assumes that a (typically very) small proportion of non-local materials, such as obsidian and Narbona Pass chert, came from quite distant sources and were probably acquired through regional exchange; such materials are excluded from this analysis. I make the calculation on the assumption that local raw materials were procured directly, not through trade or exchange. This is a subtle matter for this research because my aim is to infer whether the inhabitants of the central Mesa Verde region had a restricted territory and/or changing alliance structures over time. I follow Renfrew's definition of trade as "reciprocal traffic, exchange or movement of materials or goods through *peaceful* human agency" (emphasis added [1969:152]). When materials were traded, it indicates that there were alliances or cooperation between inhabitants who lived closer to a quarry and people who lived farther away from the quarry.

I measure energetic expenditure values in toolstone procurement to determine how the inhabitants of the central Mesa Verde region changed their mobility and/or interactions over time. Energy expenditure, though measured in arbitrary units, is designed to estimate how much energy individuals in each residential site expended to procure all their lithic raw materials. Energy (E) is measured as the sum, across all materials, of (the proportion of debitage by weight in each site multiplied by the distance from that site to the nearest quarry) for each of the 10 represented materials (2):

$$E=\sum_{i=1}^{10} p_i d_i \qquad (2)$$

where, for each raw material type i, d is the cost to travel from the site to its nearest quarry, and p is its proportion in the debitage assemblage by weight (for both flakes and angular shatter). I use the proportion of debitage weight instead of the size or amount of debitage since weight generally provides a more suitable measure for discriminating reduction stages (Ammerman and Andrefsky 1982; Andrefsky 1998) and provides results similar to measuring debitage length and width (Ammerman and Andrefsky 1982; Amick et al. 1988; Magne and Pokotylo 1981; Mauldin and Amick 1989:77; Shott 1994).

This equation is a simple modification of the distance-decay model (Renfrew 1977) that sums the products of the proportions of ten raw material types and their cost-distance. This should work well in this study area because the Mesa Verde region has well-defined and discrete periods (e.g., 100-150 year intervals) and fairly well-known quarry locations. In using this equation, I make three main assumptions:

1. debitage found at a site was not produced by craft specialists;
2. debitage found at a site resulted from *in situ* production and was discarded;
3. direct (including embedded procurement) or indirect (e.g., trade) procurement strategies were employed (the calculation is indifferent to these possibilities).

These assumptions appear to be met in this study, although I admit that this equation is indeed designed to measure E under direct procurement, but relatively small deviations (e.g., extremely small portions of Narbona Pass chert and obsidian materials) from this assumption should not be harmful. Because most stone tools found at these sites are expedient and even projectile points seem to be expediently manufactured, craft specialists probably did not produce these tools. This is important because if specialization for manufacturing tools was common, then these tools may have been traded some distance and then we could not measure energetic expenditure for the inhabitants of a site with a calculation of this form. For similar reasons, I assume that debris generated from stone tool production was probably not carried and dumped into middens of other communities. Finally, whether toolstone procurement was direct or traded is not a significant issue for this calculation because it does not focus on how or what strategies individuals used to obtain raw materials. The existence of one piece of debitage at a site implies that someone obtained and carried that raw material to his/her habitation site. It does not matter whether the material was obtained during a hunting trip, was the result of direct raw material procurement, or was brought by someone from other communities.

The energetic expenditure study provides another angle to see whether residents at various sites within inferred communities behaved differently. I especially focus on the two different types of aggregations taking place during the Pueblo I and Pueblo III periods. The former was smaller in terms of the population involved and showed in densely packed settlement aggregation, while the latter was larger with more concentrated aggregation. I analyzed assemblages of eight sites within the Dolores Valley locality during the Pueblo I period, and six assemblages from early PIII and seven from late PIII sites in the McElmo-Yellowjacket locality (especially Sand Canyon communities) during the Pueblo III period. When the accumulated energy expenditures in neighboring sites display markedly different values, this warrants further investigation, and may require an explanation based on cooperative or competitive principles. I will discuss these issues in Chapter 7.

Finally, I use the summed energy expenditures to characterize variability among four localities in lithic procurement strategies. For this analysis, I use 10 local/semi-local materials instead of the following six materials – chalcedony, Kdbq, Kbc, Morrison, Jmbc, and igneous – that are frequently found in many assemblages in the central Mesa Verde region (Arakawa 2000). Four other raw materials, including silicified mudstone, metaquartize, indurated shale, and red jasper, are uncommon and variably distributed in many assemblages in this region. When the first three of these materials are present in an assemblage, I calculated their cost-distances from the habitation site to the nearest outcrops or gravel deposits. There was one red jasper source identified during the quarry survey; thus, I calculated the cost-distance of this material from a site to the source.

Including those four materials provides a more reliable map for the total energy expenditure through time.

I argue that specific localities showing high in energy expenditures either employed high logistical mobility or experienced a great deal of external interaction. Using the kriging method to interpolate these cost maps may reveal interesting patterns in a regional context.

Sampling

The assemblages selected to investigate the above questions come from sites with a single component as well as some sites (e.g., Shields Pueblo) deposited over two or more periods, where the periods can be distinguished using tree-ring-dated contexts. For this dissertation, I reanalyzed debitage from 76 existing excavated site collections to add to the excavated assemblages.

One such assemblage, from the Duckfoot site, is a good candidate for an "in-depth analysis" as a Pueblo I habitation site because the entire site was thoroughly excavated, was well preserved, and has been precisely dated (Lightfoot 1992). In addition, the Shields Pueblo lithic assemblage (Duff and Ryan 2000) is excellent for examining early and late Pueblo II, and early and late Pueblo III periods. I obtained excavated samples to compare the Pueblo I Duckfoot lithic assemblage and the Pueblo II and III Shields lithic assemblages. I selected several large community centers from the 59 recorded by the Community Center Survey in 2002 and 2003 (Glowacki and Varien 2003; see Table 2). This survey, funded by the Village Ecodynamics Project, conducted by the Crow Canyon Archaeological Center, and in which I participated, investigated poorly known but large habitation sites in the central Mesa Verde region dating from A.D. 600-1300 to provide better estimates of their sizes and periods of occupation (Kohler and van der Leeuw 2007). Lithic data from these sites allow me to include community centers and help to delineate community boundaries within the study area.

Another reason for choosing a site from the excavated site list was the manner in which lithic materials were excavated; archaeologists in the Mesa Verde region typically did not analyze lithic debitage until the late 1970s. I visited four museums to reanalyze existing collections. I intended to select lithic assemblages for which:

1. ¼" screen was used to collect debitage;
2. there were at least 120 pieces of debitage (see below); and
3. debitage from domestic features, particularly middens or fills, was excavated.

These requirements must be related, of course, to obtain the regional data for the interpolated maps. Here again I relied on the Crow Canyon Archaeological Center and Washington State University McElmo/Yellow Jacket database (2004). I selected 120 pieces of debitage as a minimum sample size for this study because it should contain, at a confidence level of 90 percent (Drennan 1996:Table 18.1), materials that constitute at least 2 percent of the total population (e.g., the chalcedony, Kdbq, and Kbc that may be particularly sensitive to territory formation). I was able to obtain a sufficient sample size from almost all sites; however, I was unable to meet the requirement that all samples were collected using ¼-inch screens (Appendix B). One major reason was that archaeologists rarely used a screen to collect artifacts during the 1960s and 1970s, and they also generally utilized different excavation methods (for instance, some excavated pitstructures without screening until they reached the floor). Because I rely on the proportion by weight of assemblages, I argue that samples derived from using ¼-inch screened or not screened do not create a major problem in this study. Additionally, I argue that using screened or not screened is not a confounding factor because 42 percent of total assemblages in this study were gathered using ¼-inch screens. My argument is also supported by the study of confounding variability in the Dolores Archaeological Program in which ten lithic assemblages were used for this research. Kohler et al. (1988: Table 14.5) investigated the relationship between use of screens and cortex on dorsal flakes using bivariate analysis and found that there is no significant correlation coefficient between these collection variables.

Another problem I encountered while selecting lithic assemblages was that I was unable to require that all samples were collected from a domestic context. Although comparing debitage from a domestic context with other contexts would create biases, I argue that most of lithic assemblages, particularly debitage, were generally from secondary contexts (even debitage from middens and structures) so that assemblages from different proveniences would not affect dramatically the result of debitage analysis. I believe that relying on proportion by weight of assemblages also helps to reduce the biases of sampling method. In summary, since I focus on proportion by weight of assemblages and debitage which were mostly preserved from secondary contexts, either screened or not screened, then samples from different proveniences would not affect significantly the results of debitage analysis.

Is Sample Size a Confounding Factor?

Because the number of flakes from each of the sites in my sample varies, sample size might be a confounding factor in the analyses listed above. I investigated whether sample size and the proportion of each raw material type have a strong correlation for samples taken from 75 excavated sites. My null hypothesis is that there is no relationship between sample size and the proportions of various raw materials; in contrast to most statistical analyses, I hope to be unable to reject the null hypothesis here. If the null hypothesis is not rejected, I can compare the proportions of raw materials through time without worrying too much about the sample sizes. None of the six raw materials types shows a strong or significant relationship between the proportions of that material and its sample sizes (chalcedony p=0.573, r^2=0.0043, Kdbq p=0.820, r^2=0.0007, Kbc p=0.855, r^2=0.0005, Jmbc p=0.989, r^2=0.000, Red jasper p=0.126, r^2=0.0313, Morrison p=0.196, r^2=0.0225, Local materials p=0.2832, r^2=0.0155). Therefore, there is no relationship between sample size and the proportions of these raw material types. Consequently, I can use the proportions of these raw material types for all of my analyses.

Debitage Attribute Analysis

Debitage provides significant information about activities and behaviors in a habitation site because debitage was created by many people every day. Debitage is generally ubiquitously distributed in archaeological sites and remains relatively undisturbed (e.g., by pot-hunting activities) after deposition by human agents.

The detailed debitage attribute analysis helps to understand functions of flakes, and these data will help us understand why assemblages deviate from the best-fit regression line. Part of this research involves determining, for each flake analyzed, dorsal cortex amounts, material types, weight, maximum length, width, thickness, striking platform, and flake terminations (Andrefsky 1998). A complete flake includes a striking platform, a ventral surface, and a dorsal surface; these attributes are important for measuring maximum length, width, thickness, and dorsal flake scars. Four different termination types – feathered, hinged, plunging, and step – are also significant (Andrefsky 1998). Dorsal cortex amounts are measured on a four-step ordinal scale. If the dorsal surface of a flake does not have any cortex, it is recorded as 0. If a flake has less than 50 percent dorsal cortex, it is recorded as 1. If a flake has more than 50 percent but less than 100 percent dorsal cortex, it is recorded as 2. Flakes with 100 percent cortex on the dorsal surface are recorded as 3 (Andrefsky 1998). This attribute can help distinguish between direct and indirect toolstone procurement patterns and can be useful for interpreting why some sites do not fit the distance-decay model (Hess 1997).

To investigate direct or indirect toolstone procurement patterns, I selected Kdbq to investigate whether assemblages above or below the best-fit regression model are significantly different with respect to flake attributes, which might inform us about how these materials were obtained. I selected only Kdbq because this material was generally utilized for manufacturing formal tools and the quarries are ubiquitously distributed. I also investigated cortex amount because in principle, the amount of cortex should decrease as the distance from lithic sources to habitation sites increases (Andrefsky 1998; Hess 1997), unless these materials are directly procured (also frequent embedded activities occurred). I argue that when assemblages above or below the regression lines are significantly different and there is evidence for high amounts of dorsal flake cortex in those assemblages that have more than expected amounts of Kdbq, this suggests direct procurements.

Data Representation

I use a geographic information system (ArcGIS) to show the distribution of all known lithic sources and habitation sites in the central Mesa Verde region. I use the GIS to create three different series of maps – residual plots, energetic expenditure in each site, and energetic expenditure in the regional study. In a first, non-spatial analysis, I run the regression and residual analyses in a SAS program (PROC REG) using six raw material types – chalcedony, Cretaceous Dakota/Burro Canyon quartzite (Kdbq), Cretaceous Burro Canyon chert (Kbc), Jurassic Morrison Brushy Basin chert (Jmbc), igneous materials (Ign), and Morrison materials (including Jurassic Morrison Brushy Basin quartzite and Cretaceous/Jurassic Morrison silicified mudstone). I lump two different Morrison materials into one category because we find these materials ubiquitously in the Morrison Formation and/or any Pleistocene gravel terraces in the central Mesa Verde region. I identify and calculate the cost-distance of Morrison sources for all sites from the nearest canyon or the Pleistocene gravel deposits using USGS topographic maps (MAPTECH software). For the residual plot maps, I obtain the positive or negative studentized residuals from SAS and then map these values in the ArcGIS 9.1 program (Appendix A). I represent these residuals using graduated symbols (circles with colors as negative, circle without colors as positive values) and using symbol values from 8 to 25, classified into five equal-interval values.

To calculate energy expenditure using ArcGIS, the digital elevation model map is first reclassified by the percentage of slope in the study area. Then, each habitation site in each period is placed on the raster map (30m by 30m cell-size) and reclassified by slope. I then utilize a cost-weight analysis (built into ArcGIS) to calculate the least accumulated count value (calculated by cost-weight analysis from a habitation site to the nearest quarry). After the pixel values based on the slope from each site to the nearest sources are obtained, I insert those values into the equation as the d_i values to calculate a total energy expenditure estimate for comparison within and between time periods. I multiply the proportion by weight of each raw material type by its cost-distance, and then sum these ten products, plot them on a map, and compare these maps through time.

Maps of raw material energy expenditure within this region are created for each 100-150-year interval by interpolating between data points (sites) using the kriging program in ArcGIS. Kriging algorithms implement weighted averaging interpolation. This method is generally used in situations where we want to connect high points in 3-dimensional "x, y, z" coordinates and generate maps to describe these z-values across x and y space (Harro 1997). The term "kriging" is synonymous with optimal prediction. This method predicts unknown values using observed data at known locations by estimating possible values and creating contour lines. This method exploits spatial variability (spatial autocorrelation) and provides an inferred continuous surface even from irregularly spaced data points, such as I have here. The greatest distances are shown in a dark shade of grey, while the closest distances are displayed in a light grey color on a map, using 10 or 11 levels.

In summary, I display a map for all sites in each time period, the regressions and residuals of the proportion of six different raw materials on their cost-distances, and the energetic expenditure map from each site in each time period and its regional map. These maps are differenced across adjacent periods as an aid to discerning development of possible territories or alliances. To construct these models, I must correctly identify raw material types and their sources in this study area. In the next chapter, I discuss both raw material classifications and lithic source surveys in the central Mesa Verde region.

CHAPTER THREE

LITHIC RAW MATERIAL TYPES AND QUARRIES

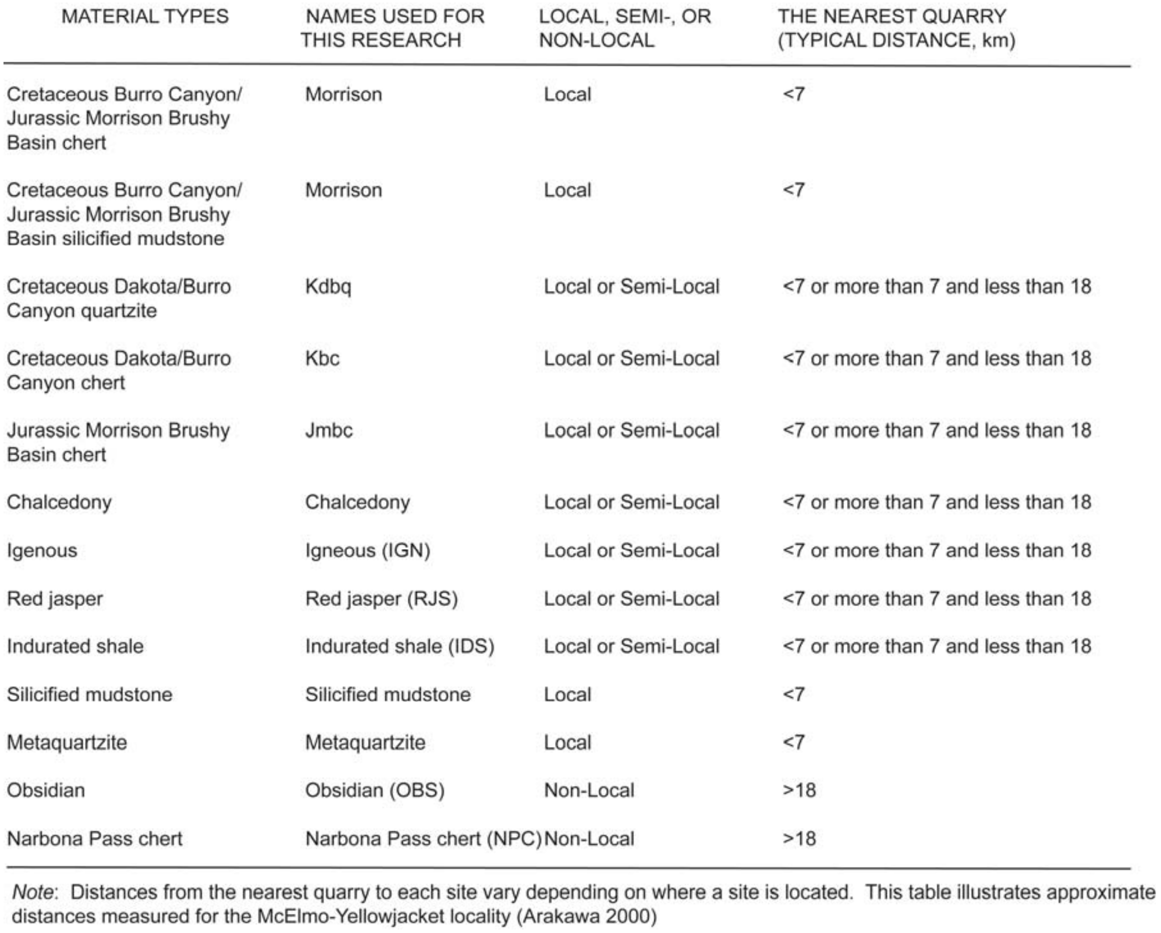
One purpose of this research is to identify and classify raw material types, and to locate them in the local geological formations. Accurate and replicable raw material classification and tracing of toolstone to geological formations is necessary for calculating the energetic expenditure model and even for creating interpolated maps of raw material frequency. In this chapter, I discuss how I classified raw material types, how I conducted geological and quarry surveys, and what I discovered regarding the relationship between the lithic sources and their raw material types in the central Mesa Verde region.

Raw Material Types

Thirty raw material types are considered in this study, but only 10 of these are found frequently in archaeological assemblages in this region (Table 3.1). Geologist Kimberlee Gerhardt (2001) created a key, which I follow, for the toolstone materials found in the Mesa Verde region. I identified all debitage material types either visually or with a 10x microscope. Toolstones are first divided into igneous, sedimentary, or metamorphic rocks. Igneous rocks are then grouped into intrusive and extrusive rocks. Intrusive rocks are formed by the process of moving magma into preexisting rocks. Extrusive rocks are classified by grain size and texture recognizing three grades: basalt, aphanetic minette, and obsidian.

For sedimentary and metamorphic rocks, texture and color are critical in classification. By texture, there are three types of sedimentary and metamorphic rocks:

Table 3.1. Material Types and Their Locations



MATERIAL TYPES	NAMES USED FOR THIS RESEARCH	LOCAL, SEMI-, OR NON-LOCAL	THE NEAREST QUARRY (TYPICAL DISTANCE, km)
Cretaceous Burro Canyon/ Jurassic Morrison Brushy Basin chert	Morrison	Local	<7
Cretaceous Burro Canyon/ Jurassic Morrison Brushy Basin silicified mudstone	Morrison	Local	<7
Cretaceous Dakota/Burro Canyon quartzite	Kdbq	Local or Semi-Local	<7 or more than 7 and less than 18
Cretaceous Dakota/Burro Canyon chert	Kbc	Local or Semi-Local	<7 or more than 7 and less than 18
Jurassic Morrison Brushy Basin chert	Jmbc	Local or Semi-Local	<7 or more than 7 and less than 18
Chalcedony	Chalcedony	Local or Semi-Local	<7 or more than 7 and less than 18
Igenous	Igneous (IGN)	Local or Semi-Local	<7 or more than 7 and less than 18
Red jasper	Red jasper (RJS)	Local or Semi-Local	<7 or more than 7 and less than 18
Indurated shale	Indurated shale (IDS)	Local or Semi-Local	<7 or more than 7 and less than 18
Silicified mudstone	Silicified mudstone	Local	<7
Metaquartzite	Metaquartzite	Local	<7
Obsidian	Obsidian (OBS)	Non-Local	>18
Narbona Pass chert	Narbona Pass chert (NPC)	Non-Local	>18

Note: Distances from the nearest quarry to each site vary depending on where a site is located. This table illustrates approximate distances measured for the McElmo-Yellowjacket locality (Arakawa 2000)

silica-cemented and highly indurated; homogeneous with no grains visible, or mass texture; and un-silicified texture. Each texture type is then classified by color. For instance, tan, white, light brown, and light gray rocks most likely originated from Cretaceous Dakota or Burro Canyon Formations, whereas green, purple, or dark gray rocks likely originated from the Jurassic Morrison Formation.

Lithic Sources and Raw Material Types in the Central Mesa Verde Region

Lithic Source Survey. Ninety-one inventory reports of lithic quarry sites (also referred as lithic procurement sites, lithic activity sites, lithic sourcing sites, and lithic scatter sites) were obtained from the State Historical Preservation Office (SHPO) in this study area. I visited all 91 of these recorded quarry sites and examined three volcanic centers (igneous sources) in Mesa Verde National Park and Ute Mountain Tribal Park (Figure 3.1). While visiting these sites, I collected non-artifact lithic materials for future reference; these are curated at the Bureau of Land Management's Anasazi Heritage Center near Dolores, Colorado. During the survey, I recorded UTM locations and sizes of each lithic source site, identified raw material types, and took pictures of the locations of and outcrops at each site.

This field survey allowed me to compare the geographic distribution of flakable lithologies in the greater area to those found in the assemblages (Arakawa and Gerhardt 2007; Gerhardt et al. 2005). Most sedimentary lithic sources are located in the Monument/McElmo region, while igneous, metamorphic (indurated shale), and river-derived gravel sources are located in and around Mesa Verde National Park and the Ute Mountain Ute Tribal Park.

Sedimentary Lithic Sources. The Jurassic (Morrison Formation) and lower-to-middle Cretaceous (Burro Canyon and Dakota Formations) sedimentary sections exposed in the canyons of the Dolores and Monument/McElmo districts contain many flakable lithologies, including quartzite, silicified mudstone, altered volcanic ash, chert, and chalcedony (Gerhardt 2006).

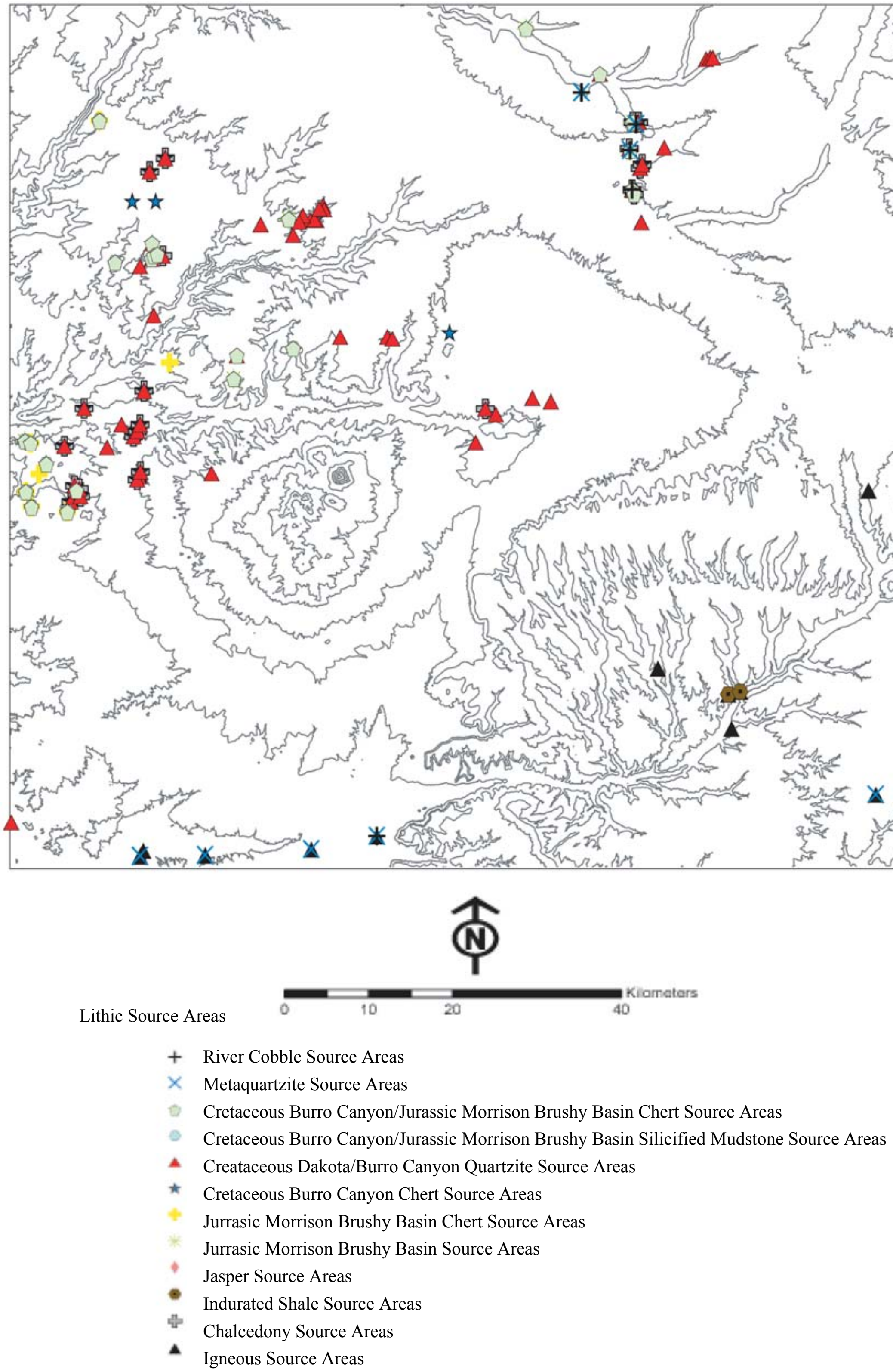


Figure 3.1. Ninety-four lithic quarry sites in the central Mesa Verde region as reported in the SHPO inventory.

The quartzites are silica-cemented sandstones, which means that microcrystalline quartz precipitated out of solution in the pore space between the sand grains eventually making the rock hard enough to flake. Cretaceous Dakota/Burro Canyon quartzite (KDB quartzite), Jurassic Morrison Brushy Basin quartzite (JMB quartzite), and generic quartzite are all sedimentary rocks. The source of the silica is debatable, but because the silicified zones of sandstone (the quartzite horizons or lenses) are interbedded with the normal sandstones in the Dakota, Burro Canyon, and Morrison Formations in this region, I believe that they were not metamorphosed. Under a microscope, silica-cemented sandstone (which is called “quartzite”), has a "tapioca pudding" texture. We can see the original sand-grains, which look like the tapioca pieces, surrounded by a matrix of chert, which looks like the pudding.

Other types of silica-cemented sandstone are Jurassic Morrison Brushy Basin chert (Jmbc) and Cretaceous Burro Canyon/Jurassic Morrison Brushy Basin silicified mudstone (Kb/Jmb silicified mudstone). The silicified mudstone and altered volcanic ash were originally deposited as volcanic ash layers in a large alkaline lake centered in the Four Corners area during the late Jurassic to early Cretaceous (Turner and Fishman 1991). The silicified mudstones are admixtures of this ash with detrital silt and clay, subsequently altered during early burial by the devitrification of ash particles and the growth of zeolithes and chalcedony (Gerhardt 2006). Because this lithology is found in both the Jurassic-age Brushy Basin Member of the Morrison Formation (termed “Jmb” by geologists), and in the Cretaceous-age Burro Canyon Formation (termed “Kb” by geologists), it is called “Kb/Jmb silicified mudstone.” The altered volcanic ashes are very similar to the silicified mudstones, but lack the detrital component (less grainy) and are more heavily silica-cemented (more chert-like). They typically form in the center of siliceous concretions within silicified mudstone layers in the Brushy Basin Member of the Morrison Formation. Locally these are called "Brushy Basin chert." I noted six Brushy Basin chert sources in the southwestern portion of the McElmo Canyon area (Figure 3.1; Arakawa and Gerhardt 2007: Figure 3).

During the survey, many lithic sources were found to contain high-chipping-quality raw materials and flakes displaying typical attributes of percussion, such as striking platforms and flake terminations. The Kb/Jmb silicified mudstone sources I encountered, however, did not contain debitage showing those typical attributes. Most of the debitage there seemed to be broken by natural processes instead of human modification. Furthermore, previous study of Kb/Jmb silicified mudstone sources indicates that this material is abundant in many areas of the McElmo/Yellowjacket, Dolores, and Ute districts in the Mesa Verde region (Arakawa 2000). This suggests that the ancestral Puebloans could have procured this material opportunistically (Arakawa 2000) and relatively ubiquitously.

The ancestral Puebloans commonly utilized Cretaceous Brushy Basin chert (KBC) in this study area. Based on my survey, there were abundant KBC lithic sources in this region, particularly in McElmo/Yellow Jacket and Dolores districts (Figure 3.1). The mineralogy of KBC material is homogeneous with no grains or mass texture visible. Because of its homogeneity and hardness, ancestral Puebloans mostly procured this material for making formal tools (Arakawa 2000).

Chalcedony and jasper are microcrystalline quartz. Both materials are generally identified and classified by colors; chalcedony is typically translucent or white, while jasper is red. There are 23 sources of chalcedony, broadly dispersed, this region. Based on the lithic source survey, whenever Cretaceous Burro Canyon chert (KBC) materials were recorded, chalcedony materials were also usually present. Interestingly, one recorded quarry site (5MT4819) in the Hovenweep district contained small deposits of jasper. This material has been considered as semi- or non-local in the central Mesa Verde region, but this indicates that the material could have been likely derived from a local source.

Narbona Pass chert is another chert type that can be identified by composition, texture, and color. The source is located in the Chuska Mountain area; it is approximately 100 km by straight line from the central Mesa Verde region (Cameron 2001). Because the source is close to Chaco Canyon and was commonly utilized by participants in the Chaco Regional System, this material provides important information about interaction and trade between Chaco and other areas in the Southwest (Cameron 2001; Ward 2004).

Metamorphic Lithic Sources. Although there are no metamorphic terraces in the Mesa Verde region, metamorphic lithologies from the bordering mountainous regions were washed down the Dolores and Mancos River drainages where they are available in gravel deposits. Indurated shale is one of these metamorphic rocks. Indurated shale is usually dark, gray, Mancos Shale which was strengthened by contact metamorphism during intrusion of igneous dikes and sills when the La Plata Mountains were formed. These lithologies may also be greenish or pink and contain traces of ore minerals if they were altered in a hydrothermal zone.

Unlike quartzite, metaquartzite is a product of intense temperature and pressure. The original sediments were caught up in a mountain-building event that pushed them down very deep in the earth. Because of erosion, they have slowly been unroofed and exposed at the surface today. Metaquartzites are found up in the San Juan Mountains, next to other regional-grade metamorphics like schist, gneiss and marble. These metamorphics wash down drainages and can be picked up from the Animas, San Juan, Dolores and Colorado river gravels as cobbles. Consequently, we expect to find metaquartzite at archeological sites in materials such as peckingstones and mauls. This material is also sometimes flakable and could be used for making flake tools.

Igneous Lithic Sources. Igneous materials include aphanetic minette and obsidian. To trace igneous materials, three geologists and I visited three volcanic centers, classified as diatremes, mapped around the borders of Mesa Verde National Park by Condon (1991). They are located 1) east of Mesa Verde National Park, adjacent to the Mancos River, at Weber Mountain, 2) at the intersection of Johnson and Mancos Canyons in Ute Mountain Tribal Park, and 3) on the southern end of Wetherill Mesa in Ute Mountain Tribal Park (Figure 3.1; Arakawa and Gerhardt 2007: Figure 2).

These centers are the northernmost outliers of the larger Navaho Volcanic Field extending to the south and west and concentrated in the Chuska Mountains (Semken 2001). The mineralogy and morphology of these volcanics indicate that the melts ascended from upper mantle sources, and so are very much more depleted in silica than the dioritic lithologies derived from shallower crystal melts that form the major igneous mountains bordering the Mesa Verde region (La Platas, Sleeping Ute, San Juans, and Carrizo Mountains). These mantle melts crystallized into a crumbling rock called “minette” which is rich in potassic feldspar, pyroxenes, micas, apatite and olivine. Although the diatremes are dominated by crumbling minettes and unflakable pyroclastics, they are occasionally intruded by dikes of dark, dense, harder basalt called “aphanitic [fine-grained] minette.” Aphanitic minette is flakable and is present in the debitage collections from Wetherill Mesa. There is a good quarry site at the foot of a dike of aphanitic minette at the Weber Mountain diatreme (Gerhardt et al. 2005). There is another good aphanitic minette source at the base of the northern end of the Johnson Canyon diatreme with quarried materials nearby, although there are not clearly associated with the source.

Because diatremes bring up pieces of deeper formations as they ascend, and entrain and contact-metamorphose adjacent formations, they are good sources of other flakable materials besides aphanitic minette. In addition, the soft, crumbling, micaceous minette is common in pottery temper from the Chuskan region and is also found in older graywares from Mesa Verde National Park and Ute Mountain Tribal Park (Gerhardt et al. 2005). This might suggest that the assumption that the nearest igneous temper sources for this region were in the Chuska Mountains (e.g., Billman et al. 2000) should be reconsidered.

Archaeologists have recorded a relatively large amount of obsidian in many assemblages in this region (Ferguson and Skinner 2003). A total of 179 pieces of obsidian from various time periods was analyzed by the University of California, Berkeley (Shackley 1999, 2002, 2005). Four obsidian quarry areas are accessible to the Four Corners – the Jemez Mountain areas in New Mexico, Mt. Taylor in New Mexico, the San Francisco Peaks in Arizona, and Government Mountain in Arizona (Shackley

2005). Cameron (2001) noted that lithic data associated with the Chaco Regional System indicates that early occupants of Chaco Canyon derived obsidian from numerous Jemez Mountain sources. In the Mesa Verde region, the 89 obsidian samples from Basketmaker III and Pueblo I periods were procured from various areas – Jemez Mountains, Mount Taylor, and Government Mountain (Shackley 2005). The ninety obsidian samples from the late Pueblo periods, however, were all obtained from the Jemez Mountains (Shackley 2005). This suggests that most of the Mesa Verde people had strong interactions or exchange relationships with eastern Puebloans, perhaps biasing their direction of emigration in the late Pueblo periods.

Gravel Deposits. Three geologists and I examined a gravel deposit on the eastern side of Chapin Mesa, left by the Mancos River during the Miocene (Mary Gillam, personal communication 2004), as well as a gravel deposit at the foot of Chapin Mesa on the modern Mancos River (Figure 3.1). A large amount of igneous (aphanitic minettte) and indurated shale was identified in both deposits. Commercial-grade gravel deposits have been mapped by Pantea (1996) farther south on Chapin Mesa as well as to the east on Moccasin Mesa.

Beyond Mancos Canyon to the southwest on the Ute Mountain Ute Reservation, the Mancos River flows through a flat landscape of soft Cretaceous shale. The modern drainage is bordered by many Pleistocene gravel terraces, perched about 40 feet above the surrounding plain, which are recorded as quarry sites. We visited some of these and confirmed that indurated shale and aphanitic minette were preferentially quarried from these deposits.

Summary

In this chapter, I discussed how I classified common lithic raw material types found in the Mesa Verde lithic assemblages and explained how I traced the raw materials to their sources. This geoarchaeological research is the most important task for this dissertation because the information generated allowed me to understand and reconstruct how far the ancestral Puebloans in the central Mesa Verde region traveled for lithic raw materials over time or alternatively, how for their exchange networks reached. Consequently, I was able to calculate the energy expenditures and also create frequency maps to understand territoriality in the central Mesa Verde region.

CHAPTER FOUR

BASKETMAKER III AND PUEBLO I PERIODS

This chapter considers how toolstone procurement patterns during the Basketmaker III and Pueblo I periods altered over time and how lithic data can reveal aspects of socio-political organization, particularly aspects of territoriality. It is important to address these issues in the context of population estimates, resource productivity, and settlement patterns in the central Mesa Verde region. Additionally, I review material remains and architecture that help illustrate interaction and technological changes during these periods. Finally, I investigate lithic data using the proportion/cost-distance relationship and the energy-expenditure model to address how socio-political organization changed, and whether any degree of territoriality emerged during this sequence, taking into account the population estimates and resource productivity. Finally, I put these results in the context of Dyson-Hudson and Smith's (1978) economic defensibility model.

Background for Basketmaker III (A.D. 600-725)

Population Estimates. Fetterman and Honeycutt's survey data (1987) from Mockingbird Mesa and Wetherill Mesa data from Hayes (1964) provide reasonable population estimates for a portion of this region during the Basketmaker III period. Using these data, and taking into account the distribution of arable lands and soil types in this region, Wilshusen (1999a:190) calculates that approximately 900 people lived in the Monument-McElmo unit, 620 lived in the Mesa Verde-Mancos unit, and fewer than 250 people in the Dolores and Ute drainages. Varien et al. (2007) developed slightly higher momentary population estimates from block surveys of small sites and community centers in the central Mesa Verde region from the Basketmaker III to late Pueblo III periods for the Village Ecodynamics project (Figure 4.1; Varien et al. 2007:Table 4). Based on these data, Varien et al. suggest that approximately 1,826 people lived in the central Mesa Verde region from A.D. 600 to 725.

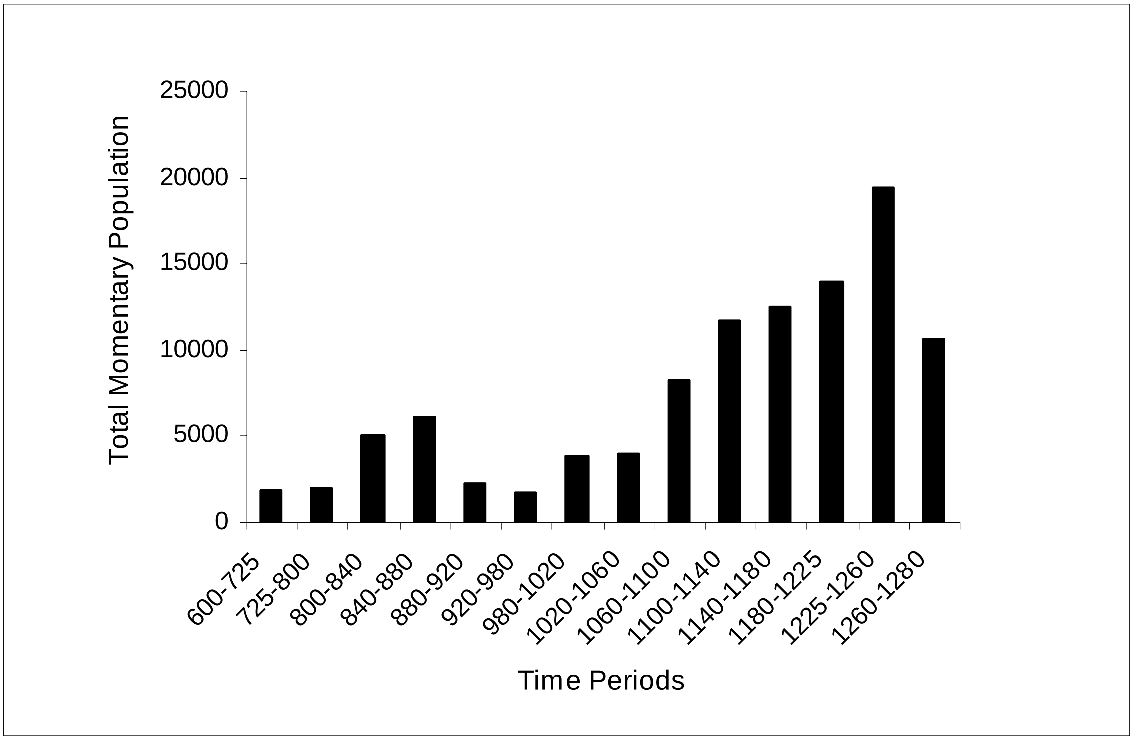


Figure 4.1. Best estimate for total momentary population in the Village Project study area (adopted from Varien et al. 2007:Table 4).

Resource Productivity. Varien et al. (2007) use new temperature data and other modifications to recalculate Van West's well-known estimates for maize production in the central Mesa Verde region (Van West 1994). Figure 4.2 shows the average potential maize yields in kg/ha per year from A.D. 600 to 1300 (Varien et al. 2007: Figure 3). Methods and data underlying these estimates are detailed in Varien et al. (2007). As they remark, "noteworthy periods of low potential production appear in the late 600s, the middle 700s, the late 800s and early 900s, around 1000, around 1100, from about 1130-1150, in the early 1200s, and in the late 1200s." It would appear that the Basketmaker III inhabitants in the central Mesa Verde region experienced relatively high productivity though quite variable conditions for maize, which was the most important subsistence resource, except for a very poor period around A.D. 690 to A.D. 710.

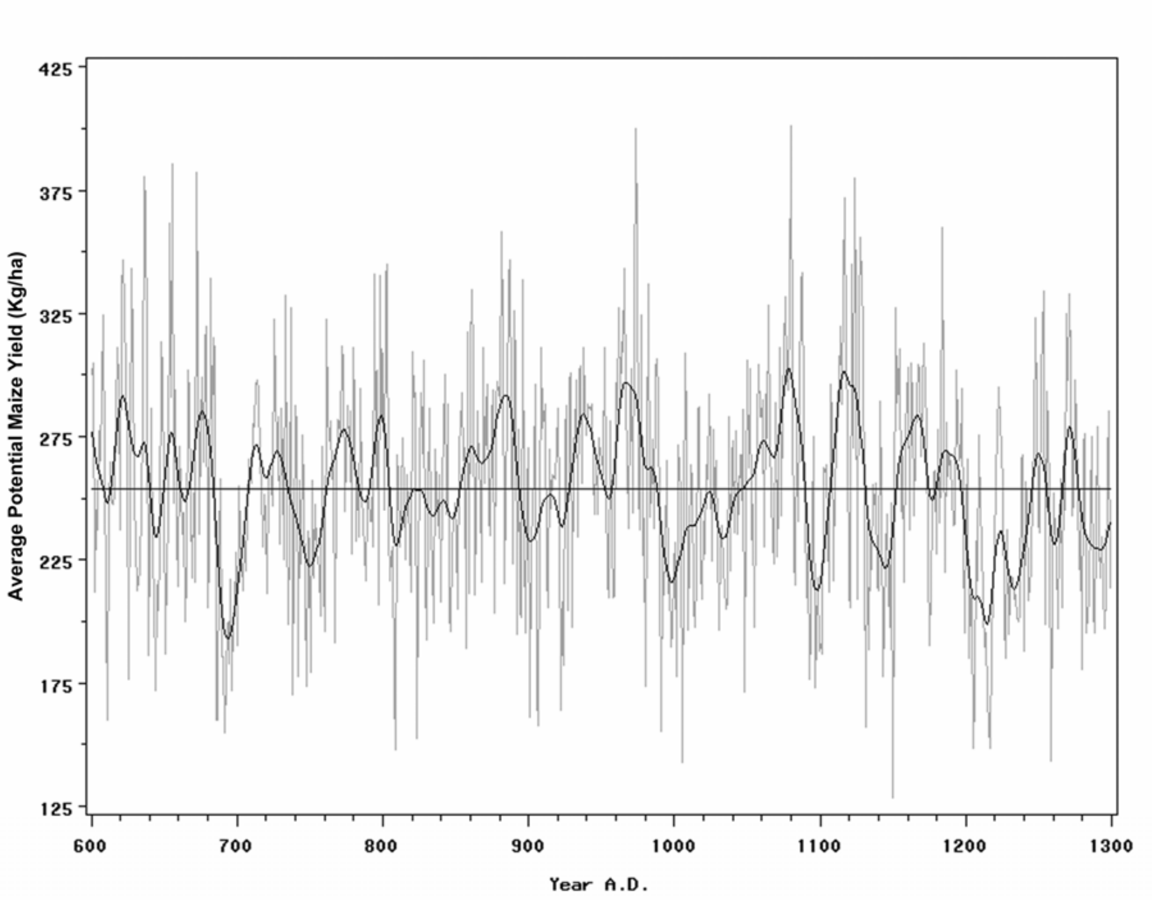


Figure 4.2. Average study-area potential maize yields in kg/ha from A.D. 600 to 1300, per year (dotted lines) and spline-smoothed (dark line). The straight line shows the mean annual yield of 254 kg/ha (from Varien et al. 2007:Figure 3).

Settlement Patterns and Social Organization. Birkedal (1976), Fetterman and Honeycutt (1987), and Wilshusen (1999a) review settlement patterns and social organization during the Basketmaker III period in this region. Reliable data show large numbers of Basketmaker III sites in the McElmo-Yellowjacket, Dolores, and Mesa

Verde-Mancos districts (Wilshusen 1999a). Basketmaker III people were probably attracted to those areas, particularly in the McElmo-Yellowjacket district, because of their high agricultural productivity, and because they may have particularly valued previously unused lands for their agriculture, which may have featured a shifting strategy (Kohler and Matthews 1986; Wilshusen 1999a).

Using ethnographic records and settlement studies, Birkedal (1976) tried to determine whether settlements on Wetherill Mesa were lineage-based or band-level in organization. He suggests that the Basketmaker III families or households on the Mesa Verde proper consisted of loosely knit localized band-level systems of less than 50 people (1976:502). In band-level social organizations, according to Service (1971:60), "territoriality seems to be often largely a social matter; it is a way of describing membership in a group rather than being rigorously a matter of economic exploitation." Although most band-level societies have a sense of territoriality, people living in this kind of organization generally do not have ownership of resources (Steward 1955:108). Based on their large pithouses and their consumption of a high proportion of agricultural products, Steward (1937) suggests that Basketmaker III inhabitants had a local lineage-based social organization. Reed (2000:15) supports Steward's inference, and notes that several Basketmaker III lineages could co-reside to create large villages. Overall, compared to more aggregated settlements in later periods, territoriality seems to have been rather casual during the Basketmaker III period.

Previous Research on Basketmaker III Period Ceramic and Lithic Assemblages

Ceramic Data. Ceramic data generally offer the most readily interpretable information on local and regional interaction and exchange because of stylistic differences and utilitarian purposes (Glowacki et al. 1998). Before A.D. 600, brown ware types (i.e., Obelisk Utility and Sambrito Utility) appear in pan-regional assemblages in the Southwest (Reed et al. 2000). Around A.D. 600, when the central Mesa Verde region was intensively colonized by agriculturalists, gray ware types became locally dominant (Wilson and Blinman 1991). Typical gray ware underwent a neutral firing regime and was unpainted. In the Southwest as a whole, igneous tempers were frequently utilized, but in the central Mesa Verde region, crushed sandstone was relatively common (Wilson 1988, 1991). The major local gray ware type during the Basketmaker III period was Chapin Gray, defined in part by unpolished rim sherds with either scraped or plain exterior surfaces (Wilson and Blinman 1991).

Lithic Data. Torres (2000) reviews Basketmaker lithic technological organization in the central Mesa Verde and San Juan Basin regions in the context of arguing against the inference that lithic technology “devolved” from the Archaic/Basketmaker II to the Basketmaker III period. Torres finds two major patterns in Basketmaker III lithic technology from the Cove-Redrock Valley area, located southeast of my study area and close to the Lukachukai Mountains (Chenault and Motsinger 2000). First, lithic technology did change as the ancestral Puebloans became more sedentary. Instead of producing abundant formal tools along with debitage, the number of flake tools increased (Torres 2000:221). Torres also asserts that a “prospective” toolstone procurement pattern became common after the Basketmaker II period. This pattern involves searching, evaluating, and collecting small pieces of raw materials during activities that, for the most part, involved procurement of other materials (Binford 1978; Wilke and Schroth 1989). As people became more sedentary, they began to rely on raw materials that were closer to their habitations (Torres 2000). Torres also notes a change from a bifacial core technology to a unidirectional core technique during the Basketmaker III period (2000:224-227; Parry and Kerry 1987). Unidirectional core technology produces elongated detached flakes with greater efficiency and regularity. This change might have been associated with more emphasis on making small corner- or side-notched points during the Basketmaker III period (Torres 2000).

Architecture. Changes in architecture provide significant information about how many people lived in a household, and, possibly, how people altered their use of areas surrounding their residence and community. During the Basketmaker III period, three architectural feature types were locally common – pithouses, pitrooms, and ramadas (Chenault and Motsinger 2000). A Basketmaker III pithouse contained a main chamber and an antechamber that was generally south or southeast of the main chamber (Chenault and Motsinger 2000:53). Although these two chambers were rectangular in shape during the Basketmaker II period, during the Basketmaker III period the antechamber became D-shaped. In the main chamber, the floor was shallower during Basketmaker III times than later, and the roofs were constructed using primary and secondary beams. A circular, basin-shaped hearth and a sipapu in the main chamber were additional standard features during this period.

Pitrooms were most likely used for storage and domestic purposes (Chenault and Motsinger 2000:57). In the central Mesa Verde region, pitrooms were surface structures, circular to oval in plan, with a relatively small (3-4 m) diameter. Ramadas appeared in some Basketmaker III sites, possibly for shade during the summer (Chenault and Motsinger 2000).

Current Perspectives on Basketmaker III Assemblages

This research poses two linked questions: 1) how did community territoriality and interaction change over time, and 2) did any signs of territoriality develop through time in the central Mesa Verde region? To investigate these questions, I employ two mechanisms – the proportion/cost-distance regressions and the energy-expenditure model – using lithic data. In the proportion/cost-distance analysis, as I discuss in chapter two, I use six raw materials: chalcedony, Cretaceous Dakota/Burro Canyon quartzite (Kdbq), Cretaceous Burro Canyon chert (Kbc), Jurassic Morrison Brushy Basin chert (Jmbc), igneous materials, and Morrison materials (including Cretaceous Burro Canyon/Jurassic Morrison Brushy Basin chert and Cretaceous Burro Canyon/Jurassic Morrison Brushy Basin silicified mudstone). I categorize Morrison materials together because outcrops or sources of Morrison materials (except Jurassic Morrison Brushy Basin chert) appear ubiquitously in this study area. Using these material types, I use bivariate linear regression and residual analyses and maps to see which assemblages in each time period deviate most from the best-fit model. For Kdbq only, I further investigate whether there is any relationship between the sign of the residuals from this analysis, and flake characteristics, using Fisher's Exact Tests in each time period. This helps determine whether toolstone procurement was direct or indirect (through trade). Specifically, I investigate just those assemblages with studentized residual values greater than |.4| for their amounts of cortex and dorsal flake scar counts (both measured ordinally). A studentized residual is a residual divided by an estimate of its standard deviation. This is an important technique in the detection of outliers in regression analysis. I examine only Kdbq material because all assemblages contain relatively large amounts of Kdbq proximal flakes, and unlike other materials, because of its high quality, proximal flakes of Kdbq nicely show cortex amounts on the flaking surfaces.

In the energy-expenditure analysis, I utilize all 10 sampled raw material types, except sandstone which was not likely used for chipped stone manufacture. In each case, I begin by providing a map (e.g., Figure 4.5) showing the energy-expenditure values calculated using equation 1 (see Chapter 2) for each site. Then, I use these values to create a smoothed isopleth map (using the ArcGIS program) displaying the values of energetic expenditure from each site generalized across the study area, to help identify where, when, and whether territoriality emerged in the region. All of the following similar energy-expenditure maps (e.g., Figure 4.17) use the north-south UTM-coordinate as the y-axis, the east-west UTM coordinate as the x-axis; the z-axis (height, a third dimension) consists of the lines produced by kriging interpolation method for values of local energy expenditure. The legend displays the lowest extrapolated values in a light gray, with dark gray colors showing the highest values.

Figure 4.3 shows the 11 well-dated Basketmaker habitation sites in the study area whose lithic assemblages were analyzed for this study. Two sites, 5MT8937 and 5MT10647, are in the McElmo-Yellowjacket locality; 5MT2525, 5MT8837, and 5MT11431 are in the Hovenweep locality; whereas 5MT4684 and 5MT4545 are in the Dolores locality. 5MV1940 and 5MV1937 are on the mesa top of Wetherill Mesa in the

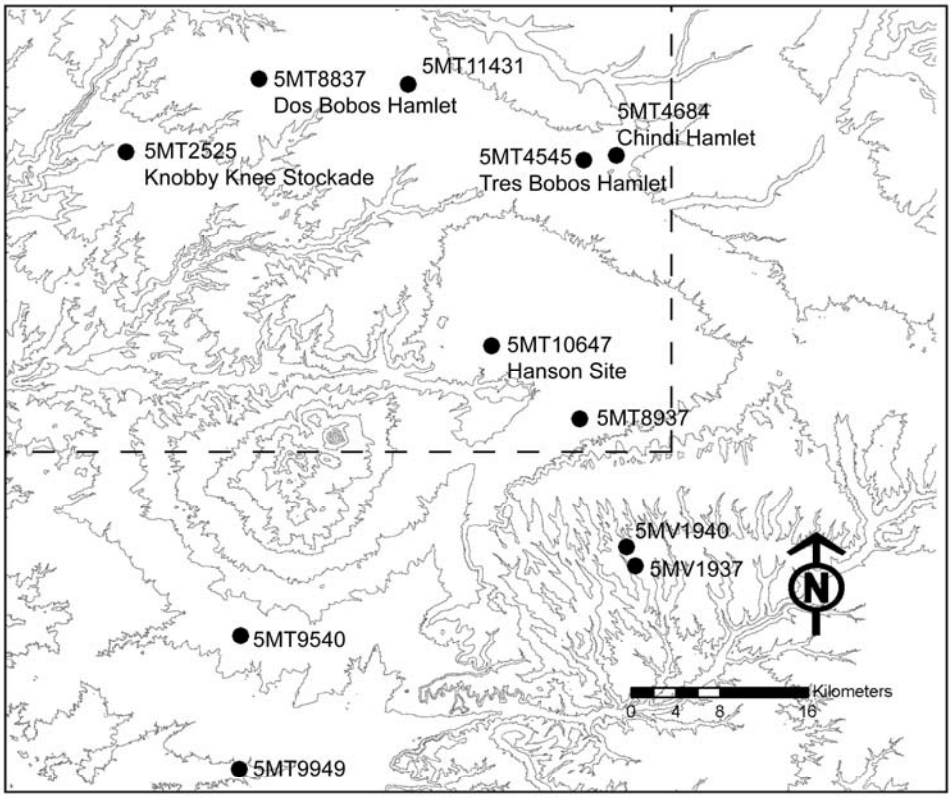


Figure 4.3. Basketmaker III habitation site numbers and major names. The dashed line shows the Village Ecodynamics study area.

Mesa Verde locality. 5MT9949 and 5MT9540 represent lithic assemblages from the Ute locality.

The Percentage/Cost-Distance Relationship for Chalcedony. Figure 4.4 shows the linear regression and residual analysis for Basketmaker III chalcedony. This reveals the expected negative linear relationship but with an extremely weak correlation (r^2 =.059; p=.472). The residual analysis shows that 5MT11431 and 5MT9540 make the linear model fit poorly. Figure 4.5 maps the studentized residuals for chalcedony; hollow circles indicate negative residual values, whereas filled circles indicate positive residual values. The sizes of the circles are proportional to the sizes of the residuals. This map shows that some inhabitants of the Hovenweep and Ute localities used more chalcedony than would be expected, given the cost-distance of its sources. In contrast, even though residents in the Dolores and McElmo-Yellowjacket localities lived closer to the source, they used less than the predicted amount of chalcedony, given the cost of acquiring this stone from their residences.

The Percentage/Cost-Distant Relationship for Kdbq. Figure 4.6 shows the relationship of percentage to cost-distances for Kdbq in the Basketmaker III. For these sites, there is a very weak negative relationship (r^2 = .099; p=.344) between the cost-distance and the percentage of Kdbq. Figures 4.7 show that two assemblages – 5MT11431 and 5MT8837 – are extreme outliers in this relationship; it is very surprising that Kdbq makes up more than 60 percent of these assemblages, even given their proximity to a source. Figure 4.6 (top) suggests that these two sites influence the slope and intercept so that all other sites have negative residuals (less Kdbq than expected).

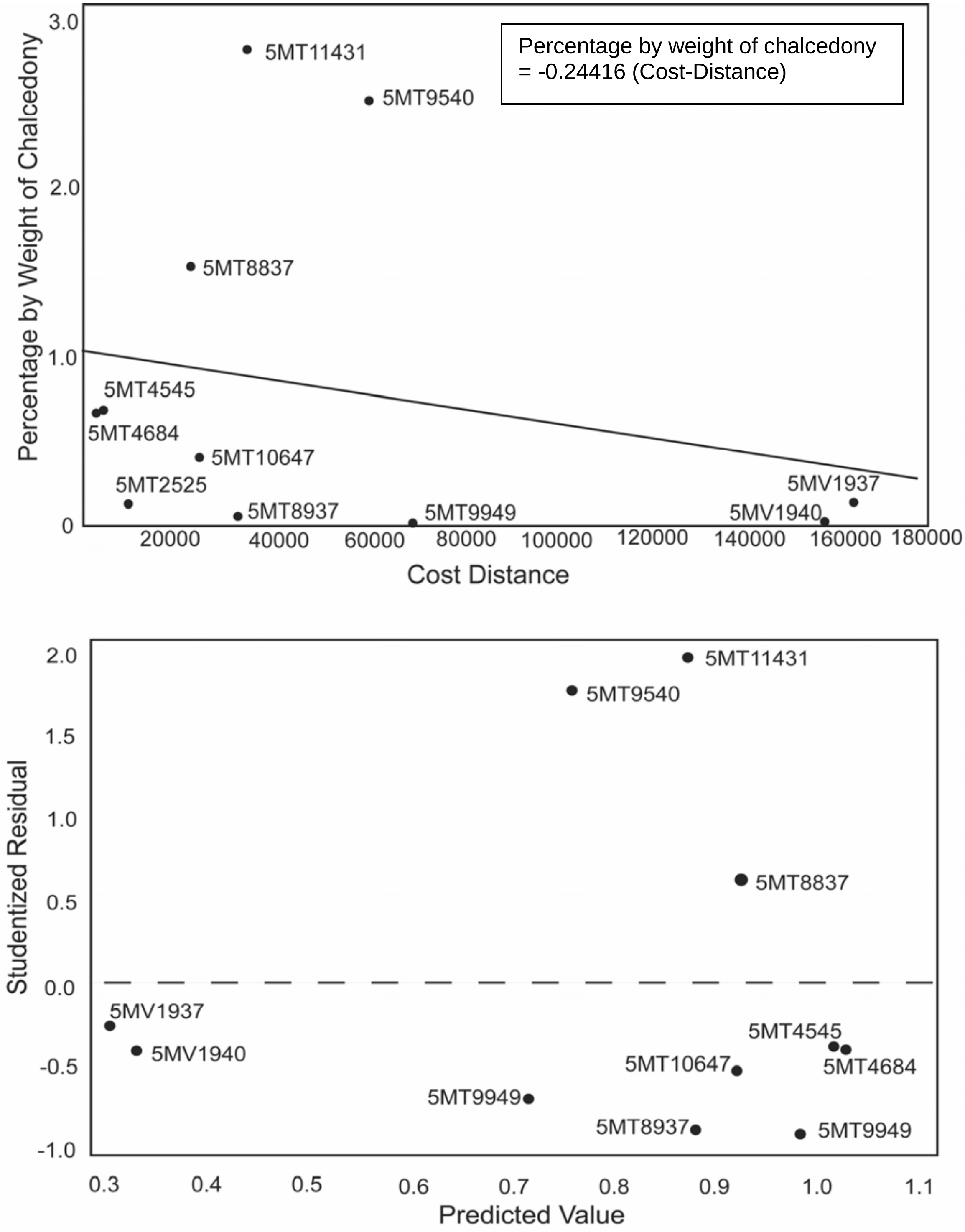


Figure 4.4. The top panel shows the Basketmaker III chalcedony percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized (and therefore the intercept is zero); coordinates on axes are unstandardized.

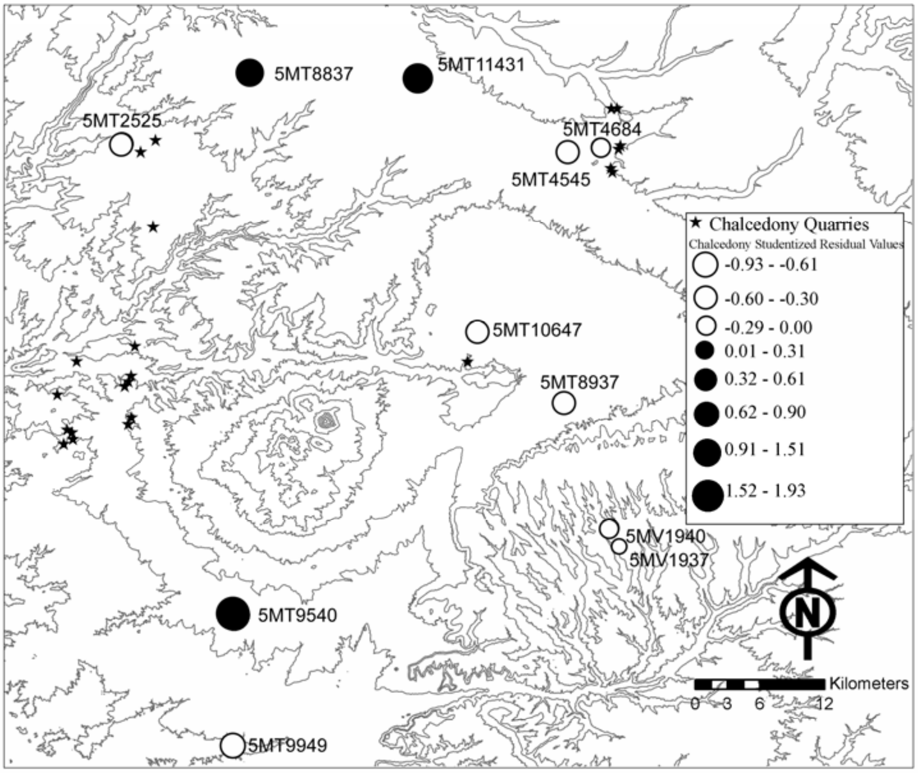


Figure 4.5. Map of chalcedony studentized residuals during the Basketmaker III period.

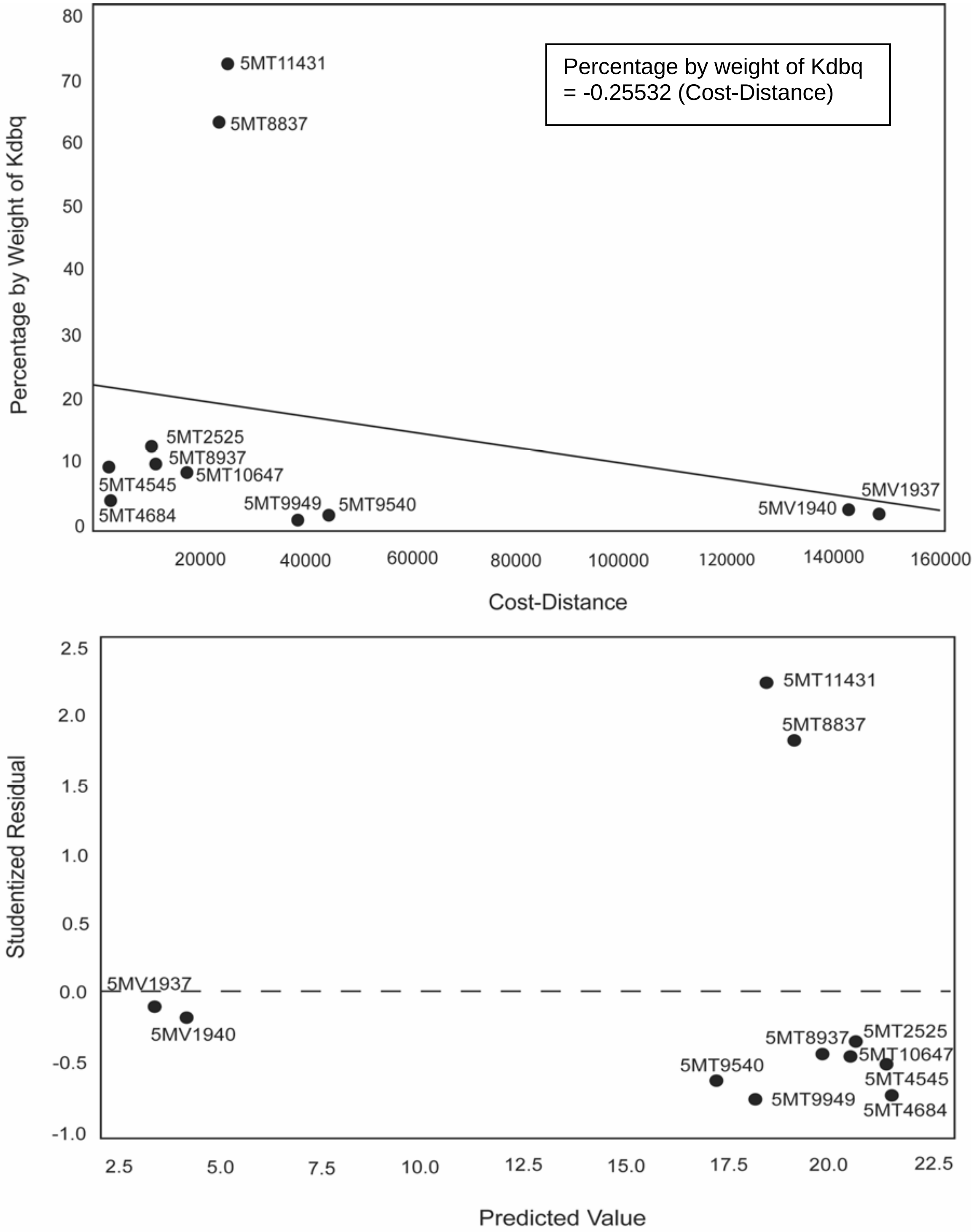


Figure 4.6. The top panel shows the Basketmaker III Kdbq percentage/cost-distance relationship; the bottom panel displays the results of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

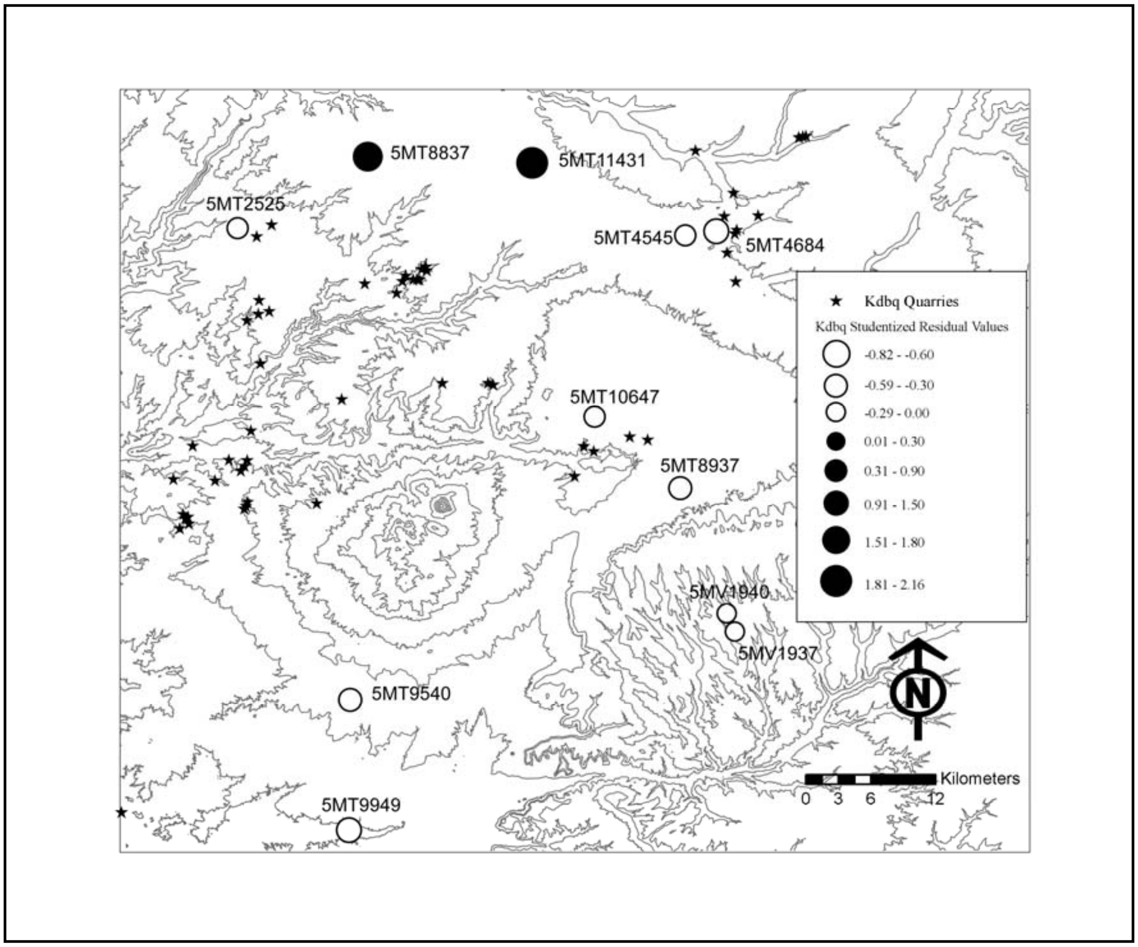


Figure 4.7. Map of Kdbq studentized residuals during the Basketmaker III period.

The Percentage/Cost-Distance Relationship for Kbc. Although the percentage by weight of Kbc in these sites is relatively small, the regression relationship (Figure 4.8) shows the expected negative line and a moderately significant negative correlation (r^2 = .359; p=.051). Within the Hovenweep locality, the residual map (Figure 4.9) shows that residents of 5MT2525, very close to several sources, procured even more of this material than expected, whereas the residents of the relatively close-by site of 5MT8837 use much less Kbc than predicted by the linear model in Figure 4.8. Such spatial anomalies may be interpreted as an existence of boundaries for hunting territories or preferences of using different high-quality materials such as chalcedony (see Figure 4.5. and 4.7). Inhabitants of the McElmo-Yellowjacket and Ute localities generally procured less of this material than expected whereas the Dolores residents procured more than predicted, given the cost of acquiring this stone from their residences.

The Percentage/Cost-Distance Relationship for Morrison. Figure 4.10 shows the expected negative relationship with a relatively weak correlation (r^2=.18; p=.194) for the percentage of Morrison materials – the most common material in most sites – against the cost-distances in the Basketmaker III period. The residual map (Figure 4.10 bottom panel and Figure 4.11) shows that 5MT8937 in the McElmo-Yellowjacket locality weakens the fit of this model, and 5MT10647 in McElmo-Yellowjacket and 5MT2525 in the Hovenweep locality also show larger percentages of Morrison than predicted by the model. Figure 4.11 shows two interesting patterns. First, the two Wetherill Mesa sites, though close by, display somewhat different residual values for procurement of Morrison materials, and second, the inhabitants of the Dolores locality uniformly procured less Morrison than would be expected, even though these materials are near their residence.

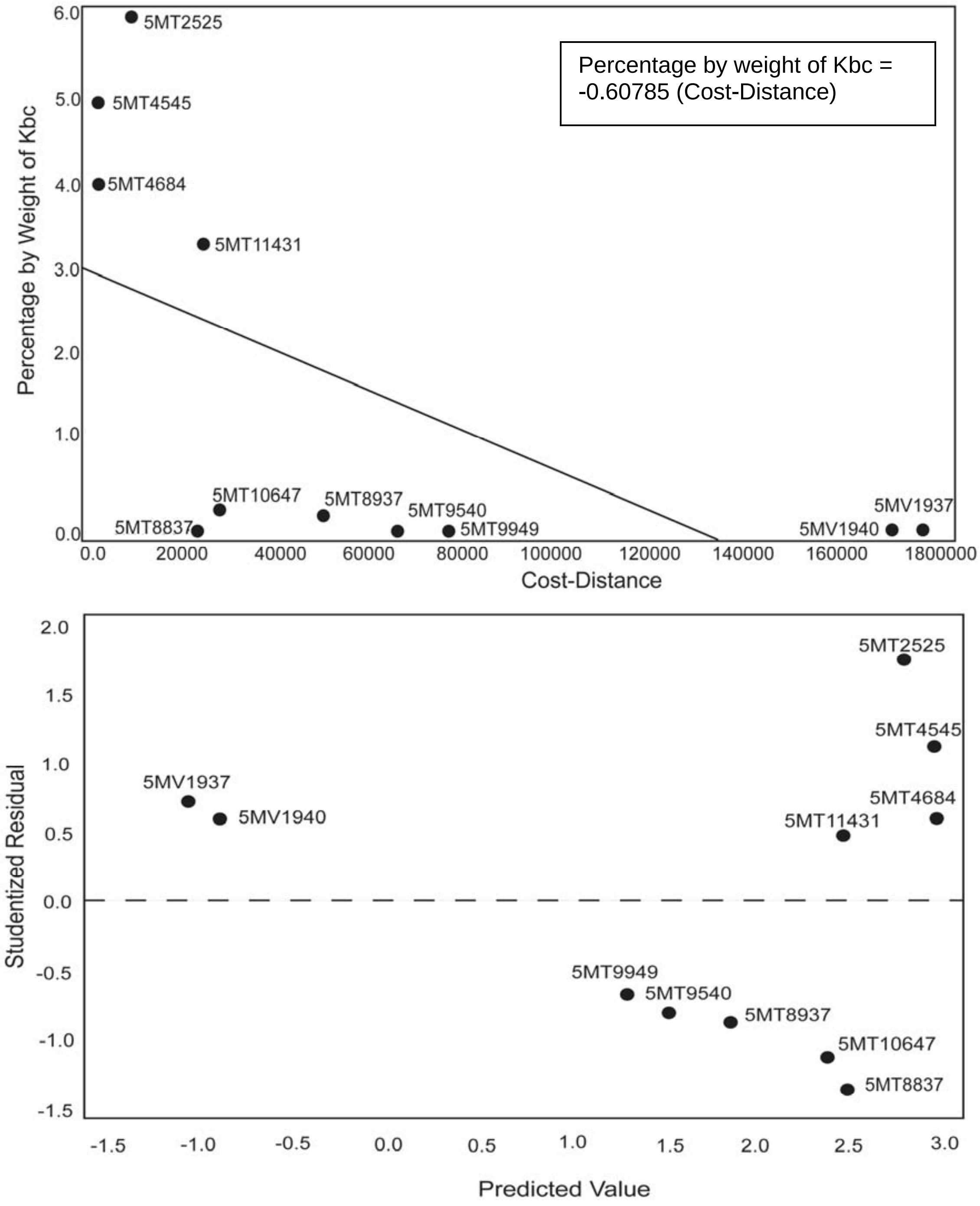


Figure 4.8. The top panel shows the Basketmaker III Kbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

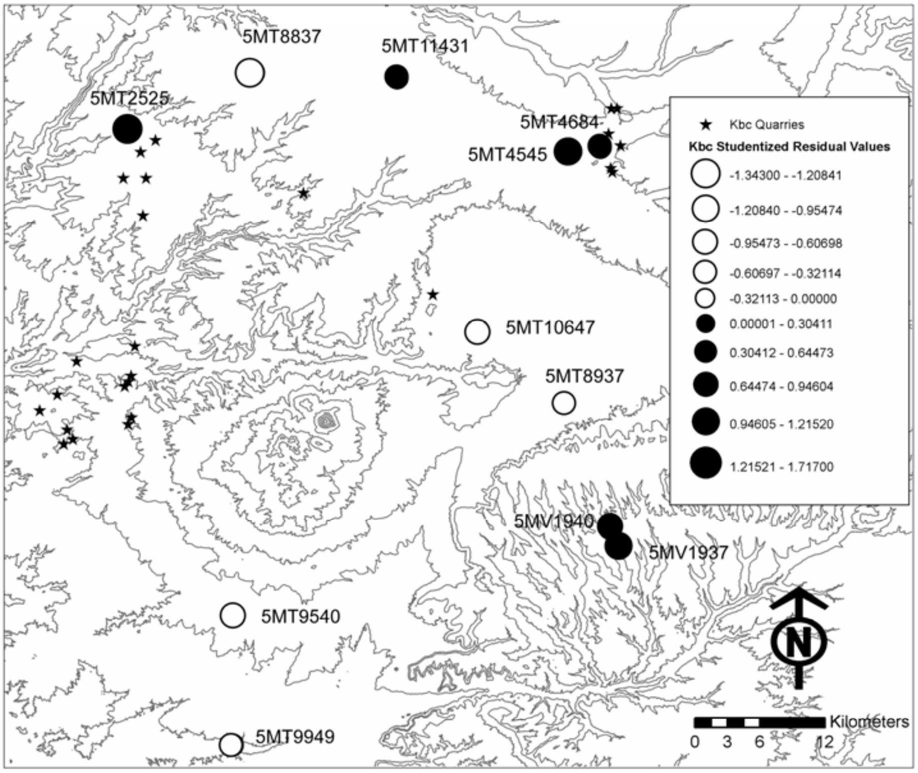


Figure 4.9. Map of Kbc studentized residuals during the Basketmaker III period.

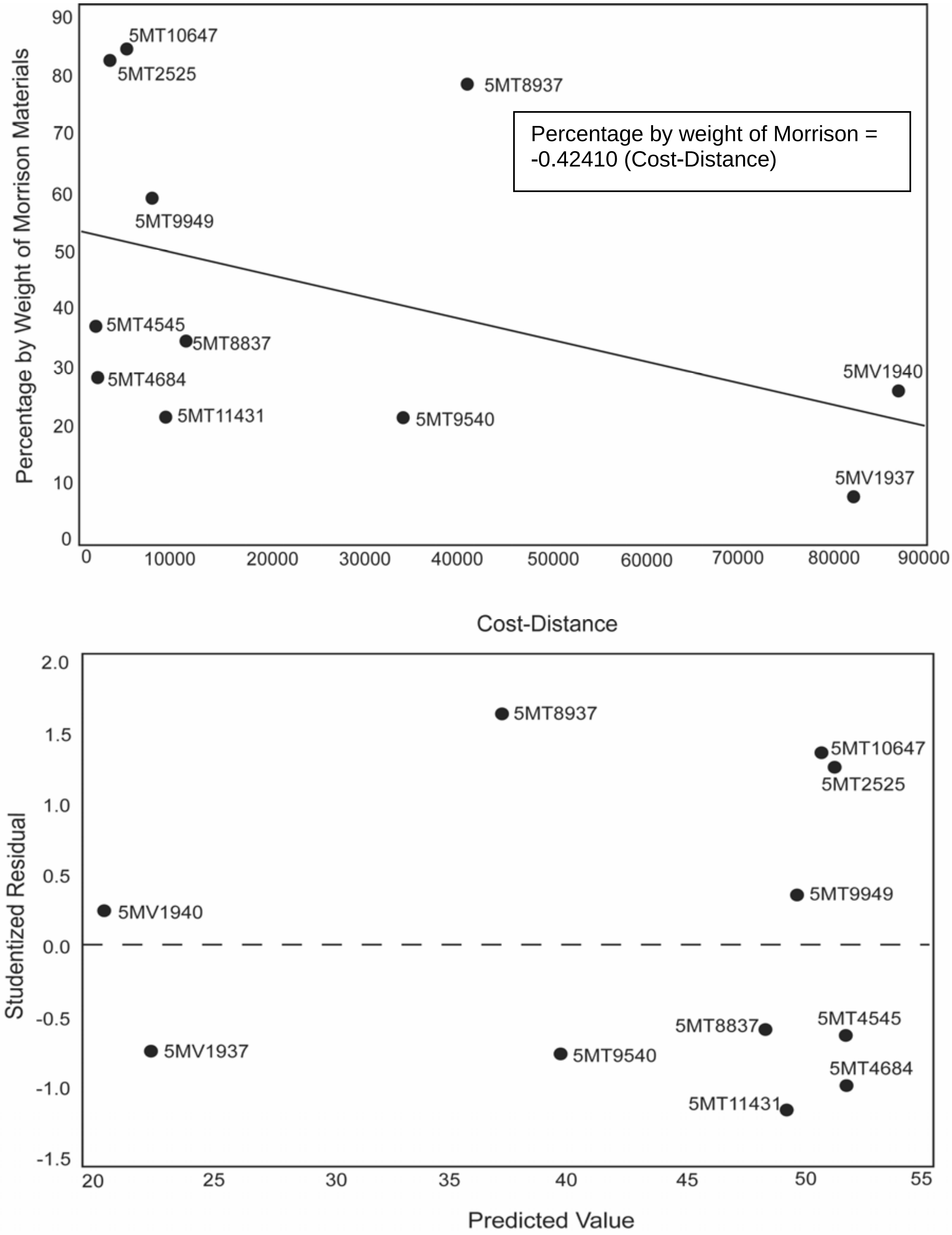


Figure 4.10. The top panel shows the Basketmaker III Morrison percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

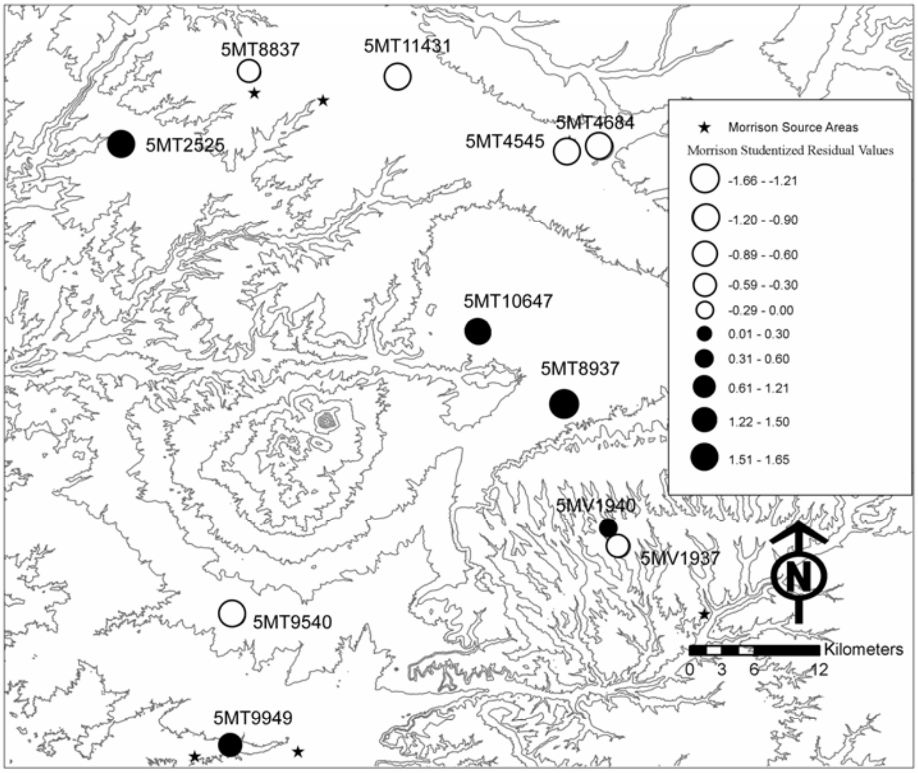


Figure 4.11. Map of Morrison studentized residuals during the Basketmaker III period.

The Percentage/Cost-Distance Relationship for Jmbc. Although only four Basketmaker III sites contain Jmbc and those only small amounts, the regression analysis (Figure 4.12) shows an unexpected positive relationship with a relatively strong correlation (r^2=.350; p=.055). The residuals and their map (Figure 4.13) show that 5MT9949 in the Ute locality contains more Jmbc than expected, decreasing the fit for the linear model. 5MV1940 in the Mesa Verde locality contains the highest percentage of Jmbc and is extremely influential in determining this positive slope. The residual map shows that most of the residents in the Dolores, Hovenweep, and McElmo-Yellowjacket localities used less than expected, where that expectation is derived from the linear model in the previous figure. In general, people in southern portions of the area procured more Jmbc than expected, whereas inhabitants of the north procured less. The sites with more Jmbc than expected, particularly from the Mesa Verde locality, suggest that people may have procured this material through community interactions, especially ritual activities that might be concentrated because the Jmbc sources are located on the western portion of this study area. The analysis of Jmbc for other periods may further confirm this idea.

The Percentage/Cost-Distance Relationship for Ign. The sources of igneous rocks are fairly confined in this region, available only in the southern portions of this study area. Figure 4.14 shows a very strong negative relationship between percentage and cost-distance (r^2=.742; p<.0007) for this material type. As Figure 4.15 shows, 5MT9540 in the Ute locality has more than the predicted amount of igneous materials. Interestingly, once again the two Wetherill Mesa sites show different residual values suggesting that inhabitants within the Wetherill Mesa locality had different patterns of mobility or interaction during the Basketmaker III period.

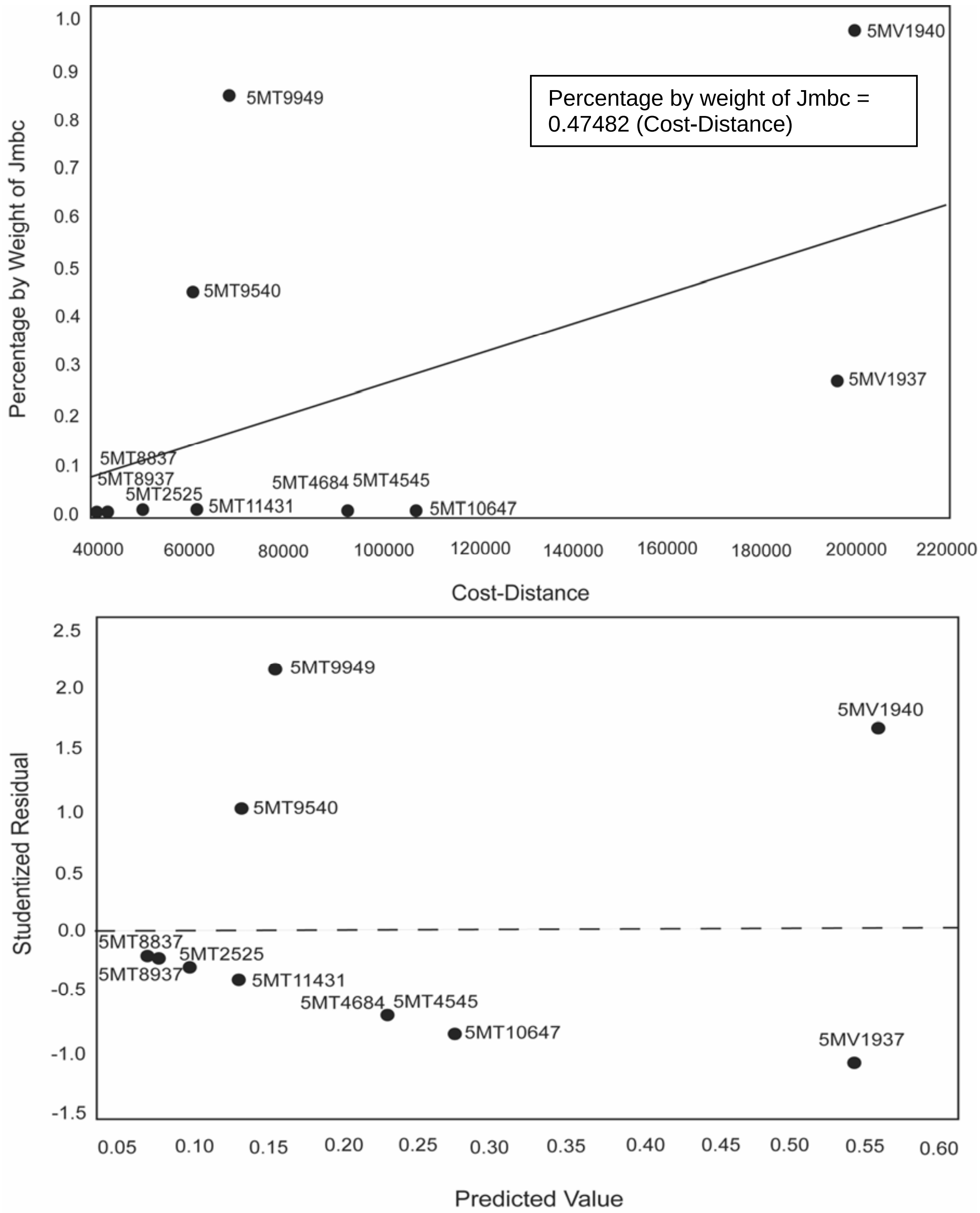


Figure 4.12. Top panel shows the Basketmaker III Jmbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

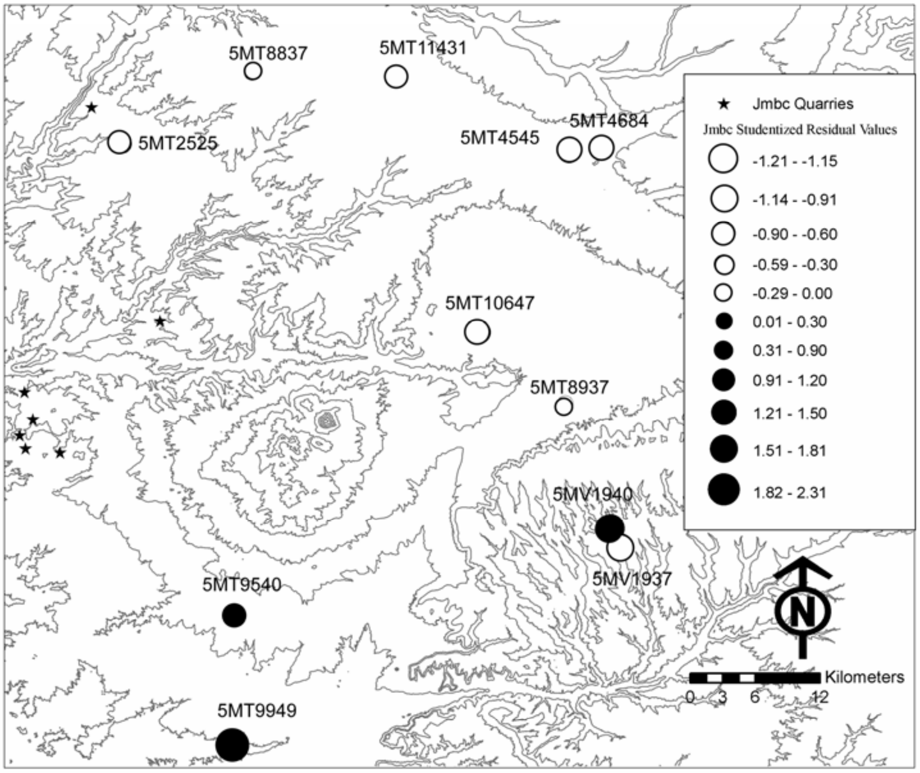


Figure 4.13. Map of Jmbc studentized residuals during the Basketmaker III period.

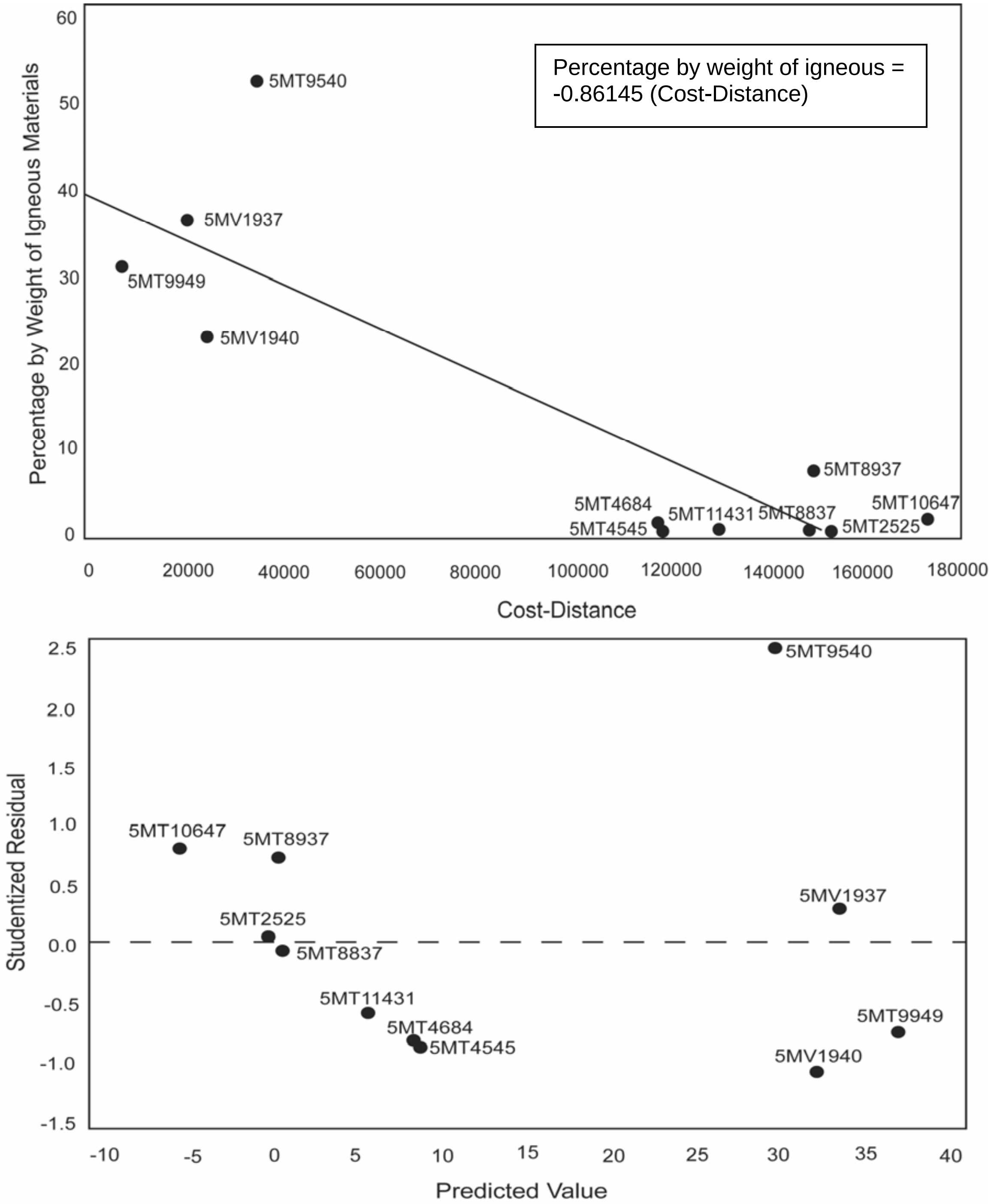


Figure 4.14. The top panel shows the Basketmaker III igneous percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

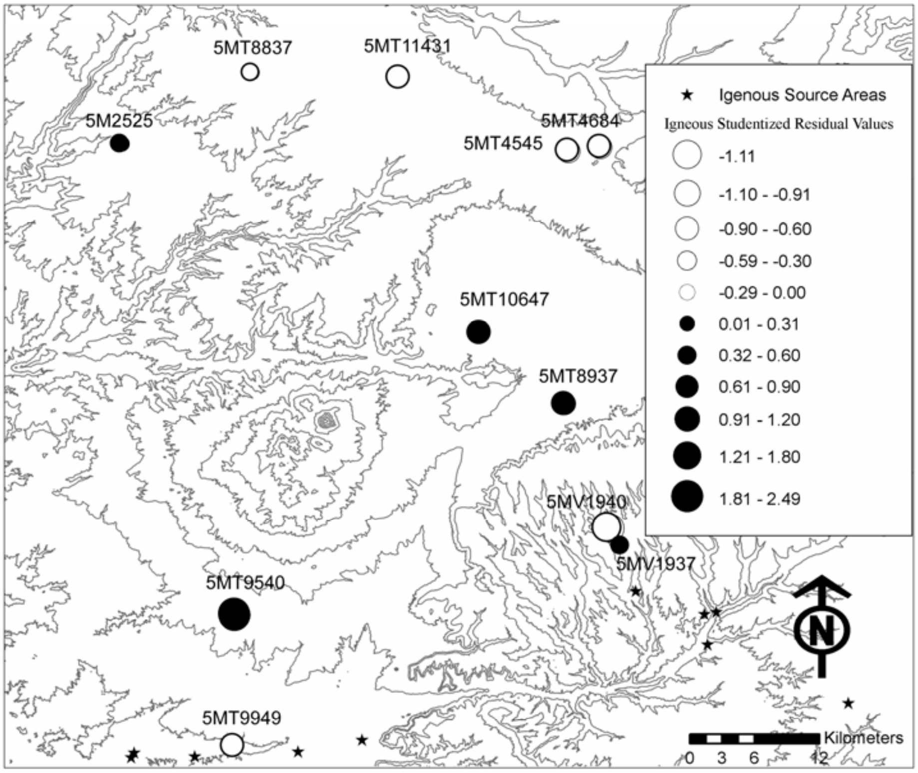


Figure 4.15. Map of igneous studentized residuals during the Basketmaker III period.

In the Basketmaker III period, all but one of the relationships between proportions of materials and their cost-distances are negative, though most of those negative relationships are not statistically significant. The only positive relationship is for Jmbc, and this is somewhat suspect because of the small sample of sites. For the Basketmaker III period, Kdbq "behaves" like most other materials in displaying an insignificant negative relationship between cost-distance and proportion. Next we try to gain insight into what that means by cross tabulating the assemblages with much more, and much less, Kdbq than expected, based on the linear relationship shown in Figure 4.6, against two attributes for flakes from those assemblages.

Direct vs. Indirect Procurement Patterns for Kdbq

As mentioned in the chapter 2, I selected Kdbq to investigate whether assemblages above or below the best-fit regression model are significantly different with respect to flake attributes that might inform us on how these materials were acquired. I chose only Kdbq because this material type was mostly used for manufacturing formal tools, the quarries are ubiquitously distributed, and dorsal flakes clearly display cortex amounts. I used a Fisher's Exact Tests to examine whether cortex amounts were randomly distributed across Basketmaker III assemblages with more, or less, Kdbq than expected. I eliminated the assemblages from 5MV1937 and 5MV1940 for this analysis because they do not deviate much from the predicted model in the regression (Figure 4.6). In principle, the amount of cortex should decrease and the number of dorsal flake scars increase as the distance from lithic sources to habitation sites increases (Andrefsky 1998; Hess 1997), unless these materials are directly procured.

Table 4.1. Fisher's Exact Test for the Kdbq Cortex Amount in Basketmaker III Assemblages Where Kdbq is More Common, and Less Common, Than Expected.

		Cortex Amount				
		none	≤50%	50-100%	100%	*n*
More Kdbq than expected from regression on distance[a]	Row Percentage	85.90	11.54	2.14	0.43	234
Less Kdbq than expected from regression on distance[b]	Row Percentage	70.49	22.95	6.56	0.00	61
	Total (*n*)	244	41	9	1	295

Fisher's Exact Test $p \leq 0.017$

[a] flakes from assemblages with studentized residuals >.4 in Figure 4.6.

[b] flakes from assemblages with studentized residuals <-.4 in Figure 4.6.

Table 4.1 shows the results of Fisher's Exact Tests for cortex amount tabulated against assemblages with more, and less, Kdbq than expected, given the regression relationship shown in Figure 4.6. Cortex amounts are significantly different for these two groups of assemblages ($p \leq .017$). Assemblages with more Kdbq than expected also have more flakes with no dorsal cortex amounts than do assemblages with less Kdbq than expected (Table 4.1). Based on these comparisons, I argue that assemblages with more Kdbq than expected may have been enriched through trade or interactions for these materials, possibly in addition to direct procurement, whereas those with less Kdbq than expected may result from direct procurement only, because these flakes were not further modified at other places, such as habitation sites, fieldhouses, and/or lithic activity areas or by other hands. I will compare this result with similar analyses for Kdbq materials from later periods to determine whether this argument is plausible.

Summary of the Proportion/Cost-Distance Relationship

This examination of six raw materials suggests three major complexities in the Basketmaker III period. I discuss them in three broad raw-material categories – high-, medium-, and low-quality. First, the percentage/cost-distance relationship for the high-quality materials (chalcedony and Kdbq) shows an extremely weak negative correlation between the distance from habitation sites to sources and the proportion by weight of raw materials. For example, inhabitants of the Hovenweep locality traveled a long distance from their residence to obtain these high-quality raw materials. This toolstone procurement pattern suggests a relatively unrestricted or open territoriality during the Basketmaker III period and, perhaps, a willingness to go some distance for superior materials. The results of Fisher's Exact Tests suggest that residents who had more than the expected amount of Kdbq materials may have procured some of them through trade; in contrast, inhabitants who procured fewer-than-expected Kdbq materials perhaps did not participate in these exchanges (Figure 4.6; Table 4.1). Since only two of 11 sites contained more than the expected amounts of Kdbq, most Mesa Verde residents apparently procured these materials through high logistic mobility, and then returned with these materials to their habitations (direct procurement).

Second, the Basketmaker III inhabitants in this region procured and utilized durable and tough (low-quality) raw material types from close to their habitation sites. The McElmo-Yellowjacket inhabitants frequently procured and utilized Morrison materials. However, the Morrison procurement pattern showed that people at sites within Hovenweep, Ute, and Mesa Verde localities behaved differently; for instance, 5MT9540 has more than expected by the model, whereas 5MT9949 in the Ute locality has less than expected. We can account for this different toolstone procurement pattern by considering interaction and/or migration, and this further suggests easy accessibility or unrestricted territoriality within this landscape.

Finally, study of the medium-quality materials (Jmbc) suggests that residents of the Ute and Mesa Verde localities procured more of this stone than expected (Figure 4.13). Because the only known quarry for this material is located on the western margins of the McElmo-Yellowjacket locality, this suggests that these three localities had strong interactions (and inter-accessibility) during the Basketmaker III period. Although igneous material evidences a strong negative correlation between its local importance and its cost-distance in general, inhabitants within a single locality procured and used this material differently. More research is needed to understand whether this variability is due to different lineage-level interaction and/or migration histories, the sizes of residences, or occupation early versus late in this period.

The Energy Expenditure Model

To provide a more global view of the costs of obtaining all the various lithic materials at each site – rather than examining one material at a time – I also present the energy expenditure model discussed in chapter two. Expenditure of energy was calculated by multiplying the proportion by weight of each of the 10 raw material types by the cost of traveling to its source from that site. Because there are only a few single-component Basketmaker III sites in each locality, no Basketmaker III community level-analysis was performed. On the locality level, energy expenditures from Basketmaker III sites are calculated and illustrated in Figure 4.16. This figure shows that the Mesa Verde inhabitants expended the most energy in procuring raw materials, followed by the residents of Ute and Hovenweep, and then McElmo-Yellowjacket and Dolores residents. The Wetherill Mesa Puebloans bore the highest costs because of the physiographic

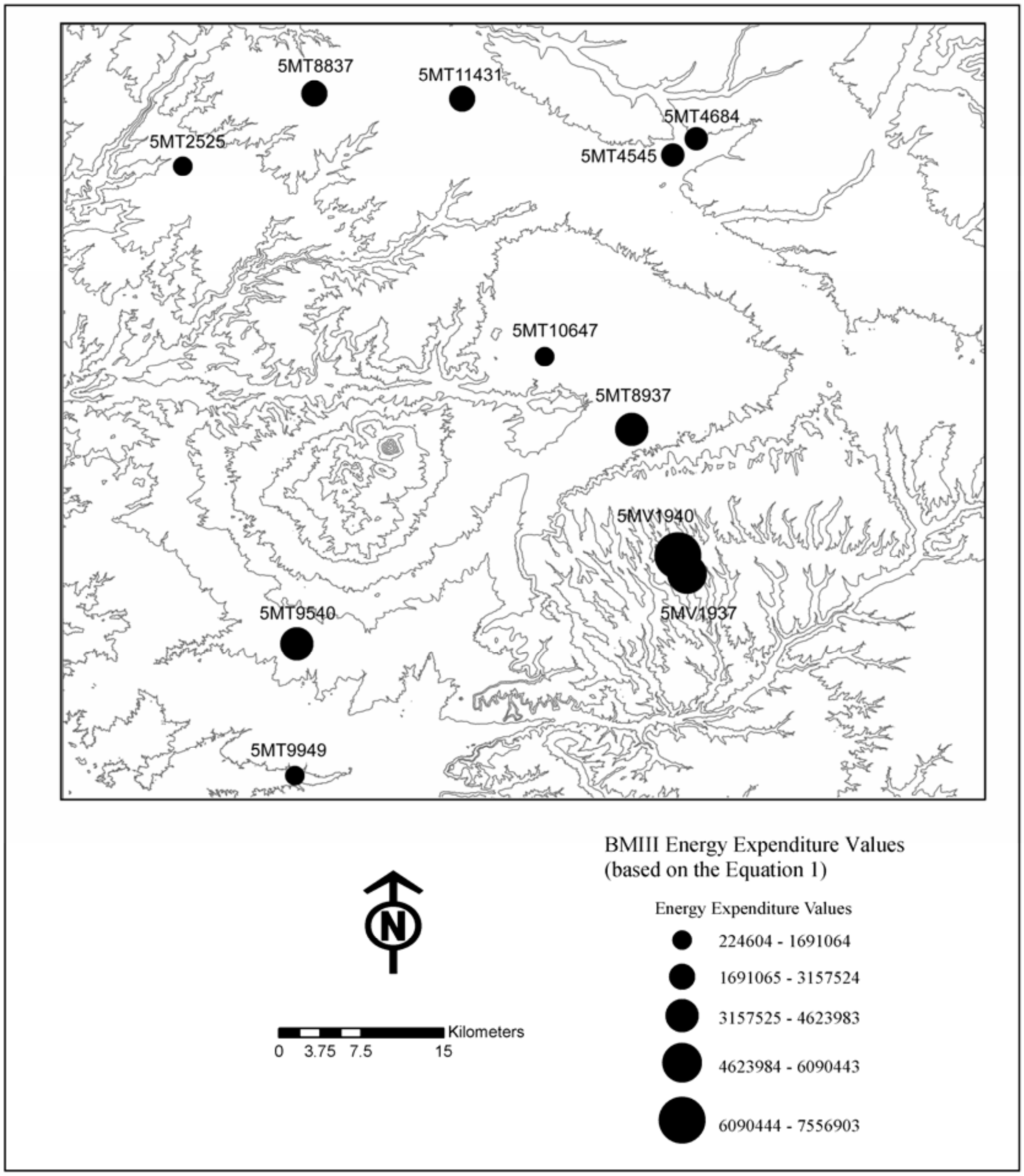


Figure 4.16. Energetic expenditure values for sampled Basketmaker III sites in the central Mesa Verde region.

features confining them on the landscape. These Wetherill Mesa sites are located on the mesa top and most of the suitable high-, medium-, and low-quality materials are located in Pleistocene gravel terraces on Chapin Mesa, approximately 7 km distance (by a straight line). 5MT9540 in the Ute locality and 5MT8837 and 5MT11431 in Hovenweep locality also show relatively high costs for acquiring lithic materials. These sites are farther away from many sources. Residents in the Dolores and the McElmo-Yellowjacket localities were able to obtain raw materials easily and at little energetic cost because of abundant sources close to their habitations.

The Energy Expenditure Map

Using kriging interpolation in the ArcGIS program, I created an isopleth map of the total energy expended by the Basketmaker III residents (Appendix A). This map (Figure 4.17) interpolates values between the points mapped in Figure 4.16, providing a smoothed representation of how much energy inhabitants of each locality in the central Mesa Verde region expended. The inhabitants of the Mesa Verde and Ute localities expended large amounts of energy to acquire the assemblages they used, whereas the Dolores and McElmo-Yellowjacket residents expended less energy, based on this toolstone procurement model. This map may illustrate two different macrobands – one in the Hovenweep and the other in the Mesa Verde and Ute localities – that coexisted in this landscape during the Basketmaker III period. Residuals of chalcedony (Figure 4.5), Kdbq (Figure 4.7), and Jmbc (Figure 4.13) show explicitly that residents of the Mesa Verde and Ute localities, and inhabitants of the Hovenweep locality procured much more of these materials than predicted by the linear model of proportion and cost-distance

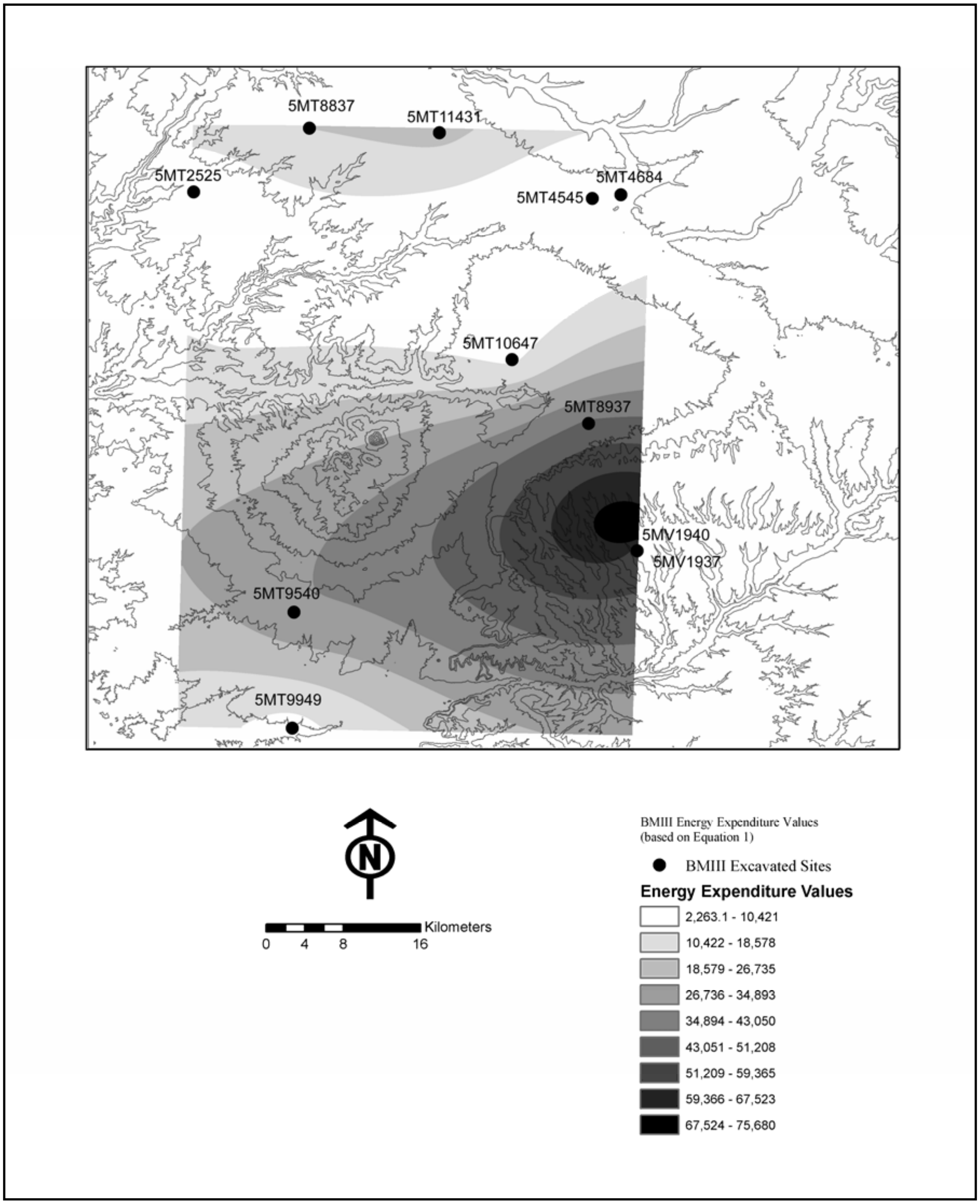


Figure 4.17. A kriged map that interpolates, across our region, the total energy-expenditure values for acquiring toolstone for the sampled Basketmaker III sites.

analyses. Although people in these two macrobands lived in similar environments and relatively close to each other in this landscape, they may have established their territorial boundary roughly in the McElmo-Yellowjacket locality. In other words, the Basketmaker III inhabitants may have to some degree restricted social accessibility or controlled hunting territories within the McElmo-Yellowjacket locality.

Summary of the Basketmaker III Period

During the Basketmaker III period, the population was fairly low (approximately 1,800), and resource productivity was generally high except between about A.D. 680 and 710 ($\bar{x}$=255.49 kilogram/hector per year). The resource productivity was relatively unpredictable because the maize productivity model shows a relatively high standard deviation (S.D.=50.23 kg/ha per year) in productivity during the Basketmaker III period (Varien et al. 2007). As mentioned in chapter 1, Dyson-Hudson and Smith's economic defensibility model, which uses resource predictability as the independent and abundance as the dependent variances, suggests that these conditions should lead to a high mobility, information-sharing, spatial-temporal territorial system. We can expect people to develop and use territories in this way when resource density is high, but resource predictability is low.

Lithic data tend to support this model. The presentation of lithic data by the percentage/cost-distance relationship and the relatively low |-0.244| values for their negative slopes we calculated in the energy expenditure model suggest that residents in the Hovenweep, Mesa Verde, and Ute localities traveled a long distance to procure or trade some of the high-quality materials. This further suggests that Basketmaker III people experienced high mobility and interaction within this region, possibly shared information regarding resources (e.g., hunting and mating choices) with neighbors, and casually defended their territory and/or resources in the open/unrestricted landscape. Based on the energy-expenditure map, Basketmaker III inhabitants would have shared information and defended their hunting territory along the north-south boundary (within the McElmo-Yellowjacket locality) of two different macroband systems.

Backgrounds for Pueblo I Period (A.D. 725-920)

The Pueblo I period spans the longest interval, approximately 200 years, of the periods we examined in this research. A major characteristic of this period is the movement towards the initial development of masonry buildings, from sites like Duckfoot towards the Pueblo II Prudden unit (Prudden 1918), which typically consists of roomblocks on the north of the settlement, a kiva (pitstructure) at the center, and midden on the south. Another characteristic is the establishment of relatively short-lived aggregated villages, particularly in the Dolores locality. As in the previous Basketmaker III section, I briefly discuss population estimates, resource productivity, and settlement patterns and social organization, then describe typical artifact and architecture types, and finally use lithic data to understand socio-political organization in this region.

Population Estimates. The Pueblo I population density increased steadily in comparison to that of the Basketmaker III period. DAP research suggested that population density increased from A.D. 600 to the mid-800s due in part to immigration from other regions, but then decreased in the late 800s to early 900s (Orcutt 1986; Schlanger 1988). Kohler and Matthews (1988) investigated changes in frequencies of woody taxa in macrobotanical samples to argue that abandonment of the late Pueblo I period was due in part to depletion of the local environment.

Wilshusen (2002) provides the most relevant population estimates for this entire region. He used survey data from Mockingbird Mesa (Fetterman and Honeycutt 1987), the Wetherill Mesa Project (Hayes 1964), the Sand Canyon locality (Adler 1990, 1992), and the Dolores Archaeological Project (Schlanger 1985, 1988) to reconstruct the paleodemography. According to Wilshusen (2002:105), there were two general cycles between A.D. 600 and 1280 in this region. Each cycle involved dispersed settlement patterns at the beginning and aggregated villages at the end, and each cycle ended with emigration and depopulation. During the local Pueblo I population peak, approximately 1,000 and 2,000 people lived in villages, then dispersed within or outside of this study area (Wilshusen 2002:105).

For the subset of my study area closely analyzed by the Village project, Varien et al. (2007) estimated that the population increased from A.D. 800 to 880 and then declined over the following 80 years or so. Varien et al. (2007) suggested that there were approximately 5,000-5,500 people from A.D. 800 to 880, then the momentary population decreased to 1,500-2,000 in the mid-900s in the Village study area.

Resource Productivity. Figure 4.2 shows potential maize yields in kg/ha per year during the Pueblo I period. Three trends can be noted. Favorable climatic conditions early in the Pueblo I period were interrupted by a series of poor years in the mid-700s, with a return to favorable conditions in the late 700s. The first half of the 800s was generally unfavorable, but most of the last half was excellent. Poor conditions prevailed again during the last 20 years of the Pueblo I period as defined here.

Settlement Patterns and Social Organization. During the early-to-mid 800s something resembling the Prudden Unit (with a roomblock on the north, pit structure in the center, and midden on the south [Prudden 1903, 1918]) appeared in many residential sites in this region (Lightfoot 1994:162; Wilshusen 1999b). Villages, or settlements with a minimum of 50 contiguous surface rooms, were also present by the late A.D. 700s, though their occupation was brief (with an average occupation span of 25-40 years [Wilshusen 1999b:210]) compared to late community centers in this region.

The study of site types during the Pueblo I period is derived from two major Pueblo I projects – the Dolores Archaeological Program (DAP) and the Duckfoot site excavations. The DAP was conducted to recover cultural resource data prior to a water impoundment project. DAP archaeologists recorded seven aggregated villages (including Grass Mesa and McPhee Villages) along with hundreds of smaller, short-lived hamlets.

In the Dolores area, there was a strong positive correlation between the presence of fieldhouses and aggregation in villages. Kohler (1992) argued that the appearance of fieldhouses represented visible claims to the use of particular parcels of land, thus establishing a land-tenure system.

Because Duckfoot was a single-component, well preserved site, it provides important information about household organization in small hamlets during the mid-to-late A.D. 850s to about 880 in the central Mesa Verde region (Lightfoot 1994; Lightfoot and Etzkorn 1993). Based on the remarkable and complete excavation of Duckfoot, Lightfoot (1994) contributed accurate estimates of ceramic use lives of the Duckfoot residences by analyzing discarded pottery (creating discard equations which helped

Varien and Mills [1997] investigate use lives of Pueblo III habitation sites in this region). The Duckfoot site was occupied for about 30 years and abandoned after A.D. 880.

Previous Research on Pueblo I Period Ceramic and Lithic Assemblages

Ceramic Data. In the central Mesa Verde region, Chapin Gray, Plain Gray, and Mancos Gray were the major gray ware types, but small amounts of Moccasin Gray were also present during the Pueblo I period (Wilson and Blinman 1991:45). Chapin Black-on-white and Piedra Black-on-white were the major decorated whiteware types; most whitewares were polished but unpainted. Abajo Red-on-Orange, Dolores Red, Abajo Polychrome, and Bluff Black-on-Red are present but were relatively rare.

Lithic Data. Carl Phagan (1988a, 1988b) and colleagues compared and contrasted large numbers projectile points found in the DAP sites and created projectile point typologies. Neusius (1988) employed a low-power microwear analysis to understand the function of 4,000 stone tools found in 19 DAP sites, contrasting habitations, seasonal sites, and limited activity sites during the Basketmaker III to Pueblo I period. Neusius noted that lithic assemblages found in most seasonal and limited activity sites had a predominance of Morrison quartzite, which was generally utilized for flake tools. In habitation sites, Morrison quartzite also comprises a large proportion of the lithic assemblages, especially for cores and flakes, whereas Burro Canyon Formation materials were utilized for finished tools, such as projectile points. His microwear analysis suggested that cores and cobble tools were used mostly for stone working and high-input production tools, whereas projectile points were utilized for the exploitation of animal resources and piercing and cutting tasks.

Hruby (1988) investigated changes in economic organization through time by looking at toolkits found in household and interhousehold contexts in the Basketmaker III and Pueblo I periods. He investigated raw material acquisition, production, and technology of lithic materials in the numerous DAP sites. In the Dolores River Valley, raw materials were acquired mostly from river gravels; cherts and orthoquartzites were from the Dakota, Burro Canyon, or Morrison Formation. Burro Canyon chert and Dakota orthoquartzite were also procured by the Dolores Puebloans, but those materials constituted a relatively small amount of the lithic assemblage. According to Hruby, tool-production patterns in Dolores sites were generally similar across space, and he stated, "tool production appears to be an expedient technology that focuses on manufacture of morphologically variable multi-functional tools" (1988:355). Additionally, there were relatively few high-production-input tools (projectile points) in the DAP assemblages. In most of DAP research, local raw materials – Morrison chert/orthoquartzite and Burro Canyon chert/orthoquartzite – were discussed briefly but their source areas were not specifically identified, except for a study of a geological survey by Leonhardy (1978) in the Dolores River area. Raw material classification for this research uses some of his definitions and identifications. However, I implemented Gerhardt's (2006) modified classification because my geological survey covers not only the Dolores locality but also the Mesa Verde, Ute, Hovenweep, and McElmo-Yellowjacket localities.

Architecture. Villages, hamlets of one to two households, and public architecture, are all recognized during the Pueblo I period (Wilshusen 1999b). Villages, defined as having at least 50 contiguous surface rooms, were constructed, particularly in the Dolores locality. Residential sites (including hamlets and villages) contained a food storage or processing area, an inhabited area, and a midden. According to Cordell, "Typically, Pueblo villages consist of long, double arched rows of contiguous surface rooms with a deep square pit structure placed to the south, or in front of the surface rooms" (1997:280). "Great kivas," at least 11 of which have been identified in the northern San Juan area and which presumably served for ceremonial and social interaction, are another characteristic of the Pueblo I period (Wilshusen 1999b:219).

Current Perspectives on Pueblo I Assemblages

Figure 4.18 shows all the Pueblo I sites in this study area whose assemblages I examined. Ten of the 14 are located in the Dolores area because of the large cultural resource management effort there in the late 1970s to 1980s. Four other sites provide important information about Pueblo I assemblages from the McElmo-Yellowjacket, Mesa Verde, and Hovenweep localities. There are no Pueblo I single-component sites in the Ute locality so that the locality is excluded from the Pueblo I analysis.

As for the Basketmaker III period, I investigated the percentage/cost-distance relationships of six raw material types, tried to determine the direct versus indirect procurement patterns for Kdbq using flake attributes, and mapped energy expenditures from the Pueblo I assemblages in my sample.

The Percentage/Cost-Distance Relationship for Chalcedony. Figure 4.19 shows the linear regression and residual analysis for Pueblo I chalcedony. This reveals a negative linear relationship with an extremely weak correlation (r^2 =.052; *p*=.435). The negative slope, -.223, is similar to, though slightly more positive than, that obtained for chalcedony in the Basketmaker III period (-.244). The residual analysis shows that

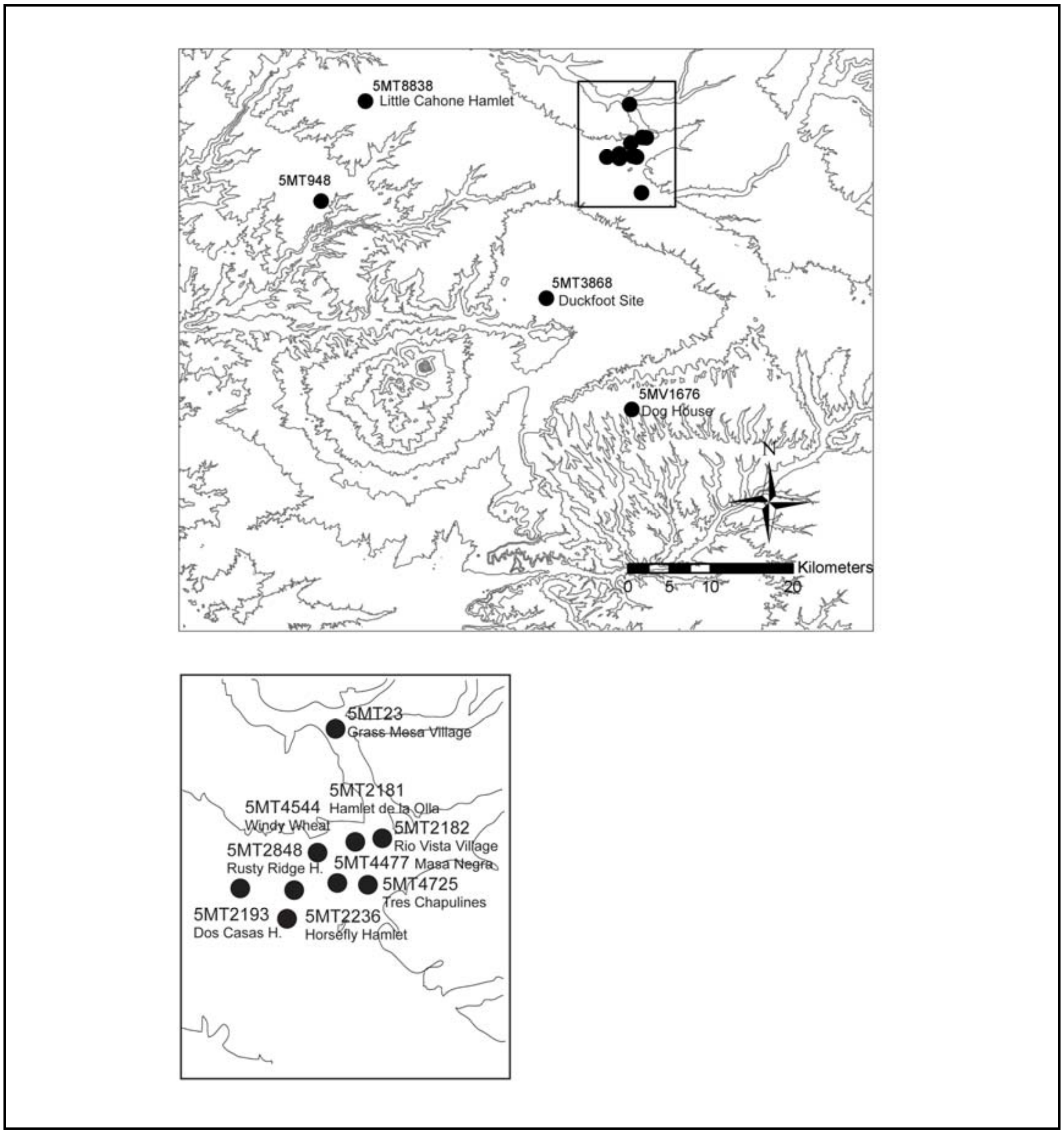


Figure 4.18. Pueblo I habitation sites in the study area. The bottom map shows the Pueblo I habitation sites in the Dolores locality.

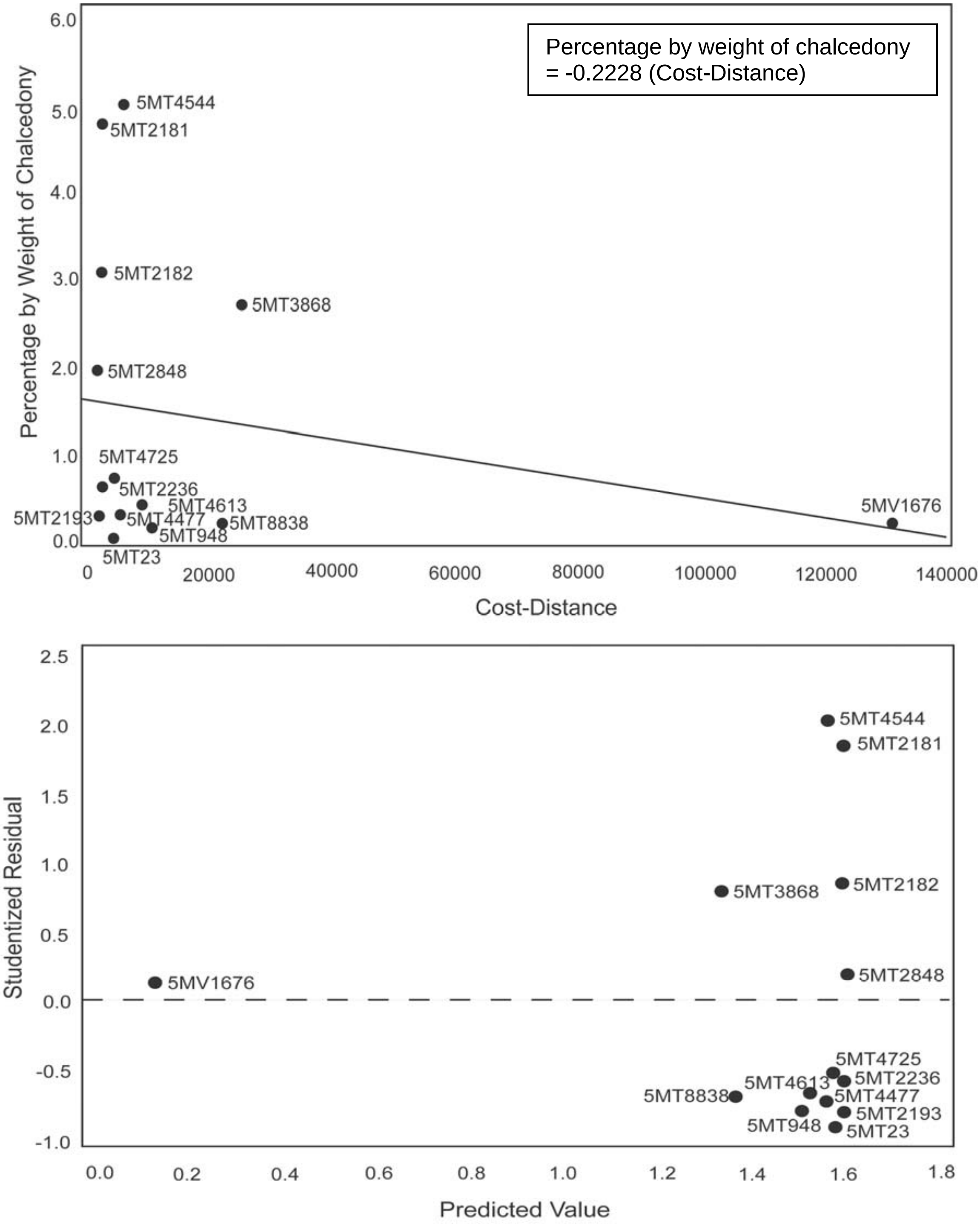


Figure 4.19. The top panel shows the Pueblo I chalcedony percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

anomalously large amounts of chalcedony at 5MT4544 and 5MT2181 contribute to the poor fit of the statistical model. Figure 4.20 maps the studentized residuals for Pueblo I chalcedony. This map shows that inhabitants of some sites (5MT4544, 5MT2181, 5MT2182, and 5MT2848) in the Dolores locality acquired more chalcedony than expected, although residents of six other sites in the same locality used less than expected. The Duckfoot site (5MT3868) in the McElmo-Yellowjacket locality contained more than the expected amount of chalcedony. In contrast, although residents in the Hovenweep locality lived close to those sources, they used less chalcedony than the model predicts.

The Percentage/Cost-Distance Relationship for Kdbq. Figure 4.21 shows the relationship between percentage and cost-distance for Kdbq in the Pueblo I period. For these sites, there is a very weak negative relationship (r^2=.009; p=.747) between the cost-distance and the percentage of Kdbq. The negative slope, -.068, is even smaller than that obtained for Kdbq in the Basketmaker III period (-.255). Figure 4.22 shows that 5MT8838 in the Hovenweep locality and 5MT3868 in the McElmo-Yellowjacket locality contain more Kdbq than predicted by the model. 5MT8838 becomes an extreme outlier in this relationship. There are several possibilities for this phenomenon. One is that residents of 5MT8838 favored Kdbq for some activities that were more common there than elsewhere, or that they had strong interactions with people who lived close to those source sites, or participated in frequent logistic activities that took them near those quarries. Another possibility is that some Kdbq quarries within this locality have not yet been recorded or identified. In either case, we need to further investigate those lithic assemblages and quarries to understand the reasons for the existence of such outliers.

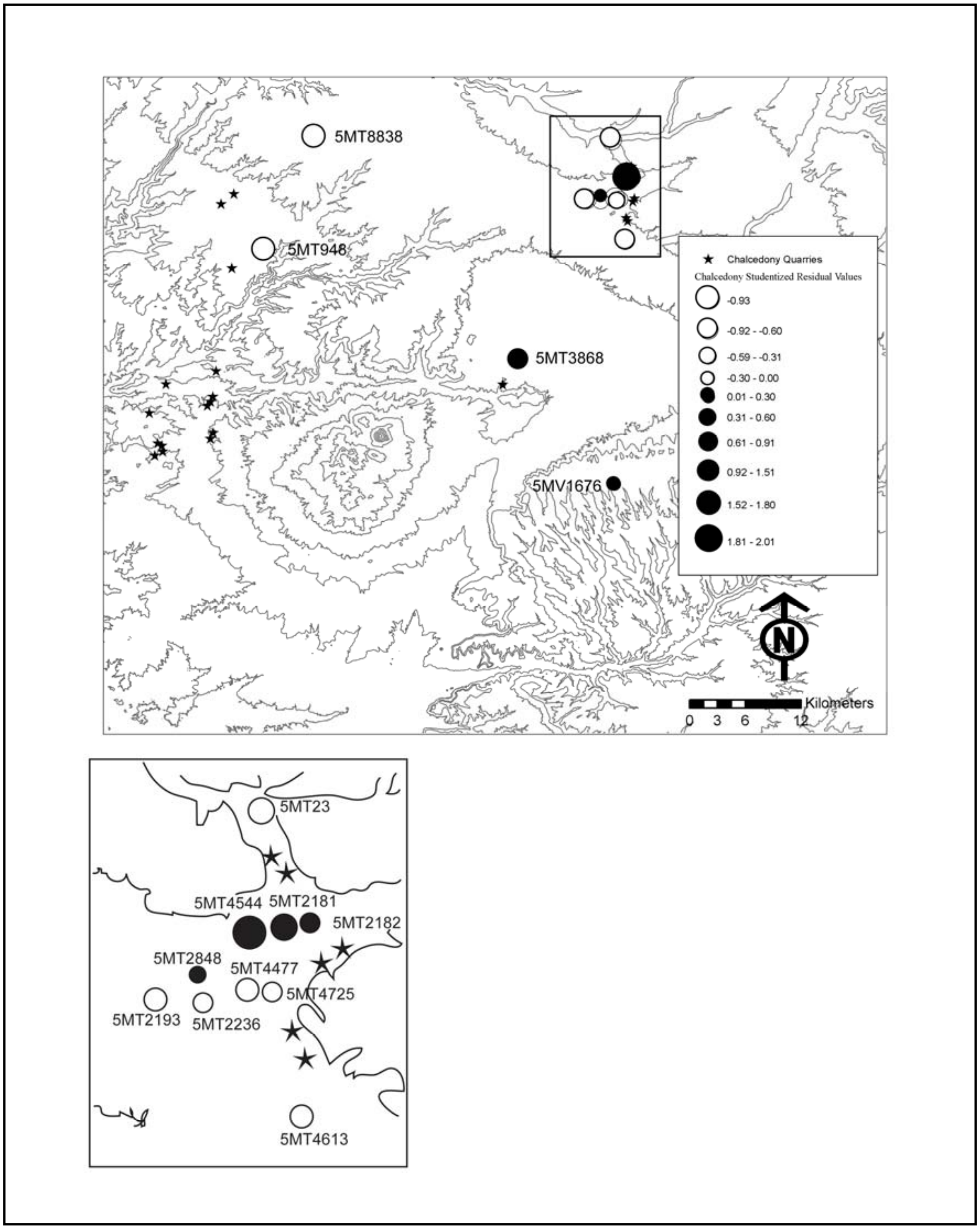


Figure 4.20. Map of chalcedony studentized residuals during the Pueblo I period. Bottom panel maps chalcedony studentized residuals in the Dolores locality.

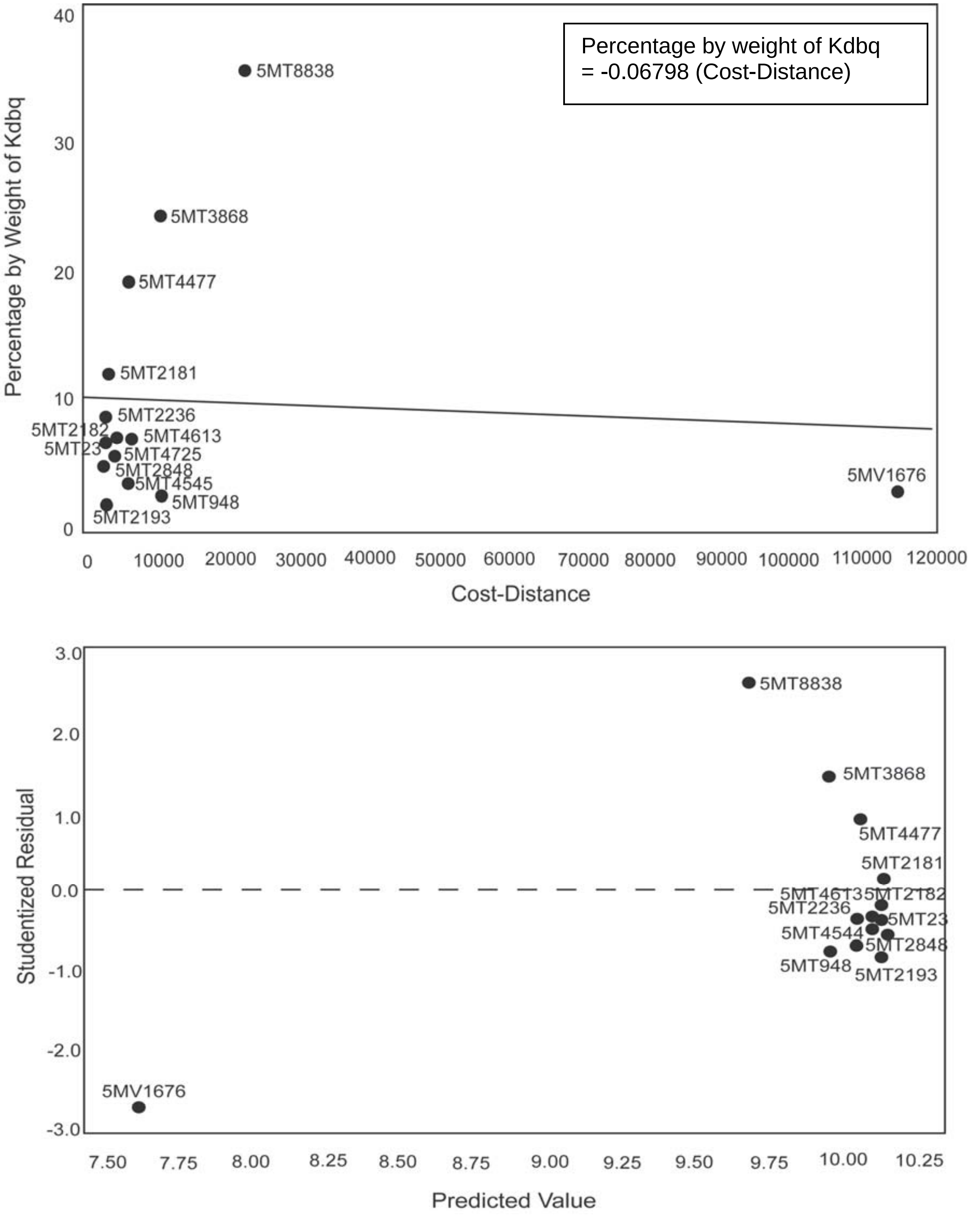


Figure 4.21. The top panel shows the Pueblo I Kdbq percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

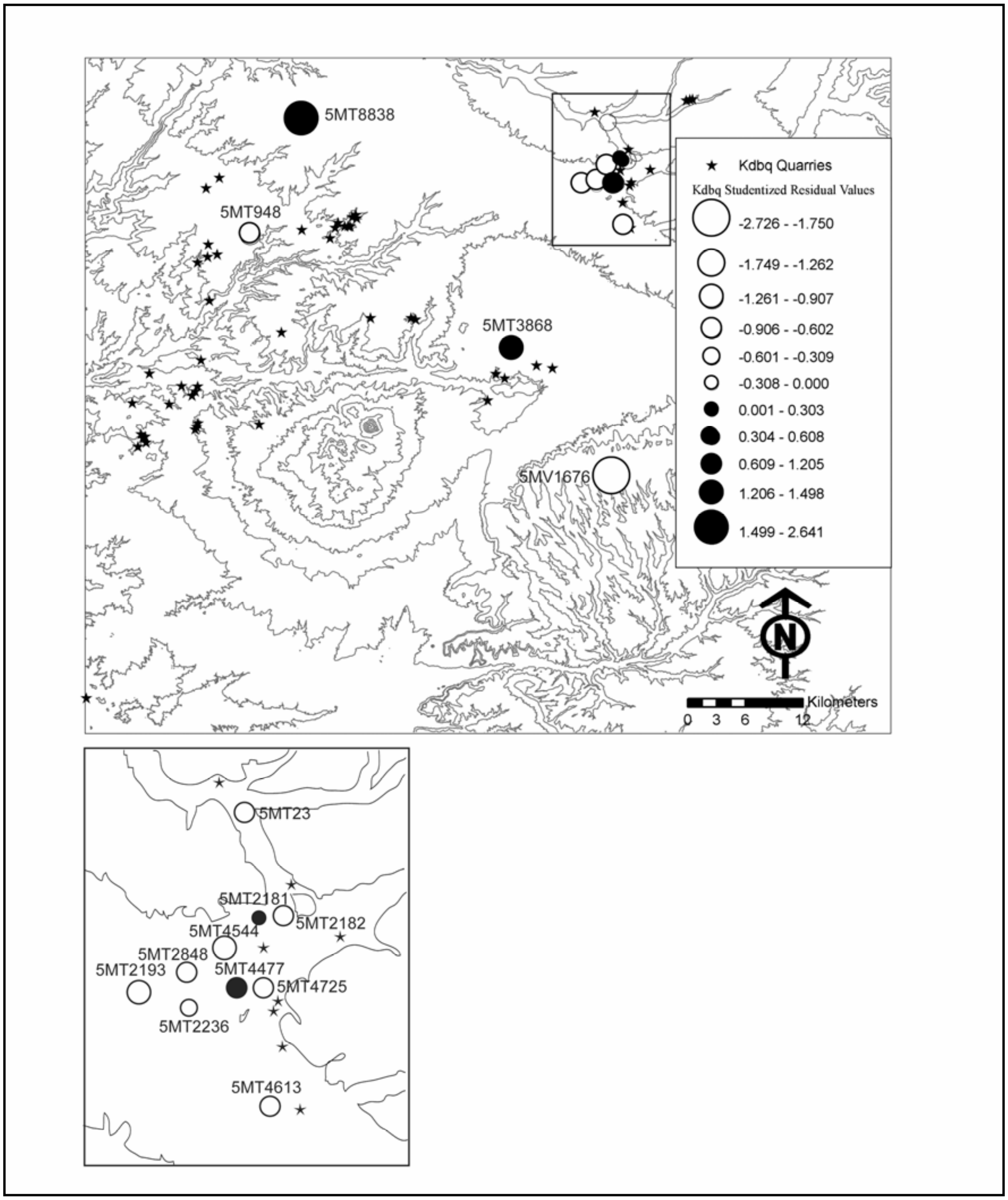


Figure 4.22. Map of Kdbq studentized residuals during the Pueblo I period. Bottom panel maps Kdbq studentized residuals in the Dolores locality.

Although the residual map shows that inhabitants of the Dolores locality were close to many Kdbq quarries, only two sites have more Kdbq than predicted by the model. This variability leads us to wonder why some residents in the Dolores locality behaved differently from others in procuring and utilizing this raw material during the Pueblo I period.

The Percentage/Cost-Distance Relationship for Kbc. Figure 4.23 shows the expected negative relationship with a very weak correlation (r^2=.099; p=.274) for the relationship between the percentage of Kbc and its cost-distances in the Pueblo I period. Except for 5MV1676 in the Mesa Verde locality and four sites in the Dolores locality, other localities contain less than predicted by the model. 5MT2181 in the Dolores locality is an extreme outlier in this relationship; it is very surprising that this assemblage contains more than 20 percent of Kbc, even though other Dolores sites close to the sources have much less. As we saw for chalcedony and Kdbq, the negative slope, -.323, is more positive than that obtained for Kbc in the Pueblo I period (-.608). The map of the studentized residuals (Figure 4.24) again shows clearly that some inhabitants of the Dolores locality behaved differently from others in their acquisition and use of the Kbc materials during the Pueblo I period.

The Percentage/Cost-Distance Relationship for Morrison. Figure 4.25 shows the expected negative relationship with a relatively weak correlation (r^2=.085; p=.312) between the percentage of Morrison materials and the cost-distances for these materials in the Pueblo I period. The residual analysis shows 5MT948 in the McElmo-Yellowjacket and 5MV1676 in the Mesa Verde locality as outliers. The negative slope,

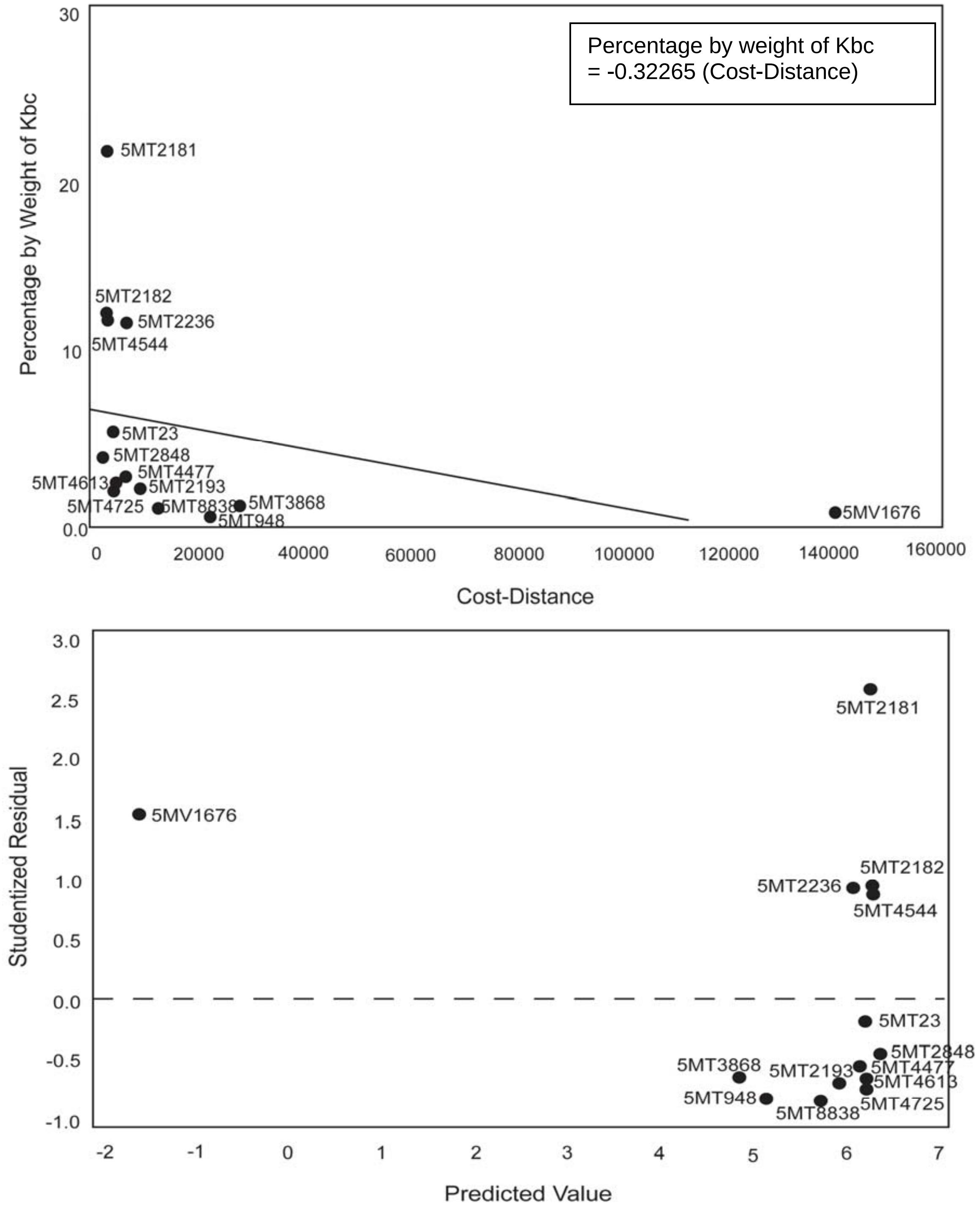


Figure 4.23. The top panel shows the Pueblo I Kbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

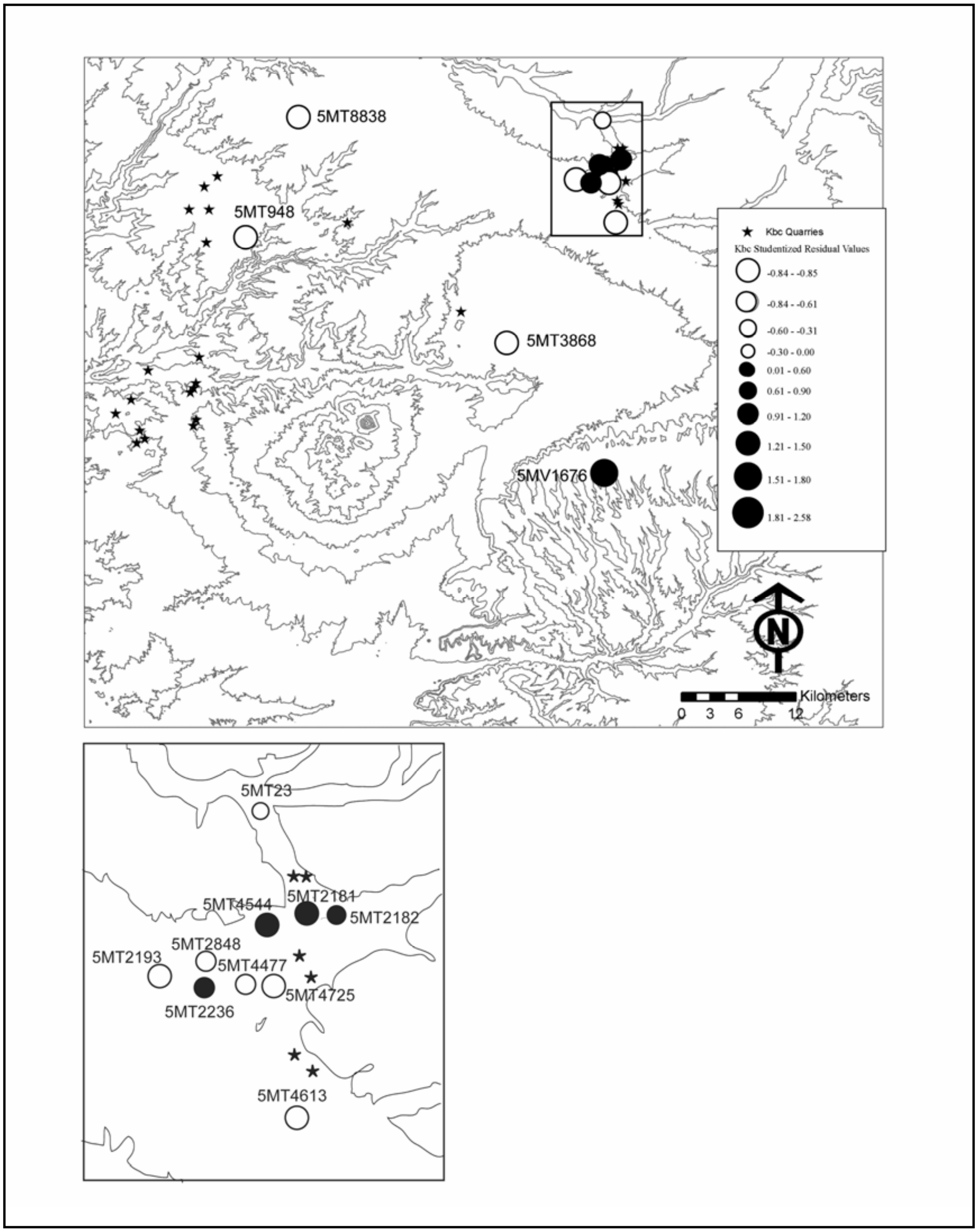


Figure 4.24. Map of Kbc studentized residuals during the Pueblo I period. Bottom panel maps Kbc studentized residuals in the Dolores locality.

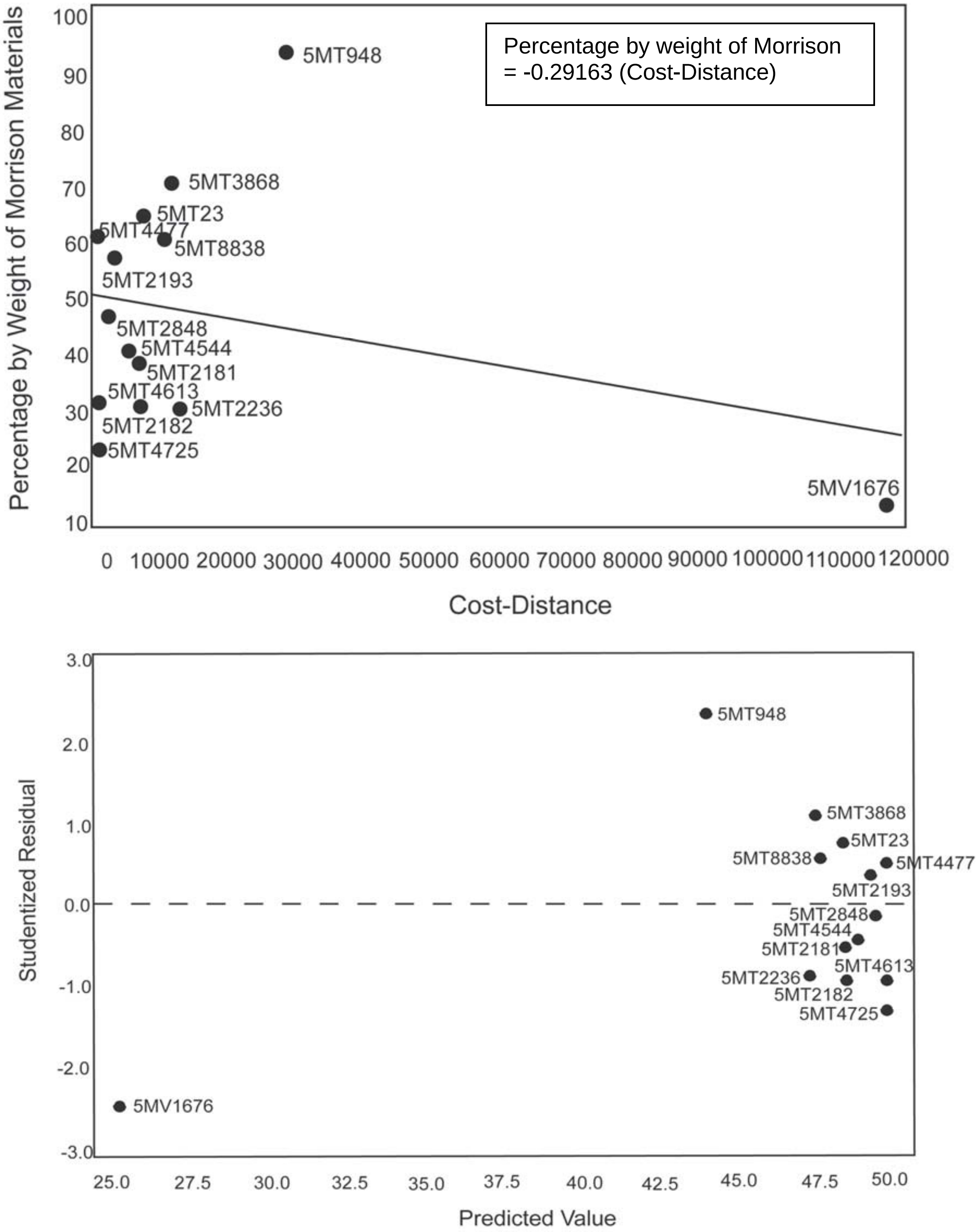


Figure 4.25. The top panel shows the Pueblo I Morrison percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

-.292, is again more positive than that obtained for Morrison in the Basketmaker III period (-.424). Figure 4.26 shows two interesting patterns. First, all inhabitants of Hovenweep and McElmo-Yellowjacket localities used more Morrison than would be expected based on this model. The Dolores sites, though uniformly close to Morrison source areas, display different residual values for the procurement and utilization of Morrison materials.

The Percentage/Cost-Distance Relationship for Jmbc. Although only five sites contained Jmbc material during the Pueblo I period, the regression analysis shows a negative relationship with a very weak correlation (r^2=.043; p=.477 [Figure 4.27]). The negative slope, -.207, for the relationship between percentage by weight of Jmbc and cost-distance is as predicted, but is unlike the significant positive slope (.475) we obtained for Jmbc in the Basketmaker III period. 5MT948 in the Hovenweep locality contains the largest percentage of Jmbc and contributes to this negative slope (Figures 4.27 and 4.28). Although 5MT948 and 5MT8838 are about equidistant from the nearest Jmbc source, it was relatively common only at 5MT948.

The Percentage/Cost-Distance Relationship of Igneous. The sources of igneous rocks are fairly confined in this region, available only in the southern portions of this study area. Figure 4.29 shows a moderate and significant negative correlation between percentage and cost-distance (r^2=.437; p<.01) for this material type. The negative slope, -.661, is similar to, though more positive than, that obtained for igneous in the Basketmaker III period (-.861). As Figure 4.30 shows, 5MV1676 in the Mesa Verde

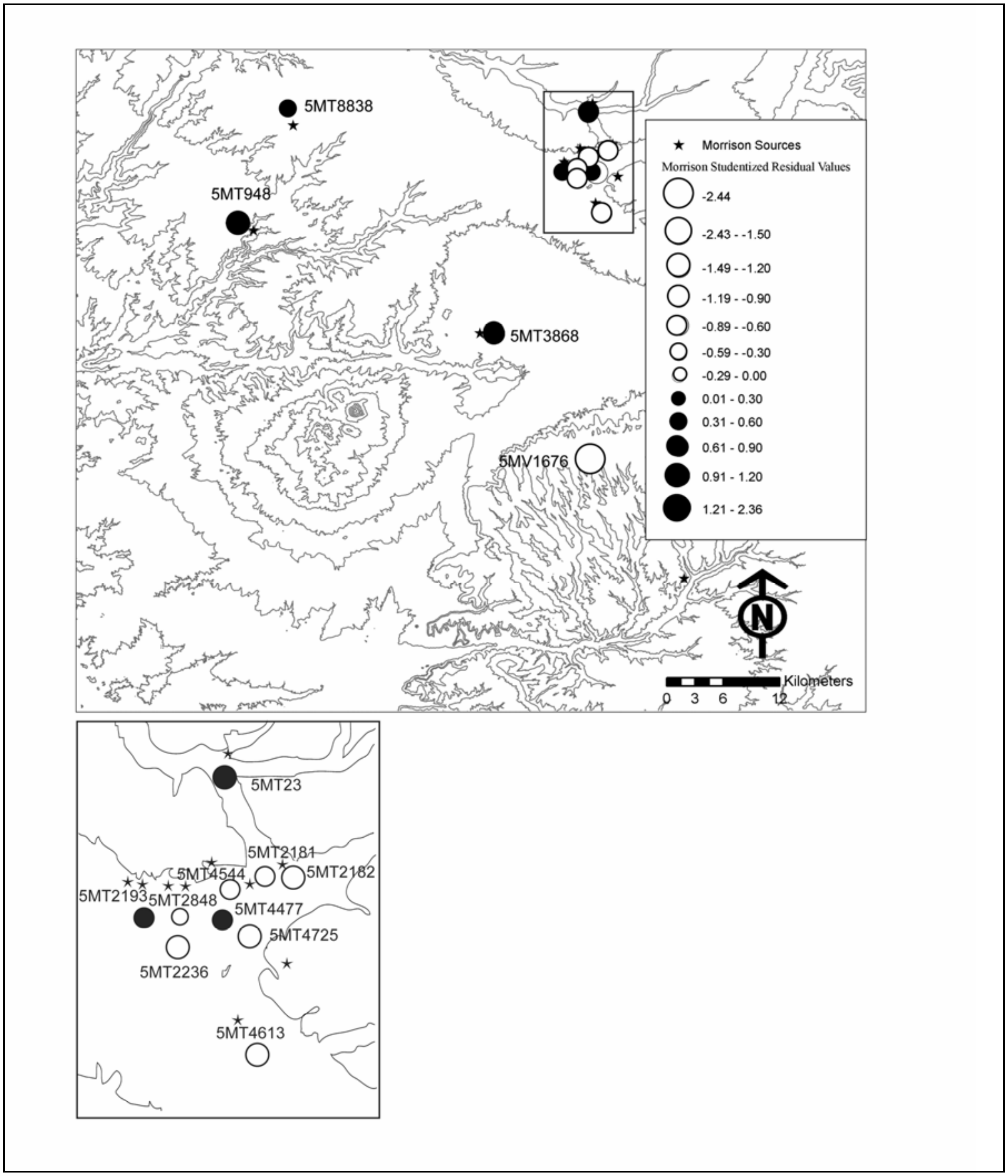


Figure 4.26. Map of Morrison studentized residuals during the Pueblo I period. Bottom panel maps Morrison studentized residuals in the Dolores locality.

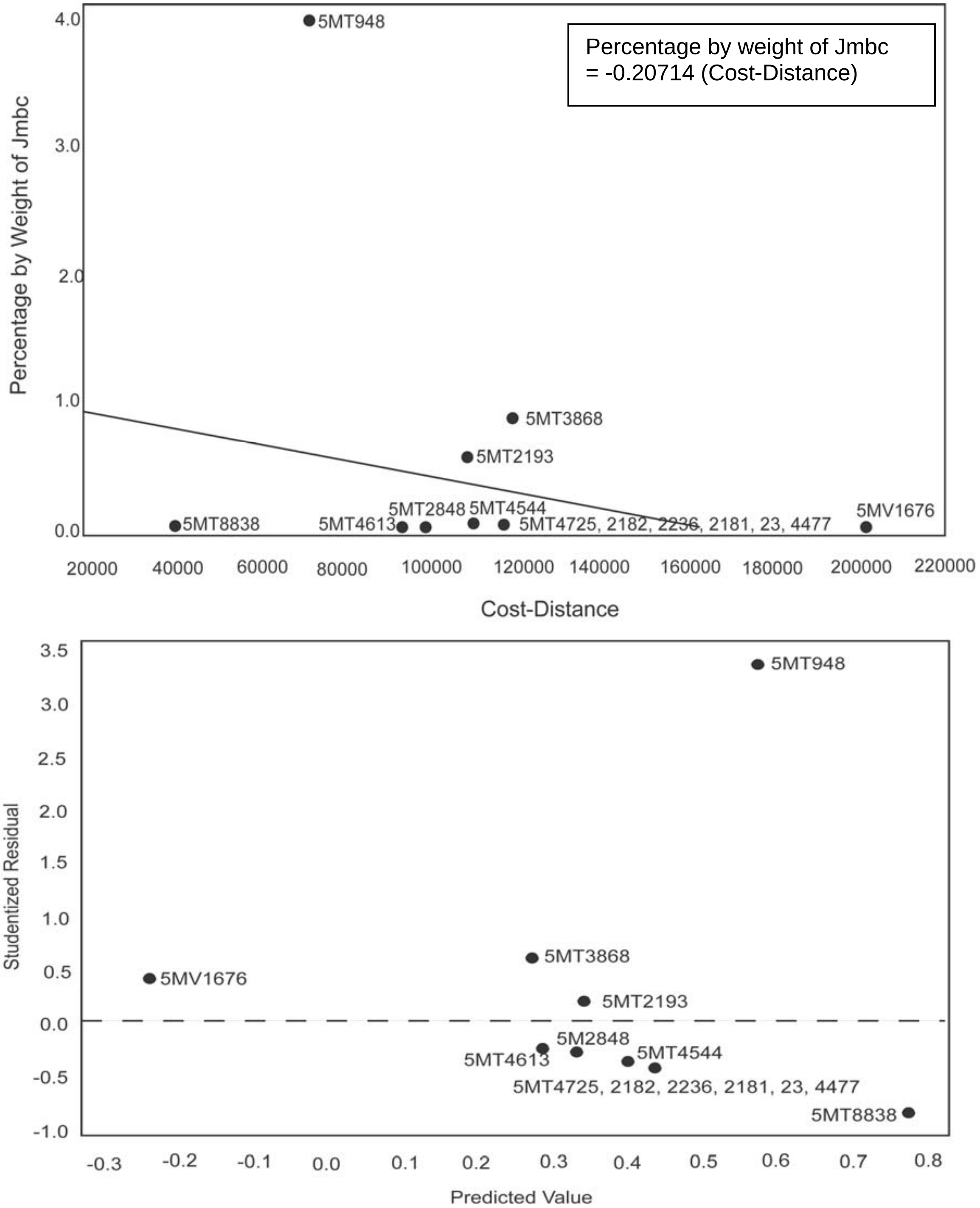


Figure 4.27. The top panel shows the Pueblo I Jmbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

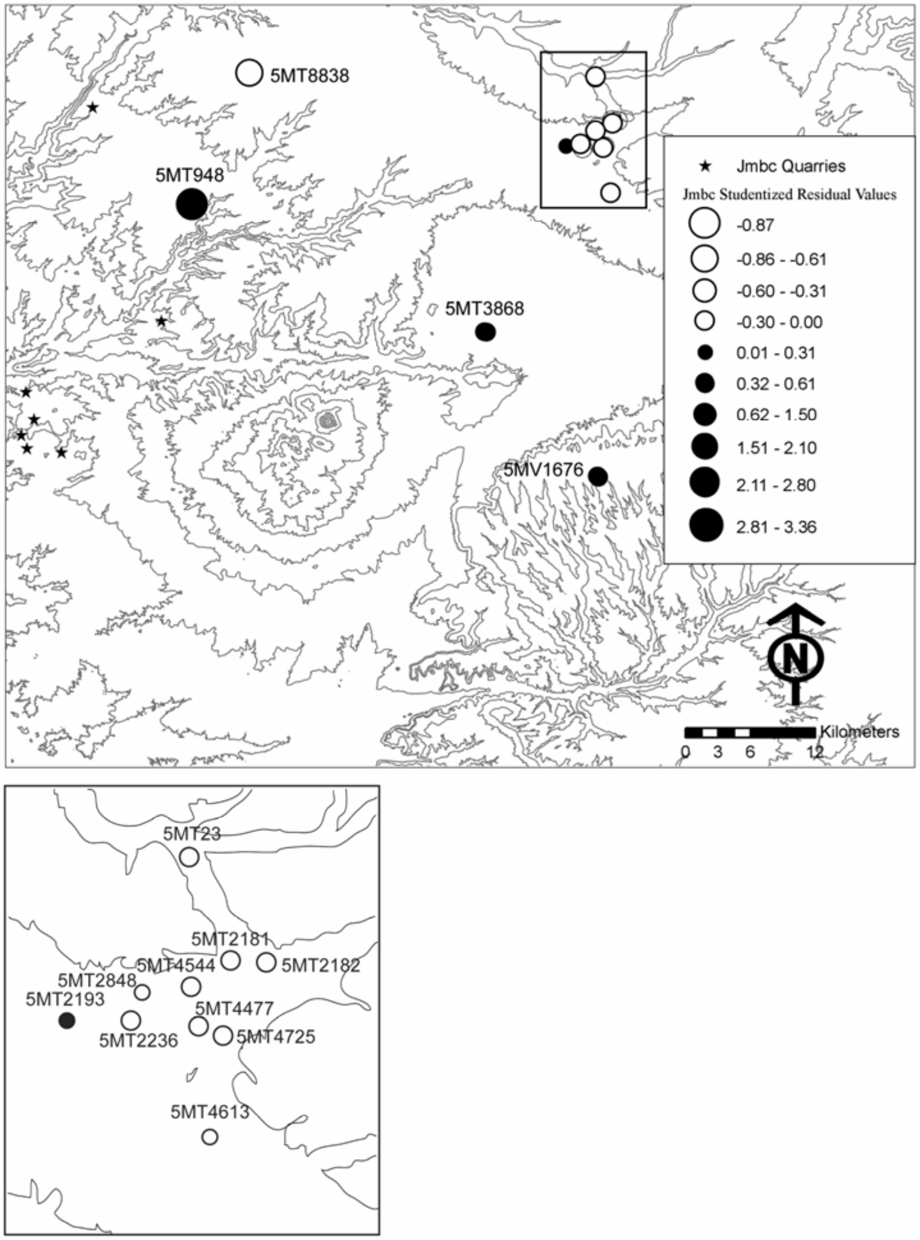


Figure 4.28. Map of Jmbc studentized residuals during the Pueblo I period. Bottom panel maps Jmbc studentized residents in the Dolores locality.

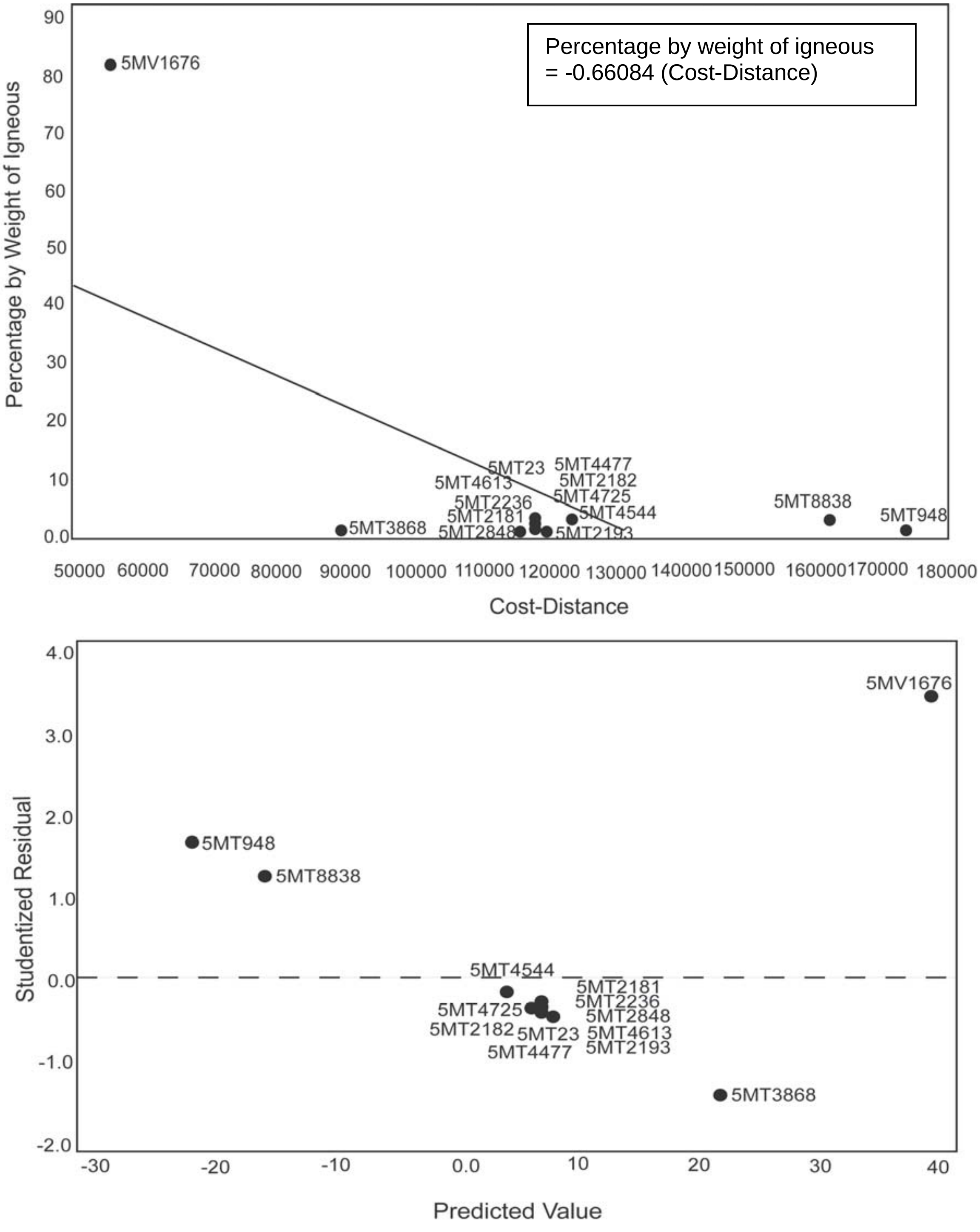


Figure 4.29. The top panel shows the Pueblo I igneous percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

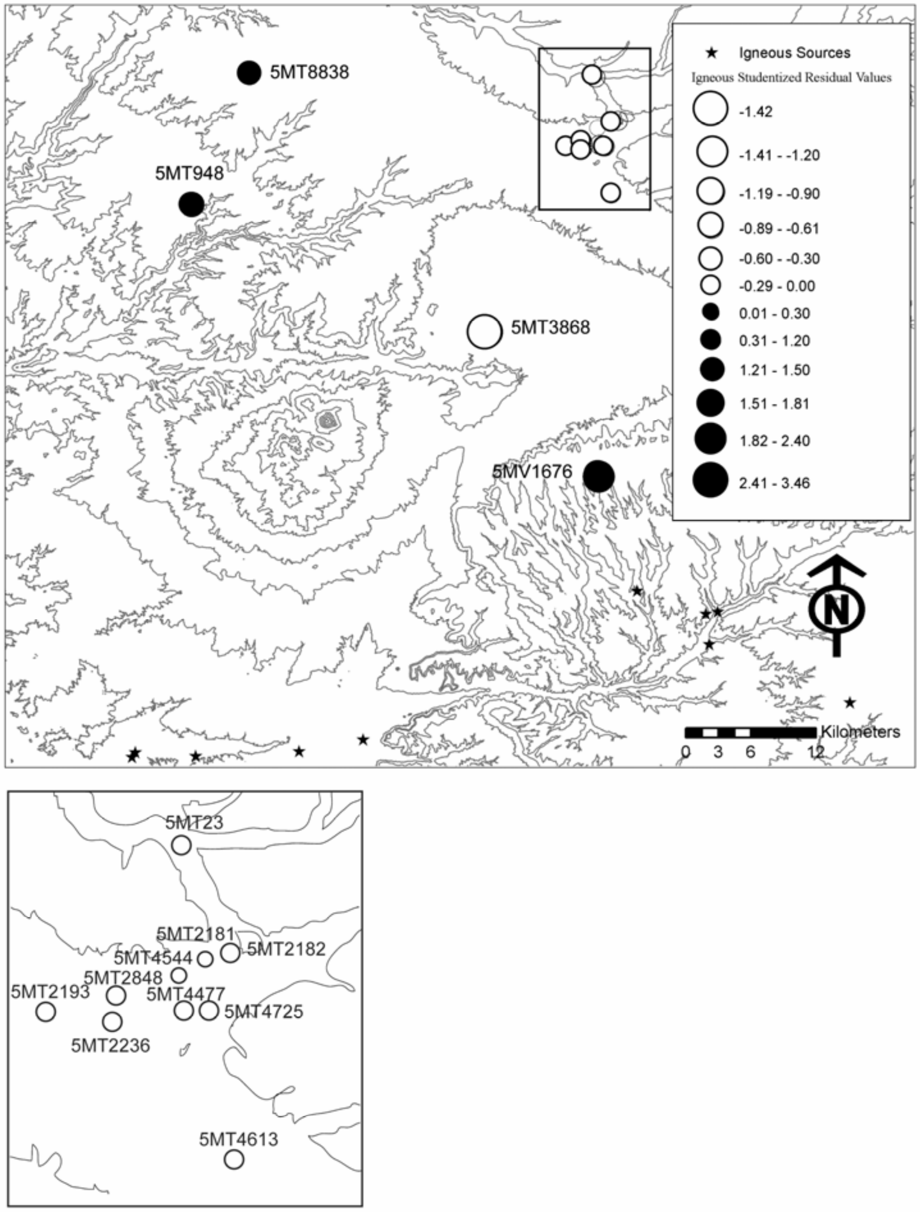


Figure 4.30. Map of igneous studentized residuals during the Pueblo I period. Bottom panel maps igneous studentized residuals in the Dolores locality.

locality has more than the predicted amount of igneous materials. 5MT8838, which is the farthest site from the igneous sources, also contains more of this material than predicted by the model.

In the Pueblo I period, all of the relationships between the proportion of materials and their cost-distances are negative, though most of those negative relationships are not statistically significant. For the Pueblo I period, Kdbq behaved like most other materials in displaying an insignificant negative relationship between cost-distance and proportion. Next I investigate what that means by cross tabulating the assemblages with much more, and much less, Kdbq than expected given the linear relationships shown in Figure 4.21.

Pueblo I Direct vs. Indirect Procurement Patterns for Kdbq

I investigated whether assemblages above or below the best-fit regression model are significantly different from each other with respect to flake attributes that might indicate how these materials ended up at the sites. As previously discussed, I contrasted flake attributes from assemblages with studentized residuals greater than |0.4| (Figure 4.21).

Table 4.2 shows the results of Fisher's Exact Tests for cortex amount tabulated against these assemblages. Cortex amounts are not significantly different for these two groups of assemblages ($p \leq 0.753$). In the category of non-cortex amount, assemblages above retain a slightly larger percentage than assemblages below. Based on these comparisons and considerations of the original assemblages, this analysis shows that all assemblages with more Kdbq than expected are from the Hovenweep, McElmo-Yellowjacket, and Mesa Verde localities, whereas all assemblages with fewer Kdbq than

Table 4.2. Fisher's Exact Test for the Kdbq Cortex Amount in Pueblo I Assemblages Where Kdbq is More Common, and Less Common, Than Expected.

		Cortex Amount				
		none	≤50%	50-100%	100%	*n*
More Kdbq than expected from regression on distance[a]	Row Percentage	70.67	20.67	6.67	2.00	150
Less Kdbq than expected from regression on distance[b]	Row Percentage	68.83	23.38	7.79	0.00	77
	Total (*n*)	159	49	16	3	227

Fisher's Exact Test $p \leq 0.7525$

[a] flakes from assemblages with studentized residuals >.4 in Figure 4.21.

[b] flakes from assemblages with studentized residuals <-.4 in Figure 4.21.

expected are from only the Dolores locality. The Dolores inhabitants probably engaged in testing or modifying Kdbq at other areas, such as fieldhouses, lithic activity areas, or quarries and brought back dorsal flakes with cortex. On the other hand, residents of Hovenweep, McElmo-Yellowjacket, and Mesa Verde would have procured this material type by trade in addition to direct procurement.

Summary of the Percentage/Cost-Distance Relationship

As for the Basketmaker III, I now summarize the correlation between the percentages and cost-distances using three broad raw material categories – high-, medium-, and low-quality. The percentage/cost-distance relationship for all the high-quality materials (chalcedony, Kdbq, and Kbc) shows an extremely weak negative correlation. One striking pattern in these analyses is that the residuals for assemblages within the Dolores locality show very different use patterns for high-quality materials, even though their quarries are quite close to all Dolores habitations. Except for the procurement of Kdbq, assemblages from the Dolores locality weaken the fit of most models. The variability among Pueblo I Dolores sites suggests that social structures (e.g., hunting territories and exchange systems) may have affected the procurement and use of high-quality materials. This may further support the possibility that different ethnic groups existed in the Dolores locality during the Pueblo I period (Wilshusen and Ortman 1999).

The low-quality material, Morrison, shows a very weak negative relationship between its percentage and its cost-distance. Although assemblages from Hovenweep and McElmo-Yellowjacket show relatively large residuals of Morrison materials, assemblages within the Dolores locality show differing residuals for Morrison materials. Again, this pattern suggests that inhabitants within the Dolores locality behaved quite differently in their procurement and utilization of Morrison materials, even though the sources of this material are ubiquitously distributed in this locality. This further suggests that the Dolores residents may have developed territoriality within this landscape in conjunction with aggregation.

The study of the medium-quality materials (Jmbc) suggests that one site (5MT948, which is a relatively close to source) dominated use of this material type during the Pueblo I period. Interestingly, although 5MT8838 is also relatively close to the sources, it does not contain a large percentage by weight of Jmbc. The regression analysis of igneous materials shows a relatively strong correlation between the percentage and cost-distance. Even though 5MT8838 and 5MT948 sites in the Hovenweep locality are the farthest away from igneous sources, they showed surprisingly positive residuals of igneous materials. In the next section, the analysis of energy-expenditure models shows this pattern more explicitly.

The Energy Expenditure Model

Here again, I calculate the energy-expenditure model for all Pueblo I assemblages, by multiplying the percentage by weight of each of the 10 raw material types, which as discussed in chapter 2, is the cost of traveling to its source from that site. Figure 4.31 maps energy expenditures from Pueblo I sites, by site. The Mesa Verde inhabitants expended the most energy in acquiring and using raw materials, followed by residents of Hovenweep and McElmo-Yellowjacket. The Dolores inhabitants expended the least energy in procuring raw materials because most of the suitable high-, medium-, and low-quality materials are located very close to their habitations. Interestingly, Dolores residents expended rather variable amounts of energy; for example, people in many small sites (5MT2236 and 5MT2848) expended relatively small amounts of energy, whereas inhabitants of the villages, for instance 5MT2182, expended relatively large amounts of energy in procuring raw materials. This suggests that the Dolores villagers may have had more frequent mobility and/or access to large territories than the people who lived in hamlets in this landscape, although it is important to take into account the time difference during the Pueblo I period (about 200 years span). During the Pueblo I period, some of the smaller sites in the Dolores locality are dated earlier. In contrast, when the population was more concentrated and developed a village in the locality, this occurred in the later Pueblo I period. This difference, however, implies that the villagers in the later Pueblo I period had more social, political, and economic power than the people who inhabited smaller households in the earlier period.

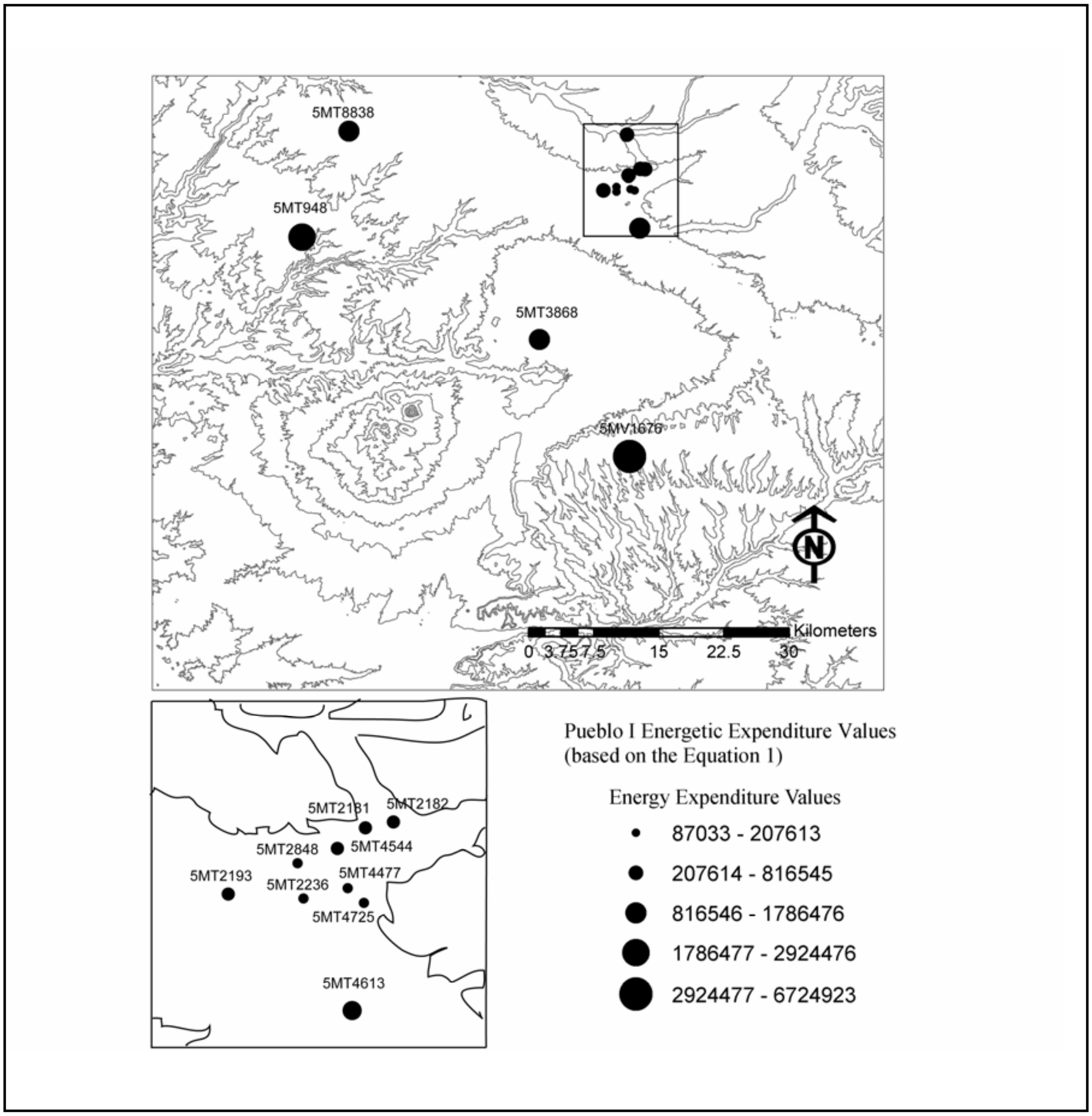


Figure 4.31. Energetic expenditure values for sampled Pueblo I sites in the central Mesa Verde region.

The Energy Expenditure Map

Using kriging interpolation in the ArcGIS program (Appendix A), I then created an isopleths map of the total energy expended by the Pueblo I residents (Figure 4.32). Virtually similar to energy-expenditure values shown by Figure 4.31, this map shows that the Pueblo I inhabitants in the Dolores locality expended much less energy in procuring raw materials; in contrast, the people in Mesa Verde and Ute expended more energy in their toolstone procurements. Comparing this map with the isopleths map of the Basketmaker III period, high energy-expenditure values are more ubiquitously distributed in the landscape during the Pueblo I period. Additionally, unlike the Basketmaker III period, Figure 4.32 does not show what I interpreted as two different macrobands or a possible territorial boundary within the McElmo-Yellowjacket locality.

Next, to identify where the central Mesa Verde inhabitants expended more or less energy in procuring raw materials as time passed, from Basketmaker III to Pueblo I, I created a difference map in ArcGIS. To do this, I clipped the Basketmaker III raster map (created from the energy-expenditure values) by the Pueblo I map, since the study area of the Pueblo I isopleths map was smaller than that of the Basketmaker III period. Then, I used raster calculation to subtract the Pueblo I map from the Basketmaker III map. Figure 4.33 shows the result of this calculation. The dark yellow indicates the largest decreases in energy expenditures in Pueblo I; the dark red color identified areas where Pueblo I residents tended to expend more energy in acquiring their lithic assemblages than had the Basketmaker III inhabitants. In short, the difference map shows that Pueblo I inhabitants expended more energy in procuring raw materials on the western margins of the McElmo-Yellowjacket locality, and slightly less energy in the Dolores and Mesa

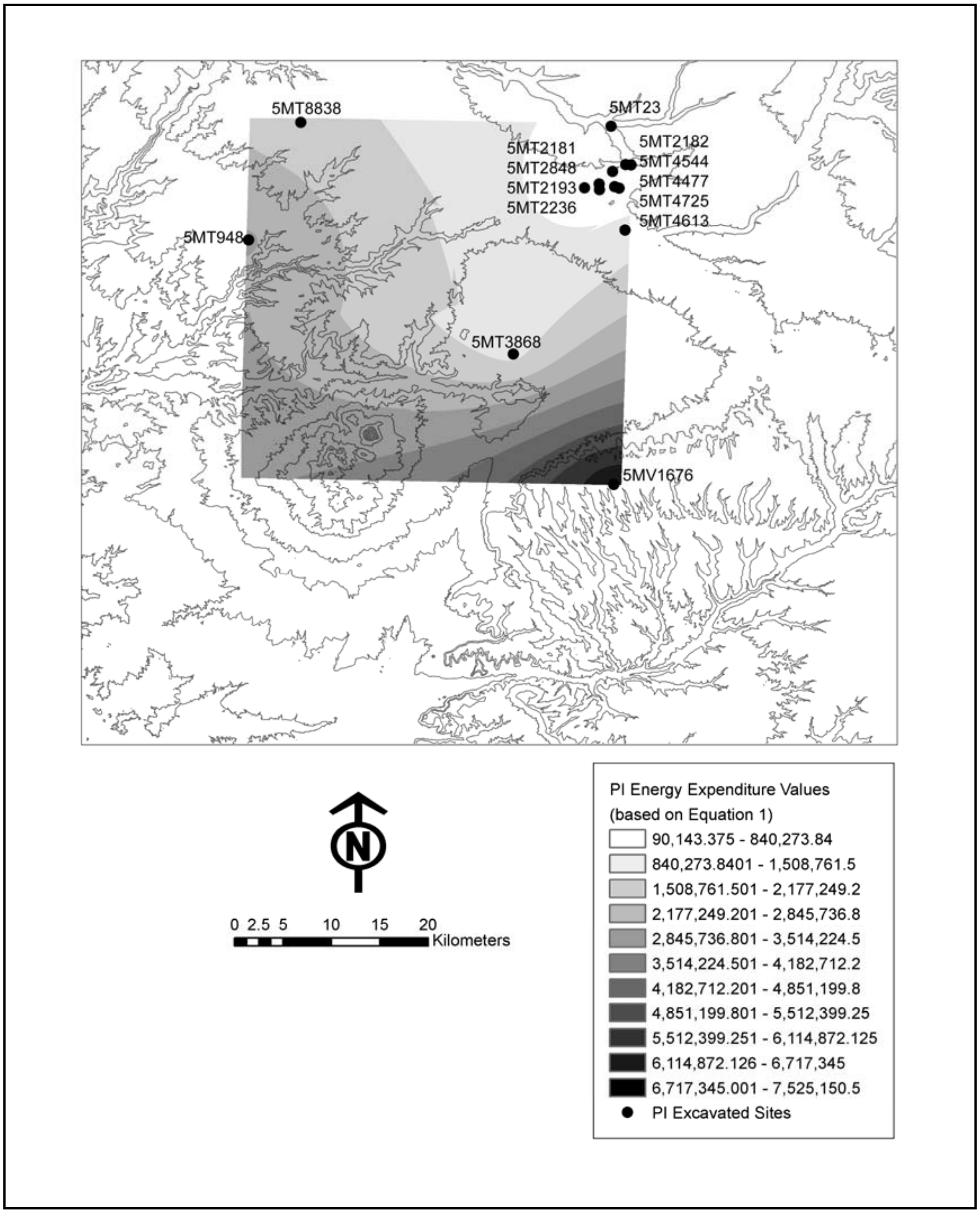


Figure 4.32. A kriged map that interpolates, across our region, the total energy-expenditure values for acquiring toolstone for the sampled Pueblo I sites.

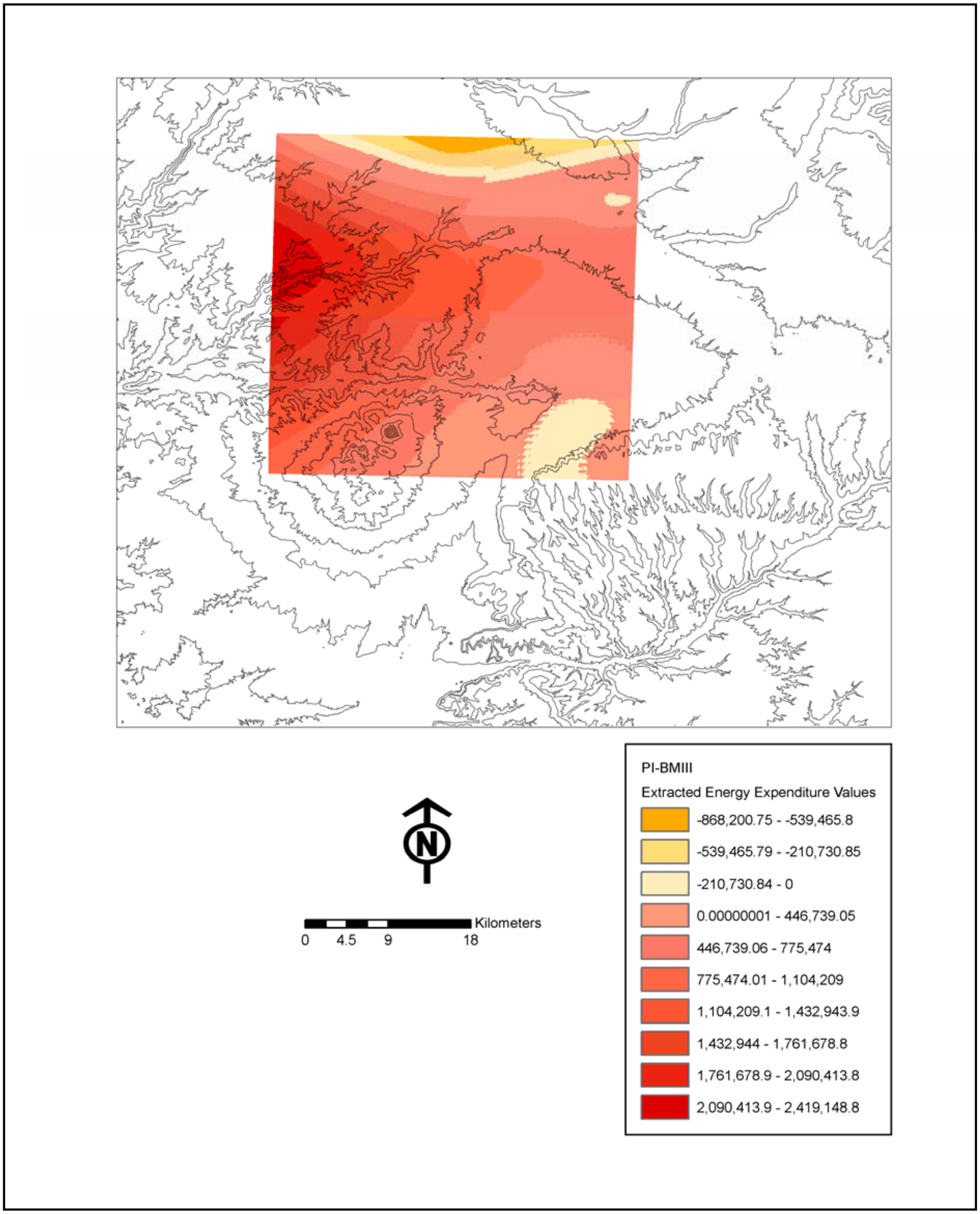


Figure 4.33. A difference map showing areas where the energy expenditure values for acquiring toolstone increased, or decreased, in Pueblo I sites relative to Basketmaker III sites.

Verde areas. Because there are more positive values in the extracted area, the Pueblo I residents appear in general to have expended more energy in toolstone procurement than did the Basketmaker III inhabitants. This suggests further that the Pueblo I lithic assemblages became more expensive because the Pueblo I inhabitants, for example, may have had to cover a much larger area in order to hunt large animals (deer) than did the Basketmaker III residents. Cowan et al. (2006) demonstrate that deer became severely depleted during the Pueblo I period; thus, the Pueblo I people encountered difficulties in supporting population levels given their resources. This condition led the Pueblo I inhabitants to cover and move over large areas in this landscape.

Summary of the Pueblo I Period

During the Pueblo I period, population was higher than in Basketmaker III (approximately 5,000). Resource productivity was generally stable and virtually identical to the Basketmaker III period ($\bar{x}$=255.83 kg/ha per year), but resource predictability was greater than that of the Basketmaker III period (S.D.=42.87 kg/ha per year). Toolstone procurement patterns of this period showed some differences from the Basketmaker III period. The percentage/cost-distance relationship of the Pueblo I period showed very weak correlations based on *r*-square values, and all six raw materials also showed flatter slopes than those same materials in Basketmaker III assemblages. This suggests that the Pueblo I people expended more energy and went farther in procuring raw materials because the amount of materials declines less rapidly with distance from the sources. This pattern may suggest easy accessibility, but many maps of residuals showed that there were locally variable signs (either positive or negative) and sizes (either large or small). Those imply that people living near each other had easy accessibility in different directions. Comparing the energy-expenditure models with the percentage/cost-distance relationship, the Pueblo I inhabitants seem in general to have expended more energy in procuring raw materials than those of Basketmaker III inhabitants, though there are some local exceptions. The energy-expenditure map shows that Pueblo I inhabitants had to cover a much large area. Both the percentage and cost-distance relationship and energy-expenditure models demonstrate that more energy was expended by the Pueblo I inhabitants in their toolstone procurement. According to the study by Cowan and others (2006), Pueblo I peoples confronted severe depletion of large game. This probably led the acquisition of Pueblo I lithic assemblages to appear more expensive than that of Basketmaker III assemblages, to the extent that procurement was embedded in hunting.

In terms of Dyson-Hudson and Smith's economic defensibility model, resource density was slightly more stable predictable in Pueblo I than in the Basketmaker III period. Those conditions should lead to a geographically stable territorial system by their model. However, based on lithic data, the modified distance-decay analysis showed lower slopes for all materials and slightly lower r^2 values than the Basketmaker III period. This suggests that the Pueblo I people participated in an increased dispersion and mobility system within this region, possibly traveling farther away from their residences to hunt large and/or medium animals and embedding raw material acquisition in these tasks. More detailed discussion of the economic defensibility model and the Pueblo I lithic data will be presented in chapter 7.

CHAPTER FIVE

PUEBLO II (A.D. 920-1140)

This chapter covers the Pueblo II period which is split into early and late sub-periods. For each sub-period, I discuss background regarding population estimates, resource productivity, settlement patterns, artifacts, and architecture. I then demonstrate lithic analyses including the distance-decay energy-expenditure model to understand sociopolitical organization in the central Mesa Verde region during each sub-period.

Background for Early Pueblo II (A.D. 920-1060)

After the short-lived villages developed in the Dolores locality during the Pueblo I period, inhabitants in the central Mesa Verde region migrated to where they could cultivate and consume agricultural products within and outside this region. On a macro-regional scale, a polity-like cultural, political, and religious center was established in Chaco Canyon during this period and reached its peak around A.D. 1080-1100. Although the central Mesa Verde residents participated in the development of their own socio-political organizations in the tenth and eleventh centuries, the Chaco "Phenomenon" influenced the central Mesa Verde region in multiple ways.

Population Estimate. Wilshusen noted that between A.D. 880 and A.D. 1080, the number of villages in our study area declined, stating "The density-derived estimates show an initial dip in population in early Pueblo II (A.D. 900-980) followed by regional population increases that ultimately surpass the peak Pueblo I population by A.D. 1120" (2002:118). In other words, the population dramatically decreased after A.D. 900 and gradually increased after the early 1000s in the central Mesa Verde region.

Varien et al. (2007) support Wilshusen's population estimate within the smaller "Village" study area. From A.D. 920 to 970, population density in the central Mesa Verde region decreased, but then gradually increased after A.D. 980. The population did not increase rapidly until the end of the early Pueblo II period (ca. A.D. 1060).

Resource Productivity: Figure 4.2 shows the average potential maize yield (kg/ha per year) in the early Pueblo II period. Central Mesa Verde residents obtained abundant and relatively predictable maize from A.D. 920 to 980, but experienced low maize production around A.D. 1000. Productivity gradually increased again through the late Pueblo II period.

Settlement Patterns and Social Organization. By the late tenth or early eleventh century, the Pueblo culture had expanded and the people occupied many areas where they could farm. In the larger Puebloan Southwest, the early Pueblo II period included the time of the Chaco florescence. The system had local elaboration, particularly Chaco Canyon itself in the 900s and early 1000s, but this became widespread in many other areas in the Southwest in the mid-1000s. Cordell (1997:305) used the term, "the regional integrated system," but it is also known as the Chaco Phenomenon. Settlement was hierarchically organized, and large amounts of territory were also structured for producing, distributing, and exchanging goods (Cordell 1997:305). The center of the regional system was the sophisticated and complex organization of Chaco Canyon, New Mexico. Characteristics of the Chaco system included great houses, great kivas, intensive agriculture, and extensive exchange networks. Archaeologists have used the term "Chaco outliers" to describe those areas having similar architectural and material remains found in many communities within Chaco society (Judge 1979:901). Chaco outliers are distributed in numerous areas, such as Aztec and Salmon Ruin, New Mexico and Lowry Ruin (Kendrick and Judge 1996; Martin 1936), Wallace Ruin (Bradley 1988), and Escalante Ruin (Hallasi 1979) in the central Mesa Verde region.

Most of the early Pueblo II archaeological data for the central Mesa Verde region was derived from several cultural resource management projects. Fetterman and Honeycutt (1987) surveyed Mockingbird Mesa from 1981 to 1984. This project was designed to record and preserve cultural resources, and used ceramic typology to identify and classify temporal site types. Based on their survey, 83 percent of the ancestral Puebloans on Mockingbird Mesa including some of the early Pueblo II habitations inhabited the mesa top where deep and arable soils were available (Fetterman and Honeycutt 1987:71).

Other cultural resource projects that covered the early Pueblo II period include the Sacred Mountain Planning Unit Survey (Chandler et al. 1980), the Bureau of Reclamation's Four Corners Archaeological Project (Hurley 1998), and surveys and excavations by Crow Canyon Archaeological Center (Adler 1990; Duff and Ryan 2000). The Wetherill Mesa Project (Badger House [Hayes and Lancaster 1975] and Two Raven House [Hayes 1984]) provided crucial information about the early Pueblo II sites in Mesa Verde National Park.

Based on those cultural resource reports, communities continued to consist of dispersed clusters of one or more habitation units (also called Prudden units [Prudden 1918]). Several great kivas that served as community gathering places also were used in this study area during the early Pueblo II period. Artifactual data indicate that there was more interregional exchange during this period than in Pueblo III periods (Neily 1983; Arakawa and Duff 2002).

Previous Research on Early Pueblo II Period Ceramic and Lithic Assemblages

Ceramic Data. In the early Pueblo II period in this area, ceramics included Cortez Black-on-white, Mancos Black-on-white, Mancos corrugated, and Mancos neckbanded sherds (Fetterman and Honecutt 1987:61). Corrugated gray types appeared early in the Pueblo II period, and the Mesa Verde corrugated style became widespread around A.D. 930 in the central Mesa Verde region (Pierce 1999; Wilson and Blinman 1991:45). Wilson and Blinman (1991) noted that gray wares in this period were dominated by Mancos Gray or Mancos corrugated sherds, Moccasin Gray, and some Chapin Gray. At the beginning of the early Pueblo II period, Cortez Black-on-white was the dominant whiteware type in the central Mesa Verde region, whereas Mancos Black-on-white became common later. Deadman's Black-on-red is the most important redware type, but Bluff Black-on-red is still plentiful during this period (Wilson and Blinman 1991:45).

Lithic Data. Technologically, some of the chipped stone tools, particularly projectile point types, differed from those of the previous periods. Bruce Bradley defined typical early Pueblo II projectile point styles as small, corner-notched arrow points with a slightly convex base and a narrow stem; the stem was distinct from the large contracting stem of the Pueblo I period (Bradley 1988:23; Lipe and Varien 1999a:261). Bradley (1988:23) and other researchers (Ellis 1998; Irwin 1993) have noted that most of the projectile points were made of local materials, but a few were from non-local sources, such as obsidian and Narbona Pass chert from New Mexico and jasper from southeast Utah.

Architecture. Major attributes of the early Pueblo II architecture are surface rooms with kivas and the influence of Chaco architecture of core and veneer stone walls, appearing around A.D. 1100 in this region in some sites (Lipe and Varien 1999a:263). Lipe and Varien (1999a:262) described three major changes in kiva structures during the Pueblo II period. Kiva architecture generally changed as follows:

> 1) from unlined to masonry lined;
> 2) from four posts set in the wall or bench to four masonry pilasters set on the bench to six masonry pilasters set on the bench; and
> 3) from no southern recess or a short rounded southern recess to a deep, well-defined keyhole-type southern recess (Lipe and Varien 1999a:262).

Lekson (1988) and Lipe and Hegmon (1989) argue that the utilization of these small kivas was different from the ceremonially specialized utilization of kivas among the Eastern Pueblos during the Pueblo IV and historic periods. They present evidence that kivas in this region were utilized for both ritual and domestic purposes.

Current Perspectives on Early Pueblo II Assemblages

Figure 5.1 shows the 10 well-dated early Pueblo II habitation sites in the study area from which lithic assemblages were analyzed for this study. Three sites – 5MT8836, 5MT8827, and 5MT8839 – are in the Hovenweep locality, while 5MT4477 is in the Dolores locality. Four sites – 5MT8371, 5MT2433, 5MT1786, and 5MT11555 – are in the McElmo-Yellowjacket locality. Two sites – 5MV1645 and 5MV1452 – represent lithic assemblages from the Mesa Verde locality. In the next section, I present patterns in the percentage/cost-distance relationships, direct/indirect procurement patterns, and

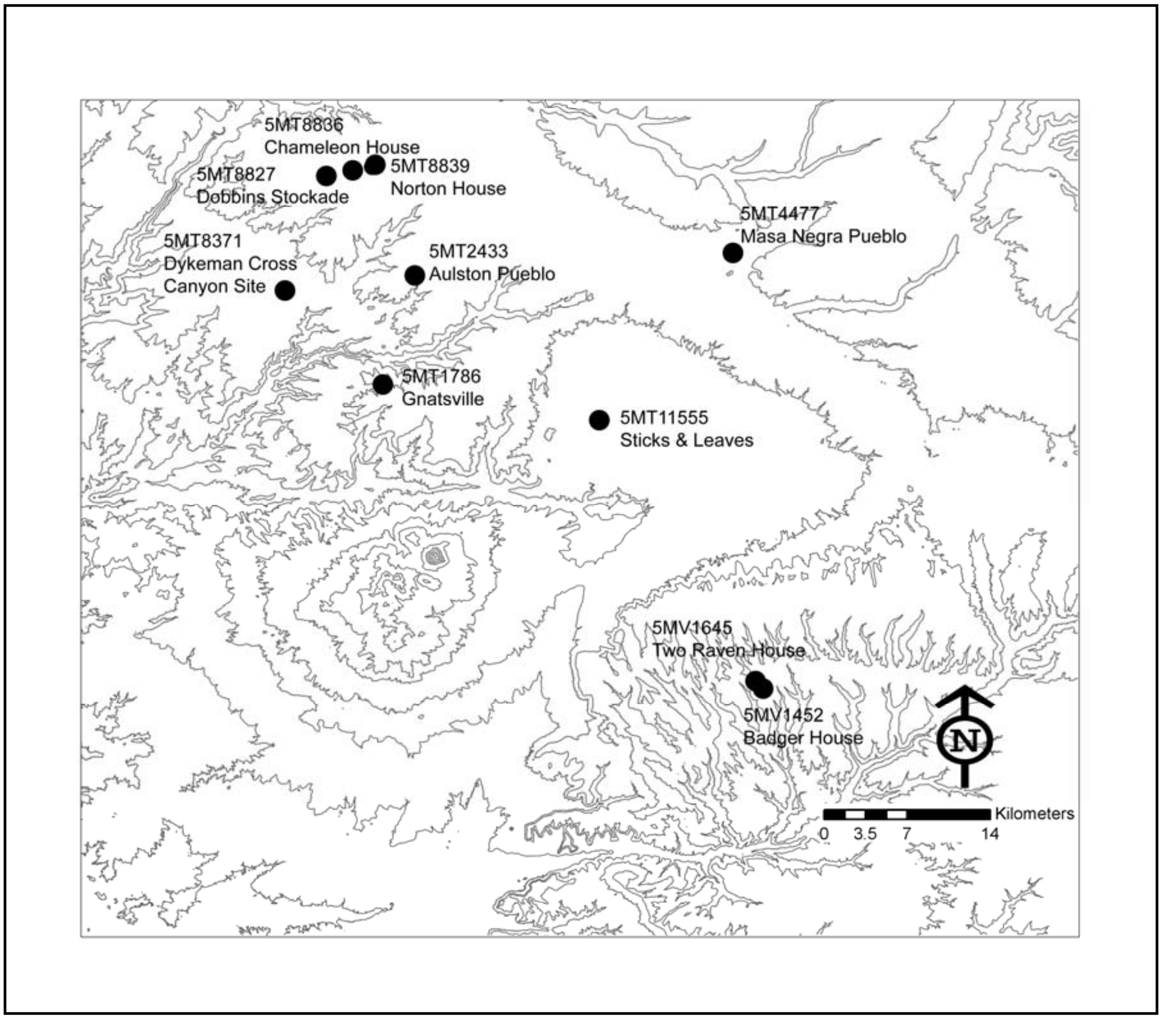


Figure 5.1. Early Pueblo II habitation sites.

energy expenditures to explore what information they may contain on sociopolitical organization during the early Pueblo II period in this region.

The Percentage/Cost-Distance Relationship for Chalcedony. Figure 5.2 shows the linear regression and residual analysis for early Pueblo II chalcedony. This shows a negative linear relationship with a moderately weak correlation (r^2=.112; p=.344). The residual analysis shows 5MT8836 and 5MT8827 in the Hovenweep locality, 5MT8371 in the McElmo-Yellowjacket locality, and 5MT4477 in the Dolores locality to be the furthest outliers from the expected negative relationship. The negative slope, -.233, is similar to that obtained for chalcedony in the Pueblo I period (-.222). Figure 5.3 maps the studentized residuals for chalcedony and shows that inhabitants of 5MT4477 utilized more chalcedony than would be expected given the cost-distance of its sources. Interestingly, Badger House (5MV1452) residents in the Mesa Verde locality also used more chalcedony than expected even though they lived farthest away from the quarries in this region.

The Percentage/Cost-Distance Relationship for Kdbq. Figure 5.4 shows the relationship in early Pueblo II for percentage representation and cost-distance for Kdbq. As for chalcedony, there is a moderately weak negative relationship (r^2=.179; p=.223) between the cost-distance and the percentage of Kdbq. The negative slope, -.418, is considerably steeper than that obtained for Kdbq in the Pueblo I period (-.068). Figure 5.5 shows that two assemblages – 5MT8839 and 5MT8836 in the Hovenweep locality – are extreme outliers in this relationship; both contained more Kdbq than would be expected. Since the distance from those sites to the closest quarry is relatively far, we

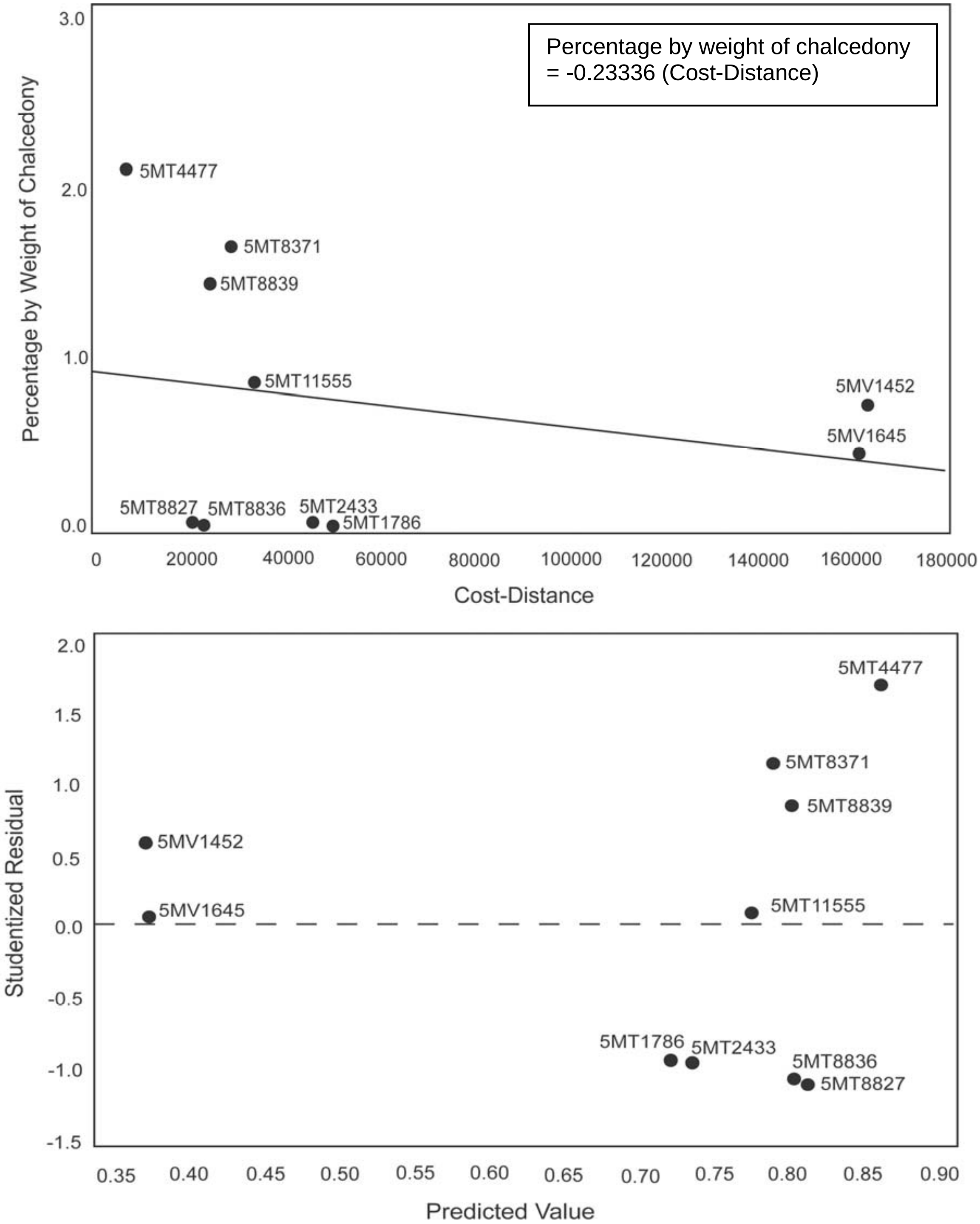


Figure 5.2. The top panel shows the early Pueblo II chalcedony percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

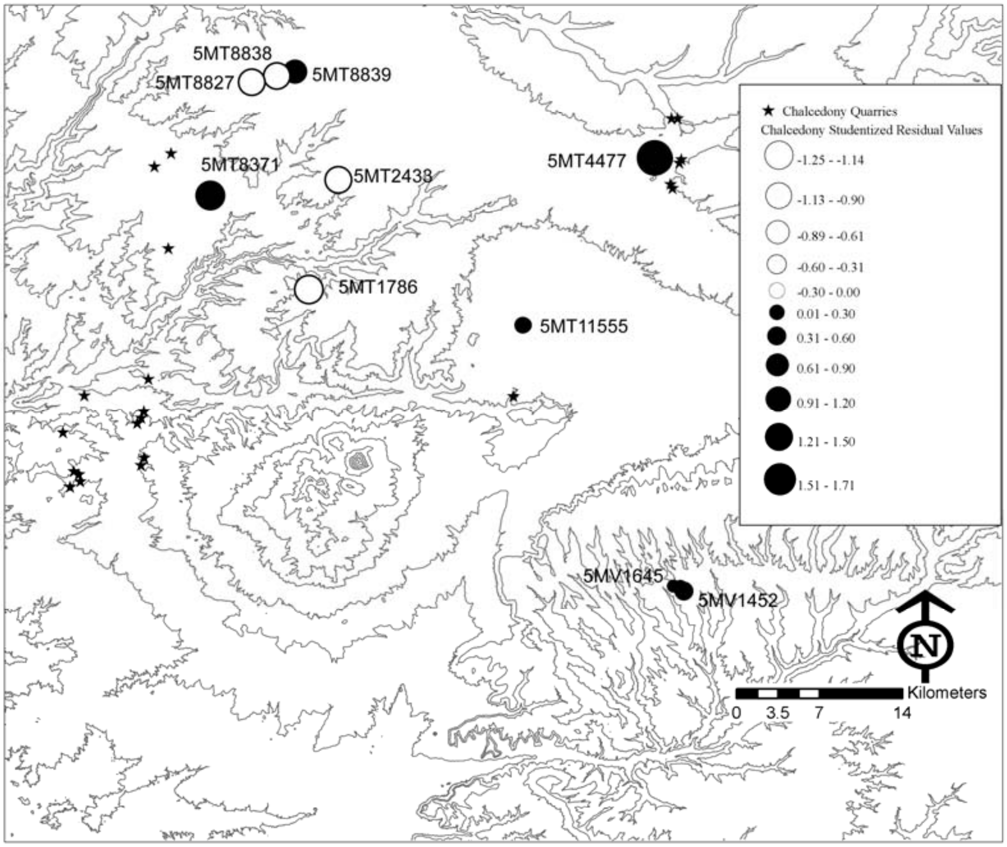


Figure 5.3. Map of chalcedony studentized residuals during the early Pueblo II period.

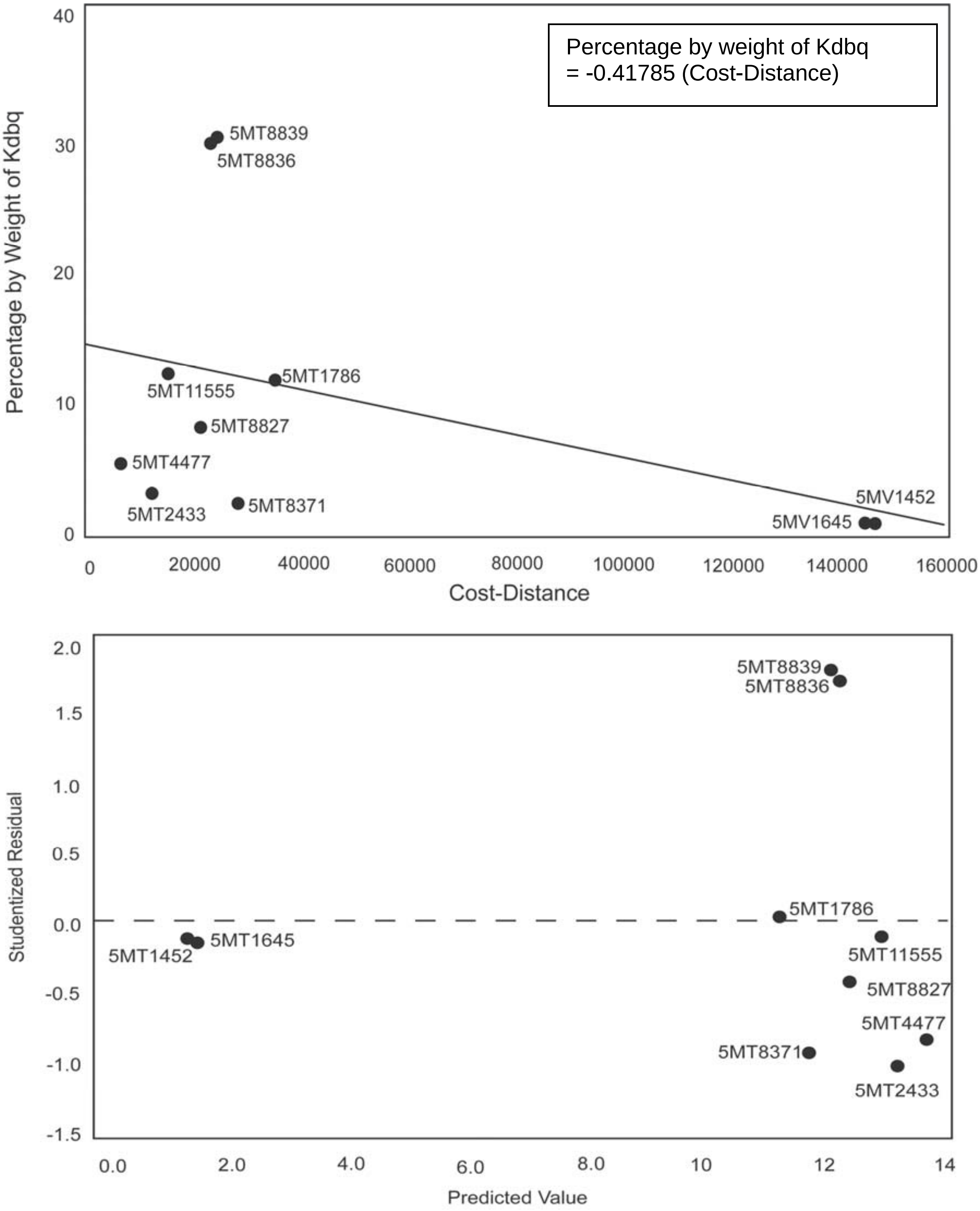


Figure 5.4. The top panel shows the early Pueblo II Kdbq percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

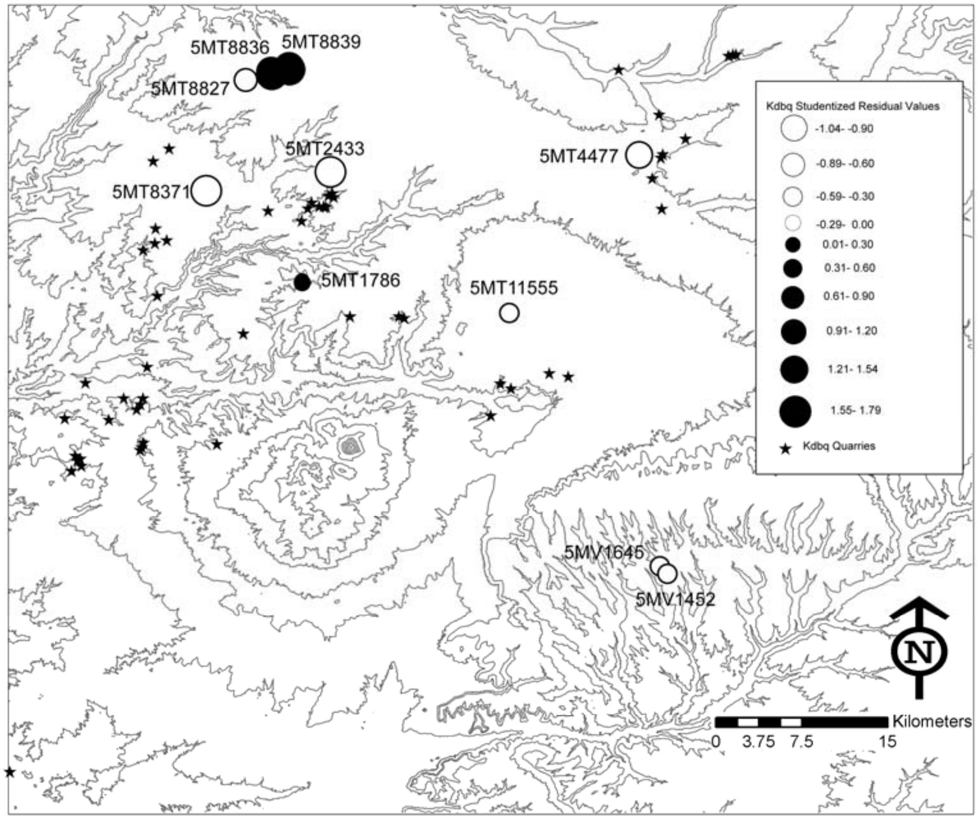


Figure 5.5. Map of Kdbq studentized residuals during the early Pueblo II period.

can consider two possibilities. First, inhabitants of those sites may have traded for this high-quality material with residents who lived closer to the quarries. Second, perhaps Kdbq quarries exist within the Hovenweep locality that has not yet been identified. The nearby 5MT8827, however, displays a value similar to that expected if Kdbq were far away. This suggests that there are no missing Kdbq quarries in the Hovenweep locality. Another intriguing result from my quarry survey is that there are numerous Kdbq quarries in the Dolores locality. Despite this, residents of Masa Negra Pueblo (5MT4477) used less of this material than expected during the early Pueblo II period.

The Percentage/Cost-Distance Relationship for Kbc. Although the percentage by weight of Kbc is relatively small, the regression (Figure 5.6) shows the expected negative relationship with a very weak correlation (r^2=.019; p=.702). The negative slope, -.232, is slightly more positive than that obtained for Kbc in the Pueblo I period (-.323). The two sites with the largest residuals are 5MT4477 in the Dolores locality and 5MT1786 in the McElmo-Yellowjacket locality. Figure 5.7 shows that inhabitants in 5MT4477, who lived very close to several Kbc source sites, procured and used this material even more than expected. Gnatsville (5MT1786) residents used surprisingly large amounts of Kbc, even though they had to cross some steep canyons to obtain it. In the Hovenweep locality, 5MT8836 inhabitants also used more Kbc than would be expected given the cost-distance of its sources. Inhabitants of 5MT8839 and 5MT8827, also in the Hovenweep locality, used less Kbc than would be expected. This suggests that residents within this locality had different procurement patterns for Kbc during the early Pueblo II period.

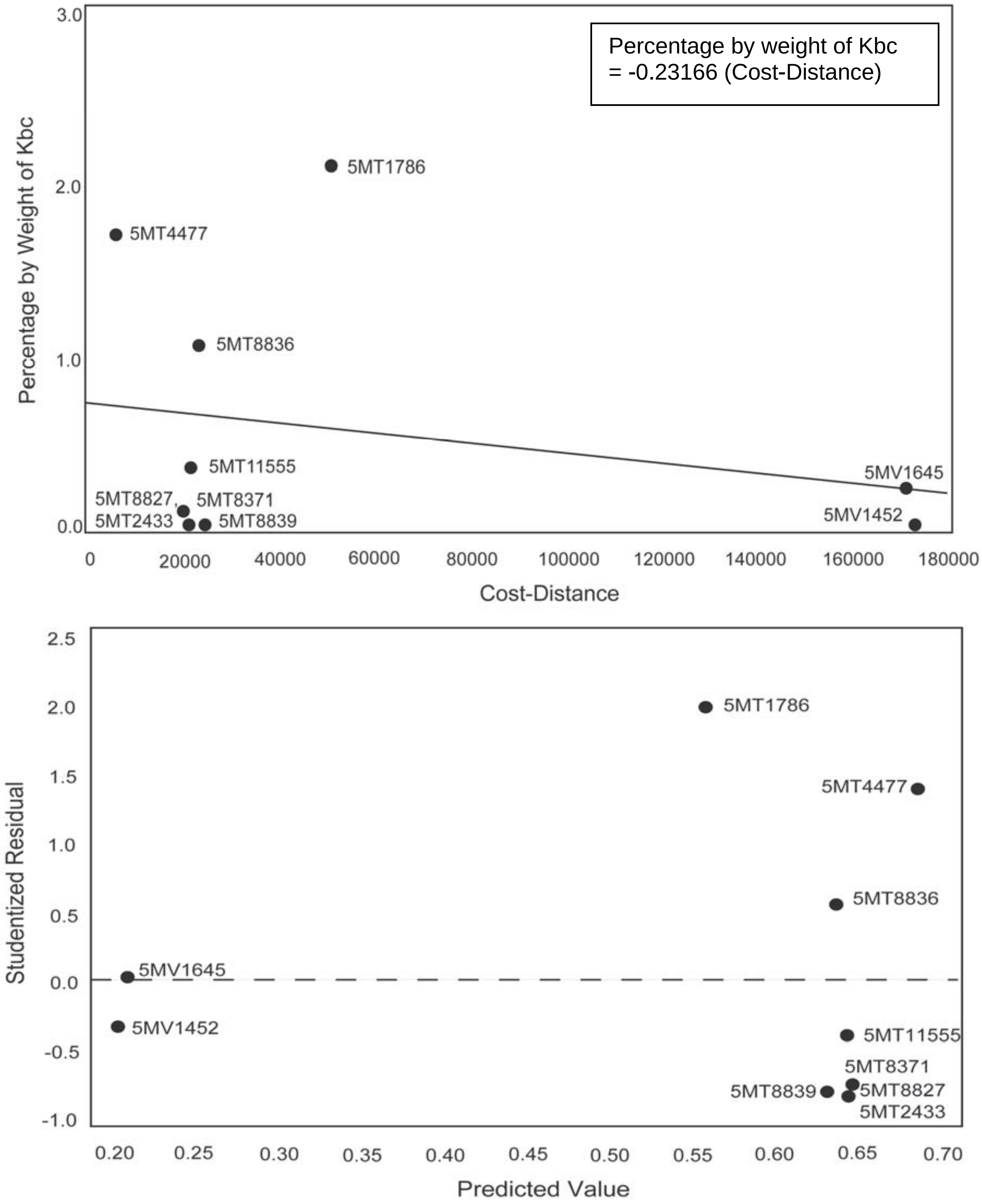


Figure 5.6. The top panel shows the early Pueblo II Kbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

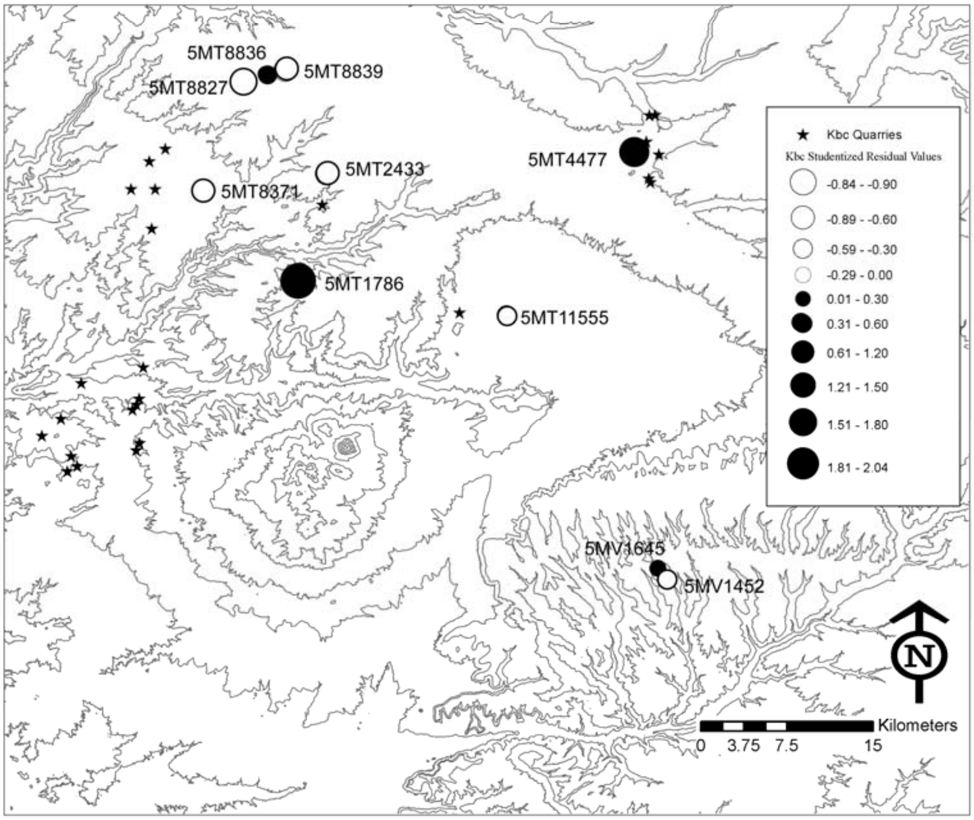


Figure 5.7. Map of Kbc studentized residuals during the early Pueblo II period.

The Percentage/Cost-Distance Relationship for Morrison. Figure 5.8 shows a negative relationship with a relatively strong correlation (r^2=.666; p=.004) for the percentage of Morrison materials against the cost-distance in the early Pueblo II period. The negative slope, -.816, is much more negative than that obtained for Morrison in the Pueblo I period (-.292). The residual map (Figure 5.9) shows that 5MT4477 in the Dolores, 5MT8827 in the Hovenweep, and 5MT1786 and 5MT2433 in the McElmo-Yellowjacket localities are outliers in this model. Here again, the residual map shows that residents within the Hovenweep locality procured and utilized Morrison materials in different ways. The positive values in this model for sites in the McElmo-Yellowjacket locality suggest that the inhabitants relied on those low-quality materials for their activities. In contrast, inhabitants of 5MT4477 in the Dolores locality utilized fewer Morrison materials for their daily tasks or activities than expected given their proximity to a source.

The Percentage/Cost-Distance Relationship for Jmbc. Figure 5.10 displays the regression analysis for Jmbc, which shows the expected negative relationship with a very weak correlation (r^2=.069; p=.464). The negative slope, -.262, is similar to, though slightly more negative than, that obtained for Jmbc in the Pueblo I period (-.207). The residual map (Figure 5.11) shows that 5MT8371 in the Hovenweep locality dominated in procuring and using this material. This pattern is understandable, though still surprising from the perspective of the linear model, because this site is very close to a Jmbc source. We should also expect plenty of this material at 5MT8827 and 5MT8836 in the Hovenweep locality, but those inhabitants in fact used less than predicted by the model.

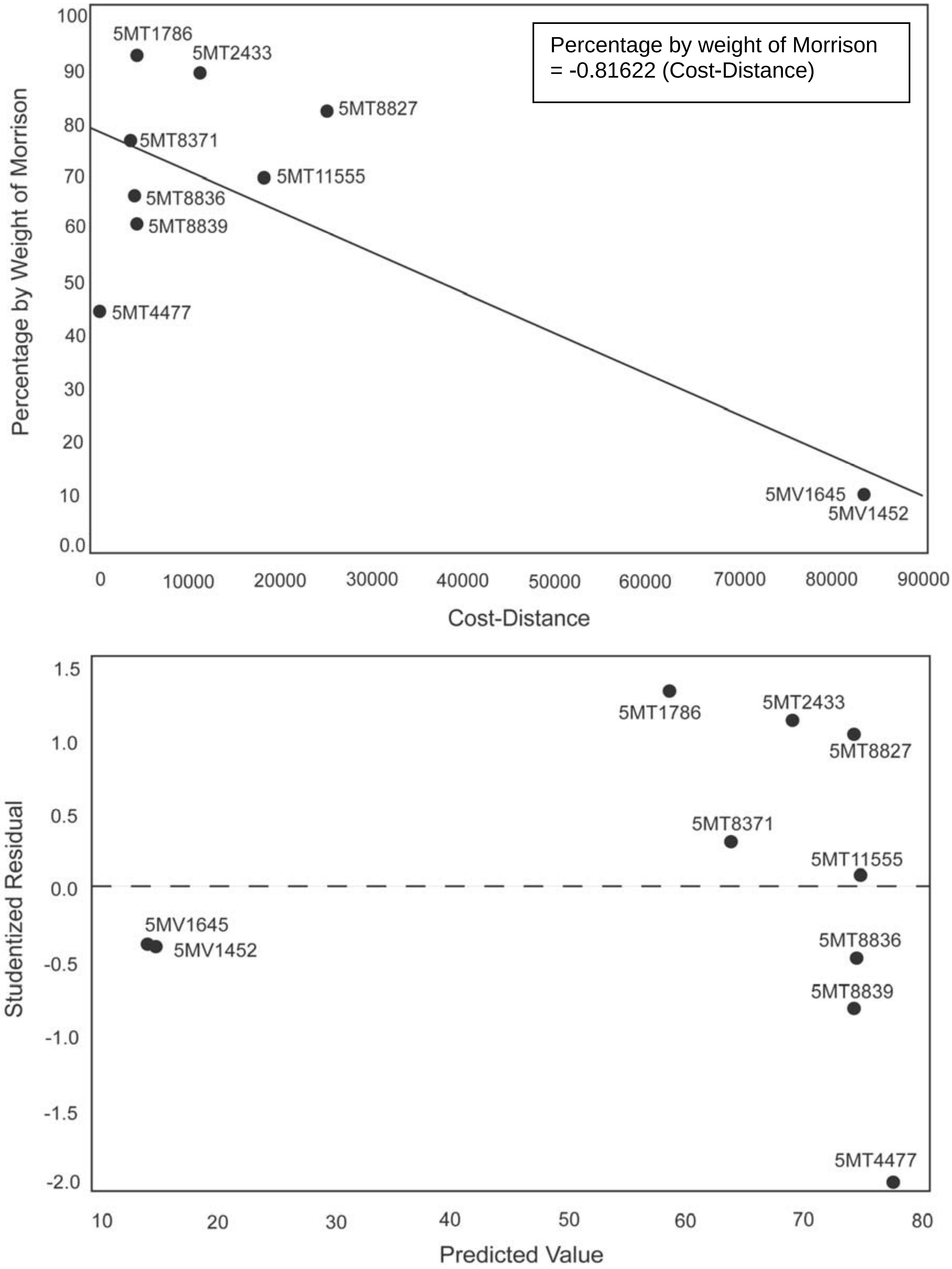


Figure 5.8. The top panel shows the early Pueblo II Morrison percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

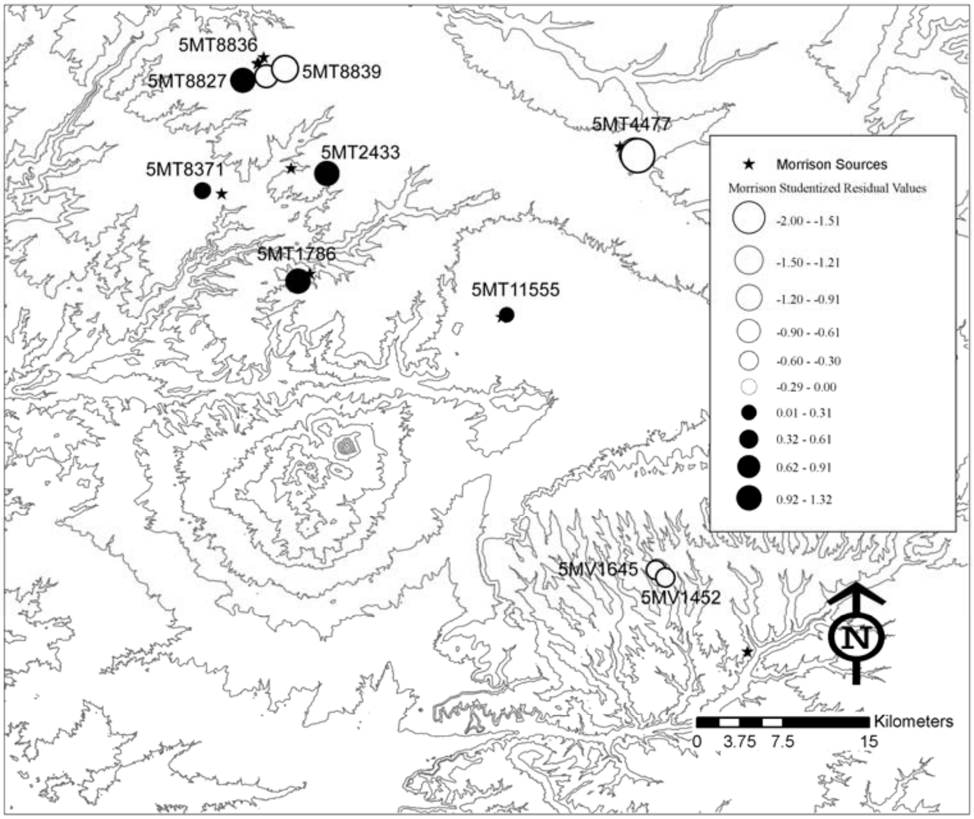


Figure 5.9. Map of Morrison studentized residuals during the early Pueblo II period.

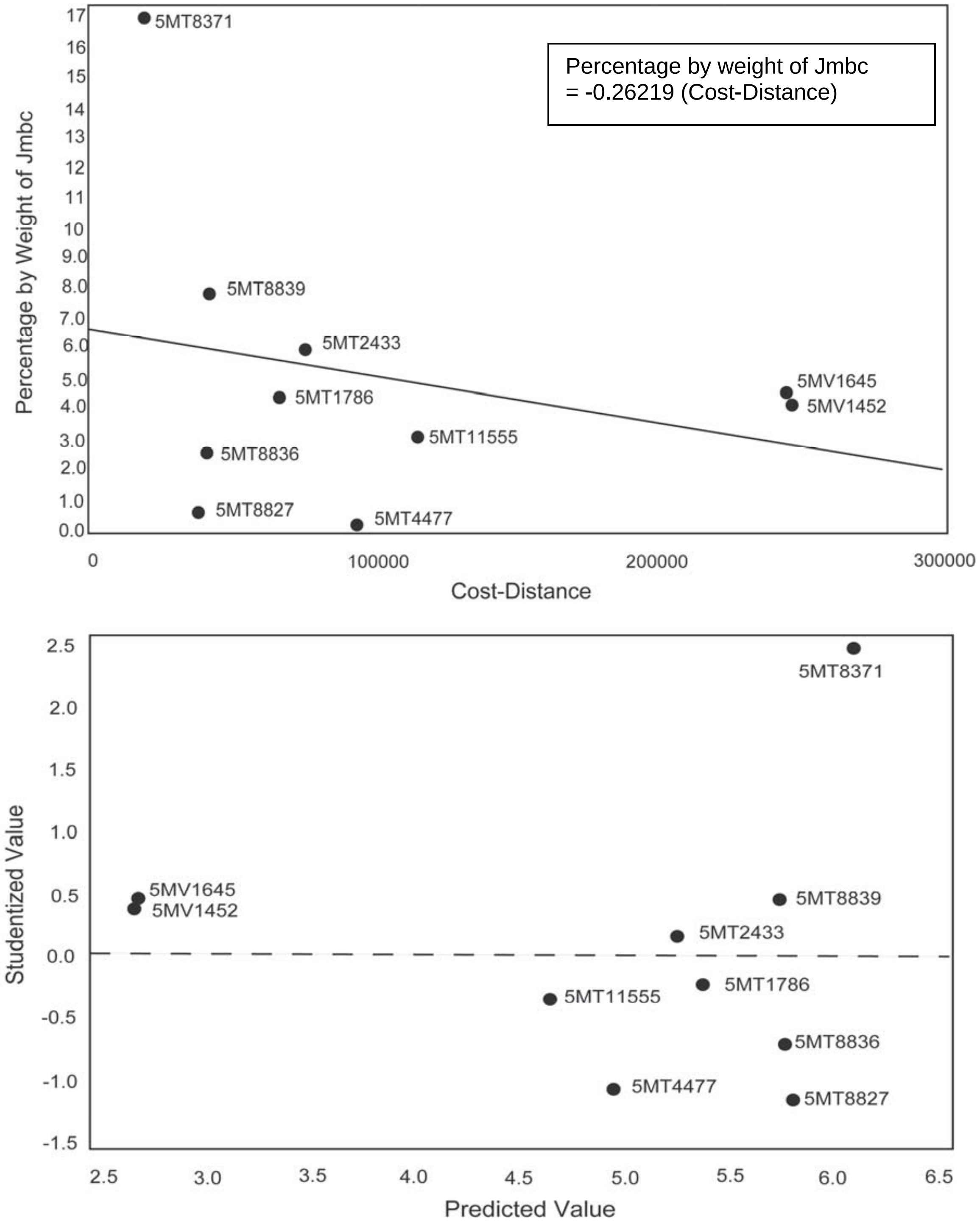


Figure 5.10. The top panel shows the early Pueblo II Jmbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

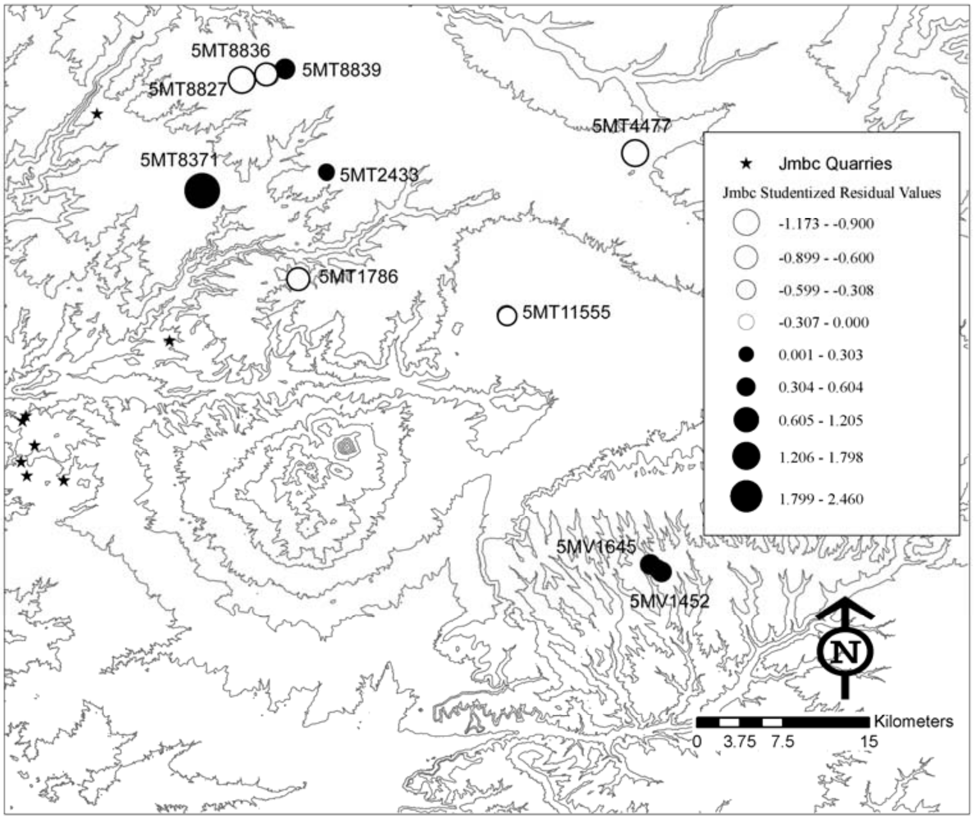


Figure 5.11. Map of Jmbc studentized residuals during the early Pueblo II period.

Even the small amounts of Jmbc used by the Mesa Verde inhabitants is more than expected during the early Pueblo II period, given their distance from the source.

The Percentage/Cost-Distance Relationship for Igneous. Although only five of the 10 early Pueblo II sites in my sample contain igneous material, the regression analysis shows a negative relationship with an extremely strong correlation (r^2=.9094; p<.0001) (Figure 5.12). The negative value, -.954, is the steepest slope among all materials in all six time periods and much steeper than that obtained for Jmbc in the Pueblo I period (-.661). As Figure 5.13 shows, 5MT4477 in the Dolores locality has less than the predicted amount of igneous materials. Two Wetherill Mesa sites – 5MV1645 and 5MV1452 – have a more-than-expected amount; the source areas of igneous rocks are relatively close to these sites. Interestingly, 5MT8836 in the Hovenweep locality also contains more than the expected amount of this material, although this site is quite far away from the igneous source areas.

Early Pueblo II Direct vs. Indirect Procurement Patterns for Kdbq

Here again, I investigate whether assemblages above or below the best-fit regression model are significantly different with respect to flake attributes that might inform us regarding how these materials were procured. I use Fisher’s Exact Tests to examine Kdbq cortex amounts of selected early Pueblo II assemblages using the two-step ordinal scale for cortex amounts. Table 5.1 shows the results of Fisher’s Exact Tests for cortex amounts tabulated against assemblages with more or less Kdbq than expected, given the regression relationship shown in Figure 5.4. Cortex amounts are not strongly different for these two groups ($p \leq 0.125$). However, the result shows that assemblages

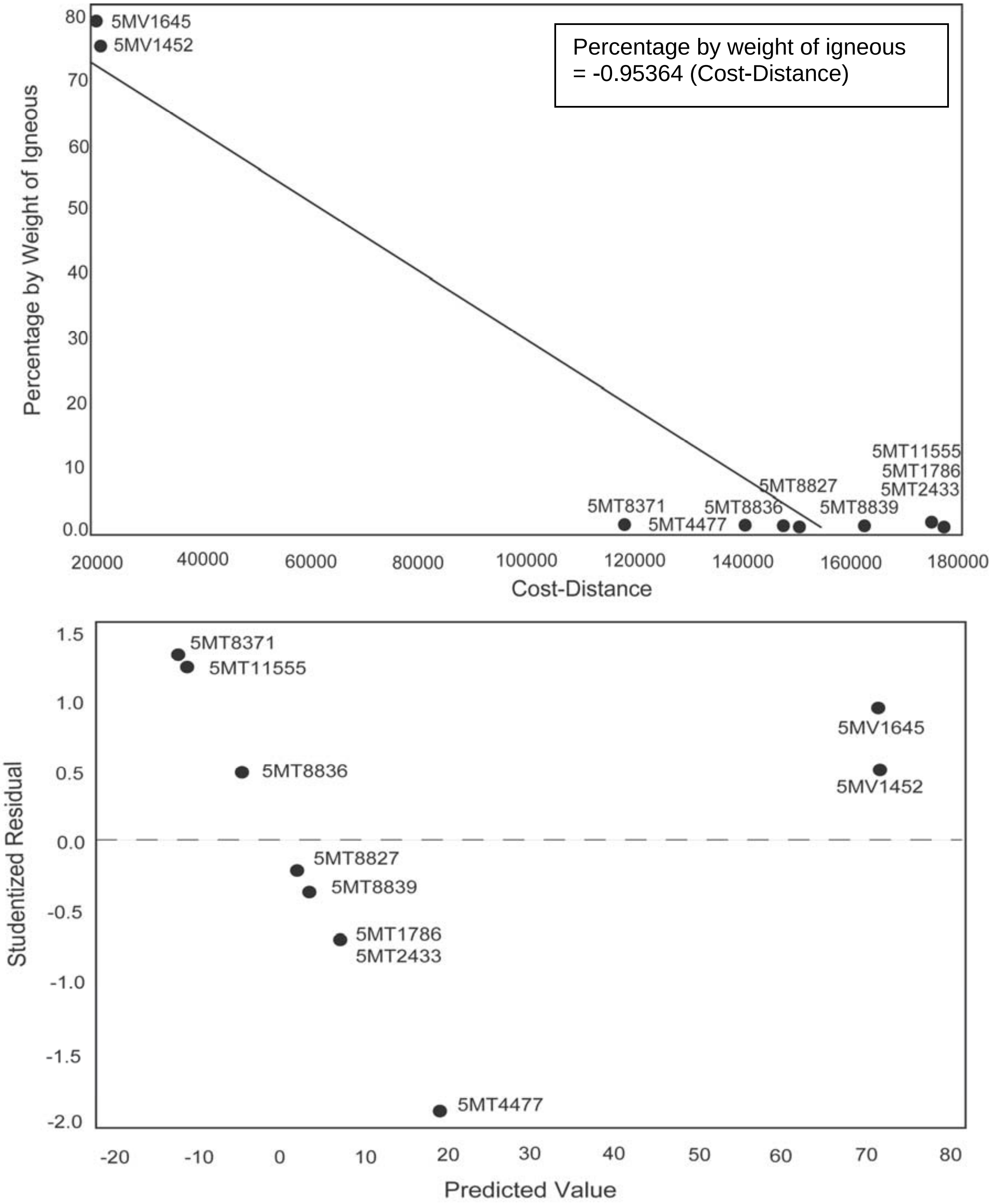


Figure 5.12. The top panel shows the early Pueblo II igneous percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

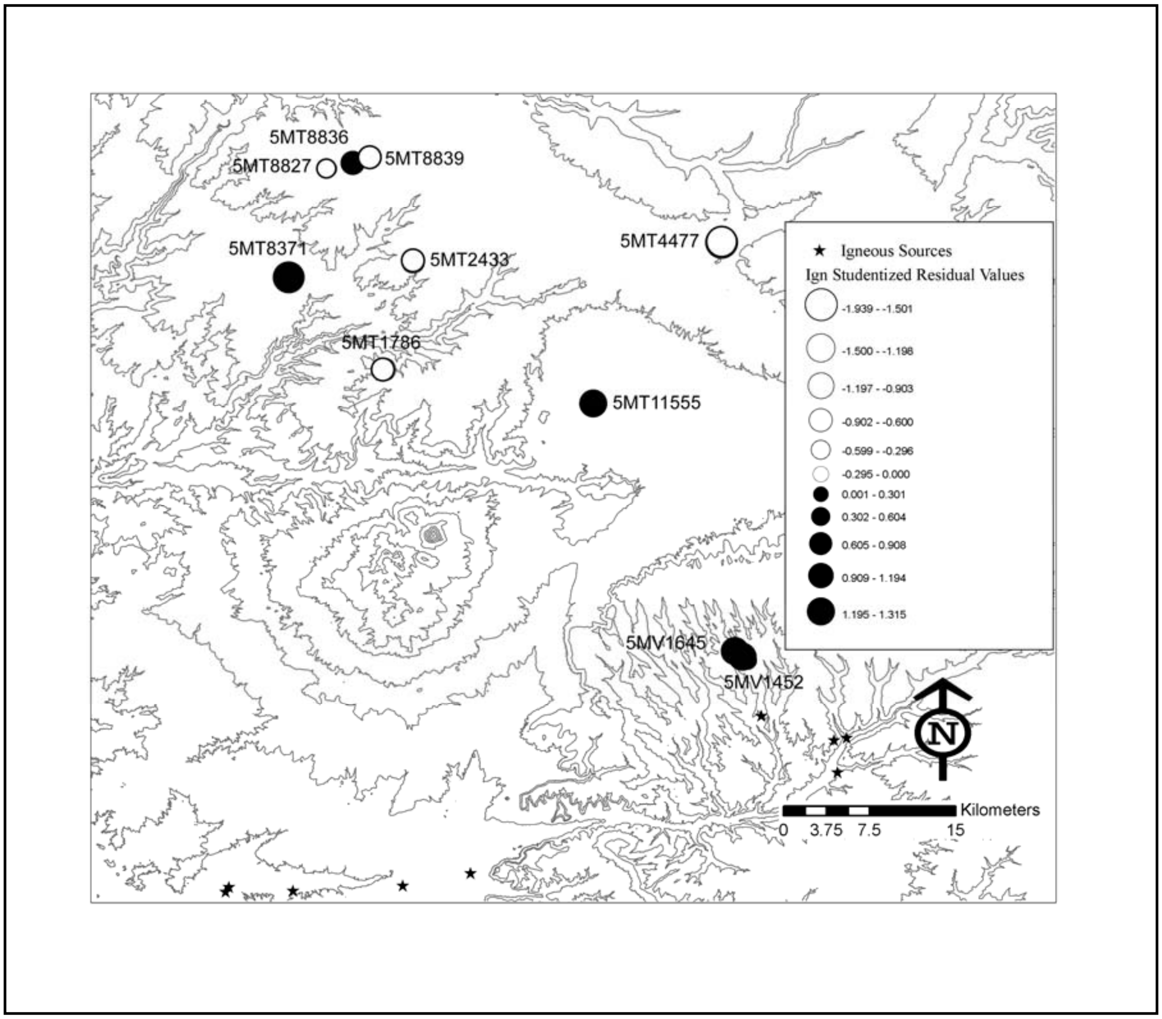


Figure 5.13. Map of igneous studentized residuals during the early Pueblo II period.

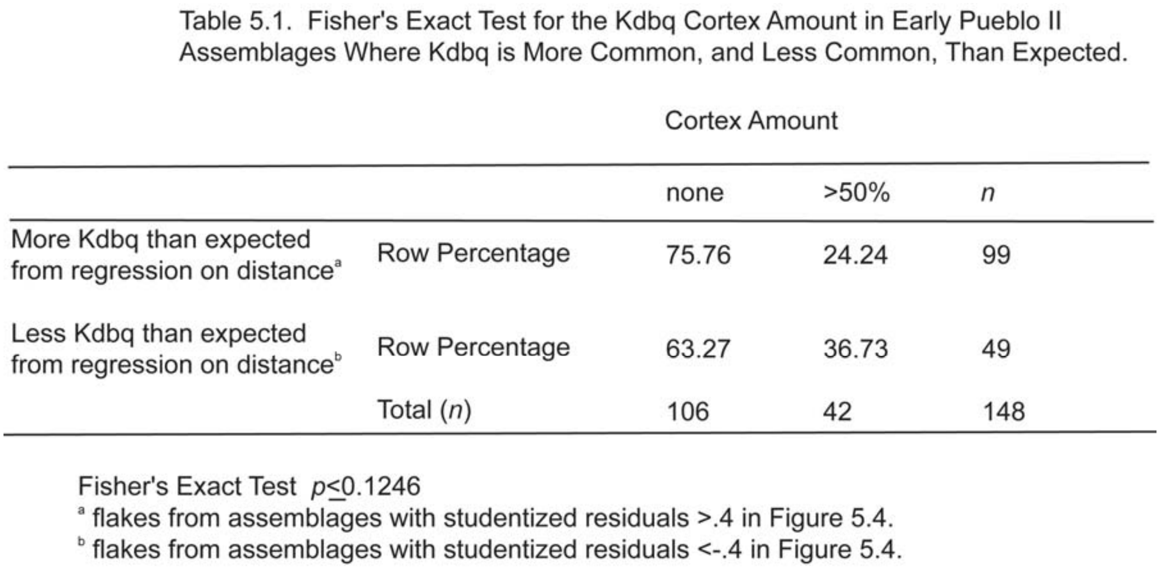


Table 5.1. Fisher's Exact Test for the Kdbq Cortex Amount in Early Pueblo II Assemblages Where Kdbq is More Common, and Less Common, Than Expected.

		Cortex Amount		
		none	>50%	*n*
More Kdbq than expected from regression on distance[a]	Row Percentage	75.76	24.24	99
Less Kdbq than expected from regression on distance[b]	Row Percentage	63.27	36.73	49
	Total (*n*)	106	42	148

Fisher's Exact Test $p \leq 0.1246$

[a] flakes from assemblages with studentized residuals >.4 in Figure 5.4.

[b] flakes from assemblages with studentized residuals <-.4 in Figure 5.4.

with more Kdbq than expected have somewhat more flakes without any more cortex amounts (75.76 percent) than assemblages with less Kdbq than expected (63.27 percent). Based on these comparisons, my previous argument that assemblages with more Kdbq than expected may have been enriched through direct or embedded procurement for these materials still seems plausible. Assemblages with less Kdbq than expected may result from indirect procurement, possibly in addition to direct procurement because these flakes were not further modified at other places.

Summary of the Percentage/Cost-Distance Relationship

Here again, I summarize the percentage and cost-distance relationships for early Pueblo II using three broad raw material categories – high, medium, and low-quality. First, the percentage and cost-distance relationships for the high-quality materials (chalcedony, Kdbq, and Kbc) show higher correlation coefficients than we found in the Basketmaker III and Pueblo I periods, except for Kbc. In the Hovenweep locality, inhabitants procured and utilized those high-quality materials in different ways; for example, inhabitants of 5MT8371 acquired a more than expected amount of chalcedony, but they did not use many Kdbq and Kbc materials. In the Dolores locality, although all three of these raw material sources were close to Masa Negra Village (5MT4477), the residents procured and used only chalcedony and Kbc and not Kdbq. In the McElmo-Yellowjacket locality, the 5MT1786 assemblage was dominated by Kbc, even though the quarries of this material were farther away from the habitation site. In the Mesa Verde locality, inhabitants of Badger House (5MV1452) and Two Raven House (5MV1645) procured and used small amounts of chalcedony during the early Pueblo II period. Based on the cost-distance analysis and the results of Fisher's Exact Tests, residents of these sites would have procured chalcedony through trade, possibly in addition to direct procurement. Although the result of these high-quality materials' percentage and cost-distance relationships varies within the locality, the steeper slopes and strong r^2 values suggest that early Pueblo II people in the central Mesa Verde region may have experienced cost-sensitivity in procuring these raw materials; in other words, their behaviors were quite confined to their local areas in this landscape than had been the case in the Pueblo I period.

Second, the negative standardized slope and significant correlation coefficient for Morrison show a much stronger relationship between its proportions and its cost-distance during the early Pueblo II period than in previous periods. This suggests that except for Dolores residents, the early Pueblo II inhabitants in this region procured and utilized durable and tough raw material types from close to their habitations. In the Hovenweep locality, residents in 5MT8827 used more than expected amounts of Morrison materials, but inhabitants of 5MT8839 and 5MT8836 utilized them less than predicted by the model.

This suggests that inhabitants within the locality behaved differently in procuring and utilizing their local materials.

Finally, study of the medium-quality material of Jmbc suggests that the residents of 5MT8371 in the Hovenweep locality unexpectedly used large quantities of this material. Because the only known quarry for this material is located on the western margins of the McElmo-Yellowjacket locality, residents of 5MT8371 may have dominated procurement and utilization of this material during this period. Although igneous materials evidence a strong negative correlation in general, inhabitants of 5MT11555 in the McElmo-Yellowjacket locality used more than expected amounts of this material. Analyses of igneous materials from the Hovenweep locality show both positive and negative residuals, which also suggests that people within this locality used different utilization and procurement patterns during the early Pueblo II period. These medium-quality material analyses suggest that the Mesa Verde people participated in strong interactions or frequent mobility during the early Pueblo II period.

The Energy Expenditure Model

Based on the energy-expenditure model presented in chapter two, early Pueblo II energy expenditures were calculated by multiplying the proportion by weight of each of the 10 raw material types by the cost of traveling to its source from that site (Figure 5.14). On the locality level, this figure shows that the Mesa Verde inhabitants expended the most energy in procuring raw materials, followed by the inhabitants of McElmo-Yellowjacket, Hovenweep, and then Dolores. Here again, the Mesa Verde residents bore the highest costs because of the physiographic features confining them on the landscape,

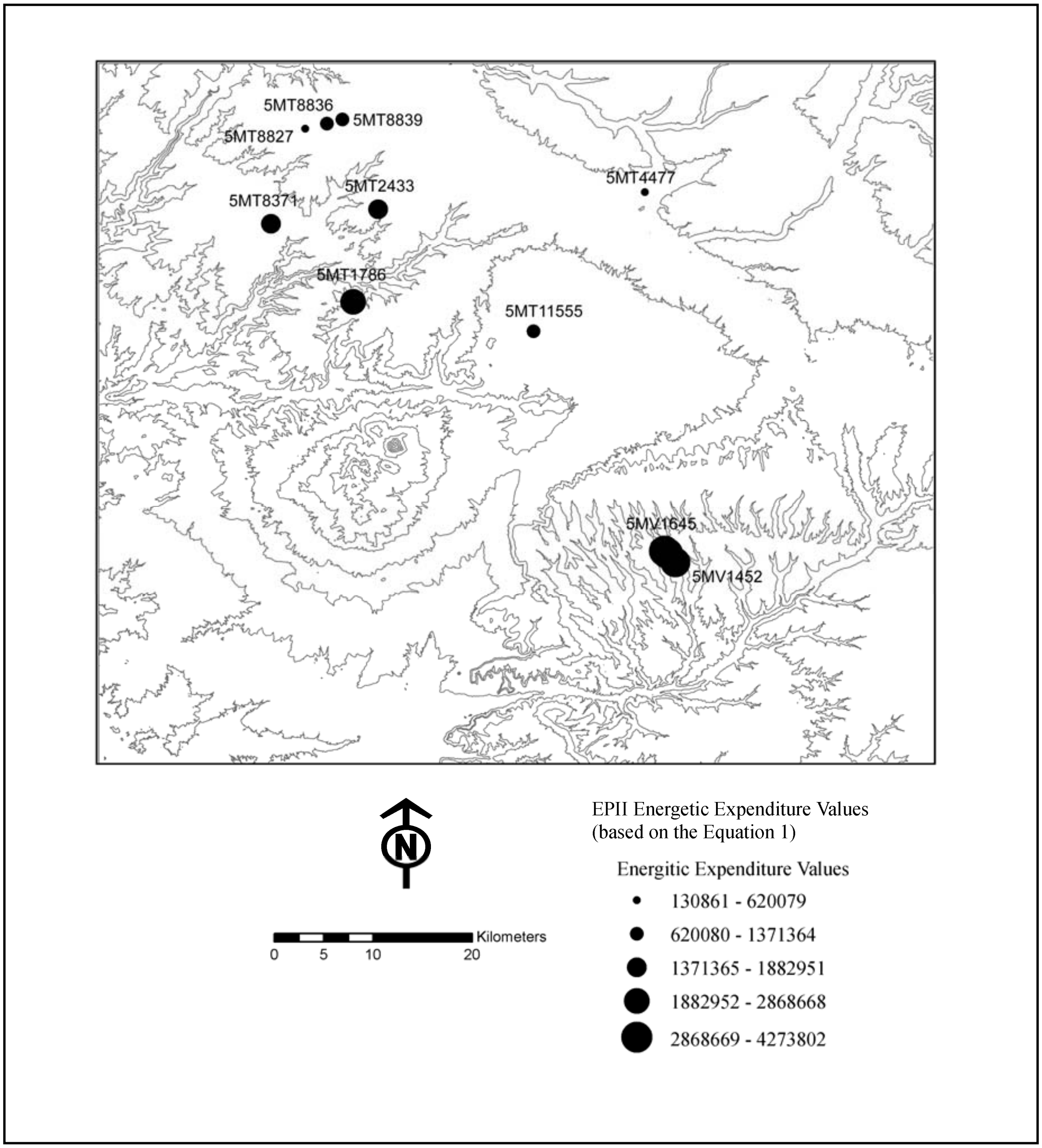


Figure 5.14. Energetic expenditure values for sampled early Pueblo II sites in the central Mesa Verde region.

and because quarries or source areas of high-, medium-, and low-quality materials are located father away from habitations in the Mesa Verde locality. The residents of 5MT1786 in the McElmo-Yellowjacket locality also expended relatively high costs in acquiring lithic materials. The toolstone procurement pattern of this site is quite intriguing because the people procured more than expected amounts of Jmbc and Kbc. We need to further investigate the lithic technological organization of this site, and determine why the residents procured and utilized so many of those materials during the early Pueblo II period. Residents in the Dolores locality did not expend much energy in procuring raw materials due to probably abundant sources close to their habitations.

The Energy Expenditure Map

Figure 5.15 shows a kriging interpolated map of the total energy expended by the early Pueblo II residents. This map shows that overall, the early Pueblo II energy expenditures are lower than those of the Basketmaker III and Pueblo I periods. In particular, both the Dolores and McElmo-Yellowjacket residents expend less energy in procuring raw materials.

Figure 5.16 shows the result of the difference map, which subtracted the interpolated map of total energy expenditure in the Pueblo I period (Figure 4.32) from that of early Pueblo II assemblages using raster calculation in ArcGIS (Appendix A). This figure shows in dark yellow the areas of largest increases in energy expenditures between those two periods. This suggests that in those areas early Pueblo II inhabitants expended more energy in procuring raw materials. The dark red shows where Pueblo I populations expended more energy in procuring raw materials than did the early Pueblo

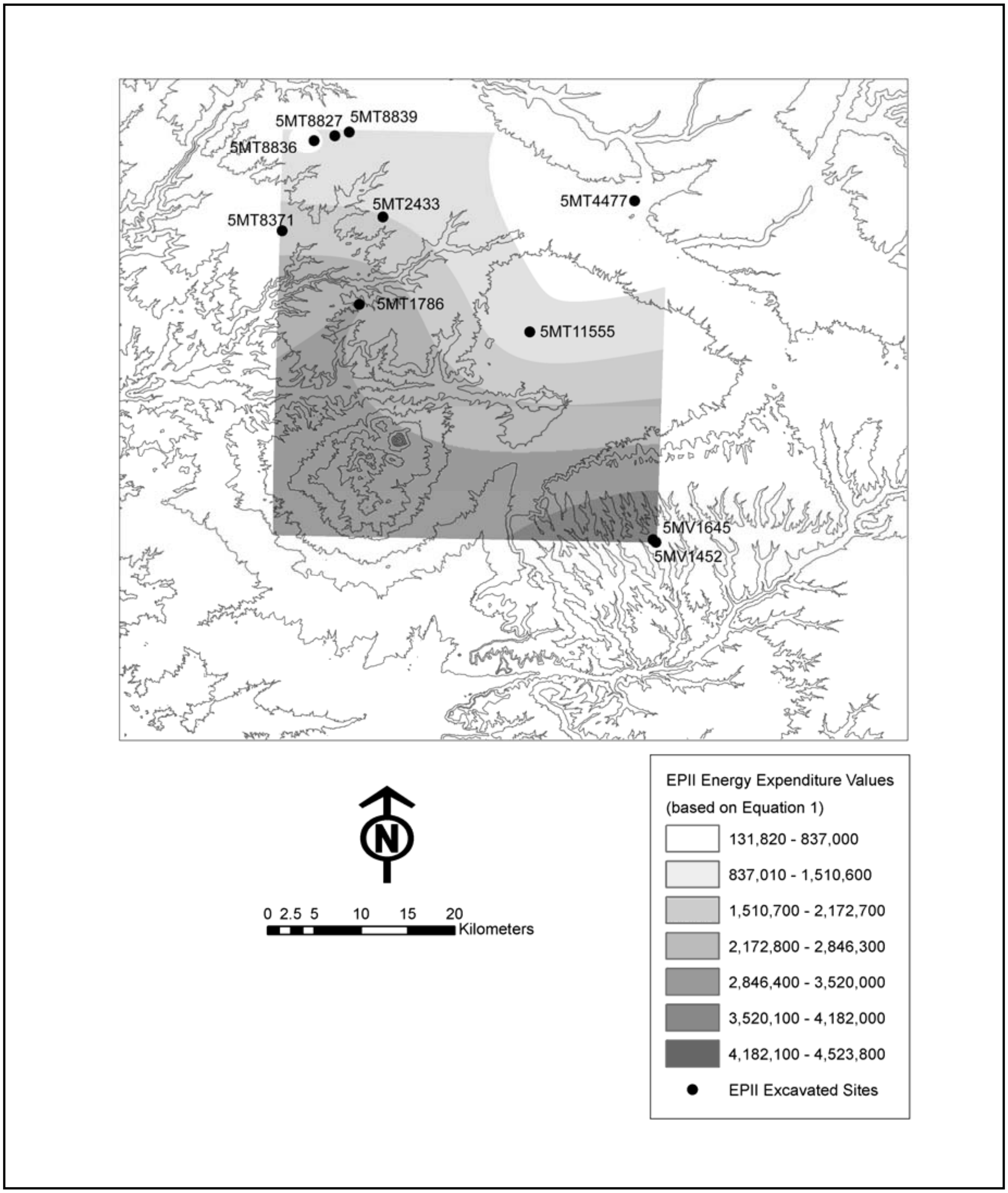


Figure 5.15. A kriged map that interpolates, across our region, the total energy-expenditure values for acquiring toolstone for the sampled early Pueblo II sites.

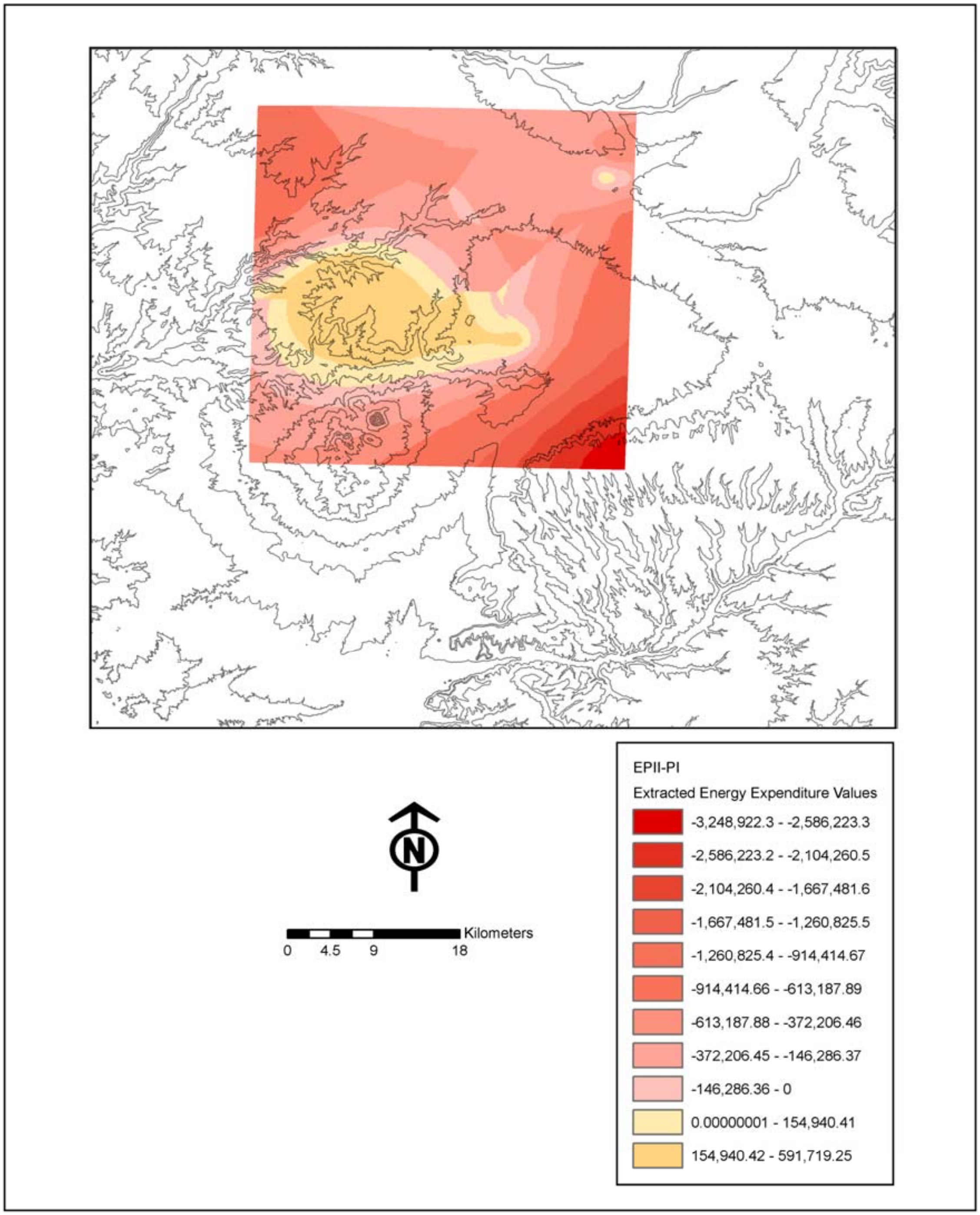


Figure 5.16. A difference map showing areas where the energy expenditure values for acquiring toolstone increased, or decreased, in early Pueblo II sites relative to Pueblo I sites.

II populations. The map shows that only the central portion of the McElmo-Yellowjacket locality has a higher energy expenditure by the early Pueblo II residents, and this suggests that most of the early Pueblo II people in this area participated in less mobility and/or interaction than had been the case during the Pueblo I period. It may also be the result of lower population levels, taking some pressure off the regional deer herds, allowing hunting to again become more local in nature. This comparison may indicate that a more restricted or structured environment occurred during the early Pueblo II period, particularly in the McElmo-Yellowjacket locality. There are a number of stockade settlements in the early Pueblo II period, including the Dobbins stockade (Kuckelman 1988), the Dripping Spring stockade (Harriman and Morris 1991), and the Ewing Site (Hill 1985), all dating to the early A.D. 1000s. Lithic assemblage from the Dobbins stockade (5MT2527) is used and analyzed for this research. This assemblage in the Hovenweep locality shows a very intriguing pattern. The percentage and cost-distance relationships show that the Dobbins stockade residents did not expend much energy in procuring high- and medium-raw materials, but they procured and used more than expected of local Morrison materials by the linear model (Figure 5.8 and 5.9). This pattern suggests that some residents, particularly those who built stockades, may have been restricted to their local areas by fear of violence or strong territoriality, especially within the Hovenweep and Mesa Verde localities. In contrast, the McElmo-Yellowjacket populations (within the yellow areas shown in Figure 5.16) may not have experienced this restricted territoriality during the early Pueblo II period.

Summary of the Early Pueblo II Period

During the early Pueblo II period, the population declined dramatically to an average of approximately 3,000, but resource productivity was relatively stable and quite high ($\bar{x}$=255.2 kg/ha; S.D.=42.2 kg/ha), except between about A.D. 980 and 1000. Dyson-Hudson and Smith's economic defensibility model (1978) suggests that these conditions should have led to a home-range system or a geographically stable territorial system. We can expect people to develop and use territories in the latter way when resources are dense and predictable.

Lithic data support this model. The r^2 values for the percentage and cost-distance relationships are generally higher in the early Pueblo II than they are in the Basketmaker III and Pueblo I periods, and the slopes of regressions also are steeper, except for Kbc and Jmbc materials. This suggests that for most raw materials, the early Pueblo II inhabitants were both more cost-sensitive (e.g., acquiring more local materials) and also more uniform in toolstone procurement patterns than the Basketmaker III and Pueblo I populations of this area. This might also suggest that the early Pueblo II people participated in less exchange and certainly less long-distance procurement. In other words, the energy expenditure model suggests that although residents in the Mesa Verde locality experienced high costs in procuring raw materials, overall early Pueblo II energy expenditures for toolstone dramatically declined from the Pueblo I period.

The difference map between the Pueblo I and early Pueblo II shows that only the central portion of the McElmo-Yellowjacket locality used more energy in acquiring toolstone during the early Pueblo II period than in the previous periods. With this exception, these results suggest that residents of the central Mesa Verde region experienced more restricted mobility and/or less interaction than those of previous periods, and they began to develop a home-range system of territoriality or geographically stable territorial system during the early Pueblo II period.

The results of lithic analyses demonstrate an unexpected pattern of socio-political organization in this landscape during the early Pueblo II period. When we consider the general correlations emerging between population levels and costs in procuring and/or traveling in this landscape during the early Pueblo II period, we expect that costs should increase when population increases. This was the case between the Basketmaker III to Pueblo I period when population increased as well as costs of toolstone procurements. We would also predict that when the early Pueblo II population decreased, then costs of toolstone procurement also should go down. The early Pueblo II lithic data support the prediction; when the early Pueblo II population decreased, costs of procuring raw materials decreased. One way we may explain or make sense of this pattern is that these lithic costs are actually tracking hunting costs (or distances). As population increases, people go further to hunt and their lithic assemblages become increasingly more non-local because of rising embedded procurement patterns. As population declined in early Pueblo II, hunting might have again been more local and costs in toolstone procurement tended to decline. If this is the plausible explanation, we will expect that this pattern might break down beginning in late Pueblo II or later periods as protein came increasingly from domesticated turkey in this study area (Cowan et al. 2006).

Background for Late Pueblo II (A.D. 1060-1140)

After the middle of eleventh century, population in the central Mesa Verde region increased dramatically, and residents in this region began to participate in the Chaco

Regional System in which people outside Chaco Canyon but within all area constructed Chaco-like structures and engaged in frequent regional exchange or trade. In the central Mesa Verde region, Chaco outliers were constructed at Lowry Ruin in the northern portion of the Hovenweep locality, and at Wallace Ruin (Bradley 1988) and Escalante Ruin (Hallasi 1979) in the McElmo-Yellowjacket localities. As in the previous chapters, I first discuss general information about population estimates, resource productivity, settlement patterns, ceramics, and architectural remains in this period and then provide lithic data to help reconstruct socio-political organization during the late Pueblo II period.

Population Estimate. Population gradually increased after the middle eleventh century in the central Mesa Verde region (Wilshusen 2002). This phenomenon can be explained by migration from other regions of the Southwest coincident with regional interactions by the Chaco influence or Chaco Phenomenon (Cordell 1997). Great house construction in Chaco Canyon reached a peak between about A.D. 1000 and 1100/1150, and then declined during the late 1100s. After the decline of Chaco Canyon, Salmon Ruin (which was built in the very late 1000s) and Aztec Ruin (which was constructed in the early 1100s) in the Totah region, may have become central places, based on the appearance of very large great houses at these sites after A.D. 1090 (Lekson 1999; Lipe 2006; Lipe and Varien 1999a:258). Lekson (1999) claims that these Chacoan influences impacted the communities of the Mesa Verde region and accelerated migration into the region during the late Pueblo II period (Lipe and Varien 1999a:259).

Varien et al. (2007) estimate total momentary population and suggest that the population within the “Village” portions of the central Mesa Verde region increased dramatically from the mid-1000s to the late-1000s. They estimated the momentary population in the “Village” study area at about 8000 people from A.D. 1060 to 1100, and at more than 10,000 people from A.D. 1100 to 1180 (Varien et al. 2007).

Resource Productivity. From A.D. 1060 to 1080, the average potential maize yield (kg/ha) was fairly favorable, but these conditions were interrupted by a series of poor years around A.D. 1100 (Figure 4.2). This downturn was as severe as those experienced locally ca. A.D. 700 and 1000, though it was more brief than the ca. 1000 reduction. Maize productivity then increased until about A.D. 1130, when it again declined rapidly. In terms of Dyson-Hudson and Smith’s model (1978), residents of this area during the late Pueblo II period experienced a generally high density of resources with rather unpredictable conditions.

Settlement Patterns and Social Organization. Chaco-like great houses appeared in the central Mesa Verde region after A.D. 1075 (Lipe 2006; Lipe and Varien 1999a:256). Wallace Ruin (Bradley 1988) and Lowry Ruin (Martin 1936) are well-known examples of Chaco-related sites in my study area. In those cases, dispersed communities of homesteads and hamlets were centered on a nucleus composed of a village-like aggregation, often with a Chacoan-style great house. As a result, community centers with more than 50 household structures appeared again during this period. Material culture indicates that long-distance trade was relatively important (Lipe and Varien 1999a:259). For example, in Escalante Ruin, traded sherds and pieces of obsidian were abundant compared to traded materials in other time periods (Hallasi 1979). This provides evidence that inhabitants of the central Mesa Verde region engaged in more frequent and strong inter-regional interactions than during the early Pueblo II period.

Previous Research on Late Pueblo II Period Ceramic and Lithic Assemblages

Ceramics. Wilson and Blinman (1991:46) identify Dolores Corrugated and Mancos Black-on-white as the most common late Pueblo II pottery types. Though Dolores Corrugated sherds dominated, Mancos and Mesa Verde Corrguated are present in small amounts in late Pueblo II assemblages. Tsegi Orange Ware, which originates from the Kayenta area, is sometimes represented in late Pueblo II assemblages in this region. This supports the idea that there were strong regional interactions in the Kayenta and central Mesa Verde regions during the late Pueblo II period (Glowacki 2006; Lipe and Varien 1999a:259; Martin 1936:79-80).

Lithic Data. Cameron (2001) investigated chipped stone tools of two raw material types – Narbona Pass chert and obsidian – to understand the Chaco Regional System during the late Pueblo II period. The study of Narbona Pass chert provides a clue for understanding and reconstructing social and political organizations within and outside Chaco Canyon. Cameron (2001) found that the Narbona Pass chert source area (approximately 75 km northwest of Chaco Canyon) was used most frequently between A.D. 1050 and 1100. In addition, this material was more commonly utilized by inhabitants of great houses than by residents of small households (Cameron 2001:94-96). Cameron also investigated tool procurement patterns for the obsidian found in Chaco Canyon. Her study suggests that many obsidian tools were imported as finished products, and procurement patterns of obsidian shifted from the source areas of Grants, New Mexico approximately 95 km to the southeast prior to A.D. 1100s, to the Jemez Mountain areas, 125 km east of Chaco Canyon, during the late 1100s (Cameron 2001:87). Cameron's research provides a great deal of information about the Chaco Regional

System using lithic data during the late Pueblo II period with which we can compare procurement patterns by the central Mesa Verde Puebloans during the late Pueblo II period.

Several cultural resource management (CRM) projects discuss lithic technological organization for the late Pueblo II period in this region (Ellis 1998; Irwin 1993). Debitage analysis for the Ute Mountain Ute Irrigation Lands Archaeological Project (UMUILAP [Ellis 1998:83]) indicates that the percentage of debitage among all artifacts, including the ceramics in their site sample, increased steadily through the late Pueblo II period. Ellis argues that an increase in on-site tool manufacture and maintenance occurred through time as the Ute residents became more sedentary. Irwin's lithic study from Towaoc Canal (1993) reported that many late Pueblo II sites displayed evidence of expedient production systems. In sum, these CRM reports indicate that residents in the central Mesa Verde relied heavily on local materials during the late Pueblo II period.

Arakawa and Duff (2002) investigated changes in local landscape use during the Pueblo II and III periods using lithic data. They used analyses of lithics from Shields Pueblo (5MT3807) and Yellow Jacket Pueblo (5MT5) to determine whether there were changes in lithic procurement as communities became more aggregated and the landscape became more crowded. According to this study, the percentage of stone tools and debitage made of local materials increased from the Pueblo II to the Pueblo III periods, and there was a slight decrease in the use of resources from outside of the region in the Pueblo III period. This suggests that as communities became more aggregated, the ancestral Puebloans relied more on local materials. Some earlier researchers also suggested that exchange networks were more open during the late Pueblo II period, with more materials coming from outside the region (Neily 1983), and that this activity decreased in the Pueblo III period.

Architecture. Multiple-unit hamlets appear to be more frequent in the late Pueblo II than in the early Pueblo II period (Lipe and Varien 1999a:257). After the late A.D. 1000s, two-stone wide walls for masonry construction or in enclosing walls became frequent in many Chaco-style outliers, but also occasionally occur at other habitation sites in the central Mesa Verde region (Lipe and Varien 1999a:262). As in the early Pueblo II period, ancestral Pueblo people during the late Pueblo II period utilized kivas for both domestic and ceremonial purposes in the central Mesa Verde region (Lekson 1988; Lipe 1989).

Current Perspectives on Late Pueblo II Assemblages

Figure 5.17 shows the ten well-dated late Pueblo II habitation sites in the study area whose lithic assemblages were analyzed for this study. Two sites – 5MT2544 and 5MT8834 – are in the Hovenweep locality; 5MT2149 is in the Dolores locality; 5MT11338, 5MT3807, and 5MT11555 are in the McElmo-Yellowjacket locality; 5MV1595 and 5MT10802 are in the Mesa Verde locality; whereas 5MT7723 and 5MT8943 represent lithic assemblages from the Ute locality. In the remainder of this chapter, I discuss the percentage/cost-distance relationship for six raw materials, attempt to determine whether those materials were procured through direct vs. indirect means, and examine the energy-expenditure model from those assemblages as an aid to understanding sociopolitical organization during the late Pueblo II period.

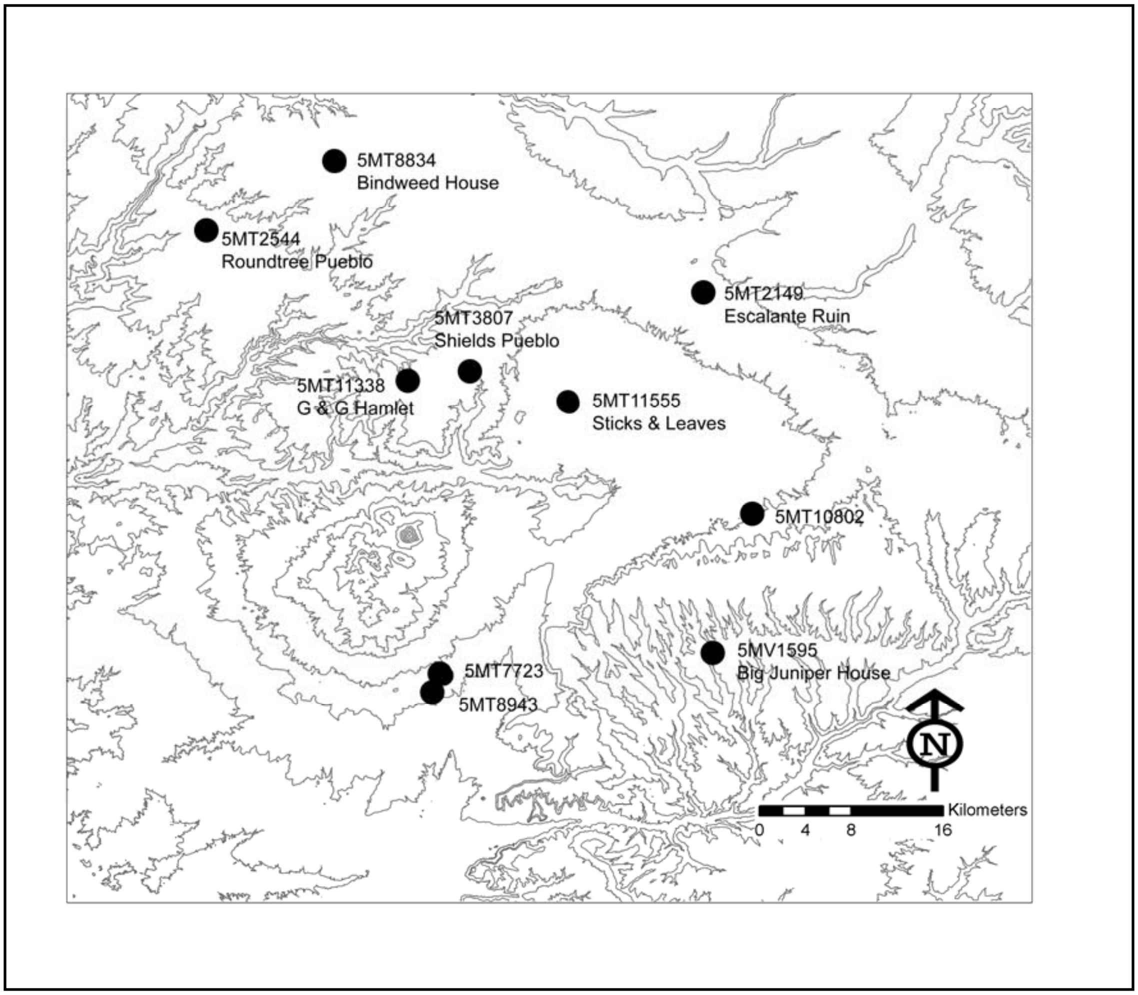


Figure 5.17. Late Pueblo II habitation sites.

The Percentage/Cost-Distance Relationship for Chalcedony. Figure 5.18 shows the linear regression and residual analysis for late Pueblo II chalcedony. This reveals a negative linear relationship with a moderately weak correlation (r^2=.109; p=.350). The residual analysis shows that 5MT2149 (Escalante Ruin) in the Dolores locality and 5MT10802 in the Mesa Verde locality make the statistical model fit poorly. The negative slope, -.279, is similar to, though slightly more negative than, that obtained for chalcedony in the early Pueblo II period (-.233). Figure 5.19 maps the studentized residuals for chalcedony and shows that those outliers acquired more chalcedony than would be expected given the cost-distance of its sources. Although residents in 5MT2544 in the Hovenweep locality lived very close to the source areas, they used less than the predicted amount of chalcedony.

Percentage/Cost-Distance Relationship for Kdbq. Figure 5.20 shows the relationship of late Pueblo II percentage/cost-distance of Kdbq. For these sites, there is a very weak negative relationship (r^2=.044; p=.561) between the cost-distance and the percentage of Kdbq. The negative slope, -.176, is slightly more positive than that obtained for Kdbq in the early Pueblo II period (-.232). Figure 5.21 shows that 5MT10802 is an extreme outlier in this relationship. It is very surprising that this assemblage contains more than 50 percent of Kdbq, since this site is relatively far from a source. We might be able to account for this in two ways. First, inhabitants might have frequently visited residents in the McElmo-Yellowjacket locality where many Kdbq quarries are located. Second, there may be some unidentified Kdbq quarries in the northern portion of the Mesa Verde locality where archaeological or geological surveys

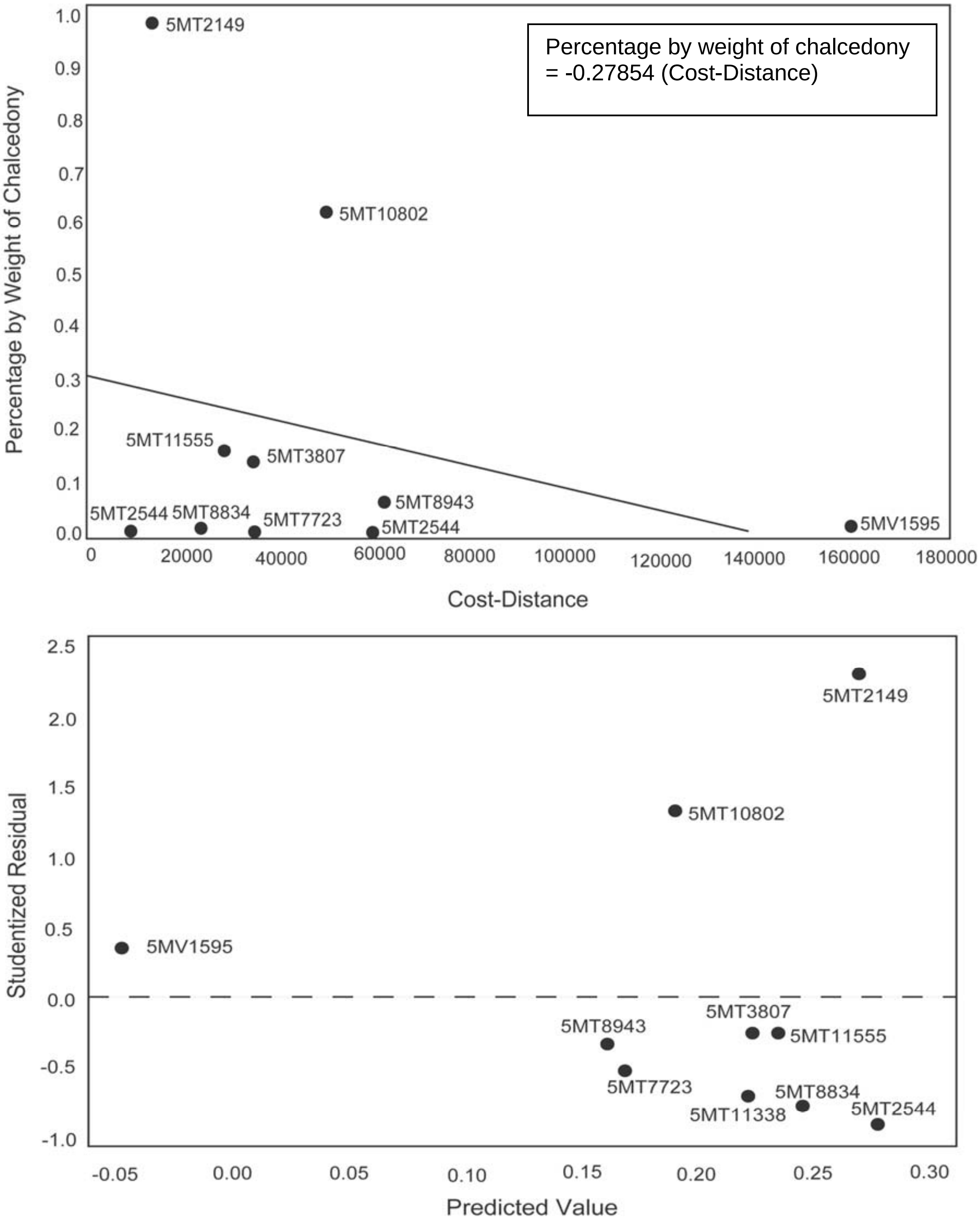


Figure 5.18. The top panel shows the late Pueblo II chalcedony percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

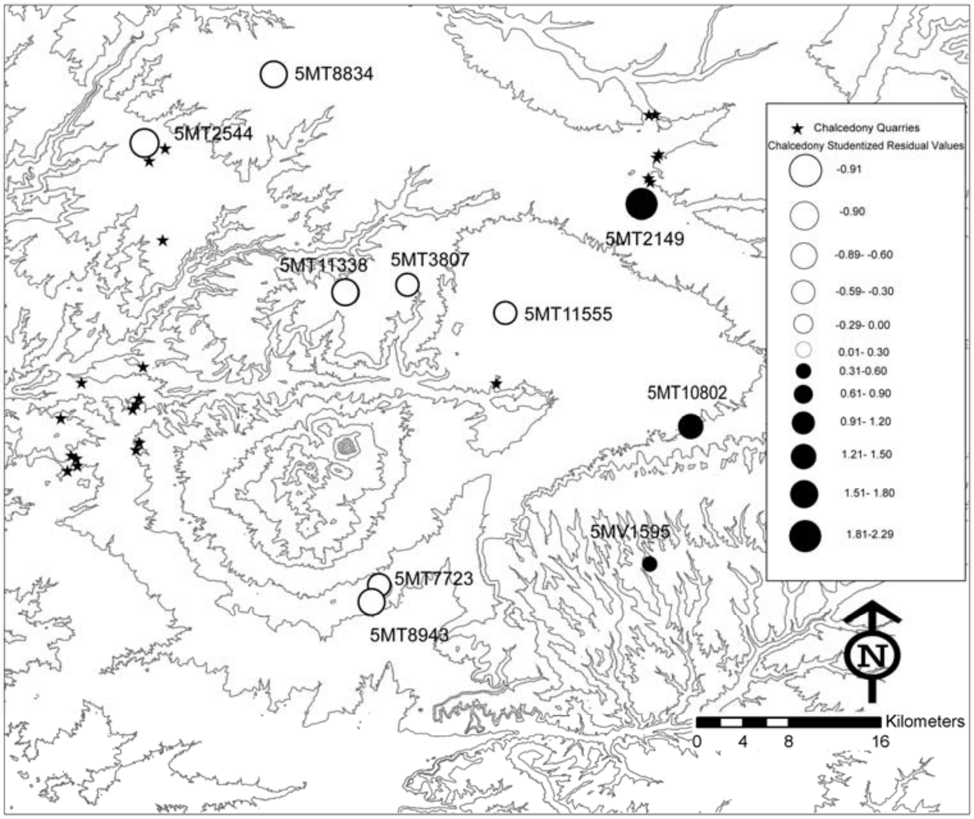


Figure 5.19. Map of chalcedony studentized residuals during the late Pueblo II period.

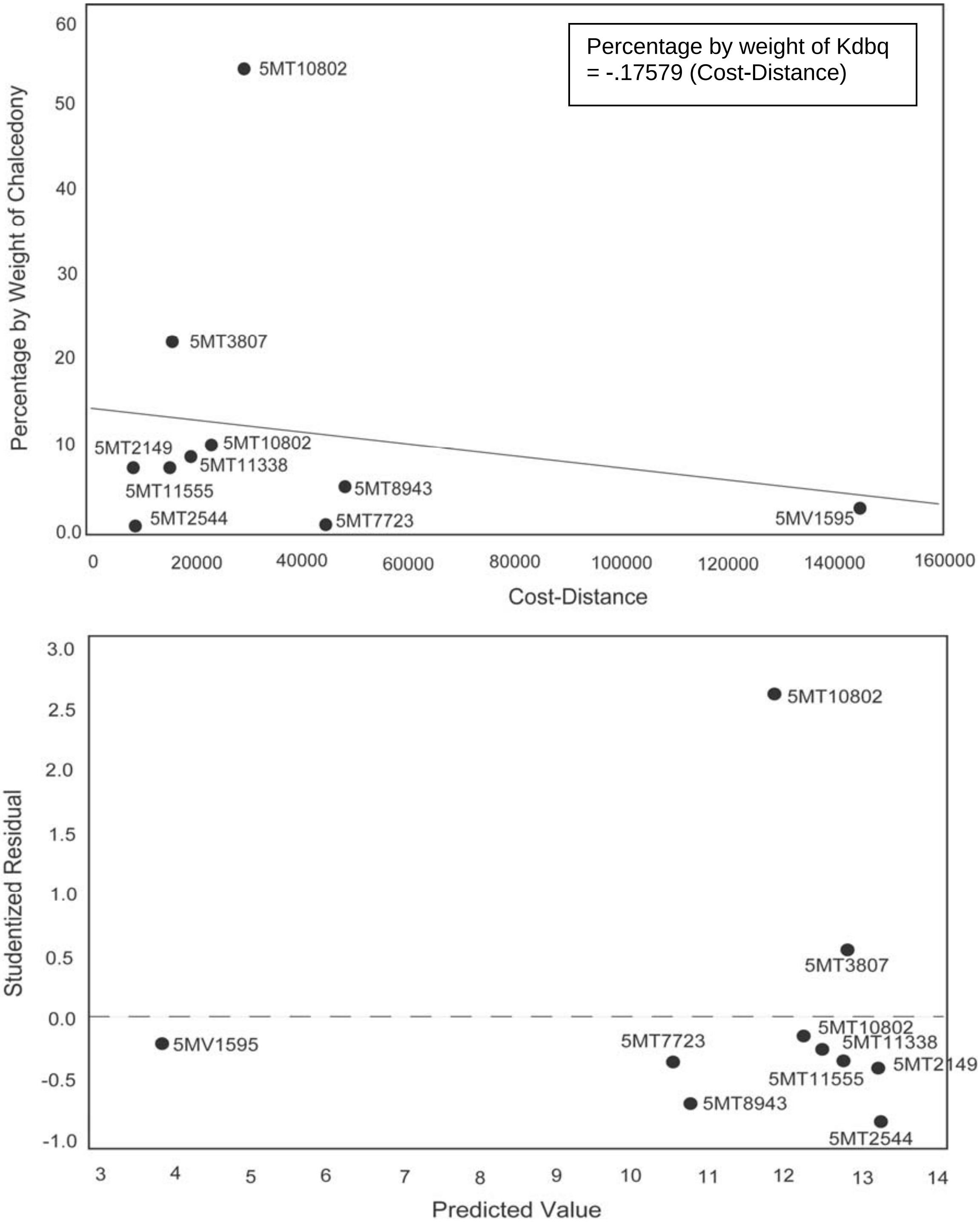


Figure 5.20. The top panel shows the late Pueblo II Kdbq percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

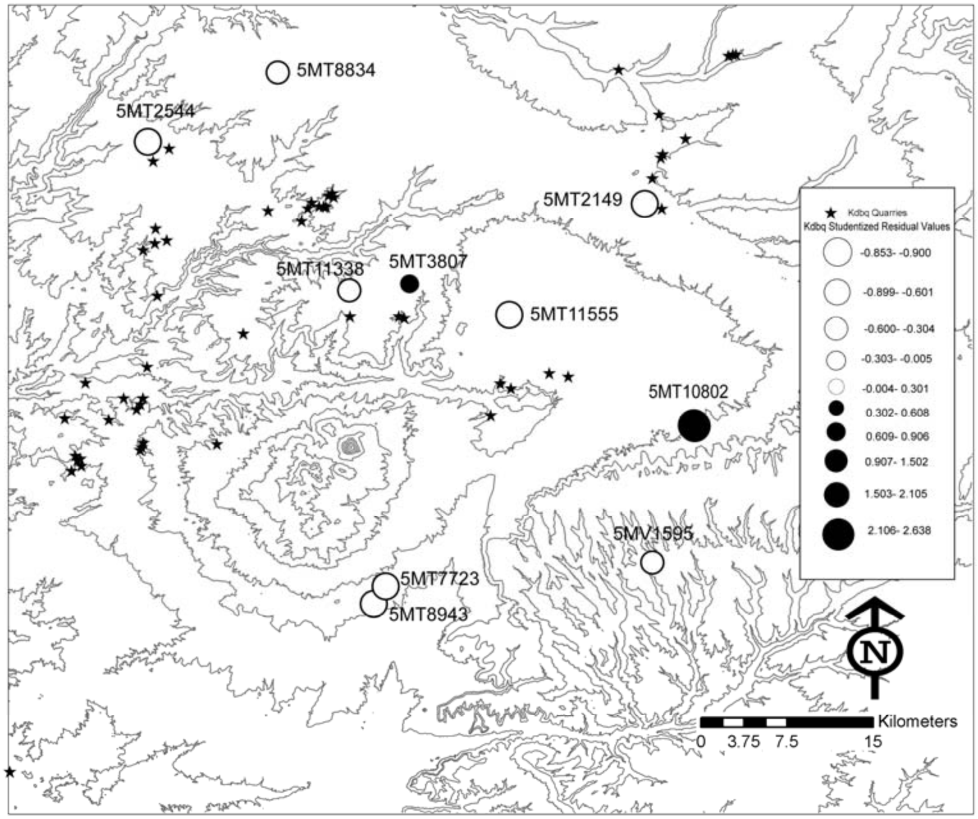


Figure 5.21. Map of Kdbq studentized residuals during the late Pueblo II period.

have not yet been conducted. In either case, we need to investigate the lithic technological organization of this assemblage using, e.g., flake attribute analysis to understand this unexpected pattern. The residual map shows that inhabitants in other localities did not use more of this material than predicted by the linear model, except for residents in Shields Pueblo (5MT3807).

The Percentage/Cost-Distance Relationship for Kbc. Although the percentage by weight of Kbc is relatively small, the regression relationship (Figure 5.22) shows the expected negative line and a moderate negative correlation (r^2=.183; *p*=.217). The slope, -.426, is considerably more negative than that obtained for Kbc in the early Pueblo II period (-.232). As with chalcedony, Escalante Ruin (5MT2149) inhabitants, who lived very close to several sources, used more Kbc than expected (Figure 5.23). In the McElmo-Yellowjacket locality, only residents in Shields Pueblo (5MT3807) used more of this material than expected; in many sites it is absent altogether. It is surprisingly that 5MV1595 shows a positive residual value even though the site is far from a source.

The Percentage/Cost-Distance Relationship for Morrison. Figure 5.24 shows a negative relationship with a very strong correlation (r^2=.585; *p*=.009) for the percentage of Morrison materials against its cost-distances in the late Pueblo II period. The slope, -.765, is similar to, though slightly more positive than, that obtained for Morrison in the early Pueblo II period (-.816). The residual analyses and map (Figure 5.25) show that 5MV1595 in the Mesa Verde locality weakens the fit of this model, as does 5MT2544 in the Hovenweep locality. Assemblages in the Ute and Dolores localities contain less

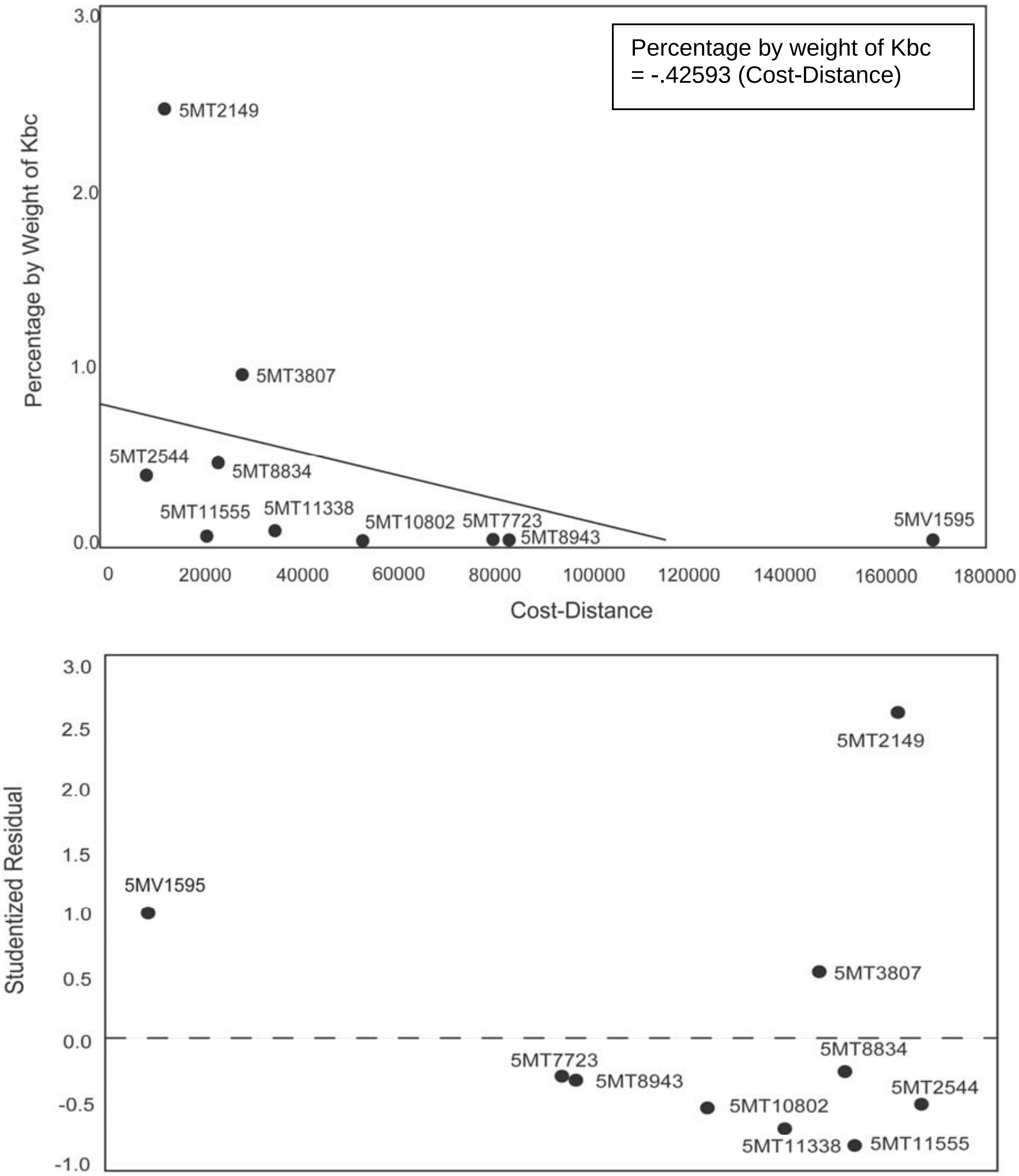


Figure 5.22. The top panel shows the late Pueblo II Kbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

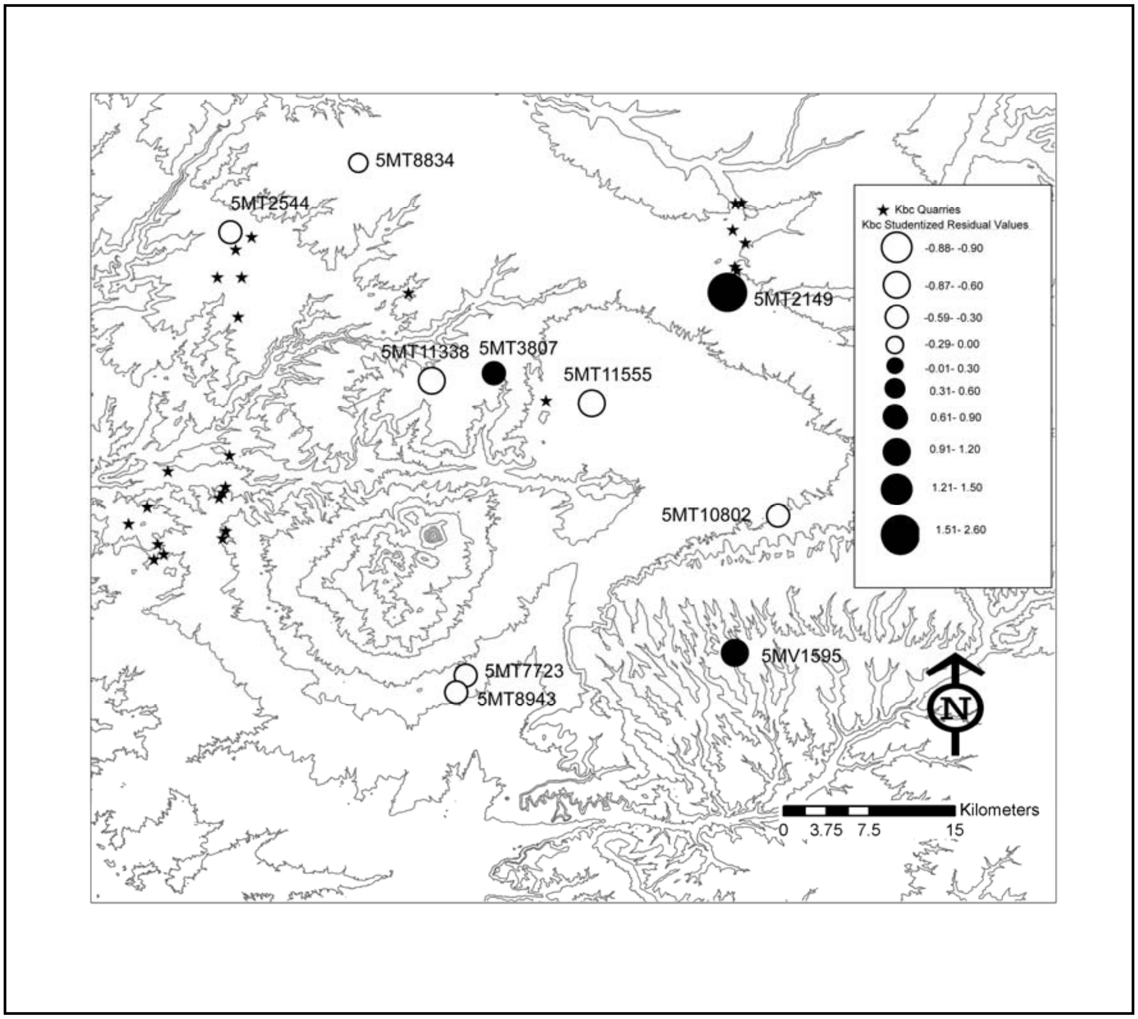


Figure 5.23. Map of Kbc studentized residuals during the late Pueblo II period.

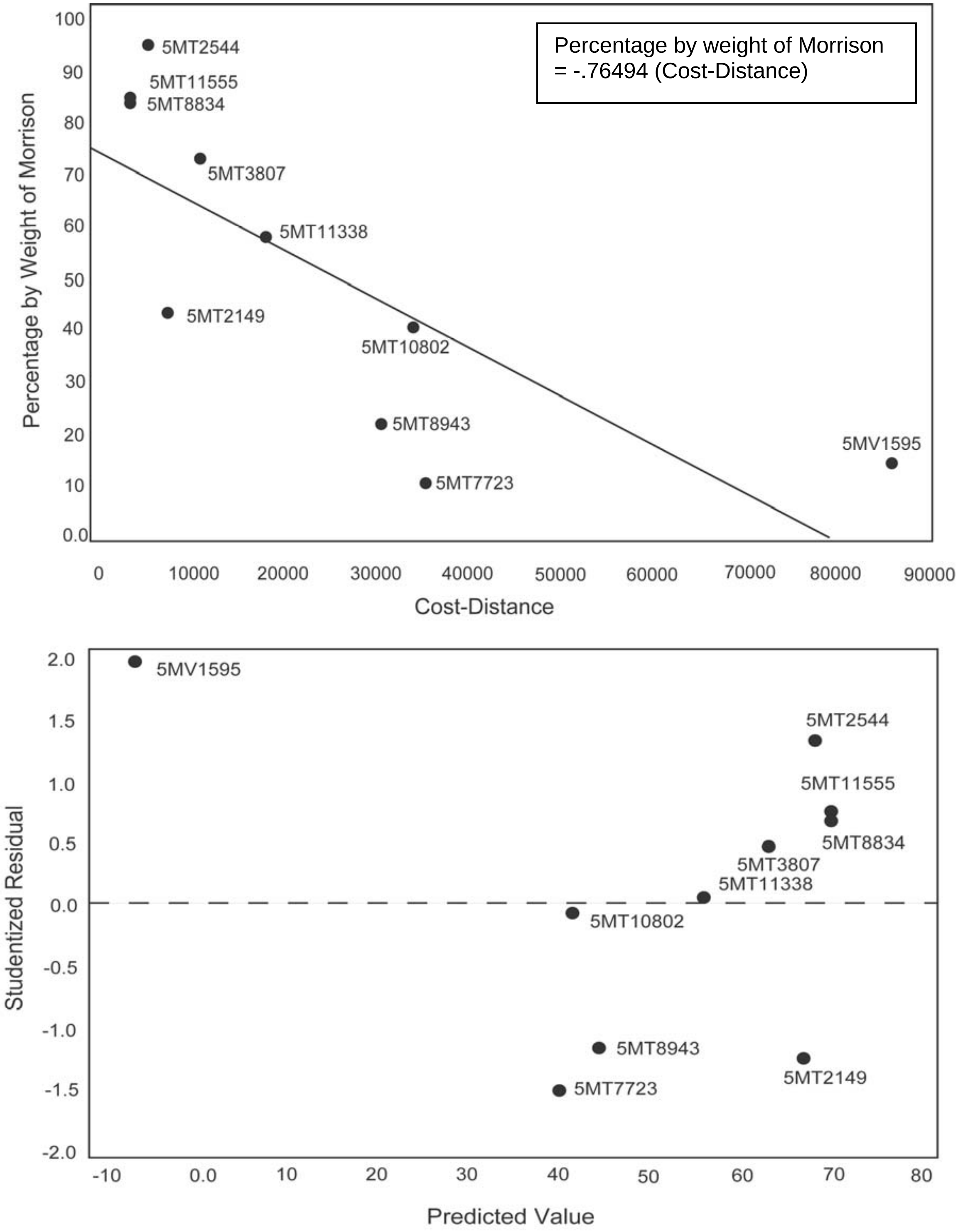


Figure 5.24. The top panel shows the late Pueblo II Morrison percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

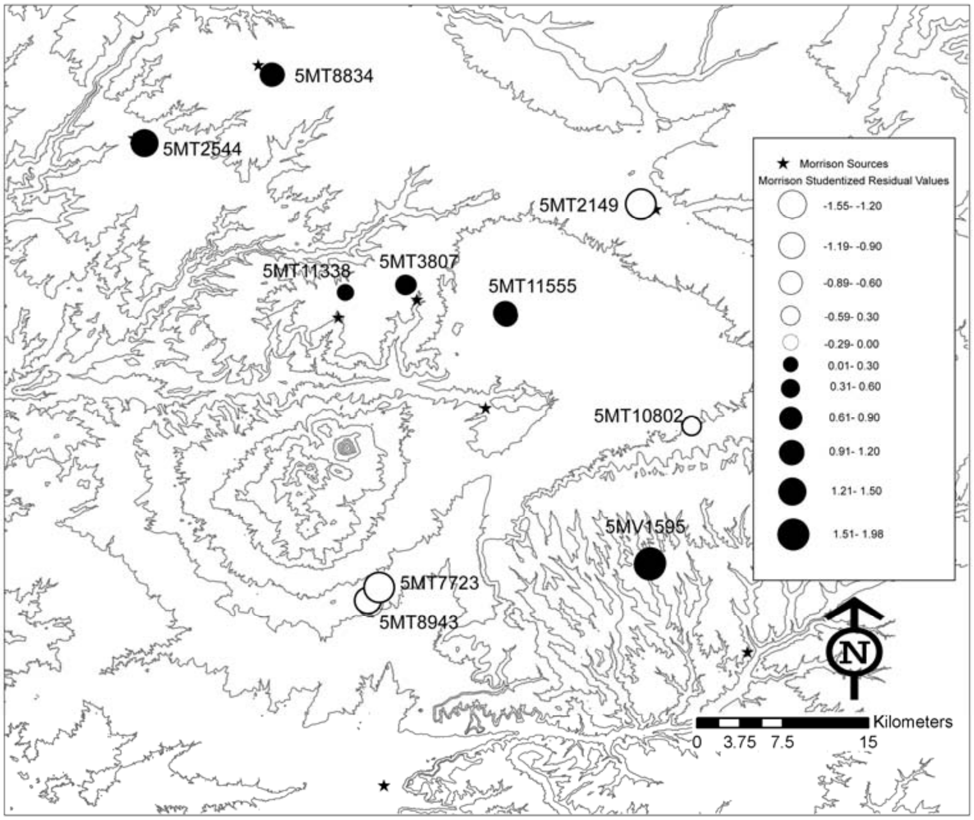


Figure 5.25. Map of Morrison studentized residuals during the late Pueblo II period.

Morrison material than expected by the linear model. The residual maps show that residents in the Hovenweep and McElmo-Yellowjacket localities procured and used somewhat more Morrison material during the late Pueblo II period than we would expect, based on the costs of obtaining it.

The Percentage/Cost-Distance Relationship for Jmbc. Figure 5.26 shows an unexpected positive relationship with a moderately strong correlation (r^2=.208; p=.186). The slope, .456, contrasts strikingly with the slope of -.262 for this relationship in the early Pueblo II period. The residuals and their map (Figure 5.27) show that 5MV1595 in the Mesa Verde locality contains the largest percentage of Jmbc, and on its own, largely determines the positive slope for the model, which without this site would have a negative slope. It is surprising that this site contains about 28 percent Jmbc, since it is quite far from known source areas. In the same locality, inhabitants of 5MT10802 did not procure or use any Jmbc material. In the McElmo-Yellowjacket locality, residents of 5MT11338 also used relatively large amounts of this material; on the other hand, inhabitants of 5MT3807 and 5MT11555 utilized very small amounts. Inhabitants of 5MT2149 in the Dolores locality also used small amounts of this material.

The Percentage/Cost-Distance Relationship for Igneous. Although only six sites contained igneous materials during the late Pueblo II period, the regression analysis once again shows a very strong negative relationship between its percentage and cost-distance (r^2=.739; p=.001; Figure 28). The slope, -.859, is similar to, though slightly more positive than, that obtained for igneous in the early Pueblo II period (-.954). As Figure 5.29 shows, although 5MT8943 in the Ute locality has about the predicted amount of igneous material, the adjacent 5MT7723 has more than predicted by the model. It is

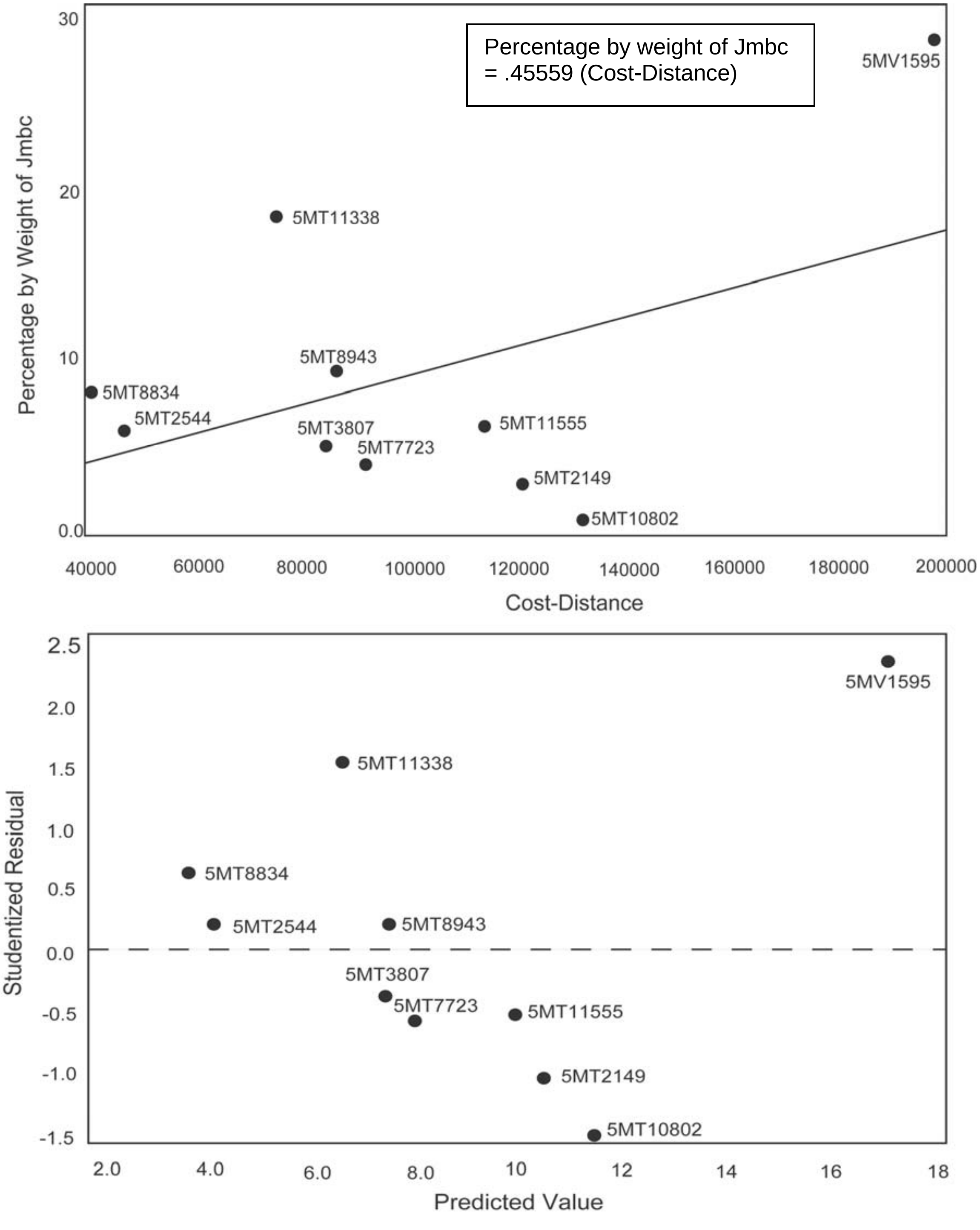


Figure 5.26. The top panel shows the late Pueblo II Jmbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

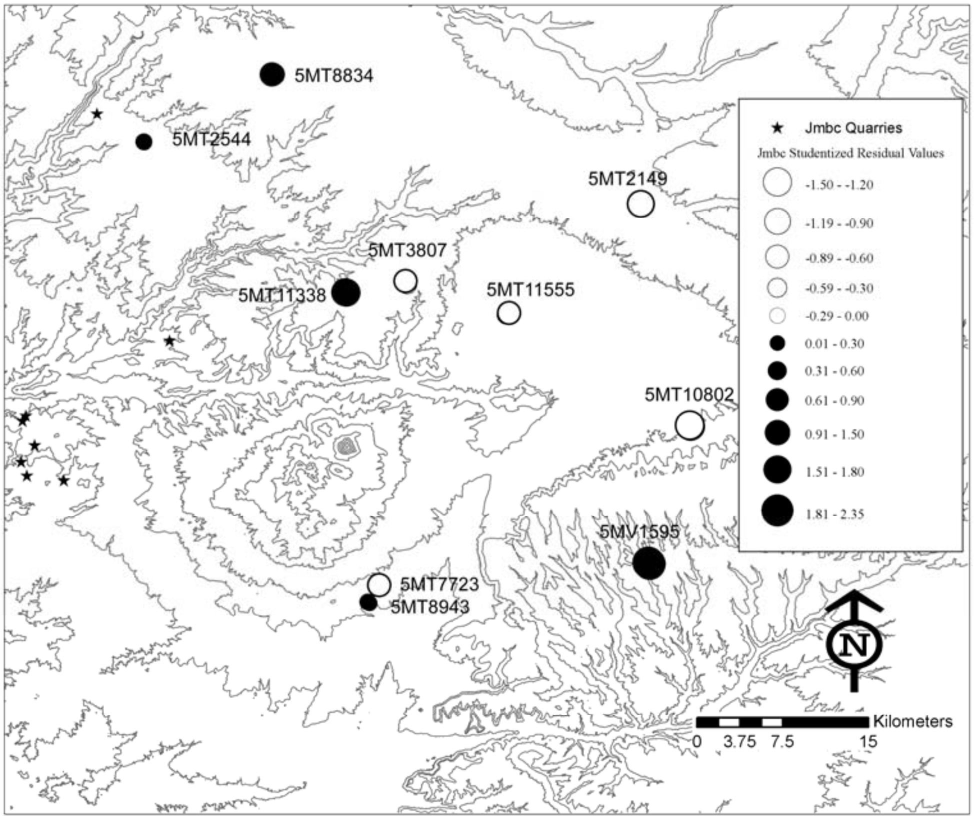


Figure 5.27. Map of Jmbc studentized residuals during the late Pueblo II period.

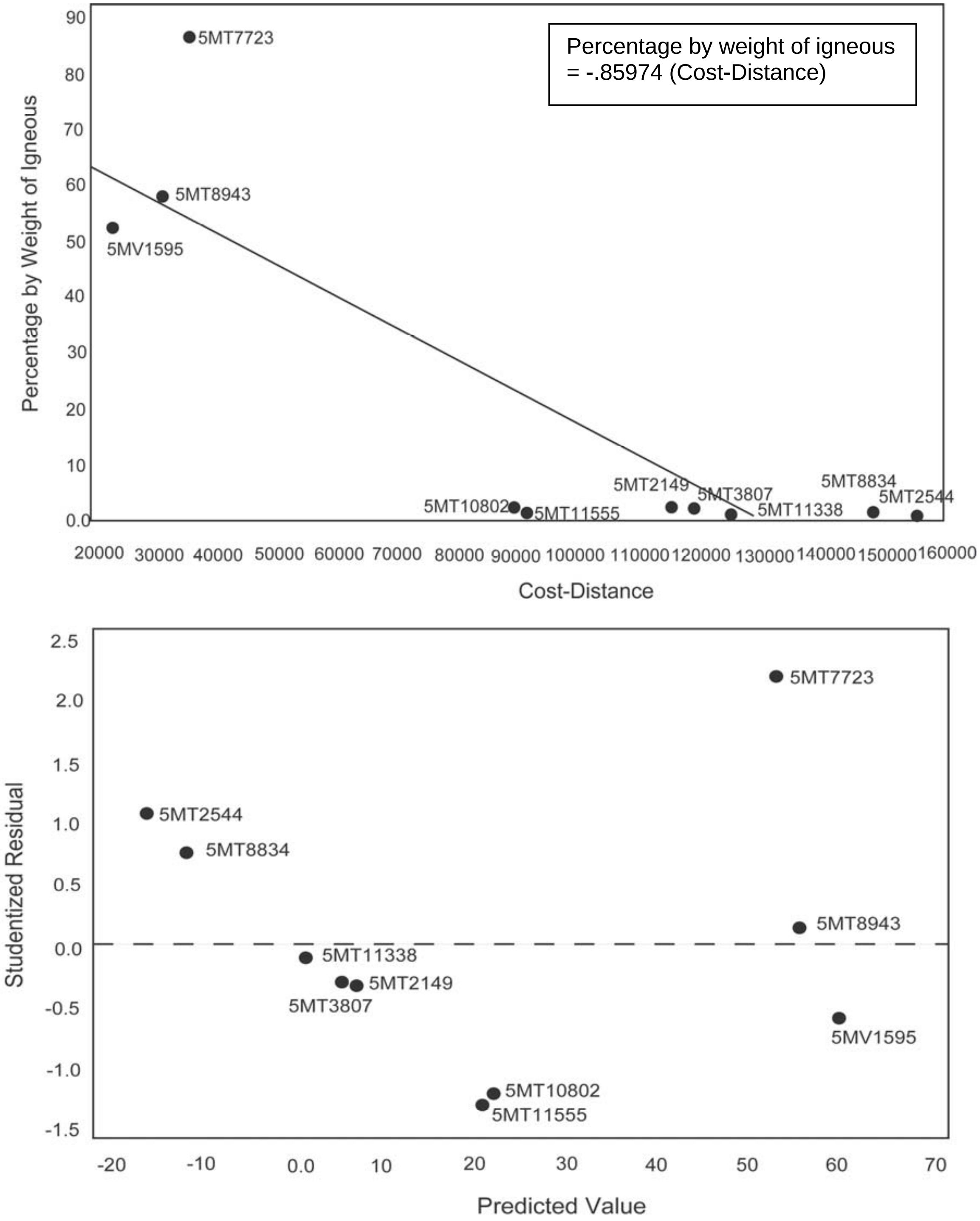


Figure 5.28. The top panel shows the late Pueblo II igneous percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

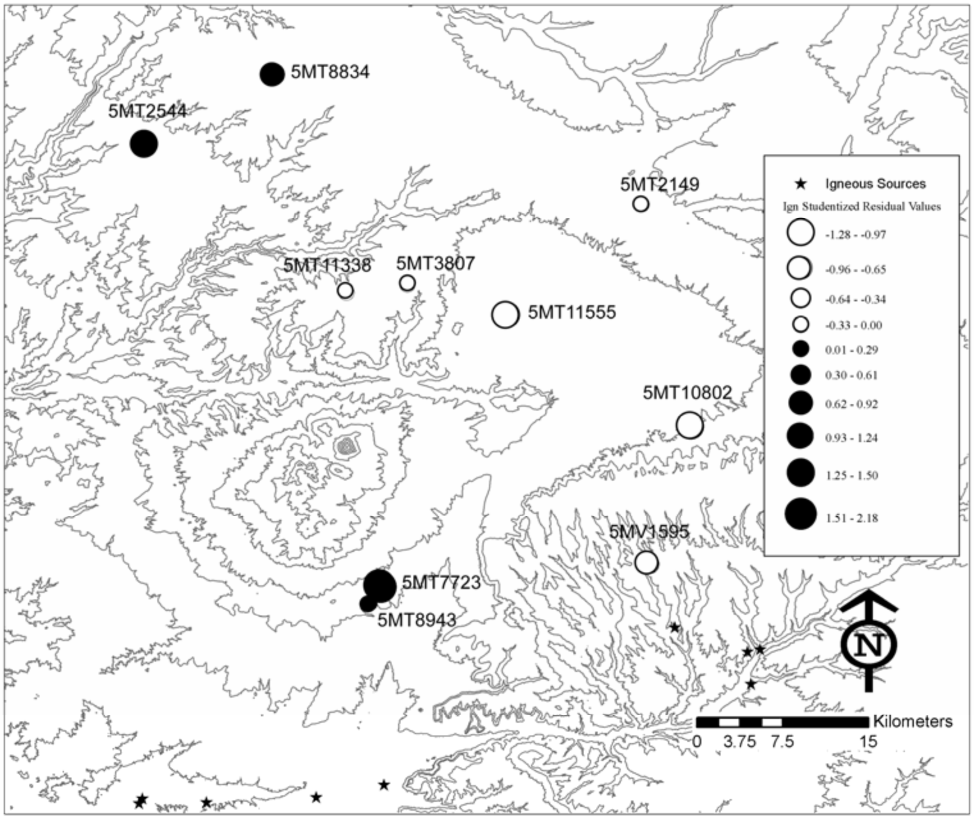


Figure 5.29. Map of igneous studentized residuals during the late Pueblo II period.

surprising that the Hovenweep sites contain as much of this material as they do, considering they are the sites farthest away from those source areas on this landscape. Residents of the Dolores, McElmo-Yellowjacket, and Mesa Verde localities did not procure or use igneous materials during the late Pueblo II period.

In the late Pueblo II period, all but one of the relationships between percentage of materials and their cost-distances are negative, though most of those negative relationships are not statistically significant. As in the Basketmaker III assemblages, the only positive relationship is for Jmbc. In the late Pueblo II period, Kdbq behaved like most other materials in displaying an insignificant negative relationship between cost-distance and percentage of materials. Below, I try to determine what that means by cross-tabulating the assemblages with much more, and much less, Kdbq than expected, based on the linear relationship shown in Figure 5.20, against two attributes for flakes from those assemblages.

Late Pueblo II Direct vs. Indirect Procurement Patterns for Kdbq

Here again, I use the procedure from the previous chapters for investigating whether assemblages somewhat above or below the best-fit regression model are significantly different with respect to flake attributes, possibly informing us about how these materials were acquired. Table 5.2 shows the results of Fisher's Exact Tests for cortex amount tabulated against assemblages with more or less Kdbq than expected, given the regression relationship shown in Figure 5.20. This test suggests that there is not a significant difference for these two groups of assemblages ($p \leq 0.863$ for cortex amount). In principle, the amount of cortex should decrease as the distance from lithic

Table 5.2. Fisher's Exact Test for the Kdbq Cortex Amount in Late Pueblo II Assemblages Where Kdbq is More Common, and Less Common, Than Expected.

		Cortex Amount			
		none	≤50%	50-100%	*n*
More Kdbq than expected from regression on distance[a]	Row Percentage	77.38	20.24	2.38	84
Less Kdbq than expected from regression on distance[b]	Row Percentage	74.58	23.73	1.69	59
	Total (*n*)	109	31	3	143

Fisher's Exact Test $p \leq 0.8630$

[a] flakes from assemblages with studentized residuals >.4 in Figure 5.20.

[b] flakes from assemblages with studentized residuals <-.4 in Figure 5.20.

sources to habitation sites increases, unless these materials were directly procured. There is no clear-cut difference in the procurement behaviors for inhabitants with much more Kdbq than expected (e.g., 5MT10802) and those inhabitants of sites with much less than expected. Because of this no-major different relationship, it appears that some late Pueblo II residents in the central Mesa Verde region were not indirectly procured Kdbq. In other words, some inhabitants of the central Mesa Verde region probably engaged in more direct procurements, possibly prospective toolstone procurement that involved searching for, evaluating, and collecting small pieces of small pieces of raw materials during activities that, for the most part, involved the procurement of other (non-lithic) materials (Wilke and Schroth 1989. This result is similar to the outcome of the early Pueblo II period, but the relationships of late Pueblo II assemblages above or below the best-fit regression model are not significantly different regarding cortex amounts.

Summary of the Percentage/Cost-Distance Relationship

Similar to previous chapters, I summarize the percentage/cost-distance relationship of these six raw materials during the late Pueblo II period using three broad categories. First, the percentage/cost-distance relationship for both of the high-quality materials (chalcedony and Kbc) shows a moderately weak negative correlation. Inhabitants of 5MT10802 in the Mesa Verde locality and 5MT3807 in the McElmo-Yellowjacket locality frequently used those high-quality materials. The Dolores residents frequently obtained and utilized these materials near their habitation, but they elected to procure only chalcedony and Kbc, but not Kdbq. The study of high-quality materials suggests that some residents would have had an opportunity to choose their favorable lithic raw materials in this landscape. This further implies that they may have engaged in frequent logistic mobility (also embedded procurement) than other inhabitants in the central Mesa Verde region. The result of Fisher's Exact Tests supports this possibility that some Pueblo II people tended to procure Kdbq by more direct procurement than in the early Pueblo II period. In short, these results suggest that some of the late Pueblo II residents employed frequent logistical mobility in procuring high-quality materials.

Second, as in earlier periods, the late Pueblo II inhabitants of this region procured and utilized low-quality raw materials (Morrison) from close to their habitation sites, except for residents of the Mesa Verde locality. More-than-expected amounts of Morrison materials from 5MV1595 in the Mesa Verde locality suggest that the residents engaged in high logistical mobility or frequent interactions with inhabitants who lived close to outcrops of the Morrison Formation in the lower elevations of this region.

Finally, residents of the Mesa Verde, McElmo-Yellowjacket, and Hovenweep localities used unexpectedly large amounts of the medium-quality materials (Jmbc and igneous materials). Because the Mesa Verde residents used more than expected amounts of Jmbc even though their sources were located far away, on the western margins of the

McElmo-Yellowjacket locality, they may have had strong interactions with people in that area or frequent logistic mobility in that direction during the late Pueblo II period. The frequent procurement of igneous materials by residents in the Hovenweep locality suggests behaviors somewhat similar to those of the inhabitants in the Mesa Verde region. This suggests a network that involved exchanging igneous for Jmbc materials between the McElmo-Yellowjacket/ Hovenweep and the Mesa Verde residents.

The Energy Expenditure Model

Here again, I utilize the energy-expenditure model presented in chapter two to determine how much energy inhabitants of sampled sites expended in procuring 10 raw material types by the cost of traveling to each of their sources from each site. Figure 5.30 shows that the Mesa Verde inhabitants expended the most energy in procuring raw materials, followed by the residents of Ute, then McElmo-Yellowjacket, Dolores, and then Hovenweep localities. Based on changes in energy-expenditure values between the early Pueblo II and late Pueblo II periods, late Pueblo II residents expended more energy in procuring raw materials than did early Pueblo II people. In the next section, I provide a global comparison of the early and late Pueblo II procurement patterns by creating the difference map for those time periods.

The Energy Expenditure Map

Here again, using kriging interpolation in the ArcGIS program (see Appendix A), I created an isopleths map of the total energy expended by the late Pueblo II residents (Figure 5.31). This map shows that the inhabitants in the Hovenweep and Dolores

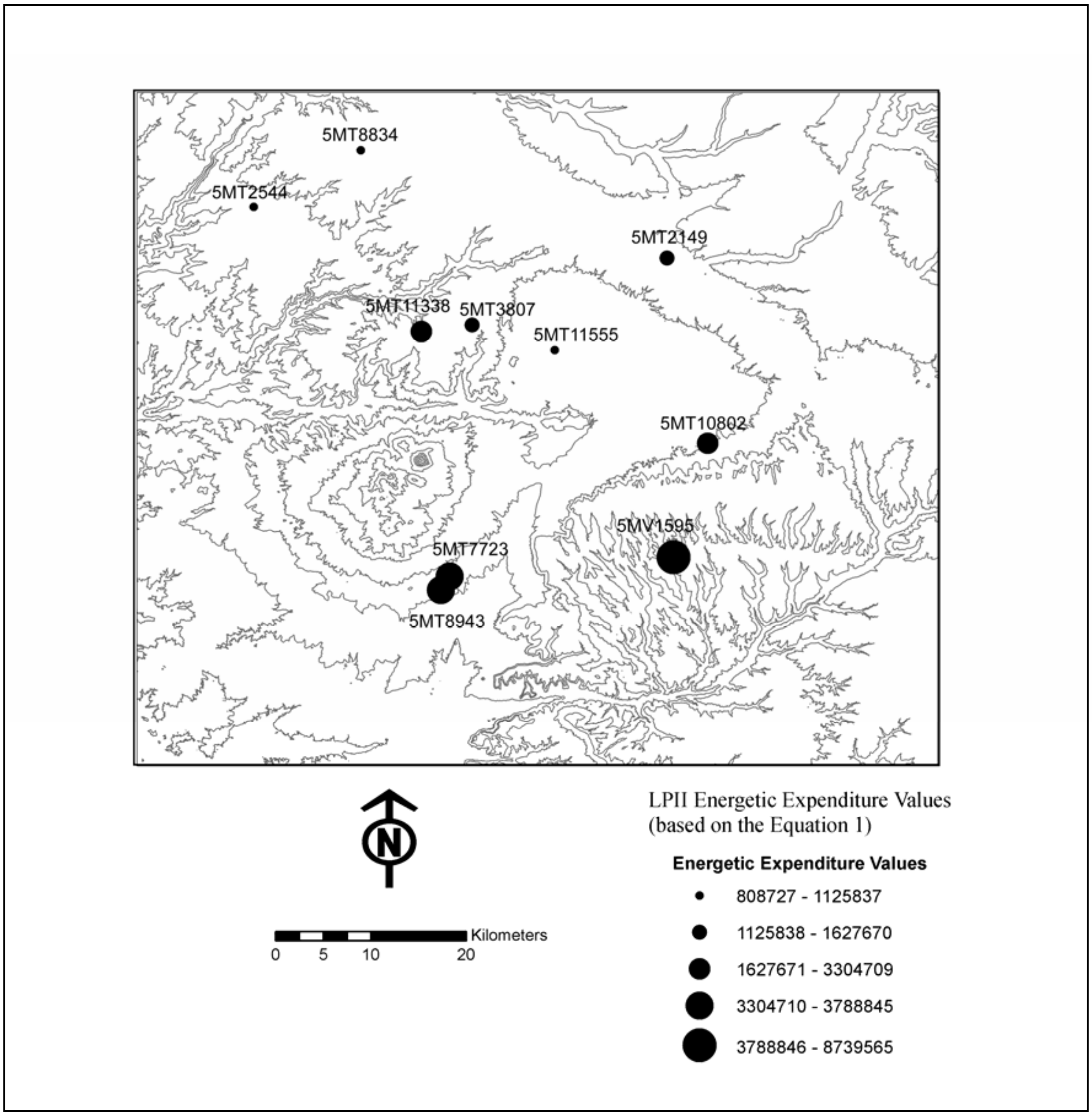


Figure 5.30. Energetic expenditure values for sampled late Pueblo II sites in the central Mesa Verde region.

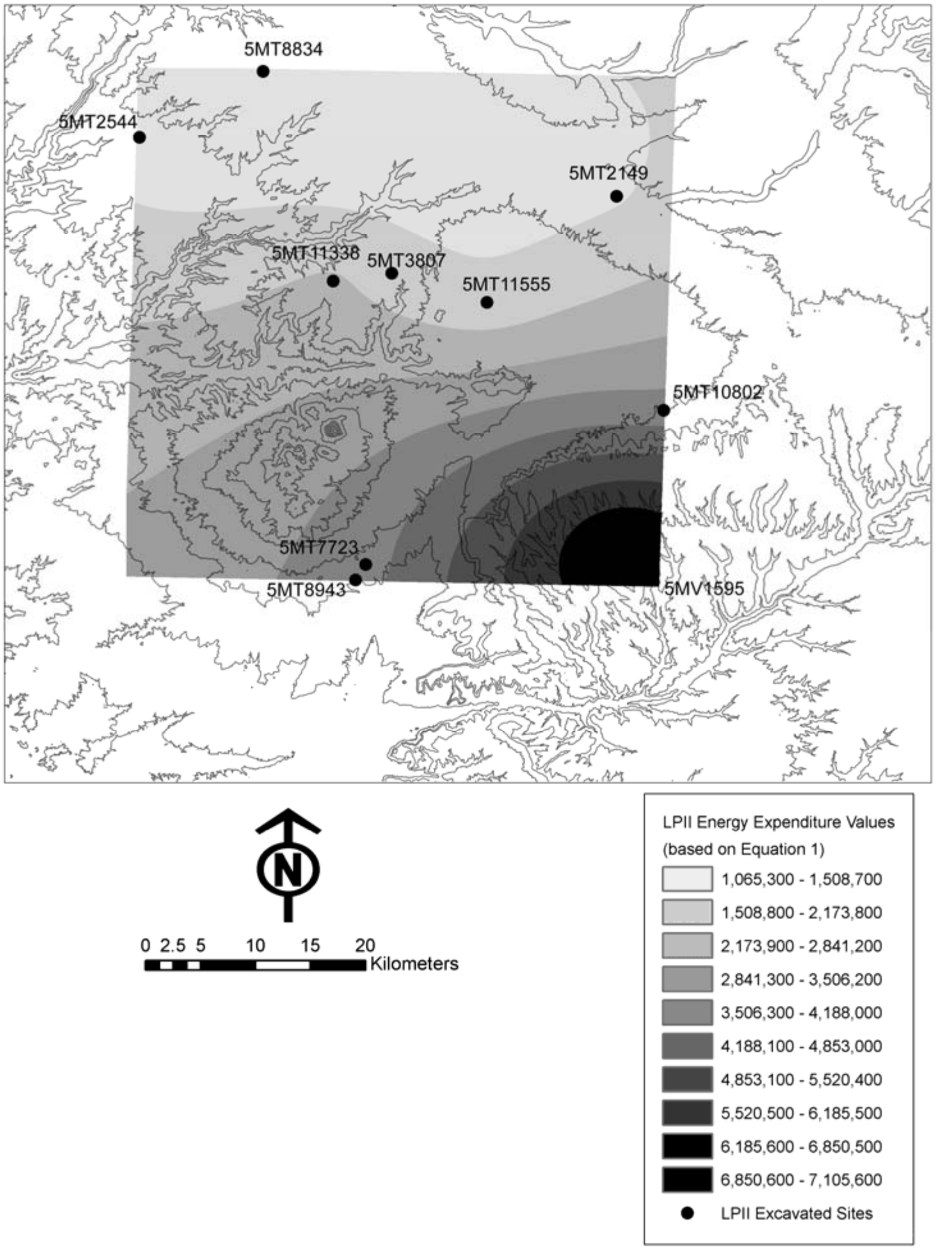


Figure 5.31. A kriged map that interpolates, across our region, the total energy-expenditure values for acquiring toolstone for the sampled late Pueblo II sites.

localities expended much less energy in procuring raw materials than did the people in the Mesa Verde locality. Comparing this map with the previous early Pueblo II map, much higher energy-expenditure values are distributed across the landscape during the late Pueblo II period.

Next, to identify where inhabitants in the central Mesa Verde region expended less or more energy to procure raw materials during the late Pueblo II period in comparison with the early Pueblo II, I created, as before, a difference map by overlaying and subtracting the total energy expended by the early Pueblo II residents from that of the late Pueblo II residents. Figure 5.32 maps the results of this calculation as extrapolated across the landscape. Dark red areas identify places with the largest increases in energy expenditures between these two periods. The prevalence of red on this map suggests that the late Pueblo II inhabitants expended more energy in general in procuring raw materials. The dark yellow shows where early Pueblo II residents expended more energy in procuring raw materials than did the later inhabitants of the same area, although this map may show the result of an artifact of extrapolation since no assemblages were present in the area. Overall, inhabitants of the Mesa Verde locality increased their expenditures the most, followed by residents of Dolores and McElmo-Yellowjacket. In contrast, residents of the Hovenweep and northern margins of McElmo-Yellowjacket localities expended less energy, based on this model. This pattern may suggest that certain groups in the Hovenweep and northern portions of the McElmo-Yellowjacket localities did not participate in the Chaco florescence, but did dominated certain areas in these localities.

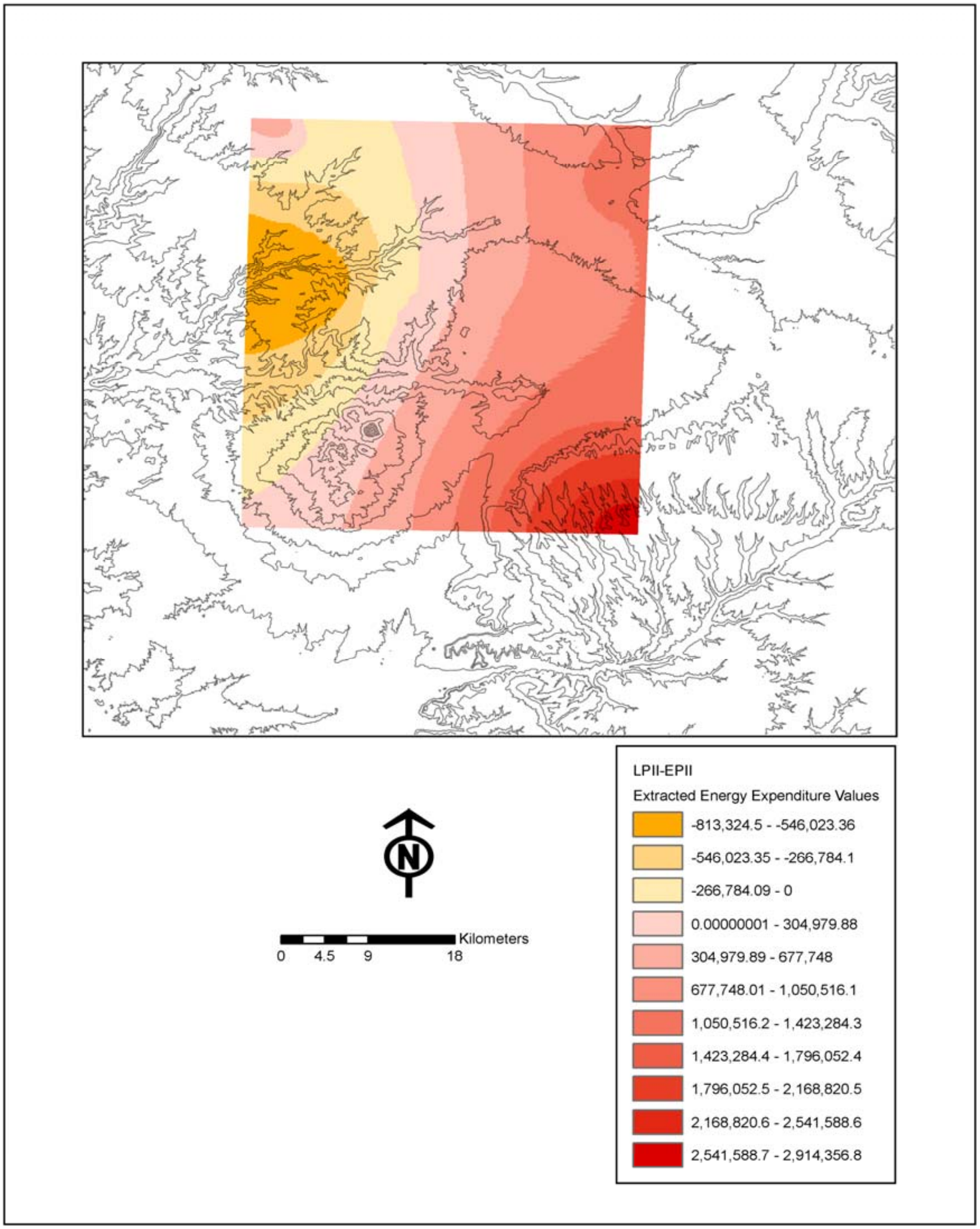


Figure 5.32. A difference map showing areas where the energy expenditure values for acquiring toolstone increased, or decreased, in late Pueblo II sites relative to early Pueblo II sites.

Summary of the Late Pueblo II Period

During the late Pueblo II period, the population became fairly high (approximately 8,000-12,000), and potential agricultural resource productivity was the highest of all the periods in the sequence, but agricultural resource predictability, as judged by the standard deviation of the annual productivity, was also the highest among our six periods ($\bar{x}$=264.44 kg/ha per year; S.D.=54.45 kg/ha per year). Dyson-Hudson and Smith's economic defensibility model (1978) suggests that these conditions should lead to high-mobility, information-sharing spatio-temporal territories.

Lithic data, however, do not support their model. Although r^2 values for the percentage and cost-distance relationship of Kdbq are relatively weak, other materials show relatively similar correlation coefficients and steep slopes for the early Pueblo II period. The one interesting aspect of late Pueblo II lithic assemblages is that the regression analyses of Jmbc showed a positive relationship between its percentage by weight and its cost-distance with a stronger correlation than in the early Pueblo II assemblages.

The energy expenditure model suggests that residents of the Mesa Verde locality expended high amounts of energy in procuring raw materials, and the total energy expenditure of late Pueblo II assemblages also suggests that inhabitants in most other localities expended more energy in procuring raw materials than did the local early Pueblo II residents. The difference map confirms this, showing that late Pueblo II inhabitants in the Mesa Verde, Dolores, and small portions of McElmo-Yellowjacket localities exerted more energy to obtain their lithic assemblages.

In summary, lithic data from the late Pueblo II period show that r^2 and slopes of four out of six raw materials become more positive than in the early Pueblo II period. Besides, as in the Basketmaker III period, the slope of Jmbc becomes positive. These results suggest that the late Pueblo residents engaged in more logistic mobility than in the early Pueblo II period. The energy-expenditure model and its values indicate also that the late Pueblo II residents expended more energy in obtaining their lithic materials on this landscape. The late Pueblo II people were perhaps able to participate in this kind of behavior because they may have been involved in the Chaco Regional System.

CHAPTER SIX

PUEBLO III (A.D. 1140-1280)

The Chaco regional system disappeared after the middle twelfth century, and the population in the central Mesa Verde region continued to increase coincident with the development of large aggregated communities in the McElmo-Yellowjacket, Hovenweep, and Ute localities. In this chapter I focus on population estimates, resource productivity, settlement patterns, archaeological remains, and toolstone procurement patterns during the Pueblo III period, split into two sub-periods: early Pueblo III (A.D. 1140-1225) and late Pueblo III (A.D. 1225-1280).

Background for Early Pueblo III (A.D.1140-1225)

Population Estimates. The population continued to increase from the late Pueblo II to the early Pueblo III period (Varien et al. 2007; Wilshusen 2002). Regional settlement patterns show that habitation sites in the Totah region decreased in number (Glowacki 2006). This suggests the possibility that a migration occurred from the Totah area north to the central Mesa Verde region in the early 1100s. Wilshusen suggested that approximately 12,000 to 14,000 people inhabited the central Mesa Verde region during the late twelfth to thirteenth century (2002:116). Varien et al. (2007) reinvestigated momentary population estimates for the "Village" study area and determine that it contained 10,000-11,000 people during the early Pueblo III period.

Resource Productivity. According to Figure 4.2, the average potential maize yields (kg/ha) in this period were relatively low, and became worse in the cold, dry conditions of the early 1200s (Varien et al. 2007). After the late Pueblo II period, the central Mesa Verde Puebloans experienced a rapid decline in maize productivity through A.D. 1170, which then slightly increased, and again severely decreased around A.D. 1200 until the end of the early Pueblo III period.

Settlement Patterns and Social Organization. Research on the Pueblo III period has been the focus for many archaeological projects in this region (e.g., Adler 1990, 1996; Cattanach 1980; Hayes 1964; Hayes and Lancaster 1975; Osborne 1965; Rohn 1971; Varien 1997). Settlement possibly became more sedentary coincident with a gradual increase in population around A.D. 1180s and 1190s (Lipe and Varien 1999b:300). In general, the central Mesa Verde Puebloans settled on good, arable lands in loosely clustered, dispersed small habitations during the early Pueblo III period. Within those dispersed habitations, each household consisted of a Prudden unit (Prudden 1918), which is composed of a small roomblock, a kiva, and a midden. On the locality level, community centers, which contain nine or more kivas, 50 or more total structures, or sites with public architecture, continued to be built (Lipe and Varien 1999b; Varien 1999; Varien et al. 2007). Furthermore, remodeled Chaco-style great houses and semi-aggregated clusters of habitations became apparent during this time period (Lipe and Varien 1999b:300). Most of those Chaco-style great houses (such as Albert Porter [Ryan 2004]), Wallace Ruin [Bradley 1988]), however, show continual use through remodeling of the original structures. Dolores-area occupation ceased entirely, perhaps because of the prevailing cold conditions during the early Pueblo III period.

Previous Research on Early Pueblo III Period Ceramic and Lithic Assemblages

Ceramic Data. According to Wilson and Blinman (1991), Dolores Corrugated and Mesa Verde Corrugated became widespread, but some Mancos Corrugated was also present from A.D. 1140 to 1180. McElmo Black-on-white pottery became the prominent type around the beginning of the early Pueblo III period, but Mesa Verde Black-on-white pottery increased towards the end of the early Pueblo III period. In the central Mesa Verde region, red wares became very rare in early Pueblo III assemblages, which suggest a decline in the interregional exchange system because most red wares were exported or traded from areas to the west (e.g., the Kayenta region) or north (e.g., White Mountain Redware).

Hegmon (1991) and Ortman (1995a, 1995b) developed seriations of whiteware attributes to distinguish between the late Pueblo II and Pueblo III periods. They used tree-ring dates to calibrate several pottery attributes. More recently, Ortman et al. (2007) used pottery types and other criteria to reconstruct temporal differences and population sizes in the "Village" project area. My research benefits from the chronological dataset compiled by those temporally calibrated data.

Lithic Data. Anasazi lithic technology has been called "devolved" and "unremarkable" (Torres 2000:221), and the lithics have been understudied in this region and the Southwest in general (Arakawa 2000). In a previous study (Arakawa 2000), I examined the possibility of a gendered division of labor using lithic data dating from A.D. 1050 to 1280 from Yellowjacket Pueblo (5MT5). This research revealed that formal tools (bifaces and projectile points) were made of high-quality, semi- or non-local materials, while the majority of expedient tools were manufactured with mostly low-quality, local materials (Arakawa 2000). I utilized ethnographic records of Hopi and

Zuni to interpret these data and to argue that the high frequency of expedient tools and their debitage found in the Yellow Jacket Pueblo site may have been associated with women's activities. Additionally, toolstone procurement patterns of local versus semi- and non-local materials may have been associated with men's and women's activities.

During the Pueblo III period, projectile points show somewhat different types and frequencies than in the Pueblo II period. Bradley (1988) compared the ratio of numbers of projectile points to rim sherds from many sites in the Four Corners region. This study showed ratios between 1:800 and 1:1200 from Mug House and Long House assemblages during the Pueblo III period. On the other hand, the late Pueblo II assemblage from Wallace Ruin showed a ratio of 1:57 (Bradley 1988). It is rare to find projectile points in most Pueblo III contexts. During both early and late Pueblo III times, central Mesa Verde residents preferred unstemmed triangular arrow points with straight to slightly concave bases and small side notches, although some small stemmed projectiles were still used (Lipe and Varien 1999b:317).

Arakawa and Duff (2002) investigated toolstone procurement patterns at Yellowjacket Pueblo and Shields Pueblo from the late Pueblo II to late Pueblo III periods. We discovered that the frequency of semi- and non-local materials declined during the early and late Pueblo III periods, but utilization of local materials increased over time. We suggested that the Mesa Verde Puebloans reduced their mobility and interaction during the early Pueblo III period. This study supported Neily's inference, based on lithics and ceramics from Cow Canyon and Squaw Point communities (1983), that residents in these communities became more isolated, or autonomous from other communities during the early Pueblo III period.

Architecture. A pecked-face "McElmo"-style masonry (Lipe and Varien 1999b:318) appeared probably during the late eleventh century. In the central Mesa Verde region, this masonry became widespread after A.D. 1150. It was produced starting from a suitably sized piece of sandstone, using percussion flaking to modify it, and then finishing the shaping by pecking with a hammerstone. Lipe and Varien (1999b:319) note that this type of masonry appears particularly in the larger sites (which contained more public architecture) rather than in the smaller sites in this region.

During the Pueblo III period, the frequency of great kivas at many community centers decreased, but multi-walled structures became widespread in the study area (Churchill et al. 1998). Towers and D-shaped structures also appeared and began to outnumber great kivas in this region during the early Pueblo III period (Lipe and Varien 1999b:319).

Current Perspectives on Early Pueblo III Assemblages

Figure 6.1 shows the 15 well-dated early Pueblo III habitation sites in the study area from which lithic assemblages were analyzed for this study. Three sites – 5MT11787, 5MT2525, and 5MT2544 – are located in the Hovenweep locality. In the McElmo-Yellowjacket locality, five sites – 5MT11338, 5MT5152, 5MT3918, 5MT3936, and 5MT3930 – are located, all in the Sand Canyon area (Varien 1997), and sites 5MT11842, 5MT3807, 5MT3892, 5MT10991 are from the McElmo-Yellowjacket locality. 5MT3778 is located in the Dolores locality, and 5MT10207 and 5MT10206 represent lithic assemblages from the Ute locality. Unfortunately, I could not obtain an early Pueblo III lithic assemblage from the Mesa Verde locality. Because residents in the

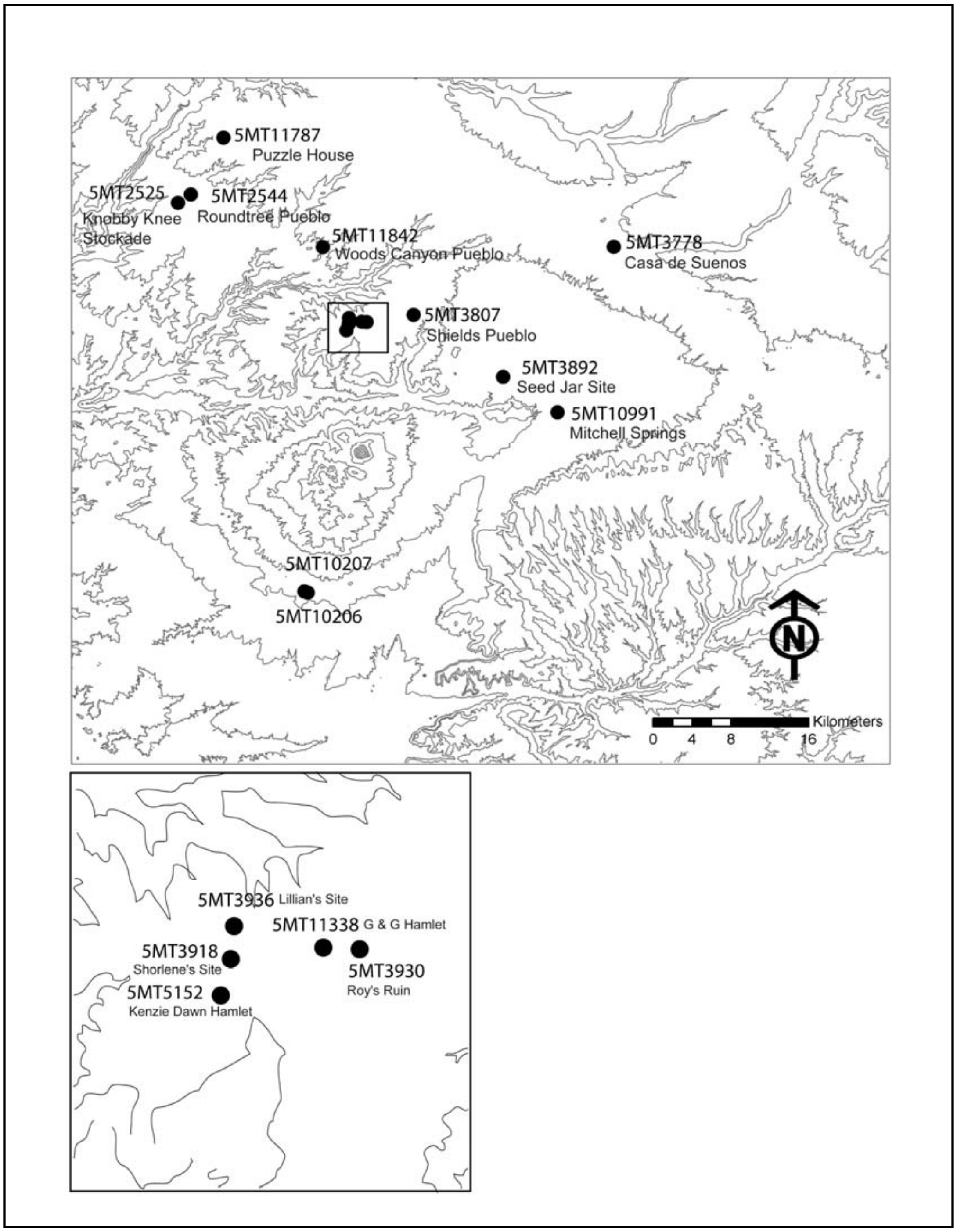


Figure 6.1. Early Pueblo III habitation sites. The bottom panel shows the early Pueblo III habitation sites in the Sand Canyon area.

Mesa Verde locality were some distance from many lithic sources, these missing data in the percentage/cost-distance and energy-expenditure model for the early Pueblo III makes them somewhat incompatible with those of different periods. To investigate the consequences of this problem, I reinvestigated assemblages from other periods without the Mesa Verde locality to determine whether the early Pueblo III assemblages would then be comparable with respect to the calculated r^2 and slopes. Except for Jmbc, which was probably procured and utilized for symbolic or special purposes, the late Pueblo II and late Pueblo III assemblages showed only small differences in r^2 and slopes when I analyzed them without the Mesa Verde assemblages. On the other hand, without the Mesa Verde assemblages, Basketmaker III, Pueblo I, and early Pueblo II assemblages showed fair differences in r^2 and slope values. This occurred because habitations in those early periods are located in mostly the Dolores and Hovenweep localities where residents lived far away from the Mesa Verde locality. The absence of assemblages from the Mesa Verde locality makes the percentage vs. cost-distance models for those early assemblages fit more poorly, (that is made the slopes flatter). In general, I think the unfortunate fact that early Pueblo III assemblages do not include data from the Mesa Verde locality does not constitute a major confounding factor for analyzing and comparing the percent/cost-distance and energy expenditure models of this time period with other time periods. Nevertheless, for the energy-expenditure model, when I compared the total energy expenditure between the late Pueblo II and early Pueblo III periods and between the early Pueblo III and late Pueblo III periods, I created the difference map after excluding the Mesa Verde locality.

The Percentage/Cost-Distance Relationship for Chalcedony. Although its percentage by weight is relatively small, the regression relationship (Figure 6.2) shows the expected negatively sloped line and a moderate correlation coefficient (r^2=.139; p=.169). The slope, -.374, is similar to, though slightly more negative than, that obtained for chalcedony in the late Pueblo II period (-.279). Figure 6.3 shows that 5MT3778 (Casa de Sueños) in the Dolores locality, near quarries of chalcedony, contains more of this material than predicted by the model. Inhabitants of a few sites of the McElmo-Yellowjacket and Ute localities obtained relatively less chalcedony than expected by this model. Most residents in the Hovenweep locality procured surprisingly less chalcedony than would be expected, even though they were relatively close to a quarry.

The Percentage/Cost-Distance Relationship for Kdbq. Figure 6.4 shows the relationship of early Pueblo III percentage/cost-distance of Kdbq. For these sites, there is a relatively strong negative relationship (r^2=.274; p=.045) between the cost-distance and the percentage of Kdbq. This is the first period in which there is a significant (negative) relationship between the percentage of Kdbq and its cost-distance. The slope, -.523, is much larger that obtained for Kdbq in the late Pueblo II period (-.176). Figure 6.5 shows that 5MT3918 (Shorlene's Site) has the highest positive residual for Kdbq, followed by 5MT5152within the Sand Canyon area in the McElmo-Yellowjacket locality. Residents of other sites in this locality – 5MT3807, 5MT3892, and 5MT11842 – used more Kdbq than expected. On the other hand, this study shows that inhabitants in 5MT3936 and 5MT3930 within the Sand Canyon area used less Kdbq than predicted by the model. Although 5MT3778 in the Dolores locality had more-than-expected amounts of

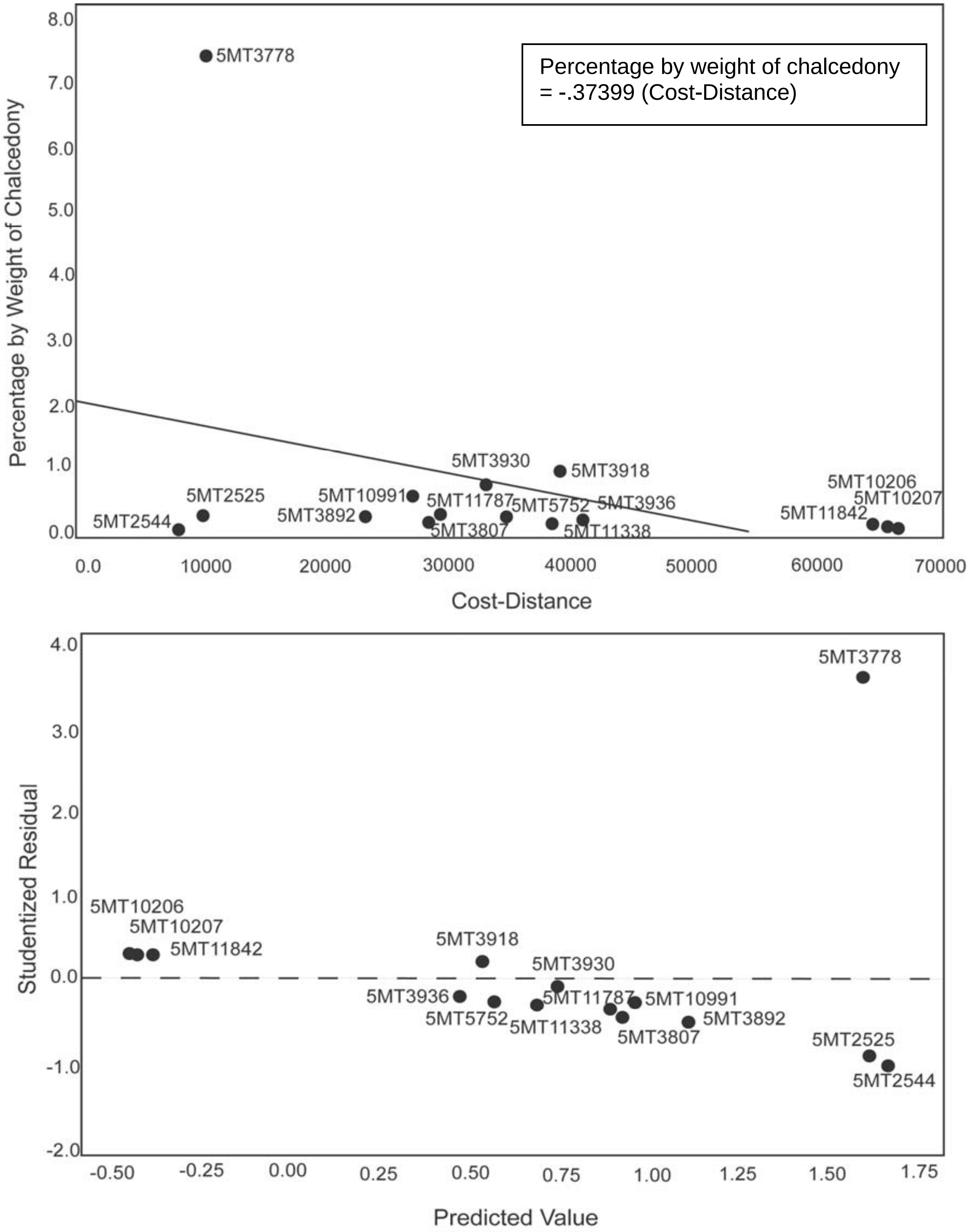


Figure 6.2. The top panel shows the early Pueblo III chalcedony percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

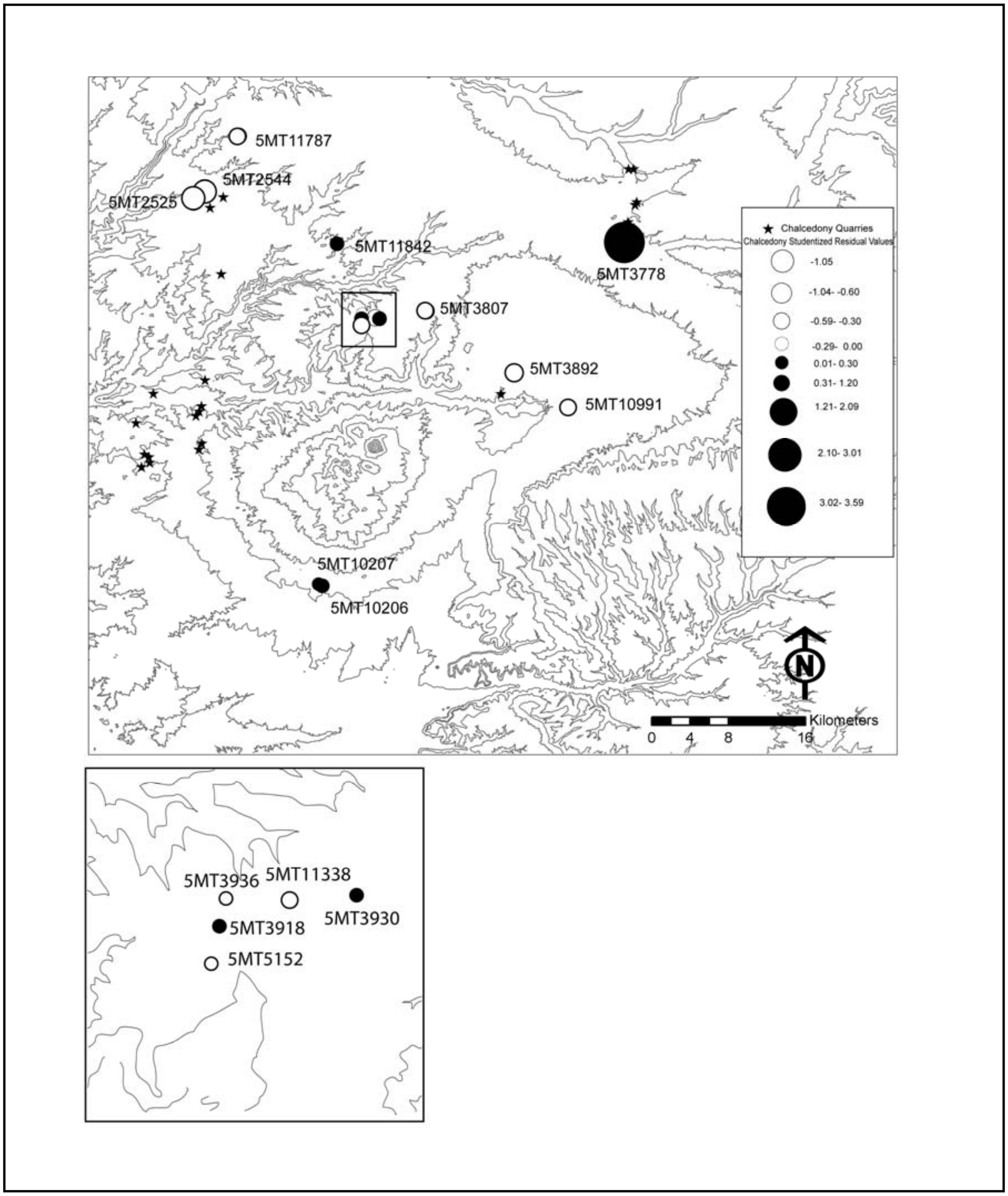


Figure 6.3. Map of chalcedony studentized residuals during the early Pueblo III period. The bottom panel shows chalcedony studentized residuals in the Sand Canyon area.

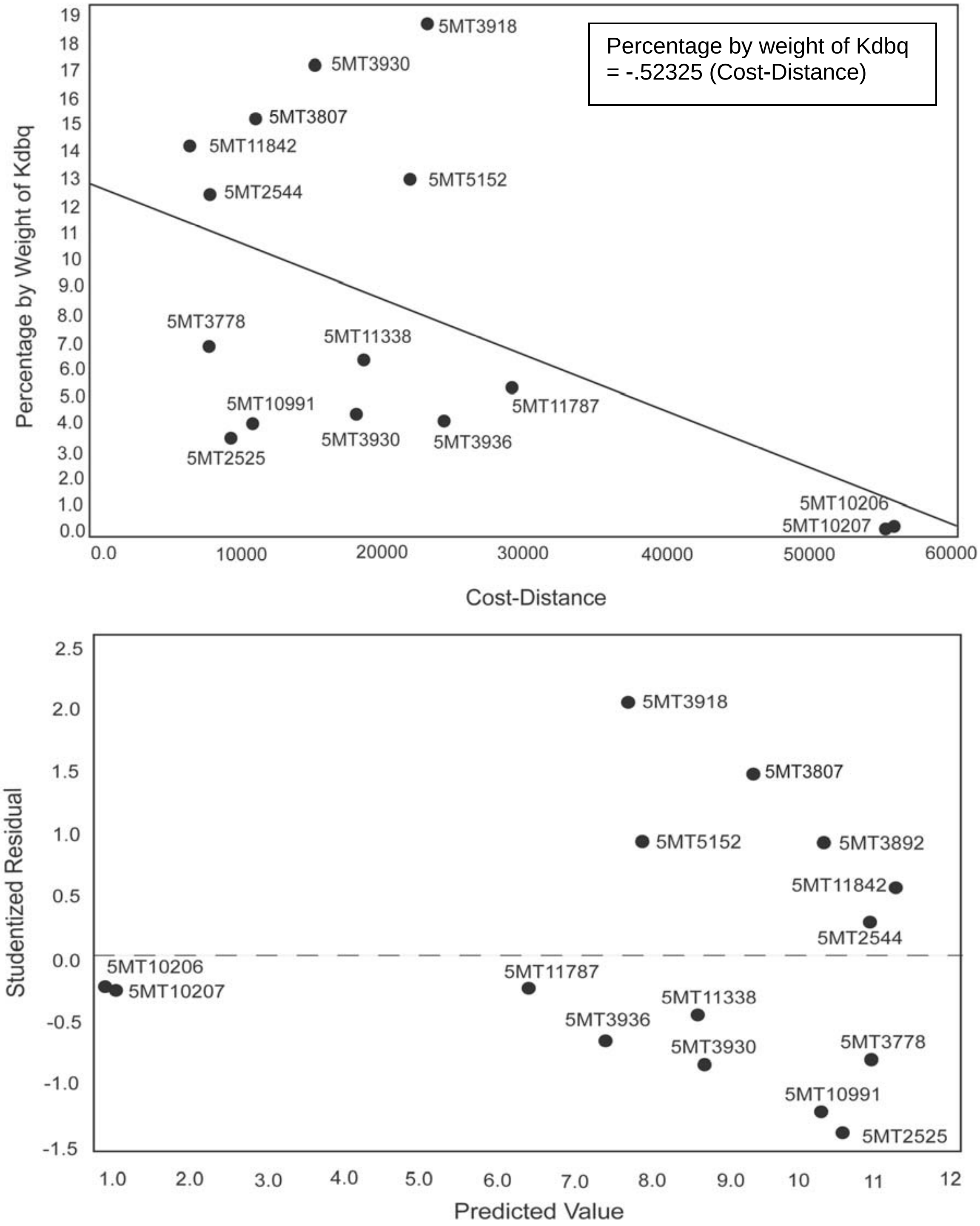


Figure 6.4. The top panel shows the early Pueblo III Kdbq percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

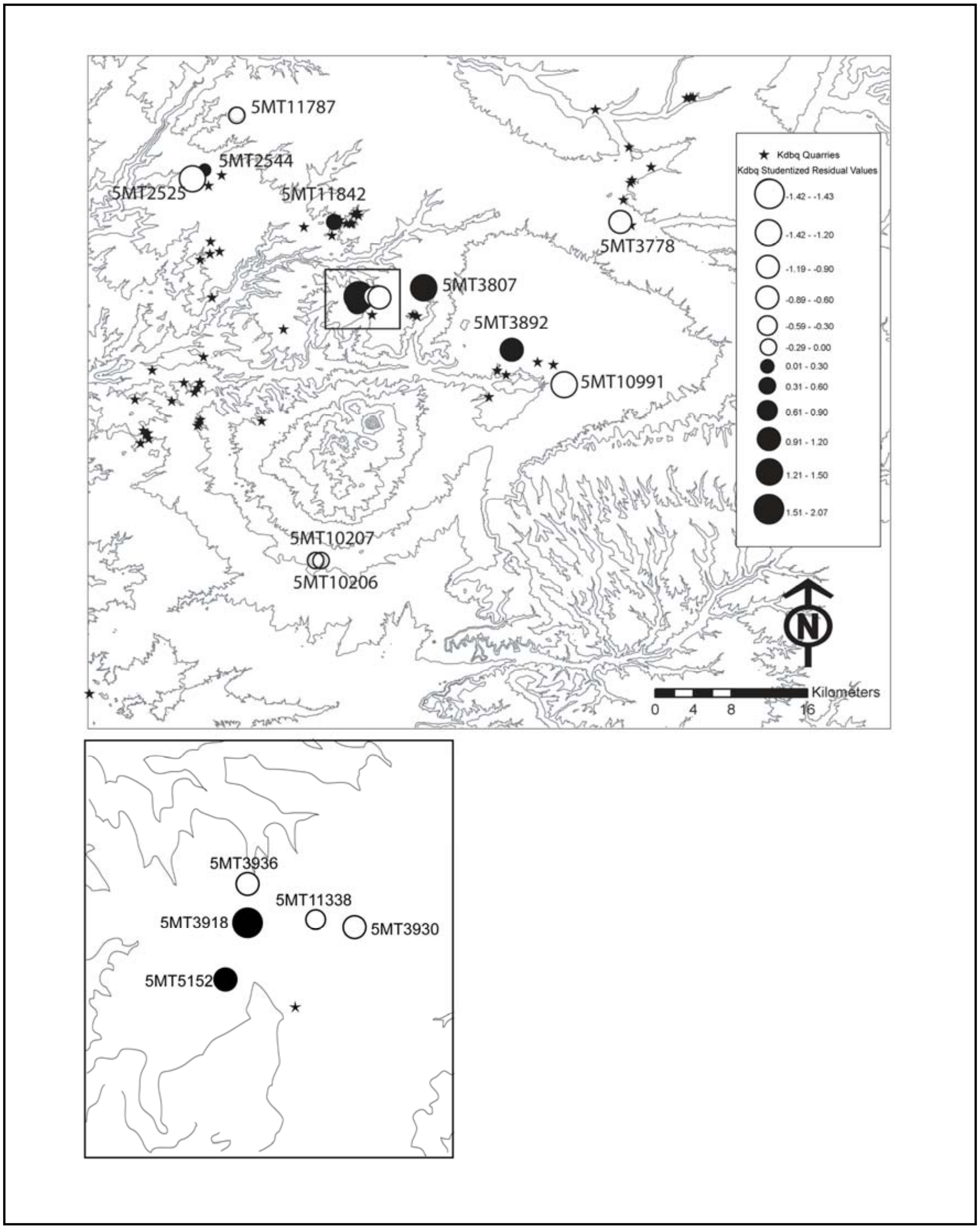


Figure 6.5. Map of Kdbq studentized residuals during the early Pueblo III period. The bottom panel shows Kdbq studentized residuals in the Sand Canyon area.

chalcedony, residents in this site did not use predicted amounts of Kdbq during this time period.

The Percentage/Cost-Distance Relationship for Kbc. Figure 6.6 shows the linear regression and residual analysis for Kbc during early Pueblo III period. This reveals a negative linear relationship with a moderately weak correlation coefficient (r^2=.108; p=.233). The slope, -.328, is similar to, though more positive than, that obtained for Kbc in the late Pueblo II period (-.426). Mapping these residuals shows that 5MT3807 and 5MT1991 in the McElmo-Yellowjacket and 5MT3778 in the Dolores locality contain more-than-expected amounts of Kbc, whereas assemblages of 5MT2544 and 5MT11842 in the Hovenweep locality have less Kbc than predicted by this model. Assemblages of 5MT3807 (Shields Pueblo) and 5MT2544 and 5MT11842 make the statistical model fit poorly. Figure 6.7, the map of the studentized residuals, locates site 5MT3807, which has the highest positive residual for Kbc, near a source for this material.

The Percentage/Cost-Distance Relationship of Morrison. Figure 6.8 shows a negative relationship with an extremely strong correlation (r^2=.811; $p \leq .0001$) for the percentage of Morrison materials against the cost-distance in the early Pueblo III period. The slope, -.900, is the steepest slope among all raw materials in these six time periods and much steeper than that obtained for Morrison in the late Pueblo II period (-.765). The residual analyses and map (Figure 6.9) show that 5MT11338 (G & G Hamlet) had more than expected amounts of Morrison, but 5MT3778 in the Dolores locality used less amounts of this material than predicted by the model. Although both assemblages somewhat weaken the fit of this model, overall it remains very strong – in fact this

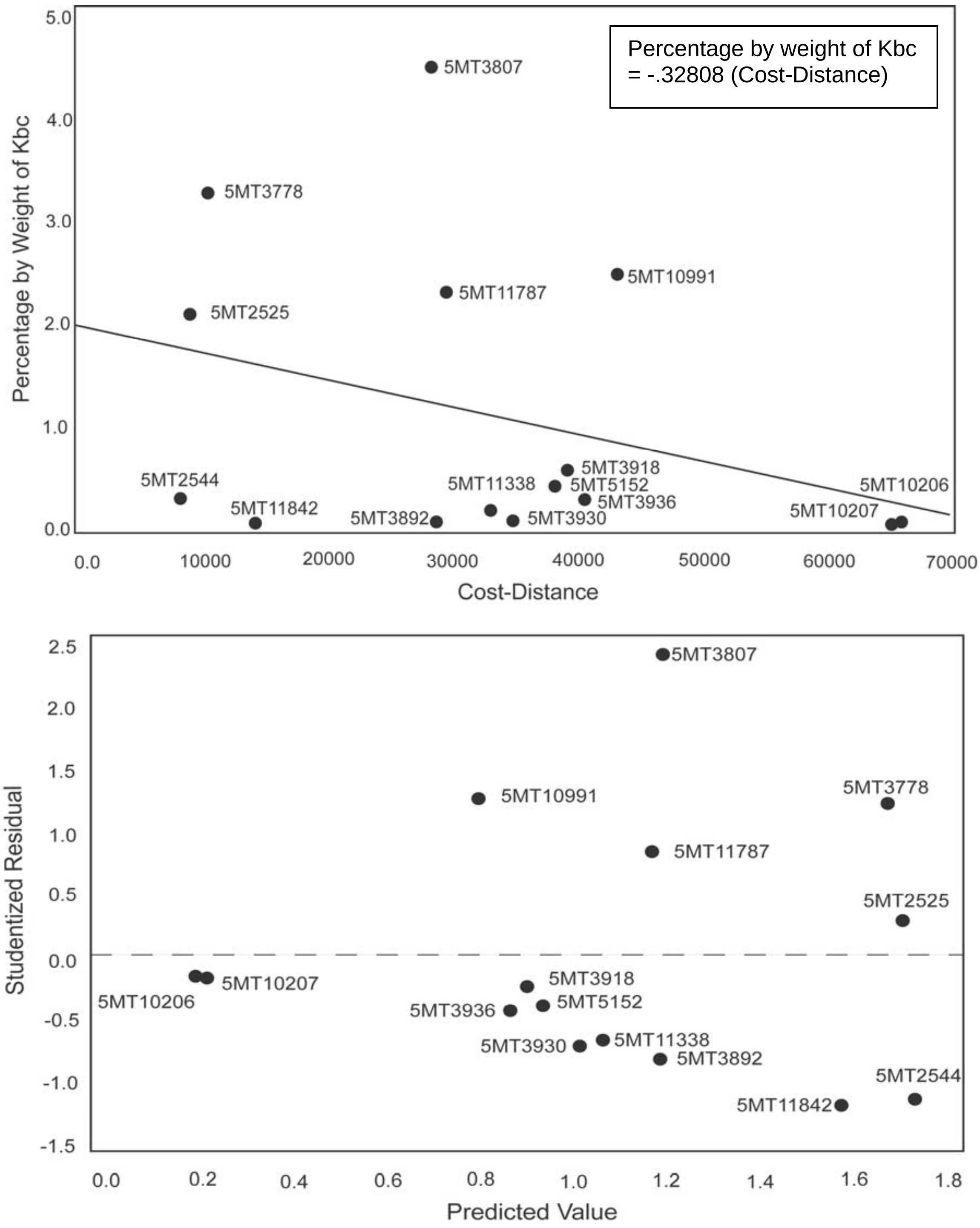


Figure 6.6. The top panel shows the early Pueblo III Kbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

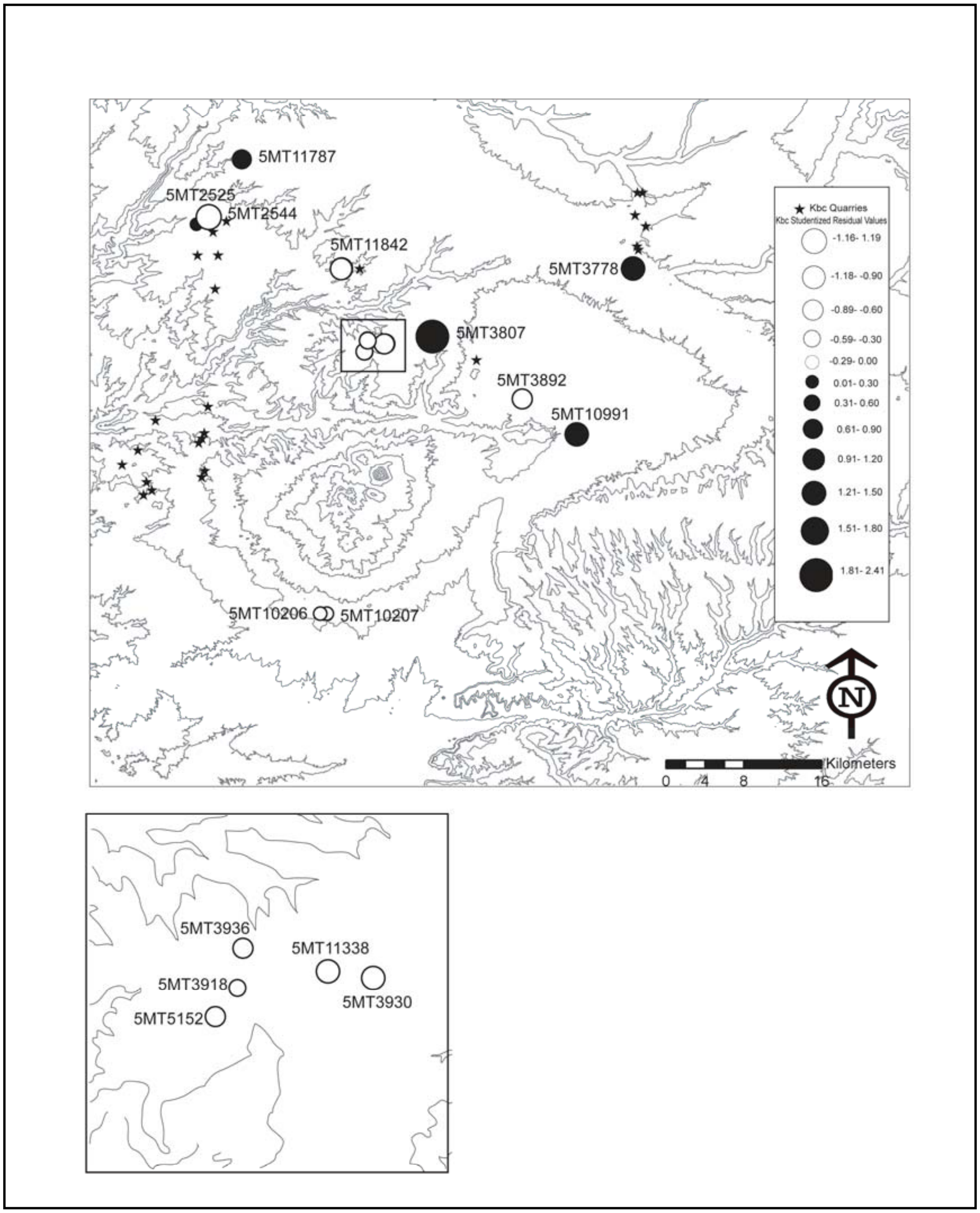


Figure 6.7. Map of Kbc studentized residuals during the early Pueblo III period. The bottom panel shows Kbc studentized residuals in the Sand Canyon area.

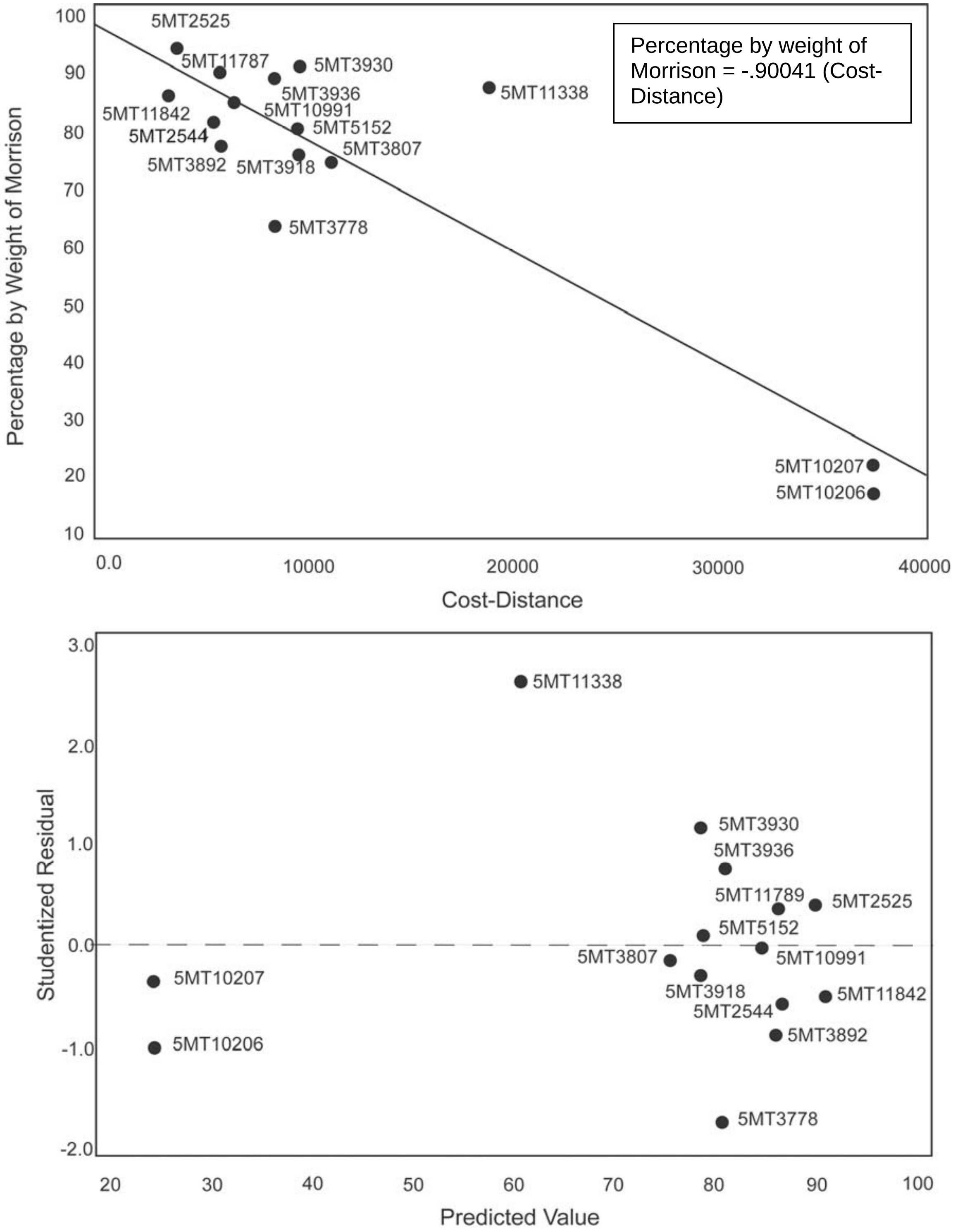


Figure 6.8. The top panel shows the early Pueblo III Morrison percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

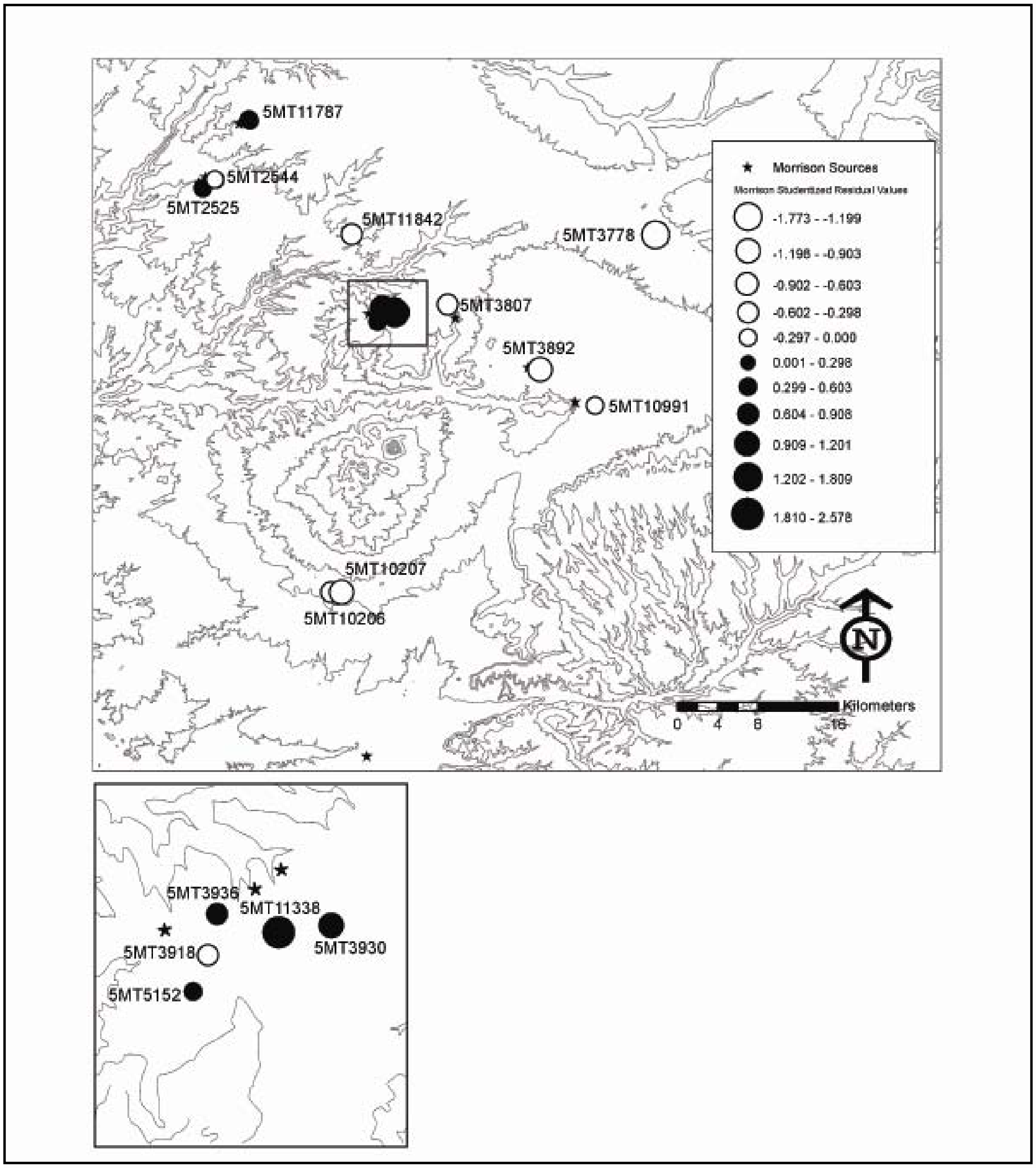


Figure 6.9. Map of Morrison studentized residuals during the early Pueblo III period. The bottom panel shows Morrison studentized residuals in the Sand Canyon area.

material in this period has the strongest fit between the percentage and cost-distance of all these analyses.

The Percentage/Cost-Distance Relationship for Jmbc. The regression analysis shows a positive relationship with a moderate correlation coefficient (r^2=.194; p=.100; Figure 6.10). Although we expect all these regressions to have a negative slope, indicating that residents who lived far away from a source used less of the material, Jmbc shows a positive correlation for its cost-distance relationships in the early Pueblo III, as it did in the late Pueblo II and Basketmaker III. This is even more surprising since the Mesa Verde site that drove this relationship earlier are absent here. The slope, .441, is similar to, though slightly smaller than, that obtained for Jmbc in the late Pueblo II period (.456). The residuals and their map (Figure 6.11) show that 5MT10991 and 5MT3778 contained more-than-expected amounts of Jmbc, even though residents were far away from a source, whereas 5MT11787, 5MT2525, and 5MT10207 had much smaller amounts of Jmbc than expected, though they were relatively near a source area. These regression analyses suggest that Jmbc might have been procured through trade and hint that this material may have had a special purpose or meaning for the early Pueblo III inhabitants, as it apparently had in the immediately preceding period, and in the Basketmaker III.

The Percentage/Cost-Distance Relationship for Igneous. Figure 6.12 shows an extremely strong negative relationship between the percentage and cost-distance (r^2=.586; p>.0009) for this material type. The slope, -.765, is similar to, though slightly more positive than, that obtained for igneous in the late Pueblo II period (-.859). As Figure 6.13 shows, 5MT11787, 5MT2544, and 5MT2525 in the Hovenweep locality had

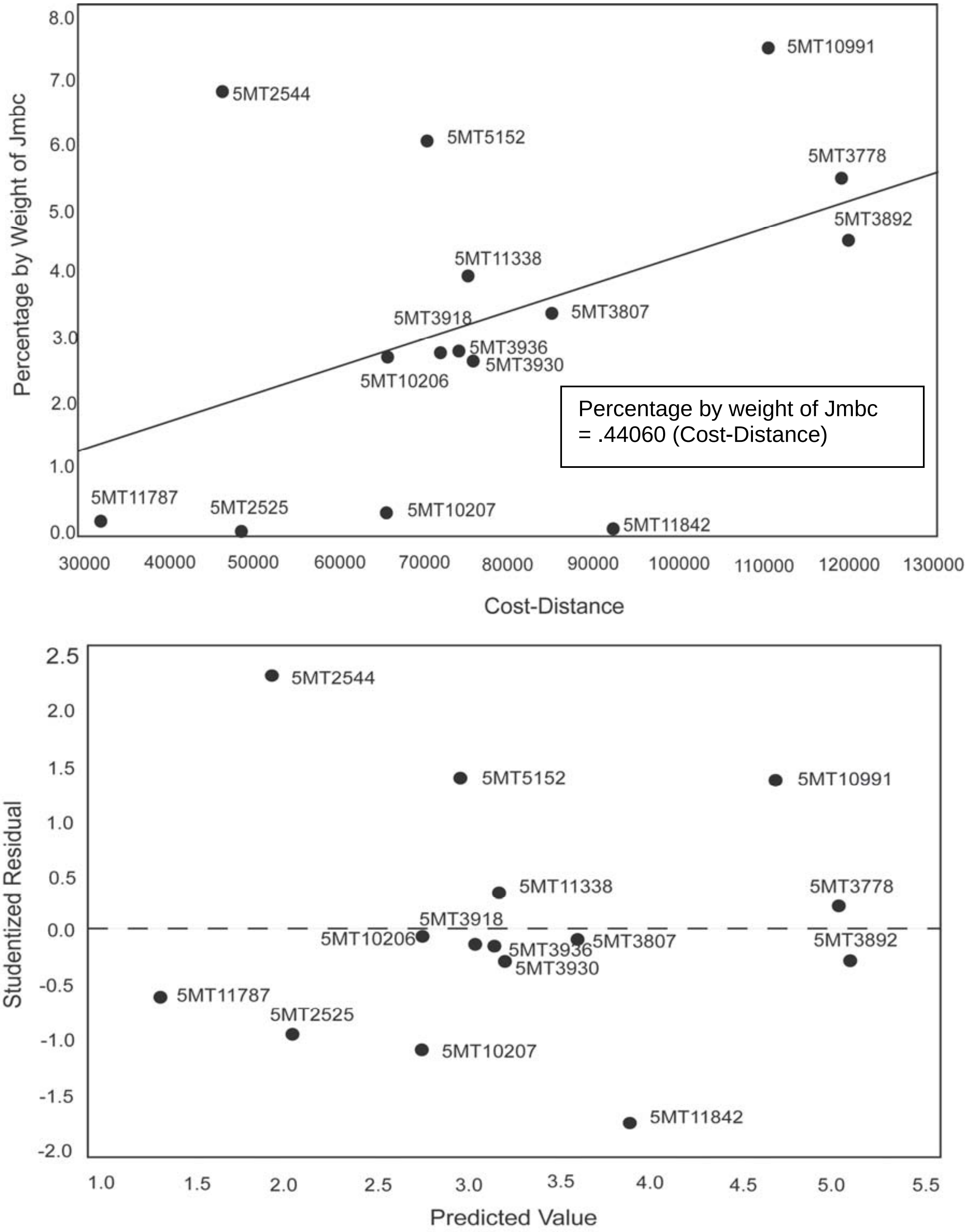


Figure 6.10. The top panel shows the early Pueblo III Jmbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

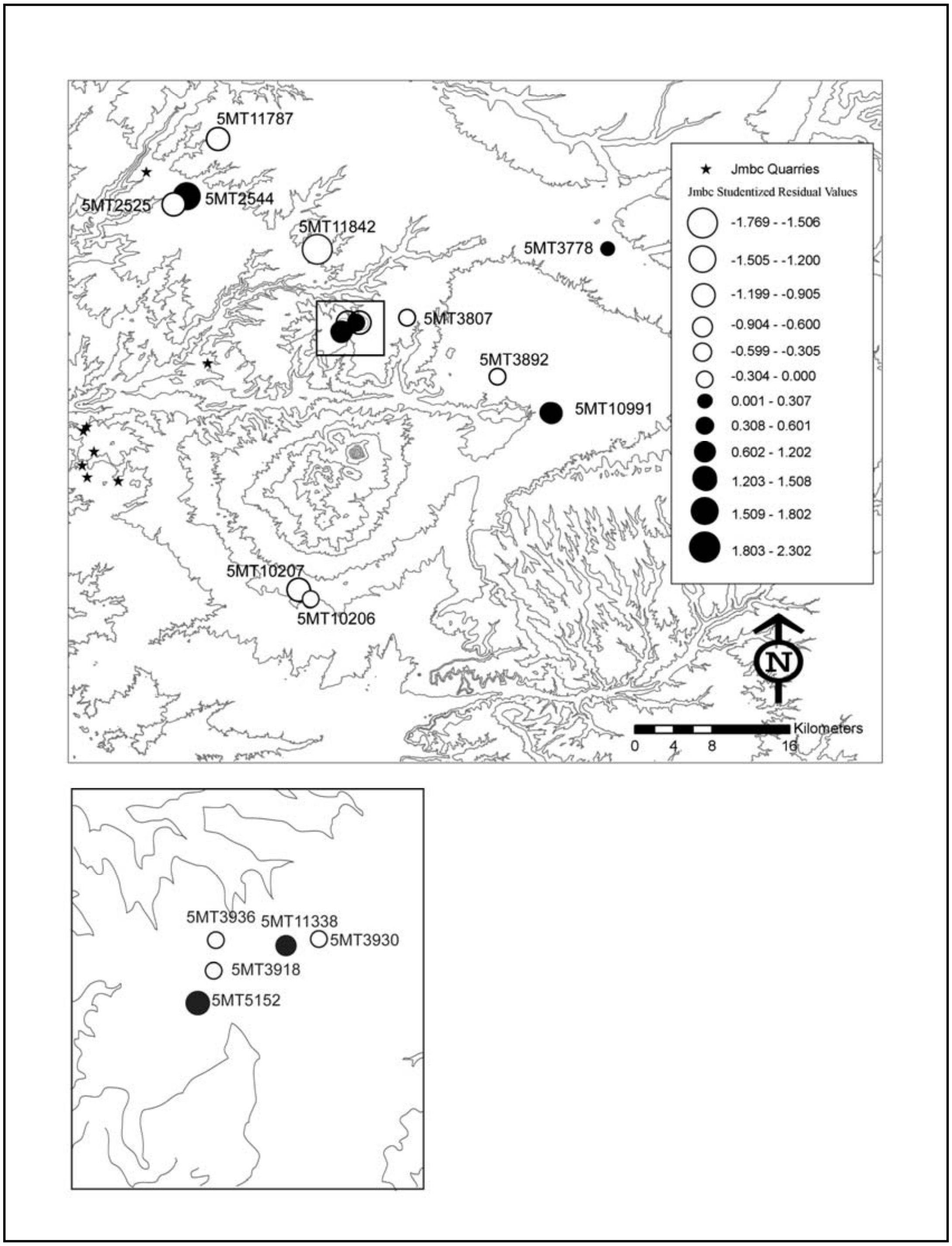


Figure 6.11. Map of Jmbc studentized residuals during the early Pueblo III period. The bottom panel shows Jmbc studentized residuals in the Sand Canyon area.

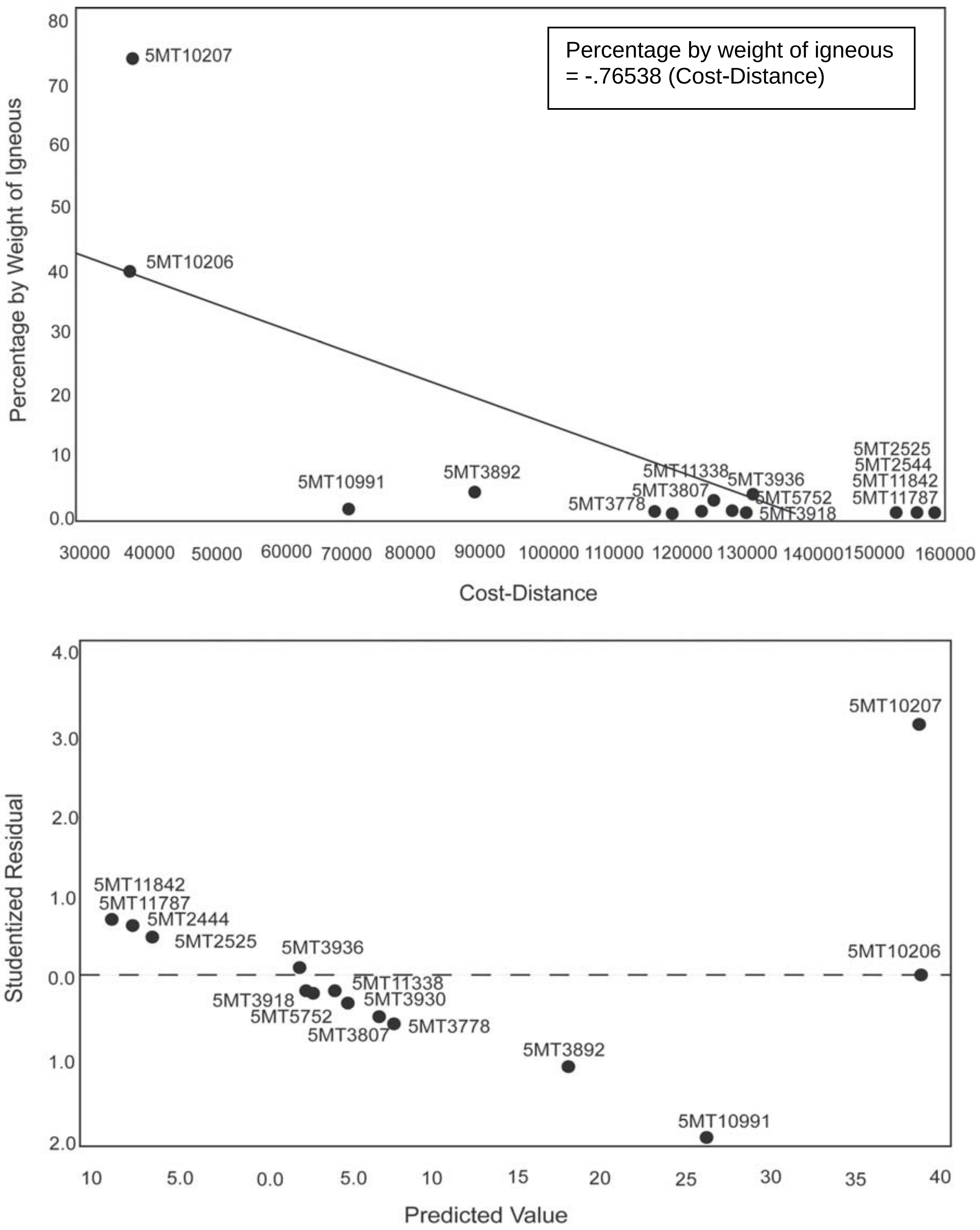


Figure 6.12. The top panel shows the early Pueblo III igneous percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

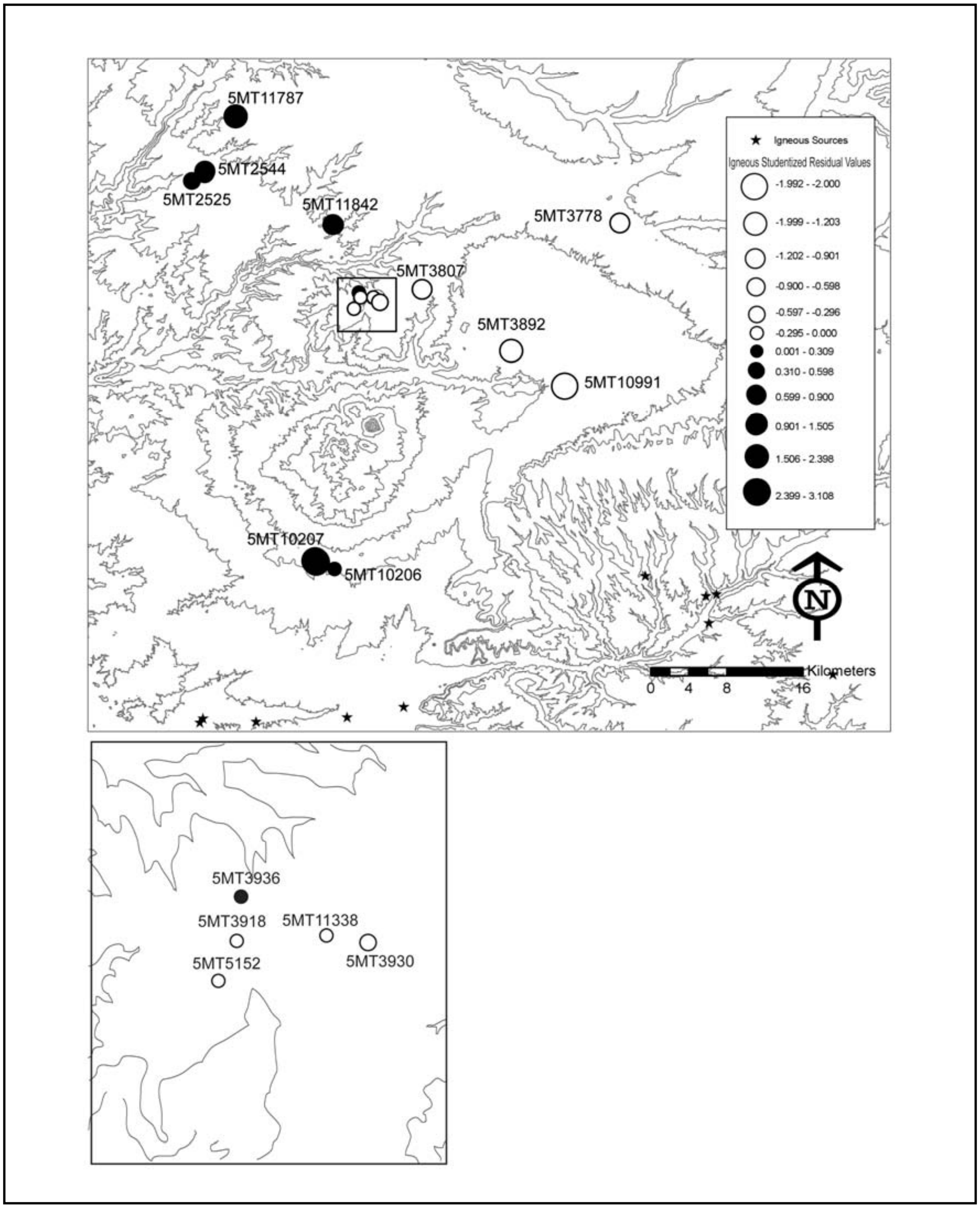


Figure 6.13. Map of igneous studentized residuals during the early Pueblo III period. The bottom panel shows igneous studentized residuals in the Sand Canyon area.

more than the predicted amount of igneous materials, although the sample is relatively small. In the Ute locality, 5MT10207 and 5MT10206 both pull the slope in a negative direction, but the former in particular is surprising with its more than 70 percent of igneous material in its assemblage. In the McElmo-Yellowjacket locality, most early Pueblo III period sites rarely contain igneous materials.

Percentage by weight is useful but not sufficient in itself to understand and reconstruct toolstone procurement patterns. In the early Pueblo III period, all but one of the relationships between percentage of materials and their cost-distances are negative, and most of those negative relationships are statistically significant. The only positive relationship is for Jmbc, and this is probably due to trading this material for special or symbolic purposes. For the early Pueblo III period, Kdbq behaved like most other materials in displaying a moderately significant negative relationship between cost-distance and percentage of raw materials. Based on the linear relationship shown in Figure 6.4, in the next section I investigate proximal Kdbq flake attributes for amount of cortex and number of dorsal flake scars to determine whether there are significant differences between two groups with more, or less, Kdbq than expected, using assemblages with studentized residuals > |0.4| to determine group membership.

Early Pueblo III Direct vs. Indirect Procurement Patterns for Kdbq

Table 6.1 shows the results of Fisher's Exact Tests for cortex amounts tabulated against assemblages with more and less Kdbq than expected given the regression relationship shown in Figure 6.4. Cortex amounts are slightly different for two groups of assemblages ($p \leq .166$). Assemblages with more Kdbq than expected seem to have

Table 6.1. Fisher's Exact Test for the Kdbq Cortex Amount in Early Pueblo III Assemblages Where Kdbq is More Common, and Less Common, Than Expected.

		Cortex Amount				
		none	≤50%	50-100%	100%	*n*
More Kdbq than expected from regression on distance[a]	Row Percentage	74.83	22.38	2.80	0.00	143
Less Kdbq than expected from regression on distance[b]	Row Percentage	80.00	15.00	2.50	2.50	80
	Total (*n*)	171	44	6	2	223

Fisher's Exact Test $p \leq 0.1664$

[a] flakes from assemblages with studentized residuals >.4 in Figure 6.4.

[b] flakes from assemblages with studentized residuals <-.4 in Figure 6.4.

more flakes with a small portion of cortex amount (less than 50 percent and 50-100 percent categories) than do assemblages with less Kdbq than expected, though assemblages with less Kdbq than expected have a slightly higher percentage in the non-cortex category. This result suggests a different pattern from that of previous periods. The category of non-cortex amount in assemblages below contains a larger percentage than assemblages above, whereas assemblages above retain the category of less than 50 and 50-100 percentage of cortex amounts than assemblage below. This suggests that early Pueblo III people in this region may have had procured Kdbq material through direct procurement only because these flakes were not modified much prior to arrival to the site, compared to the results from previous periods. This assumption can be supported by the results of the slope and r-square of lithic data, which suggests that the central Mesa Verde inhabitants procured raw materials close to their habitations during the early Pueblo III period. This further suggests that their mobility was generally constrained and that they engaged in direct procurement only.

Summary of the Percentage/Cost-Distance Relationship

This investigation of six raw materials suggests three major complexities in the early Pueblo III period. Here, I focus on three raw material types – high-, medium-, and low-quality – to discuss them. First, the percentage/cost-distance relationships for the high-quality materials (chalcedony, Kdbq, and Kbc) exhibit a moderately weak negative correlation between the distance from habitation sites to sources and the percentage by weight of raw materials; this relationship is significant only for Kdbq. The major difference in procurement of high-quality materials from previous time periods is the dominance or control over certain material types at a locality level. In other words, within a locality, residents in certain sites procured and used more high-quality materials than expected according to the percentage and cost-distance analysis. For instance, the inhabitants of 5MT3807, 5MT3918, and 5MT5152 in the McElmo-Yellowjacket locality used a large amount of Kdbq, but others in the Sand Canyon area – 5MT3936, 5MT11338, and 5MT3930 – contained less than expected by the model. This pattern may imply that there was a restricted territoriality at or within the locality level.

Another major difference during the early Pueblo III period from other time periods is that residents in the Sand Canyon area within the McElmo-Yellowjacket locality and residents in the Hovenweep locality utilized Morrison raw materials from close to their habitation sites, but inhabitants in other localities rarely procured these materials as predicted by the model. As Neily (1983) suggested based on a lithic study of Cow and Square Canyon, this study of Morrison materials supports the idea that Hovenweep residents relied heavily on local materials during the early Pueblo III period. Furthermore, the different procurement of Morrison in each locality suggests that inhabitants of the Sand Canyon area and the Hovenweep locality may have experienced difficult accessibility or restricted territories during the early Pueblo III period.

Finally, study of the medium-quality material of Jmbc suggests that some residents of the McElmo-Yellowjacket and Dolores localities unexpectedly used large amounts of this material type. The procurement pattern of igneous materials also shows that the Hovenweep inhabitants who lived far away from igneous sources procured and utilized a small amount of this material, though not enough to prevent the percentage/cost-distance relationship for igneous from being strongly and significantly negative. Consequently, study of Jmbc and perhaps igneous materials suggests that there were some strong interactions and some inter-accessibility during the early Pueblo III period in this region, although in general the results of the percentage/cost-distance relationships for high-quality materials show a restricted territoriality.

The Energy Expenditure Model

On the locality level, energy expenditures from early Pueblo III sites are calculated and illustrated in Figure 6.14. This figure shows that the Ute inhabitants expended the most energy in procuring raw materials, followed by the McElmo-Yellowjacket residents, then the Dolores residents. Residents in the Hovenweep locality did not expend much energy in procuring raw materials because they lived close to many source areas so that they could obtain them efficiently. Within the McElmo-Yellowjacket locality, residents of the G&G Hamlet (5MT11338) bore the highest costs in procuring lithic raw materials. Except for Woods Canyon (5MT11842), others expended similar amounts of energy in procuring raw materials in the McElmo-

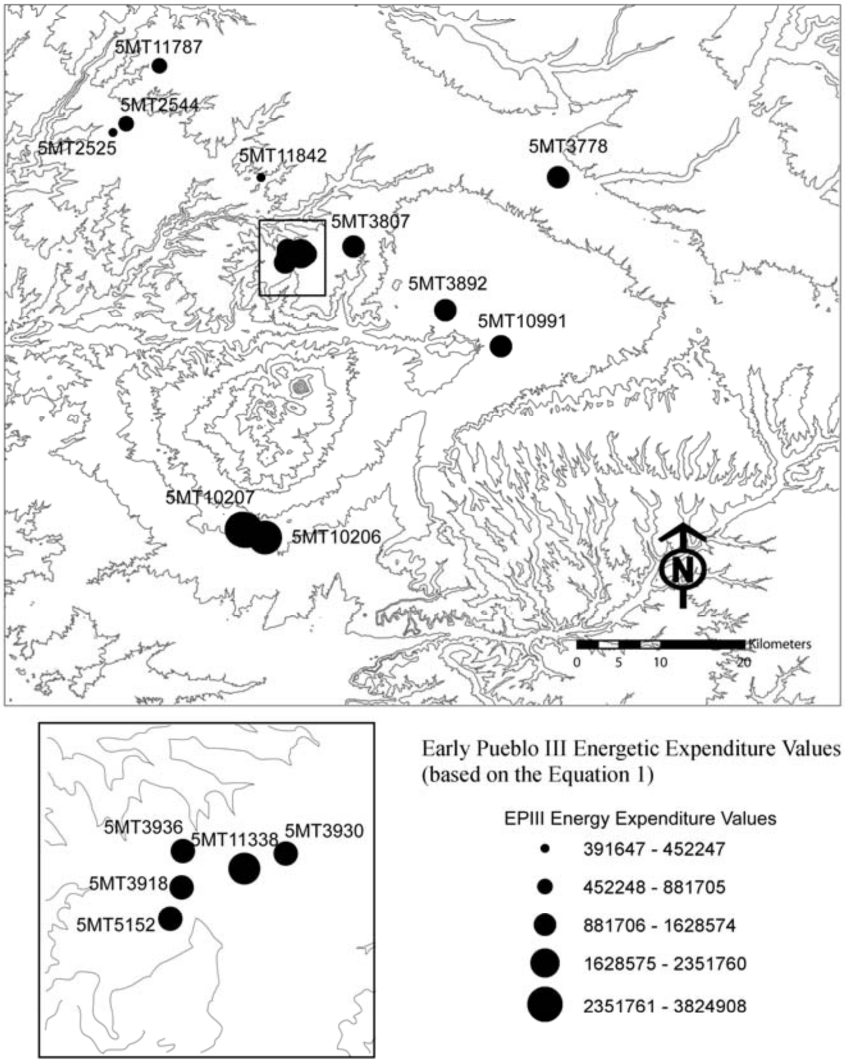


Figure 6.14. Energetic expenditure values for sampled early Pueblo III sites in the central Mesa Verde region.

Yellowjacket locality. Residents of Woods Canyon (5MT11842) did not expend much energy because they would have obtained raw materials closer to their habitations than other inhabitants in the McElmo-Yellowjacket locality. In the Dolores locality, residents of 5MT3778 expended a relatively higher amount of energy in procuring raw materials than did Dolores inhabitants in the late Pueblo II period. This different pattern becomes clear through the difference map I create in the next section.

The Energy Expenditure Map

Here again, using kriging interpolation in the ArcGIS program (Appendix A), I created an isopleths map of the total energy expended by the early Pueblo III residents (Figure 6.15). This map shows that the inhabitants in the Hovenweep locality expended much less energy in procuring raw materials; in contrast, the people in the Ute and southern portions of the McElmo-Yellowjacket localities expended more energy in procuring raw materials. Comparing this map with the isopleths map of the late Pueblo II period (Figure 5.31), overall much less energy was expended to obtain lithic materials on this landscape during the early Pueblo III period.

To make this clear, I created a difference map between these two time periods. Figure 6.16 shows the result, created by subtracting the interpolated map of total energy expenditure for late Pueblo II from the early Pueblo III map using an ArcGIS program (Appendix A). The few areas of yellow color identify places where early Pueblo III residents expended more energy to obtain their toolstone than did the late Pueblo II people, whereas the dominant dark red tones show areas where the late Pueblo II inhabitants expended more energy in procuring raw materials. This shows that the early

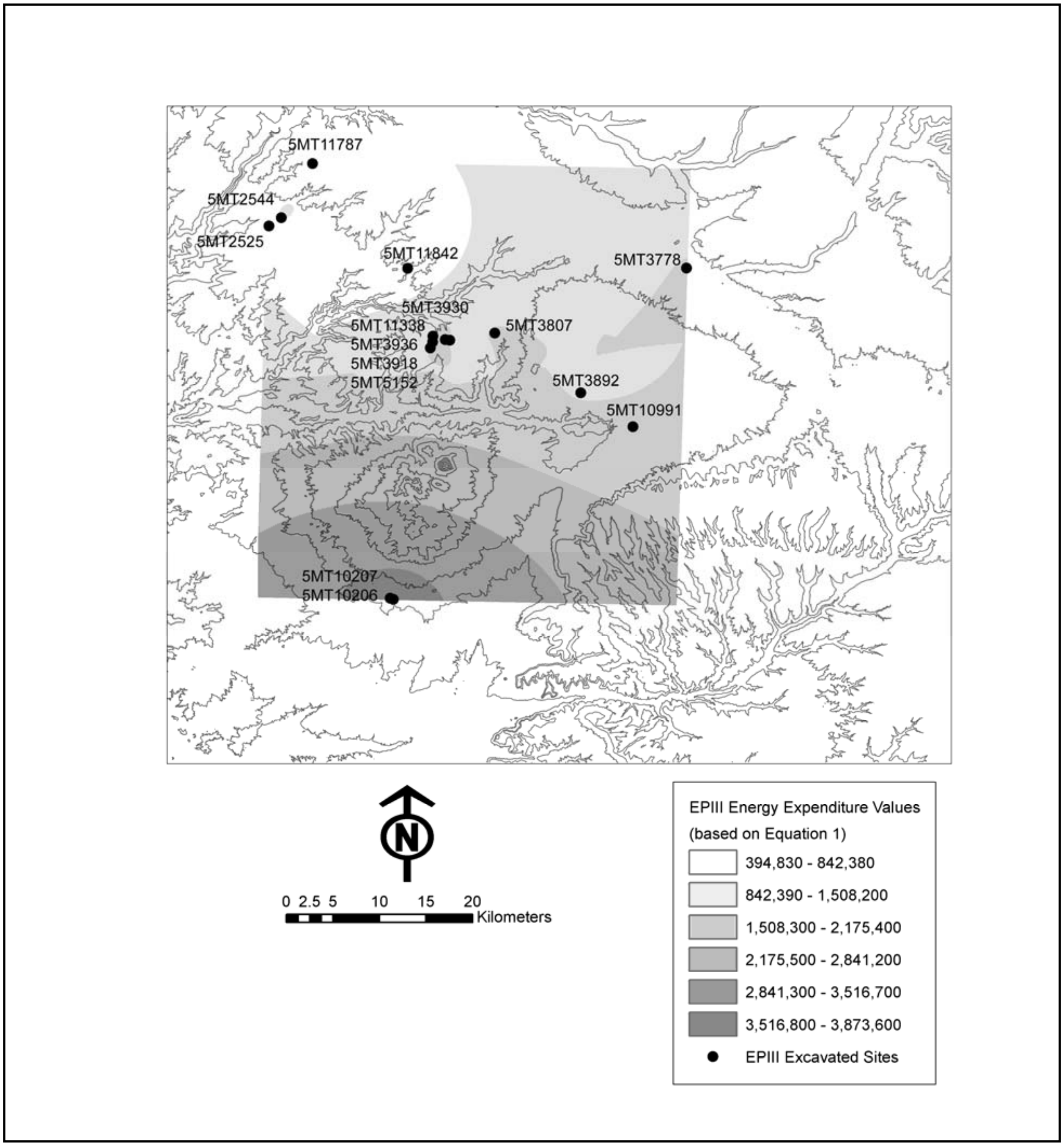


Figure 6.15. A kriged map that interpolates, across, our region, the total energy-expenditure values for acquiring toolstone for the sampled early Pueblo III sites.

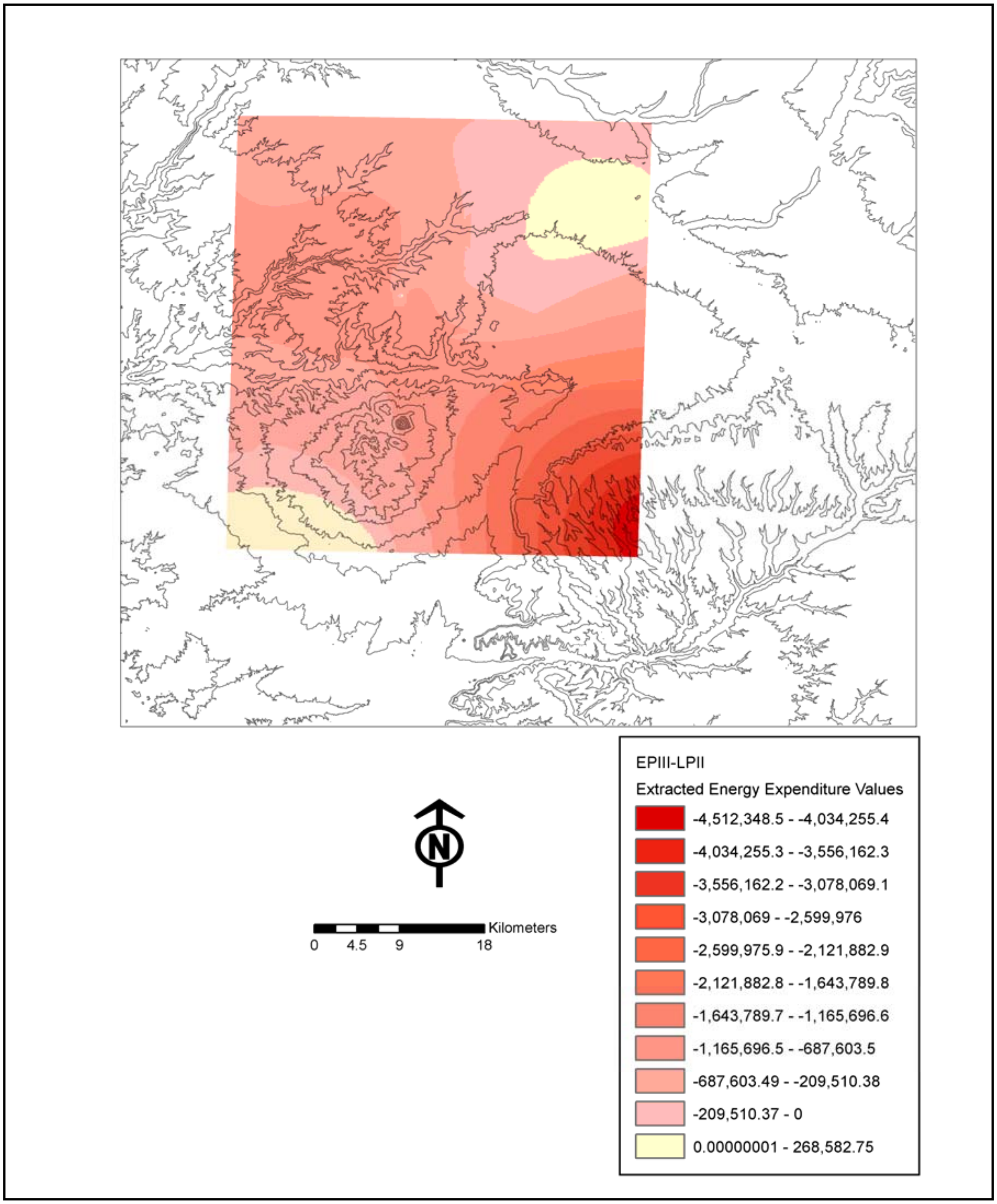


Figure 6.16. A difference map showing areas where the energy expenditure values for acquiring toolstone increased, or decreased, in early Pueblo III sites relative to late Pueblo II sites.

Pueblo III populations were using much more local toolstone than were the late Pueblo II populations. This implies that the early Pueblo III residents at most sites on this landscape were either confined by considerations of territoriality to obtain mostly local materials, or that procurement of stone embedded in long-distance hunting was much less common given the increased dominance of turkey in the faunal assemblages (Cowan et al. 2006; Driver 2002). These factors are clearly not independent, and I argue that the combination of both caused the central Mesa Verde Puebloans to exhibit lower energy-expenditure values for the early Pueblo III period than for the preceding period.

Summary of the Early Pueblo III Period

During the early Pueblo III period, the population continued to increase from the late Pueblo II period and reached approximately 10,000-11,000 people in the Village study area (Varien et al. 2007). Resource production was relatively low especially in the early A.D. 1200s but fairly predictable ($\bar{x}$=246.1 kg/ha per year; S.D.=45.21 kg/ha per year). Dyson-Hudson and Smith's economic defensibility model (1978) suggests that these conditions should lead to a home-range system. They expect people to develop and use territories in this way when resource density is low but predictable.

Lithic data, however, suggest a geographically stables constricted territorial system. The results of r^2 and standardized regression correlation for the six materials show that the relationship between the percentage by weight and cost-distance became stronger, especially for chalcedony, Kdbq, and Morrison materials, during the early Pueblo III period. This demonstrates that the central Mesa Verde residents conformed more closely than earlier to the predicted distance-decay model, in which the percentage of raw materials decreases when the cost of distance increases. Toolstone procurement of Jmbc, however, does not follow this pattern; rather, as in some earlier periods, it continues to show a positive relationship with distance, perhaps due to trade or use of this material for symbolic or special purposes. The energy-expenditure model suggests that residents in the McElmo-Yellowjacket and Ute localities expended more energy in procuring raw materials than did residents in the Hovenweep locality. In general, the difference map shows large decline in energy expenditure for lithic procurement across the late Pueblo II/early Pueblo III boundary. In summary, the steeper and stronger slopes and correlation coefficients, as well the lower amounts of energy expended by the early Pueblo III residents than those of late Pueblo II populations, suggest that the early Pueblo III inhabitants had more restricted and stable territories than the late Pueblo II inhabitants.

Background for Late Pueblo III (A.D. 1225-1280)

Around A.D. 1200, the Dolores locality was completely depopulated. Other communities in this region continued to become more aggregated throughout the thirteenth century. Some central Mesa Verde people constructed habitations in alcoves, particularly in the Mesa Verde locality – sites such as Cliff Palace, Balcony House, Long House, and Mug House. During the late Pueblo III period, evidence of violence becomes more apparent, and emigration to south and east of the San Juan Basin seems to have begun by no later than A.D. 1260 (Varien et al. 2007). In this section, I focus on population estimates, resource productivity, settlement patterns, and socio-political organization, then provide general background concerning artifacts and architecture, and finally present toolstone procurement patterns as an aid to understanding and reconstructing social and political organization during the late Pueblo III period.

Population Estimates. Lipe (1995, 2002) and Lipe and Varien (1999b:326) stated that population in the central Mesa Verde region reached its peak in the early 1200s, then rapidly decreased after about A.D. 1270. This argument was based in part on tree-ring records: "beam-cutting declined rapidly from a high level in the A.D. 1260s and 1270s, to virtually none in the 1280s" (Lipe and Varien 1999b:312). Varien et al. (2007) place the population peak in the A.D. 1225-1260 period, with markedly lower population (in the Village area at least) from A.D. 1260-1280. Lipe (1995) estimated 8,000 structures in villages just prior to abandonment of the region also including southeast Utah. Derived from this calculation, Lipe argued that there were probably 10,000 people who lived in this region around A.D. 1250 and who migrated rapidly to southern portions of the Lower Colorado River Basin area, probably beginning in the late 1260s.

Duff and Wilshusen (2000) challenged the rapid migration model and argued for a gradual process of migration from the central Mesa Verde region during the Pueblo III period. They compiled data from state site files to try to determine inter-regional migration patterns through time. On this basis, they thought that population in the central Mesa Verde region peaked as early as A.D. 1150 and gradually declined afterward (Duff and Wilshusen 2000:185). They estimated that there were approximately 20,000 people during the Pueblo III period in the Northern San Juan region, which encompasses a much larger area than the "Village" study area (Duff and Wilshusen 2000:173 Table 1).

Varien et al. (2007) recalculated the momentary population to be approximately 10,000-19,000 residents in the "Village" portions of the central Mesa Verde region during the late Pueblo III period. They suggested that emigration began at least two decades before the complete abandonment of the region in the 1280s, but that the more than 10,000 people remaining from A.D. 1260-1280 rapidly emigrated to south of the central Mesa Verde region in the late A.D. 1270s or early 1280s.

Resource Productivity. Following the very low resource production during the cold period from A.D. 1200 to 1225, residents of this area experienced relatively predictable but very low resource production for the remainder of this period (Figure 4.2). There was a major drought beginning in the 1270s (Berry 1982:106, 110; Douglass 1929). This drought created lower water tables and entrenched streams perhaps causing further declines in agricultural productivity in this region (Van West and Dean 2000:37).

Settlement Patterns and Social Organization. During the late Pueblo III period, Mesa Verde Puebloans built their households and communities in or near canyon environments (Lipe and Ortman 2000; Lipe and Varien 1999b:303; Varien 1997:177). The well-known cliff dwellings in Mesa Verde National Park are one example. Residents who lived in the lower elevations of the Mesa Verde region, for example the Great Sage Plain, generally constructed their habitations in the open on canyon rims. Most of late Pueblo III settlements (both open sites and cliff dwellings) appear to be located near domestic water sources, and many open sites also show walls enclosing the spring and at least portions of their community centers (Lipe and Ortman 2000). Many late Pueblo III centers were in less productive catchments than had been the case during the early Pueblo III period (Varien et al. 2007). According to Lipe and Varien (1999b:303), these settlement shifts occurred by about A.D. 1240 or 1250.

Varien (1999) states that many communities appeared to be composed of tightly aggregated villages, and suggests that these villages were established gradually. Lipe (1995), Varien (1999), and Lipe and Varien (1999b:303) argued that before A.D. 1225, most people lived in dispersed, small habitation sites, with some communities having a nucleus composed of multiple roomblocks. Aggregation continued during the 1200s, with most people living in aggregated villages after A.D. 1250. Furthermore, during the late Pueblo III period, towers became common along the Utah-Colorado border and D-shaped and multiple-wall structures were constructed throughout the Mesa Verde region (Lipe and Ortman 2000).

Previous Research on Late Pueblo III Period Ceramic and Lithic Assemblages

Ceramics. Wilson and Blinman (1991:47) proposed that Mesa Verde Corrugated sherds became more abundant than Dolores Corrugated during the late Pueblo III period, and Mesa Verde Black-on-white pottery also became dominant in the late Pueblo III assemblage. Red wares were rare, but when present, White Mountain Red wares were the most common type during this time period (Wilson and Blinman 1991).

Pierce et al. (2002) and Glowacki et al. (1998) investigated social interaction between the Sand Canyon locality and the Mesa Verde locality during both the early and late Pueblo III periods. They investigated the production and procurement of pottery, and looked for direct indicators of pottery production – the tools, raw materials, and by-products of pottery manufacturer – and for compositional variation using instrumental neutron activation analysis (INAA). The INAA data suggested that residents in Sand Canyon Pueblo may have been more involved than other residents in the central Mesa

Verde region in exporting pottery to the people in the Mesa Verde locality during the Pueblo III period.

Robinson (2005) further explored issues of social interaction between the Mesa Verde, Sand Canyon, and adjacent communities by investigating ceramic styles in the central Mesa Verde region. He found a bimodal pattern in the frequency of exterior designs in either large or small habitation sites. In large aggregated villages, Robinson (2005) argued that there was increased formality of ritualized food consumption, suggesting communal gatherings, during the late Pueblo III period. Based on the above research, we can further infer that there was a strong interaction between residents in the Sand Canyon area and the Mesa Verde locality during the late Pueblo III period.

Lithic Data. Neily (1983) investigated toolstone procurement patterns of Cow and Squaw Point communities from the late Pueblo II period (ca. A.D. 1050) to the late Pueblo III period. He discovered that exchange and/or procurement of semi- and/or non-local materials in communities of Cow Canyon and Squaw Point in the Hovenweep locality became less frequent through time. He believed that those communities became socially and politically independent of one another, especially during the late Pueblo III period (1983). Arakawa and Duff (2002) further investigated this hypothesis by looking at frequencies of local, semi-local, and non-local flaked lithic materials from Shields Pueblo (5MT3870) and Yellow Jacket Pueblo (5MT5). We concluded, similar to Neily, that as communities became more aggregated during the late Pueblo III period, their inhabitants relied more on local materials. Although exchange networks had become more open during the Pueblo II period with more materials coming from outside the region, residents in the McElmo-Yellowjacket locality became more isolated during the late Pueblo III period. Arakawa and Duff (2002) suggested that as population increased and communities became more aggregated, communities may have exercised greater control over their immediate territories, making it more difficult for people from outside the community to freely collect raw materials within their territory. This suggests that accessibility may have been reduced by hostilities between communities or pressure to not encroach on other groups' territories.

Arakawa and Gerhardt (2007) investigated toolstone procurement patterns on Wetherill Mesa in Mesa Verde National Park. Analysis of debitage from Wetherill Mesa demonstrated dramatic changes in toolstone procurement through time. Locally available igneous and indurated shale sources were the primary resources utilized for much of the early occupation on Wetherill Mesa. During the Pueblo II period, however, there was a shift to the use of Brushy Basin chert (Jmbc), which outcrops approximately 48 km northwest away of the Wetherill Mesa sites. By the end of the Pueblo II period, there was another change in the toolstone procurement pattern and Morrison rocks were frequently acquired and used by Wetherill Mesa Puebloans even though these also came from considerable distances, from the lower elevations of the Mesa Verde region (particularly from the McElmo-Yellowjacket locality). This study provided a great deal of information about interaction and mobility through time. This non-local acquisition by the Wetherill Mesa Puebloans of considerable amounts of Morrison rocks during the late Pueblo III period suggests that they had strong interactions with McElmo-Yellowjacket peoples who lived at a lower elevation of the central Mesa Verde region – a finding that suggests that not all communities were isolated by conflict or competition.

Architecture. The change in settlement patterns from mesa-tops to canyons or canyon-heads caused various alterations of architectural structure during the late Pueblo III period. According to Lipe and Varien (1999b:319), "these include low site-enclosing walls, towers built on detached boulders below the canyon rim, informally bounded plazas enclosed by room blocks, D-shaped structures, and structures built on the talus slope as well as on the canyon rim." Though the frequency of great kivas declined during the late Pueblo III period, the numbers of multi-walled structures increased in this region (Lipe and Varien 1999b:319). In the Hovenweep locality, large towers appear to have been common in association with residential architecture. The function of towers is unclear, though Johnson (2003) argues that they were used as mechanisms to prevent other people from encroaching on fields.

Current Perspectives on Late Pueblo III Assemblages

Figure 6.17 shows the 16 well-dated late Pueblo III habitation sites in the central Mesa Verde region from which lithic assemblages were analyzed for this chapter. Two sites – 5MT11787 and 5MT4802 – are located in the Hovenweep locality, while 5MT11842, 5MT5, 5MT3807, 5MT3951, 5MT10508, 5MT765, 5MT10246, 5MT262, 5MT1825, and 5MT10459 are in the McElmo-Yellowjacket locality. 5MT9933 and 5MT8650 represent lithic assemblages from the Ute locality, while 5MV1229 and 5MV1200 are on the top of Wetherill Mesa in the Mesa Verde locality.

The Percentage/Cost-Distance Relationship for Chalcedony. Figure 6.18 shows the linear regression and residual analysis for chalcedony in the late Pueblo III period. This reveals a negative linear relationship with an extremely weak correlation coefficient

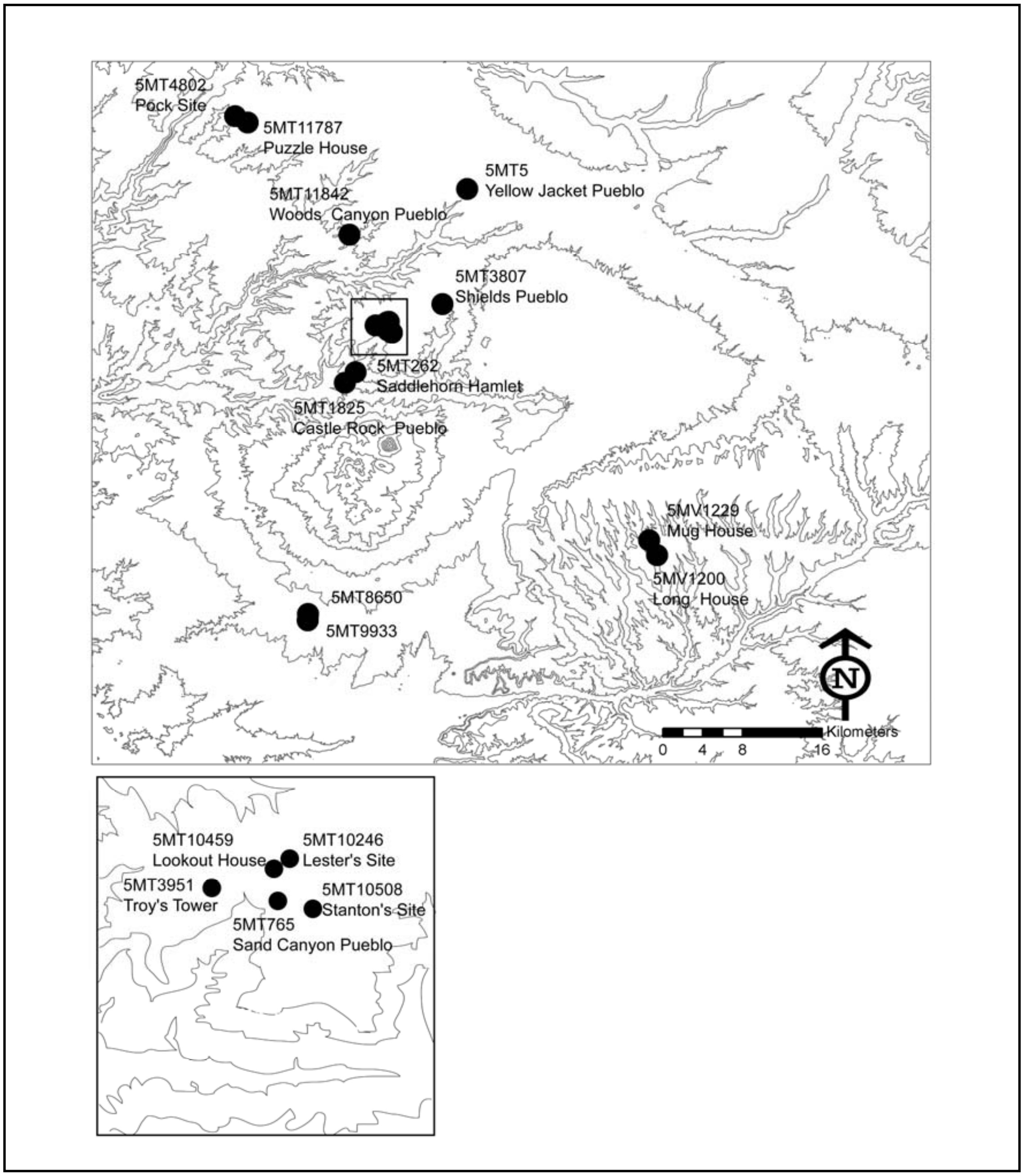


Figure 6.17. Late Pueblo III habitation sites. The bottom map shows habitation sites in the Sand Canyon area.

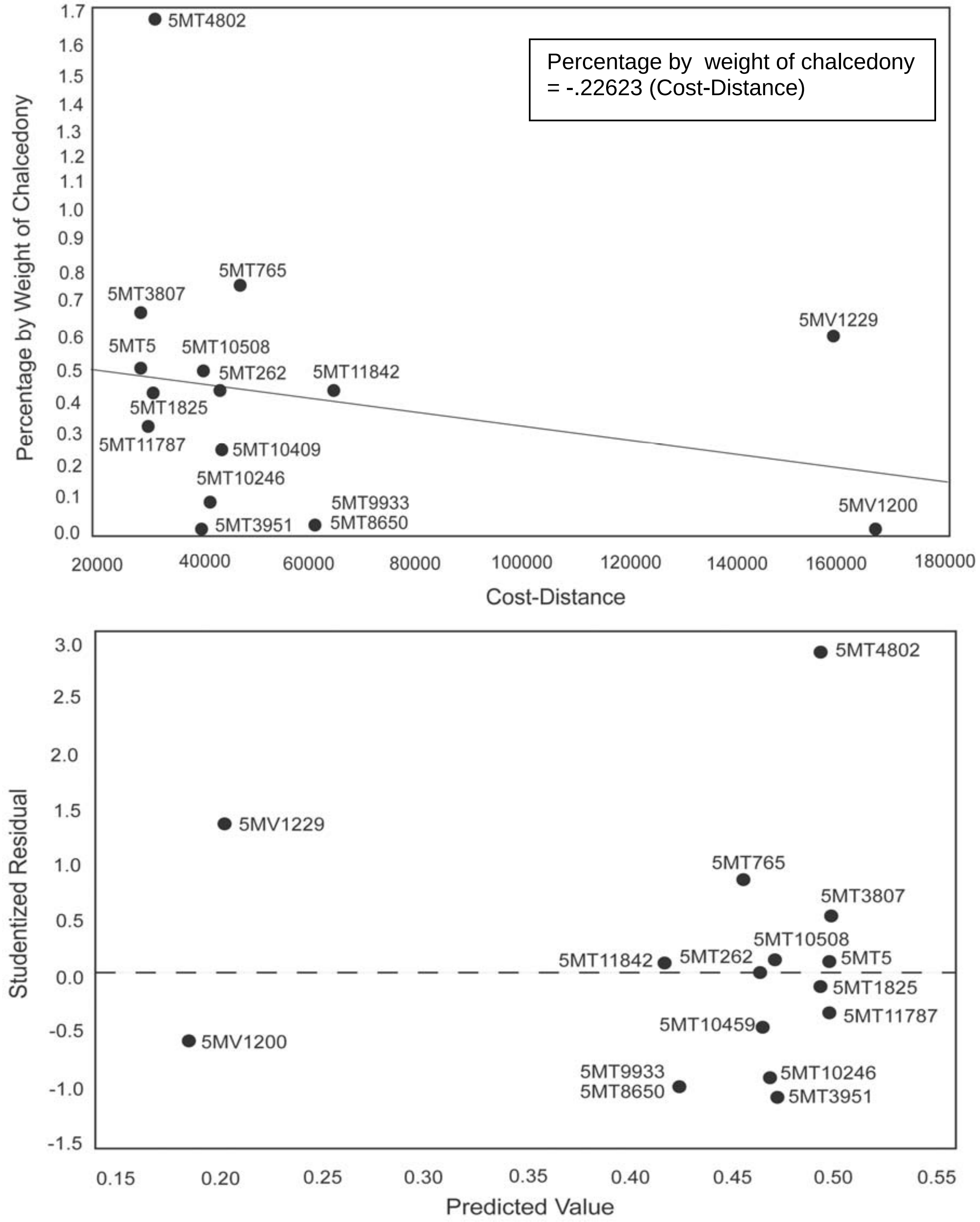


Figure 6.18. The top panel shows the late Pueblo III chalcedony percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

(r^2=.051; p=.399). The slope, -.226, is similar to, though more positive than, that obtained for chalcedony in the late Pueblo II period (-.374). The residual analysis (Figure 6.19) shows that residents of 5MT4802 within the Hovenweep locality have much more than the expected amount of chalcedony, whereas 5MT11787 in the same locality does not contain the predicted amount of this material. Some sites in the McElmo-Yellowjacket locality also show more than expected amounts of this material. Interestingly, although 5MV1229 has more chalcedony than expected, 5MV1200 in the same locality has less chalcedony than predicted by the model. Residents of 5MT9933 and 5MT8650 in the Ute locality did not use the predicted amount of chalcedony. In both the Hovenweep and Mesa Verde localities, residents in the same locality used quite variable amounts of chalcedony during the late Pueblo III period, unexplained by the cost-distance relationship.

The Percentage/Cost-Distance Relationship for Kdbq. Figure 6.20 shows the relationship between percentage and cost-distance of Kdbq in the late Pueblo III period. For these sites, there is a moderately weak correlation (r^2=.172; p=.110) between the cost-distance and the percentage of Kdbq. The slope, -.415, is similar to, though slightly more positive than, that for Kdbq in the late Pueblo II period (-.523). Figure 6.21 shows that 5MT10508 (Stanton’s Site) has much more than the expected amount of Kdbq, followed by 5MT3951 (Troy’s Tower), 5MT262 (Saddlehorn Hamlet), and 5MT10246 (Lester’s Site) in the Sand Canyon area. Within the McElmo-Yellowjacket locality, assemblages that were identified as community centers – 5MT1825 (Castle Rock), 5MT765 (Sand Canyon Pueblo), 5MT3807 (Shields Pueblo), 5MT11842 (Woods Canyon Pueblo) – do not have as much Kdbq as predicted by the model, except for 5MT5

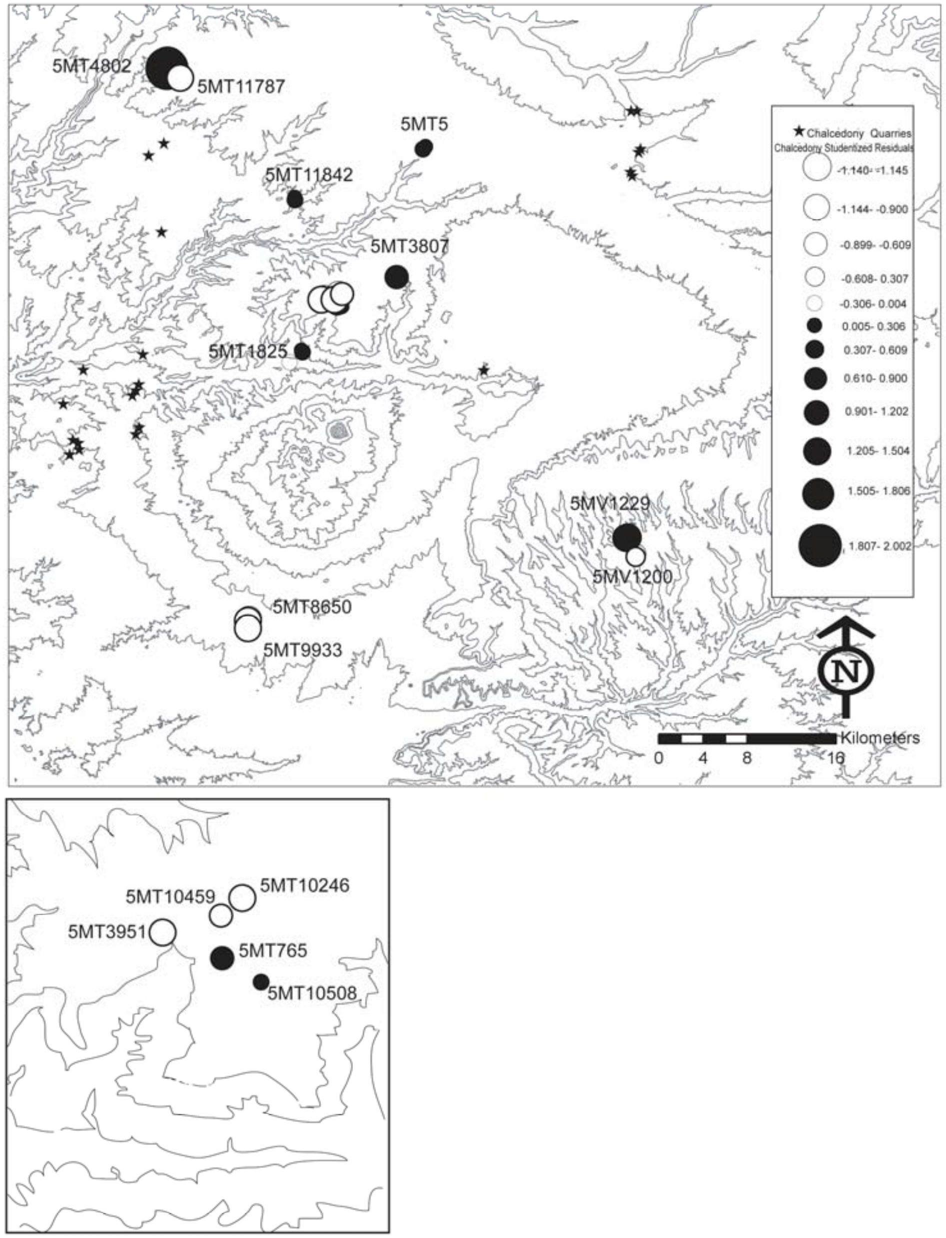


Figure 6.19. Map of chalcedony studentized residuals during the late Pueblo III period. The bottom panel shows chalcedony studentized residuals in the Sand Canyon area.

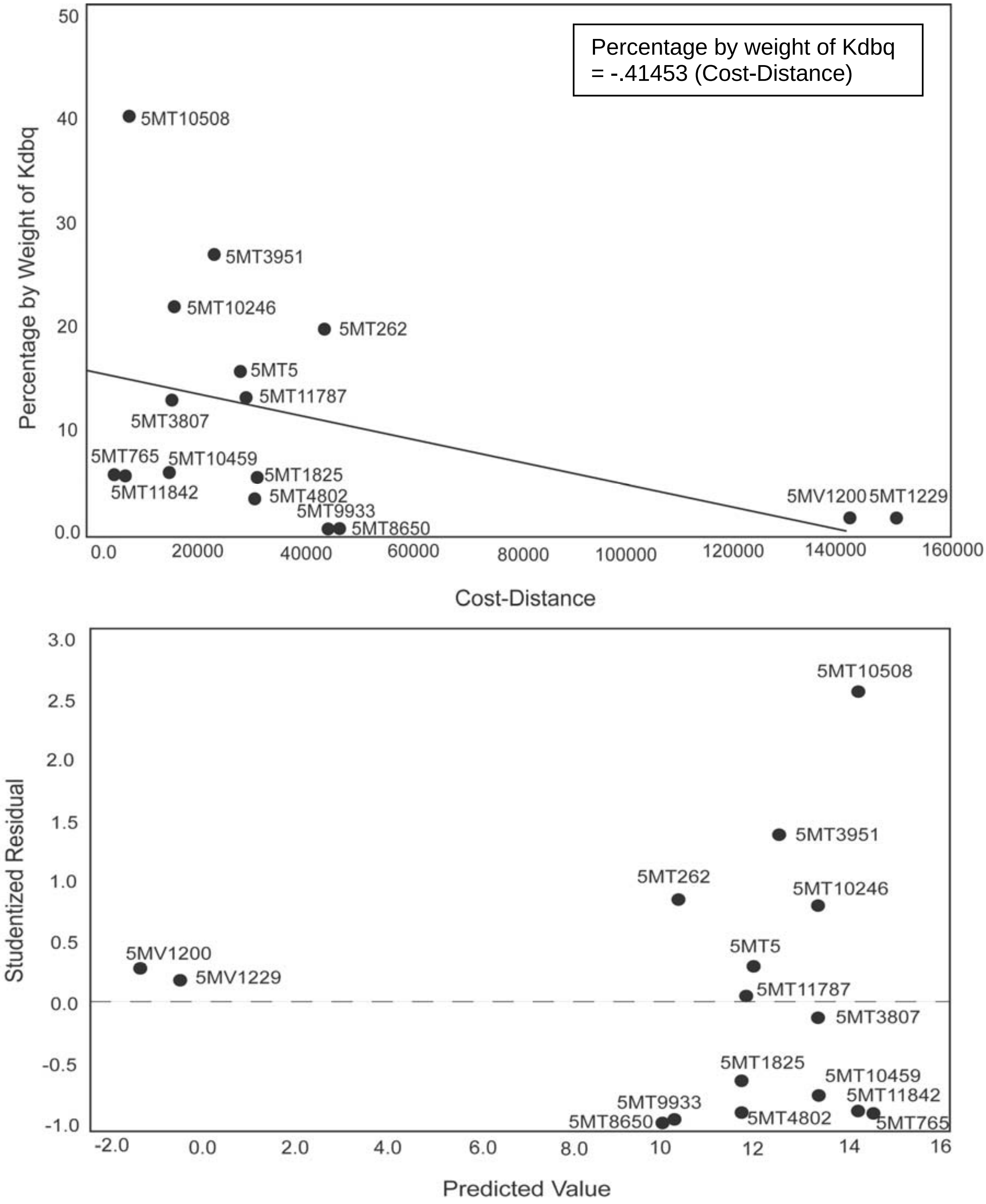


Figure 6.20. The top panel shows the late Pueblo III Kdbq percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

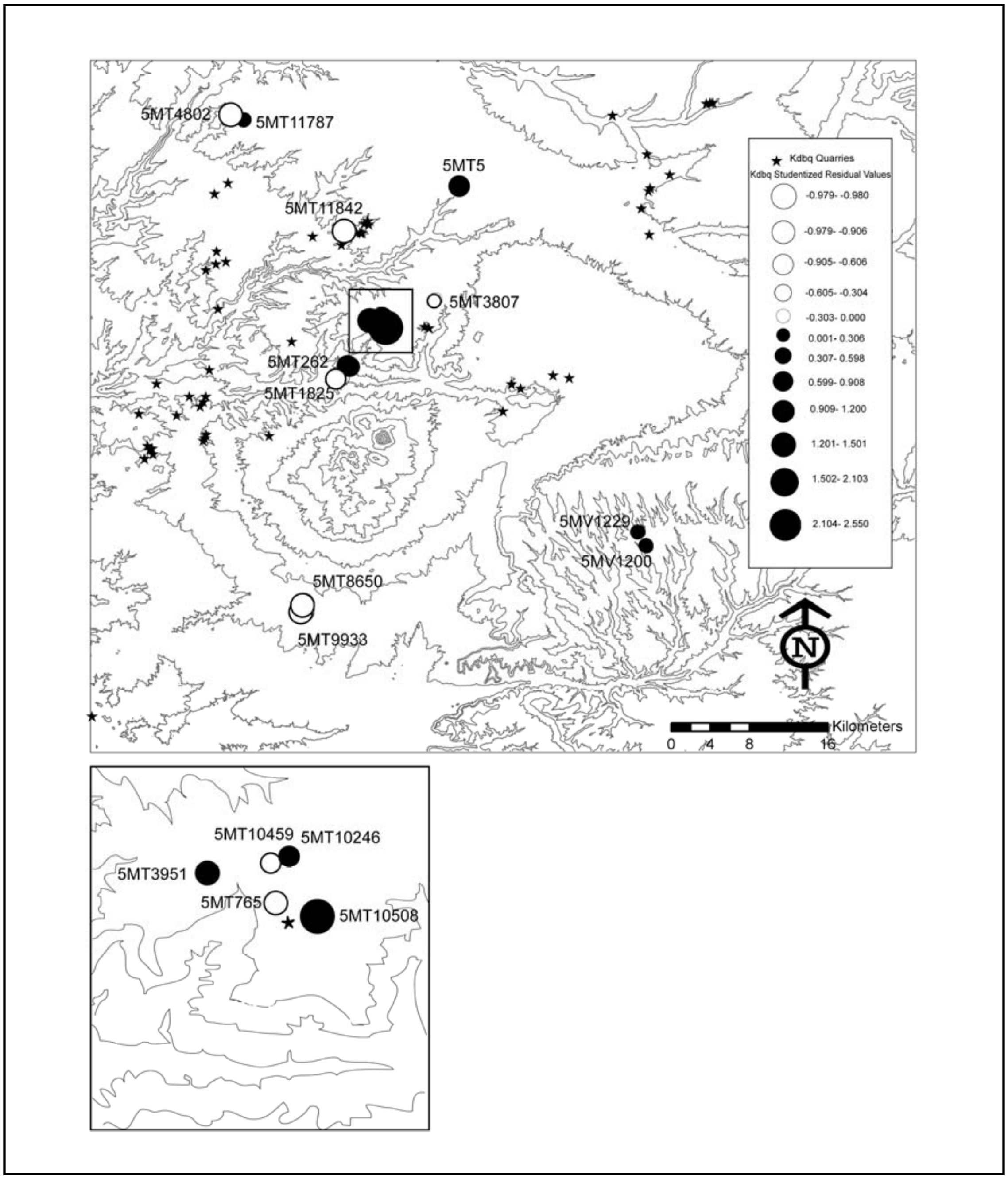


Figure 6.21. Map of Kdbq studentized residuals during the late Pueblo III period. The bottom panel shows Kdbq studentized residuals in the Sand Canyon area.

(Yellow Jacket Pueblo), which contains more than the expected amount of this material. In the Ute locality, 5MT9933 and 5MT8650 do not have the predicted amount of Kdbq. In the Hovenweep locality, 5MT4802 has less Kdbq than expected, whereas 5MT11787 contains approximately the expected amount of this material.

The Percentage/Cost-Distance for Kbc. Although the percentage by weight of Kbc is relatively small, the regression relationship (Figure 6.22) shows the expected negative slope but with a very weak relationship (r^2=.069; p=.325). The slope, -.263, is similar to, though slightly more positive than, that obtained for Kbc in the early Pueblo III period (-.328). Figure 6.23 maps the studentized residual values and shows that the Hovenweep and Ute localities do not contain the expected amounts of Kbc, whereas most sites in the McElmo-Yellowjacket locality have more of this material than expected. Within the McElmo-Yellowjacket locality, Castle Rock (5MT1825) has the largest amount of Kbc, followed by Shields Pueblo (5MT3807). Within the Sand Canyon area, Stanton's Site (5MT10508) and Lookout House (5MT10459) have more than expected, but other Sand Canyon sites have less Kbc than predicted by the model. Although 5MT11842 (Woods Canyon Pueblo), 5MT11787 (Puzzle House), and 5MT4802 (Pock Site) are community centers in this region, the inhabitants utilized less Kbc than expected. In the Mesa Verde locality, although 5MV1229 has more than the expected amount of Kbc, 5MV1200 does not have as much Kbc as predicted by the model.

The Percentage/Cost-Distance Relationship for Morrison. Figure 6.24 shows a negative relationship with a relatively weak correlation (r^2=.129; p=.172) for the percentage of Morrison materials against the cost-distances in the late Pueblo III period.

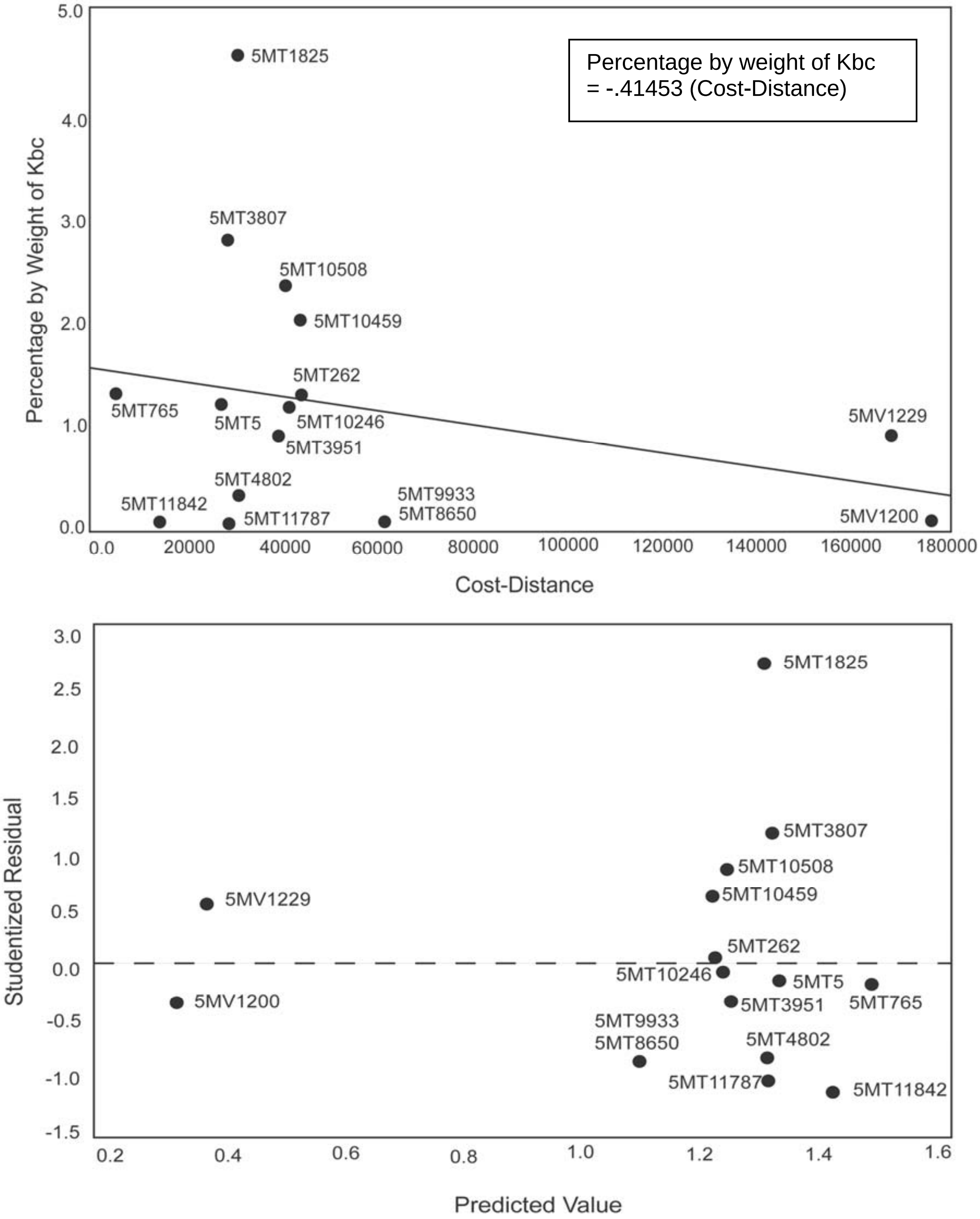


Figure 6.22. The top panel shows the late Pueblo III Kbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

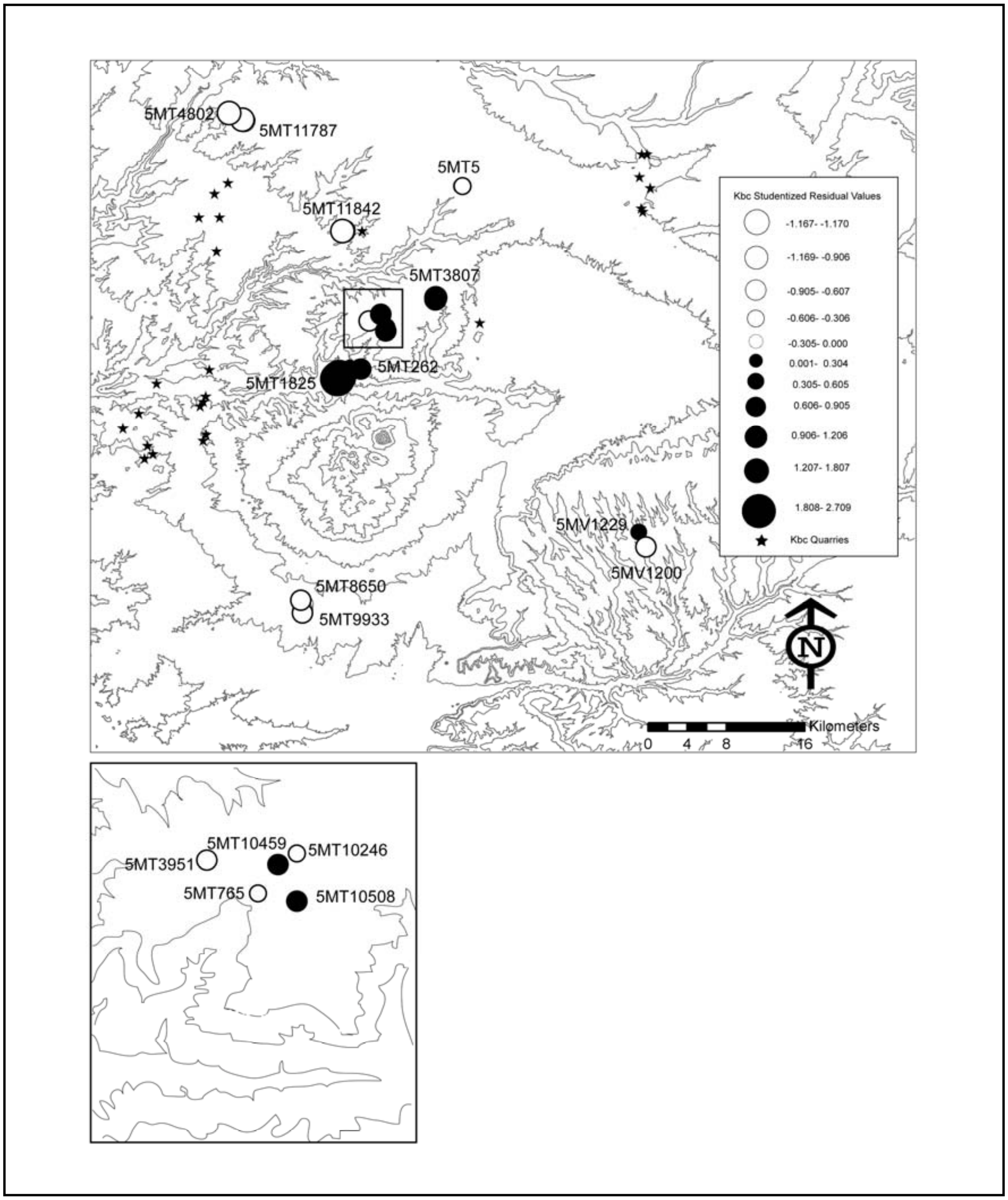


Figure 6.23. Map of Kbc studentized residuals during the late Pueblo III period. The bottom panel shows Kbc studentized residuals in the Sand Canyon area.

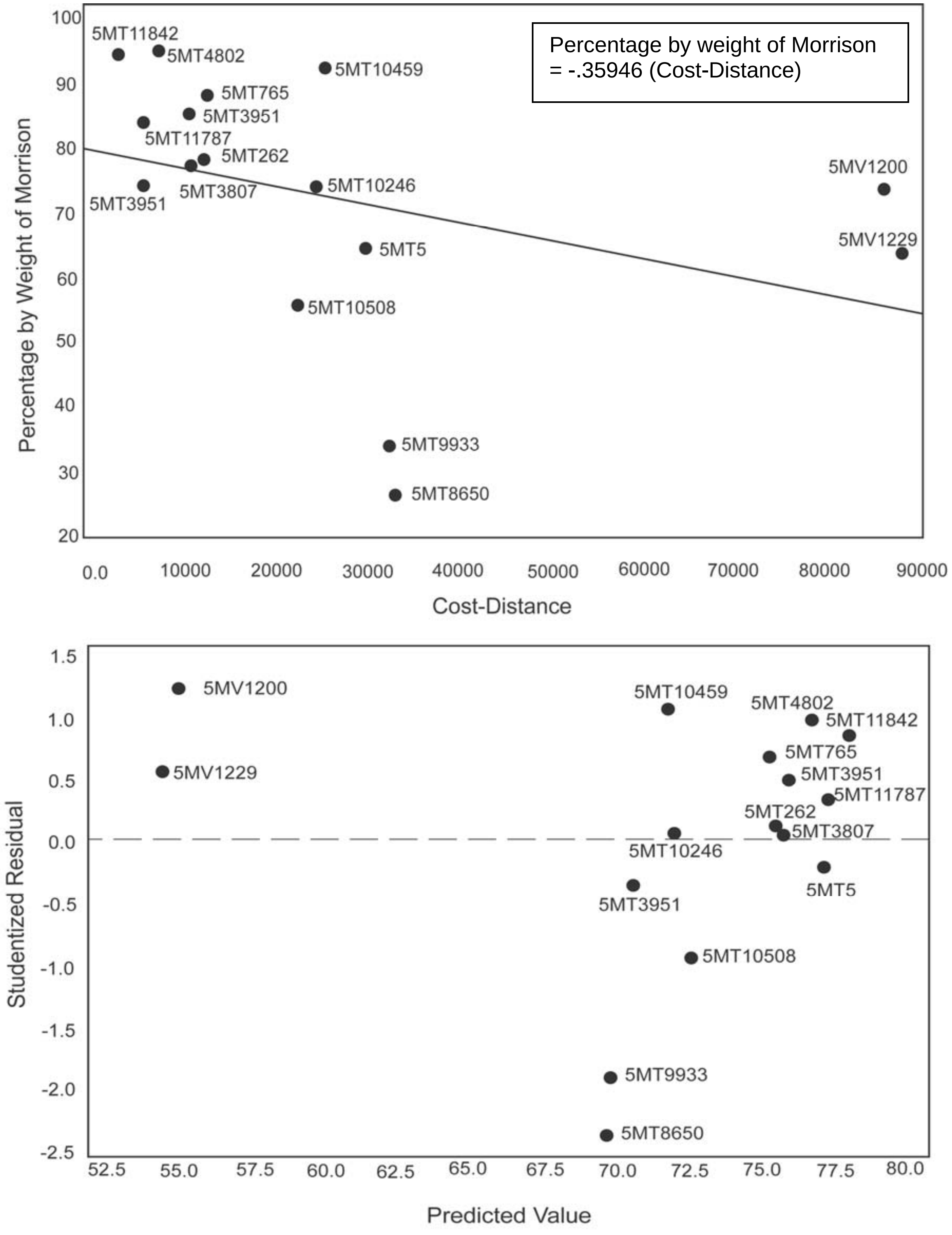


Figure 6.24. The top panel shows the late Pueblo III Morrison percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

The slope, -.359, is much more positive than that for Morrison in the early Pueblo III period (-.900). For the first time since the Pueblo I period, the correlation between the proportion of Morrison by weight and its cost distance is not significant. The residual analyses and map (Figure 6.25) show that in the Hovenweep locality, 5MT4802 (Pock Site) has more than the expected amount of Morrison materials, and 5MT11787 (Puzzle House) contains about the predicted amount of Morrison materials. In the McElmo-Yellowjacket locality, most sites have more Morrison than predicted, but 5MT5 (Yellow Jacket Pueblo), 5MT3951 (Troy's Tower), and 5MT10508 (Stanton's Site) have less of this material than expected. Two residences in the Ute locality, 5MT9933 and 5MT8630, use less Morrison than expected. In the Mesa Verde locality, 5MV1229 (Mug House) and 5MV1200 (Long House), even though they are far from outcrops or source areas of Morrison materials, have much more than the expected amount of these materials, as was also noted by Arakawa and Gerhardt (2007). Such anomalies, from assemblages in the Mesa Verde and Ute localities, work to decrease the size of the correlation coefficient for this material, and its significance.

The Percentage/Cost-Distance Relationship for Jmbc. The regression analysis of Jmbc (Figure 6.26) shows a positive relationship with a relatively moderate correlation (r^2=.322; p=.022). The slope, .567, is similar to, though larger than, that for Jmbc in the early Pueblo III period (.441). It is surprising that although all other materials in all periods have negative slopes, the correlation for Jmbc has been significant and positive since the late Pueblo II period. The Hovenweep and Ute localities contain close to the amount of Jmbc predicted by the model. Inhabitants who lived in medium/large aggregated communities, such as 5MT5 (Yellow Jacket Pueblo) and 5MT3807 (Shields

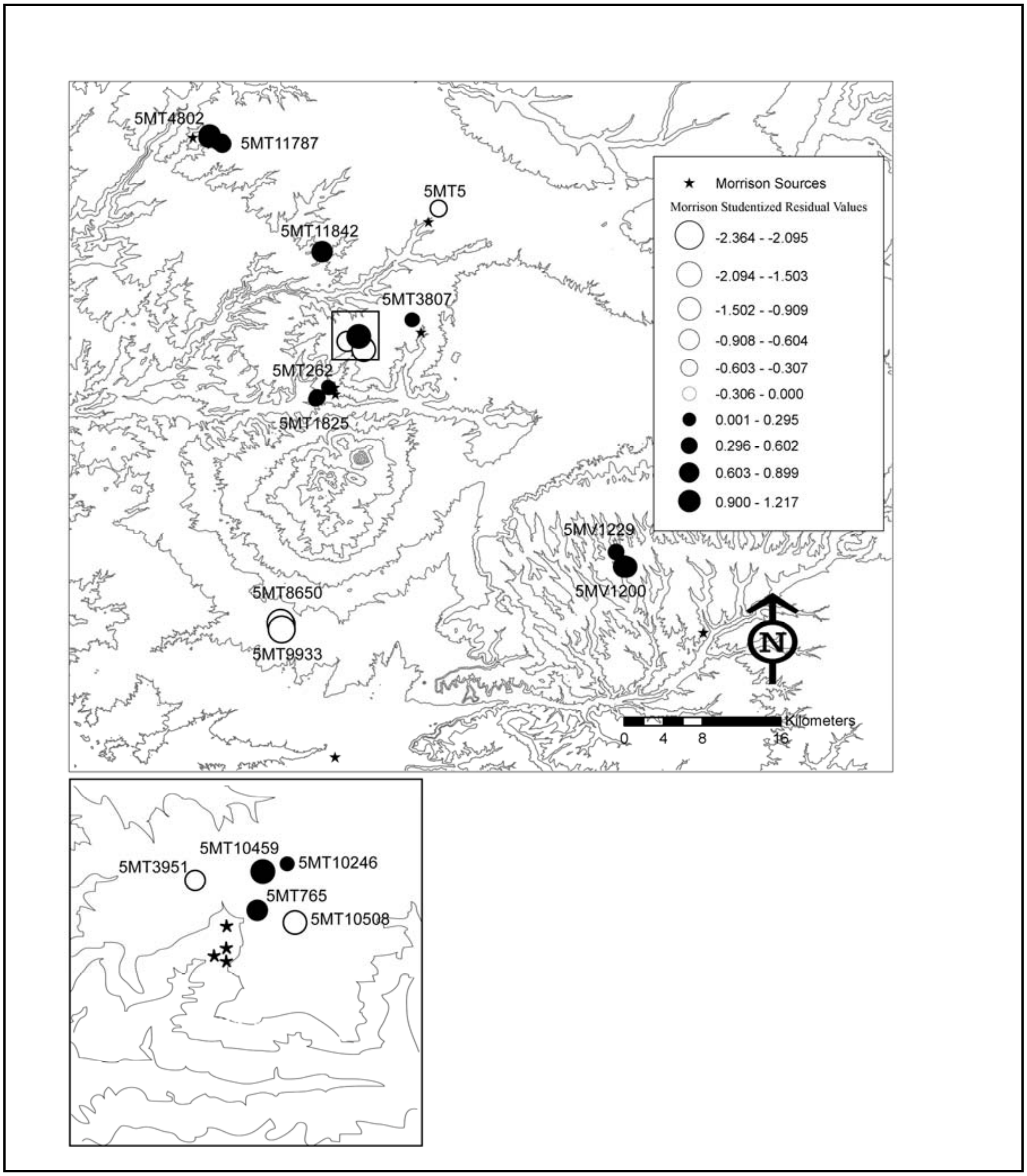


Figure 6.25. Map of Morrison studentized residuals during the late Pueblo III period. The bottom panel shows Morrison studentized residuals in the Sand Canyon area.

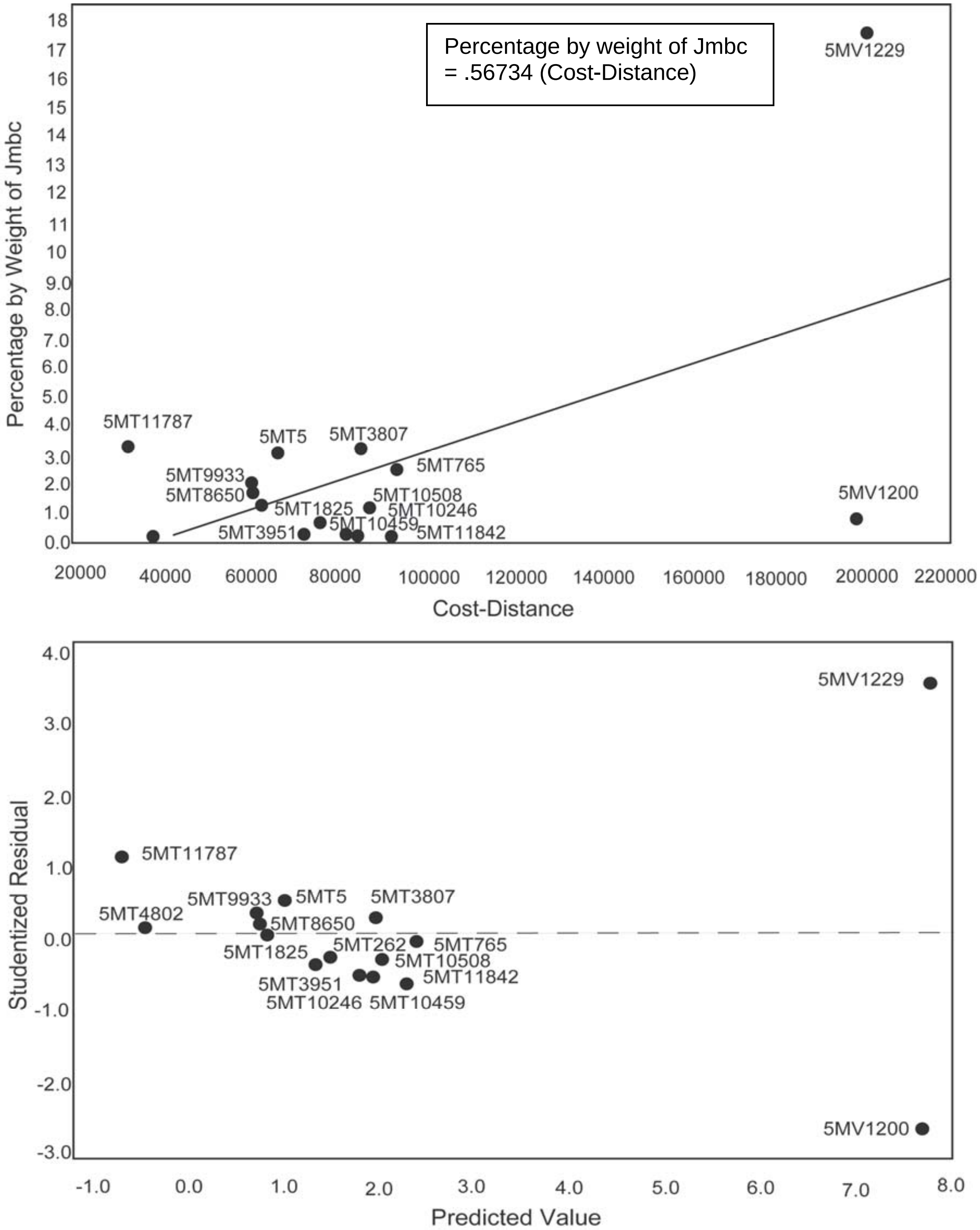


Figure 6.26. The top panel shows the late Pueblo III Jmbc percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

Pueblo), used more of this material than expected; in contrast, most Sand Canyon community residents utilized less than the expected amount of Jmbc (Figure 6.27). Although 5MV1229 (Mug House) contains more than the expected amount of Jmbc, 5MV1200 (Long House) has less than predicted by the model. This suggests that Mesa Verde residents within a single locality had quite different interactions with people who lived close to Jmbc outcrops or source areas, or that ancestral Puebloans invested this material with special meaning and exchanged it accordingly. In fact, as Figure 6.26 documents, the positive slope for this material is caused almost entirely by the anomalous abundance of this material at 5MV1229 (Mug House).

The Percentage/Cost-Distance Relationship for Ign. Figure 6.28 shows a strong negative relationship between percentage and cost-distance for igneous materials (r^2=.632; p=.0002). The slope, -.795, is very similar to that obtained for igneous in the early Pueblo III period (-.765). As Figure 6.29 shows, 5MT9933 and 5MT8650 in the Ute locality have more than expected amount of igneous materials, followed by 5MV1229 and 5MV1200 in the Mesa Verde locality. Interestingly, 5MT765 (Sand Canyon Pueblo) contains a small percentage of igneous materials, even though the sources of these materials are fairly far away from Sand Canyon Pueblo. Additionally, assemblages from the Hovenweep locality – although they have very small amounts of this material – show positive studentized residuals.

In the late Pueblo III period, then, all but one of the relationships between proportion of materials and their cost-distances are negative, though most of those negative relationships are not statistically significant. The only positive relationship is

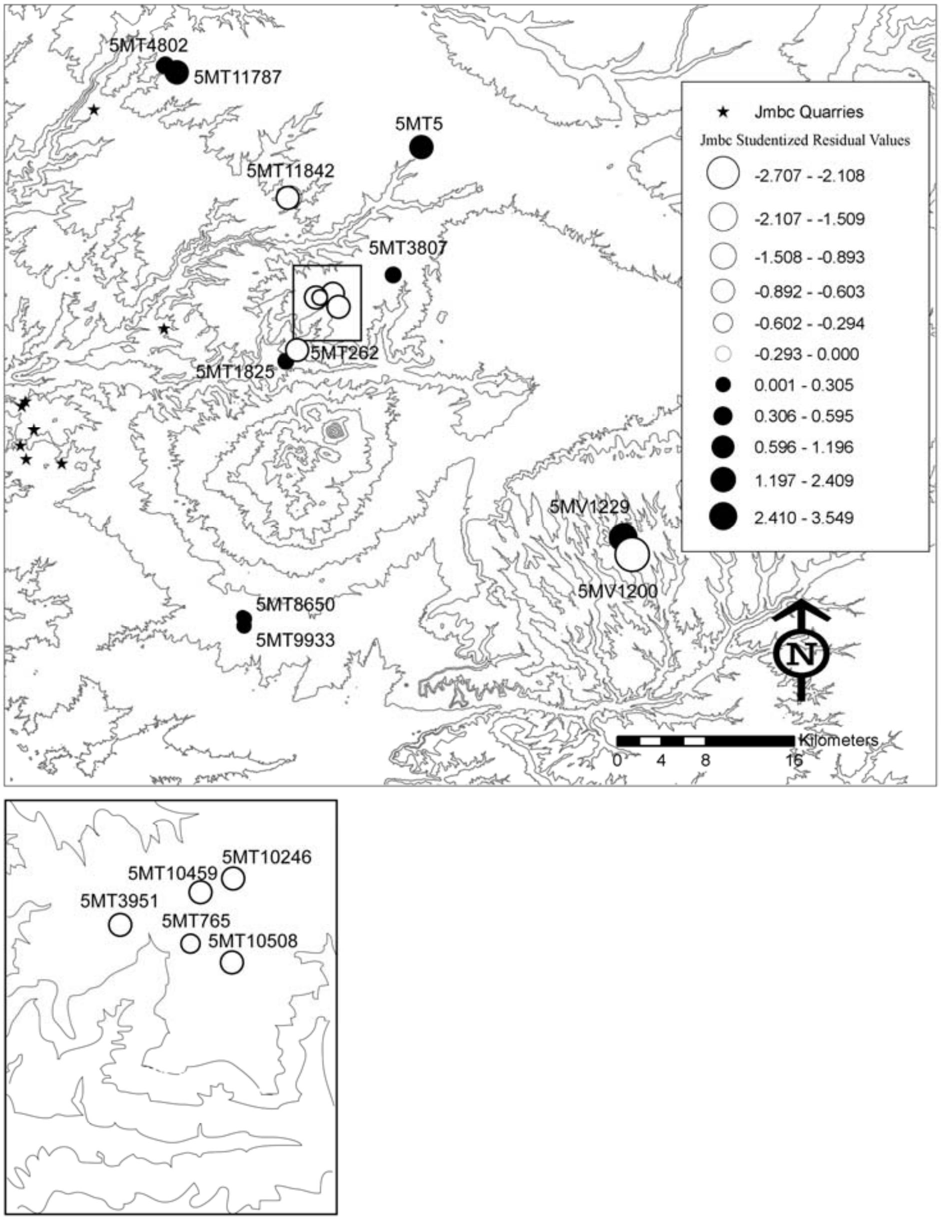


Figure 6.27. Map of Jmbc studentized residuals during the late Pueblo III period. The bottom panel shows Jmbc studentized residuals in the Sand Canyon area.

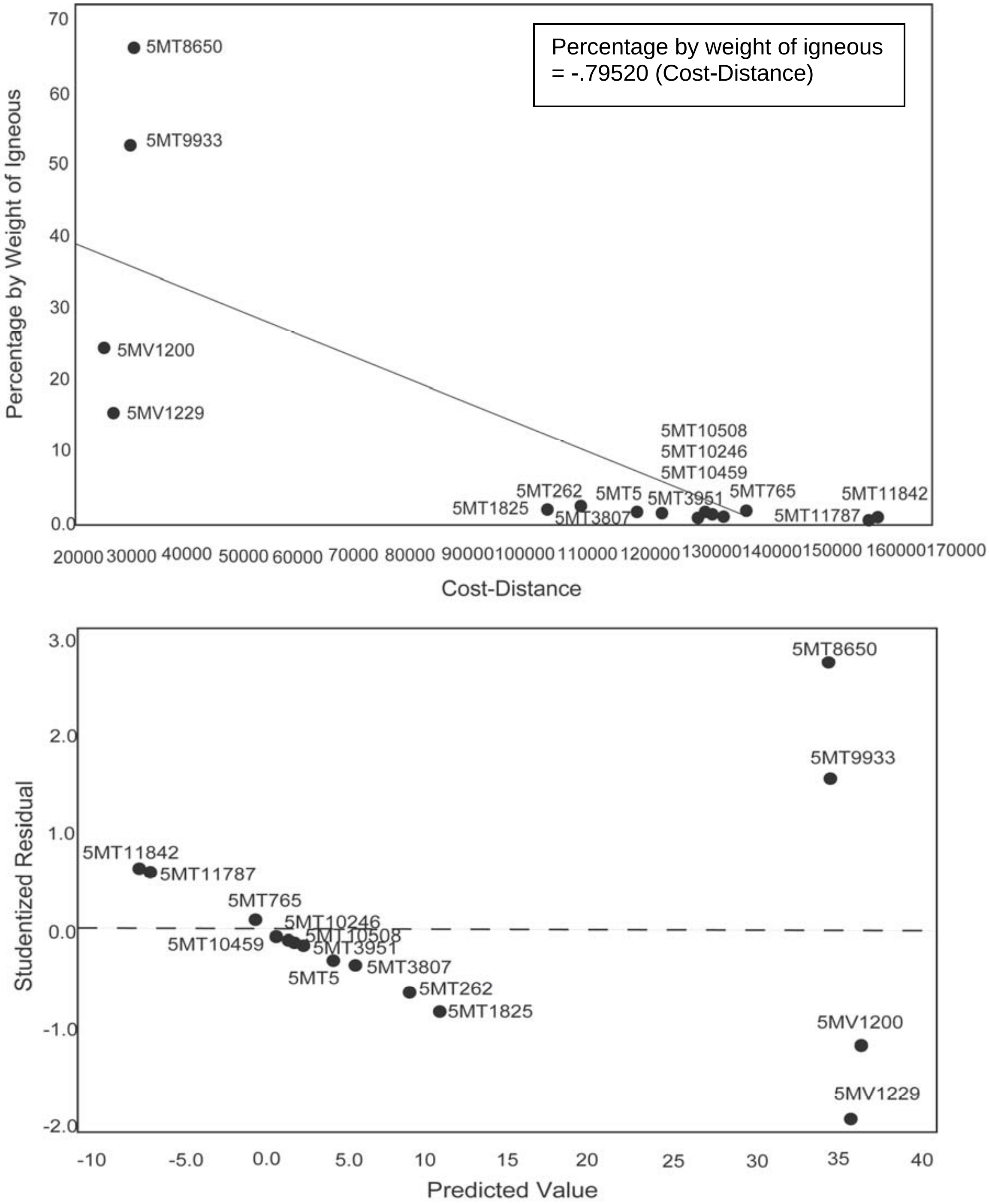


Figure 6.28. The top panel shows the late Pueblo III igneous percentage/cost-distance relationship; the bottom panel displays the result of the residual analysis. Parameter estimates reported in top panel are standardized; coordinates on axes are unstandardized.

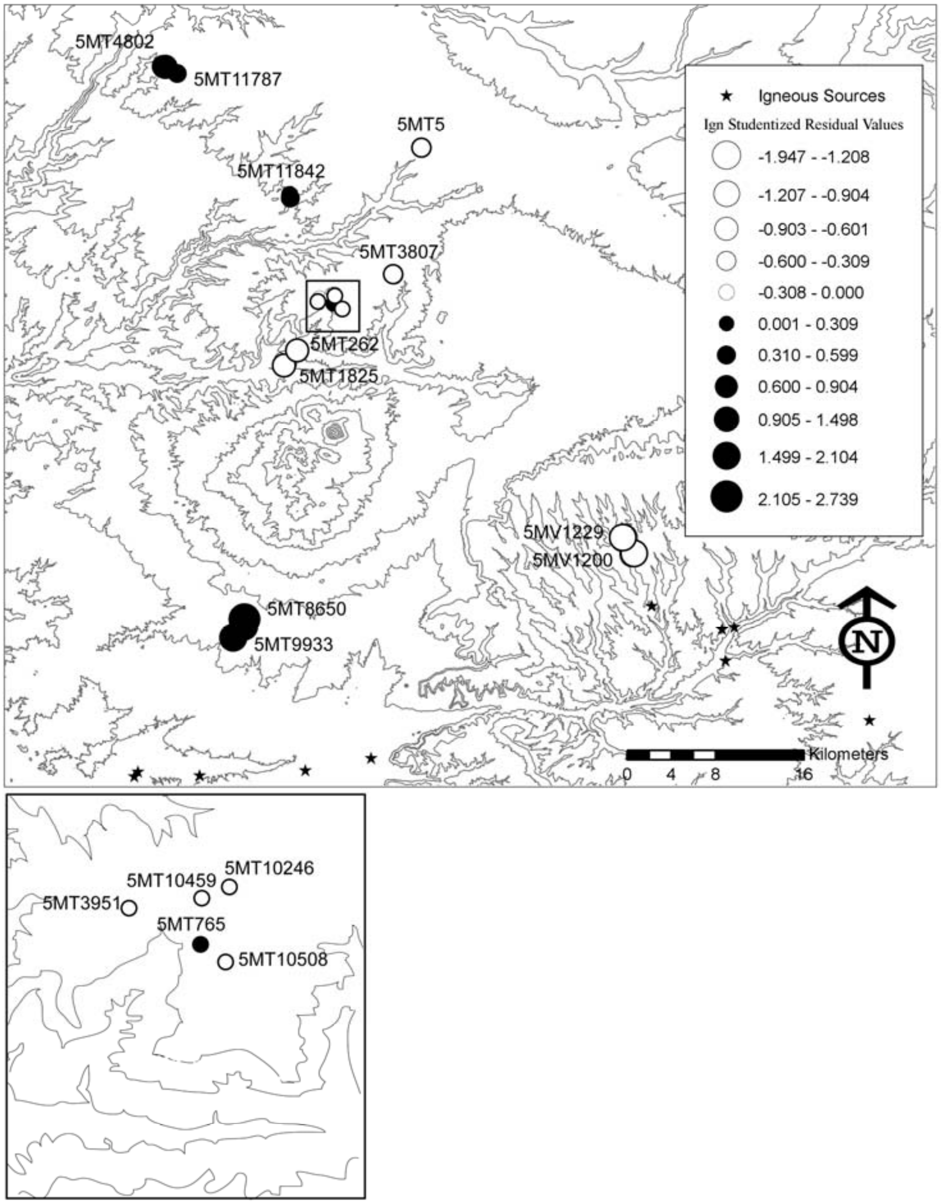


Figure 6.29. Map of igneous studentized residuals during the late Pueblo III period. The bottom panel shows igneous studentized residuals in the Sand Canyon area.

for Jmbc, caused by the assemblage of 5MV1229 (Mug House), which contains an anomalous abundance of this material, possibly indicating strong trade or interactions. For the late Pueblo III period, Kdbq behaved like most other materials in displaying an insignificant negative relationship between cost-distance and proportion. Next I attempt to gain insight into what that means by crosstabulating the assemblages with much more, and much less, Kdbq than expected, based on the linear relationship shown in Figure 6.20, against two attributes for flakes from those assemblages.

Late Pueblo III Direct vs. Indirect Procurement Patterns for Kdbq

Here again, I examine whether assemblages considerably above or below the best-fit regression line are significantly different with respect to flake attributes that may suggest how these materials were procured. As before, Fisher's Exact Tests for Kdbq was conducted for this examination. Table 6.2 shows that assemblages with more Kdbq than expected have significantly fewer flakes with no cortex, but significantly more flakes with 1-50% cortex, than the assemblages with less Kdbq than expected. Cortex amounts are significantly different for these two groups of assemblages ($p \leq .014$). Because of this result, I argue again that both assemblages with more or less Kdbq than expected may have been procured through direct procurement because those flakes were not modified or retouched further at other places prior to the arrival to the site. Similar to the result for the early Pueblo III period, although the relationship is significantly different, the people who would have been procured Kdbq material through trade in the previous periods reduced the percentage of non-cortex category in the late Pueblo III period. I believe that this pattern occurred because certain residents who lived closer

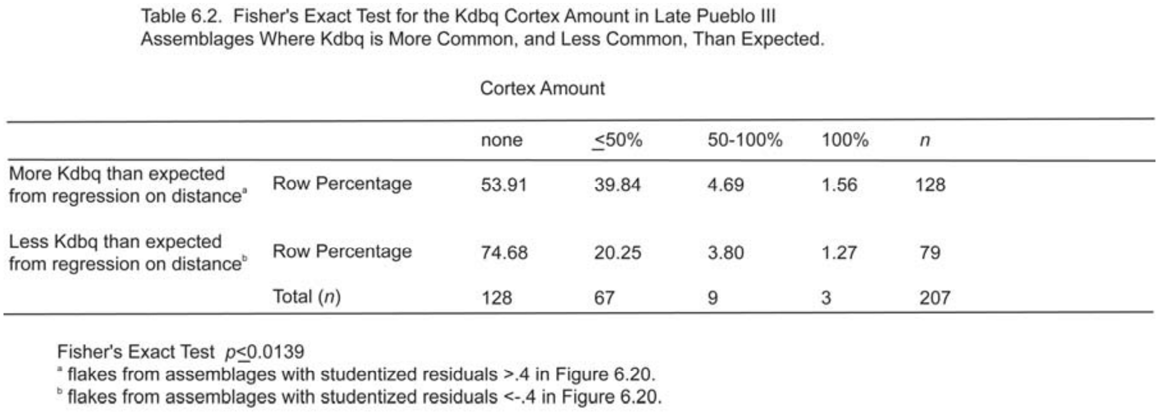


Table 6.2. Fisher's Exact Test for the Kdbq Cortex Amount in Late Pueblo III Assemblages Where Kdbq is More Common, and Less Common, Than Expected.

		Cortex Amount				
		none	$\leq$50%	50-100%	100%	*n*
More Kdbq than expected from regression on distance[a]	Row Percentage	53.91	39.84	4.69	1.56	128
Less Kdbq than expected from regression on distance[b]	Row Percentage	74.68	20.25	3.80	1.27	79
	Total (*n*)	128	67	9	3	207

Fisher's Exact Test $p \leq 0.0139$

[a] flakes from assemblages with studentized residuals >.4 in Figure 6.20.

[b] flakes from assemblages with studentized residuals <-.4 in Figure 6.20.

to Kdbq quarries probably controlled and dominated the material, probably from the early Pueblo III period. Thus, the high percentage of less than 50 percent and 50-100 percent categories in assemblages above the regression line probably reflects controlling of Kdbq quarries by certain individuals or groups.

Summary of the Percentage/Cost-Distance Relationship

I again summarize the relationship between the percentage and cost-distance relationship using three broad raw material categories – high-, medium-, and low-quality. First, the percentage/cost-distance relationships of the high-quality materials (chalcedony, Kdbq, and Kbc) show a very weak negative correlation between the distance from habitation sites to sources and the percentage by weight of raw materials. There is considerable variability within localities; some sites have more than the expected amounts of high-quality materials, whereas others nearby have less than predicted by the model. This pattern for high-quality materials is evident in the McElmo-Yellowjacket, Hovenweep, and Mesa Verde localities. In the Ute locality, all inhabitants procured fewer high-quality materials during the late Pueblo III period than expected.

Second, the late Pueblo III inhabitants in this region procured and utilized a low-quality material of Morrison source from close to their habitation sites. In the McElmo-Yellowjacket locality, although most sites have about the predicted amount of Morrison materials, some small sites (5MT10508 and 5MT3951) in the Sand Canyon area have less Morrison than predicted by the model. This suggests that there was a different casual, local procurement pattern for inhabitants of the larger sites and the small sites. An interesting aspect of toolstone procurement for these low-quality materials is that Mesa Verde residents procured and utilized more than predicted by the model. They probably had strong interactions with inhabitants who lived closer to Morrison outcrops or source areas, particularly in the McElmo-Yellowjacket locality during the late Pueblo III period (Arakawa and Gerhardt 2007).

Finally, study of the medium-quality material of Jmbc shows that large sites, such as 5MT5, 5MT3807, and 5MT4802, have more Jmbc than expected. 5MV1229 (Mug House) in the Mesa Verde locality also contains more Jmbc than predicted by the model, and this causes the regression slope to be positive. Because the only known Jmbc source areas are located on the western margins of the McElmo-Yellowjacket locality, these two localities must have had strong interactions and inter-accessibility during this period. Even though igneous materials evidence a strong negative correlation in general, residents in the Mesa Verde locality who lived fairly close to many source areas barely acquired this material during the late Pueblo III period. In contrast, residents in the Ute locality frequently procured and utilized igneous materials during the late Pueblo III period.

The Energy Expenditure Model

Figure 6.30 shows total energy expenditure for each site during the late Pueblo III period. Mesa Verde residents expended the highest amount of energy in procuring raw materials, followed by residents in the Ute and McElmo-Yellowjacket localities. As previously discussed, the Mesa Verde inhabitants procured and utilized large amounts of Jmbc and Morrison materials; thus, the total energy expended by the residents became very high. Within the McElmo-Yellowjacket locality, residents who lived in medium- to small-sized habitations, such as 5MT3951 (Troy's Tower), 5MT10246 (Lester's Site), 5MT262 (Saddlehorn Hamlet), and 5MT10459 (Lookout Site), expended large amounts of energy in acquiring raw materials. In contrast, inhabitants who lived in larger community sites, such as 5MT765 (Sand Canyon Pueblo), 5MT1825 (Castle Rock Pueblo), 5MT5 (Yellowjacket Pueblo), 5MT3807 (Shields Pueblo), and 5MT11842 (Woods Canyon Pueblo) in the McElmo-Yellowjacket locality, expended less energy in procuring lithic raw materials. This suggests either that residents who lived in large communities and small habitation sites used different patterns of logistic mobility or participated in different interactions during the late Pueblo III period. We generally expect that the large sites (e.g., community centers) have the highest proportions of semi- or non-local materials because they participate in more interactions with people in the small sites as well as populations in other large sites. Additionally, we expect that when people lived in dispersed, small sites during periods of relative calm (no socio-political, ecological, and economic pressures), the populations could safely range widely to procure raw materials. In contrast, in periods of turbulence, people use community

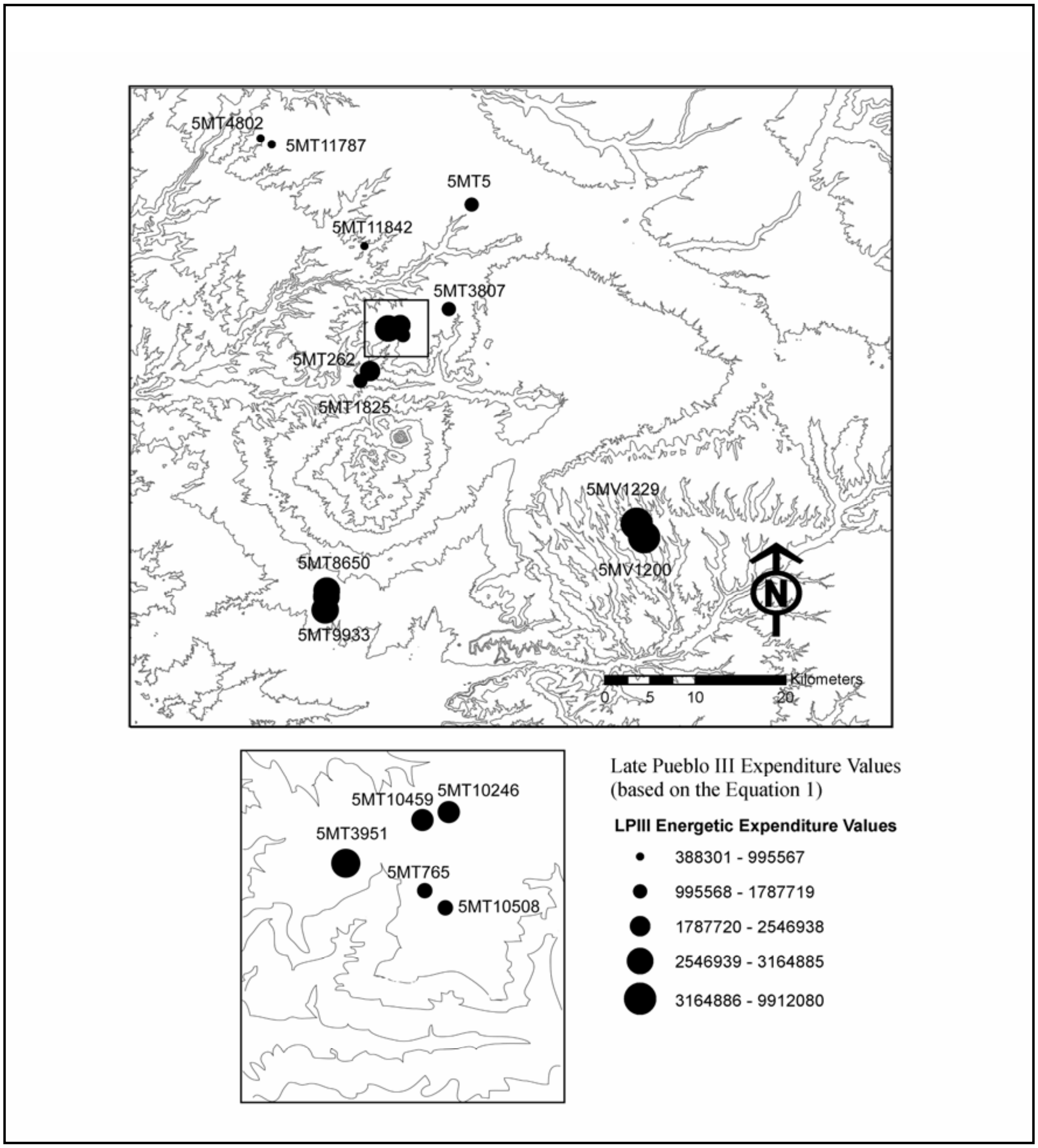


Figure 6.30. Energy expenditure values for sampled late Pueblo III sites in the central Mesa Verde region.

centers as refuges, and they were generally forced to use the most locally available materials. Based on the lithic analysis for the late Pueblo III, those expectations are not satisfied. To understand and reconstruct how the late Pueblo III inhabitants behaved differently from the early Pueblo III residents, I investigate the energy-expenditure maps to see the different behavioral patterns in the next section.

The Energy Expenditure Map

Using kriging interpolation in the ArcGIS program (Appendix A), I created an isopleths map of the total energy expended by the late Pueblo III residents (Figure 6.31), based on the values shown in Figure 6.30. Figure 6.31 shows that the late Pueblo III residents in the Mesa Verde locality expended much energy in procuring raw materials; in contrast, people in the Hovenweep locality expended less. Comparing this with the isopleths map of the early Pueblo III period (Figure 6.15), higher energy-expenditure values are broadly distributed in the landscape during the late Pueblo III period.

To make this comparison more easier and more precise, Figure 6.32 shows the difference map made by subtracting the interpolated map of total energy for the late Pueblo III period from that of the early Pueblo III period using the ArcGIS program (Appendix A). Yellow shades indicate areas where the early Pueblo III inhabitants expended more energy to obtain their toolstone, while red shades identify zones where late Pueblo III residents expended more energy in procuring raw materials. Because I have no early Pueblo III sites in my Mesa Verde locality sample, I concentrate on areas in the Hovenweep, Ute, McElmo-Yellowjacket, and Dolores localities for this comparison. This map shows that the late Pueblo III residents expended less energy in most portions

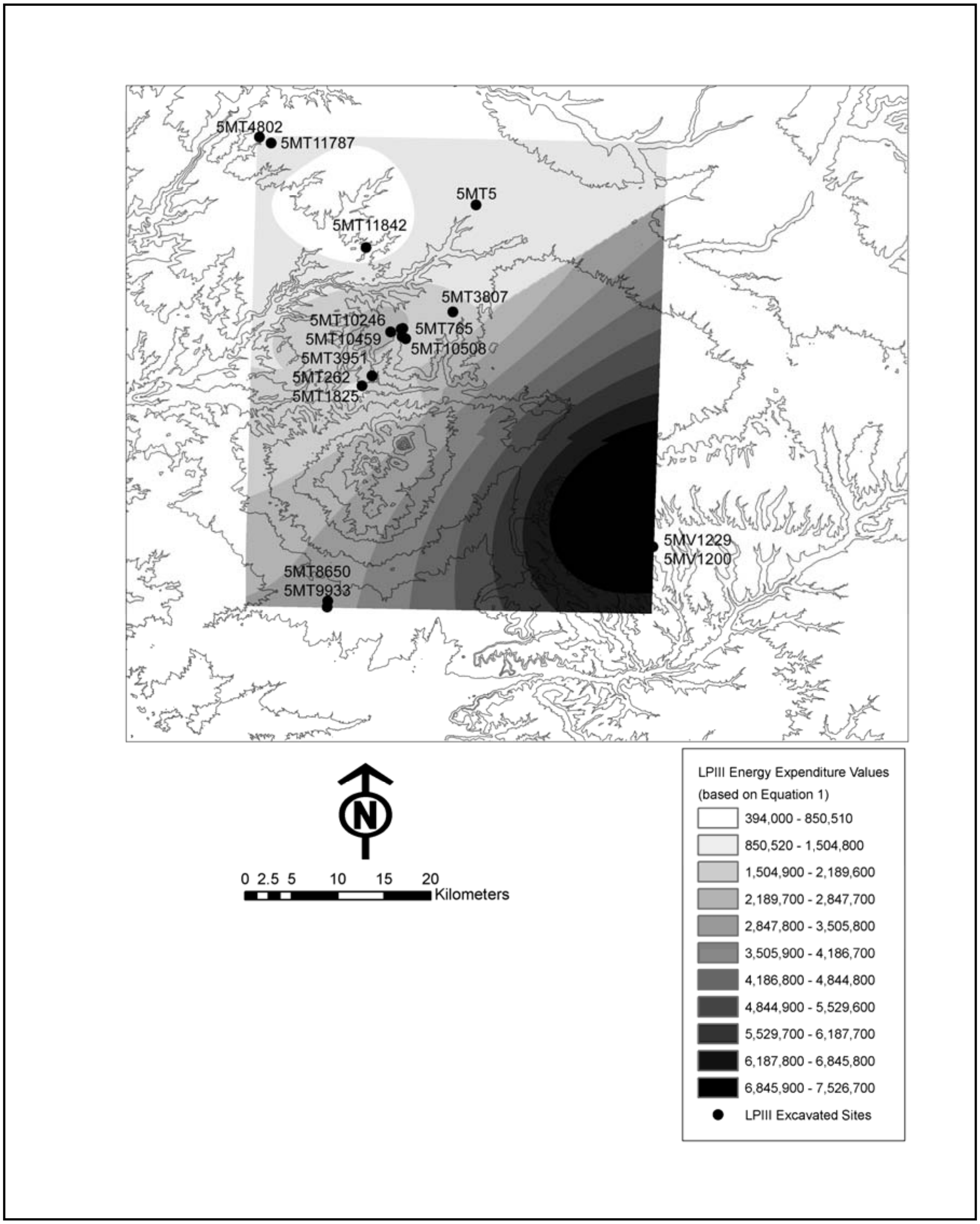


Figure 6.31. A kriged map that interpolates, across our region, the total energy-expenditure values for acquiring toolstone for the sampled late Pueblo III sites.

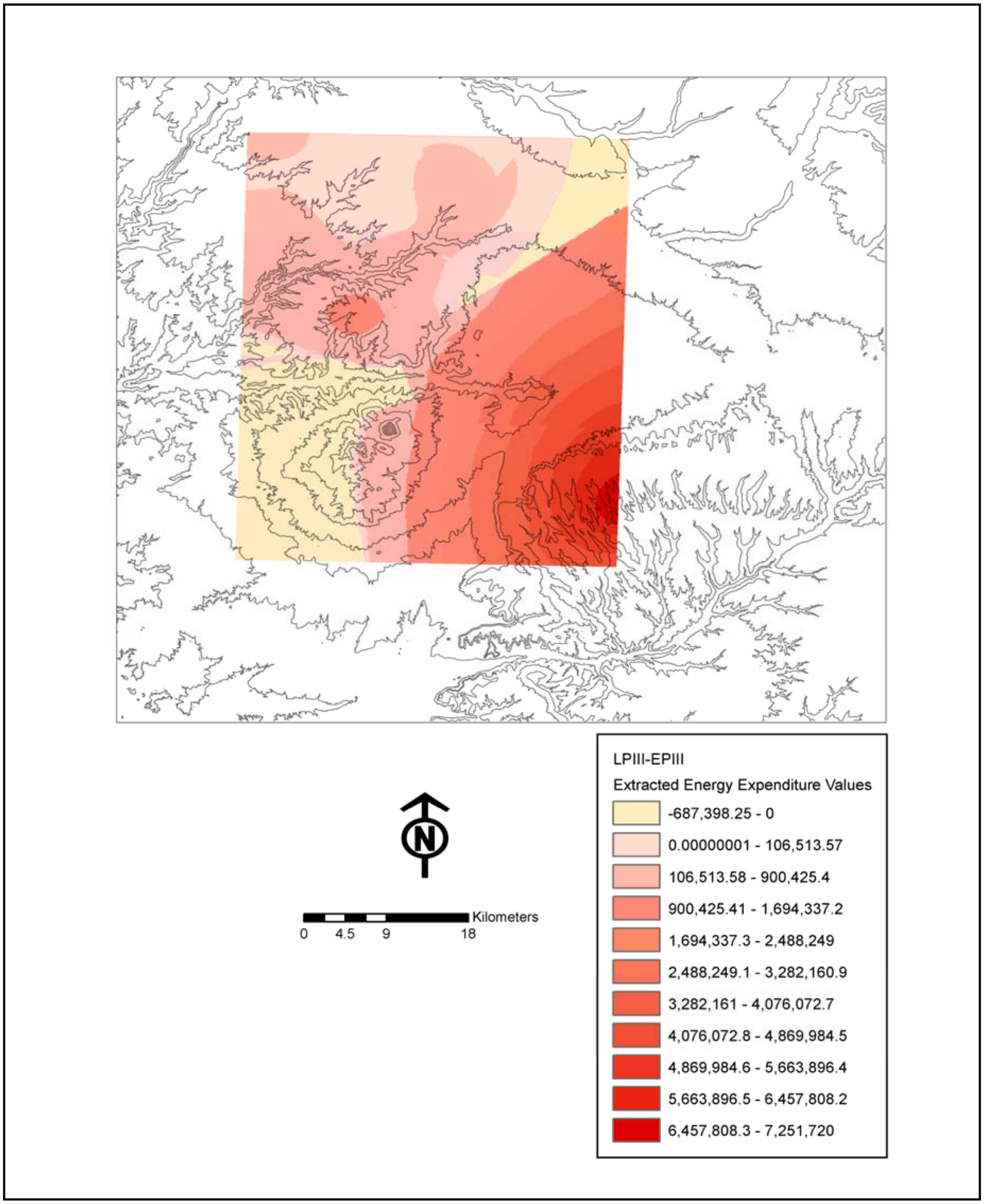


Figure 6.32. A difference map showing areas where the energy expenditure values for acquiring toolstone increased, or decreased, in late Pueblo III sites relative to early Pueblo III sites.

of the Ute locality and northeast of the Dolores locality. On the other hand, the McElmo-Yellowjacket residents expended relatively high amounts of energy in the Sand Canyon area. Based on the energy-expenditure model, residents in small sites expended more energy in procuring raw materials than residents in larger sites. Thus, this suggests that the residents in smaller habitations had more open/unrestricted logistic mobility or interaction than residents who lived in large villages.

Summary of the Late Pueblo III Period

During the late Pueblo III period, the population reached a population peak between A.D. 1225-1260 estimated at 11,000-19,000 people (Varien et al. 2007). Resource productivity, based on the average study-area potential maize yields, suggests that the late Pueblo III residents experienced extremely scarce but relatively predictable resource productivity ($\bar{x}$=240.8 kg/ha per year; S.D.=39.6 kg/ha per year). According to Dyson-Hudson and Smith's economic defensibility model, these conditions should lead to a home-range system. We can expect people to participate in developing and using territories in that way when resources are not dense but are relatively predictable.

Lithic data do not support this model, particularly for residents who inhabited large villages. Except for Jmbc during the late Pueblo III period, the r^2 values decrease in absolute value for the percentage/cost-distance relationship and the slopes for the relationships become flatter than those of the early Pueblo III period. This suggests that the late Pueblo III inhabitants participated in more dispersion and higher mobility system. The energy-expenditure model and map also suggest that residents in the Mesa Verde locality expended more energy in procuring raw materials, followed by residents in the

Ute locality. In the McElmo-Yellowjacket locality, inhabitants who lived in small sites expended more energy in acquiring raw materials, but residents of the large sites expended less. This suggests that villagers experienced more restricted territories or accessibility to other areas; thus, they obtained mostly local materials. Or, they engaged in procurement of stone embedded in long-distance hunting which was much less common given the increased dominance of turkey in the faunal assemblages during the late Pueblo III period (Cowan et al. 2006; Driver 2002). I believe that a combination of these two probably occurred in the late Pueblo III period. Study of the Morrison materials suggests that some of the large villages relied on more Morrison materials during this period. This supports Neily's hypothesis that the central Mesa Verde residents procured and utilized more local materials, probably due to more restricted territories in this region.

In the next chapter, I summarize all lithic analyses carried out from Basketmaker III to late Pueblo III periods, and attempt to reconstruct the most plausible interpretation of development of restricted territoriality in the central Mesa Verde region over time.

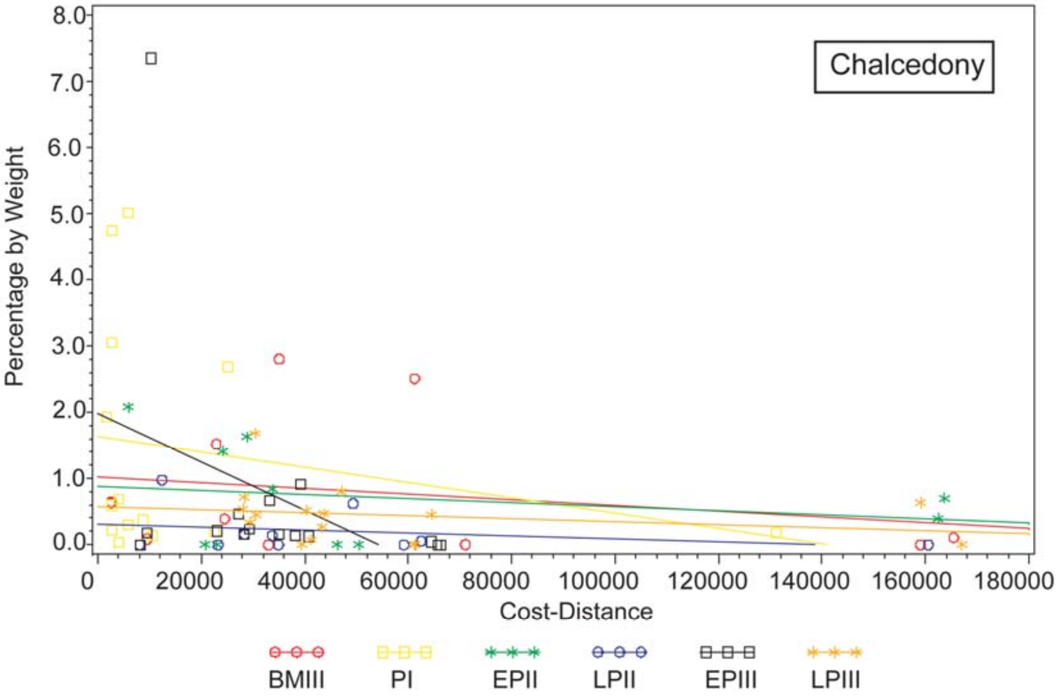
CHAPTER SEVEN

TOOLSTONE PROCUREMENT PATTERNS THROUGH TIME

This chapter summarizes the results of all analyses (both percentage/cost-distance and energy expenditure analyses) for six time periods over 700 years. I focus primarily on the question of if and when central Mesa Verde Pueblo peoples developed restricted territoriality. I also make suggestions about what toolstone procurement patterns in this region may suggest about social and political organization through time, using three different competing models. Finally, I discuss how each locality participated in interactions or alliances in the central Mesa Verde region over time.

The Percentage/Cost-Distance Relationship Through Time

Figures 7.1-7.3 show the relationships between the percentage by weight of each raw material and its cost-distance for six different time periods. The regression analyses for high-quality materials of chalcedony and Kdbq (Figure 7.1) show that the early Pueblo III assemblages display a steep negative regression line. I anticipate that this is at least in part because there are no early Pueblo III assemblages in my sample from the Mesa Verde locality, where inhabitants generally expended high amounts of energy in procuring raw materials due to the physiologically constrained environment. To explore the effects of these Mesa Verde outliers on other parts of my analysis, I also ran all these regressions for each period without the Mesa Verde assemblages. The results for the late Pueblo II and late Pueblo III periods were similar to those provided here. Analyses of Basketmaker III, Pueblo I, and early Pueblo II periods, however, were influenced slightly by the removal of the Mesa Verde assemblages. This result occurred because most



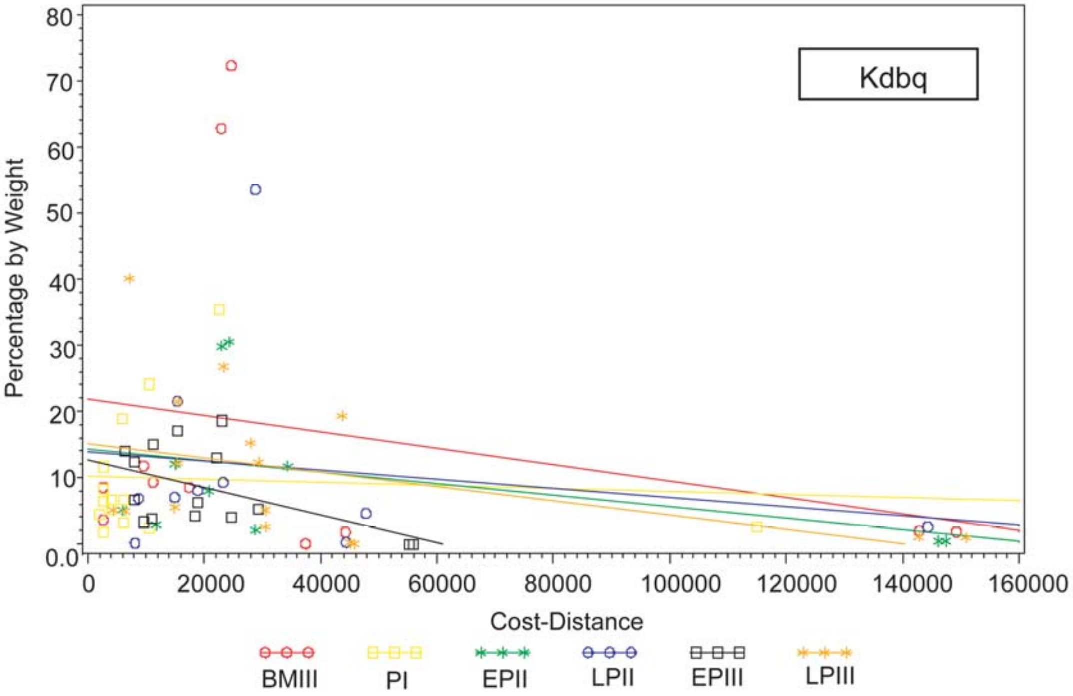
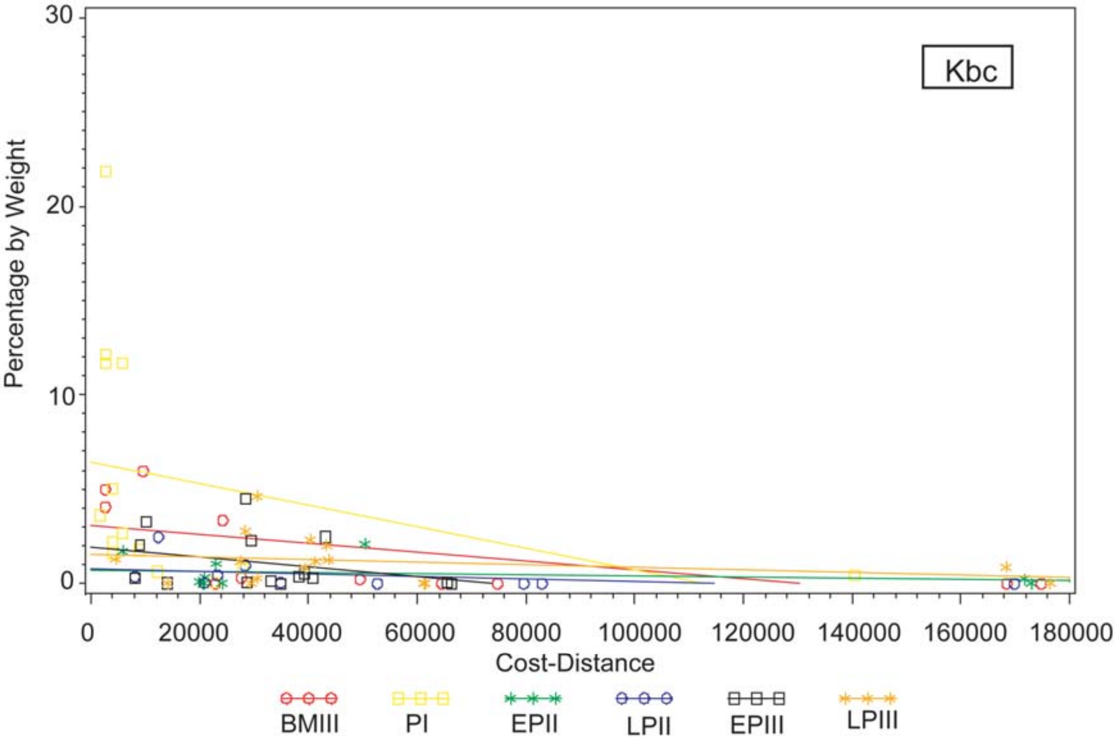


Figure 7.1. The relationship between the percentage by weight of chalcedony (above) and Kdbq (below) and their cost-distance for six time periods.



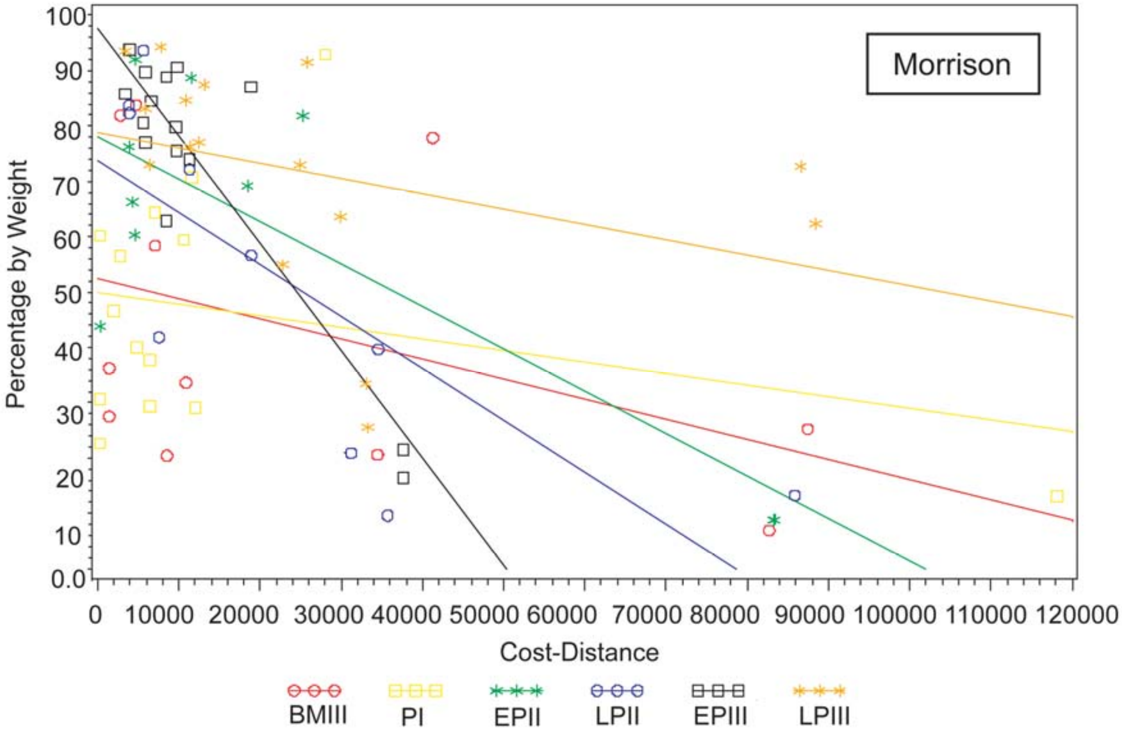


Figure 7.2. The relationship between the percentage by weight of Kbc (above) and Morrison (below) and their cost-distance for six time periods.

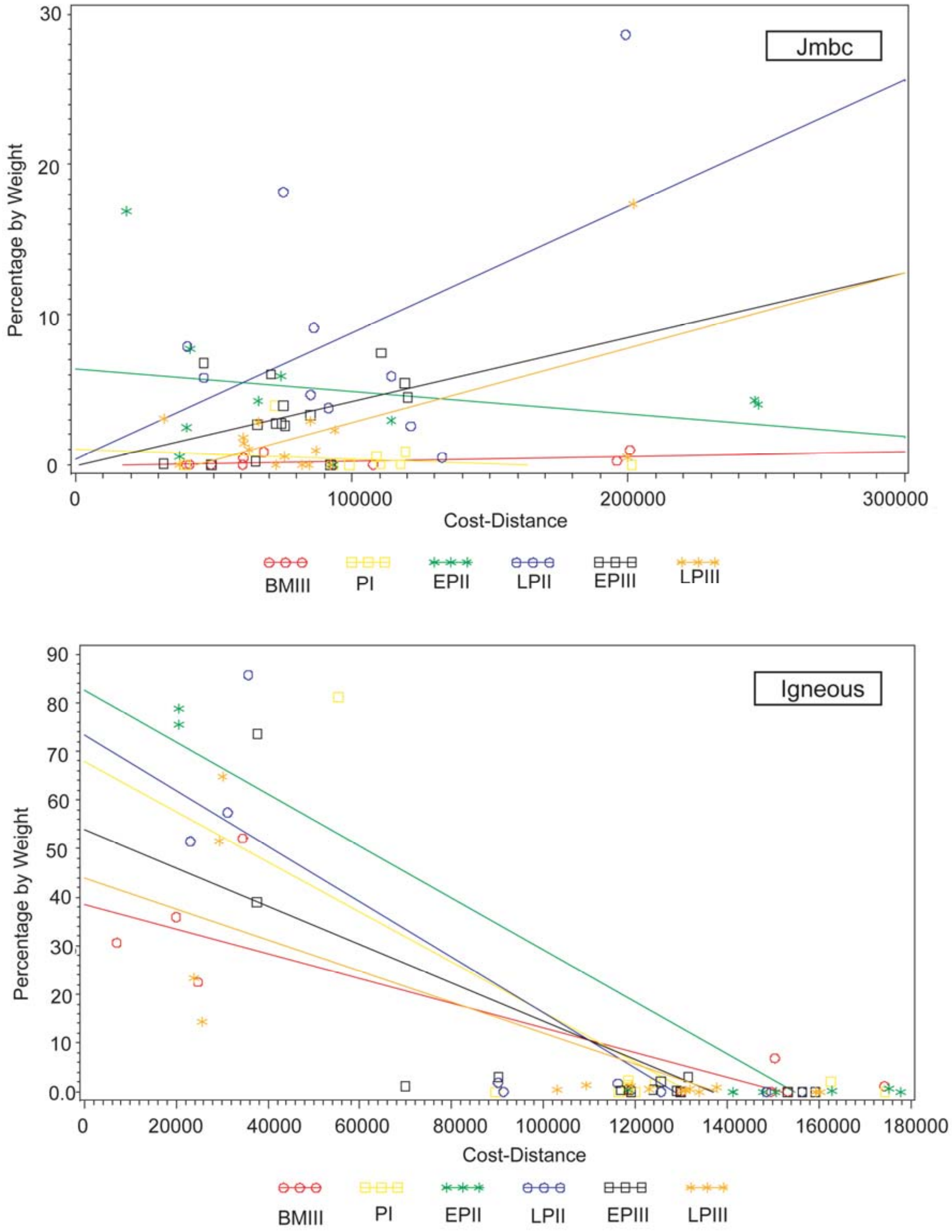


Figure 7.3. The relationship between the percentage by weight of Jmbc (above) and igneous (below) and their cost-distance for six time periods.

samples in those early periods are from the Hovenweep and Dolores localities, where the cost-distance between habitation sites and quarries is generally closer than those in the McElmo-Yellowjaket and Ute localities. Although it is unfortunate that I was unable to include early Pueblo III assemblages from Mesa Verde, I conclude from this exercise that with caution, it is reasonable to compare and contrast slopes and r^2 through time.

The top panel of Figure 7.2 shows another high-quality material, Kbc. The Pueblo I assemblage has a relatively steeper negative slope than assemblages of other periods. This suggests that Pueblo I residents had a strong tendency to use this material when it was close by, and it means also that they were very sensitive to the cost-distance relationship for this material. The Pueblo I residents might appear to be cost-sensitive because they were quite confined to their local areas by population packing (e.g., the development of villages), or because they could have obtained this material locally. For the Pueblo I period, I argue for the latter case. Since 10 out of 14 samples were derived from the Dolores locality, which was surrounded by many Kbc source areas, the Pueblo I inhabitants could have obtained Kbc materials easily and efficiently.

For the medium/low-quality Morrison materials, the bottom panel of Figure 7.2 shows that early Pueblo III assemblages again have the steepest negative slope of any period. This suggests that the early Pueblo III inhabitants in this region procured these materials close to their residences, and also implies that they were very sensitive to the cost-distance relationship for these materials. The early Pueblo III inhabitants were cost-sensitive in their procurement of Morrison toolstone because they were probably quite restricted to their local areas due to development of large aggregated villages and an accompanying territoriality.

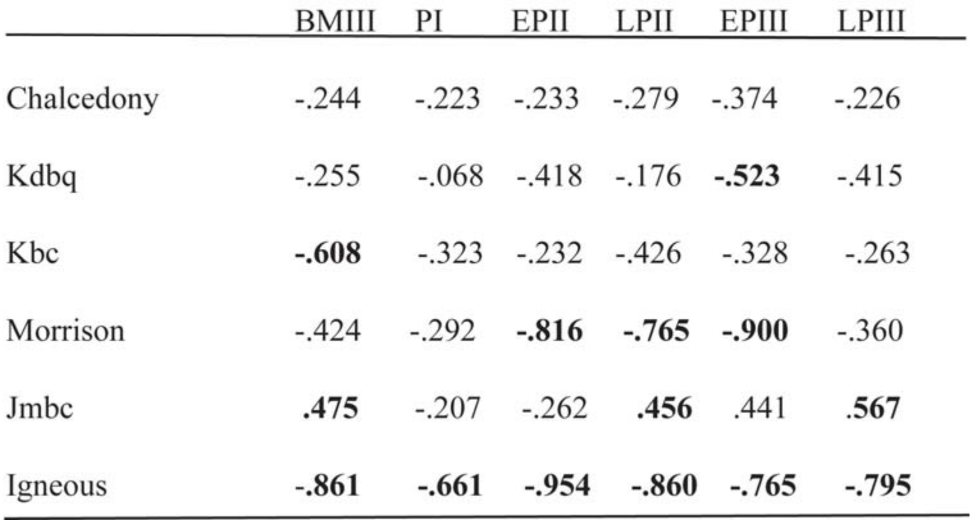
The top panel of Figure 7.3 shows the medium-quality material Jmbc. Except for the Pueblo I and early Pueblo II periods, the regression analyses show very anomalous positive relationships. We did not anticipate any positive relationships between the percentage by weight of raw materials and cost-distance because humans generally minimize their energetic costs in procuring raw materials; in other words, humans generally procure resources close to their habitations. The positive relationship between amounts of Jmbc and the cost-distances of the sources (which means that the further one was from a source, the more one used) suggests the possibility that either some residents in the central Mesa Verde region participated in strong interactions or trading networks, that this material was valued precisely because of its local scarcity, perhaps for ceremonial or symbolic purposes, or that this study has overlooked some sources for Jmbc. All these possibilities deserve more scrutiny.

Another medium-quality material, igneous material, shows the expected strong negative relationship through all periods – the strongest regression relationship of all the raw materials considered here. Early Pueblo II assemblages have the steepest slope, though all periods are fairly similar with respect to their material.

Because the comparison of the regression lines between the percentage by weight of six raw material types and the cost-distance for six time periods does not by itself reveal how strongly correlated these relationships are, I also investigate the relationships between standardized slope estimates and r^2 values for each raw material through time in the next section.

Standardized Regression Correlation (stb) and r^2. Table 7.1 summarizes the relationships between the stb and r^2 from the Basketmaker III to the late Pueblo III period.

Table 7.1. Summary of the relationships between the stb and r-square from the Basketmaker III to late Pueblo III period. This table shows stb values. The bold indicates that some stb values also have strong correlation coefficients ($r^2 > .3$).



	BMIII	PI	EPII	LPII	EPIII	LPIII
Chalcedony	-.244	-.223	-.233	-.279	-.374	-.226
Kdbq	-.255	-.068	-.418	-.176	**-.523**	-.415
Kbc	**-.608**	-.323	-.232	-.426	-.328	-.263
Morrison	-.424	-.292	**-.816**	**-.765**	**-.900**	-.360
Jmbc	**.475**	-.207	-.262	**.456**	.441	**.567**
Igneous	**-.861**	**-.661**	**-.954**	**-.860**	**-.765**	**-.795**

The bold indicates that some stb values also have strong correlation coefficients (r^2 values). The standard regression coefficient is the slope for the regression calculated after standardizing both the independent and the dependent variables. A value of -.5, for example, means that the percentage by weight declines by half a standard deviation unit as the cost-distances increases by one standard deviation unit (Shennan 1988). In chapter 2, I discussed expectations regarding the relationship between stb values and r^2. When there is a strong negative slope, this means that people have a strong tendency to use a raw material close to their residences. This also implies that they are very sensitive to the cost-distance relationship for that material. There are two plausible reasons why people might appear to be cost sensitive in toolstone procurement. First, they may have been quite confined to their localities by competitive processes among dense populations. Second, they may have been able to procure all raw materials they needed locally, perhaps because they lived close to abundant raw materials with appropriate characteristics.

The size of the r^2 value indicates the variability in toolstone procurement patterns across the landscape. When everyone is similarly sensitive to the cost-distance relationship, the r^2 value tends to be high because all sites fall near the regression line. If inhabitants in some sites exchange and others do not, the cost-distance relationship will be weakened. By the same token, if everyone exchanges raw materials across the landscape, the r^2 values become unpredictable, although exchange systems probably in general cause these values to decline. The exchange systems, however, would be identified by low negative or even positive slopes in the cost-distance relationship.

Figure 7.4 shows that the early Pueblo III assemblages tend to show the steepest stbs and strongest correlation coefficients. This suggests that the central Mesa Verde residents during the early Pueblo III period conformed to the best-fit distance-decay model. The early Pueblo III inhabitants acquired high-quality materials close to their residence. This implies that their movements across the landscape were more restricted by territoriality than was movement in other periods. If we consider that men were the hunters and were responsible for making their hunting tools, toolstone procurement patterns by men during the early Pueblo III period were more restricted than those of other time periods.

The early Pueblo III assemblages also show a strong correlation between the percentage by weight and the cost-distance of Morrison materials (Figure 7.4). The early Pueblo III residents had a tendency to use Morrison materials close to their habitations. They were sensitive to the cost-distance relationship for Morrison materials perhaps

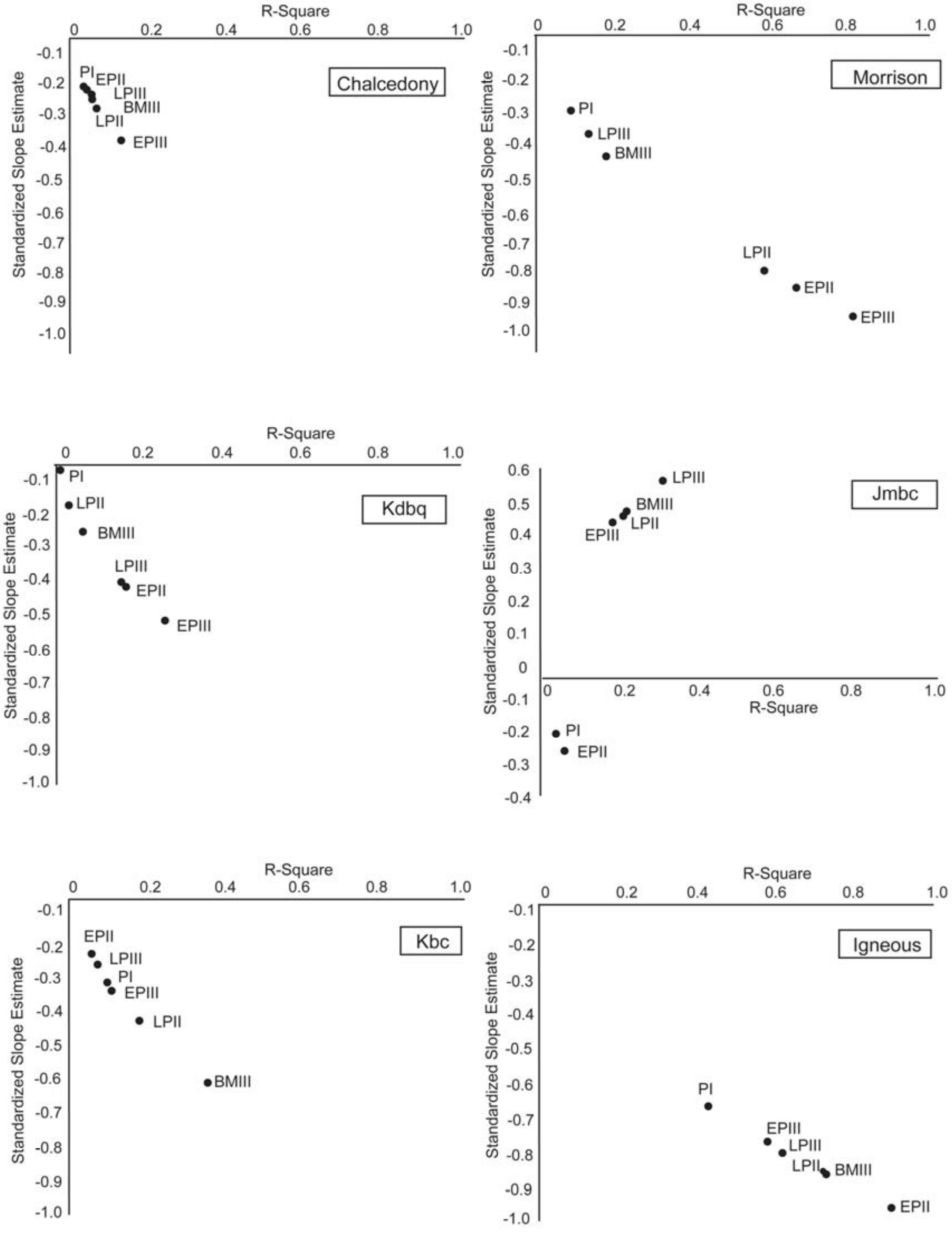


Figure 7.4. The relationship between standardized slope estimates and r-square values for each raw material through time.

because they lived in restricted territories due to increasing population and the development of large villages. The high r^2 values in the early Pueblo III indicate similar procurement patterns across this landscape, though this is affected to some extent by the absence of any Mesa Verde sites in this period since procurement behaviors on Mesa Verde appear to be different from elsewhere in this region.

Strong interaction among localities is indicated by the toolstone procurement pattern for Jmbc (Figure 7.4). Assemblages in the Basketmaker III, late Pueblo II, and early and late Pueblo IIII periods show relatively strong correlation coefficients and steep positive slopes for the relationship between the percentage by weight of Jmbc and its cost-distance. As suggested previously, the central Mesa Verde inhabitants might have procured and utilized this material for symbolic or ceremonial purposes because even people living far away procured a relatively large amounts of Jmbc, particularly during the late Pueblo periods (Arakawa and Gerhardt 2007; Glowacki 2006; Pierce et al. 2002; Robinson 2005), though this material was not suitable for manufacturing formal tools.

The toolstone procurement pattern of igneous materials conforms the most closely to the pattern predicted for increasing territoriality or accessibility over time (Figure 7.4). The slopes and r^2 values for igneous material show a consistently strong negative relationship between the percentage by weight and the cost-distance over time. Only those people living close to the sources acquired and utilized this material in any abundance, though this tendency is least pronounced in the Pueblo I period and most pronounced in the early Pueblo II period. These relationships suggest that Pueblo I people ranged widely across the landscape, or that some Pueblo I people obtained this material through trade. On the other hand, the early Pueblo II inhabitants, especially in the Mesa Verde and Ute localities, procured igneous materials only if they were close to their habitations.

To help determine whether toolstone procurement was direct or through trade, I used Fisher’s Exact Tests to compare selected Kdbq assemblages on proximal flakes of cortex amount in all time periods. In the next section, I summarize the results of these tests.

Direct vs. Indirect Procurement Patterns Through Time. I investigated whether assemblages above or below the best-fit regression model were significantly different with respect to flake attributes, and whether that may provide information regarding whether these materials were procured directly or indirectly. I selected only the Kdbq material because it constituted a relatively large percentage by weight of all assemblages. The aim of this analysis is to help inform our notions as to how central Mesa Verde residents procured and utilized toolstone, even though there may have been different procurement patterns for different material types through time.

I utilized a Fisher’s Exact Tests to investigate Kdbq cortex amounts, using studentized residual values of +/- |0.4| to identify two groups of assemblages for comparison (Table 7.2). I expected that the amount of cortex should decrease as the distance from lithic sources to habitation sites increases, unless these materials are directly procured.

Fisher’s Exact Tests for those assemblages in the Basketmaker III period shows a significant difference in cortex amounts. Because non-cortex amounts on dorsal flakes are apparent in assemblages above the regression line, I argue that residents who

Table 7.2. Summary of Fisher's Exact Test for the Kdbq cortex amount of Basketmaker III to Late Pueblo III assemblages, where Kdbq is more common, and less common, than expected. The bold indicates a strong difference between more Kdbq than expected and less Kdbq than expected from regression lines.

		None	<50%	50-100%	100%	n
Basketmaker III Period						
More Kdbq than expected from regression on distance	Row Percentage	85.90	11.54	2.14	0.43	234
Less Kdbq than expected from regression on distance	Row Percentage	70.49	22.95	6.56	0.00	61
	Total (n)	244	41	9	1	295
Fisher's Exact Test	**p< 0.017**					
Pueblo I Period						
More Kdbq than expected from regression on distance	Row Percentage	70.67	20.67	6.67	2.00	150
Less Kdbq than expected from regression on distance	Row Percentage	68.83	23.38	7.79	0.00	77
	Total (n)	159	49	16	3	227
Fisher's Exact Test	$p \leq 0.7525$					
Early Pueblo II Period						
More Kdbq than expected from regression on distance	Row Percentage	75.76	24.24	0.00	0.00	99
Less Kdbq than expected from regression on distance	Row Percentage	63.27	36.73	0.00	0.00	49
	Total (n)	106	42	0	0	148
Fisher's Exact Test	$p \leq 0.1246$					
Late Pueblo II Period						
More Kdbq than expected from regression on distance	Row Percentage	77.38	20.24	2.38	0.00	84
Less Kdbq than expected from regression on distance	Row Percentage	74.58	23.73	1.69	0.00	59
	Total (n)	109	31	3	0	143
Fisher's Exact Test	$p \leq 0.8630$					
Early Pueblo III Period						
More Kdbq than expected from regression on distance	Row Percentage	74.83	22.38	2.80	0.00	143
Less Kdbq than expected from regression on distance	Row Percentage	80.00	15.00	2.50	2.50	80
	Total (n)	171	44	6	2	223
Fisher's Exact Test	$p \leq 0.1664$					
Late Pueblo III Period						
More Kdbq than expected from regression on distance	Row Percentage	53.91	39.84	4.69	1.56	128
Less Kdbq than expected from regression on distance	Row Percentage	74.68	20.25	3.80	1.27	79
	Total (n)	128	67	9	3	207
Fisher's Exact Test	**p< 0.0139**					

procured more than expected amounts of Kdbq, would have acquired it through trade in addition to direct procurement. In contrast, inhabitants who procured and used less than expected amount of Kdbq might have obtained it through direct procurement only in those periods. In the Basketmaker III period, assemblages below the regression line show a large percentage of cortex amounts in the less than 50 percent and between 50 and 100 percent categories. I believe that people who procured this material directly engaged in testing and modifying cores at quarries, and then brought it back to residential sites (Arakawa 2003).

The Pueblo I and late Pueblo II Kdbq assemblages show relatively similar cortex amounts for assemblages above or below the regression line, though assemblages above contains relatively smaller amounts of cortex than assemblages below (e.g., the category of non-cortex amount in assemblages above retains a larger percentage than assemblages below). The early Pueblo II Kdbq assemblage displays a moderate difference in cortex amounts. Similar to the results of the Pueblo I and late Pueblo II Kdbq assemblages, the early Pueblo II assemblage above shows more highly modified dorsal flakes in the non-cortex category than the assemblage below the regression line. Assemblages below the regression line contain a relatively larger percentage in the categories of less than 50 percent than assemblages above the line. This outcome was probably due to the occurrence of core reductions at quarries and brought back dorsal flakes with cortex. In summary, the analysis of the Pueblo I, early Pueblo II, and late Pueblo II assemblages suggest that people occupying sites above the regression line in general procured and/or modified more greatly the Kdbq dorsal flakes than did people in sites below the regression line. Thus, people who procured more Kdbq than expected would have acquired this material through more indirect procurement, in addition to direct procurement.

The analysis of early Pueblo III and late Pueblo III Kdbq assemblages show a moderate and strong difference in cortex amounts for assemblages above or below the regression line. Both results nicely support my expectation. The category of non-cortex amount suggests that people occupying sites below the regression line modified more Kdbq dorsal flakes than did people in sites above the regression line. The people, who could have procured Kdbq material by trade in previous periods, reduced the percentage of non-cortex category in the Pueblo III periods. I believe that this pattern occurred because certain residents who lived closer to Kdbq quarries probably controlled and dominated the material in the Pueblo III period. Thus, the higher percentage of less than 50 percent and 50-100 percent categories in assemblages above the regression line is probably a reflection of Kdbq quarries controlled by certain individuals or groups during the Pueblo III period.

Although these results are somewhat difficult to interpret, I conclude that the central Mesa Verde Puebloans probably engaged in relatively similar toolstone procurement patterns from the Basketmaker III to late Pueblo II periods. Residents in sites above the regression line procured Kdbq by trade in addition to direct procurement. On the other hand, people in sites below the regression line probably obtained the material by direct procurement until the early Pueblo III period. Since the early Pueblo III period, some of the central Mesa Verde residents may have dominated and controlled Kdbq, and they participated in more direct procurement than people in previous periods.

To visualize where and how they expended more or less energy in toolstone procurement patterns through time, I create interpolated maps and interpret these changes in the next section.

Energy Expenditure Model Through Time

Figure 7.5 shows an interpolated map of the energy expenditure, using the kriging method in the ArcGIS program, for the six time periods in the central Mesa Verde region (Appendix A). These maps show how much energy was expended by these residents of the central Mesa Verde region in various portions of my study area in procuring raw materials, based on Equation 1 in chapter two.

During the Basketmaker III period, a high amount of energy was expended to procure raw materials in the Mesa Verde and Ute localities, followed by the northern portion of the Hovenweep locality. This suggests that two macrobands might have existed during the Basketmaker III period. During the Pueblo I period, the central Mesa Verde residents continued to expend a higher amount of energy in procuring raw materials in the Mesa Verde locality, but they did not expend much energy in the Dolores locality.

During the early Pueblo II period, the figure shows no dark colors across the landscape; this suggests that the early Pueblo II residents expended overall less energy in procuring raw materials. Residents in the Ute, Mesa Verde, and portions of McElmo-Yellowjacket localities expended a relatively high amount of energy in toolstone procurement during the early Pueblo II period. However, residents of the Dolores

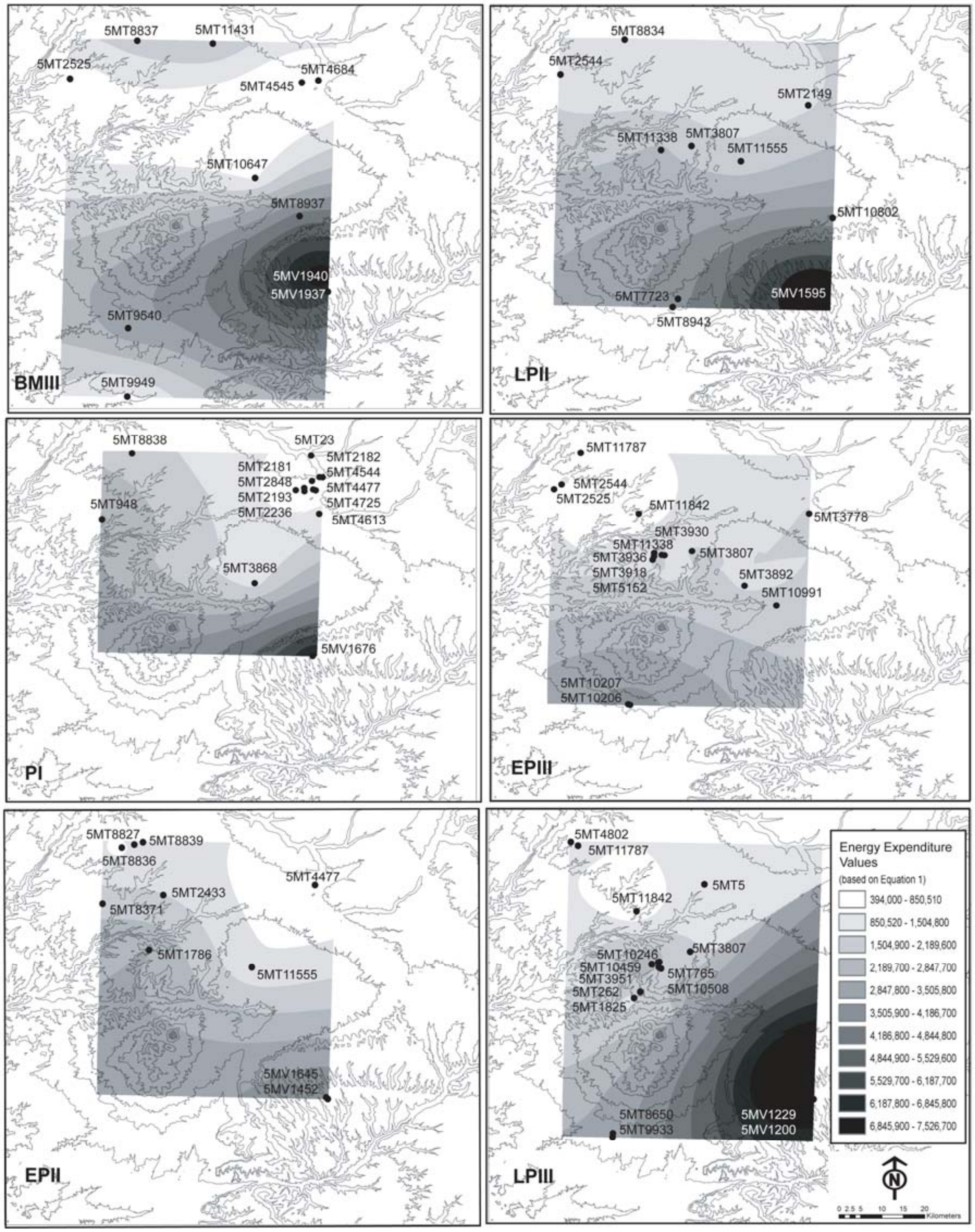


Figure 7.5. Interpolated map of the energy expenditure using kriging GIS for six time periods in the central Mesa Verde region.

Locality, as in the two earlier periods, expended the least energy in procuring raw materials. During the late Pueblo II period, inhabitants expended more energy in acquiring raw materials in the Mesa Verde locality than did residents in the previous periods, meaning that materials on average were traveling further across the landscape during this period. On the other hand, the people in the Hovenweep locality expended less energy in acquiring raw materials during the late Pueblo II period.

During the early Pueblo III period, residents of 5MT3778 (Casa de Sueños) in the Dolores locality and inhabitants in the Ute locality expended relatively high amounts of energy in procuring raw materials. In general, though, the energy expenditures for toolstone procurement in the early Pueblo III period were less than those of the late Pueblo II residents. I suggest that this toolstone procurement behavior was strongly related to the development of restricted territories in the central Mesa Verde region during the early Pueblo III period. During the late Pueblo III period, inhabitants of the Mesa Verde locality expended a higher amount of energy in acquiring raw materials. Energy expenditures were also relatively high in the Sand Canyon area in the McElmo-Yellowjacket locality. Interestingly, comparisons of energy-expenditure values for the community centers of Yellow Jacket Pueblo, Shields Pueblo, Sand Canyon Pueblo, and Castle Rock Pueblo were lower than for the small sites in the Sand Canyon area during the late Pueblo III period. Overall it can be concluded that the late Pueblo III inhabitants participated in strong interactions, especially between the McElmo-Yellowjacket and Mesa Verde localities, that caused toolstone to move large distances within this study area (Arakawa and Gerhardt 2007). This is an interesting factor because other studies indicate that this region appears to be isolated from other regions (Lipe and Varien 1999;

Neily 1983), but internally the central Mesa Verde residents participated in exchange or movement.

In general, we expect that a geographically stable territorial system (Dyson-Hudson and Smith 1978) would have emerged in the late Pueblo III period because there were more aggregated settlements then, a larger population (at least in the first part of the late Pueblo III period), more evidence of violence, and more defending resources and territories (Kohler et al. 2006; Kuckleman et al. 2000, 2003; Kuckleman 2002). Lithic data, however, seem to suggest maximum territoriality in this landscape in the early Pueblo III period. In the next section, I compare these lithic with three competing models to analyze the relationship between demography, agricultural resources, and landscape use.

Models and Territoriality Through Time

To understand and reconstruct the development of territoriality using toolstone procurement patterns, I consider three competing models – the naïve cultural-evolutionary model, Dyson-Hudson and Smith's (1978) model, and Dyson-Hudson and Smith's model modified to control for population size.

According to a naïve cultural-evolutionary model (e.g., Johnson and Earle 1987; Sanders and Price 1968; Service 1962), we might assume that when population density increases coincident with aggregation of communities or establishment of villages in an agricultural society, people participate in more complex socio-political organizations (Figure 7.6). We expect further that agriculturalists generally develop increasingly restricted territorial or land-tenure systems (Adler 1996; Kohler 1992; Netting 1982) as

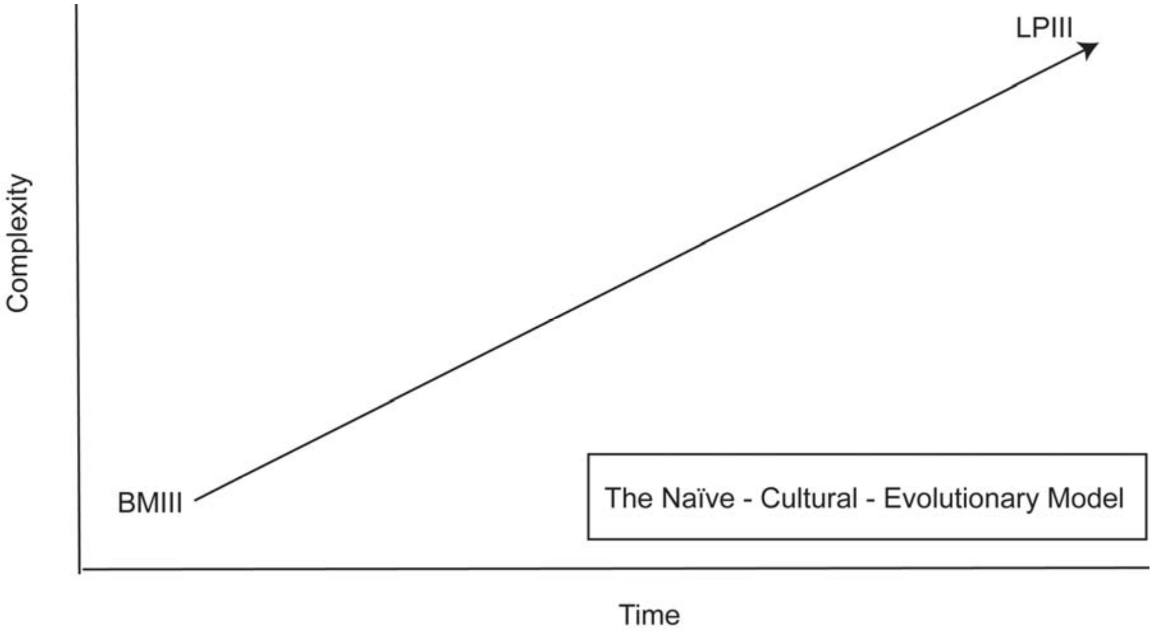


Figure 7.6. The Naïve-Cultural-Evolutionary Model.

population density increases. By these expectations, population and subsistence intensification are the most crucial factors in determining land-use or territorial patterns. Accordingly, assuming that both population increases and subsistence intensifies gradually over time, Basketmaker III residents would exhibit the most dispersion and mobility, and people in following periods would change towards increasingly geographically stable territorial systems over time.

Dyson-Hudson and Smith's economic defensibility model is another that can be used to investigate the relationships between territoriality and agricultural resources. I am fortunate here to be able to draw on recently reconstructed maize productivity and population estimates from the central Mesa Verde region by Kohler et al. (2007) and Varien et al. (2007). These enable me to develop expectations for territorial behavior in the central Mesa Verde region over time using Dyson-Hudson and Smith's model (the top panel of Figure 7.7). Dyson-Hudson and Smith (1978) propose that four different kinds of territorial systems will develop depending on whether resources are dense or scarce, and predictable or unpredictable. If this model fits with my analyses of toolstone procurement in the central Mesa Verde, then this suggests in turn that environmental variability is critical for understanding territorial patterns. Dyson-Hudson and Smith's model, however, was originally developed for hunting and gathering societies, whereas the societies considered here are sedentary and agricultural. Since agricultural societies develop local, abundant, and relatively stable resources through agriculture, they should in general appear in quadrant C in Dyson-Hudson and Smith's model (top panel, Figure 7.7). Therefore, we will be interested in deviations primarily within this quadrant, as shown by the lower panel of Figure 7.7. This modification also reflects the greater mobility restrictions imposed by population packing among agriculturalists, and the way that farmers change the productivity structure of the landscape. Due to all these considerations, I argue that all the societies I am examining are in compartment C, but that they may move slightly in one of the A, B, or D directions depending on the productivity considerations by period, if Dyson-Hudson and Smith's model is correct.

The top panel of Figure 7.8 locates periods within Dyson-Hudson and Smith's compartment C according to the mean annual maize productivity and its standard deviation, derived from the village study area data (Varien et al. 2007). This reveals that the late Pueblo II and Basketmaker III inhabitants may have higher mobility and more information-sharing in their territorial systems, than do the other periods. The early and late Pueblo III inhabitants, on the other hand, may have some characteristics of a home-range system, according to this model.

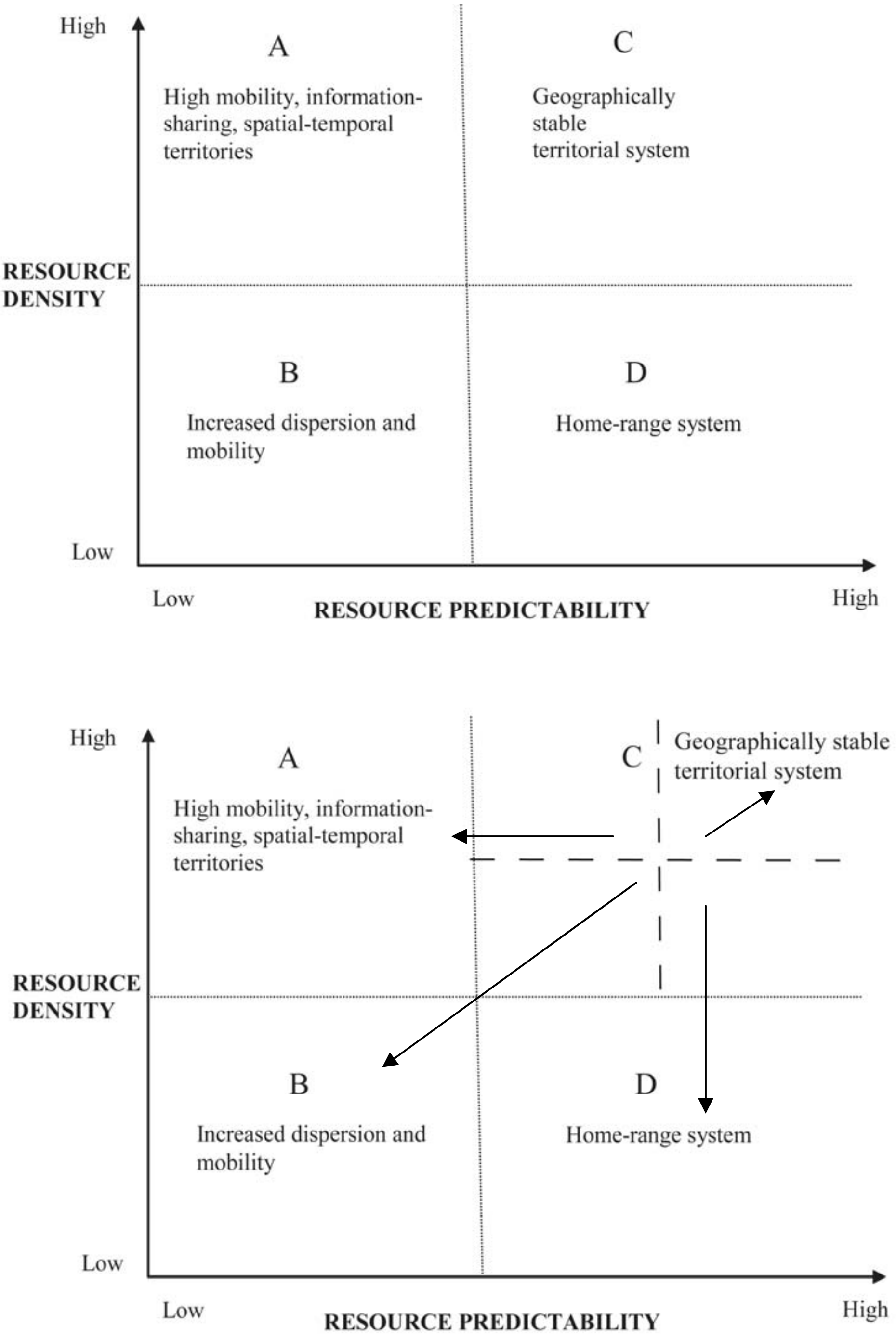


Figure 7.7. The top panel shows Dyson-Hudson and Smith's original model. The bottom panel displays my modification Dyson-Hudson and Smith's model.

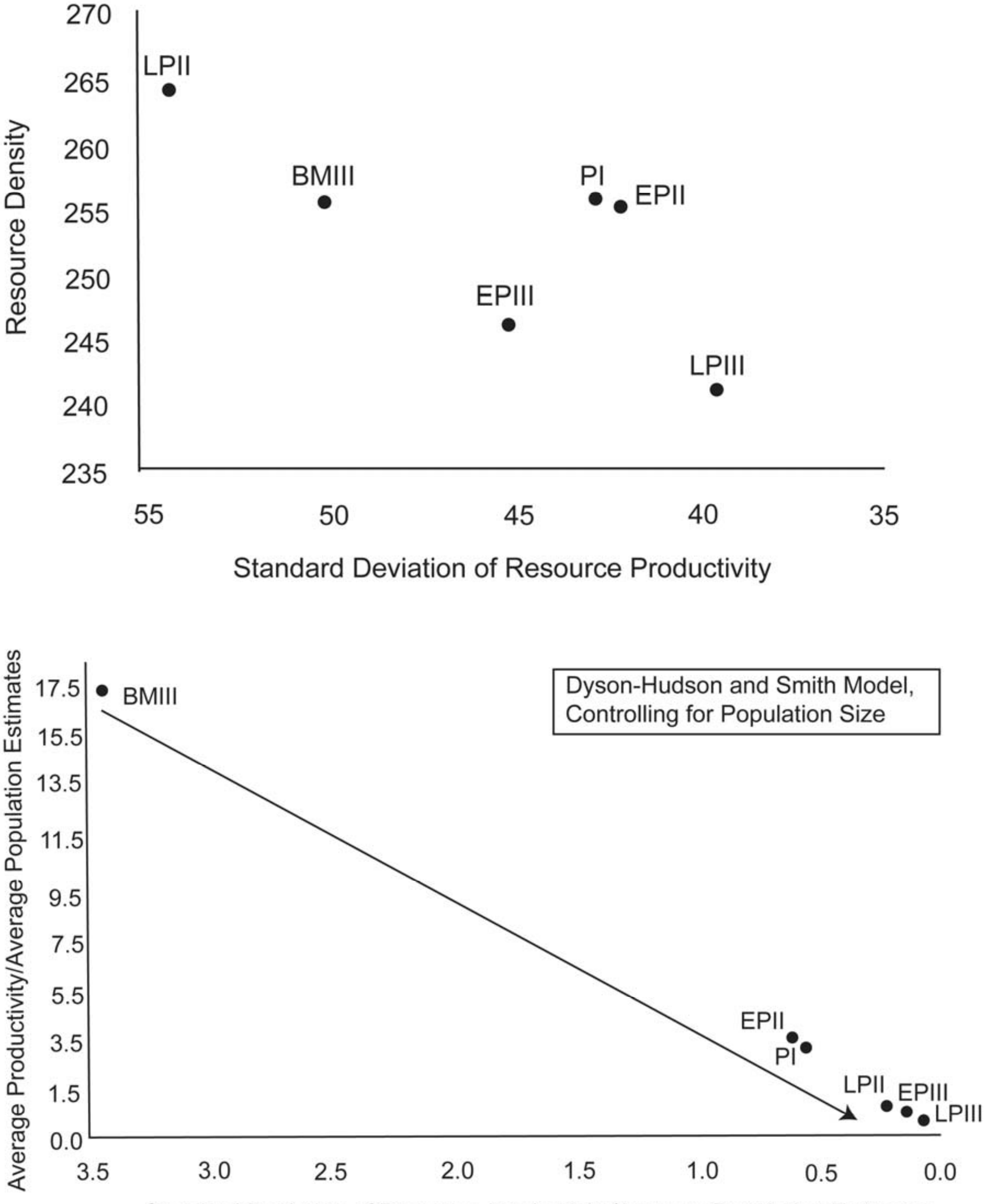


Figure 7.8. The top panel shows predictions for period placement based on Dyson-Hudson and Smith's model, using estimates of agricultural resource productivity and its standard deviation through time in the central Mesa Verde region. The lower panel shows Dyson-Hudson and Smith's model (based on resource abundance and predictability), controlling for population size.

The third model is Dyson-Hudson and Smith's model, modified to control for population size (the lower panel of Figure 7.8). This was done by dividing the average potential maize productivity by the average population estimates in each period, and plotting that against the standard deviation of potential maize productivity divided by the average population estimate for each period. This predicts each period's placement in Dyson-Hudson and Smith's territorial scheme, based on resource productivity and predictability controlling for population density. This suggests that the Basketmaker III residents only should have some of the characteristics of societies with high mobility, information-sharing, spatial-temporal territories, whereas societies in all other periods, but especially in the late Pueblo III, should have territorial characteristics more suggestive of a home-range system.

Lithic Data (stb and r^2). I evaluated these three models with lithic data of using the stb and r^2 values over 700 years and six periods. Figure 7.9 shows the location of each period based on the lithic analysis (assuming that negative stbs are related to high productivity, and high r^2 values are related to high resource predictability), using a circle. I plotted the lithic values based on average standardized slope estimates against the average *r*-square in each period. Then, this was compared using three models: the "naïve cultural evolutionary" temporal trajectory (shown by a dotted line); Dyson-Hudson and Smith's model (plotted by a rectangular); and Dyson-Hudson and Smiths model, controlling for population size (plotted by a star).

I argue that examining the predictions of these models against the lithic data is plausible only if vertical and horizontal axes are reasonably comparable. Based on

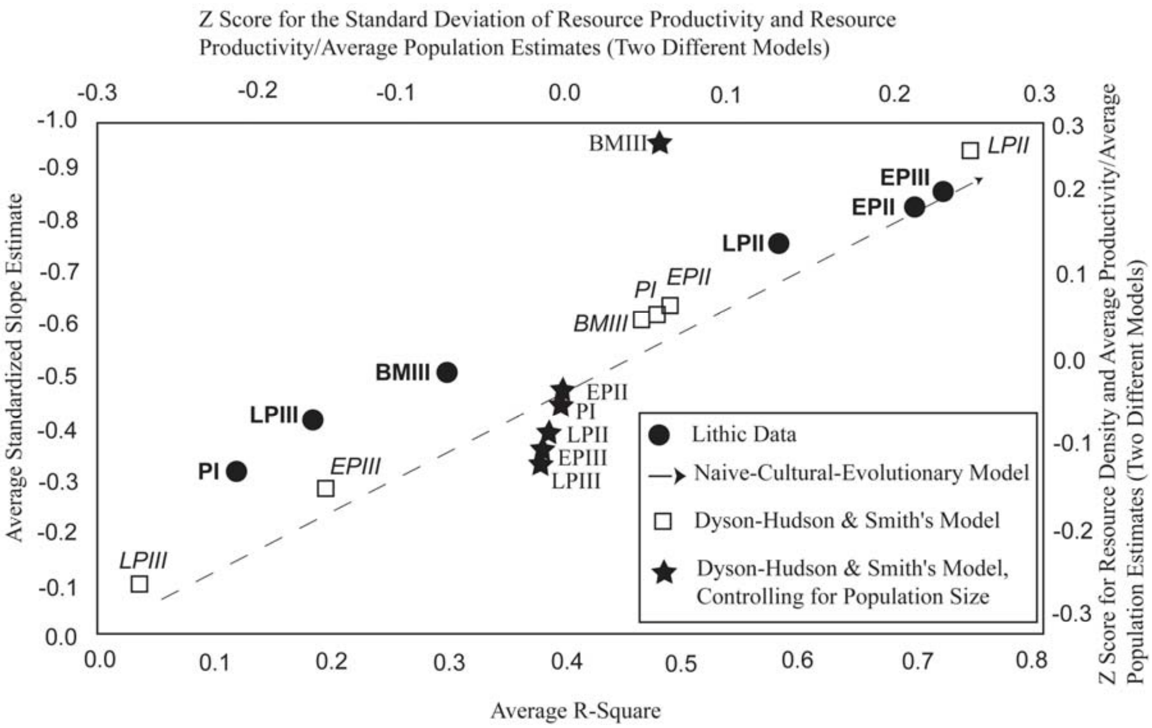


Figure 7.9. This figure shows the results of standardized slope estimate and r^2 values.

Dyson-Hudson and Smith's model, resource density is used as a dependent variable (the y-axis). This is comparable to the negative standard regression coefficient (stb) in lithic data. As a territory becomes increasingly restricted, resource procurement in a landscape also becomes constrained in according to Dyson-Hudson and Smith's model, and then people rely on locally dense resources. This suggests that using horizontal axes of resource density and stb are logically comparable. For the horizontal dimension, I argue that resource predictability in Dyson-Hudson and Smith's model and *r*-square values in lithic data are also comparable. When *r*-square values are high, this suggests that everyone on the landscape behaves the same way. In Dyson-Hudson and Smith's model, when resources become more predictable across the entire landscape, people can probably consume equal amounts of resources. In contrast, if resources are unpredictable or only predictable in some areas, we expect the system to move to the left on the horizontal axis in Dyson-Hudson and Smith's model.

To compare those three models with lithic data, dependent and independent variables in both Dyson-Hudson and Smith's model and its controlling for population size are adjusted by z-score values. The x-axis for those two models represents z-scores for the standard deviation of resource productivity and the value of resource productivity divided by population estimates in each period. The y-axis denotes z-scores for resource density and the values of average productivity divided by average population estimates.

Figure 7.9 shows obviously that there are no similar relationships between the slopes and r^2 and population, the naïve cultural-evolutionary model, Dyson-Hudson and Smith's model, and the modification of the Dyson-Hudson and Smith prediction controlling for population size model. In other words, the lithic data with three competing models for the relationship between demography, agricultural resources, and landscape use are not strongly related, and none of those three models explains how the central Mesa Verde people behaved with respect to their toolstone procurement patterns. In the next section, I discuss how we can make sense of the lithic data by describing primarily two different regimes and then using two different trajectories.

Two Different Regimes. The top panel of Figure 10 shows explicitly two different regimes according to the results of lithic data for these six time periods. One contains the relationships of average stb and r^2 values of Basketmaker III, Pueblo I, and late Pueblo III periods, whereas another regime includes those of early Pueblo II, late Pueblo II, and early Pueblo III periods. People who belonged to the former regime would have

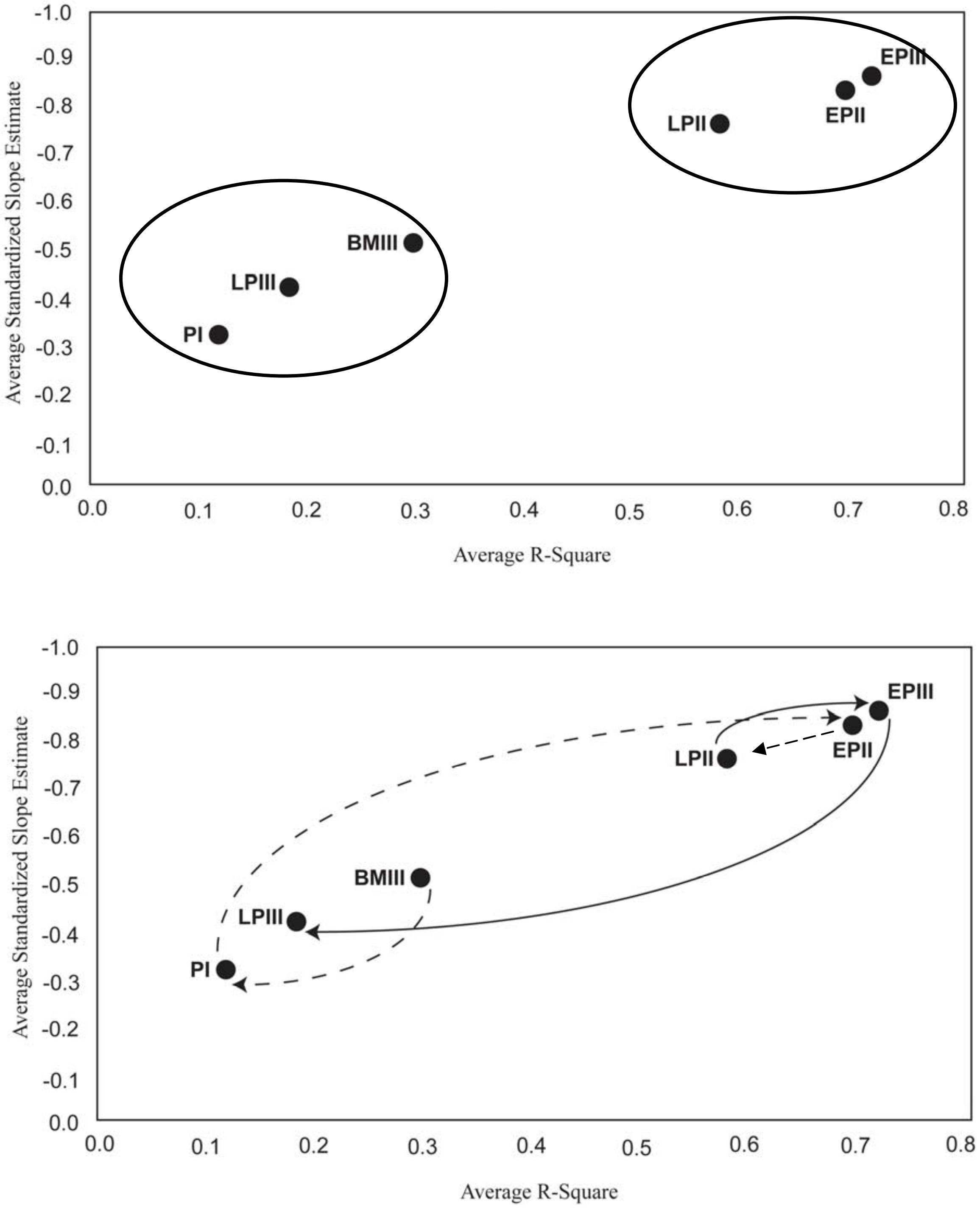


Figure 7.10. The top panel shows two different regimes. The bottom panel displays two trajectories of toolstone procurement patterns from the Basketmaker III through the late Pueblo III period.

experienced higher mobility or interactions across the entire landscape than those of the latter regime. In contrast, people in the latter regime probably procured their raw materials close to their residences and also behaved in a similar way throughout the entire landscape. By looking at those two regimes, it is difficult to explain why people in the former regime behaved differently from the other regime. To better understand these differences, I further consider cultural trajectories over time in this study area.

Two Different Trajectories. The bottom panel Figure 7.10 shows two different trajectories, the first beginning with an initial occupation, possibly occurring during the Basketmaker II period, continuing through the end of decreasing population during the Pueblo I period, and a second trajectory starting with increasing population during the late Pueblo II period though abandonment of the region in the late Pueblo III period (Varien et al. 2007). In the first trajectory, the Basketmaker III inhabitants tended to procure many raw materials locally, but they participated in long-distance activities such as hunting large and medium-sized animals (Cowan et al. 2006). The Pueblo I inhabitants procured varied raw material types where located probably far away from their residences. Pueblo I residents on the entire landscape behaved differently in toolstone procurement patterns because this was probably related to the development of villages or aggregated settlements in the Dolores locality from which people had to travel far away to procure raw materials. Furthermore, the increased dispersion and mobility model might explain behaviors of the Pueblo I residents because several families in this region began to move within or outside this region. Then, the first cycle ended with the early Pueblo II residents composed of fairly small populations of low density. Since population size and density declined at this time, the early Pueblo II inhabitants in each locality could have relied on local resources close to their habitations for acquiring protein and calories. Thus, they did not need to participate in frequent long-distance activities because they lived in an area with abundant local resources and developed or relied on the local system, including economic and socio-political organization. Consequently, these may have led them to settle in stable territories during the early Pueblo II period.

The second cycle began with increasing population through emigration that occurred during the late Pueblo II period (Varien et al. 2007). The late Pueblo II inhabitants relied on and procured local materials close to their habitations. Their behaviors were moderately restricted in this landscape under the suggestive characteristics of a home-range system according to the Dyson-Hudson and Smith model. Additionally, the central Mesa Verde people lived under socio-political pressure within this confined territory (e.g., warfare or land-tenure system), and began during the late Pueblo II period to depend on the domestication of turkey to obtain protein rather than deer or other medium/large game animals (Cowan et al. 2006; Driver 2002). In the early Pueblo III period, the central Mesa Verde residents participated in the most similar toolstone procurement patterns; in other words, they lived in very restricted territories due to increasing population size, developing large aggregated villages, and relying on more domesticated turkey rather than deer. During the late Pueblo III period, population continued to increase and more aggregated villages emerged. Some of the inhabitants participated somewhat in strong interactions, particularly the Mesa Verde and McElmo-Yellowjacket residents during the late Pueblo III period (Arakawa and Gerhardt 2007). Neutron activation analysis of black-on-white bowl sherds from Sand Canyon and Castle

Rock in the McElmo-Yellowjacket locality and the Mesa Verde locality in the late Pueblo III period also suggests that those localities had strong interaction (Glowacki et al. 1998; Pierce et al. 2002). Based on Dyson-Hudson and Smith's model, they had territorial characteristics more suggestive of the increased dispersion and mobility system. I believe that this pattern occurred, not only because residents who lived in small habitations participated in more frequent mobility, but also because some families in the central Mesa Verde region continued to participate in the process of emigration during the late Pueblo III period.

These two trajectories suggest that the central Mesa Verde residents engaged in territorial characteristics suggestive of increased dispersion and mobility when they had large populations and lived in aggregated settlements (e.g., Pueblo I and late Pueblo III periods). I believe that this pattern is strongly related to the incidence of emigration.

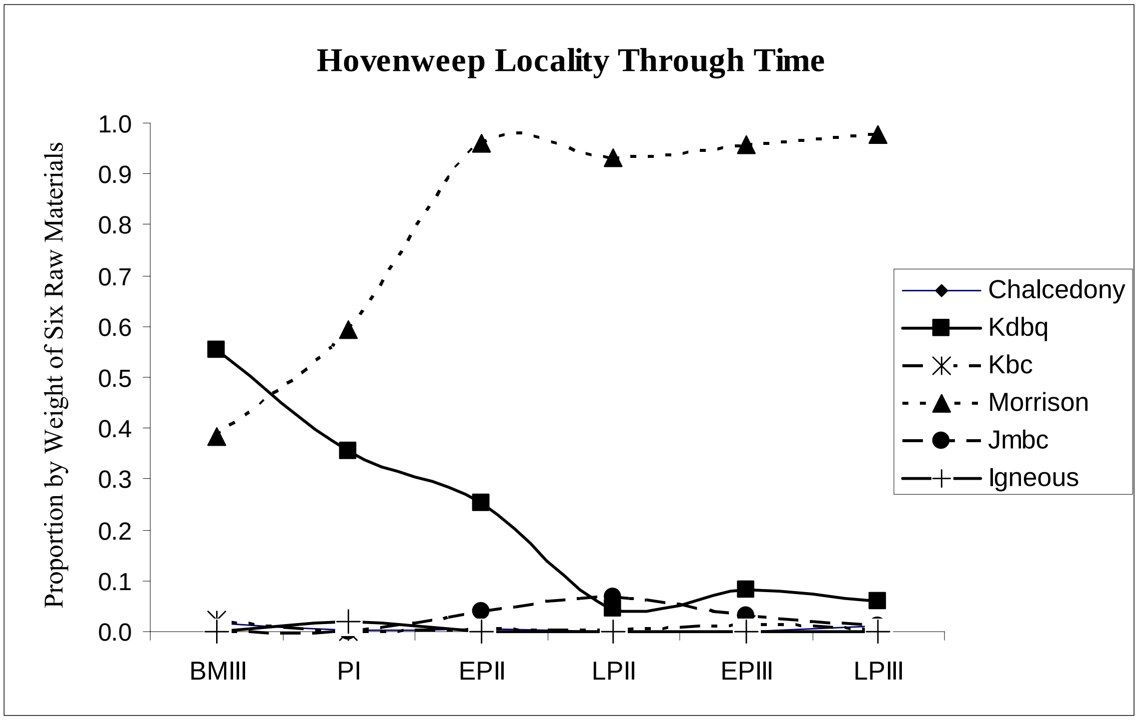
To understand and reconstruct toolstone procurement by the central Mesa Verde inhabitants, we need to consider not only population size and resource productivity and predictability, but it is also crucial to consider socio-political organization, such as territoriality or land-tenure systems, interactions (trade), and subsistence patterns. Toolstone procurement patterns are very useful for understanding and reconstructing human behaviors because they are related to many other aspects of life in the past.

Toolstone Procurement Patterns of Six Raw Material Types Through Time

Restricted territories developed in the central Mesa Verde region during the early Pueblo III period. Although we generally assume that the ancestral Puebloans participated in isolation or were independent from other groups under a restricted territorial environment, the central Mesa Verde inhabitants continued to maintain interaction among localities, particularly the McElmo-Yellowjacket and Mesa Verde localities (Arakawa and Gerhardt 2007). To understand and reconstruct interactions from a different angle, I investigated toolstone procurement patterns of six raw material types for five localities over time. This study may explain deviated toolstone procurement patterns for particular raw material types in a certain time and space, particularly the unexpected results of Pueblo I and late Pueblo III periods by the relationship between the average standard slope estimate and the average r^2 values (Figure 7.10).

Figure 7.11 shows the proportion by weight of six raw materials in the Hovenweep and Dolores localities through time. In the Hovenweep locality, inhabitants procured and utilized large amounts of Kdbq during the Basketmaker III period and then shifted their preferences to acquiring and utilizing a large amount of Morrison materials from the Pueblo I period through the late Pueblo III period. The Hovenweep residents also procured a relatively larger amount of Jmbc during the late Pueblo II period than other time periods. In the Dolores locality, inhabitants increasingly acquired Morrison materials through time, and they also frequently procured Kdbq, even though the proportion by weight of the material is relatively small. Residents of Casa de Sueños (5MT3778) during the early Pueblo III period acquired and utilized more Morrison materials than other Dolores inhabitants in other periods.

Figure 7.12 shows toolstone procurement patterns in the McElmo-Yellowjacket and Ute localities over time. Inhabitants in both increasingly procured and utilized Morrison materials as well as Kdbq over time. Similar to toolstone procurement patterns in the Hovenweep locality, the McElmo-Yellowjacket residents acquired a relatively



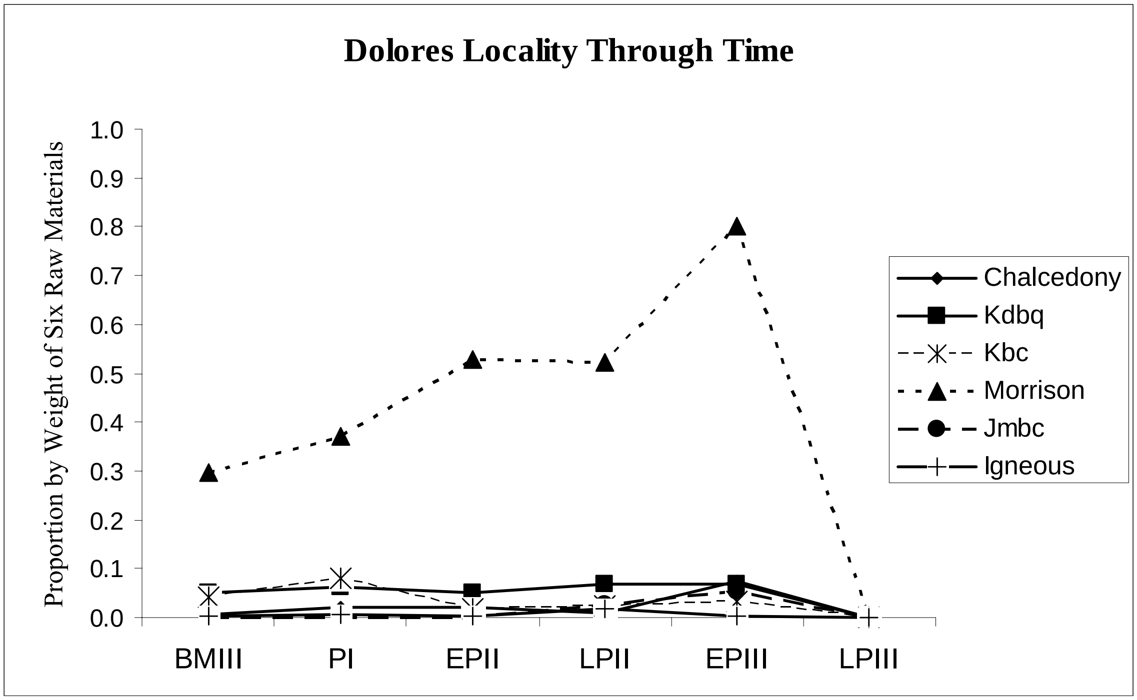
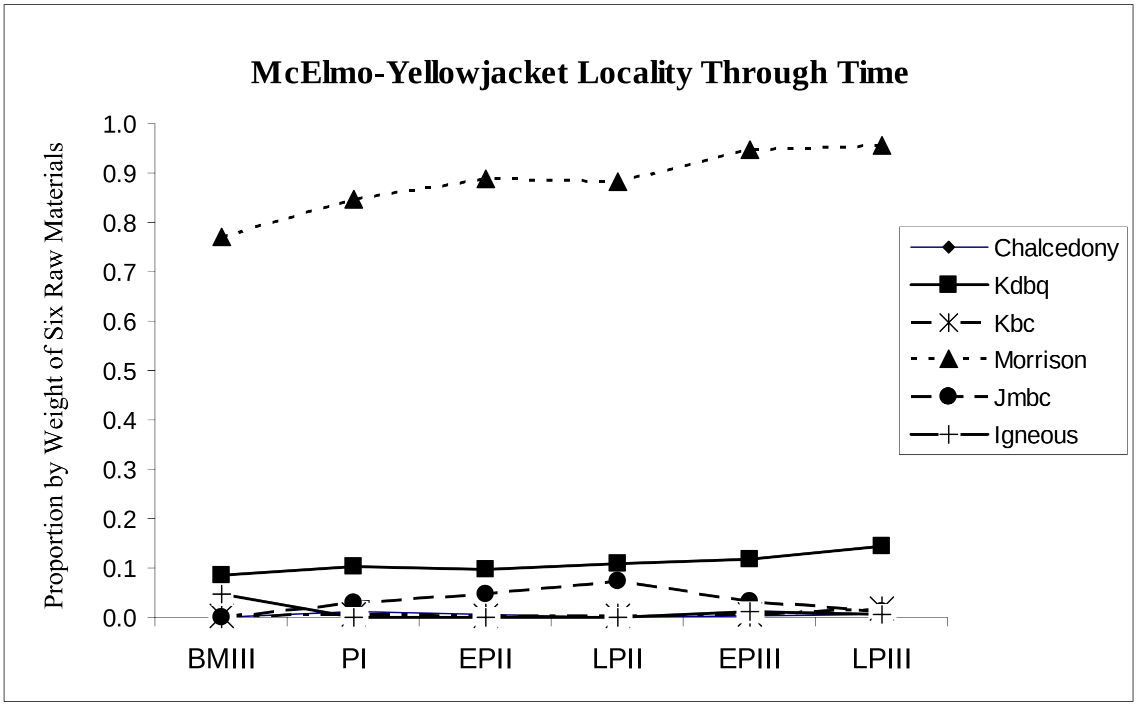


Figure 7.11. The proportion by weight of six raw materials and toolstone procurement patterns in the Hovenweep and Dolores localities through time.



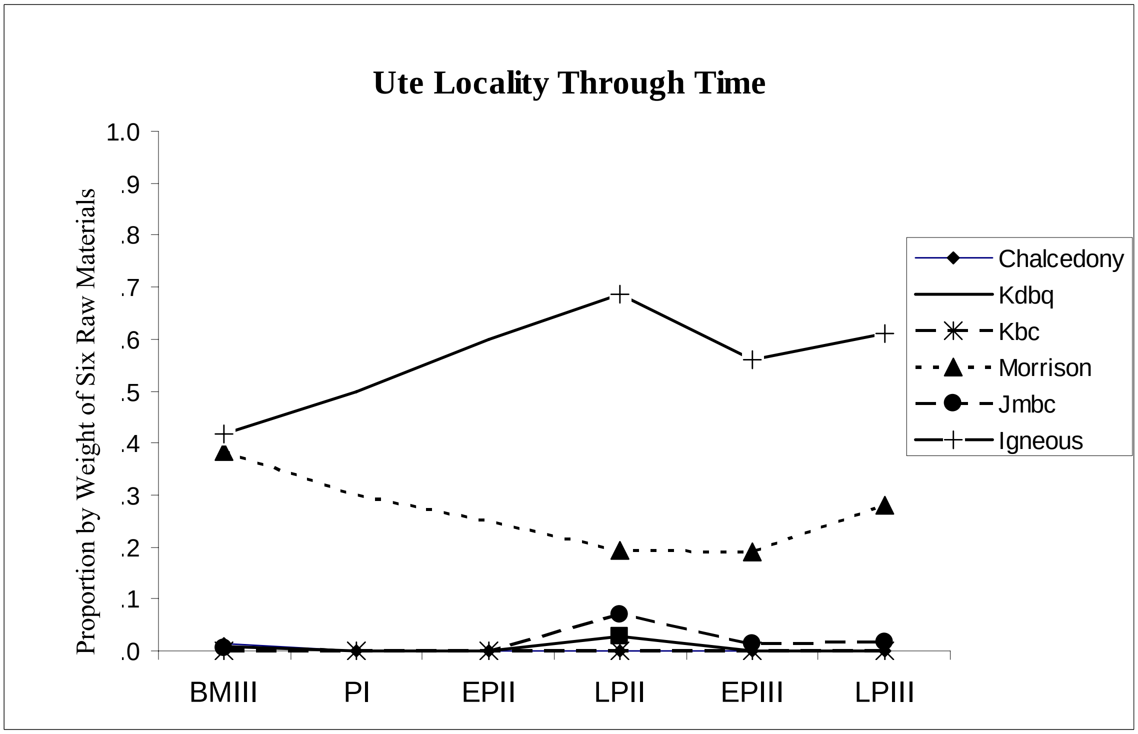


Figure 7.12. The proportion by weight of six raw materials and toolstone procurement patterns in the McElmo-Yellowjacket and Ute localities through time.

large amount of Jmbc during the late Pueblo II period. In the Ute locality, although there are no data for Pueblo I and early Pueblo II periods (hence, the continuous lines across the missing period), this figure shows that residents generally procured larger percentages of igneous materials over time. Although toolstone procurement of Morrison materials declined from the Basketmaker III to the late Pueblo II period, the Ute residents increasingly acquired Morrison materials from late Pueblo II through late Pueblo III periods.

Figure 7.13 shows the proportion by weight of six raw materials in the Mesa Verde locality through time; I made the lines continuous across the missing early Pueblo III period. Arakawa and Gerhardt (2007) explored Osborne's study of toolstone procurement patterns among the Wetherill Mesa residents by sourcing raw materials in the central Mesa Verde region (Osborne 1965:30-44). As shown in Figure 7.13, Mesa Verde inhabitants procured igneous materials during the Basketmaker III through the early Pueblo II periods, but shifted their preferences to Morrison during the later periods. We also noticed that the Mesa Verde inhabitants acquired and utilized a relatively large amount of Jmbc during the late Pueblo II period. We concluded that the Mesa Verde residents had strong connections to or interactions with inhabitants in the McElmo-Yellowjacket locality because quarries of Jmbc and the closest sources of Morrison materials were located there.

Toolstone procurement patterns, particularly an increase of Jmbc during the late Pueblo II period in those localities and an increase of Morrison materials in the Mesa Verde locality, suggests that the central Mesa Verde residents within each locality participated in strong interactions with other localities through time. Increasing

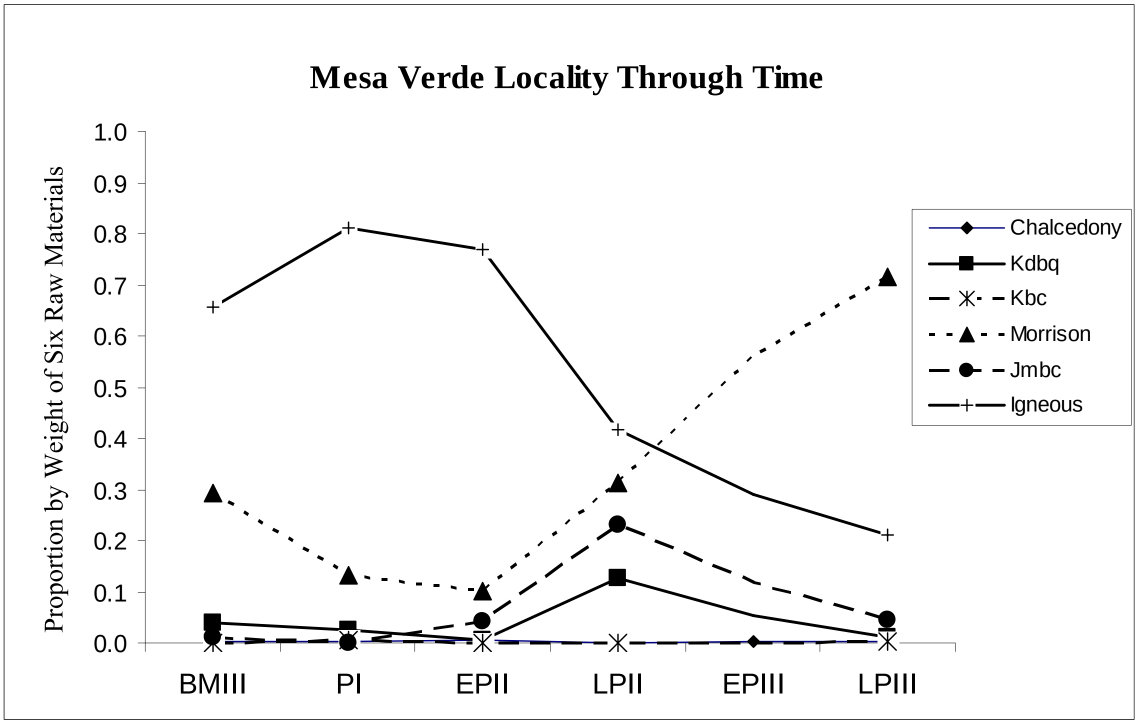


Figure 7.13. The proportion by weight of six raw materials and toolstone procurement patterns in the Mesa Verde locality through time.

procurement of Morrison materials over time can be explained by a possibility that the central Mesa Verde Puebloans needed those materials for more expedient activities, such as intensive cultivation and house construction. Toolstone procurement patterns in the Mesa Verde and Ute localities through time, however, show that inhabitants increasingly acquired Morrison materials, even though they would have more likely procured and utilized igneous materials that were tougher and more durable, and more suited for expedient purposes than Morrison materials. Therefore, an increasing procurement of Morrison materials through time suggests that inhabitants in the central Mesa Verde region had strong inter- and intra-locality interactions.

We have strong evidence that central Mesa Verde inhabitants experienced a hostile environment just prior to the abandonment of the region around A.D. 1280

(Billman et al. 2000; Kuckelman et al. 2003; Martin 1997). Although archaeological records dealing with social and political organization have suggested competitive modes in this region, particularly during the late Pueblo periods, this research has found some evidence of the cooperative activities in the region through time. I argue that even though we are able to study the prehistory of the central Mesa Verde region as a model to understand and reconstruct environment and socio-political organization, we still need to explore and answer another question: Why didn't some residents in the central Mesa Verde region stay in the region since they could have occupied and dominated all resources and lands after everyone left the region around A.D. 1280? To understand and answer this, we need to know to where the central Mesa Verde residents emigrated to and also what kinds of relationships occurred between the central Mesa Verde inhabitants and residents who accepted them into their region. In the next chapter, I investigate whether the migration to the Rio Grande was a process and a solution for overcoming the competitive mode in the central Mesa Verde region in the A.D. 1200s, and whether the strong and long-time affiliations between the central Mesa Verde residents and the Rio Grande over 700 years helped to unify and maintain an egalitarian way of life among the Pueblos for a long period of time.

CHAPTER EIGHT

CONCEPTUALIZING THE PUEBLO WORLD IN THE CENTRAL MESA VERDE REGION OVER TIME

Archaeologists have learned much about central Mesa Verde Pueblo people, such as their relationship with the environment, how they participated in social, economic, and political organizations through time, what caused them to aggregate and develop villages across the landscape, and why they left the area around A.D. 1280. In previous chapters, I suggested that well-marked territories were established in the early Pueblo III period. Some archaeologists (Lipe 1995; Lipe and Varien 1999b; Varien 1999) have argued that prior to the abandonment of the region, the central Mesa Verde Puebloans experienced very negative socio-political and environmental circumstances (Lipe 1995; Van West and Dean 2000:32, 35-37; Varien 1999), and those push factors encouraged them to leave the area. Lipe and Varien (1999b) further suggested that the Mesa Verde Puebloans would have also experienced “pull” factors from the south, especially in the direction of the Northern Rio Grande area, New Mexico, where arable lands would have been better than those of the central Mesa Verde region around thirteenth century (Ahlstrom et al. 1995).

Very recent research (Johnson 2006; Kohler and van der Leeuw 2007) has investigated the abandonment of the region using an agent-based model, adding other resources – water, fuel, wood, and animals – to a revision of Van West’s agricultural productivity model (1997), in which she claimed that the central Mesa Verde inhabitants could have satisfied their carrying capacity even during the severe periods. This research seems to show that the central Mesa Verde residents experienced relatively difficult times in the 1200s, when population density increased coincident with the decrease in carrying capacity (Kohler and van der Leeuw 2007; Varien et al. 2007). Thus, the relationship between the people and environment might have strongly encouraged the central Mesa Verde Pueblo people to emigrate during the late Pueblo III period.

Glowacki (2006) used an historical approach to understand and reconstruct ancestral Puebloan from emigration from the Northern San Juan region from A.D. 1150 to 1300. Based on her ceramic and architectural analyses, she argued that the inhabitants of the central Mesa Verde region were strongly tied to the eastern portion of the Pueblo world, including the Keres and Tewa people, while the inhabitants of Western Mesa Verde (e.g., Cedar Mesa) were strongly tied to the Hopi (Glowacki 2006:154). Glowacki (2006) further suggested that the cause of emigration from the central Mesa Verde region was associated with the disruption of ceremonial practices and social networks due to imbalance between environment and demographic/social factors, and these conditions caused the Mesa Verde Puebloans to migrate to the south.

In this chapter, I further investigate the large picture of emigration, building on Glowacki's arguments and focusing on affiliations between the central Mesa Verde Pueblos and the Rio Grande residents from A.D. 600 to 1300. I use procurement patterns of obsidian for understanding the process of migration and interaction between the central Mesa Verde inhabitants and the Eastern Pueblos through time. To this end, I argue that migration from the central Mesa Verde region to the Rio Grande helped the central Mesa Verde Puebloans to diffuse social power_within local communities. This process prioritized the maintenance and reproduction of healthy households, and was a conscious solution for overcoming conflict and competitive modes of socio-political organization during the late Pueblo III period. Additionally, I suggest that we can learn how the central Mesa Verde Pueblo peoples dealt with and resolved competitive modes in socio-political organization by examining the process of migration. We may find it helpful to conceptualize their decisions and solutions as applicable to contemporary situations and problems regarding to how people deal with accumulations of power by certain individuals or elites in large-scale societies.

Questions about the Pueblo World

I have argued that the central Mesa Verde Puebloans experienced relatively strict territoriality in the early Pueblo III period. This implies a competitive or conflictive mode of socio-political organization prior to the abandonment of the region. I have two major questions about the Pueblo World: First, why didn't the central Mesa Verde peoples develop a powerful, hierarchical political organization (like a chiefdom), but rather chose to migrate to other areas, particularly to the Rio Grande? Although archaeologists have argued about whether the central Mesa Verde Puebloans participated in rapid or gradual migration in the A.D.1200s, in either case, they had left the area by around A.D. 1280 and continued to maintain their socio-political organization as a "middle-range society" (e.g., Feinman and Nieitzel 1984; Lightfoot and Upham 1989) with relatively egalitarian lifeways after moving into the Rio Grande area.

Some archaeologists (e.g., Graves and Spielmann 2000; Lekson 1999; Wilcox 1996) argue for the existence of hierarchical structures among the protohistoric Pueblo peoples in the Rio Grande area. For example, Lekson (1999) suggested that ancestral Puebloans participated increasingly in a structured political organization over time, drawing on evidence from architecture, demography, and ideology. He argued that

Chaco Canyon was the central place among the ancestral Puebloans around A.D. 1000. The ancestral Puebloans then may have moved the organization north to Salmon and Aztec Ruins in New Mexico around A.D. 1100; they may have migrated into the central Mesa Verde region around A.D. 1200s, and then migrated to Casa Grande in Mexico after A.D. 1300. Another advocate for relatively great sociopolitical complexity, though not much definitive hierarchy, is Spielmann (1994), who argued that the protohistoric Puebloans may have participated in a sequential hierarchical system, which consisted of consensus-based decision making at each social organizational level, such as the nuclear family, extended family, and lineage, although they probably had a confederacy similar to the Iroquois and Huron of prehistoric and historical eastern North America. Based on archaeological data from two sites from the protohistoric pueblos in the Rio Grande Valley (Pueblo Colorado and Gran Quivira), Graves and Spielmann (2000) argued further that differences in archaeological remains of long-distance trade and feasting suggested that certain groups or individuals had attained greater social-political power than others. Despite these arguments for some hierarchical structure to late prehistoric Rio Grande societies, these authors have not provided convincing explanations regarding why there is so little evidence for individual prestige and wealth accumulation found in the local archaeological records, and why the mortuary record evidences little or no status differences among groups and individuals in prehistoric Rio Grande pueblos.

A second question is whether we can label the ancestral Puebloans' migration as a "collapse" (e.g., Diamond 1997, 2005) in human history, or whether we need to conceptualize it in a different way. Diamond (2005) has argued the abandonment of Chaco Canyon and the Mesa Verde region by Pueblo peoples are excellent examples for understanding and reconstructing the process of collapse in human history. He considered the causes of collapse to be related to the scale of population increase, the complexity of sociopolitical organization, and the destruction of the environment. Diamond does not consider the process of migration as a solution for maintaining a relatively a non-hierarchical socio-political organization after the abandonment of the region. To understand the process of migration as a solution for the central Mesa Verde Puebloans, it is crucial to investigate interaction and migration between the central Mesa Verde and the Rio Grande inhabitants over a long period of time (Cameron 1995). I use exchange of obsidian as a clue to understanding the interaction between residents of these two areas over time. In the next section, I briefly review archaeological debates concerning these migrations and then discuss how quarrying behavior and analysis of obsidian in the Southwest may help us understand the interactions among peoples in the central Mesa Verde region and in the Rio Grande.

Process of Migration/Movement of People

Based mostly on demography, archaeologists have argued that the central Mesa Verde Puebloans migrated to the south in the late A.D. 1200s (Cameron 1995; Duff 2002; Duff and Wilshusen 2000; Lipe 1995). Duff (1998) discussed demographic movements in both the Eastern and Western Pueblos from A.D. 1000 to 1400. Based on his study of long-term demographic trends across the Southwest, Duff argued that migration was a process rather than an event (1998). By this he means that people who decide to move should know the culture, environment, and people at the destination through interaction and/or exchange prior to migration, and that this reveals the process of migration as somewhat predictable and identifiable (Duff 1998:14). In the Western Pueblo case, the process of and decision to move was determined at the level of multiple households or the lineage rather than at the community level, and migration occurred gradually within a district rather than suddenly over a large region (Duff 1998). In contrast, Duff claimed that the Mesa Verde Puebloans participated in a slightly different mode of migration at the abandonment of the region around A.D. 1280. Figures 8.1 and 8.2 show the trend of migrations from A.D. 1200 to 1400 in both the Eastern and Western Pueblos (Duff 1998). These figures show that high population densities occurred in the central Mesa Verde region around A.D. 1200, and the ancestral Puebloans then migrated into the Rio Grande (or elsewhere) by the A.D. 1300s.

By contrast, Lipe (1995) argued for the central Mesa Verde region that the thirteenth century migration was a rapid process, based on evidence of the continuation of architectural structures just prior to the abandonment of the region. Duff and Wilshusen (2000) challenged this claim by arguing again for a gradual emigration using arguments based in population dynamics (and focusing on site occupation spans) from A.D. 950 to 1300. They claimed that population densities in the central Mesa Verde probably peaked around A.D. 1150, and that gradual migration may have begun by A.D. 1200 (Duff and Wilshusen 2000:185). They suggested implicitly that the central Mesa Verde Puebloans participated continuously in interaction and/or migration with the Rio Grande people through time because the central Mesa Verdeans would have known the people and area into which they planned to move, if they were to encounter unexpected social, economic, and/or environmental turmoil.

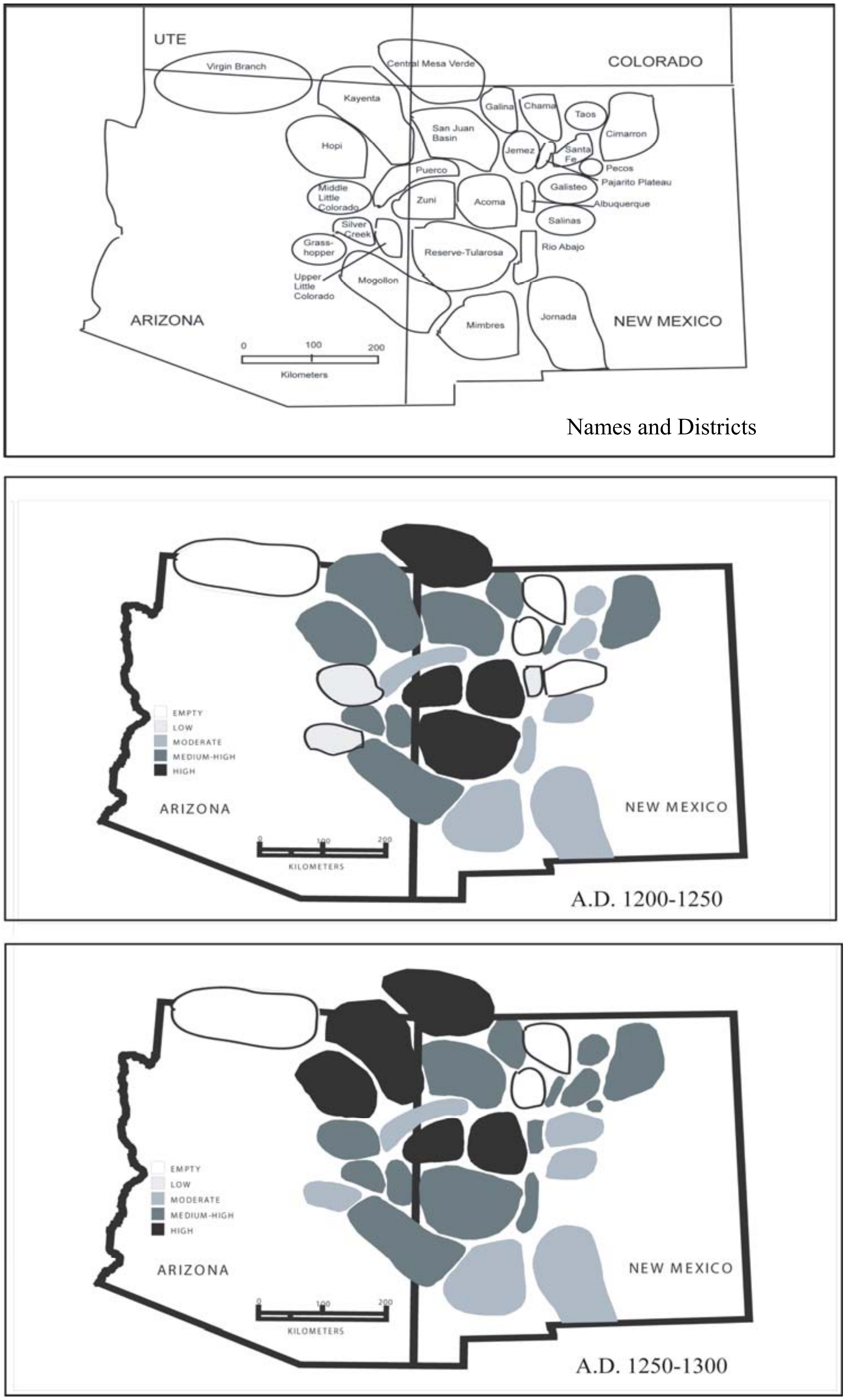
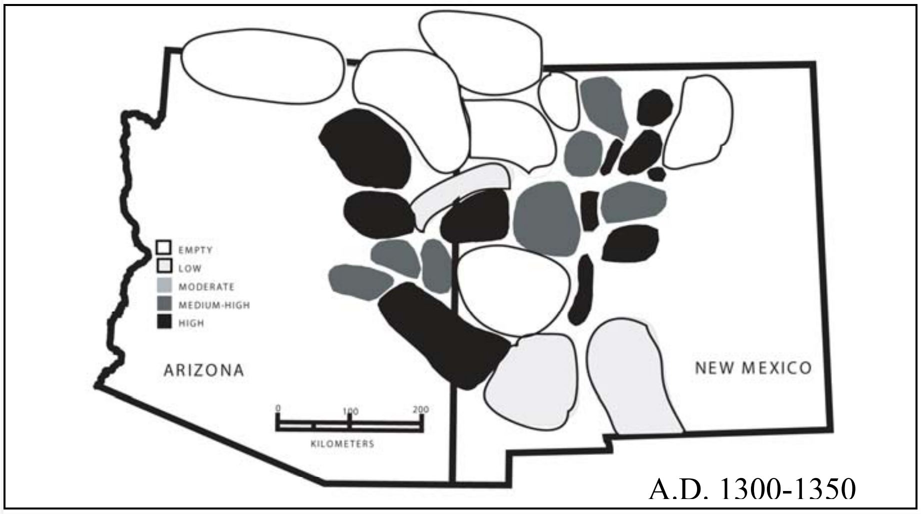
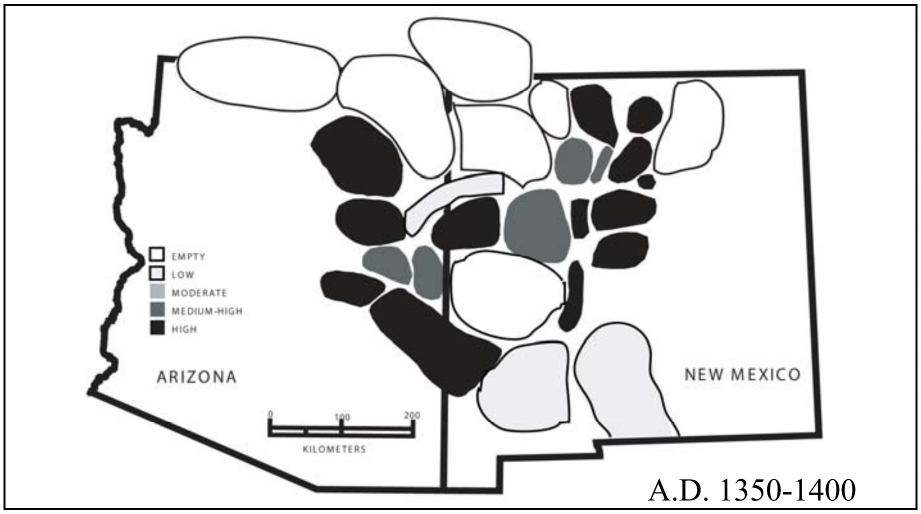


Figure 8.1. Population densities by district, A.D. 1200-1300 (adapted from Duff 1998:35-41, Figures 2.1-2.6).





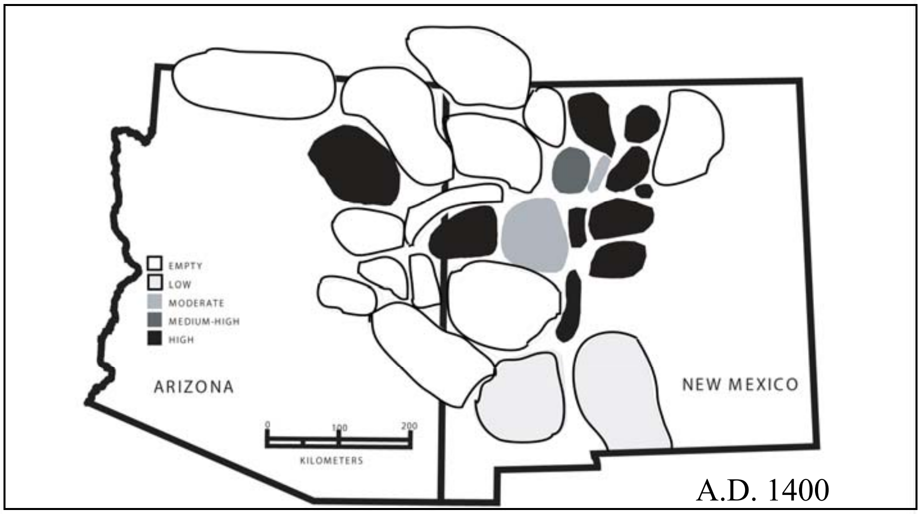


Figure 8.2. Population densities by district, A.D. 1300-1400 (adapted from Duff 1998:41-43, Figure 2.7-2.9).

Even though emigration from the central Mesa Verde now appears to have been more sudden than envisaged by Duff (see Figure 4.1 and Varien et al. 2007), it still appears that departures of small groups prior to A.D. 1300s may have settled into districts in the Northern Rio Grande (or elsewhere) and created the information and migration streams that would facilitate later, large-scale movements (Duff 1998:13). Kohler (2004:110, 115) documented several cases on and near the Pajarito Plateau in the Northern Rio Grande where ceramic assemblage diversity appears to have been increased by immigrants ca. A.D. 1200; this is in line with Duff's prediction of the process of emigration from the central Mesa Verde region, although the specific source for the Pajarito cases is unknown.

Obsidian Sources in the Southwest

Shackley (1988, 1995, 1998) has argued that reconstructing sources of obsidian through chemical analysis is important for understanding archaeological issues of territory, exchange, and interaction in the greater American Southwest (1988:769). Tracing obsidian in the Southwest provides spatially precise provenience data because obsidian sources can be chemically identified by their unique tectonic origins in the middle-to-late Tertiary (Shackley 1988:768-769).

Based on x-ray fluorescence, using the quantitative form of data calibrated by international standards, Shackley (1988, 1995, 1998) has identified more than 20 obsidian sources in the Southwest (Figure 8.3). These sources occur in three broad regions – Western Southwest, West and Central Arizona/Northern Sonora, and Eastern

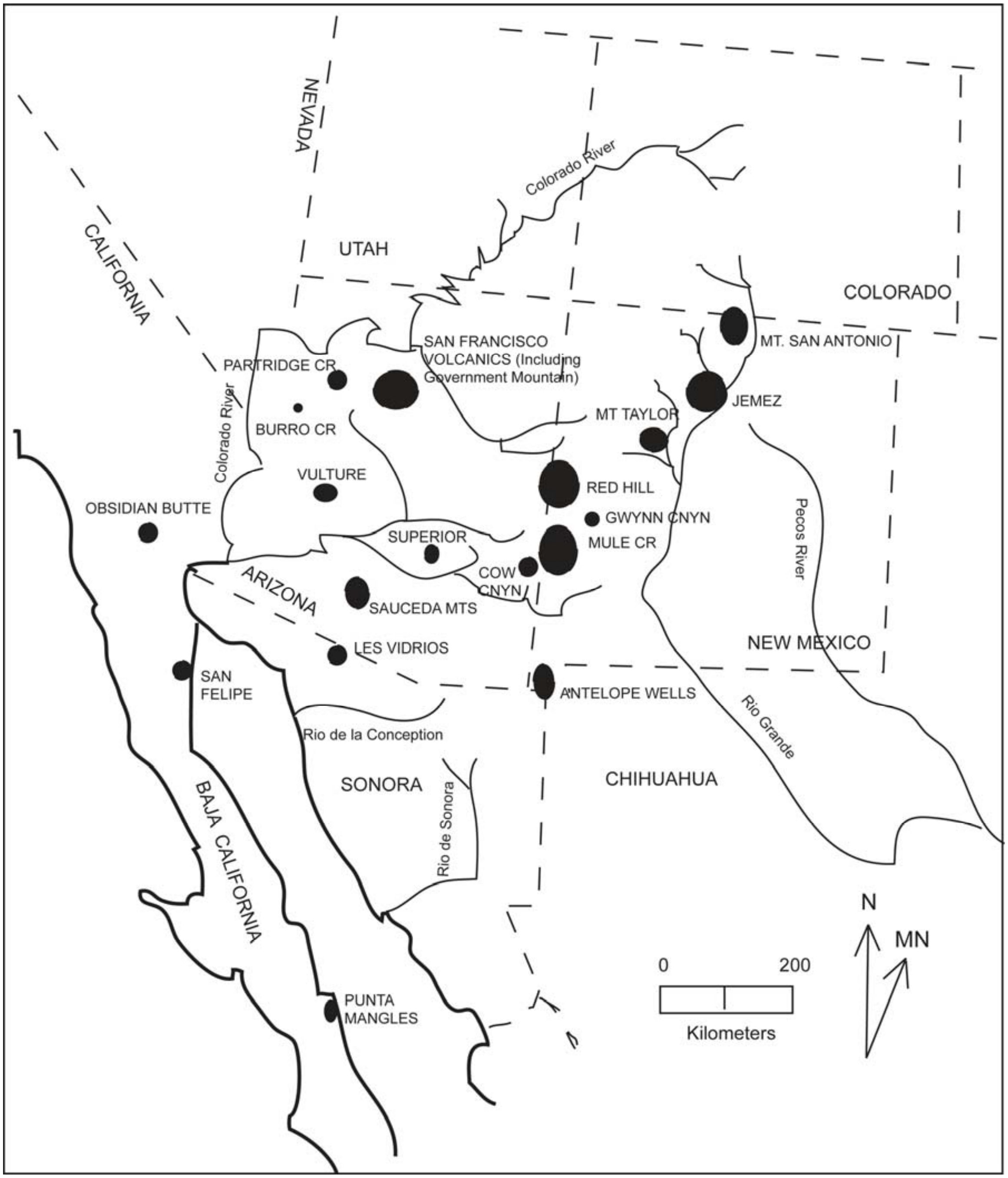


Figure 8.3. Archaeological sources of obsidian in the American Southwest (adapted from Shackley 1988:754, Figure 1).

Arizona/Western New Mexico (Shackley 1998). Because obsidian sources in each region have distinct silica compositions, it is possible to reconstruct which was used and, ultimately, how ancestral Puebloan peoples participated in interaction and exchange through time. Mitchell and Shackley (1995:547) documented that the Hohokam residents procured more obsidian during the Classic period in central Arizona than earlier periods. They argued that Classic period Hohokam residents supported more specialists possibly living on the platform mounds, who became interested in exotic obsidian materials during the Classic period. Also of interest during this period is that residents of Escalante Ruin in Arizona locality may have been excluded from the nearly Superior obsidian source, since they obtained the majority of obsidian from the Sauceda Mountains source near Gila Bend, which is considerably farther from their residence (Mitchell and Shackley 1995). Those two examples demonstrate that tracing obsidian to sources from archaeological sites can provide crucial information about social-political interaction, exchange, and territoriality. Although the central Mesa Verde region is located at a greater distance from obsidian sources in the Greater Southwest, the XRF analyses can also from the central Mesa Verde assemblages provide reliable data for understanding issues of social-political organization and interaction. In the next section, I discuss samples and results of XRF analyses for obsidian found in the central Mesa Verde region, and then propose that we can conceptualize the interaction and exchange by the central Mesa Verde residents using obsidian procurement patterns through time.

Obsidian Samples from the Central Mesa Verde Region

Shackley (1999, 2002, 2005) implemented the wavelength and energy-dispersive x-ray fluorescence method to analyze 163 pieces of obsidian from the central Mesa Verde region. Table 8.1 shows the obsidian materials that were analyzed by the Archaeological X-Ray Fluorescence Spectrometry Laboratory at the University of California, Berkeley (Shackley 1999, 2002, 2005; NSF DDIG16 0408793 to Kohler and Arakawa). In these analyses, 32 items were tools, such as projectile points or bifaces, while the rest were debitage. Although procurement patterns might be different for formal tools and debitage, I argue that obsidian debitage found in these assemblages was mostly from those formal tools because analysis of the obsidian debitage showed that most were not primary or secondary flakes; instead most were retouching or pressure flakes. Furthermore, the fact that very few obsidian cores are found in these assemblages supports the view that most obsidian debitage was produced by retouch/reduction of formal tools. Therefore, formal tools and debitage may be pooled in our attempts to understand and reconstruct obsidian procurement and exchange patterns through time.

The Results of XRF Analyses

The XRF analyses show that 150 of these 163 obsidian items from the central Mesa Verde region were procured or exchanged from the Jemez Mountains, New Mexico (Table 8.1). Previous provenance work by archaeologists have obtained somewhat similar results (see Ferguson and Skinner [2003] and Ward [2004]), but the research here is novel in reporting that 12 of the 163 obsidian items, dating from Basketmaker III through the early Pueblo II period, came from Mount Taylor and Government Mountain

Table 8.1. Obsidian Samples Analyzed by X-Ray Fluorescence

SOURCES OF OBSIDIAN	SITE NUMBER (NAME)	TIME PERIOD	n
Government Mountain	5MT2182 (Rio Vista)	PI	1
	5MT3868 (Duckfoot Site)	PI	1
Mount Taylor	5MT4545 (Tres Bobos)	BMIII	2
	5MT23 (Grass Mesa)	PI	3
	5MT3868 (Duckfoot Site)	PI	3
	5MV1676 (Dog House)	PI	1
	5MV1452 (Badger House)	EPII	1
	5MT3807 (Shields Pueblo)	EPII or LPII	1
Rio Grande	5MT4545 (Tres Bobos Hamlet)	BMIII	4
	5MT2182 (Rio Vista Village)	PI	11
	5MT23 (Grass Mesa Village)	PI	13
	5MT3868 (Duckfoot Site)	PI	4
	5MT4477 (Masa Negra Pueblo)	PI	4
	5MT4613 (Pozo Hamlet)	PI	3
	5MT4725 (Tres Chapulines)	PI	1
	5MV1645 (Two Raven House)	EPII	1
	5MV1452 (Badger House)	EPII	3
	5MV1595 (Big Juniper House)	LPII	1
	5MT2149 (Escalante Ruin)	LPII	12
	5MT765 (Sand Canyon Pueblo)	LPIII	1
	5MT10246 (Lester's Site)	EPIII or LPIII	1
	5MT10508 (Stanton's Site)	EPIII or LPIII	2
	5MT11338 (G & G Hamlet)	EPIII or LPIII	4
	5MT3807 (Shields Pueblo)	LPII-LPIII	64
	5MT5 (Yellow Jacket Pueblo)	LPII-LPIII	21
		Total	163

in Arizona. Two items from Rio Vista Village (5MT2182) in the Dolores locality and from the Duckfoot Site (5MT3868) in the McElmo/Yellowjacket locality, both dating to the Pueblo I period, were also from Government Mountain. Shackley (2005:2) notes that this is the first time this source has been reported in southwestern Colorado. Two pieces of obsidian from the Tres Bobos site (5MT4545) dating to the Basketmaker III period were from Mount Taylor, and seven items from Grass Mesa (5MT23), Duckfoot (5MT3868), and Dog House (5MV1676) dating to the Pueblo I period were from Mount Taylor. Additionally, one piece of obsidian from Badger House (5MV1452) dating to the early Pueblo II period in the Mesa Verde locality was from Mount Taylor as well as one from Shields Pueblo, which dated to either the early or late Pueblo II period.

The majority of obsidian (92.6%) was from Jemez Mountain in New Mexico (Shackley 2005). Except for one piece of obsidian from Mount Taylor in Shields Pueblo, dating to either the early or late Pueblo II period, all the obsidian from late Pueblo II through late Pueblo III periods obsidian came from the Jemez Mountains. This XRF analysis suggests that two broad patterns can be identified: An early obsidian procurement from Basketmaker III through early Pueblo II periods was from various sources in the Southwest, and later obsidian procurement from the late Pueblo II through late Pueblo III periods was from the single source of the Jemez Mountains. I next compare these procurement patterns for obsidian with larger demographic trends in the Southwest through time, and then in the next section discuss how we can connect the processes of migration and obsidian procurement to understand changing interaction and affiliation through time.

Obsidian Toolstone Procurement Patterns Through Time

Figure 8.4 maps the interaction and/or exchange systems for obsidian materials between the central Mesa Verde region and Rio Grande through time. The map of BMIII-EPII shows interactions and exchanges from various areas – Government Mountain, Mount Taylor, and Jemez Mountains – with the majority of obsidian originating from the latter. The demographic map of A.D. 1200-1300 in Figure 8.1 shows that the ancestral Puebloans participated in dramatic movements in various regions in the Southwest. The comparison of obsidian sourcing from various areas with these movements suggests that migrations and/or strong interactions took place prior to the late Pueblo III period in the Southwest.

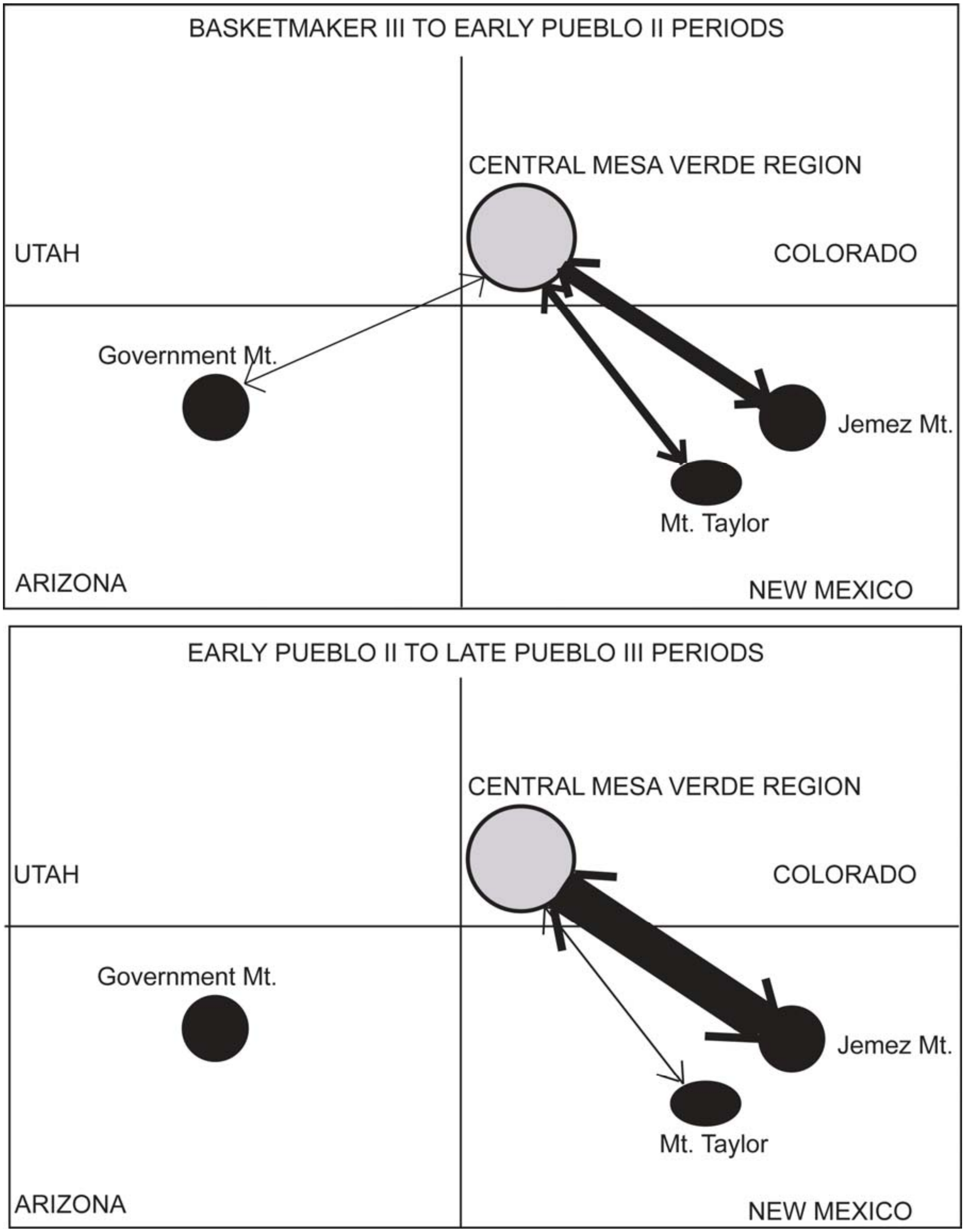


Figure 8.4. The interaction and/or exchange systems for obsidian connecting the central Mesa Verde region to other portions of the Southwest. Width of lines suggests degree of interaction.

The diagram for LPII-LPIII (Figure 8.4, bottom) shows use of a single source in the Jemez Mountains, except for one item from Shields Pueblo dating to either the early or late Pueblo II period. Comparing this with the demographic trends of A.D. 1300-1350 in Figure 8.2, obsidian procurement patterns seem to strongly precede movement by central Mesa Verde Pueblo peoples toward the Rio Grande. Although archaeologists have long discussed possible migration between these regions, obsidian toolstone procurement patterns provide additional information about the interactions, exchanges, and patterns of alliance between the central Mesa Verde region and Rio Grande that prefigure these movements.

Consideration of the Pueblo World

Based on the obsidian toolstone procurement patterns through time, I argue that the migration of the ancestral Puebloans was a process and that they were familiar with the Rio Grande before they moved into it (Cameron 1995; Duff 1998). Although the process of migration helped the ancestral Puebloans cope with the environmental, socio-political, and economic turmoil in the A.D. 1200s prior to the abandonment of the central Mesa Verde region (Dean et al. 1994; Kohler et al. 2006; Lipe 1995; Varien 1999; Varien et al. 2000), the process of migration itself does not completely explain why the ancestral Puebloans were able to sustain their social and political organization as a middle-range or non-hierarchical society after they migrated into Rio Grande area.

I conceive of the process of migration as a both mechanism for solving social-political and environmental turmoil and a conscious effort to avoid the further development of hierarchical or “network” political organization (Feinman 2000). I further argue that the ancestral Puebloans understood their actions as a way to overcome the power of scale problem. According to Bodley (2005:514), when power and scale increase in a society or culture, the gap between the powerful and the weak increases, particularly in the commercial world (modern capitalist countries). Bodley (2005:514) notes what he defines as the "localization process" involves limiting growth and the concentration of power by diffusing social power among communities and regions. Authority and control therefore remain at the regional and local levels. In the central Mesa Verde region, population density dramatically increased in the mid-1200s prior to the abandonment of the region around A.D. 1280, and sociopolitical organization was trending to greater hierarchy (Lipe 2002), with regional populations approaching thresholds requiring a regional polity (Kosse 1996; Lipe 2002). However, the ancestral Puebloans decided to migrate to the Rio Grande (Cameron 1995; Glowacki 2006; Lipe 1995; Ortman 2000). I consider of their decisions as a choice to diffuse social power by limiting growth and reducing the scale of complexity, a strategy similar to what Bodley (2005) refers to as "localization." The ancestral Puebloans allocated much of their energy and time toward activities that required reorganization due to migration to other areas, such as constructing new communities. In Rio Grande communities of the early 1300s, the Katsina cult (Adams 1991; Glowacki 2006; Schaafsma 1994) appears to have been part of the social landscape (Schaafsma 1994:78). This ritual program emphasizes communal well-being and the integration of groups from divergent backgrounds, including migrants (Adams 1991). Thus, the ancestral Puebloans participated in cultural processes that helped to integrate their households in their new communities. As such, their behaviors and activities resulted in a successful “localization process,” the distribution of power among a larger proportion of the newly founded communities.

For these reasons, I argue that the concept of “collapse” (e.g., Diamond 2005) for understanding and conceptualizing the Pueblo World, particularly in the central Mesa Verde region, is not correct. Rather, the point made by Kohler (1992:631), that the ancestral Puebloans knew how to manage and overcome tensions and complications in their social and political organization through residential mobility, is more appropriate. I consider their process and solution as a success rather than failure or collapse.

Summary

In this chapter, I focused on obsidian toolstone procurement patterns with the occurrence of migration from the central Mesa Verde region to Rio Grande from A.D. 600 to 1300s. I reviewed sources of obsidian in the Greater Southwest and presented sourcing results for 163 obsidian samples analyzed by XRF. We can see from these results that the central Mesa Verde Puebloans participated in two different obsidian procurement patterns: one pattern during the Basketmaker III and early Pueblo periods, in which the Mesa Verde Puebloans engaged in interactions and/or migration from various areas in the Greater Southwest, and another, beginning in the early Pueblo II period, in which they strengthened their affiliations with the people in the Rio Grande in particular. Those obsidian procurement patterns are nicely related to migration of people in the Greater Southwest. I followed Duff’s argument for migration as a process rather than an event, and further argued that the ancestral Puebloans understood the process of migration as a way to sustain their sequential hierarchical organization (decisions made by consensus per decision-making level) by re-localizing their households and/or communities in another area. Because of this process, I argued that conceptualizing their process of migration as "collapse" is misleading; we should conceptualize their solution as a success.

CHAPTER NINE

CONCLUSIONS

Lithic analysis has not commonly been considered as useful for understanding and reconstructing ancestral Puebloans' social and political organization in the central Mesa Verde region or the Southwest in general. In this dissertation, I attempted to achieve several goals: 1) to standardize raw material classification and understand the nature of lithic sources or quarries in the central Mesa Verde region; 2) to reanalyze lithic artifacts and create a regional database; 3) to determine whether and when territorial organization emerged in this region; and 4) to provide a conceptualization of their migration as a successful way to sustain non-hierarchical organization or middle-range societies by the ancestral Puebloans.

Working with a sedimentary geologist and igneous and Pleistocene-deposit specialists, I was able to reclassify and standardize the classification of most of the lithic artifacts from assemblages found in the region (Arakawa and Gerhardt 2007). I collected and reanalyzed 76 lithic assemblages and also revisited 94 quarries in the central Mesa Verde region. Additionally, reconnaissance of the region allowed us to identify and understand the nature of sources, and to match debitage found in the assemblages with those sources. Using this information, I investigated territorial organization in the region through time using two different approaches – a modified distance-decay model and an energy-expenditure model. In the distance-decay model, I focused particularly on interpretation of slopes and correlation coefficients from regressions of cost-distances on proportions of materials of various sorts to understand the development of territories through time. For the energy-expenditure model, I created a regional map in each time period using a simple equation that calculated minimum distances from a habitation site to a quarry and the percentage of each raw material type found in the archaeological site. For interpreting the results of those approaches, I applied Dyson-Hudson and Smith's model (1978) of economic defensibility (in which the critical variables are resource predictability and density) to gauge the possible development of territoriality through time. I concluded that the ancestral Puebloans probably developed strict economic territories during the early Pueblo III period. The Dyson-Hudson and Smith model is not useful for describing the development of territoriality during this period. The ancestral Puebloans not only experienced relatively scarce and unpredictable resource productivity coincident with dramatic population increase during the early Pueblo III period, but they also remembered very difficult climatic conditions and low resource productivity during the drought from A.D. 1130-1180 (Van West and Dean 2000:37). I argue that this situation triggered the establishment of strict territoriality in the region during the early Pueblo III period. The energy expenditure model also indicates that the ancestral Puebloans expended less energy in most of the central Mesa Verde region, except the central McElmo-Yellowjacket locality during the Pueblo III period. This also suggests that the central Mesa Verde Puebloans during the Pueblo III periods participated in a competitive environment in which access to non-local resources was highly constrained.

In chapter eight, I investigated the larger picture of toolstone procurement patterns in the Southwest and, using obsidian found in the central Mesa Verde region, also considered migration of the ancestral Puebloans. The XRF analyses of 163 obsidian samples enabled me to identify and understand the pre-migration interaction of other areas with the central Mesa Verde region. In the early periods (Basketmaker III to early

Pueblo II), the central Mesa Verde Puebloans affiliated with the people around the San Francisco Volcanic field, Mount Taylor, and the Jemez Mountains, whereas later ancestral Puebloans, after the late Pueblo II period, had strong relationships with only the people in Rio Grande (Jemez Mountains source). These latter data both reflect pre-existing connections that structured later migration flow patterns, and prefigure the direction of the much larger 1260-1280 depopulation of the northern Southwest. Thus, I argued that some Puebloans migrated into Rio Grande areas from the Basketmaker III through the late Pueblo periods, and that their migrations are best seen as a process rather than as an event (Duff 1998). I further argued that the migration by the ancestral Puebloans during the late Pueblo III period was a mechanism for resolving the social and political turmoil in the central Mesa Verde region. Furthermore, I argued that the way in which migration and the diffusion of social power was conducted by the ancestral Puebloans should be considered at least a partial success rather than a complete failure or collapse (Diamond 2005).

The central Mesa Verde region not only provides an ideal locus for understanding interactions between the people, environment, subsistence patterns, and social-political organization (e.g., Johnson 2006; Kohler and van der Leeuw 2007), but also that how they responded to the concentration of social power provides a model that can be applied to problems today, such as increasing social inequality and elite power. Archaeology is a subfield of anthropology in the U.S. and uses both scientific and humanistic perspectives for understanding human behavior, societies, and cultures. This study incorporates those perspectives to provide a conceptualization of the Pueblo world in its competitive and cooperative modes.

Recommendations for Further Research

Although study of lithic materials in the Southwest is generally underdeveloped in its methods and datasets, there are many ways to improve lithic analyses. First, considering the central Mesa Verde region as a model for ecodynamic analysis, more lithic assemblages can be added to this dataset to re-examine and possibly strengthen the argument using the distance-decay and energy expenditure approaches that economic territoriality developed during the early Pueblo III period. Unfortunately, this research does not contain any early Pueblo III assemblages from the Mesa Verde locality; thus, including assemblages from that locality could improve the evidence about territoriality over time in this region.

Second, although I visited 94 recorded quarry sites in the region, it is essential to engage in more reconnaissance of lithic sources and geological surveys and to expand that portion of the database. It is also important to understand how the ancestral Pueblo peoples utilized those quarries by analyzing debitage (attribute analysis), including data from local materials as well as non-local materials (obsidian and Narbona Pass chert). Although I attempted to answer the question of direct procurement pattern versus trade by looking at Kdbq cortex amounts, debitage data from quarries provide another way to understand how the ancestral Puebloans manufactured and utilized cores and large flakes at quarries.

Third, study of debitage alone does not provide a full picture of lithic technological organization or the complete “biographical” information on lithic uses (Ward 2004), including how people manufactured and utilized lithic materials, where they discarded these materials, and whether males or females manufactured those tools.

The analysis of formal tools (bifaces and projectile points), expedient tools (modified flakes and peckingstones), and cores is essential to answer those questions. When this information becomes available, it will not only upgrade efforts to reconstruct socio-political organization in the central Mesa Verde region through time, but also enhance our understanding of technological and mechanical aspects of local lithic technological organization.

Understanding the larger picture of interaction and migration in the Southwest by including more obsidian data, particularly dating to Basketmaker III and Pueblo I periods, should strengthen my argument for two patterns of migration and/or interaction over time. Fewer than 50 pieces of obsidian from the early Duckfoot (5MT3868) and Dolores sites have been analyzed, whereas more than 120 pieces from late occupation sites – Shields (5MT3870) and Yellow Jacket Pueblo (5MT5). This research indicates that obsidian from the early sites was procured from various areas, including Jemez Mountain, Mt. Taylor, and Government Mountain (Shackley 2005), whereas almost all obsidian from the later sites was from the Jemez Mountains (Shackley 1999, 2002). Investigating more local Basketmaker III and Pueblo I obsidian samples would enhance the database and make it possible to compare and contrast earlier obsidian toolstone procurement patterns with those of the Pueblo II and III periods in the central Mesa Verde region. When obsidian sourcing data support use of various quarries in the Southwest during the early periods, we may confirm that the ancestral Puebloans participated in strong interactions or migration from many areas in the Southwest. Additionally, more XRF analyses of obsidian from late Pueblo periods promises to strengthen my argument that the central Mesa Verde Puebloans participated in the process of localization by migrating at either the household or community levels to the Rio Grande area through time. This further strengthens my argument that Puebloan history represents a successful model, and we may be able to apply this case study or “model” to consider and solve current issues, such as increasing social power by certain individuals or elites and the lack of an equitable distribution of power in the commercial world.

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APPENDICES

Appendix A. GIS Analysis

The geographic information system (GIS) analyses conducted in this dissertation contained a number of steps. I use the ArcGIS 9.1 mapping software for five different GIS approaches, including: (1) building a digital elevation model (DEM) for the study area; (2) implementing a cost-weight analysis from each habitation site to the nearest quarry; (3) visualizing residuals and energy-expenditure values for each habitation site through time; (4) using the kriging program to generate the energy-expenditure values across my study area for the six different periods, and (5) creating a difference map based on the results of kriging maps by subtracting the values in the later periods from the next-earlier period using map algebra. In this section, I discuss each of the above steps so that others may replicate these procedures if desired.

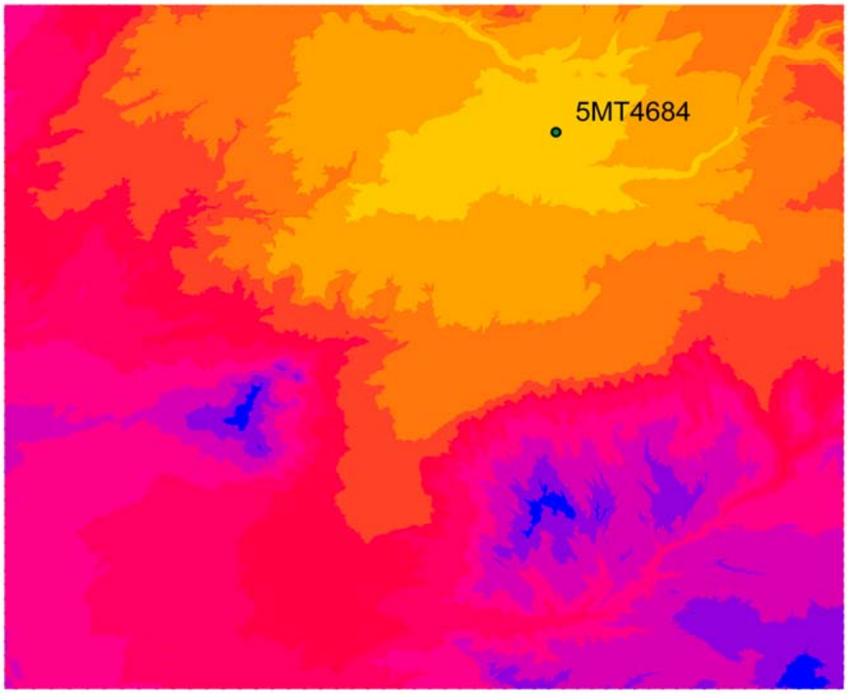
Building the DEM

I obtained a high resolution raster map of the central Mesa Verde region with adjacent regions for free from the USGS worldwide web-page (http://seamless.usgs.gov/). Then the map was projected at an x- and y-cell size of 30 m and converted to UTM NAD 1983 coordinates. The DEM map was then reclassified by slope, instead of elevation, because the slope reflects the terrain traveled by humans in this canyon environment. All quarries and excavated sites were used for this research were then added to the DEM map.

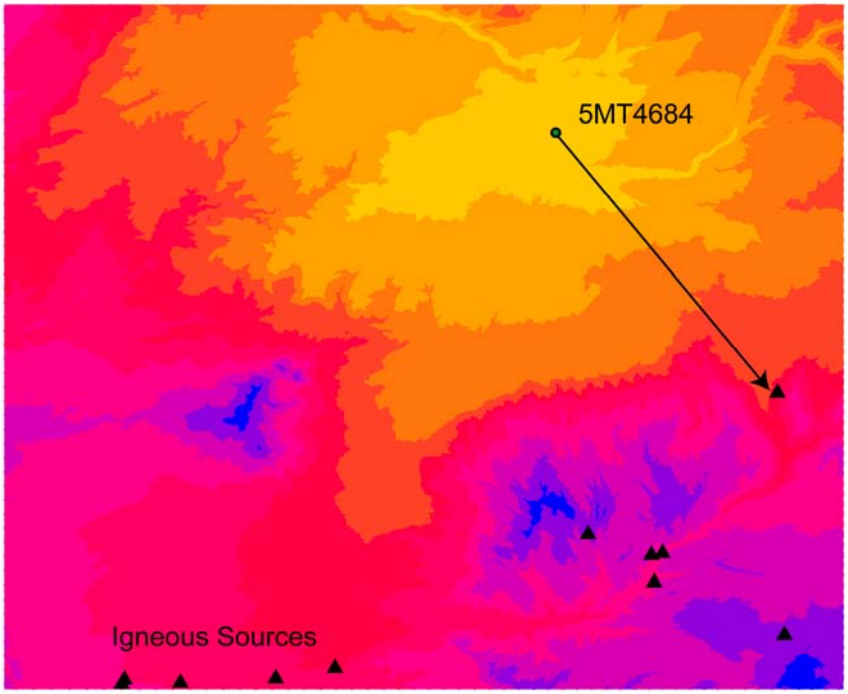
Cost-Weight Analysis

In ArcGIS, a cost-weight analysis is a method by which one can calculate approximate energy-expenditure values by knowing the minimum distance from point x to point y. A major advantage of using the energy-expenditure values (or cost-distances) is that they may better reflect walking costs in this mesa and canyon landscape than would straight-line distances.

The calculation of minimum energy between a habitation site to the nearest quarry is conducted by the cost-weight procedure in ArcGIS Spatial Analyst extension (the figures in next page show how the cost-weight analysis was conducted). Although there is a shortest-path function in spatial analysis, it does not calculate and identify which quarry site is closest to a habitation. In the cost-weight analysis, each habitation site was selected and run the cost-weight function for all 75 existing excavated site collections. Next, all habitation and quarry sites were entered into the model as a beginning point and destination. In order to identify the nearest quarry from a habitation site, the Extract Values to Point function was used. Then the habitation point features were input, as well as all quarry sites for each raw material; then the habitation sites were input as a raster layer. After this calculation was complete, the attribute table was opened and all cost-weight values from the habitation site to all quarries were examined. The values in the table are the minimum-accumulated energy value (energy-expenditure value) for the quarry sites and for each raw material type.



This figure shows the cost-weight analysis of 5MT4684



This figure shows the shortest path from the 5MT4684 site to the nearest igneous source.

A.1

Visualizing residuals and energy-expenditure values for each habitation site through time.

In order to visualize spatial residual values for the six different raw materials and energy-expenditure values in each period, the classifying features function was used. First, in the show box, “Quantities” and then “Graduated Symbols” were clicked. In the fields frame, the “Value” drop-down arrow was clicked and residuals or energy-expenditure values were selected. In the symbol column, circle marks of 10 or 11 different classes based on equal intervals were chosen. This symbology was selected because it provides a general trend of similarities and differences of residuals and energy-expenditure values across the study area through time. Finally, those values were entered into the DEM map and exported to Adobe Illustrator and Photoshop.

Using the kriging program.

In order to visualize how energy-expenditure values are spread across this landscape, kriging map based on the total energy-expenditure values through time were created. First, the “Spatial Analyst” function was selected and then “Interpolate to Raster” command. There are three different methods for interpolation – Inverse Distance Weighted, Spline, and Kriging; kriging was selected from this analysis. Kriging, also known as Gaussian process regression, is a regression technique used in geostatistics to approximate or interpolate data. This method provides better results than others because it provides the conditional expectation (also known as conditional means) as a best estimate for all unsampled locations in a field, and it also minimizes error variance at each location. When energy-expenditure values were input, minimum values of 394,000 and maximum values of 7,526,700 were standardized for all analyses.

Difference maps

To emphasize area where energy expenditures by central Mesa Verde inhabitants for procuring raw materials changed from one period to another, series of ArcGIS maps were created. First, I clipped the larger interpolation map of energy expenditure to fit the boundaries of the smaller energy-expenditure interpolation map, by creating a polygon to fit the spatial extent of the smaller raster data set in ArcCatalog. Then, an empty shapefile of a polygon was created in ArcCatalog. The new polygon shape file was then added to the layout along with the smaller raster data set of energy expenditures. Then the polygon was edited and a new polygon feature was drawn. The “Sketch Tool” was used to trace around the boundary of the smaller raster data set and the spatial extent of this polygon was used to clip the larger raster data sets of energy expenditures from the other time periods. The raster was then clipped by the Ymax, Ymin, Xmax, and Xmin from the properties of the polygon created in the step above. This creates two raster data sets with the same spatial extent. Then, in Spatial Analyst, the Raster Calculation tool was used to subtract energy-expenditure values of later assemblages from earlier assemblages. Finally, a map of the difference in values between the two data sets was created to visualize changes in expended energy from one period to the next.

APPENDIX B. ANALYZED LITHIC ASSEMBLAGES

Sites	Time Period	Locality	Analyzed Debitage Counts	Provenience	Screening
5MT8837	BMIII	Hovenweep	228	Mix	No
5MT2525	BMIII	Hovenweep	195	Midden	1/4-inch
5MT11431	BMIII	Hovenweep	200	Mix	1/4-inch
5MT4545	BMIII	Dolores	281	Midden	Except on floor[a]
5MT4684	BMIII	Dolores	217	Midden & others	Except on floor
5MT10647	BMIII	McElmo-Yellowjacket	259	Mix	Except on floor
5MT8937	BMIII	McElmo-Yellowjacket	192	Fill	Except on floor
5MT9540	BMIII	Ute	215	Fill	Except on floor
5MT9949	BMIII	Ute	202	Mix	Except on floor
5MV1937	BMIII	Mesa Verde	149	Pithouse	No
5MV1940	BMIII	Mesa Verde	108	Pithouse	No
5MT8838	PI	Hovenweep	241	Mix (fill & surface)	No
5MT23	PI	Dolores	343	Midden & room	Except on floor
5MT4544	PI	Dolores	219	Midden	1/4-inch
5MT4725	PI	Dolores	232	Mix (mostly fill)	Except on floor
5MT2848	PI	Dolores	203	MGS	No
5MT2181	PI	Dolores	190	Midden & others	Except on floor
5MT2182	PI	Dolores	708	Fill	1/4-inch
5MT4477	PI	Dolores	119	Mix	Except on floor
5MT2193	PI	Dolores	266	Midden & fill	1/4-inch
5MT4613	PI	Dolores	229	Mix (fill & room)	Except on floor
5MT2236	PI	Dolores	234	Midden & pitstructure	Except on floor
5MT3868	PI	McElmo-Yellowjacket	795	Midden	1/4-inch
5MT948	PI	McElmo-Yellowjacket	311	Mix	Unknown
5MV1676	PI	Mesa Verde	317	Midden & others	No
5MT8827	EPII	Hovenweep	151	Midden & fill	Except on floor
5MT8836	EPII	Hovenweep	209	Mix	Except on floor
5MT8839	EPII	Hovenweep	157	Mix	No
5MT4477	EPII	Dolores	229	Mix	Except on floor
5MT2433	EPII	McElmo-Yellowjacket	175	Mix (mostly fill)	Except on floor
5MT8371	EPII	McElmo-Yellowjacket	357	Midden	1/4-inch
5MT1786	EPII	McElmo-Yellowjacket	173	Midden & MGS	1/4-inch
5MT11555	EPII	McElmo-Yellowjacket	784	Fill	Unknown
5MV1645	EPII	Mesa Verde	336	Mostly midden	No
5MV1452	EPII	Mesa Verde	418	Midden & pitstructure	No
5MT8834	LPII	Hovenweep	135	Midden & fill	No
5MT2544	LPII	Hovenweep	384	Midden & fill	1/4-inch
5MT2149	LPII	Dolores	340	Fill	No
5MT11338	LPII	McElmo-Yellowjacket	251	Midden	1/4-inch
5MT3807	LPII	McElmo-Yellowjacket	306	Midden	1/4-inch
5MT11555	LPII	McElmo-Yellowjacket	300	Fill	Unknown
5MT7723	LPII	Ute	219	Midden	No
5MT8943	LPII	Ute	225	Midden & fill	Except on floor
5MT10802	LPII	Mesa Verde	147	Mix	Unknown
5MV1595	LPII	Mesa Verde	286	Midden & others	No

Sites	Time Period	Locality	Analyzed Debitage Counts	Provenience	Screening
5MT11787	EPIII	Hovenweep	221	Fill	1/4-inch
5MT2525	EPIII	Hovenweep	149	Midden & fill	Except on floor
5MT2544	EPIII	Hovenweep	377	Midden & fill	1/4-inch
5MT3778	EPIII	Dolores	147	Mix	No
5MT11842	EPIII	McElmo-Yellowjacket	231	Midden & fill	1/4-inch
5MT3936	EPIII	McElmo-Yellowjacket	424	Midden	1/4-inch
5MT3930	EPIII	McElmo-Yellowjacket	366	Midden	1/4-inch
5MT3918	EPIII	McElmo-Yellowjacket	555	Midden	1/4-inch
5MT3807	EPIII	McElmo-Yellowjacket	325	Midden	1/4-inch
5MT11338	EPIII	McElmo-Yellowjacket	238	Midden	1/4-inch
5MT5152	EPIII	McElmo-Yellowjacket	356	Midden	1/4-inch
5MT3892	EPIII	McElmo-Yellowjacket	237	Mix	Unknown
5MT10991	EPIII	McElmo-Yellowjacket	114	Fill & room	1/4-inch
5MT10207	EPIII	Ute	199	Midden & fill	Except on floor
5MT10206	EPIII	Ute	232	Mix	Except on floor
5MT11787	LPIII	Hovenweep	88	Fill	1/4-inch
5MT4802	LPIII	Hovenweep	317	Fill	1/4-inch
5MT11842	LPIII	McElmo-Yellowjacket	198	Fill	1/4-inch
5MT5	LPIII	McElmo-Yellowjacket	491	Fill	1/4-inch
5MT3807	LPIII	McElmo-Yellowjacket	297	Midden	1/4-inch
5MT3951	LPIII	McElmo-Yellowjacket	180	Midden	1/4-inch
5MT10508	LPIII	McElmo-Yellowjacket	405	Midden	1/4-inch
5MT765	LPIII	McElmo-Yellowjacket	523	Midden	1/4-inch
5MT10246	LPIII	McElmo-Yellowjacket	295	Midden	1/4-inch
5MT262	LPIII	McElmo-Yellowjacket	373	Midden	1/4-inch
5MT1825	LPIII	McElmo-Yellowjacket	462	Midden	1/4-inch
5MT10459	LPIII	McElmo-Yellowjacket	344	Midden	1/4-inch
5MT9933	LPIII	Ute	199	Midden	Except on floor
5MT8650	LPIII	Ute	191	Midden	Except on floor
5MV1200	LPIII	Mesa Verde	668	Midden	No
5MV1229	LPIII	Mesa Verde	247	Midden	No
Total			21684		

[a] Archaeologists used screens when they excavated a floor context.

[b] Modern ground surface.

APPENDIX C. LITHIC RAW DATA

Appendix C shows lithic raw data that was used for all analyses in this research.

Abbreviations and notes of the table are noted below.

Site: site numbers
Time: six different temporal periods used for this study (see Table 1.1).
Chalc: counts of chalcedony.
Chalw: weight of chalcedony.
Chalp: proportion by weight of chalcedony.
Chalper: percentage by weight of chalcedony.
Chalee: energy-expenditure values of chalcedony (calculation of the minimum distance from a habitation to the nearest chalcedony quarry).
Chalcost: percentage by weight of chalcedony is multiplied by energy-expenditure values.
Chalres: residual values of chalcedony by linear regression analysis.
Kdbqc: counts of kdbq materials.
Kdbqw: weight of Kdbq.
Kdbqp: proportion by weight of Kdbq.
Kdbqper: percentage by weight of Kdbq.
Kdbqee: energy-expenditure values of kdbq (calculation of the minimum distance from a habitation to the nearest Kdbq quarry).
Kdbqcost: percentage by weight of Kdbq is multiplied by energy-expenditure values.
Kdbqres: residual values of chalcedony by linear regression analysis.
Kbcc: counts of Kbc.
Kbcw: weight of Kbc.
Kbcp: proportion by weight of Kbc.
Kbcper: percentage by weight of Kbc.
Kbcee: cost-weight values calculated from a habitation to the nearest Kbc quarry.
Kbccost: percentage by weight of Kbc is multiplied by energy-expenditure values.
Kbcres: residual values of Kbc by linear regression analysis.
Morrisonc: counts of Morrison materials.
Morrisonw: weight of Morrison materials.
Morrisonp: proportion by weight of Morrison materials.
Morrisonper: percentage by weight of Morrison materials.
Morrisonee: cost-weight values calculated from a habitation to the nearest Morrison source or outcrop.
Morrisoncost: percentage by weight of Morrison materials is multiplied by energy-expenditure values.
Morrisonres: residual values of Morrison by linear regression analysis.
Jmbcc: counts of Jmbc.
Jmbcw: weight of Jmbc.
Jmbcp: proportion by weight of Jmbc.
Jmbcper: percentage by weight of Jmbc.
Jmbcee: cost-weight values calculated from a habitation to the nearest Jmbc quarry.
Jmbccost: percentage by weight of Jmbc is multiplied by energy-expenditure values.

Jmbcres: residual values of Jmbc by linear regression analysis.
Ignc: counts of igneous materials.
Ignw: weight of igneous materials.
Ignp: proportion by weight of igneous materials.
Ignper: percentage by weight of igneous materials.
Ignee: cost-weight values calculated from a habitation to the nearest igneous source.
Igncost: percentage by weight of igneous materials is multiplied by energy-expenditure values.
Ignres: residual values of igneous by linear regression analysis.
Rjsc: counts of red jasper materials.
Rjsw: weight of red jasper.
Rjsp: proportion by weight of red jasper.
Rjsper: percentage by weight of red jasper.
Rjsee: cost-weight values calculated from a habitation to the nearest red jasper quarry.
Rjscost: residual values of red jasper by linear regression analysis.
Localc: counts of local materials. Local materials include metaquartizte, and indurated shale, and quartzite.
Localw: weight of all local materials.
Localp: proportion by weight of all local materials.
Localper: percentage by weight of all local materials.
Localee: cost-weight values calculated from a habitation to the nearest outcrops.
Localcost: percentage by weight of local materials is multiplied by energy-expenditure values.
TotalCost: the sum total of energy-expenditure values for all raw materials.

Site	*Time*	*Chalc*	*Chalw*	*Chalp*	*Chalper*	*Chalee*	*Chalcost*	*Chalres*	*Kdbqc*	*Kdbqw*	*Kdbqp*	*Kdbqper*	*Kdbqee*
5MT8937	BMIII	0	0	0.0000	0.0000	33092	0	-0.8830	9	212.9	0.0857	8.5700	17451.5
5MT8837	BMIII	8	29.7	0.0152	1.5187	22994.6	34921.54	0.6040	148	1229.04	0.6285	62.8500	22994.6
5MT4684	BMIII	11	19.2	0.0063	0.6343	2702.5	1714.172	-0.3920	15	109.3	0.0361	3.6108	2702.5
5MT2525	BMIII	2	0.7	0.0009	0.0856	9653.2	826.776	-0.9220	38	96.4	0.1179	11.7900	9653.2
5MT4545	BMIII	12	7.5	0.0064	0.6447	2702.5	1742.2	-0.3813	52	99.8	0.0858	8.5800	2702.5
5MV1937	BMIII	1	2.6	0.0011	0.1066	165491.8	17637.26	-0.2590	3	44.8	0.0184	1.8400	149280.3
5MV1940	BMIII	0	0	0.0000	0.0000	159111.7	0	-0.4170	3	28.8	0.0199	1.9900	142900.3
5MT10647	BMIII	6	5.2	0.0039	0.3903	24591.9	9599	-0.5310	21	124.3	0.0933	9.3300	11253.6
5MT11431	BMIII	7	38.5	0.0280	2.8033	35134.6	98491.49	1.9390	133	993.1	0.7231	72.3100	24682.9
5MT9540	BMIII	2	79.1	0.0251	2.5116	61306.8	153977.5	1.7520	2	55.9	0.0177	1.7700	44340.9
5MT9949	BMIII	1	0.1	0.0000	0.0035	71137.7	252.154	-0.7120	1	1.4	0.0005	0.0500	37451.9
5MT2181	PI	17	107	0.047501	4.7501	2702.5	12837.15	1.8480	40	263	0.116754	11.6754	2702.5
5MT8838	PI	16	2.7	0.001992	0.1992	22616.1	4505.127	-0.6820	68	481.28	0.355115	35.5115	22616.1
5MT2236	PI	14	10.9	0.005964	0.5964	2705.2	1613.381	-0.5880	44	153	0.083716	8.3716	2702.5
5MT2848	PI	14	56.3	0.019377	1.9377	1671.4	3238.672	0.1920	12	129.8	0.044674	4.4674	2024.7
5MT4613	PI	7	13.4	0.003722	0.3722	8908.1	3315.595	-0.6740	49	240.6	0.066824	6.6824	6244.9
5MT2193	PI	13	5.5	0.002254	0.2254	2725.8	614.3953	-0.8050	36	41.4	0.016966	1.6966	2725.8
5MT4544	PI	23	175.9	0.050101	5.0101	5922.7	29673.32	2.0160	9	110	0.031331	3.1331	6276.0
5MT4725	PI	5	30.2	0.006884	0.6884	4017.2	2765.44	-0.5240	19	233.6	0.053247	5.3247	4017.2
5MT2182	PI	66	238	0.030490	3.0490	2702.5	8239.923	0.8500	71	500.5	0.064118	6.4118	2702.5
5MT3868	PI	39	111.6	0.026834	2.6834	25312.3	67923.03	0.7860	121	1003.2	0.241218	24.1218	10540.9
5MT23	PI	11	6.8	0.000309	0.0309	4017.2	124.1315	-0.9100	31	148.1	0.067358	6.7358	4017.2
5MT4477	PI	9	1.7	0.003023	0.3023	5967.0	1803.824	-0.7360	18	106.6	0.189579	18.9579	5967.0
5MV1676	PI	3	8.6	0.001700	0.1700	131238.1	22310.48	0.1520	9	135.4	0.026760	2.6760	115026.9
5MT948	PI	2	10	0.001399	0.1399	10513.3	1470.811	-0.7980	8	168.1	0.023514	2.3514	10513.3

Kdbqcost	*Kdbqres*	*Kbcc*	*Kbcw*	*kbcp*	*Kbcper*	*Kbcee*	*Kbccost*	*Kbcres*	*Morrisonc*	*Morrisonw*	*Morrisonp*	*Morrisonper*
149559.4	-0.4520	2	5.4	0.0022	0.2200	49540.5	10898.91	-0.8810	151	1936.7	0.7792	77.9200
1445211	1.7780	0	0	0.0000	0.0000	22994.6	0	-1.3470	69	658.4	0.3367	33.6700
9758.187	-0.7430	11	122.6	0.0405	4.0502	2702.5	10945.67	0.5980	68	834.2	0.2756	27.5600
113811.2	-0.3640	17	48.8	0.0597	5.9700	9653.2	57629.6	1.7320	131	670	0.8198	81.9800
23187.45	-0.5360	39	57.9	0.0498	4.9800	2702.5	13458.45	1.1130	104	422	0.3627	36.2700
274675.8	0.0857	0	0	0.0000	0.0000	174868.3	0	0.7160	23	169.9	0.0696	6.9600
284371.6	-0.1150	0	0	0.0000	0.0000	168488.1	0	0.5930	19	365.6	0.2525	25.2500
104996.1	-0.4560	3	4	0.0030	0.3000	27701.1	8310.33	-1.1210	219	1116.9	0.8384	83.8400
1784820	2.1670	11	46	0.0335	3.3500	24310	81438.5	0.4750	47	281.1	0.2047	20.4700
78483.39	-0.5870	0	0	0.0000	0.0000	64648	0	-0.8110	58	650.3	0.2065	20.6500
1872.595	-0.6910	0	0	0.0000	0.0000	74836.5	0	-0.6870	127	1648.7	0.5844	58.4400
31552.77	0.1590	53	492.9	0.218814	21.8814	2702.5	59134.48	2.5620	55	850.9	0.377700	37.7700
803131.6	2.6410	3	0.9	0.000664	0.0664	22616.1	1501.709	-0.8330	147	805.8	0.594600	59.4600
22624.25	-0.1800	36	213.4	0.116765	11.6765	2702.5	31555.74	0.8840	53	560.4	0.306600	30.6600
9045.145	-0.5820	17	105	0.036138	3.6138	1671.4	6040.105	-0.4530	106	1354.6	0.466200	46.6200
41730.92	-0.3430	15	63.9	0.017748	1.7748	8908.1	15810.1	-0.6830	54	1046.5	0.290700	29.0700
4624.592	-0.8640	13	53.8	0.022047	2.2047	4040.5	8908.09	-0.6610	111	1379.1	0.565200	56.5200
19663.34	-0.7060	39	409.8	0.116722	11.6722	5922.7	69130.94	0.9110	86	1407.7	0.401000	40.1000
21390.38	-0.4880	16	71.1	0.016207	1.6207	4017.2	6510.676	-0.7570	77	993.6	0.226500	22.6500
17327.89	-0.3810	141	948.4	0.121498	12.1498	2702.5	32834.83	0.9610	222	2299.4	0.294600	29.4600
254265.5	1.4450	9	35	0.008416	0.8416	28056.4	23612.27	-0.6570	611	2942.5	0.707500	70.7500
27059.06	-0.3440	22	111.2	0.050575	5.0575	4017.2	20316.99	-0.1920	210	1418	0.644900	64.4900
113121.8	0.9100	3	15	0.026676	2.6676	5967.0	15917.57	-0.5660	64	338.5	0.602000	60.2000
307812	-2.7260	2	22.2	0.004388	0.4388	140614.7	61701.73	1.5300	51	665.6	0.131500	13.1500
24720.97	-0.7740	4	45	0.006295	0.6295	12398.2	7804.667	-0.8370	282	6643.6	0.929300	92.9300

Morrisonee	***Morrisoncost***	***Morrisonres***	***Jmbcc***	***Jmbcw***	***Jmbp***	***Jmbcper***	***Jmbcee***	***Jmbccost***	***Jmbcres***	***Ignc***	***Ignw***	***Ignp***
41329.4	3220386.848	1.6350	0	0	0.0000	0.0000	41329.4	0	-0.2400	12	171.7	0.0691
10919	367642.73	-0.5920	0	0	0.0000	0.0000	40185.2	0	-0.2300	0	0	0.0000
1469.2	40491.152	-0.9970	0	0	0.0000	0.0000	93301.6	0	-0.7190	2	12.7	0.0042
2848.6	233528.228	1.2540	0	0	0.0000	0.0000	49170.4	0	-0.3130	0	0	0.0000
1469.2	53287.884	-0.6390	0	0	0.0000	0.0000	93301.6	0	-0.7190	0	0	0.0000
82753.8	575966.448	-0.7520	2	6.4	0.0026	0.2600	196067.4	50977.52	-1.1070	41	877.6	0.3597
87488.5	2209084.625	0.2420	1	14.1	0.0097	0.9700	200802	194777.9	1.6420	26	326.6	0.2256
4744.2	397753.728	1.3520	0	0	0.0000	0.0000	107779	0	-0.8590	1	15.3	0.0115
8584.8	175730.856	-1.1620	0	0	0.0000	0.0000	60550.5	0	-0.4180	0	0	0.0000
34527.6	712994.94	-0.7650	2	13.9	0.0044	0.4400	60827.9	26764.28	0.9640	103	1643.1	0.5217
7111.6	415601.904	0.3510	3	23.6	0.0084	0.8400	68135.1	57233.48	2.1380	56	865.6	0.3068
6470	244371.9	-0.5150	0	0	0.000000	0.0000	93302	0	-0.4270	2	56	0.0249
10677	634854.42	0.5670	0	0	0.000000	0.0000	39807	0	-0.8740	2	27.8	0.0205
329	10087.14	-0.9240	0	0	0.000000	0.0000	93302	0	-0.4270	1	0.9	0.0005
2000	93240	-0.1350	1	1	0.000344	0.0344	110606	3804.846	-0.2880	1	0.4	0.0001
12053	350380.71	-0.8740	3	0.9	0.000250	0.0250	117842	2946.05	-0.2550	0	0	0.0000
2863	161816.76	0.3500	2	13.1	0.005368	0.5368	108958	58488.65	0.1870	1	34.4	0.0141
4865	195086.5	-0.4200	0	0	0.000000	0.0000	99224	0	-0.3900	7	61.6	0.0175
329	7451.85	-1.3110	0	0	0.000000	0.0000	93302	0	-0.4270	4	37.2	0.0085
6470	190606.2	-0.9140	0	0	0.000000	0.0000	93302	0	-0.4270	1	17.7	0.0023
11608	821266	1.1170	3	35.9	0.008632	0.8632	119524	103173.1	0.5710	0	0	0.0000
7083	456782.67	0.7740	0	0	0.000000	0.0000	93302	0	-0.4270	1	1.1	0.0005
329	19805.8	0.5040	0	0	0.000000	0.0000	93302	0	-0.4270	1	1.3	0.0023
118157	1553764.55	-2.4420	0	0	0.000000	0.0000	201389	0	0.4010	243	4107.89	0.8119
28044	2606128.92	2.3590	14	282.2	0.039475	3.9475	72033	284350.3	3.3560	0	0	0.0000

Ignper	***Ignee***	***Igncost***	***Ignres***	***Rjsc***	***Rjsw***	***Rjsp***	***Rjsper***	***Rjsee***	***Rjscost***	***Localc***	***Localw***	***Localp***
6.9100	150483.20	1039839	0.7160	0	0	0.0000	0.0000	11670.1	0	3	5	0.0000
0.0000	149651.50	0	-0.0626	0	0	0.0000	0.0000	40185.2	0	3	38.5	0.0197
0.4200	118507.60	49773.19	-0.8530	0	0	0.0000	0.0000	93301.6	0	105	1910.7	0.6312
0.0000	153294.80	0	0.0387	1	1.4	0.0017	0.1700	49170.4	8358.968	0	0	0.0000
0.0000	118507.60	0	-0.8970	1	1.1	0.0009	0.0900	93301.6	8397.144	57	561	0.4822
35.9700	20016.10	719979.1	0.2830	0	0	0.0000	0.0000	203565.9	0	75	1208.4	0.4953
22.5600	24750.70	558375.8	-1.1120	0	0	0.0000	0.0000	208300.6	0	58	712.9	0.4923
1.1500	174334.70	200484.9	0.7850	0	0	0.0000	0.0000	107779	0	4	53.7	0.0403
0.0000	130078.60	0	-0.5910	0	0	0.0000	0.0000	60550.5	0	1	0.1	0.0000
52.1700	34527.60	1801305	2.4920	0	0	0.0000	0.0000	64648	0	41	469	0.1489
30.6800	7111.60	218183.9	-0.7320	0	0	0.0000	0.0000	76059.8	0	14	89.1	0.0316
2.4860	118508.00	294610.9	-0.2760	0	0	0.000000	0.0000	93302	0	20	468.1	0.2078
2.0514	162683.00	333727.9	1.2330	0	0	0.000000	0.0000	39807	0	2	11.1	0.0082
0.0492	118508.00	5830.594	-0.4260	0	0	0.000000	0.0000	93302	0	79	851.2	0.4657
0.0138	120179.00	1658.47	-0.3750	1	1.3	0.000447	0.0447	94973	4245.2931	51	1254.4	0.4317
0.0000	116528.40	0	-0.4920	2	1.4	0.000389	0.0389	102210	3975.969	88	2204.6	0.6123
1.4097	118531.00	167093.2	-0.3420	0	0	0.000000	0.0000	93325	0	63	848.4	0.3477
1.7545	124430.00	218312.4	-0.1330	0	0	0.000000	0.0000	99224	0	46	1263.8	0.3600
0.8479	118508.00	100482.9	-0.3770	0	0	0.000000	0.0000	93302	0	106	2967.4	0.6764
0.2268	118508.00	26877.61	-0.4150	1	205.5	0.026326	2.6326	93302	245626.8452	182	3559.2	0.4560
0.0000	89625.70	0	-1.4170	1	1.3	0.000313	0.0313	119935	3753.9655	1	1.6	0.0004
0.0500	118508.00	5925.4	-0.4260	0	0	0.000000	0.0000	93302	0	47	504.2	0.2293
0.2312	118508.00	27399.05	-0.4150	0	0	0.000000	0.0000	93302	0	23	99.1	0.1762
81.1870	55419.00	4499302	3.4590	0	0	0.000000	0.0000	208816	0	9	120.1	0.0237
0.0000	174447.50	0	1.6440	0	0	0.000000	0.0000	74710	0	0	0	0.0000

Localper	***Localee***	***Localcost***	***TotalCost***
0.0000	41329.4	0	4420684.025
1.9700	10919	21510.43	1869285.311
63.1219	1469.2	92738.695	205421.0644
0.0000	2848.6	0	414154.804
48.2200	1469.2	70844.824	170917.9516
49.5300	82753.8	4098795.7	5738031.818
49.2300	87488.5	4307058.9	7553668.809
4.0300	4744.2	19119.126	740263.1772
0.0000	8584.8	0	2140481.343
14.8900	34527.6	514115.96	3287640.981
3.1600	7111.6	22472.656	715616.681
20.7800	6470	134446.6	776953.7853
0.8200	10677	8755.14	1786475.938
46.5700	329	15321.53	87032.63513
43.1700	2000	86340	207612.5316
61.2300	12053	738005.19	1156164.529
34.7700	2863	99546.51	501092.1531
36.0000	4865	175140	707006.5288
67.6400	329	22253.56	160854.8446
45.6000	6470	295032	816545.3061
0.0400	11608	464.32	1274458.176
22.9300	7083	162413.19	672621.4362
17.6200	329	5796.98	183845.0122
2.3700	118157	280032.09	6724923.185
0.0000	28044	0	2924475.639

Site	***Time***	***Chalc***	***Chalw***	***Chalp***	***Chalper***	***Chalee***	***Chalcost***	***Chalres***	***Kdbqc***	***Kdbqw***	***Kdbqp***	***Kdbqper***
5MT8371	EPII	18	13.9	0.016339	1.6339	28800.9	47057.79	1.1300	12	18.1	0.021277	2.1277
5MT4477	EPII	12	49.1	0.020822	2.0822	5967.0	12424.49	1.6940	16	120.3	0.051016	5.1016
5MT8839	EPII	1	33.7	0.014161	1.4161	24268.5	34366.62	0.8230	35	726.6	0.305333	30.5333
5MT8836	EPII	0	0	0	0.0000	23032.2	0	-1.0940	85	862.9	0.299099	29.9099
5MT8827	EPII	0	0	0	0.0000	20795.0	0	-1.1070	26	121.7	0.079908	7.9908
5MT1786	EPII	0	0	0	0.0000	50519.9	0	-0.9590	19	86.2	0.117295	11.7295
5MT2433	EPII	0	0	0	0.0000	46389.4	0	-0.9970	5	41.9	0.028777	2.8777
5MV1645	EPII	9	22.2	0.003986	0.3986	162411.6	64737.26	0.0400	3	25.1	0.004506	0.4506
5MV1452	EPII	15	61.3	0.007029	0.7029	163698.7	115063.8	0.5800	3	38.8	0.004449	0.4449
5MT11555	EPII	21	53.8	0.008369	0.8369	33791.2	28279.86	0.0812	196	776.07	0.12073	12.0730
5MT8834	LPII	0	0	0	0.0000	23312.3	0	-0.7740	17	234.6	0.092911	9.2911
5MT7723	LPII	0	0	0	0.0000	59241.8	0	-0.5250	1	8.5	0.002564	0.2564
5MT2544	LPII	0	0	0	0.0000	8170.0	0	-0.9050	2	3.7	0.001306	0.1306
5MT8943	LPII	1	2.8	0.000554	0.0554	62596.9	3467.868	-0.3320	2	233	0.046071	4.6071
5MT3807	LPII	1	2.1	0.00153	0.1530	28440.7	4351.427	-0.2560	50	295.5	0.215285	21.5285
5MT11338	LPII	0	0	0	0.0000	34990.8	0	-0.6860	41	59.1	0.080694	8.0694
5MT2149	LPII	14	54.1	0.009803	0.9803	12474.3	12228.56	2.2860	16	379.6	0.068781	6.8781
5MV1595	LPII	0	0	0	0.0000	160570.3	0	0.3490	11	105	0.025716	2.5716
5MT11555	LPII	2	4.5	0.001401	0.1401	33791.2	4734.147	-0.2600	62	225.7	0.070285	7.0285
5MT10802	LPII	2	6.2	0.006197	0.6197	49414.9	30622.41	1.3250	69	536	0.535732	53.5732
5MT3778	EPIII	22	69.8	0.073489	7.3489	10322.8	75861.39	3.5660	11	63.9	0.067277	6.7277
5MT10207	EPIII	0	0	0.000000	0.0000	65720.0	0	0.2730	0	0	0.000000	0.0000
5MT11338	EPIII	5	2.4	0.001537	0.1537	34990.8	5379.407	-0.3150	56	96.7	0.061944	6.1944
5MT10206	EPIII	0	0	0.000000	0.0000	66341.6	0	0.2890	0	0	0.000000	0.0000
5MT5152	EPIII	3	1.7	0.001414	0.1414	38309.2	5415.399	-0.2520	35	155.4	0.129220	12.9220

Kdbqee	***Kdbqcost***	***Kdbqres***	***Kbcc***	***Kbcw***	***kbcp***	***Kbcper***	***Kbcee***	***Kbccost***	***Kbcres***	***Morrisonc***	***Morrisonw***	***Morrisonp***
28800.9	61279.67	-0.9440	5	0.6	0.000705	0.0705	19917.6	1404.191	-0.7550	117	621.3	0.692
5967.0	30441.25	-0.8730	9	40.6	0.017217	1.7217	5967.0	10273.38	1.3820	121	1245.2	0.438997
24268.5	740997.4	1.7930	0	0	0	0.0000	24268.5	0	-0.8280	102	2196.4	0.603479
23032.2	688890.8	1.7240	2	30.3	0.010503	1.0503	23032.2	24190.72	0.5400	114	2806.4	0.663154
20795.0	166168.7	-0.4440	0	0	0	0.0000	20795.0	0	-0.8440	107	1523.9	0.920683
34382.5	403289.5	0.0397	1	15.5	0.021091	2.1091	50519.9	106551.5	2.0000	144	703.3	0.818615
11843.4	34081.75	-1.0350	0	0	0	0.0000	20697.8	0	-0.8440	159	1334.7	0.887912
146200.2	65877.81	-0.1390	3	12.2	0.00219	0.2190	171788.1	37621.59	0.0157	37	558.4	0.089568
147487.2	65617.06	-0.1260	0	0	0	0.0000	173075.2	0	-0.3540	53	877.1	0.089092
14957.2	180578.3	-0.0938	11	21.8	0.003391	0.3391	20958.5	7107.027	-0.3990	484	5755.37	0.762845
23312.3	216596.9	-0.1870	1	11	0.004356	0.4356	23312.3	10154.84	-0.2600	102	2325.9	0.823881
44469.9	11402.08	-0.6640	0	0	0	0.0000	79665.8	0	-0.3400	28	329.2	0.096736
8170.0	1067.002	-0.8530	3	10.2	0.003602	0.3602	8170.0	2942.834	-0.5310	371	2668.0	0.937182
47825.0	220334.6	-0.3760	0	0	0	0.0000	83020.9	0	-0.3090	69	1293.5	0.209139
15413.7	331833.8	0.5590	6	13	0.009471	0.9471	28440.7	26936.19	0.5230	225	1302.0	0.722279
18933.5	152782	-0.2850	2	0.3	0.00041	0.0410	34990.8	1434.623	-0.7060	164	474.3	0.566494
8773.2	60342.95	-0.4120	18	135.8	0.024606	2.4606	12474.3	30694.26	2.6030	150	2880.4	0.418717
144358.9	371233.3	-0.2380	0	0	0	0.0000	169946.8	0	0.9910	43	648.2	0.133036
14957.2	105126.7	-0.3710	1	0.8	0.000249	0.0249	20958.5	521.8667	-0.8780	218	2921.6	0.83788
28841.3	1545121	2.6320	0	0	0	0.0000	52764.9	0	-0.5890	65	939.6	0.397201
8073.1	54313.65	-0.8260	12	30.8	0.032428	3.2428	10332.8	33507.08	1.2190	84	761.2	0.628238
55342.7	0	-0.2730	1	1	0.000278	0.0278	65720.1	1824.849	-0.1550	49	777	0.215472
18933.5	117280.7	-0.4770	0	0	0.000000	0.0000	34990.8	0	-0.7460	151	1459.5	0.871437
55964.2	0	-0.2450	0	0	0.000000	0.0000	66341.6	0	-0.1650	68	607.9	0.164484
22171.7	286502.8	0.9240	1	4.6	0.003825	0.3825	38309.2	14653.44	-0.4040	280	1121.9	0.798437

Morrisonper	***Morrisonee***	***Morrisoncost***	***Morrisonres***	***Jmbcc***	***Jmbcw***	***Jmbp***	***Jmbcper***	***Jmbcee***	***Jmbccost***	***Jmbcres***	***Ignc***	***Ignw***
69.2000	18451	1276809.2	0.3030	192	143.8	0.169037	16.9037	18451	311890.2	2.4600	0	0
43.8997	328.7	14429.83139	-1.9980	0	0	0	0.0000	93301.6	0	-1.0660	1	8.2
60.3479	4584.3	276652.878	-0.8260	13	183.3	0.077027	7.7027	41459.1	319347	0.4310	0	0
66.3154	4372.4	289957.455	-0.4870	6	71.4	0.024749	2.4749	40222.8	99547.41	-0.7290	1	7.2
92.0683	4717.5	434332.2053	1.0300	2	7.9	0.005187	0.5187	37745.1	19578.38	-1.1730	0	0
81.8615	25307.6	2071718.097	1.3230	7	31.3	0.042591	4.2591	66200.2	281953.3	-0.2420	0	0
88.7912	11497.1	1020841.306	1.1260	9	85.7	0.05886	5.8860	74334.5	437532.9	0.1360	0	0
8.9568	83424.7	747218.353	-0.3930	36	238.8	0.042872	4.2872	245771.7	1053672	0.4450	234	4386.2
8.9092	83311.2	742236.143	-0.4020	23	350.4	0.040177	4.0177	247058.7	992607.7	0.3790	289	6588.01
76.2845	3921.1	299119.153	0.0741	8	189.4	0.029464	2.9464	114389	337035.7	-0.3660	6	0
82.3881	3960	326248.6372	0.6370	15	199.1	0.078851	7.8851	40503	319370.2	0.6080	0	0
9.6736	35756	345886.3395	-1.5490	9	125.1	0.037735	3.7735	91683	345965	-0.5630	179	2842
93.7182	5710	535130.922	1.3010	8	164	0.05791	5.7910	46553	269586.1	0.2200	0	0
20.9139	31232	653180.8334	-1.1850	33	461.7	0.091292	9.1292	86368	788474.4	0.2010	98	2906.5
72.2279	11367	821000.0937	0.4590	20	63.9	0.046554	4.6554	85146	396388.2	-0.3760	3	5.3
56.6494	18926	1072157.874	0.0281	36	132.9	0.181458	18.1458	75300	1366375	1.5330	0	0
41.8717	7605	318446.84	-1.2720	19	141.3	0.025602	2.5602	121409	310830.3	-1.0650	6	96.1
13.3036	85890	1142651.525	1.9810	110	1169.9	0.286522	28.6522	199204	5707633	2.3450	115	2104
83.7880	3921	328541.1268	0.7080	8	189.4	0.058981	5.8981	114389	674677.8	-0.5380	0	0
39.7201	34591	1373942.091	-0.0844	3	4.8	0.004798	0.4798	132775	63705.4	-1.4980	3	18.9
62.8238	8556.10	537526.7152	-1.7730	6	51.8	0.054538	5.4538	119257.10	650402	0.2080	1	3
21.5472	37689.10	812094.5755	-0.3670	2	8.5	0.002360	0.2360	65241.20	15398.18	-1.1270	103	2650.9
87.1437	18926.20	1649299.095	2.5780	13	61.3	0.039267	3.9267	75299.80	295681.1	0.3430	3	33
16.4484	37653.40	619338.1846	-1.0190	15	98.2	0.026571	2.6571	65862.70	175001.8	-0.0452	107	1444.5
79.8437	9660.70	771346.0326	0.0912	23	72.4	0.060203	6.0203	70752.70	425951.7	1.3710	1	2.9

Ignp	***Ignper***	***Ignee***	***Igncost***	***Ignres***	***Rjsc***	***Rjsw***	***Rjsp***	***Rjsper***	***Rjsee***	***Rjscost***	***Localc***	***Localw***
0.0000	0.0000	177856.80	0	1.3150	0	0	0	0.0000	73764.9	0	11	85.6
0.0035	0.3477	118507.60	41205.09	-1.9390	2	1.7	0.000721	0.0721	93301.6	6727.04536	65	1101.9
0.0000	0.0000	147956.10	0	-0.3780	0	0	0	0.0000	41459.1	0	0	0
0.0025	0.2496	162904.20	40660.89	0.4740	0	0	0	0.0000	40222.8	0	0	0
0.0000	0.0000	150656.30	0	-0.2310	0	0	0	0.0000	37745.1	0	0	0
0.0000	0.0000	141221.60	0	-0.7440	1	0.3	0.000408	0.0408	126362	5155.5696	0	0
0.0000	0.0000	141333.50	0	-0.7380	0	0	0	0.0000	74334.5	0	2	35.6
0.7875	78.7454	20687.00	1629006	0.9430	0	0	0	0.0000	204236.9	0	11	377.6
0.7554	75.5381	20573.50	1554083	0.5120	2	10.6	0.001215	0.1215	204123.4	24800.9931	27	815.9
0.0068	0.6814	175376.90	119501.8	1.2400	0	0	0	0.0000	102998.8	0	33	424.4
0.0000	0.0000	148655.40	0	0.7450	0	0	0	0.0000	40503	0	0	0.0
0.8573	85.7264	35755.70	3065207	2.1810	0	0	0	0.0000	95503	0	2	18.9
0.0000	0.0000	156417.60	0	1.0650	0	0	0	0.0000	46552.6	0	0	0.0
0.5747	57.4702	31231.90	1794904	0.1360	0	0	0	0.0000	90188.5	0	22	395.7
0.0039	0.3861	119142.30	46000.84	-0.3110	0	0	0	0.0000	95350.4	0	1	1.4
0.0000	0.0000	125692.40	0	-0.1070	0	0	0	0.0000	124113.2	0	2	123.5
0.0174	1.7413	116262.80	202448.4	-0.3270	0	0	0	0.0000	105776	0	102	2368.9
0.5153	51.5295	23152.70	1193047	-0.5980	0	0	0	0.0000	206702.6	0	5	154.5
0.0000	0.0000	91380.70	0	-1.2820	0	0	0	0.0000	102998.8	0	9	100.2
0.0189	1.8891	90154.20	170310.3	-1.2100	0	0	0	0.0000	126992.8	0	4	35.0
0.0032	0.3159	116914.10	36928.02	-0.5660	3	2.2	0.002316	0.2316	103624.50	24002.30575	6	131.1
0.7361	73.6075	37689.10	2774200	3.0870	0	0	0.000000	0.0000	69061.30	0	32	165
0.0211	2.1139	125692.40	265700.4	-0.1720	2	1.6	0.001025	0.1025	124113.30	12720.59958	2	4.7
0.3908	39.0849	37653.40	1471680	0.0072	0	0	0.000000	0.0000	69682.80	0	34	1530.1
0.0024	0.2411	129010.80	31110.2	-0.2150	1	0.1	0.000083	0.0083	120493.30	1001.939963	3	2.3

Localp	***Localper***	***Localee***	***Localcost***	***TotalCost***
0.1	10.0000	18451	184510	1882951.025
0.467283	46.7283	328.7	15359.592	130860.68
0	0.0000	4584.3	0	1371363.901
0	0.0000	4372.4	0	1143247.269
0	0.0000	4717.5	0	620079.2746
0	0.0000	25307.6	0	2868667.994
0.024451	2.4451	11497.1	28111.559	1520567.484
0.067791	6.7791	83424.7	565544.38	4163677.927
0.093552	9.3552	83311.2	779392.94	4273801.785
0.066022	6.6022	3921.1	25887.886	997509.7669
0	0.0000	0	0	872370.5909
0.005701	0.5701	35756	20384.325	3788845.233
0	0.0000	5710	0	808726.8646
0.078242	7.8242	31232	244364.63	3704725.828
0.00102	0.1020	11367	1159.4136	1627670.027
0.168624	16.8624	18926	319141.15	2911890.748
0.429226	42.9226	7605	326439.25	1261430.567
0.037839	3.7839	85890	325000.68	8739565.461
0.031203	3.1203	3921	12235.008	1125836.59
0.034983	3.4983	34591	121008.3	3304709.23
0.138029	13.8029	8556.10	118098.99	1530640.106
0.045816	4.5816	37689.10	172676.38	3776193.889
0.003011	0.3011	18926.20	5698.6788	2351760.031
0.41401	41.4010	37653.40	1558888.4	3824908.059
0.001913	0.1913	9660.70	1848.0919	1537829.599

Site	***Time***	***Chalc***	***Chalw***	***Chalp***	***Chalper***	***Chalee***	***Chalcost***	***Chalres***	***Kdbqc***	***Kdbqw***	***Kdbqp***	***Kdbqper***
5MT3892	EPIII	3	5.3	0.002070	0.2070	23222.9	4807.678	-0.5390	14	386.4	0.150932	15.0932
5MT2525	EPIII	3	1.9	0.001844	0.1844	9653.2	1779.996	-0.8910	7	34.2	0.033191	3.3191
5MT3918	EPIII	6	20.5	0.009072	0.9072	39305.0	35657.5	0.2130	109	420.2	0.185954	18.5954
5MT3826	EPIII	2	2.3	0.001276	0.1276	40844.6	5211.794	-0.2070	20	71	0.039390	3.9390
5MT2544	EPIII	0	0	0.000000	0.0000	8170.0	0	-1.0490	34	270.6	0.123084	12.3084
5MT3807	EPIII	4	2.1	0.001505	0.1505	28440.7	4281.089	-0.4570	38	238.7	0.171099	17.1099
5MT3930	EPIII	3	7.9	0.006652	0.6652	33261.7	22124.04	0.0547	19	49.7	0.041846	4.1846
5MT10991	EPIII	4	3.4	0.004609	0.4609	27282.1	12574.1	-0.3010	8	28.5	0.038634	3.8634
5MT11842	EPIII	1	1	0.000436	0.0436	64488.9	2810.219	0.2690	26	323.4	0.140927	14.0927
5MT11787	EPIII	3	3.4	0.002426	0.2426	29461.8	7147.861	-0.3810	26	72.7	0.051877	5.1877
5MT262	LPIII	4	8.7	0.004679	0.4679	43780.0	20483.25	0.0068	33	359.2	0.193170	19.3170
5MT10459	LPIII	4	4.9	0.002633	0.2633	43350.0	11413.41	-0.4850	18	102.2	0.054914	5.4914
5MT10508	LPIII	11	10.3	0.005224	0.5224	40329.8	21066.89	0.1190	119	791.4	0.401359	40.1359
5MT1825	LPIII	9	8.8	0.004478	0.4478	30584.5	13696.88	-0.1140	22	100.2	0.050992	5.0992
5MT3951	LPIII	0	0	0.000000	0.0000	39446.3	0	-1.1400	32	158.9	0.266835	26.6835
5MT765	LPIII	5	26.2	0.008066	0.8066	47173.2	38051.1	0.8350	53	166.4	0.051230	5.1230
5MT10246	LPIII	1	1.1	0.000770	0.0770	41299.7	3178.234	-0.9440	25	306.7	0.214566	21.4566
5MT3807	LPIII	3	7.2	0.007143	0.7143	28440.7	20314.79	0.5200	34	122.6	0.121627	12.1627
5MT5	LPIII	7	9	0.005350	0.5350	28212.4	15092.4	0.0843	82	256.6	0.152522	15.2522
5MV1200	LPIII	0	0	0.000000	0.0000	167084.8	0	-0.6080	6	59.1	0.009569	0.9569
5MV1229	LPIII	3	12.5	0.006354	0.6354	159040.8	101047.6	1.3260	3	21.8	0.011081	1.1081
5MT11842	LPIII	6	4.9	0.004588	0.4588	64488.9	29584.83	0.0968	17	53.2	0.049808	4.9808
5MT11787	LPIII	2	2.8	0.003393	0.3393	29461.8	9995.522	-0.3830	11	101.7	0.123228	12.3228
5MT4802	LPIII	21	26.9	0.016863	1.6863	30545.3	51508.81	2.8820	20	41.4	0.025953	2.5953
5MT9933	LPIII	0	0	0.000000	0.0000	61172.7	0	-1.0160	2	1.4	0.001958	0.1958
5MT8650	LPIII	0	0	0.000000	0.0000	61481.4	0	-1.0140	1	0.1	0.000058	0.0058

Kdbqee	***Kdbqcost***	***Kdbqres***	***Kbcc***	***Kbcw***	***kbcp***	***Kbcper***	***Kbcee***	***Kbccost***	***Kbcres***	***Morrisonc***	***Morrisonw***	***Morrisonp***
11196.3	168987.6	0.9180	1	1.2	0.000469	0.0469	28802.2	1350.05	-0.8320	186	2364.9	0.770282
9653.2	32039.93	-1.4160	4	21.2	0.020575	2.0575	9094.4	18711.3	0.2750	127	1024.5	0.938665
23168.3	430823.5	2.0380	4	12.3	0.005443	0.5443	39305.8	21394.93	-0.2670	418	2161.3	0.755985
24707.1	97320.62	-0.6780	1	4.8	0.002663	0.2663	40844.6	10876.79	-0.4420	370	1680	0.88871
8170.0	100559.6	0.2640	2	5.8	0.002638	0.2638	8170.0	2155.379	-1.1550	322	2047.9	0.805777
15413.7	263726.6	1.4580	11	62.7	0.044943	4.4943	28440.7	127821.1	2.4120	248	1336.4	0.740377
18492.5	77382.95	-0.8750	2	1.5	0.001263	0.1263	33261.7	4200.77	-0.6860	291	1135.9	0.906626
11176.1	43177.29	-1.2430	5	18.2	0.024671	2.4671	43311.7	106855.5	1.2310	85	674.1	0.845872
6548.3	92283.43	0.5500	1	0.4	0.000174	0.0174	14138.5	246.4441	-1.1830	199	2294.8	0.858463
29461.8	152838.1	-0.2560	5	32.2	0.022977	2.2977	29461.8	67694.45	0.8250	173	1366.5	0.897816
43780.0	845699.2	0.8640	4	23.5	0.012638	1.2638	43780.0	55328.31	0.0317	319	1825.9	0.771444
14900.9	81826.45	-0.7770	7	37.5	0.020149	2.0149	43350.0	87347.54	0.6390	309	1848.9	0.915749
7180.3	288187.9	2.5440	7	45.8	0.023228	2.3228	40329.8	93676.07	0.8720	245	1930.6	0.549295
30584.5	155957.6	-0.6450	23	90.9	0.046260	4.6260	30584.5	141482.5	2.7020	381	1864	0.84687
23308.8	621959.4	1.3700	1	5	0.008396	0.8396	39446.3	33120.32	-0.3370	124	543.4	0.63728
4372.0	22397.73	-0.9350	7	41.6	0.012807	1.2807	4713.2	6036.425	-0.1780	435	3078.3	0.87562
15463.2	331787	0.7860	7	16.4	0.011473	1.1473	41299.7	47384.57	-0.0756	241	1369.1	0.731006
15413.7	187472.2	-0.1210	7	28.2	0.027976	2.7976	28440.7	79566.24	1.2000	222	928	0.763889
27937.7	426111.5	0.3090	13	19.5	0.011591	1.1591	27564.9	31949.71	-0.1450	360	1514.88	0.730976
150873.4	144377.6	0.2720	0	0	0.000000	0.0000	176461.3	0	-0.3460	531	4553.3	0.7277
142829.4	158263.7	0.1690	1	17.3	0.008793	0.8793	168417.2	148094.8	0.5310	171	1280.6	0.624682
6548.3	32615.82	-0.9230	1	0.2	0.000187	0.0187	14138.5	264.7411	-1.1670	171	1058.4	0.936336
29461.8	363051.6	0.0412	0	0	0.000000	0.0000	29461.8	0	-1.0800	68	790.6	0.831334
30545.3	79273.79	-0.8880	7	4.5	0.002821	0.2821	30545.3	8616.716	-0.8430	251	1576.2	0.942452
45153.0	8839.911	-0.9670	0	0	0.000000	0.0000	61172.7	0	-0.8970	66	240.3	0.334079
45807.6	267.6147	-0.9790	0	0	0.000000	0.0000	61481.4	0	-0.8950	55	436.5	0.254951

Morrisonper	***Morrisonee***	***Morrisoncost***	***Morrisonres***	***Jmbcc***	***Jmbcw***	***Jmbp***	***Jmbcper***	***Jmbcee***	***Jmbccost***	***Jmbcres***	***Ignc***	***Ignw***
77.0282	5932.20	456946.688	-0.8950	27	114.9	0.044881	4.4881	120270.20	539785.4	-0.3020	4	78.6
93.8665	3958.40	371561.1536	0.3850	0	0	0.000000	0.0000	49170.40	0	-0.9600	0	0
75.5985	9723.50	735082.0148	-0.3090	12	62.6	0.027703	2.7703	72620.50	201179.1	-0.1240	0	0
88.8710	8474.90	753172.8379	0.7460	16	49.6	0.027517	2.7517	74637.50	205382.5	-0.1710	10	55.2
80.5777	5710.00	460098.667	-0.5890	16	149.1	0.067819	6.7819	46552.60	315714.9	2.3020	0	0
74.0377	11366.80	841571.7284	-0.1500	13	46.4	0.033259	3.3259	85145.90	283189	-0.1150	0	0
90.6626	9806.10	889046.5219	1.1680	4	30.6	0.025764	2.5764	75895.30	195537.3	-0.2730	2	4.6
84.5872	6647.30	562276.4946	-0.0167	9	55	0.074556	7.4556	110642.10	824903.8	1.3380	2	8.3
85.8463	3451.60	296307.0891	-0.5080	0	0	0.000000	0.0000	92434.00	0	-1.7690	0	0
89.7816	5905.20	530178.3043	0.3510	1	1.3	0.000928	0.0928	32038.20	2972.004	-0.6250	0	0
77.1444	12534.90	966997.3396	0.0912	2	9.6	0.005163	0.5163	75790.20	39128.04	-0.3140	8	23.8
91.5749	25840.60	2366350.361	1.0570	0	0	0.000000	0.0000	84534.20	0	-0.5880	0	0
54.9295	22790.50	1251870.77	-0.9440	2	18.6	0.009433	0.9433	86947.60	82017.72	-0.3510	2	6.5
84.6870	10874.10	920894.9067	0.4740	8	20.3	0.010331	1.0331	62594.90	64665.47	0.0260	2	9
63.7280	29943.10	1908213.877	-0.3680	0	0	0.000000	0.0000	72452.20	0	-0.4150	2	1.5
87.5620	13154.60	1151843.085	0.6610	9	75.1	0.023121	2.3121	93791.00	216856.1	-0.0543	7	32.6
73.1006	24935.40	1822792.701	0.0580	0	0	0.000000	0.0000	82126.30	0	-0.5530	2	8
76.3889	11366.80	868297.3485	0.0331	11	29.5	0.029266	2.9266	85145.90	249186.9	0.2470	3	11.1
73.0976	6363.30	465141.9581	-0.2210	6	48.2	0.028650	2.8650	66339.10	190060.8	0.5040	1	9.5
72.7700	86618.50	6303228.245	1.2170	6	30.9	0.005003	0.5003	199932.00	100032.4	-2.7070	110	1442.7
62.4682	88481.60	5527286.285	0.5610	35	341.3	0.173478	17.3478	201795.10	3500695	3.5490	26	282.5
93.6336	3451.60	323185.7338	0.8590	0	0	0.000000	0.0000	92434.00	0	-0.7020	0	0
83.1334	5905.20	490919.3537	0.3190	2	25.3	0.030656	3.0656	32038.20	98214.77	1.1050	0	0
94.2452	7805.00	735583.786	0.9500	0	0	0.000000	0.0000	37469.80	0	0.0929	0	0
33.4079	33047.90	1104060.938	-1.9450	6	12.8	0.017900	1.7900	60693.70	108639.3	0.2740	98	369
25.4951	33342.90	850080.5698	-2.3640	3	24.6	0.014372	1.4372	61002.50	87670.82	0.1670	93	1110

Ignp	*Ignper*	*Ignee*	*Igncost*	*Ignres*	*Rjsc*	*Rjsw*	*Rjsp*	*Rjsper*	*Rjsee*	*Rjscost*	*Localc*
0.0307	3.0702	90281.20	277180.7	-1.1640	1	1.3	0.000508	0.0508	117845.40	5984.102965	1
0.0000	0.0000	153294.80	0	0.5010	1	5.9	0.005726	0.5726	49170.40	28154.63509	0
0.0000	0.0000	130007.40	0	-0.2040	0	0	0.000000	0.0000	106215.50	0	3
0.0306	3.0624	131546.20	402848.8	0.0727	0	0	0.000000	0.0000	107754.40	0	4
0.0000	0.0000	156417.60	0	0.6000	2	1.5	0.000682	0.0682	46552.60	3176.206504	0
0.0000	0.0000	119142.30	0	-0.5240	1	2.5	0.001792	0.1792	132448.30	23734.55308	2
0.0039	0.3873	123963.30	48011.38	-0.3530	0	0	0.000000	0.0000	100171.40	0	2
0.0113	1.1251	70025.60	78787.11	-1.9920	0	0	0.000000	0.0000	104860.10	0	0
0.0000	0.0000	159433.20	0	0.6970	0	0	0.000000	0.0000	92434.00	0	0
0.0000	0.0000	159290.80	0	0.6930	9	19.4	0.013843	1.3843	32038.20	44351.43999	0
0.0128	1.2799	109367.00	139980.3	-0.6460	0	0	0.000000	0.0000	70008.10	0	0
0.0000	0.0000	134051.60	0	-0.1070	0	0	0.000000	0.0000	110259.80	0	0
0.0033	0.3296	131031.40	43194.24	-0.1590	2	1.2	0.000609	0.0609	126611.70	7705.347398	0
0.0046	0.4580	103113.70	47227.65	-0.8770	0	0	0.000000	0.0000	56812.80	0	6
0.0025	0.2519	130147.90	32782.85	-0.1890	1	1.1	0.001847	0.1847	106356.00	19645.94458	18
0.0100	1.0037	137874.90	138380	0.0772	0	0	0.000000	0.0000	114083.00	0	0
0.0056	0.5597	132001.30	73877.88	-0.1150	0	0	0.000000	0.0000	108209.50	0	12
0.0110	1.1012	119142.30	131198.4	-0.4060	1	0.3	0.000298	0.0298	132448.30	3941.91369	7
0.0056	0.5647	123156.40	69543.49	-0.3460	3	0.9	0.000535	0.0535	66339.10	3548.852816	5
0.2336	23.3602	23880.70	557856.9	-1.1890	0	0	0.000000	0.0000	207430.60	0	9
0.1436	14.3591	25743.80	369656.6	-1.9470	0	0	0.000000	0.0000	209293.70	0	4
0.0000	0.0000	159433.20	0	0.5800	0	0	0.000000	0.0000	92434.00	0	1
0.0000	0.0000	159290.80	0	0.5760	3	8.6	0.010420	1.0420	32038.20	33385.25627	0
0.0000	0.0000	160374.30	0	0.6070	7	3	0.001881	0.1881	37469.80	7046.727683	6
0.5160	51.6012	29331.70	1513550	1.5290	0	0	0.000000	0.0000	64513.80	0	25
0.6485	64.8478	30110.40	1952594	2.7390	0	0	0.000000	0.0000	64822.60	0	39

Localw	***Localp***	***Localper***	***Localee***	***Localcost***	***TotalCost***
0.4	0.000156	0.0156	5932.20	92.54232	1455134.682
0	0	0.0000	3958.40	0	452247.0193
13	0.005753	0.5753	9723.50	5593.9296	1429730.987
8.7	0.004827	0.4827	8474.90	4090.8342	1478904.227
0	0	0.0000	5710.00	0	881704.7421
7	0.005018	0.5018	11366.80	5703.8602	1550027.94
15.2	0.012798	1.2798	9806.10	12549.847	1248852.783
0	0	0.0000	6647.30	0	1628574.3
0	0	0.0000	3451.60	0	391647.1849
0	0	0.0000	5905.20	0	805182.1348
0	0.000000	0.0000	12534.90	0	2067616.459
0	0.000000	0.0000	25840.60	0	2546937.754
0	0.000000	0.0000	23777.80	0	1787718.964
47.7	0.024275	2.4275	10874.10	26396.878	1370321.877
49.5	0.083123	8.3123	29943.10	248896.03	2864618.433
0	0.000000	0.0000	13154.60	0	1573564.51
38.6	0.027004	2.7004	24935.40	67335.554	2346355.945
38	0.037698	3.7698	11366.80	42850.563	1582828.315
108.5	0.064492	6.4492	6363.30	41038.194	1242486.848
114.7	0.018572	1.8572	86618.50	160867.88	7266363.042
23.8	0.012097	1.2097	88481.60	107036.19	9912079.903
8.2	0.007677	0.7677	3451.60	2649.7933	388300.9208
0	0.000000	0.0000	5905.20	0	995566.522
16	0.010030	1.0030	30545.30	30636.936	912666.7625
93	0.130052	13.0052	33047.90	429794.55	3164884.834
140.6	0.082141	8.2141	33342.90	273881.91	3164494.486

APPENDIX D. QUARRY DATA

Appendix D shows quarry information that was used for this research. This table contains information about site numbers (SITE #), site types that recorded in the SHPO database (SITE TYPE), and locations of quarry or lithic source areas (AREA). CANM refers to quarry/lithic source areas found in Canyon of the National Monument in Colorado and Utah. The UTM coordinates and elevation of each quarry is reported (UTMEast, UTMNorth; Elevation). I used a x-mark to note whether or not I visited these quarries or lithic source areas. Finally, I provided information about raw material types that present in each quarry (MATERIAL TYPE). Abbreviations and notes of material types are noted in Table 3.1. in Chapter 3.

SITE #	***SITE TYPE***	***AREA***	***UTMEast***	***UTMNorth***	***ELEVATION***	***VISITED***	***MATERIAL TYPE***
5MT.4973	OPEN LITHIC; STONE QUARRY	CANM	673357	4128072	5046	X	SALT WASH QUARTZITE
5MT.9235	OPEN LITHIC; QUARRY?	CANM	674343	4131145	5018	X	MORRISON
5MT.9236	OPEN CAMP; QUARRY-STONE	CANM	674509	413054	5036	X	MORRISON
5MT.4925	STONE QUARRY	CANM	674922	4125766	4976	X	MORRISON
5MT.9237	OPEN LITHIC; QUARRY	CANM	674751	4130984	5028	X	MORRISON
5MT.7590	OPEN ARCHITECTURAL; STONE QUARRY	CANM	674955	4142448	5554	X	BROWN SANDSTONE
5MT.9242	OPEN ARCHITECTURAL; QUARRY	CANM	675910	4129306	5045	X	KBC & MORRISON
5MT.8005	OPEN CAMP; STONE QUARRY	CANM	677185	4130809	5103	X	KDBQ, KBC, CHALCEDONY
5MT.631	QUARRY-STONE	CANM	677491	4125423	5110	X	MORRISON
5MT.628	STONE QUARRY; OPEN CAMP	CANM	677744	4126239	5334	X	KDBQ, CHERT, CHALCEDONY, GREEN KBC
5MT.9215	OPEN CAMP; QUARRY?	CANM	677968	4127564	5317	X	KBC, CHALCEDONY, POOR KDBQ, JASPER
5MT.8398	STONE QUARRY	CANM	678131	4127159	5217	X	POOR GRAY/WHITE KDBQ, MORRISON, & CONGLOMERATE
5MT.9734	OPEN CAMP; QUARRY	CANM	678417	4126709	5192	X	POOR KDBQ, KBC, CHERT, CHALCEDONY
5MT.8399	STONE QUARRY	CANM	678334	4127314	5280	X	KDBQ CHERT, CHALCEDONY
5MT.4304	OPEN CAMP; STONE QUARRY	CANM	680500	4145920	5786	X	MORRISON
5MT.8082	OPEN LITHIC; STONE QUARRY	CANM	680246	4130747	5222	X	WHITE AND GRAY KDBQ
5MT.8160	STONE QUARRY	CANM	681249	4132676	5133	X	KDBQ
5MT.10574	QUARRY-STONE	CANM	681626	4150978	6116	X	YELLOW AND RED KBC

SITE #	***SITE TYPE***	***AREA***	***UTMEast***	***UTMNorth***	***ELEVATION***	***VISITED***	***MATERIAL TYPE***
5MT.10444	OPEN LITHIC; QUARRY	CANM	682149	4131697	5353	X	KDBQ, CHERT, YELLOW KBC, CHALCEDONY
5MT.7401	STONE QUARRY	CANM	682292	4145632	5904	X	POOR WHITE KDBQ
5MT.10305	QUARRY	CANM	682411	4132153	5360	X	KDBQ, WHITE AND YELLOW KBC, CHALCEDONY
5MT.10303	OPEN LITHIC; QUARRY	CANM	682582	4128420	5493	X	POOR KDBQ
5MT.10456	QUARRY-STONE	CANM	682468	4128176	5571	X	YELLOW AND WHITE KBC, KDBQ, CHALCEDONY, JASPER
5MT.1996	OPEN LITHIC; STONE QUARRY	CANM	682697	4128812	5610	X	KDBQ, CHERT, GREEN AND WHITE KBC, CHALCEDONY
5MT.4907	STONE QUARRY	CANM	682810	4135450	5571	X	KDBQ, KBC, CHALCEDONY
5MT.7958	STONE QUARRY	CANM	683135	4147541	6050	X	WHITE AND GRAY KDBQ, YELLOW AND WHITE KBC, MORRISON, CHERT (FROM CONGLOMERATE)
5MT.9298	STONE QUARRY	CANM	683113	4146258	5964	X	KDBQ, MORRISON
5MT.7960	OPEN ARCHITECTURAL; STONE QUARRY	CANM	683271	4146514	5944	X	MORRIOSN
5MT.9299	OPEN CAMP; STONE QUARRY	CANM	683512	4146622	5958	X	MORRISON
5MT.6345	STONE QUARRY; OPEN LITHIC	CANM	683376	4141672	5670	X	POOR KDBQ (RED/TAN)
5MT.8013	OPEN CAMP; STONE QUARRY; CEREMONIAL	CANM	684147	4137498	5525	X	POOR SALT WASH SILICIFIED SANDSTONE
5MT.11820	QUARRY-STONE	CANM	683914	4154543	6340	X	KDBQ, KBC, CHALCEDONY
5MT.8014	STONE QUARRY	CANM	684600	4137789	5707	X	JMBC
5MT.9801	STONE QUARRY; QUARRY?	CANM	683915	4146525	6067	X	KDBQ, CHALCEDONY

SITE #	***SITE TYPE***	***AREA***	***UTMEast***	***UTMNorth***	***ELEVATION***	***VISITED***	***MATERIAL TYPE***
5MT.9617	OPEN LITHIC; STONE QUARRY	CANM	685321	4127541	5867	X	POOR SALT WASH SILICIFIED SANDSTONE
5MT.7795	STONE QUARRY	CANM	687187	4119131	5673	X	SALT WASH QUARTZITE, CHERT (FROM CONGLOMERATE)
5MT.9244	OPEN LITHIC; STONE QUARRY	CANM	687810	4128800	6042	X	POOR WHITE AND GRAY KDBQ
5MT.4857	OPEN LITHIC; STONE QUARRY	CANM	693244	4148431	6396	X	KDBQ
5MT.4854	STONE QUARRY; OPEN CAMP	CANM	694900	4149700		X	KDBQ
5MT.8949	STONE QUARRY	UTE	695700	4098160		X	METAQUARTZITE, IGENOUS, APHANETIC MINETTE
5MT.4851	OPEN LITHIC; STONE QUARRY	CANM	700200	4140260		X	KDBQ
5MT.4848	OPEN LITHIC; STONE QUARRY	CANM	700573	4140122	6646	X	KDBQ
5MT.4899	STONE QUARRY; ISOLATED FIND	CANM	706780	4131760	5870	X	KDBQ
5MT.4889	STONE QUARRY	CANM	707388	4134562	5983	X	WHITE, YELLOW, AND GRAY KDBQ, CHALCEDONY
5MT.2746	STONE QUARRY	CANM	708148	4134131	6003	X	POOR WHITE KDBQ
5MT.10512	QUARRY	CANM	709535	4165734	6633	X	MORRISON
5MT.6802	OPEN LITHIC; STONE QUARRY	CANM	713644	4160598	7516	X	METAQUARTZITE (RIVER COBBLE)
5MT.4760	STONE QUARRY	CANM	717490	4152756	6950	X	MORRISON, KDB Q, CHALCEDONY, KBC, RIVER COBBLES
5MT.4744	STONE QUARRY; OPEN LITHIC	CANM	717628	4152417	7010	X	CHALCEDONY, MORRISON, GREEN AND WHITE KBC

SITE #	***SITE TYPE***	***AREA***	***UTMEast***	***UTMNorth***	***ELEVATION***	***VISITED***	***MATERIAL TYPE***
5MT.5532	STONE QUARRY; OPEN LITHIC	CANM	718021	4154562	7117	X	WHITE KDBQ, CHALCEDONY
5MT.5548	STONE QUARRY	CANM	718154	4154852	7078	X	CHALCEDONY, YELLOWISH KBC, YELLOW KDBQ
5MT.4517	STONE QUARRY	CANM	722493	4163598	7632	X	WHITE/RED KDBQ
5MT.4520	STONE QUARRY	CANM	722790	4163709	7574	X	GRAY KDBQ
5MT.4526	STONE QUARRY	CANM	722997	4163719	7365	X	KDBQ
5MT.5821		CANM	683960	4137650			
5MT.15329		CANM	689240	4136564	6024	X	MORRISON
5MT.15339		CANM	689433	4138500	6065	X	KDBQ, MORRISON
5MT.15434		CANM	693445	4139188	6460	X	MORRISON
5MT.4853		CANM	694912	4149905		X	POOR KBC
5MT.15056		CANM	694444	4149713	6478	X	WHITE AND YELLOW KDBQ
5MT.15097		CANM	694734	4149737	6456	X	WHITE KDBQ
5MT.15096		CANM	695341	4150903	6523	X	WHITE KDBQ
5MT.15090		CANM	695425	4150578	6430	X	GREEN KDBQ
5MT.15091		CANM	693904	4150044	6464	X	WHITE KDBQ
5MT.15073		CANM	692900	4149721	6243	X	MORRISON
5MT.15046		CANM	693644	4149523	6408	X	KDBQ, CONGLOMERATE
5MT.15014		CANM	695062	4150673	6406	X	POOR GREEN KDBQ
5MT.8108	STONE QUARRY	UTE	674000	4099900		X	KDBQ
5MT.5291	STONE QUARRY	UTE	683580	4097780		X	IGNEOUS
5MT.8964	STONE QUARRY; OPEN CAMP	UTE	700420	4099370			RIVER COBBLES, METAQUARTZITE, APHANETIC MINETTE (TRACHYBASALT)
5MT.9504	STONE QUARRY	UTE	736360	4103720		X	METAQUARTZITE, IGNEOUS APHANETIC MINETTE
5MT.5295		UTE	688060	4097540		X	METAQUARTZITE, IGNEOUS, APHANETIC MINETTE
5MT.8949		UTE	695700	4098160		X	METAQUARTZITE, IGNEOUS APHANETIC MINETTE

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5MT.5293		UTE	683340	4097340		X	METAQUARTZITE, IGNEOUS, APHANETIC MINETTE
5MT.12261	QUARRY STONE	PRIVATE	674488	4126965	5054	X	JMBC, MORRISON
5MT.8190	OPEN LITHIC; STONE QUARRY	PRIVATE	674368	4128506	5098	X	SALT WASH QUARTZITE
5MT.5491	STONE QUARRY; OPEN LITHIC; ISOLATED FIND	PRIVATE	678546	4133951	5025	X	WHTE KDBQ, KBC, CHERT (FROM CONGLOMERATE), CHALCEDONY
5MT.1983	OPEN LITHIC; STONE QUARRY	PRIVATE	681070	4125300			
5MT.11633	OPEN LITHIC; QUARRY	PRIVATE	682834	4153411	6219	X	KDBQ, CHALCEDONY, & KBC
5MT.8239	QUARRY; OPEN CAMP	PRIVATE	683298	4151011	6158	X	YELLOW KBC
5MT.3905	STONE QUARRY	PRIVATE	710764	4135546	6065	X	KDBQ
5MT.12751	QUARRY?; OPEN LITHIC	PRIVATE	712088	4135288	5954	X	POOR KDB Q
5MT.4781	STONE QUARRY	UNDERWATER	714913	4162172	7043	X	MORRISON & POOR KDBQ
5MT.4769	STONE QUARRY; SHELTERED LITHIC	UNDERWATER	717260	4155950	6900		MORRISON, KBC, METAQUARTZITE (RIVER COBBLE), INDURATED SHALES
5MT.2186	OPEN CAMP; STONE QUARRY	UNDERWATER	717623	4158101	6881		METAQUARTIZTE (RIVER COBBLE)
	QUARRY	CANM	690896	4149248	6400	X	KDBQ
	QUARRY	CANM	696817	4140184	6731	X	KDBQ
5MT.5675	QUARRY	CANM	674650	4122950			
5MT.5385	QUARRY/SHELTER?	CANM	718211	4150111	6897	X	KDBQ
	QUARRY	CANM	675414	4128445	5055	X	JMBC
5MT.5096	QUARRY	CANM	717805	4158297	7026	X	KDBQ, KBC, CHALCEDONY
5MT.5533	LITHIC SCATTER	CANM	719702	4156245	7008	X	KDBQ

SITE #	***SITE TYPE***	***AREA***	***UTMEast***	***UTMNorth***	***ELEVATION***	***VISITED***	***MATERIAL TYPE***
5MT.4671	STONE QUARRY	DOLORES	717399	4158277	6210		MORRISON, KBC, CHALCEDONY
5MT. 4819		CANM	679118	4157472	6060	X	MORRISON, JAPSER, JMBC
		DOLORES	717191	4156117	6892	X	CHALCEDONY, KDBQ
		PRIVATE	682582	4132695	5156	X	KDBQ, WHITE KBC, CHALCEDONY
5MT16630		CANM	704680	4140740		X	KBC
5MT264		CANM	685296	4168126	6220		
Chapin Gravel		MESA VERDE	725482	4111636	7000	X	GRAVEL DEPOSITS
River Cobble in Mancos Canyon		MESA VERDE			6000	X	RIVER COBBLES, METAQUARTZITE, APHANETIC MINETTE (TRACHYBASALT)