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REPORTS

Going with the Flow: The Impact of Holocene Fissure Eruptions on Obsidian Source Use in Southeastern Idaho

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A chemical analysis of diagnostic projectile points from the Craters of the Moon National Monument and Preserve in southern Idaho suggests that direct procurement of raw material from local obsidian sources was a long-term pattern in the region. However, significant trends in the frequency of specific sources associated with particular projectile point types were noted in this study. Statistical tests suggest that these trends are linked with atlatl versus bow and arrow technology. Although changes in mobility or population movements could have influenced this pattern of distribution, a more reasonable explanation for fluctuations in the frequency of particular sources suggests that they may be due to barriers created by Holocene lava flows that coincidentally prevented access during specific time periods.

Due to the recent accrual of relatively large data sets, the application of obsidian chemical analyses in archaeological research has shown them to be an extremely useful analogue for human mobility on a regional scale (e.g., Eerkens and Rosenthal 2004; Ericson 1982; Jones et al. 2003; Yacobaccio et al. 2004). With its plethora of local obsidian sources, southern Idaho's Snake River Plain provides an excellent opportunity to both examine patterns in the distribution of obsidian from a diachronic perspective and to consider the behavioral correlates potentially responsible for such patterns.

While previous studies on the Snake River Plain have already attempted to decipher patterns in the transportation of obsidian within the region, these efforts have been somewhat frustrated by the lack of temporally sensitive data (Holmer 1997; Hughes and Pavesic 2005; Plager 2001). Despite these limitations, a consistent pattern of local source utilization has emerged, prompting Holmer (1997:192) to discount the possibility "of complex trade systems and redistribution centers" in the region. Due to the availability of numerous local sources, obsidian was likely procured directly in conjunction with subsistence activities associated with a highly mobile seasonal round (cf. Basgall 1989). This supposition is congruent with other archaeological evidence suggesting that climatic and vegetational changes over the last 8,000 years did not significantly alter long-term site distribution patterns, and—by implication—were not sufficient to alter mobility or subsistence practices in the region in any major way (Henrikson 2002).

With financial support from the National Park Service, recent archaeological research on the Craters of the Moon National Monument and Preserve (Fig. 1) provided the opportunity to reexamine our current understanding of aboriginal mobility by determining how far temporally diagnostic obsidian projectile points collected from a specific sector of the Snake River Plain had been transported from their source of origin. While the results of this study suggest that direct procurement was a long-term pattern in the region, there are significant trends in the frequency of specific sources associated with certain projectile point types. Although these trends are statistically significant and appear to be associated with dart versus arrow points, there is no evidence to suggest that certain sources had characteristics that were preferred for specific technologies. Because raw materials from available sources did not create limitations in the manufacture of particular stone tools, other explanations need to be pursued. Although changes in mobility or population movements need to be considered, the unique geography of the region may have also influenced patterns of obsidian utilization.

ENVIRONMENTAL SETTING

The Craters of the Moon National Monument and Preserve in southern Idaho encompasses 750,000 acres, of which almost 500,000 are covered by late Pleistocene and Holocene basalt flows (Fig. 1). The remaining acres are primarily contained within *kipukas*, a Hawaiian term that refers to an island of vegetated land surrounded on all

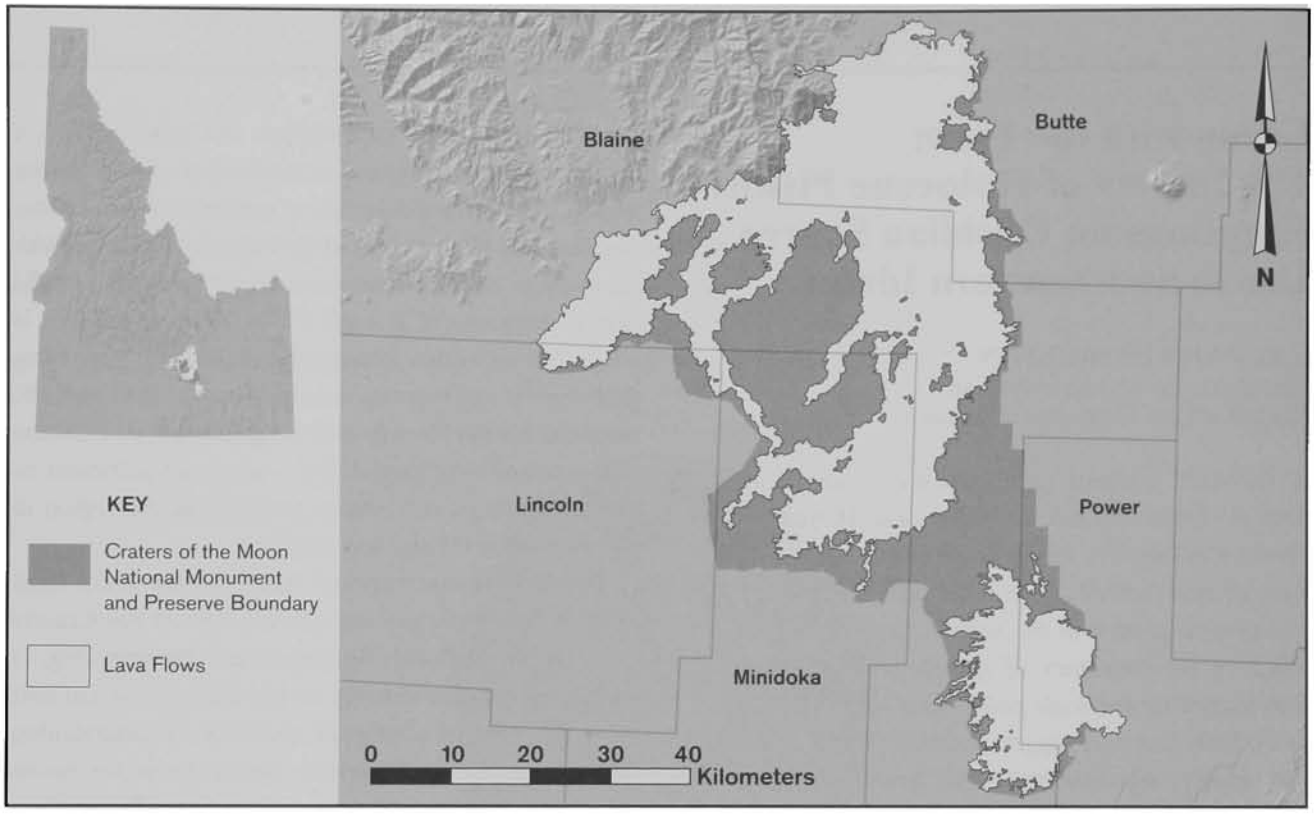

Figure 1. View of Craters of the Moon National Monument and Preserve, showing the location of Holocene lava flows.

sides by lava. The Preserve is located in a sagebrush-steppe environment with elevations ranging from 1,500 to 2,000 meters above sea level. Winter snow and early spring rains produce less than ten inches of annual precipitation (Butler 1978). The region, bordered by the Basin and Range Province to the south and the Northern Rocky Mountain Province to the north, is characterized by landforms of low topographic relief. These include rolling basalt pressure ridges, shallow basins, swales, knolls, buttes, and vegetated areas surrounded and isolated by lava flows (*kipukas*). These features were created primarily by pahoehoe basalt flows from low shield volcanoes and fissure eruptions ranging from Pliocene to Holocene in age (Greeley and King 1977; Kuntz et al. 1992). Sediments consist primarily of aeolian-deposited silty or sandy loams, with most accumulations occurring on the lee sides of prominent land features. The Snake River, the region's only major waterway, transects the Plain, arcing east to west. Because of the incline of the plain and catastrophic events such as the Bonneville Flood around 14,000 years ago (Currey and James 1982), much of the river corridor is characterized by deep, narrow gorges.

REGIONAL CHRONOLOGY

A projectile point chronology for the eastern Snake River Plain has been developed, with slight variations, by Butler (1986), Franzen (1981), Holmer (1995, 1997, 2008), Reed et al. (1986), and Ringe (1993). This chronology has been employed here to structure the analysis of archaeological data from the Preserve.

The terminal Pleistocene/early Holocene period on the eastern Snake River Plain is generally characterized by large fluted, stemmed, and lanceolate points. Most have been found in an isolated surface context (Titmus and Woods 1992), but they are thought to be contemporaneous with Clovis, Folsom, and Plano projectile points from datable contexts on the Great Plains. Large stemmed and lanceolate forms, referred to in the region as Windust, Great Basin Stemmed, Agate Basin (Butler 1968), and Birch Creek (Swanson 1972), appear between ca. 10,000–7,500 B.P.

The beginning of the middle Holocene (7,500 to 5,000 B.P.) is delineated by the appearance of Bitterroot or Northern Side-notched dart points (Miller 1972; Swanson 1972) with Stemmed Indented-base points and

lanceolate points of the McKean tradition occurring between 5,000–3,500 B.P. (Henrikson 2002; Holmer 2008). Although a time frame of 3,500–1,500 B.P. was originally proposed for Elko Corner-notched points (Holmer 1995, 1997), recent studies suggest that this point type may have a much lengthier chronology in the region, possibly ranging from 7,500 to 1,200 B.P. (Arkush 2002; Holmer 2008).

The development and domination of bow and arrow technology and the use of small corner-notched points (Rose Spring and Eastgate) emerge around 1,700 B.P. (Holmer 1986; 1997). It is uncertain when pottery first appears in the region, but it is clearly associated with Desert Side-notched and Avonlea points, which dominate point assemblages between 750 B.P. and the historic period (Holmer 1997; Holmer and Ringe 1985).

METHODS

Although previous studies of obsidian utilization on the Snake River Plain have primarily included nondiagnostic artifacts and waste flakes (Holmer 1997; Plager 2001; Thompson 2004), diagnostic projectile points were considered to be much more useful in a study designed to address potential changes in obsidian use through time.

The Preserve contains over 600 documented archaeological sites and isolated finds, of which 68 produced temporally-diagnostic projectile points. A total of 133 projectile points from sites within the study area were submitted for geochemical analysis. The majority of these were collected during intensive pedestrian surveys associated with large-scale fire rehabilitation efforts over the past twenty-five years. To date, roughly 20% of the Preserve has been intensively inventoried.

Prehistoric archaeological sites on the Preserve are suggestive of short term occupation, with artifact assemblages representative of field camps or short-term base camps occupied for several days or weeks (Henrikson 2002; Henrikson et al. 2006). This pattern of high residential mobility and seasonal use appears to have remained stable until shortly after 1,000 B.P., with recent evidence suggesting more intensive use of the area after that time period (Henrikson and Pace 2006).

To reduce sampling bias, points from a wide range of sites within the study area were selected for analysis (Fig. 2). In many cases, several projectile points from multi-component sites were included. The geochemical analyses were performed by the Northwest Research Obsidian Laboratory. Points were attributed to a source only if their trace element values fell within two standard deviations of the known upper and lower limits of a source's chemical finger print (Skinner 2005a, 2005b, 2006a, 2006b, 2006c).

The analyses involved 51 middle Holocene projectile points, of which 12 were Northern Side-notched, 19 were Stemmed Indented-base, and 20 were McKean lanceolate. Eighty-two late Holocene points were analyzed, including 25 Elko Corner-notched, 26 Rose Spring, and 31 Desert series projectile points (including small side-notched, Avonlea, and Cottonwood Triangular).

To date, no fluted points have been found on the Preserve. There are only two projectile points that can likely be assigned to the early Holocene. These crypto-crystalline silicate lanceolate specimens are similar to Agate Basin-style points recovered from the Wasden Site (Butler 1968). The scarcity of terminal Pleistocene/early Holocene sites within the region encompassing the Preserve has been addressed elsewhere (Long 2007).

RESULTS

The results of the research indicate that the obsidian utilized in projectile point manufacture originated from ten identified sources across southern Idaho (Fig. 3). These sources include American Falls, Bear Gulch, Big Southern Butte, Brown's Bench, Cannonball Mountain, Malad, Owyhee, Teton Pass, Timber Butte, Wedge Butte, and two unknown sources. Three sources, including Big Southern Butte (33%), Brown's Bench (32%), and American Falls (15%), make up 80% of the assemblage (Fig. 4). The remaining sources (Cannonball Mountain, Malad, Owyhee, Teton Pass, Timber Butte, and Wedge Butte) account for roughly 20% of the sample. A total of four projectile points are associated with as yet unidentified obsidian sources. These specimens are not included in the statistical analyses because the distance to source could not be determined. According to Skinner (personal communication, 2006), Unknown Source One was initially recognized during the Butte Valley project in eastern Nevada. However, recent analyses indicate that this source may be located in the Bennett Hills to the west of the study area (Skinner, personal communication 2008). Unknown Source Two is also suspected of being local, based on its chemical signature.

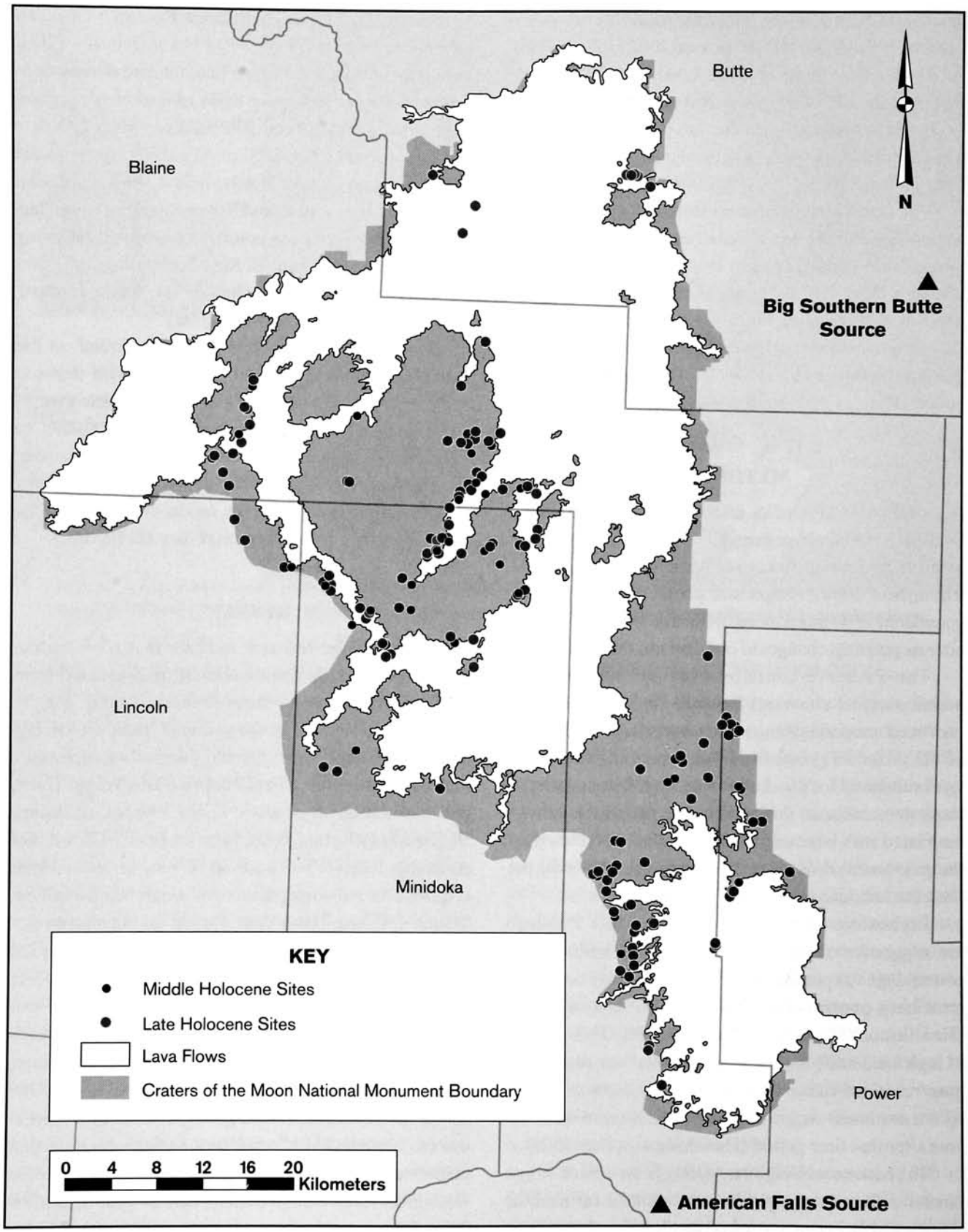

Figure 2. Location of sourced projectile points within the study area.

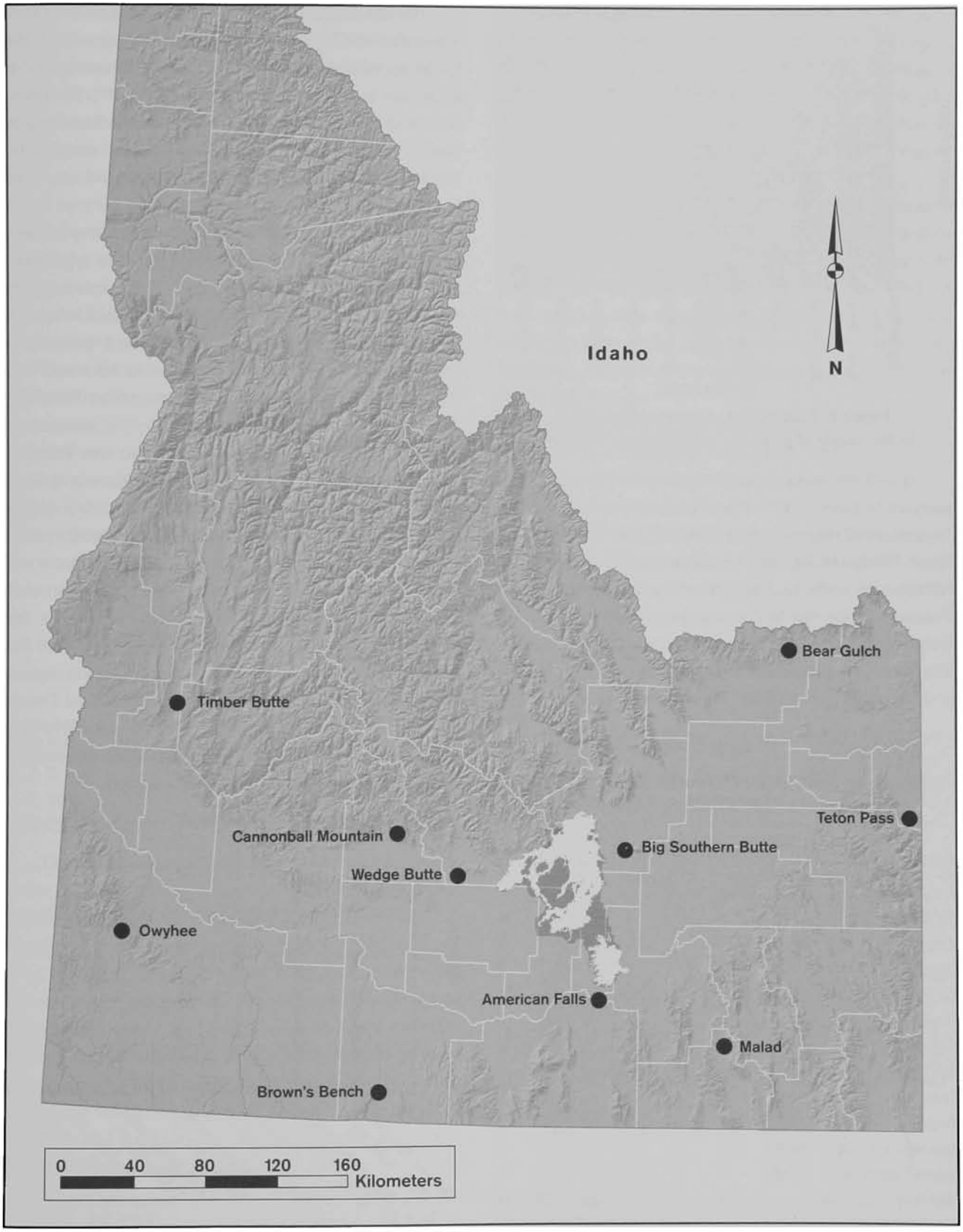

Figure 3. Sources of obsidian utilized in projectile points collected from the Craters of the Moon National Monument and Preserve.

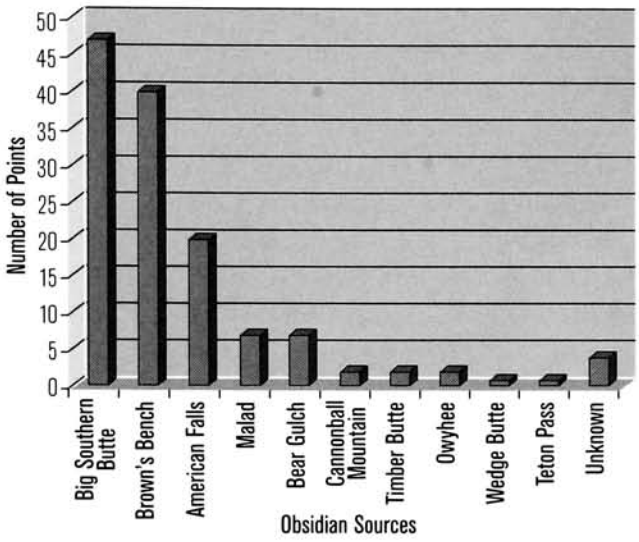

Figure 4. Distribution of sources represented in the sample of projectile points from the Preserve.

All of the sources represented in the sample of projectile points from the Preserve are within 275 kilometers of the study area (Table 1). The Big Southern Butte, Wedge Butte, and American Falls sources, located between 35 and 65 kilometers away, are nearest to the Preserve, while the Malad, Cannonball Mountain, and Brown's Bench sources are all within 150 kilometers. The Teton Pass, Bear Gulch, Timber Butte, and Owyhee sources are in excess of 200 kilometers away.

Table 1

AVERAGE DISTANCE OF OBSIDIAN SOURCES REPRESENTED IN PROJECTILE POINTS FROM THE MONUMENT

Source	Distance (km.)	NSN	SIB	MCK	ECN	RS	DS
American Falls	35	3	3	5	4	3	2
Big Southern Butte	35	5	3	4	8	13	14
Wedge Butte	65	0	0	0	0	1	0
Malad	100	1	1	1	0	2	2
Cannonball Mountain	110	1	1	0	0	0	0
Brown's Bench	150	2	10	9	8	6	5
Teton Pass	205	0	1	0	0	0	0
Bear Gulch	215	0	0	0	2	0	5
Timber Butte	240	0	0	0	1	0	1
Owyhee	275	0	0	0	0	0	2
Unknown Source One	Unknown	0	0	1	0	0	0
Unknown Source Two	Unknown	0	0	0	2	1	0
Total (n=)		**12**	**19**	**20**	**25**	**26**	**31**

Key: NSN = Northern Side-notched, SIB = Stemmed Indented-base, MCK = McKean, ECN = Elko Corner-notched, RS = Rose Spring, DS = Desert Series.

For this study, distance from source calculations were generated in GIS by measuring the distance from the UTM coordinates provided for sites to source locations identified in previous studies (Holmer 1997). However, it should be noted that some of the obsidian sources identified in the study area are not represented by localized outcrops, but extend over large areas (e.g., Brown's Bench).

The distances of individual projectile point specimens from the study area, grouped according to type, have been plotted in Figure 5. Although the graph suggests a gradual increase in the distance over which obsidian projectile points have been transported from their source of origin through time, it should be noted that three sources, Big Southern Butte, American Falls, and Brown's Bench, consistently dominate the assemblage throughout the middle and late Holocene (see Table 1). The suggestion of a bimodal distribution in source distances in the McKean and Elko Corner-notched samples reflect the discrete clustering of projectile points originating from nearby sources (Big Southern Butte and American Falls) and the more distant source, Brown's Bench. One Elko Corner-notched point is from the Timber Butte source, and two Elko points are from the Bear Gulch source, located in excess of 200 kilometers away (see Fig. 3; Table 1). The pattern of sourced Desert series points from the Preserve is more indicative of a trimodal distribution, with seven specimens represented by sources greater than 200 kilometers away.

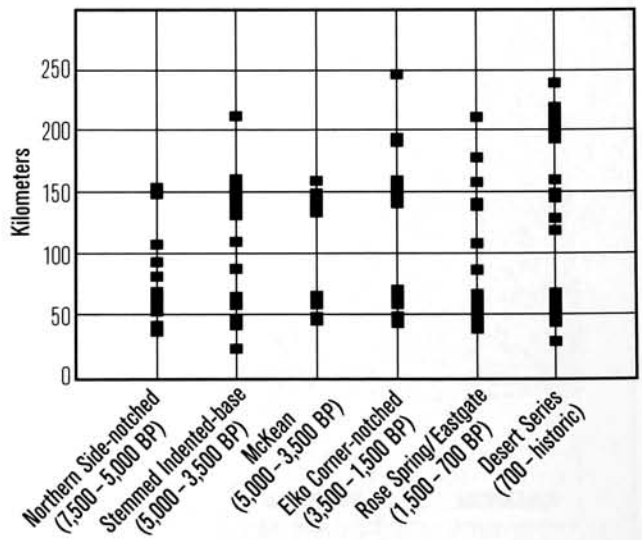

Figure 5. Graph showing the distance from source for individual projectile point types collected from the study area.

Although Figure 5 suggests the possibility that obsidian projectile points traveled greater distances from their source during later time periods (most notably Desert Series points), a simple statistical test was used to evaluate whether this pattern may reflect actual differences in transport distances. Because the source distances between Northern Side-notched and Desert Series samples were the most disparate (see Fig. 5), these two data sets were compared using the Kolmogorov-Smirnov test. This statistical procedure "examines the difference between two samples which have been measured in ordinal categories [and] arranged into a set of cumulative proportions" (Thomas 1986:322).

The null hypothesis of this test maintains that there will be little difference in transport distances between the cumulative proportions of Northern Side-notched and Desert Series points; the greater the difference between these proportions, the less likely that the null hypothesis is true. Table 2 compares the cumulative proportions of the two projectile point types.

Table 2

COMPARISON OF NORTHERN SIDE-NOTCHED AND DESERT SERIES POINTS IN THE STUDY AREA IN RELATION TO DISTANCE FROM SOURCE

Distance from Source (km.)	Northern Side-notched (N=12)		Desert Series (N=31)		Difference
	Raw	Cum. %	Raw	Cum. %	
0-75	7	0.583	16	0.516	0.067
75-150	5	0.416	6	0.166	0.250
150-225	0	0.000	9	0.290	0.290

The largest deviation between the two samples is seen in the proportion of Northern Side-notched and Desert Series points that have traveled between 150 and 225 kilometers from their source. This figure (0.290), referred to as the "D Statistic" in the Kolmogorov-Smirnov test (Thomas 1986), represents the "observed" difference between the cumulative proportions of Northern Side-notched and Desert Series points. The observed value of D must then be tested against the critical value of D, which in this case will be set at the 95% confidence interval (or $\alpha = 0.05$). The following formula will generate the critical value of D under these conditions:

$$1.36\sqrt{\frac{n1 + n2}{n1n2}} \quad \text{or} \quad 1.36\sqrt{\frac{12 + 31}{12 \times 31}}$$

These calculations resulted in 0.462 as the critical value of D. Because the observed value of D (0.290) is well below the critical value of D, the null hypothesis can not be rejected. Based on the current sample, the difference in transport distances between Northern Side-notched and Desert Series points is not statistically significant at the 95% confidence level.

These results likely reflect the long term, consistent use of local obsidian in the manufacture of projectile points with more distant sources represented in relatively insignificant proportions (see Fig. 4). While a larger data set may alter these results, it is apparent that the consistent, heavy reliance on local sources may offset any potential evidence of increased mobility or expanding interaction spheres.

Although the Kolmogorov-Smirnov test did not demonstrate a significant increase in transport distance through time, there appear to be notable changes in the frequency with which local sources are represented in specific projectile point types. At the beginning of the middle Holocene, the sample of Northern Side-notched points from the Preserve exhibits a relatively equitable distribution between the three primary local sources (Fig. 6), while the frequency of the Brown's Bench source doubles in the sample of Stemmed Indented-base

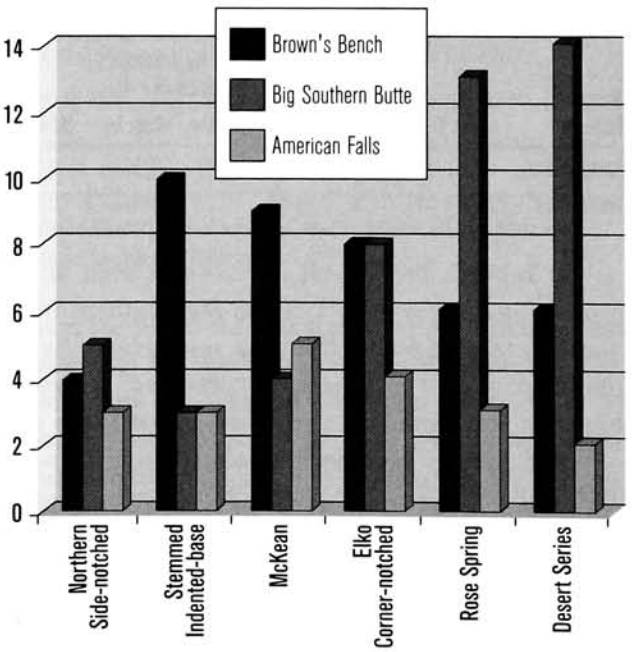

Figure 6. Frequency of Brown's Bench, Big Southern Butte, and American Falls obsidian present in projectile points from the Preserve.

and McKean points, both of which date between 5,000 and 3,500 B.P. in the study area. The use of Brown's Bench obsidian then proceeds to decline in conjunction with an increase in Big Southern Butte obsidian, with a notable spike in the use of Big Southern Butte obsidian represented in the Rose Spring and Desert Series assemblages (see Fig. 6).

The Kolmogorov-Smirnov test can also be applied here to evaluate the significance of fluctuations in local source use. Because the frequency of projectile points generated from the American Falls source appears to be relatively stable through time, these specimens were not included in the test. The null hypothesis in this case maintains that there will be little difference in the cumulative proportions of Brown's Bench and Big Southern Butte obsidian in the sample of diagnostic projectile points from the Preserve. Because the trends noted in Figure 6 appear to be correlated with atlatl versus arrow point technology, the test was constructed accordingly. Table 3 presents the cumulative proportions of Brown's Bench and Big Southern Butte obsidian represented in each technological type.

Table 3

COMPARISON OF THE PROPORTIONS OF BROWN'S BENCH AND BIG SOUTHERN BUTTE OBSIDIAN IN ATLATL AND ARROW POINTS FROM THE STUDY AREA

Projectile Point Type	Age (years B.P.)	Brown's Bench (N=40)		Big Southern Butte (N=47)		Difference
		Raw	Cum. %	Raw	Cum. %	
Arrow Points	1,500 - 0	11	0.275	27	0.574	0.299
Dart Points	7,500 - 1,500	29	0.725	20	0.425	0.300

In Table 3, the largest deviation is seen in the proportion of Brown's Bench and Big Southern Butte obsidian in dart points from the assemblage. Again, this figure (0.300) represents the "observed" difference between the cumulative proportions of these two obsidian sources in projectile points dating between 7,500 and 1,500 years B.P. Testing the observed value of D against the critical value of D (at the 95% confidence interval, or $\alpha = 0.05$), can be done by using the following formula:

$$1.36\sqrt{\frac{n1 + n2}{n1n2}} \quad \text{or} \quad 1.36\sqrt{\frac{40 + 47}{40 \times 47}}$$

These calculations resulted in 0.292 as the critical value of D. Because the observed value of D (0.300) is above the critical value of D, the null hypothesis is rejected. In other words, the proportion of Brown's Bench obsidian in dart points is statistically significant at the 95% confidence level. Assuming that the quality of the Brown's Bench and Big Southern Butte sources remained relatively equitable and that they were consistently productive, there appears to be a genuine increase in the occurrence of Brown's Bench obsidian in middle Holocene atlatl points within the boundaries of the study area. The test also demonstrates that the proportion of Big Southern Butte obsidian is indeed higher in arrow points (with an observed value of 0.299). Because this figure also exceeds the critical value of D, the null hypothesis is again rejected. The proportion of Big Southern Butte obsidian in arrow points from the study area is statistically significant at the 95% confidence level.

DISCUSSION

The preponderance of local obsidian represented in projectile points from the Preserve suggests a pattern of direct procurement extending through most of the Holocene. If subsistence patterns remained relatively stable through much of the Holocene, obsidian from nearby sources such as Big Southern Butte (representing 33% of the assemblage) and American Falls (representing 15% of the assemblage) could have been acquired as part of the seasonal subsistence round and transported to sites within the study area in the form of blanks, cores, tools, or finished projectile points. While the Brown's Bench source is more than 100 kilometers away, finished tools and/or raw materials from this source were clearly being transported to the study area as early as 7,500 years ago, either directly or through interactions with other, perhaps related, groups. It should also be noted that the Brown's Bench source was near important salmon fishing locations along the Snake River, and served as a spring destination for the Northern Shoshone, Bannock, and Paiute during the ethnographic period (Murphy and Murphy 1960, 1986; Steward 1938).

Significant fluctuations in the frequency of Brown's Bench and Big Southern Butte obsidian represented in dart versus arrow points from the study area (see Fig. 6)

are likely not related to the character or availability of each source. Both sources are known to have contained high quality raw material of sufficient size to produce large tools. However, before these fluctuations are attributed to changes in resource availability, mobility, or shifts in territorial range (which have not been detected in regional site distribution patterns), the unique character of the local geography should be considered as a potential trigger. It is suspected that Holocene volcanic eruptions in the study area may have significantly influenced the seasonal movement of people. The Craters of the Moon lava field is the largest in the continental United States and includes over 60 individual flows from cones or fissure eruptions (Fig. 7). These eruptions range in age from 15,000 B.P. to 2,100 B.P. (Kuntz et al. 1986, 1992) and have been associated with eight separate eruptive periods.

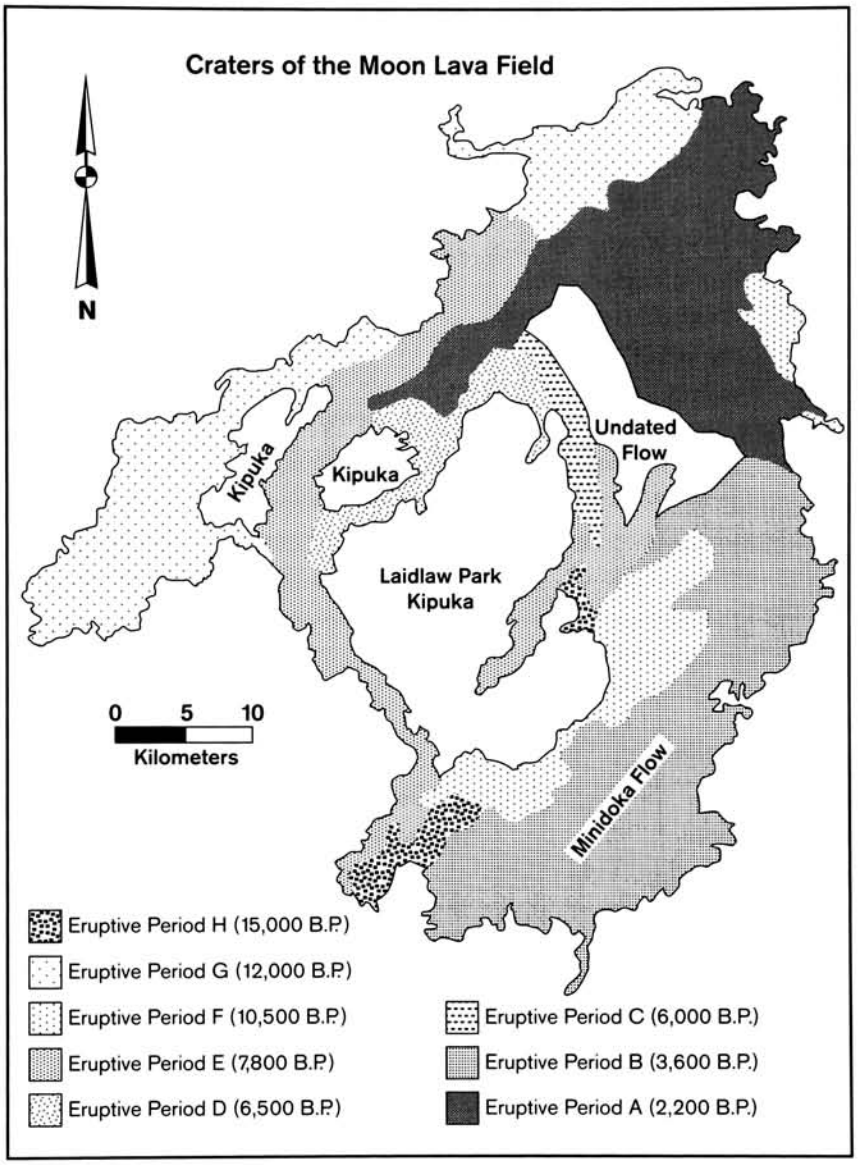

Figure 7. Eruptive periods documented in the Craters of the Moon lava field (adapted from Kuntz et al. 1992).

Based on radiocarbon dates from charcoal recovered under individual flows, Eruptive Periods E, F, G, and H occurred during the Terminal Pleistocene and early Holocene, and lava flows associated with Eruptive Period E appear to have created the *kipuka* constituting Laidlaw Park (see Fig. 7). However, it is uncertain whether the dearth of early Holocene points within the Preserve can be attributed to active fissure eruptions during this time frame. Long (2007) argues that human groups would have ignored the region encompassing the Preserve during the Terminal Pleistocene and Early Holocene, opting for richer resource patches associated with perennial water courses and pluvial lakes to the east.

Eruptive Periods B, C, and D occurred during a time frame roughly corresponding to the middle Holocene. Eruptive Period B and its associated flows range in age between 4,500 and 2,600 B.P. The largest of the Period B flows is the Minidoka, situated about fifteen kilometers southwest of Big Southern Butte (see Figs. 3 and 7). This massive flow is roughly 40 kilometers long and 5 to 10 kilometers wide, extending from the northern end of the Preserve to the Wapi lava field to the south. It is thought to have occurred around 3,600 B.P. (Kuntz et al. 1986). Eruptive Period A, the youngest of the Holocene flows, dates to 2,200 B.P.

Over 70 dart points were recovered from sites on the Preserve, indicating that periodically-active lava flows did not discourage people from utilizing the *kipukas* during the middle Holocene. However, it is possible that such

flows created barriers during certain periods, prompting people to alter or modify their seasonal movements or traditional subsistence rounds until the flows cooled and became passable. In fact, there are a number of prehistoric trails known to cross flows within the study area (Henrikson et al. 2006).

The seismic activity and heat from a mass of flowing lava the size of the Minidoka flow may have created unsuitable conditions in the immediate area and blocked access to the sagebrush steppe east of the Laidlaw Park *kipuka* for a period of months or years. Other middle Holocene flows associated with Eruptive Periods C and D, identified in the northeastern portion of the Preserve, would have created episodic barriers between the *kipukas* and Big Southern Butte. Eruptive Period A, the most recent lava field, also flowed from fissure eruptions northeast of the *kipukas*, again blocking access to Big Southern Butte from the west during the time frame associated with Elko Corner-notched points.

If middle Holocene lava flows did influence how people accessed and utilized the region encompassing the study area, the preponderance of Brown's Bench obsidian represented in dart points could have been predicted. If active flows periodically hindered east-west movement, access to Big Southern Butte from the *kipukas* would have required traveling over or around extremely dangerous, volatile terrain. However, during these periods, the *kipukas* could still be safely entered from the west and southwest by groups that may have included the Brown's Bench obsidian source in their territorial range.

Following Eruptive Period A at 2,200 B.P., active flows on the eastern Snake River Plain ceased. Although east-west movement across the a'a lava of the Minidoka flow would have been arduous, the danger posed by earthquakes and hot, flowing magma would have been over. Caves and open sites located in small *kipukas*, as well as trails within the Minidoka flow, confirm that people were indeed crossing this rugged landscape after the advent of bow and arrow technology (Henrikson et al. 2006). The surge in the frequency of Big Southern Butte obsidian represented in the 57 arrow points (see Fig. 6) from the Preserve also provides evidence that groups utilizing the *kipukas* had little difficulty accessing this source during the latter part of the Holocene.

CONCLUSIONS

Although the rugged landscape of the Craters of the Moon National Monument and Preserve may appear relatively inhospitable, geospatial analyses suggest a very strong positive correlation between lava edges and prehistoric sites within the study area (Fig. 2; Henrikson et al. 2006). Some potential advantages of residing at lava edges have already been brought to light by Ringe's (1992) analysis of site distributions on the Idaho National Laboratory, located east of the study area. During the winter, the lava edge captures drifting snow, which during spring and early summer months provides essential moisture for grasses and forbs. These highly productive microenvironments would have been attractive to both animals and humans. In addition, numerous alcoves and rockshelters along the lava edge provided shelter from the ever blowing wind.

Diagnostic projectile points recovered from the Preserve substantiate the continual appeal of this region to pre-contact humans, despite potential complications from episodic tremors and fissure eruptions. Because site distribution patterns show little change through time, fluctuations in the frequency of Brown's Bench and Big Southern Butte obsidian in the assemblage are likely due to lava barriers between the *kipukas* and Big Southern Butte during specific time periods, most of which occurred during the middle Holocene. This study also reflects the long-term, consistent use of local obsidian in the manufacture of projectile points, with more distant sources (in excess of 200 kilometers away) represented in relatively insignificant proportions (cf. Holmer 1997; Plager 2001; Reed 1985). Although there may be a slight increase in the frequency with which more distant obsidian sources (i.e., Bear Gulch, Timber Butte, and Owyhee) are represented in arrow points from the study area, existing data suggest that it is not a significant increase.

While the results of the geochemical analysis have enhanced our understanding of aboriginal mobility and land use in the region encompassing the Preserve, questions emerge regarding the relatively low frequency of representation of "local" sources such as Malad and Cannonball Mountain in eastern Snake River Plain assemblages. Although the Malad source is 40–50 kilometers closer to the study area than Brown's Bench, only four percent (4%) of the sampled projectile points

from the Preserve originate from this source. These results correspond with previous geochemical analyses indicating a limited use of Malad obsidian on the eastern Snake River Plain north of the Basin and Range Province (Holmer 1997). This pattern is unlikely to be a reflection of the quality of the source, since Malad material has traveled great distances outside the region (Thompson 2004).

The Wedge Butte and Cannonball Mountain sources, located northwest of the study area (see Fig. 3, Table 1), are also poorly represented in the Preserve sample and in other assemblages from the eastern Snake River Plain (Bailey 1992). While Wedge Butte obsidian (often referred to as "snowflake" obsidian) contains inclusions or phenocrysts that make it more difficult to work than other readily available sources (Gene Titmus, personal communication 2005), significant quantities of Cannonball Mountain material have appeared in Owyhee County sites on the western end of the Snake River Plain (Plager 2001).

Although waste flakes are not sensitive as time markers, future geochemical studies should focus on the frequency of individual sources represented in the wealth of obsidian debitage present at archaeological sites on the Preserve. The frequency of individual sources represented in waste flakes may help to refine or refute the results presented here. Additional studies should also be performed on diagnostic projectile points from beyond the boundaries of the Preserve. As other preliminary studies suggest (Hughes and Fortier 1997; Thompson 2004), Idaho obsidian may have traveled great distances outside the region. Therefore, temporally sensitive patterns in the distribution of obsidian have tremendous potential to expand our understanding of the territorial ranges, mobility, and interaction spheres of pre-contact peoples inhabiting the Intermountain West.

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