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Networked Glass: Lithic Raw Material Consumption and  
Social Networks in the Kuril Islands, Far Eastern Russia

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**Abstract**

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This research assesses the effects of environmental conditions on the strategic decisions of low-density foragers in regards to their stone tool raw material procurement and consumption behavior. Social as well as technological adaptations allow human groups to meet the challenges of environments that are circumscribed due to geographic isolation, low biodiversity, and the potential impacts of natural events. Efficient resource management and participation in social networks can be viewed within the framework of human behavioral ecology as optimal forms of behavior aimed at increasing the chances of successful adaptations to dynamic island environments.

A lithic resource consumption behavioral model is constructed and predictions derived from the model are tested through the analysis of lithic flake debitage from artifact assemblages representing 2,100 years of human occupation in the Kuril Islands of Far Eastern Russia in the North Pacific Ocean. The relative proportions of debitage across lithic reduction sequence stages provides a measure of lithic reduction intensity, which is compared with the model predictions based on the environmental conditions and local availability of lithic resources in six archaeological sites. A specific raw material type, nonlocal obsidian, was further analyzed through a source provenance study that traces the procurement, transportation, and use of obsidian from Hokkaido and Kamchatka in the Kuril Islands. The distribution and diversity of obsidian sources in Kuril Island archaeological sites provide the basis for constructing and analyzing past social networks of human relationships.

Results indicate that the marine-adapted hunter-gatherers of the late Holocene Kuril Islands adapted their lithic technology to meet the conditions of specific island environments in relation to lithic resource availability and subsistence resource predictability, particularly in the Central Kuril Islands. Changes in the level of lithic reduction intensity were detected in conjunction with a change in the specific culture group who occupied the island chain that occurred around 1400 BP. Variation in the distribution and diversity of obsidian from sources in Hokkaido and Kamchatka also coincided with this population change, suggesting a re-orientation of social networks that provided access to nonlocal resources. This study supports the growing body of evidence that living in an island environment does not necessarily equate to living in social isolation, but that insular island societies display a high degree of communication and interaction which may refer to a successful adaptation against the potential perils of isolation.

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**Dedication**

To my wife,  
Kris Phillips

## **Chapter 1: Introduction**

In all parts of the world and throughout time, humans have had to develop strategies for dealing with the unpredictable nature of their environment, and for adapting to the conditions in their environment that change at varying scales. Within the framework of optimization models, it is proposed that behavioral decisions regarding resource procurement and consumption activities are made by low-density foragers with the ultimate goal of maintaining or increasing their fitness in an efficient manner. In some contexts, participation in social networks can be considered an optimal behavioral strategy for mitigating deficiencies in the acquisition of information, or subsistence or material resources. In the Kuril Islands of Far Eastern Russia, foraging groups lived for more than 4,000 years in an isolated environment prone to stochastic natural events and resource unpredictability. Pursuing dual strategies of efficient resource management and participation in social networks arguably allowed these groups to maintain a degree of cultural resiliency in the face of challenges at various scales, from regional climate change to local fluctuations in subsistence resources.

In many archaeological cases, the study of stone tool raw material consumption and the interaction of social groups through the exchange of lithic resources have been pursued as separate research agendas. The lack of integration of these human behavioral components represents a missed opportunity to view technological and social behavior as an interrelated suite of adaptive strategies that can be evaluated in terms of forager behavior optimization models. The current study seeks to bridge the gap between the empirical archaeological record and the socially constructed concept of networks of human relationships in order to explore and understand variation in human adaptive behavior.

### **Islands and Insularity**

In volcanic island environments, the potential factors of geographic insularity, low biodiversity, and stochastic natural events create additional dimensions of complexity that require flexible decision-making and the ability to weigh the costs and risks associated with various behavioral strategies. While island societies are inherently circumscribed by virtue

of their island environments, the geographic and social isolation of these populations has been overstated in the past, and the current view is that many island inhabitants saw the water that surrounded them as a means of communication and transportation rather than a barrier (Erlandson and Fitzpatrick 2006; Irwin 1992; Lape 2004; Moss 2004).

Theories of island biogeography developed in the 1960s in part by MacArthur and Wilson (1967) once provided anthropologists with deterministic models of human variability in island environments (see Fitzhugh and Hunt 1997 for an overview of islands as laboratories in archaeological research). Based on studies of prehistoric exploration of the Pacific, human colonization events have been proven to be systematic, non-random, and purposeful (Irwin 1992, Keegan and Diamond 1987). The ability to expand into and colonize isolated areas coincided not just with biological and ecological characteristics, but also with technological and cultural ones. Additionally, human traits such as intelligence, creativity, perseverance, as well as stupidity and short-sightedness make applying strictly biogeographical principles and models to human cases difficult (Lomolino et al 2006).

Building on his studies of early Polynesian sailing technology, Irwin (1992) challenged the assumptions that living on oceanic islands meant living in isolation. Colonization included not only exploration and settlement, but also the maintenance of “interaction spheres” as evidenced by tracing the movement of different types of materials through the Pacific. Similarly, in their study of the Arawes islands and the Lapita cultural complex, Gosden and Pavlides (1994) found that Lapita connections across the Pacific represented a social strategy of colonization that involved cohesive relationships over large distances and long periods of time.

Islands may not necessarily be good indicators of human population isolation, but the variability found on them creates unique constraints on cultural evolution (Fitzhugh and Hunt 1997). Island inhabitants may be better understood by considering them as a geographical set of local populations that have followed separate but interconnected pathways to local adaptation and culture change (Terrell and Welsch 1990). Such an approach is more critical of models of cultural evolution based on insularity, and emphasizes the importance of interaction and agency in the context of human and island biogeography (Fitzhugh and Hunt 1997).

## **The Kuril Islands**

The Kuril Islands are an appropriate place to explore the limits of human survival and adaptation – not in the sense of treating the islands as pristine laboratories (the remote and sparsely populated Kuril archipelago is not untouched by modern human activity), but because the environmental and ecological conditions that could affect human adaptive behavior are so apparent there, and human behavioral responses should be represented in the archaeological record.

Stretching between the northern Japanese island of Hokkaido and the southern tip of the Russian Kamchatka peninsula, the Kuril archipelago is composed of 32 islands of varying size, environmental and ecological diversity, and primary productivity. The islands at the southern and northern ends of the chain tend to be larger (up to 3200 km<sup>2</sup> in area) and more productive and biologically diverse, while the centrally located islands are small (as small as 5 km<sup>2</sup> in area) and lie in a zone of lower primary productivity. The islands are separated by a number of straits between the Sea of Okhotsk and the North Pacific Ocean, several of which are over 70 km wide and may have, at times, represented significant barriers to the movement of people through the island chain.

The Kuril Islands lie along the tectonically active Greater Kuril Trench, which generates volcanic eruptions, submarine earthquakes, and tsunamis (MacInnes et al. 2009; Melekevtsev 2009). These events occur stochastically but frequently today, and analysis of geological deposits from across the islands indicates that they were not uncommon in the past (MacInnes et al. 2009). The climate of the Kuril Islands is strongly affected by water currents in the North Pacific Ocean and the Sea of Okhotsk and by the weather patterns of continental northeast Asia, and can be generally characterized as severe and unpredictable. Winters are cold with heavy snow; summers are cool with dense fog that surrounds the islands.

While the Kuril Islands represent a geographically isolated and tectonically dynamic environment that would have posed a number of challenges to human colonizers, they also provided a rich subsistence base for human groups with the appropriate adaptations. Marine resources such as sea mammals, sea birds, and fish are abundant in the islands and would have been a significant draw for people to the region. The distribution of subsistence and material resources is highly heterogeneous across the island chain, requiring a variety of

adaptive strategies and behaviors depending on the specific mix of environmental and biological diversity and productivity.

### **A Theoretical Framework**

Human behavioral ecology (HBE) provides a theoretical framework that seeks to explain the complexity of human behavior through the use of models that simplify some of the inherent variability and complexity of human activity (Winterhalder 2001). A key focus of HBE is on the link between variation in environmental conditions, and the human behavioral variation that is seen as an adaptive response to those conditions (Smith 2000). Human behavior is representative of the human phenotype, and the plasticity of human behavior is a result of evolutionary processes such as natural selection that have produced the capacity in humans for developing adaptive strategies (Cronk 1991; Gremillion and Piperno 2009). Much of the initial HBE research focused on resource production behavior, which was operationalized through the development of optimization models aimed at predicting human behavior in specific environmental contexts (Winterhalder and Smith 2000).

Based on microeconomics, evolutionary biology, and Darwinian selection, HBE optimization models make a crucial assumption that individual foragers will choose between different behavioral strategies based on their ability to evaluate the fitness costs and benefits of each choice and to maximize the benefits of their behavior while minimizing the costs. In relation to this type of optimizing behavior, it is assumed that the environment people live in and the information that is available to them provides a set of constraints on the strategy they can actually act upon, and some form of currency (time, energy, risk) is used to evaluate the range of choices (Fitzhugh 2003; Kelly 1995; Wilson 2007). According to Winterhalder (2001), while total foraging optimality is rarely achieved, the selective tendency towards optimization is evidenced by the long-term success of the foraging survival strategy all over the world. Optimization models allow for the generation of testable predictions about a forager's options and constraints, making them inherently useful for the study of human behavior in the context of determining which behavioral strategies may have had adaptive significance (Cronk 1991).

As heuristic devices, optimization models attempt to specify a few basic decision rules based on some form of cost and benefit analysis, which allows for the generation of hypotheses that can be tested with data gathered from the observation of forager behavior (Smith 1983). At a certain level, the archaeological implementation of these models can be problematic, because the archaeological record does not provide observations of behavior, but only the material traces that resulted from that behavior (Boone and Smith 1998). The archaeological record represents the aggregated behavior of multiple individuals which has undoubtedly been transformed by various formation processes (Schiffer 1983, 1987; Smith 2000). Given this construction and transformation of the archaeological record, optimization models are not useful for predicting specific day-to-day activity, but are more appropriate for predicting general behavioral patterns of forager decision-making (Simms 1983). And since it is normally not possible to generate complete information about the prehistoric condition of specific resource abundance and availability (Kuhn 1991, Simms 1983), estimating certain model cost parameters such as search time is difficult at best.

Nevertheless, a great deal of utility has been found in certain types of optimization models, specifically for exploring subsistence resource procurement strategies. Prey-choice and diet breadth foraging models are used to predict the range of plant and animal species hunter-gatherers should pursue and the intensity of their foraging activities (Broughton 2002; Butler 2000; Grayson and Cannon 1999; Grayson and Delpech 1998; Nagaoka 2002; Ugan 2005; Winterhalder and Lu 1997). Central-place foraging models predict patterns of hunter-gatherer movement between residences and distant sites for the purposes of gathering resources (Zeanah 2000), and have been adapted to predict the amount of field processing that should be done to make the transport of resources more efficient in terms of time and energy expenditures (Barlow and Metcalfe 1996; Metcalfe and Barlow 1992). In order to consider what forms optimal lithic resource procurement and consumption behavior might take, it is necessary to review some of the key concepts and decision-making variables related to lithic technological organization including curation, mobility, raw material choice and availability, transport, and procurement methods, all of which are outlined in the next chapter.

Human behavioral ecology and optimization models provide a framework for evaluating the range of behavioral adaptations, specifically the technological and social

behavior that allowed people to thrive in the insular, low-diversity and tectonically dynamic Kuril Island environment. The innovation of new technologies or modification of an existing technological strategy is one type of response to a new or changing environmental condition. Additionally, personal relationships provide humans with the ability to share information, ideas, and resources as a way to mitigate environmental unpredictability. In the Kuril Islands, continued inter-island and island-mainland exchange could have been linked to the long-term economic and biological survival of colonists inhabiting the Central Kurils. Given the environmental and ecological variability present across the Kurils, expectations for human adaptive behavior in different parts of the island chain can be developed from a basic model and tested with empirical data from the Kuril archaeological record. It should be possible to trace the variability of technological and social behavior in the Kuril Islands across time and space in the archipelago.

However, the ability to clearly resolve issues of cultural evolution, interaction, and island occupational sequences in the Kuril Islands is currently hampered by the lack of an interpretive cultural historical framework tailored specifically to the Kuril Islands. It is currently believed the Southern Kuril Islands were first inhabited roughly 7000 years ago, and that concentrated migrations into the Central and Northern Kurils began with the northern movement of Epi-Jomon groups around 2900 BP. The Epi-Jomon of Hokkaido represent the last remnants of the Jomon hunter-gatherers who were indigenous to the Japanese islands between ca. 13,000 and 2900 BP. By 1500 BP, the Epi-Jomon had been replaced in the Kuril Islands by the Okhotsk culture group, a highly marine-adapted population with origins in the Sea of Okhotsk. It is also possible that foraging groups from the southernmost Kamchatka peninsula could have utilized the Northern Kurils, though at this time there is little in the way of diagnostic cultural material to differentiate these occupations. Few artifact typologies exist for the Kuril Islands beyond basic ceramic chronologies tied to the Hokkaido archaeological sequence, and inter-island variation is currently poorly understood. Overall, Kuril artifact assemblages demonstrate little obvious change through time and space with the exception of pottery changes at the period scale (e.g. Epi-Jomon to Okhotsk).

## **Aim and Scope**

The aim of the research presented here is to test the predictions of a model for the efficient use of stone tool-making resources given the variable conditions of lithic resource availability and subsistence resource predictability in the Kuril Islands. A fundamental assumption throughout this study is that patterns in the procurement and use of lithic raw materials can provide reliable information on hunter-gatherer technological and social organization. Consequently, the analysis of lithic reduction intensity provides a basis for developing higher-order interpretations and the evaluation of behavioral models based on archaeological data (Shott and Nelson 2008; Wenzel and Shelley 2001). The provenance analysis of nonlocal lithic resources, such as obsidian, creates an empirical platform from which the origin, direction, and intensity of human social relationships can be traced and characterized.

Given the differences in island location, physical geography, and human colonization and occupation histories, it is reasonable to expect spatial and temporal variability in lithic resource management and social networks across the Kuril Islands. The current study will evaluate this variability detected through comparisons of multiple geographical and chronological assemblages of lithic artifacts from Kuril Island archaeological sites. An attempt will be made to build network structures based on lithic artifact data that can be used to elucidate the nature of social network relationships that played a role in ability of human colonists to survive and thrive in a dynamic environment such as the Kuril archipelago. This will be done within a new chronological framework for the sequence of Kuril Island occupations based on radiocarbon dates.

## **Dissertation Organization**

Chapter 2 outlines the variables that impact lithic resource management strategies and presents a model of lithic technological behavior based on environmental conditions with predictions about specific characteristics of Kuril Island lithic artifact assemblages and social network structures.

Chapter 3 provides a general overview of the natural environment of the Kuril Islands, including the geography, climate, flora and fauna, and geology of the island chain. Chapter 4 reviews the history of archaeological research in the Kurils and the culture-

historical framework that has been developed for the region and is currently in use, and proposes a new chronological designation for Kuril occupation sequences.

The results of flake assemblage lithic analyses are presented in Chapter 5. First, the individual archaeological site contexts and assemblages are described, followed by comparisons of assemblages within and between geographical and chronological groupings. Significant findings about assemblage raw material composition and lithic reduction intensity are discussed in terms of the environmental conditions and expectations of the model.

Chapter 6 describes the obsidian source provenance study, and provides background on obsidian source analysis techniques, as well as the baseline of regional obsidian source data for northeast Asia. The results of the source analysis, and the comparisons of assemblage source diversity measures, are then presented. Chapter 7 utilizes the obsidian source data to build network structures that are analyzed with social network analysis methods in an attempt to quantify the position and role of sites in Kuril Island social networks.

Chapter 8 concludes the research and discusses the overall results in regards to the original predictions, the contributions and broader implications of this study, and future research avenues that can enhance the current study specifically, and advance our currently limited understanding of the human presence in the Kuril Islands generally.

## Chapter 2: A Model of Lithic Resource Procurement, Consumption, and Social Networks

### Introduction

Stone artifacts are the most durable and ubiquitous types of material traces of past human behavior in the archaeological record, and the study of lithic technological organization is a study of the way that people structured their behavior in relation to their production and use of stone tools (Andrefsky 2009). The life history of stone tool artifacts is conceptualized by archaeologists through sequence models made up of a series of discreet steps that capture the stone tool production, use, and discard processes (Bleed 2001). Stone tools are initially crafted from specific lithic raw materials; they may be resharpened when they become dull from use, and/or they may be reshaped into a different form for a different task, perhaps multiple times; and they may be discarded when broken, or simply lost unknowingly. Various forms of sequence models have been used for over 100 years to capture and explain these processes, including Americanist reduction sequence models focused on the context of lithic tool production and use (Andrefsky 2009; Shott 2003), the French *chaîne opératoire* cognitive approach (Leroi-Gourhan 1993; Perles 1992), and the Japanese *giho* concept of structured behavior patterns (Bleed 2001).

Regardless of the perceived differences in the approach, purpose, and theoretical underpinnings between each of these approaches to sequence models, each of them begins with the same first step – procurement of the lithic raw material that is needed to produce stone tools. Before the first flake can be struck to set in motion the process of making and using a stone tool, a number of strategies, tactics, and decisions must be employed which guide the process of obtaining lithic raw material. Procurement is not only the first step in any sequence model, but is arguably the most important step because the specific nature and results of raw material procurement activities directly influence the subsequent steps of the stone tool-making process, and ultimately shapes the lithic assemblages that are deposited into the archaeological record.

While procurement is the most important step in the stone tool production process, the actual strategies and tactics related to obtaining raw material are difficult to see in the archaeological record. Many stone tool assemblages contain artifacts made from a mix of local and nonlocal raw materials, and while single artifacts of nonlocal material may just

represent unique instances of tool curation or a rare trade event or trip to a nonlocal source, an abundance of nonlocal materials suggests more prolonged direct or indirect procurement activities (Beck and Jones 1990). Since lithic material may be consumed while it is being transported back from a logistical direct procurement trip to a source, or it may be consumed as it is passed through a series of trade transactions while being procured indirectly, the resulting lithic assemblages may look very similar. Thus, due to issues of equifinality it is difficult to determine whether nonlocal materials were procured directly or indirectly (Meltzer 1989). One approach to this problem is to consider the optimal conditions for various procurement strategies given the environmental, economic, and social factors that shape procurement.

### *Curation*

Curation as a component of lithic technological organization was initially introduced in by Binford (1973) as a seemingly useful yet vague concept related to tool use and transport behavior. On one hand, he related curation to the transport of tools between sites as part of a mobility system, while on the other hand characterized it as a form of efficient tool use. Over time, archaeologists developed their own uses and attached their own meanings to the concept of curation until it represented a range of ideas about lithic technological organization including tool manufacture in advance of use, multifunctional tool design, tool transport between sites, tool maintenance, and tool recycling (Bamforth 1986). In his essay on curation, Shott (1996:267) attempts to clarify Binford's original ambiguity and to subsume the multiple other uses of curation with his own definition: "the degree of use or utility extracted, expressed as a relationship between how much utility a tool starts with – its maximum utility – and how much of that utility is realized before discard." Shott implies that curation is a continuous property of tool use, and one that is influenced by raw material availability, though he does not specify what lithic assemblages that result from curation behavior might look like. Andrefsky (2009:71) similarly characterizes curation as "a process reflecting a tool's actual use relative to its potential maximum use," which can then be quantified through various measures of tool retouch within the context of raw material availability and quality.

Curation has also been characterized as a form of economizing behavior in regards to the management of lithic raw material. Jeske (1989) defines economy as the management of resources with the goal of maximizing the ratio of yield to cost in terms of procuring and using raw material. The continuum or process of tool use relative to potential maximum tool use as defined above can be thought of as one indicator of the level of economizing behavior that is being exhibited in a lithic assemblage. A hypothesis developed from this concept would be that as the cost of procuring lithic raw material increases, hunter-gatherers will engage in economizing behavior related to their consumption of the raw material (Jeske 1989).

The concept of curation has a “property of significance” (Shott 1996:264) because it is useful for understanding the relationship between behavior and lithic assemblage formation. Curation can be seen as an adaptive response to the high cost of procuring lithic raw material (or the low availability of raw material) with an emphasis on maximizing the consumption of raw material through tool maintenance and recycling activities. The results of these activities should be seen as specific patterns in archaeological assemblages, specifically the debitage assemblages that represent the by-products of tool production, maintenance, and recycling. Depending on ways raw material is distributed and procured, curation activities may vary within a single culture group if the cost and availability of the raw material varies, resulting in differing assemblage characteristics for behaviorally and ethnically identical sites (Bamforth 1986).

### *Mobility*

The technological relationship between mobility and lithics has been explored through models based on Binford’s (1979, 1980) emphasis that mobility patterns were an important aspect of human settlement and land use systems and directly impacted technological organization (Bamforth 1990, 2002; Kelly 1983, 1988; Parry and Kelly 1987; Shott 1986; Thacker 2006; Torrence 1983). Binford differentiated between two settlement/subsistence systems: residential mobility, with the movement of entire hunter-gatherer groups from one residential base to another; and logistical mobility, with the movement of small task groups on temporary trips away from and back to the residential base. Hunter-gatherer groups were then categorized as foragers, who practiced residential

mobility and moved their camps to exploit specific subsistence resource areas, or as collectors who moved their residences less frequently and used logistical trips to acquire subsistence resources that were brought back to the residential base.

The idea that lithic technology exhibited a range of curation behavior in the form of different tool types was mapped onto Binford's hunter-gatherer mobility pattern and subsistence/settlement systems (Andrefsky 1991; Bamforth 1986, 1990; Bleed 1986; Kelly 1988; Nelson 1991). Curated tools were identified as having been made with a great deal of effort represented by a large amount of retouch (such as bifaces and cores), and were associated with foraging groups that practiced high residential mobility in their pursuit of subsistence resources. Expedient tools (such as utilized flakes) were associated with more sedentary, less residentially-mobile collector groups (Andrefsky 2009). Additionally, technological diversity was seen as a relevant measure of mobility, with tool assemblage diversity declining as mobility is increasing (Shott 1986).

#### *Raw Material Choice*

The archaeological record demonstrates that prehistoric stone tool makers utilized a wide variety of lithic raw materials for tool production, and archaeologists have explored the idea that stone tool makers chose lithic materials based on their effectiveness for specific tool tasks (Andrefsky 1994, 2005; Bamforth 2009; Beck and Jones 1990; Close 2006; Frison 1991; Luedtke 1992). Most types of raw materials chosen by stone tool producers such as fine-grained basalt; cryptocrystalline silicates including chert, chalcedony, and petrified wood; and volcanic glass, share basic qualities that make them desirable for stone tool production – homogenous structure and fine-grained texture exhibiting predictable conchoidal fracture capability – properties that archaeologists have used to classify materials as “high quality” (Braun et al. 2009a, 2009b). Bamforth (2009) has noted that in North America, Paleoindian projectile points that required highly precise flaking patterns are primarily made from materials exhibiting those qualities, and Jones et al. (2003) describe a similar relationship between stemmed projectile points and obsidian raw material in the Paleoarchaic Great Basin.

Raw material quality is not necessarily a simple variable, but contains a number of components including package or nodule size and shape, texture, brittleness, and durability

(Andrefsky 2009; Brantingham et al. 2000), making some materials more optimal for some types of tools and tool tasks than others. While obsidian is easily worked and creates an extremely sharp edge, it is brittle and the edge does not hold up well to heavy scraping activities. Chert or basalt provides greater toughness needed to last effectively for tools such as end scrapers. In some cases, humans have consciously chosen to use coarse-grained, “low quality” materials due to some technological requirement such as edge durability (Braun et al. 2009a, 2009b; Hayden 1977).

Raw material quality is also relevant to time scheduling considerations related to the production of stone tools. High-quality, homogeneous raw materials such as chert, chalcedony, and obsidian are useful not only for making tools that require precise flaking pattern, but also because tools made from these materials are easily re-shaped and re-sharpened, and allow the use-lives of the tools to be extended. While useful tools can be created from lower quality, coarse-grained materials, they are not as easily or as effectively maintained. This is an important consideration not only for the conservation of lithic raw material, but also for the conservation of time (Torrence 1983). Producing a brand new bifacially flaked stone tool requires an initial investment in “start-up” time or costs related to the initial procurement of the raw material, removal of cortex, and initial shaping and thinning that are part of the early and middle stages of the reduction process. Using high-quality materials is a way to avoid having to re-invest in the start up costs or time of making a new tool every time one becomes worn or dull, as would be required if using low-quality materials. Thus, the costs of technological investment are as important as the potential benefits when trying to assess the raw material choices available (Ugan et al. 2003).

These choices are important because the qualities or characteristics of a specific raw material may influence the methods of production independent of the skill or cultural technological traditions of the individual tool maker (Dobosi 1991). Several measures including the intensity of reduction and degree of raw material transport have been used to identify and track the variable quality of the raw materials that were available to people (Braun et al. 2009a, 2009b; Hahn 2002; Kuhn 2004; Straus 2002; Wenzel and Shelley 2001).

### *Raw Material Availability*

While it is easy to accept that prehistoric stone tool makers had the agency to make individual decisions about the lithic raw material that was best suited to their needs, the range of choices available to people was a function of the natural lithic raw material availability on the physical landscape. The distribution of lithic raw materials over the earth's surface is highly heterogeneous, with some landscapes/environments containing a multitude of high-quality raw materials, and others practically devoid of any useable stone for tool-making purposes. According to many archaeologists, raw material availability and quality are the most important factors imposing technological constraints on lithic tool production and use (Amick 1999; Andrefsky 1994; Bamforth 1986; Braun et al. 2009a, 2009b; Dibble 1991; Morrow and Jeffries 1989; Wenzel and Shelley 2001; though see Torrence 1989 for an alternative perspective). When raw material is scarce, lithic assemblages exhibit evidence of greater reduction in the form of tool maintenance and rejuvenation activities (Bamforth 1986; Dibble 1987, 1991). Raw material availability also influences stone tool design and the techniques used for their production. Bifacial cores designed to enable production of bifacial tools can be used as tools themselves as well as provide flakes with predictable morphologies to serve as expedient tools or blanks for further reduction. They seem to have evolved in environments with uneven distribution of lithic resources on the landscape as a tactic for always having a sufficient supply of tools and toolstone (Beck et al. 2002; Hiscock 1994). These results demonstrate the utility for viewing the variability of lithic artifact assemblages as a result of adaptive responses to raw material quality and availability (Braun et al. 2009a, 2009b).

The proximity of lithic sources to stone tool makers is an important component of raw material availability that influences raw material selection and consumption. As the length of travel to a lithic raw material source increases, distance becomes a more powerful variable in shaping lithic assemblages (Marks et al. 1991). All else being equal, shorter distances mean that less time and energy must be expended in obtaining raw materials (Bar-Yosef 1991), making locally available materials less costly to procure. When distance to the raw material increases, the cost of procuring that material rises in terms of time, energy, and risk as less time is available for subsistence resource procurement and other activities. A much greater emphasis on maximizing the consumption of more expensive non-local

material should be represented by curated tools and tool maintenance debitage (Beck and Jones 1990).

### *Transport*

The effect of transport distance on lithic assemblage variability has also been evaluated in terms of raw material processing, use, and maximizing the weight of the load that must be transported. The field-processing model applied to lithic raw material predicts that as transport time (i.e. distance) increases, more time should be spent removing useless material through initial reduction activities at the source site in order to make the transport of the material more efficient (Beck 2008; Bettinger et al. 1997; Metcalfe and Barlow 1992). Transport distance may affect the size and abundance of material in a lithic assemblage if that material is repeatedly reduced and consumed (i.e. tools are made and used) during travel from the material source back to the site of its ultimate use (Brantingham 2003; Kuhn 2004; Newman 1994; Wilson 2007). Based on source provenance studies, this relationship was initially explored through a family of distance decay models predicting that the amount of a specific raw material in a site should decrease as the distance from its source increases, also described as the law of monotonic decrement (Renfrew 1977; Renfrew et al. 1966). While many researchers have found the relationship to be quite strong (Beck 2008; Blumenschine et al. 2008, Feblot-Augustins 1993; Newman 1994; Renfrew 1977), others have found the evidence less convincing (Close 1999; Cottrell 1985), and Brantingham (2003) has gone so far as to suggest that raw material procurement may be completely random and not subject to optimizing behavior at all. His neutral model of stone raw material procurement challenges the idea that lithic assemblage variability in terms of representation of raw material types is directly related to human functional or adaptive variability. Using material richness and distance to source as the key variables in the model, Brantingham simulated a forager's encounters and procurement of stone raw materials of equal quality and density that are randomly distributed in an environment. The neutral model provides a null baseline against which to test specific archaeological cases; where the expectations of the neutral model are not met, more interesting examples of adaptive human behavior may exist.

### *Direct vs. Indirect Lithic Resource Procurement*

As outlined above, optimization models provide a basic yet theoretically significant foundation for generating testable hypotheses regarding the optimal consumption of lithic raw material based on a variety of factors and conditions. Given that the use of lithic technology is an important form of hunter-gatherer behavior subject to optimization goals, I believe that these models are appropriate for the study of the variation observed in lithic assemblages representative of group-level decision making.

Strategies for acquiring raw material necessary for stone tool production (and which initiates the successive stages and processes of stone tool production, use, and discard), are defined as either direct or indirect procurement. Direct procurement occurs when an individual or group travels directly to a raw material source and obtains the material themselves. Indirect procurement occurs through some form of exchange relationship. Within these basic definitions, there is no *a priori* assumption being made about the specific conditions that might influence one form of procurement behavior over the other (such as geographic distance to the material source or issues pertaining to territorial access). Optimization models can guide the logical assumptions about when direct or indirect procurement is an expected behavioral strategy based on a consideration of the time and energy costs of obtaining raw material.

The direct procurement of lithic raw material can be considered optimal behavior when regional mobility or settlement patterns place groups at a source for some part of the year (Beck and Jones 1990). In environments where raw materials that meet technological needs are locally available near the residence site and are considered abundant and easily accessible, their acquisition should be possible with low expenditures in time and energy because transport distance is short. In these settings raw material economy should be least developed and curation least visible in the archaeological record for the local material (Marks et al. 1991). In terms of Binford's (1979) framework of embedded direct procurement based on ethnoarchaeological observations, mobile foragers obtain lithic materials at little or no cost because procurement is conducted in conjunction with other basic subsistence resource gathering tasks (though see Bamforth [2006] for evidence of hunter-gatherers expending large amounts of effort to mine stone from local quarry sites).

In some environments local materials may not be available in the necessary abundances to meet the demands of producing and using stone tools, or may not meet the technological specifications of the tools that are needed. If foraging groups do not reside near, or do not regularly come into contact with, suitable sources of lithic raw material, then indirect procurement via exchange is a more optimal procurement strategy. Traveling long distances to nonlocal sources requires greater expenditure of time and energy, and may require time spent field processing the material at the source resulting in the procurement of a lower volume of material. Long-distance travel may also consume time and energy that could be spent on other important activities such as the procurement of subsistence resources, searching for reproductive partners, etc. Choosing to procure lithic raw material through an exchange relationship may be the optimal strategy given an evaluation of the relevant currencies, constraints, and other behavioral choices.

Social relationships can be included as a basic component of optimization models related to decision making about direct versus indirect raw material procurement strategies. However, relying solely on optimization models to explain procurement does not provide a way to characterize the nature of the social relationships trade and exchange are embedded within, or how the network of relationships may differ or change given a variety of environmental factors. Reconstruction and analysis of network relationships provides an additional line of inference that can be used to explain raw material procurement behavior.

### **Exchange and Social Networks**

Exchange can be simply defined as a form of material transfer with social as well as economic properties that reflects linkages at a range of social levels (individuals, groups, societies). Early archaeological observations in Europe, Asia, Oceania, and the Americas identified the movement and transfer of materials in the past, but it was the work of historians and economic anthropologists that related trade and exchange to issues such as social complexity, distribution of resources, and wealth (Oka and Kusimba 2008).

Researchers of exchange such as Malinowski (1922) and Mauss (1990) saw exchange as a way to create and strengthen relationships between people based on the socially defined and enforceable obligations of reciprocity. Later, Wilmsen's (1972) edited volume *Social Exchange and Interaction* explored how exchange acted as a mechanism that structured

social systems, and Sahlins (1972) sought to correlate different types of reciprocity with varying levels of social distance.

The critical aspects of material exchange are fundamentally based on *information*: information about the types of materials to exchange, information about the way exchange takes place, information about the physical routes and meeting places for exchange (Smith 1999). While the material-economic component of exchange can reinforce the social relationships which may overshadow economic gain (Hutterer 1977), studies of exchange must concern the immaterial as well as the material. Knowledge, ideas, and relationships are passed between individuals and groups just as physical resources are, and may actually be more important than the physical materials that are traded in terms of what is gained by participating in an exchange relationship. Strategies for obtaining information will vary given the scale of information required and ability or ease of acquiring it. At a local level, individuals can use multiple methods to gain information such as obtaining it for themselves or tapping into within-group information sharing. At a regional level, individuals will have incomplete knowledge about the state of the regional environment, and must depend on information sharing networks with regional contacts (Moore 1981). Participation in networks plays a role in helping foragers reduce the uncertainty of having incomplete information about relevant environmental or social phenomena.

Personal relationships between and among human groups and individuals provide a social means for circumventing the local subsistence and material resource constraints that are inherent to geographically isolated environments (Mackie 2001). These social ties also have the effect of distributing environmental risks and benefits among regional participants, providing channels of communication about environmental conditions on different spatial scales, and defining lines of fusion and fission for cycles of spatial aggregation and dispersion of human groups (Braun and Plog 1982; Whallon 1989). It is expected that some form of social network can be found on every populated physical landscape due to the unpredictability of all natural environments and the need to propagate (Anderson and Gillam 2001; Wobst 1974). Of importance to the study of hunter-gatherer networks is the scale of social integration among human groups, which will have implications for the structure of networks that are created and maintained, and the type of information that is exchanged (Fitzhugh et al., in press).

In the context of resource procurement, the scale of interaction is tied to the scale of the variance in productivity or availability of those resources (Cashdan 1985). When the variance of resources is localized, social networks at the local group level can aid in the day-to-day extraction of subsistence and material resources that are unevenly distributed. Hunter-gatherers can reduce their procurement costs (time and energy) by obtaining information about the locations or conditions of resource patches from other groups, and thus have the incentive to seek out social interaction and information exchange (Cashdan 1983). Local networks are also important in areas where there is direct competition for resources among various social groups. When resource patches are unevenly distributed, some groups will be able to settle at the patches while others will not, and some level of economic specialization and trade may develop as a result of the differential access to a resource patch (Cashdan 1987, 1992). Social networks based on resource acquisition goals are motivated by the need for efficacy in procuring subsistence resources, which can produce competitive or entrepreneurial characteristics among those participating in the network (Kadushin 2002).

When the variance of resource productivity or availability is due to factors operating at much larger scales, such as changes in regional climatic or geological conditions, exchange partners over a wider geographic area are necessary (Cashdan 1985). At a regional level, social networks are cooperative strategies that often form a 'safety net' of support that can be critical in times of local resource scarcity or failure (Bender 1978; Kennett and Kennett 2000; Rautman 1993; Rensink et al 1991; Whallon 1989, 2006), as a result of environmental uncertainty (e.g. natural catastrophic events). Contemporary studies of disaster events and their aftermath have shown that individuals who participate in some type of kinship or other social network have a higher rate of survival and recovery than those who do not (Chakraborty et al. 2005; Clarke 1998; Haug 2002; Hutton and Haque 2004; Tobin and Whiteford 2002). Research on historic and prehistoric events suggests similar results. For example, Galipaud (2002) found that on the island of Vanuatu, situated on the Melanesian tectonic arc in the South Pacific Ocean, societies with low population density and a network of well-organized alliances and obligations allowed vulnerable groups to relocate to avoid destruction due to volcanic events, and then return home later when the danger had passed. Torrence's research on the environmental and social effects of

the Witori volcano in West New Britain, New Guinea proposed that a dependence on social networks tied to the exchange of subsistence resources and cultural materials may have lessened the ecological impact of the volcanic event on local subsistence resources and facilitated the eventual reoccupation of areas damaged by the eruptions (Torrence 2002; Torrence and Summerhayes 1997; Torrence et al. 2000).

In order to meet the needs of others (or to be helped by others to meet one's own needs) a structured set of social relations must be in place, which ensure that a reliable way to mitigate risks is always present and can be passed from generation to generation (Wiessner 1982). In Wiessner's !Kung case study, the Kalahari Desert can be a productive yet highly variable environment. !Kung groups seek to reduce the risk of variable resource availability by pooling the risk among them through the storage of social obligations, the *hxaro* relationship. From ethnographic studies it has been inferred that exchange of material goods for maintaining social relationships, which is common among contemporary hunter-gatherers, may have existed in the past (Rensink et al. 1991). This indicates that exchange may lead to the circulation of materials over large areas in short periods of time (Bender 1978, Burch 1988, Whallon 1989, Wiessner 1982) and that this type of exchange is inherent in the maintenance of interregional alliance networks (Gamble 1983, 1986; Whallon 1989).

Establishing and maintaining inter- as well as intra-group social ties can be viewed as a form of optimal behavior in terms of mitigating the risks associated with environmental unpredictability. In more formal biological terms, the development and maintenance of social networks through exchange interaction between individuals is an adaptive trait that has the potential to increase the fitness of the individuals participating in the network (Hill 2009). Such networks should then be a prerequisite for colonizing and maintaining a long-term presence in insular and unpredictable environments, enabling a form of adaptive flexibility to deal with events that cause environmental and/or social uncertainties (Fitzhugh 2004; Kirch 1988). However, network participation may also place constraints on individuals or groups in the form of social obligations that must be honored and maintained, since human relationships are not static entities but are dynamic connections that are constantly being negotiated. The concept of exchange among hunter-gatherers becomes more interesting not only as an optimal behavioral strategy for procuring material

resources, but also because participation in exchange relationships can be linked to more anthropological issues of human interaction.

### *Social Network Analysis*

Networks that represent exchange-based social relationships can be reconstructed from the distribution patterns of material items that are inferred to have been obtained indirectly. Social network analysis (SNA) is a systematic approach that utilizes visualization, mathematical and statistical models, and empirical data sets to explore network structure and the effects of that structure on participants in a network (Freeman 2004; Mizruchi and Marquis 2006). Social network analysis focuses on network actors (which can be individuals, groups of individuals, or entities such as corporations or governments) and their relationships (which can be based on communication, economic transactions, kinship, etc.) (Thompson 2003).

Social network analysis was pioneered in sociology and social psychology, but was also implemented in anthropology as early as the 1950s by J.A. Barnes (1954) and his studies of Norwegian church parish social classes (Wasserman and Faust 1994). Within archaeology the use of SNA is not well known, but over the last several decades a number of archaeologists have begun to apply network structure and analysis methods to archaeological data sets, particularly in coastal and island regions. Hage and Harary (1991) examined network structure in their study of Oceanic exchange systems, and Hunt (1991) compared measures of island/site network position to explore models of Lapita culture exchange and communication networks across Western Polynesia, the Solomon Islands, and the Bismarck Archipelago. John Terrell has studied the impact of geographic distance on human interaction based on material culture and language groups along the Sepik Coast of Papua, New Guinea, and on Pacific Islander genetic structure in Melanesia (Terrell 1976, 1986, 2010a, 2010b). In central Europe, Knappett et al. (2008) generated optimization models for Bronze Age maritime interaction networks among islands in the Aegean Sea.

Actor centrality, which is the measurement of how many ties a participant has in a network, is a key concept in social network analysis because it can be used to describe an actor's position or role in a network. Participants with more social relationships are more "central" in the network, which may provide them with access to more or different

resources and information than other less connected network participants (Freeman et al. 1991; Hanneman and Riddle 2005). This concept was applied archaeologically by Mizoguchi (2009) in his analysis of emergent hierarchy and state formation during the Kofun period in Japan. By analyzing the network relationships between regional polities (the network nodes) based on the movement and inter-regional stylistic hybridization of pottery during the Late Yayoi V and Initial Kofun periods, he found that the rise and decline of political centers was tied to the social power generated by their position as measured by their centrality in the regional network. In a similar use of centrality as a measurement of power, Hill (2009) characterized the differences between male and female social position in Middle and Late Archaic societies in the Great Lakes region of the United States based on symbolic burial artifacts. This characterization was used to explore the inferred fitness benefits gained by individuals and communities that had access to prestige goods through their participation in exchange networks.

For the Kuril Islands, SNA provides a method for quantifying the level of network participation of occupations sites in different parts of the island chain. By focusing on the relationships between sites rather than just comparisons of site attributes, some patterns that are not immediately obvious in the archaeological data may become visible. This allows for an additional set of conclusions to be drawn from the Kuril lithic data that may support or expand inferences and ideas generated by other forms of analysis about the unobserved relationships that may have been important in the occupation history of the Kuril Islands.

### **A Simple Integrated Model**

Optimization models provide an approach for studying human behavior within the context of the opportunities and constraints that condition decision making based on the goal of trying to maximize activity returns while minimizing costs (Winterhalder and Smith 2000). These models propose that through the process of evolution, humans have acquired the ability to weigh the costs and benefits associated with their potential resource procurement and consumption strategies. Social network analysis is a way to describe structures of human relationships and measure the position and role of participants in a network with differential access to information and resources. Integrating concepts from optimization modeling and social network analysis provides a way to test hypotheses about

the procurement and use of lithic resources and the impact that participation in exchange networks has on hunter-gatherer economic behavior.

The model that follows is built on several basic assumptions derived from these two approaches. First, hunter-gatherers, acting as individuals as well as groups, flexibly orient their behavior to seek optimal returns on their investments in procuring and consuming resources. They have limited time, energy, and social capital that they must decide how to spend in a balanced way in the context of the conflicting needs that confronts them. While full optimization is rarely achieved, the selective tendency is towards optimization as a behavioral strategy. Second, participation in regional exchange-based social networks has a benefit beyond just the procurement of material resources. Establishing and maintaining regional ties is a way for people to access information, ideas, and relationships that may provide an aid or safety mechanism during times of environmental unpredictability. This model also assumes that complex local relationships are found at the local scale of hunter-gatherer societies, but does not attempt to describe those relationships.

Models are convenient heuristic devices that allow us to work with simplified versions of the complex systems or concepts we are interested in exploring or testing (Winterhalder 2002). One of the challenges faced when developing a model is achieving an appropriate level of simplification and placing the model in a context relevant to the research questions at hand. A model that is too abstract and lacks context may apply very broadly and generally, but it may be difficult to derive testable hypotheses from it. A model that is too precise and is embedded within a very specific context may be easier to test, but the information derived from it may have little applicability beyond the specific test case (Levins 1966).

In an attempt to avoid being too abstract, the model presented here is framed in the context of the availability of lithic resources in the Kuril Islands and the expectations about lithic raw material procurement, use, and the resource-based network of relationships that may have existed. While some higher-level or more general conclusions about resource procurement, use, and networks may be inferred from the findings of this study, this model is not meant to be universal in its applicability. It may however serve as a building block for other cases under similar conditions and in similar environments.

### *Model Parameters*

The environments that humans live in can be characterized in terms of the predictability of resources that people depend on for survival. In the present study, the conditional states of two types of resources are considered for modeling the procurement and consumption of lithic raw material for stone tool production. The first is lithic raw material availability, which influences the procurement and economic consumption of lithic material for the production of stone tools. The second is subsistence resource predictability, which influences the time spent on pursuing subsistence resources, and the resulting time that is available for stone tool production activities.

Thus, expectations or predictions regarding the consumption of lithic resources can be created based on the lithic raw material availability and subsistence resource predictability of the local environment (Fig. 2.1). In high-availability lithic resource environments, lithic raw material that meets stone tool production needs in terms of the abundance and quality can be obtained at a low cost measured in terms of the expenditure of time, energy, and effort needed to procure the material. Because raw material procurement costs are low, there is no incentive for hunter-gatherers living in a high-availability lithic environment to organize their technology with the goal of conserving lithic raw material since it can easily and cheaply be replaced once a supply has been exhausted. If there are a number of different types of lithic raw material that are abundantly available (raw material diversity is high), stone tool makers may settle on using only one, or a few of the highest quality materials, effectively narrowing their lithic material “diet breadth”. Even in an environment with high-availability of local, high-quality raw materials, some exotic/non-local materials may also be procured. If these materials have different functional or performance characteristics from the locally available material, they may be used to make specific types of tools and may be conserved for that purpose.

Low-availability lithic environments are characterized by having an insufficient quantity and/or low quality raw material. If a variety of material types are present, stone tool makers will broaden their lithic material diet breadth and procure many different types of materials of varying quality in order to meet their toolstone needs. If high-quality materials are available, but are rare or costly to procure, hunter-gatherers should be conservative in their lithic material consumption, curating or economizing the material

through technological methods that are highly efficient (making more implements out of a given resource, extending tool use life through re-sharpening or re-shaping, and utilizing tools more intensely). Exotic/non-local materials that are procured, presumably at a higher cost, should also be conserved, but may be used for a wider range of tool types, especially if non-local materials must make up for a deficiency in the supply of locally available materials.

In environments where subsistence resources are highly predictable, either based on their local abundance or the knowledge that hunters have about their location, movements, seasonality, etc., less time is spent locating and pursuing subsistence resources. This makes more time available that could be spent on alternative activities such as creating new stone tools. In this environment, there is a greater time budget available for investing in the start-up costs of producing stone tools, and people can be less concerned about the tool maintenance qualities or capabilities of the type of stone tool raw material that they choose to make tools out of. Conversely, when subsistence resources are unpredictable, hunters must commit more time to subsistence location and pursuit activities. Less time is available for investing in the start up costs of producing new stone tools making tool maintenance a more optimal strategy, and people should be more concerned about the tool maintenance qualities of their lithic raw materials. The assumption being made here is that the ecological conditions which govern the amount of time hunter-gatherers must spend pursuing subsistence resources are constant throughout the year. For environments where there are specific seasons of subsistence resource production and then “off-seasons” when large chunks of free time are available, people would likely employ a combination of time-budgeting strategies throughout the year.

Archaeologically, this could have the effect of creating “seasonal-averaged” assemblages that are combinations of “high season” activity when efficient time-budgeting is important and maintaining tools is the optimal lithic technological strategy, and “off season” activity when there is a relaxation in the time-budgeting and more time available to create new tools from the beginning of the tool production reduction sequence. For aggregated assemblages that represent several hundred years of occupations, this might be a reality, and the impact of the time-budgeting signal may not be apparent. In these cases, it should be the environmental availability of lithic resources that drives the overall lithic

resource use signal that exists in the assemblages. Even in periods when time budgeting is of lower importance (off seasons), low lithic-availability environments should still demonstrate a higher level of lithic resource conservation than high lithic-availability environments. The result would be a lower magnitude, but still detectable, difference in aggregated assemblages based on variation in lithic consumption strategies across the Kuril Islands.

		<b>Subsistence Resource Predictability</b>	
		High	Low
<b>Lithic Resource Availability</b>	High	<ul style="list-style-type: none"> <li>•Lithic raw material is abundant/available at lower cost</li> <li>•Less incentive for raw material conservation</li> <li>•Subsistence resources highly predictable, more time budget for tool production</li> <li>•Less concern for material maintenance qualities</li> </ul>	<ul style="list-style-type: none"> <li>•Lithic raw material is abundant/available at lower cost</li> <li>•Less incentive for raw material conservation</li> <li>•Subsistence resources unpredictable, less time budget for tool production</li> <li>•More concern for material maintenance qualities</li> </ul>
	Low	<ul style="list-style-type: none"> <li>•Lithic raw material is scarce/available at higher cost</li> <li>•More incentive for raw material conservation</li> <li>•Subsistence resources highly predictable, more time budget for tool production</li> <li>•Less concern for material maintenance qualities</li> </ul>	<ul style="list-style-type: none"> <li>•Lithic raw material is scarce/available at higher cost</li> <li>•More incentive for raw material conservation</li> <li>•Subsistence resources unpredictable, less time budget for tool production</li> <li>•More concern for material maintenance qualities</li> </ul>

Figure 2.1: Matrix of lithic resource availability and subsistence resource predictability conditions and implications for lithic raw material conservation.

Imported items found in archaeological sites are often interpreted as evidence for the transport of materials via the movement/migration of people or through trade/exchange networks (Pires-Ferreira 1978). The directions and distances associated with materials that have been transported, especially over long-distances, can provide insight into the nature of material exchange among hunter-gatherer groups that are essentially independent and economically self-sufficient (Eriksen 2002; Whallon 2006). Non-local lithic raw material used for the production of stone tools is one type of material that can represent hunter-gatherer social networks (Eriksen 2002), and the changing patterns of lithic raw material distribution can be used to characterize the dynamic nature of these networks (Hofman et al. 2007).

Obsidian is an ideal material for use in tracing human migration and settlement patterns, trade/exchange interactions, and stone tool technological organization (Eerkens et

al. 2007; Hughes and Smith 1993; Shackley 2008). Because obsidian is relatively homogeneous in its chemical composition, individual obsidian flows have unique trace-element combinations that create a distinct geochemical “fingerprint” or “signature”, and obsidian outcrops are geographically limited, provenance analysis studies can trace obsidian artifacts back to their volcanic source (Eerkens et al. 2007; Tykot and Chia 1997). These characteristics give obsidian an advantage over other types of raw materials in being able to pinpoint sources and determine the distances over which obsidian was transported. These data are the keys to making inferences about hunter-gatherer lithic raw material procurement strategies, specifically the decision to obtain obsidian directly by traveling to the source, or indirectly via trade/exchange, given the procurement costs.

It is assumed that exchange networks that facilitate the indirect procurement of obsidian are likely to be tied to a specific obsidian source, or a few sources located in relative proximity. In broad regions that contain multiple obsidian sources separated by large geographic distances, multiple obsidian exchange or procurement networks may exist. The presence of multiple obsidian sources in a site’s artifact assemblage could indicate that the site procured obsidian through a number of different exchange partners, evidence of maintaining a number of different social relationships.

The association of sites with obsidian source groups provides a proxy for characterizing the social network relationships that were the vehicle for the indirect procurement of obsidian resources. The centrality of Kuril Island sites can be considered a measure of “connectedness” that sites located in various parts of the island chain have in terms of social relationships with other sites or mainland areas. The level of network participation, and in some cases dependence on network relationships for successful island colonization and occupation, should vary across the island chain based on a set of geographic and environmental conditions. When, and where, people are initially colonizing new environments that are unfamiliar, have smaller or non-existent established populations, are geographically isolated and ecologically less diverse, and the predictability of resources is low, networks should play a more important role in the adaptive colonizing process. This should be evidenced by sites that have more network connections measured as higher centrality based on greater obsidian source diversity in a site’s lithic assemblage (Fig. 2.2), resulting in networks that are more “tightly woven.” Conversely, for environments that are

more familiar with higher resource predictability, are less isolated and have greater ecological diversity, and support larger established populations, networks should be less important. Sites in these networks should have fewer connections resulting in “looser” network structure.

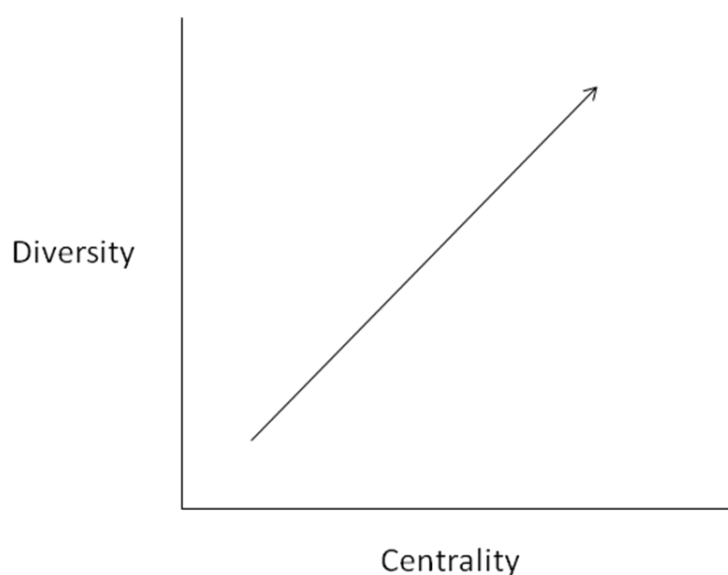


Figure 2.2. The relationship between obsidian source diversity and network actor centrality measures.

The structure and formation of a social network is based on the conditions and contexts that make the initiation and maintenance of human relationships beneficial and a form of optimizing behavior. The theory of the “strength of weak ties” (Granovetter 1973, 1983) provides support for the notion that network participation is important for individuals or groups living in constrained environments, which can be defined by information or resource unpredictability or low availability, geographic isolation or dependence on fewer options in response to stochastic natural events. Ties among inhabitants of a local area are strongly built on homophily – people maintain relationships with others that are most like themselves. In these types of close-knit local networks, network participants share cultural and behavioral norms thoroughly. This can lead to the retardation of innovation and make mobilizing for change more difficult. Weak ties that are maintained in a more regional network beyond the local group allow network participants to reach other participants and their ideas, ideas, resources that are not available locally. These weak outside ties may be critical to survival under conditions of extreme environmental unpredictability, and may

supply access to much needed material resources. Participation in exchange-based social networks can be perceived as a relationship-based behavioral strategy aimed at increasing personal and group fitness (Hill 2009).

### *Predictions for the Kuril Islands*

The general expectations from this model can be applied to the Kuril Islands, specifically the geographic grouping of islands located in the southern, central, and northern parts of the archipelago (Table 2.1). Due to the complex geological history of the Kuril Islands and currently incomplete nature of raw material sourcing across the islands, it is only possible to provide a rough outline of lithic resources that are available in different parts of the archipelago.

<b>Island Group</b>	<b>Lithic Resource Availability</b>	<b>Subsistence Resource Predictability</b>	<b>Lithic Resource Conservation</b>	<b>Assemblage Raw Material Quality</b>	<b>Obsidian Source Diversity</b>	<b>Obsidian Tool Form</b>	<b>Network Centrality Measure</b>
Southern	High	High	Low	Mixed	Low	Specific	Low
Central (Initial Colonization)	Low	Low	High	High	Low	Broad	Low
Central (Later Occupation)	Higher	Low	Lower	High	High	Specific	High
Northern	High	High	High	Mixed	Low	Specific	Low

Table 2.1: Basic predictions of the model for lithic resource consumption across the Kuril Islands.

The Southern Kuril Islands are believed to contain the widest variety and abundance of lithic raw materials. While basalts and cherts of varying quality are the most widely distributed raw material types across the island chain, the Southern Kurils also contain siliceous tuff and dacite, which is not found in the central or northern islands. The Southern Kurils are also the largest in terms of island area, and thus should contain a wider selection and greater overall abundance of material than the Central or Northern islands. Thus the Southern islands can be characterized as a high-availability lithic environment. The Southern Kurils also have a much higher diversity of plant and animal resources and greater resource predictability, the ability to support larger human populations, and a less geographic insularity. The lithic availability and subsistence resource predictability factors should affect lithic assemblages in several ways. More time budget should be available for stone tool production, meaning less attention is paid to the maintenance qualities of lithic

raw materials and resulting in less conservation of raw material resources. Flake debitage assemblages should have a higher proportion of Early and Late stage flakes representative of an emphasis on tool production rather than maintenance. The quality of raw materials in the assemblages should be representative of what is most available locally; in the Southern Kurils the expectation that high quality materials are available and make up the majority of the flakes in the assemblages.

Given that the Southern islands are located the closest to Hokkaido, it is expected that the vast majority of obsidian artifacts in southern island assemblages will be traced to Hokkaido obsidian source groups. This would be in line with general neutral model distance decay relationships based on the distance between lithic sources and consumption sites. However, due to the greater selection and abundance of locally available raw materials, obsidian is not expected to make up a significant portion of the overall lithic assemblages. Regarding obsidian flakes specifically within Southern island site assemblages, non-local obsidian should be used for specific tool types and functions, rather than used generally. The consumption of non-local obsidian should be more conservative or economic than the locally available materials.

The inhabitants of the Southern islands also may have less of a need for long-distance, regional network ties, and focus primarily on local social relationships, potentially making social networks less important for the procurement of resources such as lithic raw material. This would predict participation in fewer obsidian procurement networks, and a lower diversity of different obsidian sources in the lithic assemblages, resulting in lower site network centrality values.

Based on artifact assemblage composition and limited raw material source surveys, it is currently believed that the Central Kuril Islands offer a narrower variety of lithic resources than the Southern islands. The Central islands also have the smallest area, and tend to have steeper topographic relief including high terrace cliffs and narrow beaches, making the lithic resources that are available potentially difficult to reach. For island colonizers with little knowledge about the Central Kuril environment, these islands can be characterized as a low-availability lithic resource environment. The Central Kurils have only one-third to one-half the overall ecological diversity as the southern islands. The smaller carrying capacity of the Central islands coupled with their greater geographic

isolation makes them overall less predictable and more insular. Given the low availability of local lithic resources, early Central island assemblages should show greater conservation of lithic raw material resulting in a high proportion of Late stage flakes representative of intense tool maintenance. This may also be heightened due to a smaller time budget for investing in the production of brand new stone tools, and tool maintenance qualities should be an important factor in choosing raw material. Given the potential for restricted access to high-quality raw materials, lower-quality materials may be present in the assemblages representing a widening of the lithic raw material diet breadth, and resulting in assemblages with a mixture of high- and low- quality toolstone.

Given the inferred direction of island colonization in the Kurils with people moving northward out of Hokkaido into the island chain, early Central islands assemblages are expected to contain a much larger amount of obsidian from Hokkaido source groups than Kamchatka source groups. If obsidian is an important resource for making up deficiencies in locally available materials, it should be represented by a wider variety of tool types.

As Central island inhabitants become more knowledgeable about the lithic resources that are available, the Central Kurils may not be considered as much of a low-availability lithic environment, and the need to intensely conserve lithic resources may be relaxed, resulting in assemblages with a lower proportion of Late reduction stage flakes. The time budget for investing in the production of new tools may remain small due to low subsistence resource predictability, and so tool maintenance activities may remain high compared to other parts of the Kuril Island chain.

It should be advantageous for human groups in the Central islands to maintain regional connections outside of their local networks. These networks may serve to provide access to material resources as well as serve as a safety net in the face of catastrophic environmental events or localized subsistence resource depression. In this analysis, the presence of nonlocal obsidian source groups represents network connections and the level of participation in a network (network centrality). The presence of a higher number of different obsidian sources in an assemblage (high obsidian source diversity) will result in higher network centrality values, indicating more network participation in regards to obsidian procurement. At a basic level, the number of network connections alone, not taking into account the directional orientation of the connections, can be considered a

measure of “network fitness” – having more network connections is better for survival in an unpredictable environment than having fewer network connections. However, the directional orientation of network connections matters if there are some barriers that make maintaining network connections in a certain direction more costly than in another direction.

The Central islands are separated by the Southern island group by the Bussol Strait, a potentially significant barrier that increases the cost of maintaining access to non-local obsidian from Hokkaido source groups, and causing Central island inhabitants to seek out obsidian from Kamchatka. As the network connections to the south maintained by early settling groups are transitioned to the north, Central island assemblages are expected to contain a much larger amount of obsidian from Kamchatka source groups than Hokkaido source groups, though some legacy connections to the south may be maintained. The result will be an obsidian artifact assemblage with overall higher source group diversity and containing obsidian from multiple Hokkaido and Kamchatka source groups. Given the potential for overall increased knowledge about the Central island lithic environment, obsidian may not be required for use in a wide range of tools, and may become more restricted to specific tool types that take advantage of the functional characteristics of obsidian (i.e. extremely sharp edge for cutting tools).

Expectations for lithic resource availability in the Northern Kuril Islands are less clear. The Northern islands are larger than the Central islands, but some of the additional material types available on the Southern islands such as tuff and dacite are not found there, and overall Northern island assemblages should have lower lithic raw material diversity. Northern island proximity to Kamchatka predicts a predominance of Kamchatka obsidian source groups in obsidian artifact assemblages. As with the Southern islands, obsidian is not expected to make up a significant portion of the overall lithic assemblages and it should be used for specific tool types and functions, rather than used generally.

While the Northern islands are larger in size than the Central islands and have greater ecological diversity, they are not as diverse as the Southern islands. The Northern islands have greater carrying capacity and are less geographically isolated than the Central islands, and so social relationships there may mirror the structure predicted for the Southern islands. Networks may be more locally oriented and less important for access to material

resources compared to in the Central islands, and Northern island sites should access obsidian from closer sources located in Kamchatka, resulting in lower obsidian source group diversity and lower network centrality measures.

### **Summary**

There are a number of environmental and economic factors that shape lithic raw material procurement and consumption, and which have implications for the social network strategies that foraging groups might pursue as part of their suite of adaptive behavior. This chapter has outlined some of the key concepts and decision-making variables related to lithic technological organization which provides context for a model of procurement and consumption based on the parameters of lithic resource availability and subsistence resource predictability. A number of expectations regarding lithic technology and social networking specific to different parts of the Kuril archipelago have been derived which represent the basis for evaluating forager behavior optimization models in a way that integrates technological and social behavior. Testing the predictions of the model outlined here forms the core of the rest of this study. The following chapters will use lithic analysis data, obsidian artifact source provenance, and the analysis of social networks constructed from the archaeological record of the Kuril Islands to explore the role that social networks played in the procurement of lithic raw materials, and by extension, linking human groups across the Kuril archipelago.

## Chapter 3: Environmental Setting of the Kuril Islands

### Introduction

One of the ideas developed in the introductory chapter was that human groups make a range of adaptive decisions based on risks and resources that are present in their environment. The purpose of this chapter is to characterize the environmental setting of the Kuril Islands as one that presented Kuril inhabitants with a unique set of challenges that they had to negotiate in order to survive and thrive, and which ultimately shaped the nature of the social networks that were developed among the human groups living there.

This chapter describes the geography and climate of the Kuril Islands, and provides an overview of the significant climate changes that took place from the mid- to late-Holocene in the Kurils. This includes a description of the distribution of plants and animals across the Kuril Islands, including the heterogeneous nature of ecological resource patterning across the islands that is directly related to the geography of the archipelago. This chapter also examines the geology of the island chain, including the geological history and mechanisms of island formation, as well as how the tectonic past of the Kuril Islands has influenced the types of lithic resources that were available to prehistoric stone-tool makers.

### Geography, Climate and Paleoenvironment

Geographic information about the Kuril Islands provides not only a way to situate the island chain on a map or globe, but also to begin to understand other environmental factors and realities that would have faced the prehistoric populations that colonized the Kurils. Stretching between the northern Japanese islands of Hokkaido and the southern tip of the Russian Kamchatka Peninsula, the Kuril Archipelago is an 1150 km-long chain of 32 islands that spans the Okhotsk Sea–Pacific Ocean boundary in the western edge of the North Pacific Ocean (Fig. 3.1). The Kuril Islands vary in size from 5 km<sup>2</sup> to 3200 km<sup>2</sup> covering a total area of 15,600 km<sup>2</sup> with 2409 km of coastline. The archipelago consists of two island ridges, the Lesser Kuril Ridge and the Greater Kuril Ridge. The Lesser Kuril Ridge includes the Nemuro Peninsula of northeastern Hokkaido, the six small islands of the Habomai island group, Shikotan Island, and the underwater Vityaz Ridge. The Greater

Kuril Ridge includes the Shiretoko Peninsula of northeastern Hokkaido, all of the Kuril Islands from Kunashir in the south to Shumshu in the north, and the southernmost tip of the Kamchatka Peninsula (Gorshkov 1970; Pietsch et al., 2003). The archipelago is bounded to the east by the Kuril-Kamchatka Trench which reaches depths of 8500 m, and to the west by the Kuril Basin in the Sea of Okhotsk with a depth of over 3400 meters. The islands that make up the Greater Kuril Ridge (the Greater Kuril Islands) can be divided into three groups, the southern, central, and northern islands, with major straits that run between the Sea of Okhotsk and the Pacific Ocean acting as the boundaries of the three island groups. The southern Kuril Islands consist of, from south to north, Kunashir, Iturup, and Urup; the islands Chirpoi, Brat Chirpoi, and Broutona, which lie 30 km northeast of Urup in the 108 km-wide Bussol Strait, are also considered part of the southern group. North of the Bussol Strait the central islands include Simushir, Ketoi, Yankicha, Ryponkicha, Rasshua, Matua, Raikoke, and Lovushki Rocks. The 70 km-wide Kruzenstern Strait separates the central islands from the northern islands of Chirinkotan, Shiashkotan, Ekarma, Kharimkotan, Avos Rocks, Makanrushi, Onkotan, Antsiferova, Paramushir, Atlasova and Shumshu (Gorshkov 1970). In some cases, the inter-island straits represent significant biogeographical barriers to the migration or movement of plants and animals through the island chain. While humans using simple boat technology and basic navigational knowledge could have easily moved between islands across the narrower straits, movement across the wider straits may have been quite challenging, particularly in bad weather. The decision to cross larger expanses such as the Bussol Strait, where the islands are less intervisible, may have required more thoughtful consideration of the potential costs and risks associated with such voyages. These considerations would have also been incorporated into the cost evaluation of participation in network participation over long distances, which may have shaped the overall structure and orientation of Kuril Island social networks.



Figure 3.1: Map of Kuril Islands

The climate of the Kuril archipelago is strongly influenced by its marine geography and the ocean currents and continental weather patterns that combine to create often severe and unpredictable weather. During the winter months, a strong atmospheric Siberian High weather system interacts with the Aleutian Low creating northerly winds that bring cold air masses from the Asian continent producing severe cold and snow, with February mean temperatures ranging between  $-5.3$  to  $-5.9$  °C (Leonov 1990; Razjigaeva et al. 2008). The cold winds also affect sea surface temperatures and facilitate the formation of sea ice on the Sea of Okhotsk that extends as far south as 43 degrees latitude. By the end of the winter season, sea ice covers up to one-third of the Sea of Okhotsk, typically reaching the southern Kuril Islands from the west and remaining offshore for an average of 77 days/year (Bulgokov 1996; Nurnberg and Tiedemann 2004). In some years, sea ice completely

surrounds the southern Kuril Islands of Kunashir, Iturup, and Urup (Schneider and Faro 1975). Continuous snow cover on the islands ranges from 110 days/year in the southern islands to 140 days/year in the northern islands (Urusov and Chipizubova 2000), time when some environmental resources such as lithic raw material may be obscured or harder to locate.

Summer weather is affected by the interaction of cool Pacific air masses that move south towards the Asian low pressure area and creating cool and moist conditions. Average temperature ranges in the month of August are 16.1 to 16.3 °C, and the average number of frost-free days ranges from 120 days/year in the northern islands to 180 days/year in the southern islands (Razjigaeva et al. 2008; Urusov and Chipizubova 2000). The Soya current brings warm water from the Sea of Japan into the Sea of Okhotsk, providing a warming effect on the eastern side of the island chain. The Oyashio current brings cold water from the western North Pacific Ocean and produces fog which covers the islands for more than 180 days/year and can be particularly heavy on the Pacific side of the islands (Bulgokov 1996; Razjigaeva et al. 2004), making boat travel and navigation potentially hazardous and difficult. The Kuril Islands experience 60-90 stormy days/year, with strong winds (over 15 m/sec) and heavy precipitation, and two to eight typhoons with winds of at least 50 m/sec reach the islands every year. Storm surges on island beaches average 1.2 to 1.7 m, with a maximum surge of 6 m (Bulgokov 1996). Overall, the marine currents, continental weather systems, varied topography, and pockets of volcanic hot springs create a range of microclimates throughout the island chain (Razjigaeva et al. 2004).

While the climate and weather of specific parts of the Kuril Island chain is currently variable based on latitudinal position, the climate of archipelago as a whole has also varied throughout its human occupational history. The study of Holocene deposits from the Sea of Okhotsk and the southern Kuril Islands has been used to reconstruct paleoclimatic change in the Kurils over the last 7000 years. Analysis of pollen and spores obtained from sediment cores taken in the southern Sea of Okhotsk indicate two broad climate periods that existed, with warm pollen assemblages from 7240 – 3050 BP and cool pollen assemblages from 3050 – 150 BP (Kawahata et al. 2003). Razjigaeva et al. (2002, 2004) integrated fossil pollen, diatoms, marine mollusks, tephratigraphy and <sup>14</sup>C dating to reconstruct vegetation and climate for the southern Kuril Islands and characterized a change from a dry

and cool to a warm and moist climate beginning around 7000 – 6500 BP. During the Holocene Optimum around 6000 BP, temperatures were warmer than present by an average of 2-3 °C and the highest sea-level position is estimated at 2.5 – 3 m above the present level. This warm period in the Kuril Islands is correlated with Early Jomon warming on the Japanese islands and the Holocene Optimum of Sakhalin and Primorye in Far Eastern Russia (Korotky et al. 2000). Slight climate cooling coincident with a drop in sea level began around 4700 – 4500 BP, though island vegetation is not thought to have been affected due to the continued influence of warm ocean currents on the southern Kuril Islands. This cool period was followed by warmer periods between 4010 – 3400 BP and 2900 – 2600 BP before a significant cooling event took place around 1700 – 1300 BP which is correlated to the Kofun cold stage on the Japanese islands (Sakaguchi 1983). A short warm period and rise in sea level of up to 1 m above the present level at 1000 BP was followed by cooling and slight transgression during the “Little Ice Age” at 850 BP (Korotky et al. 2000).

The impacts of these episodes of climatic change on Kuril forager populations are not yet well understood. Changes in sea level could have affected the availability of littoral zone resources such as shellfish, and altered island coastlines and locations where boats could be safely landed at habitation sites. More significant may have been changes to the ecological productivity of specific parts of the islands chain, particularly the Central islands which are characterized as having lower taxonomic diversity and primary productivity than the Southern or Northern islands. Climate-driven ecological changes between 4000 and 800 BP, while potentially slow-moving, could have required foragers to practice a high level of tactical flexibility within their overall long-term strategic adaptations to the Kuril environment. Cycles of dramatic ecological change that severely altered local subsistence resources may have initiated new rounds of migration into or out of certain parts of the archipelago.

### **Flora and Fauna**

While the geographic and climatic setting of the Kuril Islands paints a picture of an isolated, harsh, and often unpredictable environment, for over 4000 years human groups were attracted to a range of subsistence resources that made surviving, and thriving, in the

Kurils possible. However, the distribution of these resources is uneven across the island chain, and was shaped by the archipelago's geographic history and heterogeneous environments, potentially requiring a continuum of forms of human adaptation across different islands.

The present-day biotic communities of the Kuril Islands were initially formed as a result of colonization events from two different source areas that took place from the Last Glacial Maximum (ca. 18,000 BP) to the early Holocene. During this time, Sakhalin, Hokkaido, Kunashir, and Iturup were connected in a single landmass to the Russian mainland, allowing warm-adapted species spread northward into the southern Kurils. At the northern end of the archipelago, Paramushir, Atlasova and Shumshu were connected to Kamchatka, facilitating the colonization of boreal and arctic-alpine species in the northern Kurils (Pietsch et al. 2003). The Kurils exhibit a habitat-gradient from south to north through the island chain, with habitat diversity declining with increasing latitude (Hoekstra and Fagan 1998). The Kuril Islands have a very low number of endemic species that are present only in the island chain; almost all of the plants and animals found in the Kurils have distributions beyond the archipelago (Pietsch et al. 2003). Prior knowledge of the habits of key species utilized as subsistence resources by human groups in the Kurils would have greatly aided their initial island colonization efforts. The main factors impacting biotic diversity in the Kurils are island size and available habitat, as well as the historic effects of island connections with adjacent landmasses and their source biotas (Pietsch et al. 2001).

The flora of the Kuril Islands is relatively diverse, consisting of 1194 species, 550 genera, and 135 plant families, though plant communities are not evenly distributed and are represented in an ecological gradient from south to north across the archipelago. Species richness also varies across the island chain, with southern island flora twice as rich as that in the northern islands, and three times as rich in the central islands (Pietsch et al. 2003). Several open-water straits act as ecological boundaries or transition zones between biogeographic regions within the archipelago. The Bussol Strait represents a significant boundary between the relatively warm southern and cool northern flora, also characterized as a separation between Circumboreal and East Asiatic flora (Barkalov and Eremenko 2003; Pietsch et al. 2003). The Fourth Kuril Strait between Onkotan and Paramushir islands subdivides the less diverse northern Kuril Islands, with floral communities on

Paramushir, Shumshu, and Atlasova more closely resembling those of the Kamchatka Peninsula (Pietsch et al. 2003). The geographic distribution of modern plants on any particular Kuril island relates to latitudinal and altitudinal zones which are affected by location on either the windward or leeward side of the island and by the warm ocean currents on the Sea of Okhotsk side and cool currents on the Pacific Ocean side (Urusov and Chipizubova 2000). Biogeographically, Pietsch et al. (2003) divide the Kuril archipelago into two distinct regions: the southern Kurils (Kunashir, Iturup and Urup islands) and the central/northern Kurils, including all of the remaining islands north of the Bussol' Strait.

Currently, the southern Kuril Islands support a mosaic of contrasting types of vegetation that occur across several altitudinal zones. Broadleaf forests consisting of oak (*Quercus crispula*), castor-oil tree (*Kalopanax septemlobus*), maple (*Acer pictum*), white elm (*Ulmus laciniata*), and birch (*Betula ermanii*) in conjunction with bamboo (*Sasa kurilensis*), winterberry (*Ilex rugosa*), and rhododendron (*Rhododendron tschonoskii*) are present up to 400 meters above sea level (m asl). Boreal coniferous forest with Kuril larch (*Larix kurilensis*), Sakhalin fir (*Abies sakhaliensis*) and spruce (*Picea microsperma*) is present up to 700 m asl, with a *Betula ermanii* zone from 400 to 600 m asl, and a stone pine (*Pinus pumila*) zone up to 1500 m asl. Grasslands with shrubs are present on marine terraces and in river valleys, and wetlands with swamps are located on coastal lowlands (Razjigaeva et al. 2004).

The vegetation of the central and northern Kuril Islands can be characterized as tundra dominated by a mix of shrub thickets and herbs, including three types of plant communities: thickets of brush alder (*Duschekia fruticosa*) and *Pinus pumila*; Cyperaceae-moss bogs; and alpine tundra. Trees are limited to gallery forests along the Tukharka River valley on Paramushir Island, primarily made up of *Chosenia macrolepis* (Lozhkin et al. 2010; Urusov and Chipizubova 2000). In the central Kurils, plant communities are dominated by crowberry (*Empetrum sibiricum*) and heath shrubs in a variety of settings, from marine terraces to high mountain slopes, with tussock tundra typical of the interior of the central islands (Grishin et al. 2005). The vegetation of the central Kurils is affected by its more severe weather, and is considered depauperate compared to the floral communities on Paramushir or the Kamchatka Peninsula (Lozhkin et al. 2010).

Freshwater, marine and anadromous fish, marine mammals and birds are common fauna found in the Kuril Islands. Sea otter (*Enhydra lutris*), northern fur seal (*Callorhinus ursinus*), and sea lion (*Eumetopias jubatus*) inhabit the numerous shores and bays throughout the islands, and there are specific sea mammal rookeries located at several off-shore rocky outcrops (Fitzhugh et al. 2002). Englishman H.J. Snow, who hunted sea otters in the Kuril Islands in the late 19<sup>th</sup> century and kept observations on Kuril fauna, also noted dolphins (*Lagenorhynchus obliquidens*) and several species of whales including humpback (*Megaptera novaeangliae*), finback (*Balaenoptera physalus*), and gray (*Eschrichtius robustus*) whales in Kuril waters (Snow 1897).

Anadromous fish including Pacific redbfin (*Tribolodon brandti*), Dolly Varden char (*Salvelinus malma malma*), Kamchatka steelhead (*Parasalmo mykiss*), and a variety of salmon species (chum, pink, sockeye, and coho) spawn in larger rivers in summer. Herring (*Clupea pallasii*) and pelagic fish such as stickleback (*Gasterosteus aculeatus aculeatus*), cod (*Gadus macrocephalus*) and mackerel (*Scomber australasicus*) are found in coastal waters of the northern and southern groups (Hacker 1951; Pietsch et al. 2001) The waters around the Kuril Islands have historically been very productive; in the early 20<sup>th</sup> century a number of Japanese canneries existed on several islands, and today there is both legal and illegal competition for fish resources in this region (Cobb 1996; Stephan 1974). Recent biogeographic surveys of the Kuril Islands have found that southern-source freshwater fish extend north only to Iturup, while freshwater fish and mollusks from the north have made it south only to Paramushir, rendering the majority of islands in the center of the island chain relatively impoverished in these taxa, and lowest in overall species richness (Pietsch et al. 2003). Shellfish are also abundant in the Kuril Islands, including freshwater and terrestrial mollusks, mussels, clams, sea urchin, and periwinkles (Snow 1897), though their distribution throughout the islands is uneven and dependent on the intertidal zone of each island.

Over 170 species of birds inhabit or migrate through the Kuril Islands, with the greatest diversity in the southern islands where wrens (*Troglodytes troglodytes*), swifts (*Apus pacificus*), crows (*Corvus corone*), falcons (*Falco peregrines*), and eagles (*Haliaeetus albicilla*) are found. Ground-breeding birds such as auks (*Aethia cristatella*, *Aethia pygmaea*), puffins (*Fratercula corniculata*, *Lunda cirrhata*) and guillemots

(*Cepphus carbo*, *Cepphus columba*) are most prevalent in the central islands where there are few if any terrestrial mammals. Gulls, specifically the Burgomaster gull (*Larus hyperboreus*) which often feeds on the eggs of other birds, are the most common birds across the island chain (Hacker 1951; Nechaev n.d.).

The mainland areas of Hokkaido with thirty mammal species, and Kamchatka with twenty-five mammal species, represent the most likely sources for colonizing populations of terrestrial mammals in the Kuril Islands. The initial colonization of the Kurils by land mammals likely took place during the Last Glacial Maximum, though under some winter conditions when sea ice creates bridges between islands, cross-ice dispersal is possible in the southern islands. However, as insularity increases, faunal communities on islands typically develop trophic or taxonomic biases and become less representative of neighboring mainland communities, and the number of terrestrial mammal species on any specific Kuril island ranges from one to thirteen (Hoekstra and Fagan 1998). As of the mid-20th century, few land mammals were present in the Kurils, with most concentrated on the larger islands close to the mainland and only fox (*Vulpes vulpes*) being common throughout the archipelago (Hacker 1951). In the southern group from Kunashir Island to Urup Island, Hacker (1951) reported bear (*Ursus arctos yesoensis*), fox (*Vulpes vulpes*), river otter (*Lutra lutra*), pine marten (*Martes martes*), sable (*Martes zibellina*), and squirrel (*Sciurus vulgaris*) in abundance. On the northern islands of Paramushir and Shumshu, voles (*Clethrionomys* sp.), shrew (*Sorex caecutiens*), weasel (*Mustela nivalis*), and brown bear (*Ursus arctos*) are recorded. In the central Kurils, only fox (*Vulpes vulpes*), which is a good cross-ice colonizer, can live on sea birds and eggs, fish, and shellfish, and can cache food, is known today, though this may be a non-native species introduced by humans on some islands (Hacker 1951; Hoekstra and Fagan 1998).

The overall taxonomic diversity of subsistence resources is limited in the Kuril archipelago compared to the Hokkaido and Kamchatka mainland areas, and the distribution of species is uneven across the island chain. Yet the islands would have provided a rich subsistence base for human groups specifically adapted to foraging in marine ecosystems which could be considered a “pull” factor that brought people into the Kurils. Human occupation of the islands for much of the middle to late Holocene is one indication of a sufficient level of ecological productivity in this region.

## Geology and Lithic Resources

The geological history of the Kuril Islands contains information that is relevant to understanding the tectonically dynamic environment inhabitants of the Kurils would have experienced. The Kuril archipelago is situated on the central portion of the Kuril-Kamchatka Island Arc formation which includes eastern Hokkaido, the Kuril Islands, and southern Kamchatka (Cook et al. 1986; Gorshkov 1970). The Kuril Islands began forming approximately 90 million years ago during the Cretaceous Period when part of the Kula Plate collided with the Siberian continent, initiating the creation of a subduction zone at what is now the Kuril-Kamchatka Trench. The tectonically derived volcanism that subsequently occurred formed the Lesser Kuril Ridge, and uplift in this area resulted in the emergence of the Lesser Kuril Ridge above sea level during the Paleocene and Eocene (Kimura and Tamaki 1986). During the late Oligocene and early Miocene, the Okhotsk terrane began to move counter-clockwise and the Kuril back-arc basin in the southern Sea of Okhotsk was opened west of the Kuril arc. Volcanic activity near the Kuril-Kamchatka Trench was focused in the area of the Greater Kuril Ridge, with the emergence of the present-day Kuril Islands sometime in the Pliocene or early Pleistocene (Bulgakov 1996; Derkachev et al. 2009). Based on K-Ar dating to determine the ages of Kuril Island rocks, the islands making up the Greater Kuril Ridge become younger from south to north, with ages ranging from 4.21 +/- 0.13 Ma for Urup Island in the southern part of the chain, to 0.43 Ma for Ekarma of the central islands (Yoishi Ishizuka, personal communication 2009).

Most of the islands are covered by Quaternary volcanic deposits (Bulgakov 1996), and the Greater Kuril Ridge is still tectonically and volcanically active, with thirty-two volcanoes that are known to have erupted during the past 300 years, including that 20 have erupted since 1945 (Ishizuka 2001; Melekevtsev 2009). The most recent example of volcanic activity in the Kuril Islands occurred in mid-June 2009 with the explosive eruption of the Sarychev volcano on Matua Island measured as a 4 on the Volcanic Explosivity Index (VEI) scale of eruptions and with a minimum volume of tephra estimated at 0.4 km<sup>3</sup>, making it one of the largest historic eruptions in the Kuril Islands (Smithsonian Institution 2009). The Kuril Islands are also subject to the effect of tsunamis generated as a result of tectonic activity along the Kuril-Kamchatka Trench. Since 1742, at least 38 earthquake and tsunami events have been recorded in the Kuril Islands, including the large 1952 tsunami

that struck the northern Kurils and devastated entire communities with considerable loss of life (Kaistranko and Sedaeva 1999; NGDC 2009). On November 15, 2006, an earthquake (Mw 8.1-8.4) in the Kuril-Kamchatka subduction zone generated a tsunami with a run-up (elevation above sea level at inundation) on average of 10 m, and a maximum of 22 m on Matua Island that created massive erosion and significantly altered the island's coastline. This tsunami was followed by an earthquake in January 2007 (Mw 7.9-8.1) in the same area that also generated a measurable tsunami (Laverov et al. 2009; MacInnes et al. 2009b). The analysis of paleotsunami deposits in the central Kuril Islands indicates that tectonic events similar in scale to the November 2006 event were not uncommon in the past (MacInnes et al. 2009a).

The tectonic systems that have driven the geological history of the Kuril Island region have not only influenced the formation of the islands, but also the lithic resources that are available on them that prehistoric populations could have exploited for stone tool making activities. There is a great variety in the types of igneous rocks that are associated with the tectonic processes that are the mechanisms behind the movement of lithospheric plates. Convergent and divergent plate boundaries, intraplate tectonic regions, and areas of continental rifting all have their own characteristic magmatic activity, and in turn produce different suites of igneous rocks (Hess 1989; Martynov et al. 2007). The basement of the continental volcanic arc tectonic system in Kamchatka was formed by repeatedly folded geosynclinal terrains varying ages, and differs sharply from the Kuril island arc volcanic system that developed from thinner oceanic crust and does not have a long-term geosynclinal history (Erlich 1979, 1986). Continental volcanic arcs tend to be associated with acid volcanism that produce igneous rocks with SiO<sub>2</sub> content of greater than 60% by weight in the form of andesites and rhyolites. The rocks associated with acid volcanism in Kamchatka are generally dacites with SiO<sub>2</sub> content of 63-65% by weight, as well as rhyolites with higher silica content that occur with andesites (Gorshkov 1970).

The Kuril island-arc system is composed of Neogene and Quaternary deposits of basalt, andesite, volcanic conglomerate and marine and continental lithic facies (Markov and Khotin 1973). The rocks formed in the Kurils belong to the calc-alkali family, with the chemical constituent of SiO<sub>2</sub> by weight that ranges from 50% (basalt) to over 70% (rhyolite). The Kuril Islands and Kamchatka share the same parent magma material, though

in the Kurils the resulting calc-alkalic rocks are primarily basalt and andesite-basalt and the occurrence of dacites and rhyolites is rare, while in Kamchatka the effects of time and geosynclinal folding have produced the higher silica rocks associated with acid volcanism (Gorshkov 1970).

An understanding of the distribution of various lithic raw materials across the Kuril Islands is important for the analysis of procurement and consumption which are developed in later chapters. However, due to the complex tectomagnetic system (Martynov et al. 2007) and currently incomplete nature of raw material sourcing in the Kurils, it is still only possible to develop a basic outline of raw material distribution patterns.

Basalt rocks are found on virtually all of the Kuril Islands in various types of deposits, including thick extrusive flows, columnar formations (such as the columnar basalt cliffs at Cape Stolbchatiy on Kunashir Island), and as cobbles on beaches and in streams and rivers. These basalts generally have an aphanitic (without visible crystals), fine-grained texture with homogenous particle size, though some forms have small light-colored plagioclase feldspar phenocrysts or glassy olivine phenocrysts embedded in the basalt matrix. Color ranges from dark green or gray to black, and weathered basalt cobbles often have a light-gray cortex with darker inner matrix. The most fine-grained basalt rocks exhibit conchoidal fracture without following any natural planes of separation, making them useful for stone tool making. In addition to basalt, other rocks such as tuff, quartz, and chert make up the most abundant lithic raw materials that would have been available to Kuril Island occupants for stone tool production.

Siliceous tuff is a type of fine-grained rock found primarily in the southern Kuril Islands, usually occurring in well-defined layers of volcanic deposition. Tuff is composed of small volcanic rock fragments and ash compacted together by heat and pressure, and hardened through time by the precipitation of silica (Chesterman 1978). Siliceous tuff in the Kurils is represented in a variety of colors including white, pink, brown, yellow and gray, and often has a multi-colored banded structure. The hardest forms of tuff break conchoidally, though softer, less consolidated tuff can be scratched and carved (Tarbuck and Lutgens 1990).

Quartz is one of the most common minerals on earth and is present in the Kuril archipelago in the form of chalcedony. Chalcedony is a variety of quartz that has a fibrous

microstructure and often forms in gas bubbles within igneous rocks that are in-filled with secondary quartz minerals (Chesterman 1978; Luedtke 1992). Chalcedony in the Kurils ranges from transparent to translucent and occurs in white to gray colors with some blue and brown banding. The fine-grained texture of chalcedony gives it a smooth, waxy feel. Chalcedony is usually found as small nodules in secondary beach and stream deposits.

Chert is the most abundant type of sedimentary rock found in the Kuril Islands. Made up of microcrystalline quartz formed by the chemical precipitation of silica, chert is formed in a variety of environments, including bedded layers in ocean floor strata as well as nodules in limestone and dolomite formations (Andrefsky 2005). Chert is also associated with volcanic deposits formed near the edges of converging continental plates (Luedtke 1992). Chert is resistant to erosion, and in the Kurils it is found in primary deposits as beds and outcrops on weathered surfaces, and in secondary deposits as small nodules on beaches and in streambeds. Colors range from white to black, with specific varieties including green, yellow, orange, red, and brown, and which often occur in multi-colored banded or mottled combinations. Red chert, both in solid-color and banded/mottled structure, is the most abundant color variant of chert found in the Kurils. Cryptocrystalline chert is typically very fine-grained, though cherts subjected to the high heat and pressure associated with volcanic activity can re-crystallize and appear coarse and sugary (Luedtke 1992), and this type of chert is present in the Kurils. Chert can be broken in a controlled manner and forms a sharp, durable edge, making it an extremely useful stone tool-making raw material.

Silica-rich rocks are less abundant in the Kuril Islands, and dacite is found primarily in pumice deposits around major calderas on Kunashir and Iturup islands and as a domes in the Ushishir group of islands; lava flows composed of dacite are not found in the Kurils (Gorshkov 1970). Dacite colors range from white to various shades of gray and brown with both light and dark-colored phenocrysts, including hornblende which is green (Chesterman 1978). Porphyritic dacite with large crystals does not fracture as predictably as other finer-grained raw materials, and is less useful for making stone tools.

Obsidian, which is found in artifact form throughout the Kuril Islands, is notably absent as a naturally occurring lithic raw material in the Kuril archipelago. Obsidian is a form of volcanic glass that is produced when silica-rich lava extrudes from a volcano and cools so rapidly that its constituent ions do not have time to crystallize into minerals

(Dietrich and Skinner 1979). It has been recognized as a highly useful raw material for making stone tools because it is entirely isotropic and can be flaked predictably to create extremely sharp edges (Andrefsky 2005; Shackley 2005; Whittaker 1994). Obsidian is most commonly found at the crustal margins of rhyolitic lava flows (Shackley 2005) which are rare in the Kurils. Several pieces of pitchstone, a type of volcanic glass related to obsidian, have been recovered from natural geologic contexts on Kunashir, Ketoi, and Yankicha islands. Pitchstone is a glassy, igneous rock with a dull, pitch-like luster that contains more than 5% H<sub>2</sub>O (obsidian by comparison is nearly anhydrous with less than 1% water) and a high concentration of crystallites and spherulites. Pitchstone is essentially obsidian that has gone through the process of devitrification – the natural breakdown of the glassy component of the rock material into crystal minerals due to the uptake of water (Ballin and Faithfull 2009; Dietrich and Skinner 1979). The volume of water change in pitchstone induces small fractures, which when combined with presence of abundant phenocrysts negatively impacts the ability of the material to be broken in a controlled manner (Ballin and Faithfull 2009). To date no artifacts made from pitchstone have been recovered from archaeological sites in the Kuril Islands, an indication that it was not an important material for making stone tools.

Much like the subsistence resources in the Kuril Islands, the lithic resources can be considered to have low diversity and heterogeneous distribution across the islands. While high-quality cryptocrystalline raw materials are found in most parts of the archipelago, the conservation of those materials and/or some reliance on lower-quality raw material types may have been necessary in order to support the requirements of Kuril stone tool technology.

## **Summary**

The Kuril archipelago represent an environment that can be characterized as insular based its geographic location and orientation, and dynamic and unpredictable based on the climate, weather, and tectonic perturbations that affect the island chain's physical landscape. The Kuril Islands are also as a region that is rich in specific resources that provided a productive environment for human groups that were highly adapted to the exploitation of marine mammals, fish, and shellfish. The geology of the Kuril Islands created a landscape upon which the raw materials suitable for stone tool technology were

available, but which also required Kuril inhabitants to make specific decisions about the types of material they chose for stone-tool making, and how their strategies for procuring and consuming those materials.

In general, the range of variation in the lithic resources that are available on a landscape is only partially associated with stone tool production. This is due to the specific characteristics of certain stone types – grain size, brittleness, homogeneity, ability to fracture conchoidally – that humans have identified as important for stone-tool making (Andrefsky 2005). The choices made about stone raw material are based not only on the physical qualities, but also on other factors such as what material is available locally versus what material has to be travelled to or traded for, and what type of tool is being manufactured. The lithic materials selected for stone tool making represent pragmatic as well as cultural choices made by people, and provide a framework for comparing lithic assemblages across sites in order to develop information about patterns of lithic procurement and use (Kooyman 2000). The strategies and tactics associated with the procurement and consumption of lithic material in the Kuril Islands can be positioned as part of the suite of adaptations that Kuril inhabitants made in order to increase their chances for survival and fluorescence in the Kuril environment.

## **Chapter 4: Kuril Island Culture History and Proposal of a New Chronological Framework**

### **Introduction**

The Kuril Islands occupy an unsettled position within the archaeology of the greater northeast Asian region. Geographically, the island chain lies between Japan and Russia, and the archaeology of the Kuril Islands has been influenced by the work of archaeologists from both countries. The strategic location of the island chain has prevented research from being conducted there for political and militaristic reasons, and the logistics that must be coordinated and distances that must be traveled to reach the Kurils make it a very expensive place to work. This has left present-day archaeologists with an incomplete and problematic culture-historical framework within which to try and place new research on the colonization of, and adaptation to, the island chain.

This chapter reviews the culture history of the Kuril Islands as it is currently understood, and seeks to untangle some of the problems and issues with the present culture-historical constructions as well as offer a way forward in giving the Kuril Islands a distinct historical identity. Re-thinking the cultural and chronological framework within which this research is placed is necessary in order to fully account for historical research biases that may otherwise influence interpretations about Kuril Island migration, colonization, and adaptive sequences.

### **History of Archaeological Research in the Kuril Islands**

Archaeological research has established that people lived in the Kuril Islands beginning roughly 7,000 years ago. But before the Kurils became a subject of scientific archaeology, explorers, hunters, and traders in the 17<sup>th</sup>-19<sup>th</sup> centuries provided initial information about the island chain's inhabitants. It is likely that while the Japanese of the Tokugawa shogunate had the first trading contact with Ainu inhabitants in the southern Kurils during the early seventeenth century, they did not have actual experience traveling to the islands and wrote no accounts of Kuril populations. Though a number of Dutch, Russian, and Japanese explorers entered the Kuril Islands in the late seventeenth century, Russian Cossack Petrovich Kozyrevskii is credited with providing the first sketches and descriptions of Ainu traders that he met on Paramushir Island during his exploratory visits

there between 1711 and 1713 (Stephan 1974). Georg Stellar (1751) and Stephan Krasheninnikov (1972) provided the first detailed ethnographic descriptions of the northern Kuril Ainu living on Paramushir and Onekotan, including their house structures, trading practices, hunting methods, and manner of dress. In 1897, Captain H.J. Snow, a prolific sea otter hunter who led expeditions in the Kuril Islands between 1872 and 1888, published a comprehensive account of the geography, geology, flora and fauna, and inhabitants of the Kurils (Snow 1897). He was the first to detail the differences between Ainu populations living in the southern Kurils and those living in the northern islands.

The initial phase of scientific archaeological research in the Kuril Islands was led by Japanese archaeologists in the first part of the twentieth century prior to WWII. Ryuzo Torii and Osamu Baba conducted excavations primarily at the far southern and northern ends of the island chain, including extensive excavations on Shumshu Island (Baba 1934, 1937, 1939; Baba and Oka 1938; Chard 1956; Torii 1919). The Kuril Islands, control over which had been disputed between Japan and Russia through much of the 18<sup>th</sup> and 19<sup>th</sup> centuries, were a part of Japanese territory before and during WWII, but were given up to the Soviet Union at the end of the war, effectively ending accessibility to the islands by Japanese archaeologists. After a research hiatus during WWII and the early part of the Cold War, Soviet archaeologists returned to the Kuril Islands, again primarily focusing on the larger islands of Kunashir, Iturup, and Urup in the south, and Shumshu and Paramushir in the north (Chubarova 1960; Golubev 1972; Shubin 1977; Stashenko and Gladyshev 1977). Much of this research was descriptive and typological (Fitzhugh et al. 2002), and continued the work begun by Baba in the 1920s and 1930s. American archaeologists, most notably Chester Chard, also became interested in the Kuril Islands in relation to broader themes of migration and northern latitude cultures (Befu and Chard 1964; Chard 1956, 1960a, 1960b; Fitzhugh et al. 2002).

In the 1970s, Russian research programs in the Kurils began with field surveys of prehistoric sites primarily in the Southern and Northern islands. In the 1980s and 1990s, work focused on radiocarbon dating significant middle and late Neolithic sites in the southern part of the island chain, and on linking Kuril ceramic typologies with those developed for Hokkaido (Knozorov et al. 1989; Shubina 1986; Zaitseva et al. 1993).

Work was also led by Valery Shubin of the Sakhalin Regional Museum to document 18<sup>th</sup> and 19<sup>th</sup> century Russian settlements in the islands, and the translocation of Aleut natives employed in the Kuril sea otter trade (Shubin 1990a, 1990b, 1994). Additionally, Japanese scholars began to publish research on the Kuril Islands again (Tezuka 1993, 1998; Ushiro 1996; Ushiro and Tezuka 1992).

This period was followed by a new era of international and interdisciplinary archaeological work in the Kuril Islands that began to address more complex questions about migration and colonization of the island chain, and the history of human-environmental interaction and impacts in the archipelago. In 1999, archaeologist Tim Allen from the University of Washington accompanied a biotic survey project known as the International Kuril Island Project (IKIP) to document basic information on archaeological sites that had been noted by IKIP biologists working in the region since 1994. The following year, a team of Russian, Japanese, and American archaeologists and geologists spent three weeks investigating 14 islands across the southern, central, and northern parts of the island chain (Fitzhugh et al. 2002). This research presented new information on the settlement history and human biogeography of the Kurils, including a biogeographical analysis of lithic and faunal artifacts and the development of an occupation chronology based on new radiocarbon dates (Fitzhugh et al. 2002, 2004).

The new information generated by the relatively brief archaeological component of the IKIP program spurred the development of a much larger, multi-year, interdisciplinary project with an archaeological focus. In the fall of 2005, the Kuril Biocomplexity Project (KBP) began to examine the archaeological, geological, ecological, and climate records of the Kuril Islands with the goal of developing human-environmental systems models for understanding issues of human vulnerability, resilience, and adaptations to the Kuril environment. This project brought together archaeologists from the University of Washington in the United States, the Sakhalin Regional Museum in Russia, and the Historical Museum of Hokkaido and Hokkaido University in Japan to conduct archaeology within a problem-oriented framework. Field work in the islands was conducted during the summers of 2006, 2007, and 2008 and included visits to over 60 archaeological sites on 17 different islands. Most of these sites were investigated for only one day with test excavations designed to obtain a small sample from sites spanning the entire 1,200 km-long

island chain, but six sites were excavated for a week or more in order to recover a richer record of human occupation and activity. A large collection of lithic, ceramic, and faunal artifacts was excavated; finished lithic and bone tools and all ceramic artifacts were curated at the Sakhalin Regional Museum in Yuzhno-Sakhalinsk, Russia where they continue to be studied, and lithic debitage, faunal remains, and geological samples were brought to the University of Washington for further analysis.

### **Current Cultural Periods of Northern Japan and the Kuril Islands**

Including research conducted in the first decade of the 21<sup>st</sup> century, relatively little archaeological work has been conducted in the Kuril Islands compared to the surrounding regions of Japan, Sakhalin Island, and the mainland of the Russian Far East. Thus the culture-historical periods constructed for the Kuril Islands are borne out of and intertwined with the culture histories developed for other areas, particularly Japan and its Jomon culture-historical framework.

The Jomon period in Japan (13,000 – 2900 BP) is marked by the appearance of pottery, and more specifically cord-marked pottery (Jomon means cord-marked in Japanese) (Habu 2004; Kodu 2004), as well as microblades and large biface stone tool industries (Aikens and Higuchi 1982). Jomon groups have generally been characterized as fully sedentary hunter-gatherer-fishers practicing a collector system of resource procurement (Bleed 1992; Habu 1996; Imamura 1996). Collector systems are associated with environments that have heterogeneously distributed resources and a low amount of residential mobility, a high amount of logistical mobility, and the use of a number of different site types (task sites, cache sites, etc.) (Binford 1980). Mizoguchi (2002) describes an increased “fixity” that Jomon people have to certain locales that are repeatedly visited and the scheduling of visits to specific places for the procurement of subsistence resources.

The Early Jomon period (7300-5500 BP) coincides with the Jomon Transgression, a warm period when sea level reached its highest point in Japan two to six meters above present sea level, and the development of shell midden and aggregated pithouse village sites (Imamura 1996; Kobayashi 2004; Okada 1998; Yamaura and Ushiro 1990). These sites contain shells from both freshwater species that live in brackish water as well as marine species such as clam, abalone, and oyster. Evidence for fishing is through the presence of

net weights and fish hooks made of deer antler; fish weirs indicate inland stream fishing was also practiced. Faunal remains including bear, dog, hare, wild boar, pheasant, and duck indicate terrestrial hunting was also an important subsistence strategy, and a large number of pit-traps are found in conjunction with Jomon sites (Imamura 1996; Yamaura 1998).

By the mid-Holocene intensive plant gathering and cultivating had become a central part of the Jomon subsistence strategy, with the use of chestnuts, walnuts, acorns, fern bulb, and arrowroot (Aikens and Rhee 1992). During the Late Jomon (4500-3200 BP), the climate became cooler after the peak warm period of the Jomon Transgression, and sea level fell. The number of inland sites decreased as people followed the receding coastline, and a trend in population concentration in coastal areas continued until the end of the Jomon period (Imamura 1996). In the Final Jomon (3200-2900 BP) there is a perceived decrease in the availability of plant foods that had been a staple of the Jomon diet based on the increase of aggregated sites in coastal areas (Imamura 1996). This may have initiated a shift towards more sea mammal hunting as the climate in Hokkaido deteriorated and temperatures cooled and local populations of pinnipeds increased (Niimi 1994), though the relationships between climate change, ocean systems, and ecological productivity are not yet well understood in this region and this climate change scenario remains unsupported with specific evidence (see Fitzhugh in press for a discussion of climate/oceanography/productivity relationships). Carbon and nitrogen isotope analysis of human skeletal remains from this period indicate that sea resources were an important part of the diet, particularly in Hokkaido (Minigawa and Akazawa 1992; Yamaura 1998).

The earliest published archaeological radiocarbon date for the Kuril Islands comes from the Yankito site on Iturup island which is dated to 7055 +/- 45 BP (Yanshina and Kuzmin 2010; Yanshina et al. 2009). This date falls within the Early Jomon (7300 – 5500 BP) of the overall Jomon culture historical sequence used in Japan and on the northern Japanese island of Hokkaido, and is supported by Early Jomon ceramics found at the Yankito site (Shubina and Samarin 2009).

The Kuibyshev site on Iturup and the Sernovodsk site on Kunashir are also assigned to the Early Jomon based on cord-marked ceramic designs and microblade lithic tools that are present in Hokkaido at this time (Vasilevsky and Shubina 2006), and Middle Jomon pottery has been noted at several sites on Iturup including Kasatka Bay, Malovodnaya 2,

Rybaki (Shubina and Samarin 2009). This period is referred to generally by Russian archaeologists as the Early Neolithic in the Kuril Islands. Other early sites in the Southern Kurils have been dated to the Late Jomon (4500 – 3200 BP) and Final Jomon (3200 – 2900 BP) (characterized as Middle and Late Neolithic in Russian cultural chronologies and labeled as the Yuzhno-Kurilsk culture in the Kurils) including the Berezovka, Kasatka, Tankovoye Ozero and Rybaki sites on Iturup island, and the Olya site on Kunashir island (Kuzmin 2006; Vasilevsky and Shubina 2006). Several sites in the central and northern Kurils have recently been dated to between 4000 and 3200 BP, coinciding with the Late Jomon and potentially representing the earliest human occupations in the central and northern parts of the island chain (see Fitzhugh et al. 2007, 2009a, and 2009b).

The earliest inhabitants of the Kuril Islands are likely closely related to the Jomon groups living throughout the Japanese islands ca. 13,000 to 2900 BP (Aikens and Higuchi 1982). The presence of people in the southern Kurils during the Early Jomon period is not unexpected given their geographical proximity to Hokkaido, and also their environmental similarity to Hokkaido. Kunashir and Iturup are the largest and most ecologically diverse islands in the Kuril archipelago, and share many of the same plant and animal species with Hokkaido. The hunting-gathering-fishing adaptation prevalent in the central and northern Japanese islands would have applied with little modification in the southern Kurils during this period. Late and Final Jomon occupations in the central Kurils represent the earliest extension beyond the southern islands of the Jomon way of life.

### *Epi-Jomon Culture*

Beginning around 2900 BP in Japan there was a period of significant change in subsistence, cultural, and political systems with the initiation of the Yayoi period (2900-1500 BP) on the main Japanese islands of Kyushu and Honshu. The Yayoi period is characterized by the establishment of wet rice agriculture and the importation of an entire technological suite to support an agricultural subsistence strategy, including the manufacture of bronze and iron tools. Rapid social changes and new cultural and economic patterns were established that formed the foundations for the traditional Japanese society known today. This wave of change is associated with continental immigrants from Korea and China who replaced the Jomon hunter-gatherers on Honshu and Kyushu islands of

central Japan, but did not cross the Tsugaru Strait to Hokkaido (Aikens and Higushi 1982; Imamura 1996). In Hokkaido, the Jomon indigenous culture continued for another 1600 years during what is recognized as the Epi-Jomon (also known as Zoku Jomon) period (2900-1300 BP) that was contemporaneous with the Yayoi culture in Honshu (Imamura 1996).

By the Epi-Jomon period, lithic microblade technology had been abandoned in favor of small triangular arrow points, scrapers, and awls, along with flaked and groundstone axes and adzes (Akazawa 1986; Aiken and Higuchi 1982). Pottery was of a deep-bowl type similar to earlier Jomon ceramics, but retained the cord-marked and incised patterns that were long out of use on pottery from mainland Japan (Imamura 1996). Deer and wild boar continued to be important terrestrial resources where available in appropriate ecological zones, and Epi-Jomon shell mound sites in Hokkaido contain evidence of a maritime-oriented subsistence economy through faunal remains that include halibut, tuna, bonito, fur seal, sea lion, and whale (Akazawa 1986; Okada 1998).

While the Epi-Jomon culture is most well-known in Hokkaido, human groups carrying the imprint of an Epi-Jomon cultural adaptation expanded to southern Sakhalin and the Kuril Islands (Okada 1998). Following the low density of archaeological sites in the Kurils during the Early to Final Jomon, the Epi-Jomon period represents an initial colonization of the entire island chain from Kunashir to Shumshu, the southern and northern termini of the archipelago respectively. Just over 47% (n=155) of the radiocarbon dates for the Kurils fall within the Epi-Jomon time frame as defined for Hokkaido, representing archaeological sites on Kunashir, Iturup, Urup, Simushir, Matua, Rasshua, Shiashkotan, Ekarma, Chirinkotan, Paramushir, and Shumshu islands (Fig. 4.1). Epi-Jomon pottery, including the Shimodanosawa-type 1 which is associated with the early Epi-Jomon period of Hokkaido, has been found in the central Kurils (Tezuka and Fitzhugh 2004). While it is probable that Epi-Jomon groups reached the northernmost Kuril Islands, there is currently no certainty that the sites excavated and dated there represent specific Epi-Jomon occupation. The Epi-Jomon period represents the first consistent, archipelago-wide colonization of the Kuril Islands at least through the central part of the island chain, though the reason for human migration into the islands is still not well understood. Sea mammal hunting further expanded during the Epi-Jomon, potentially as a result of climate cooling

that took place during the Final Jomon making Hokkaido and the southern Kurils an attractive area for sea mammals and hunting (Yamaura 1998), though connections between climate change and the distribution of sea mammals have not yet been explicitly made. Maritime fishing and hunting techniques advanced with use of toggling harpoon, one-piece and composite fish hooks, and fish hooks made of iron, possibly obtained from Yayoi farmers through exchanges of Yayoi rice for sea mammal products from Hokkaido (Akazawa 1986; Yamaura and Ushiro 1999).

### *Okhotsk Culture*

By around 1500 BP, a new group of people emerged in the Sea of Okhotsk region who would eventually flourish in the Kuril Islands. The Okhotsk culture (1500-800 BP) first appears as early as 1600 BP in the Amur River delta and northern Sakhalin Island (Yamaura 1998). The Okhotsk culture is characterized as being highly adapted to maritime environments based on specialized tool kit that included toggling and barbed harpoons, composite fish hooks, needles and net sinkers indicative of net use (Befu and Chard 1964; Hudson 2004). Okhotsk culture sites contain marine fauna including seal, fur seal, and Stellar sea lion, as well as a variety of fish (Okada 1998; Otaishi 1994). On Sakhalin Island and on Rebun and Rishiri islands off the coast of Hokkaido there is evidence of pig raising in Okhotsk sites (Hudson 2004; Watanabe et al. 2001). Symbolic items associated with the Okhotsk culture include stone pendants, tooth pendants, and zoomorphic figures (Befu and Chard 1964). The Okhotsk people lived in villages of up to 100 pentagonal or hexagonal pit houses, often arranged around protected bays or coves and sometimes fortified (Yamaura and Ushiro 1999). Okhotsk pottery is sand-tempered and low-fired with flat to rounded vessel bottoms, and appears to share many traits with pottery found along the Amur River. Similar pottery and harpoon styles are found in sites belonging to the Tokarev culture along the northern Sea of Okhotsk coast, suggesting an ancestral relationship between the Okhotsk and Tokarev cultures (Befu and Chard 1964; Ponkratova 2006; Yamaura 1998). Overall, the Okhotsk have been described as one of the most marine-adapted culture groups in Japanese prehistory (Hudson 2004), and stable isotope research on Okhotsk human remains indicates a heavy reliance on marine mammal protein (Chisholm et al. 1992; Okada 1998).

The movement of people from the Amur River south into Sakhalin as the Okhotsk culture, and north around the western Sea of Okhotsk as the Tokarev culture, may have been the result of social unrest due to conflict with Manchurian dynastic expansion into the Amur River area (Yamaura and Ushiro 1999). Okhotsk groups were initially present in southern Sakhalin Island by 1500-1400 BP and along the coast of northern Hokkaido by 1400-1300 BP (Amano 1978; Okada 1998; Yamaura 1998). They may have been prevented from moving into the interior of Hokkaido by Satsumon people, who had replaced or grew out of the Epi-Jomon in northern Japan. The Satsumon practiced millet and wheat agriculture in addition to salmon fishing, and had strong trading ties to the Kofun period clan groups to the south on Honshu (Imamura 1999; Yamaura and Ushiro 1999). The Okhotsk are seen as an intrusive group who maintained a unique cultural identity separate from the Satsumon on Hokkaido, though they may have had indirect trade for metal items from Honshu through interaction with the Satsumon. The application of Okhotsk pottery designs on Satsumon vessel types may be an indication that there was some cultural assimilation between Okhotsk and Satsumon groups in eastern Hokkaido around 1000 BP towards the end of the Okhotsk period (Hudson 2004; Okada 1998; Yamaura and Ushiro 1999).

Okhotsk-era sites are present throughout the Kurils in southern, central, and northern islands; evidence of Okhotsk presence or trade contact with groups in southern Kamchatka is indicated by the presence of caribou antlers in northern Kuril Okhotsk sites (Yamaura 1998). Given their specialized focus sea mammal hunting, Okhotsk groups were well adapted to thrive in the central and northern Kurils. Climate data indicate that temperatures that were colder than present during the early part of the Okhotsk period (1500-1300 BP) (Koizumi et al. 2003) followed by a warmer climate from 1300-900 BP (Elvin 1993; Razjigaeva et al. 2002). One hypothesis (currently not supported with specific data) is that this warming trend may have reduced the sea mammal population resulting in poor hunting conditions in Hokkaido and the southern Kurils (Yamaura 1998). If sea mammal populations retreated into the central and northern Kurils, these areas may have been refugia for some Okhotsk groups while others in Hokkaido were being subsumed by the expanding Satsumon (Fitzhugh et al. 2002; Hudson 2004).

### *Ainu Culture*

The last indigenous culture group to inhabit northern Hokkaido and the Kuril Islands is known as the Ainu. Around 800 BP the Ainu replaced the Satsumon on Hokkaido and then moved into the Kurils 100-200 years later (Kikuchi 1999). The origin of the Ainu people is not well understood or agreed upon by researchers of this region. One argument is that the Ainu are the direct descendants of the Satsumon on Hokkaido (Kikuchi 1999; Kono and Fitzhugh 1999; Okada 1998), while others see a strong connection between the Okhotsk and the Ainu based on the *ioymante* bear spirit sending ceremony (Yamaura and Ushiro 1999), which is central to Ainu culture and believed to have originated with the Okhotsk. Skeletal morphological research indicates that the Okhotsk were physically different from Ainu and Satsumon populations and more similar to present-day Nivkhi and Ulchi people of Sakhalin and the Amur River valley. Okhotsk mitochondrial DNA data show a closer genetic affinity with Ainu people, and supports the hypothesis that the Ainu are descendants of combined Okhotsk and Satsumon groups (Sato et al. 2007).

Ethnographically, the Ainu are associated with terrestrial hunting, riverine salmon fishing, and plant-food collecting on Hokkaido (Watanabe 1972). Additionally, A. Okada (1998) and I. Okada (1998) describe roughly 60 shell mound sites on Hokkaido attributed to Ainu settlements, and that closed-socket harpoons used by the Okhotsk culture were used by the Ainu for sea mammal hunting. Regional variation in Ainu culture has been detailed by ethnologist Ohnuki-Tierney (1976) who differentiated between three different Ainu groups living on Sakhalin Island, Hokkaido, and in the Kuril Islands. Sakhalin Ainu lived on the southwestern coast of the island in small settlements of 20 houses or less. Summer villages were located on the coast, but moved further inland during the winter. Winter subsistence focused on terrestrial hunting of large animals such as deer and bear, marine mammal hunting, and ice fishing. The primary summer subsistence activity was fishing. They did not produce pottery and utilized dogs to pull sleds in the winter. These groups had contact with Manchuria and China through the so-called “Santan” trade networks that extended throughout Sakhalin Island (Walker 2001). In Hokkaido many Ainu lived in the interior of the island and focused on terrestrial hunting and riverine fishing, using dogs for hunting as well as poison darts tipped with aconite; other Hokkaido Ainu lived on the coast and the far southern Kurils and engaged in sea mammal hunting and ocean fishing. Overall,

Hokkaido Ainu had a more permanent residence pattern than Sakhalin or Kuril Ainu groups. The Ainu living in the central and northern Kurils led a life quite different from those in the southern Kurils and Hokkaido. Dogs were used to pull sleds in the winter, and were also a source of meat. Fishing was an important subsistence activity, as was sea mammal hunting, which also provided oil and materials for making clothing and tools. Kuril Ainu also used birds extensively for food and clothing material. They lived in large pit house villages, but also had different summer and winter settlements, and moved frequently in search of food, though within a prescribed area (Fitzhugh et al. 2002; Ohnuki-Tierney 1976).

Following their move into the Kuril Islands in the 14<sup>th</sup> or 15<sup>th</sup> centuries, the Ainu interacted initially with indigenous Kamchadal and Itelmen groups in southern Kamchatka – as evidenced by Ainu Naji-style pottery found at several sites on Cape Lopatka (Dikova 1983) – and were later heavily influenced by Russian and Japanese trading enterprises. When Russian Cossacks colonized Kamchatka, they came into contact with northern Kuril Ainu living on Paramushir and Shumshu islands, and implemented a tribute program known as *yasak* for obtaining sea mammal furs. They also traded products such as liquor, tobacco, flour, butter, sugar, and salt to the northern Ainu (Walker 2001; Stephan 1974). The northern Kuril Ainu also provided sea otter pelts and eagle feathers to the southern Ainu living on Kunashir and Iturup, who in turn traded them to Japanese populations on Honshu in exchange for iron pots and swords, cotton, silk, and Japanese lacquerware. These items were traded north and also exchanged by the northern Kuril Ainu with the Russians in Kamchatka and also probably Kamchadal/Itelmen groups (Tezuka 1998). In the 18<sup>th</sup> century, the Matsumae clan which controlled trade in Hokkaido prohibited Ainu trading north of Iturup Island, the Hokkaido Ainu were eventually forced into working in forest and fishing resource procurement enterprises run by Japanese merchants in Hokkaido (Walker 2001). In 1875, the remaining Kuril Ainu, approximately 1,000 people, were relocated to the southern Kuril island of Shikotan by the Japanese Meiji government when the island chain was acquired from Russia in exchange for Sakhalin Island (Fitzhugh 1999; Rees 1985; Stephan 1974). At the end of WWII, the Soviet Union attacked the remaining Japanese military outposts in the northern Kurils and ultimately took control of the entire island chain from Shumshu to Kunashir, the Habomai group of islands, and Shikotan

Island. The Soviets found only three Ainu remaining in the entire island chain, two on Iturup and one on Paramushir; the rest of the Ainu population had been moved from Shikotan to Hokkaido by the Japanese during the war. These final three representatives of the Ainu in the Kuril Islands were eventually deported back to Japan by the Soviets (Stephan 1974).

In terms of KBP work in the Kuril Islands, Ainu archaeological deposits have been more ephemeral than older deposits. Site components that date to the Ainu period or that contained Ainu artifacts, such as ceramic pots with inner lugs, were found on Urup, Matua, Rasshua, Shiashkotan, and Ushishir islands, and are represented by 45 radiocarbon dates, 13.9% of the total radiocarbon date distribution. The most significant Ainu site was located on Rasshua Island, which contained a likely historic Ainu house structure and an 18<sup>th</sup>/19<sup>th</sup> century glass trade bead (Fitzhugh et al. 2009b).

### **A Chronological Historical Sequence**

The culture-historical sequences as described above provide a spatio-temporal and cultural background against which to place the present work in the Kuril Islands, but are problematic in terms of being directly applied to Kuril sites and cultural materials due to the way that the cultural frameworks have been constructed by previous generations of archaeologists.

Japanese pottery typologies were developed to assign sites to cultural and chronological periods, and this approach was to classify archaeological materials into types composed of recurring associations of traits representing archaeological cultures. It is recognized that there are many cultural subdivisions within the overall Jomon framework, which has more than 70 regionally defined pottery types (Kaner 1996). But there has been little agreement on how to deal with this variation, and much of the post-WWII archaeology in Japan was conducted with little theoretical or anthropological orientation. Culture histories based on extensive pottery typologies were seen as an end rather than a means to reaching higher level interpretation and explanation (Ikawa-Smith 1982). For example, the Epi-Jomon culture of Hokkaido is not well-defined or understood. It is essentially a complex of pottery types that are distinctive from the Yayoi types representing early agriculture groups on Honshu.

Stratigraphically, the Epi-Jomon types are preceded by Final Jomon pottery and followed by Satsumon pottery (Aikens and Higuchi 1982). Japanese archaeology has also been accused of muting variability and diversity in the archaeological record in order to develop a specifically Japanese version of prehistory that is free from the influence of outside ideas and material culture (a concept called *nihonjinron*) (Fawcett 1996; Kaner 1996). Finally, a compounding problem is that often the pottery types are not connected with chronometric scales because as Imamura (1996:17) describes, “most Japanese archaeologists think deviations and occasional errors in radiocarbon dating are larger than the timescales made by pottery chronology,” and Japanese archaeologists are reluctant to give equal weight to radiocarbon chronologies and consider pottery chronologies more reliable.

Using the pottery-based culture-historical frameworks developed for Hokkaido in the Kuril Islands is problematic because in many cases it is difficult to match pottery from the Kurils to specific the Epi-Jomon and Okhotsk typological divisions that are defined for Hokkaido. While there are specific connections of ceramics in the southern Kurils to Hokkaido types, the variation present in ceramic assemblages from the central and northern islands can be tied to general cultural groups (Epi-Jomon and Okhotsk), but does not correlate to the Hokkaido the more fine-grained typological phases (Erik Gjesfjeld and Kaoru Tezuka, personal communication).

It could be that the Hokkaido typologies fail to distinguish between the variation introduced into ceramics through different cultural, environmental, or adaptive processes that exist in the Kuril Islands – differential cultural transmission of pottery styles, influence of outside cultural groups, cultural evolution in insular environments, technological innovation and adaptation, etc. If our goal is to identify the social and cultural system reflected in the production and use of material objects (Read 2007), then it is difficult and potentially misleading to assign human populations in the Kuril Islands to culture groups defined by a pottery typology that was created specifically for Hokkaido.

Research on the ceramics of the Kuril Islands is still being developed, and there are currently no other material culture typologies (for stone tools, bone tools, art forms, etc.) that can contribute to outlining the key cultural material traits of the groups of people who occupied the Kuril Islands at various times and in varying intensities. A forthcoming

analysis of faunal data might indicate differences in subsistence strategies between Kuril occupants, but it is still in development. While useful artifact typologies specific to the Kuril Islands may be developed in the future, what is currently needed is a temporal framework that is specific to human occupation of the Kurils and that acknowledges the cultural trajectories of the adjacent regions from which Kuril Island colonizers likely migrated from, but without being locked into specific culture historical units that are defined by the central tendencies of typological divisions created for those regions. The method used here is to review the frequency distribution of radiocarbon dates for the Kuril Islands and define occupation sequences based on significant peaks and gaps in the distribution, an approach first developed for this data set by Ben Fitzhugh and William Brown who are working to provide a detailed analysis of the cultural chronology for the Kuril archipelago (Fitzhugh et al. in press; Brown and Fitzhugh in prep). The interpretation of temporal frequency curves is subject to several forms of bias, including the frequent activities of small but highly mobile foraging groups, differential visibility of certain type of archaeological sites, and the taphonomic processes that may destroy the oldest sites (Louderback et al. 2010; Surovell and Brantingham 2007; Surovell et al. 2009). Given these potential complexities, the use of radiocarbon frequency distributions represents the best current way to investigate human occupation intensity in the Kuril Islands. As suggested by Louderback et al. (2010:4), the peaks and troughs of the frequency distribution are not meant to represent a linear relationship between the number of radiocarbon dates and human occupation sites, but rather a general indication of the density of people in the island chain.

Figures 4.1 and 4.2 present radiocarbon date frequency histograms in 50 and 100 year bins respectively that have been converted to stacked area plots across 4500 years of time in the Kuril Islands (244 radiocarbon dates are represented in the 50-year bin distribution, 207 in the 100-year bin distribution). To eliminate the over-contribution of radiocarbon dates to the distribution from sites that were more extensively excavated and from which a larger number of dates were obtained, one radiocarbon date per bin period was chosen per site. In the case that there were multiple dates available, the oldest date was used (for example if for the 2350 BP 50-year bin there were three dates available from a site, 2310, 2335, and 2340, the 2340 date was used in the frequency distribution).

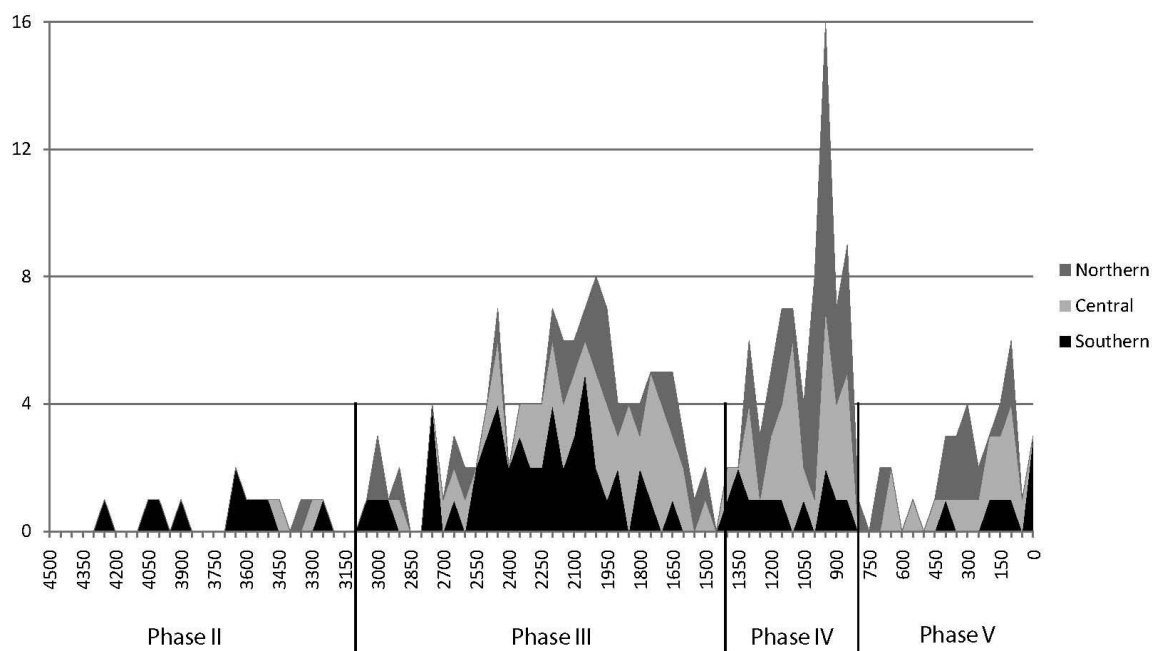


Fig. 4.1: Distribution of Kuril Island radiocarbon dates in 50-year bins (adapted from Brown and Fitzhugh in prep).

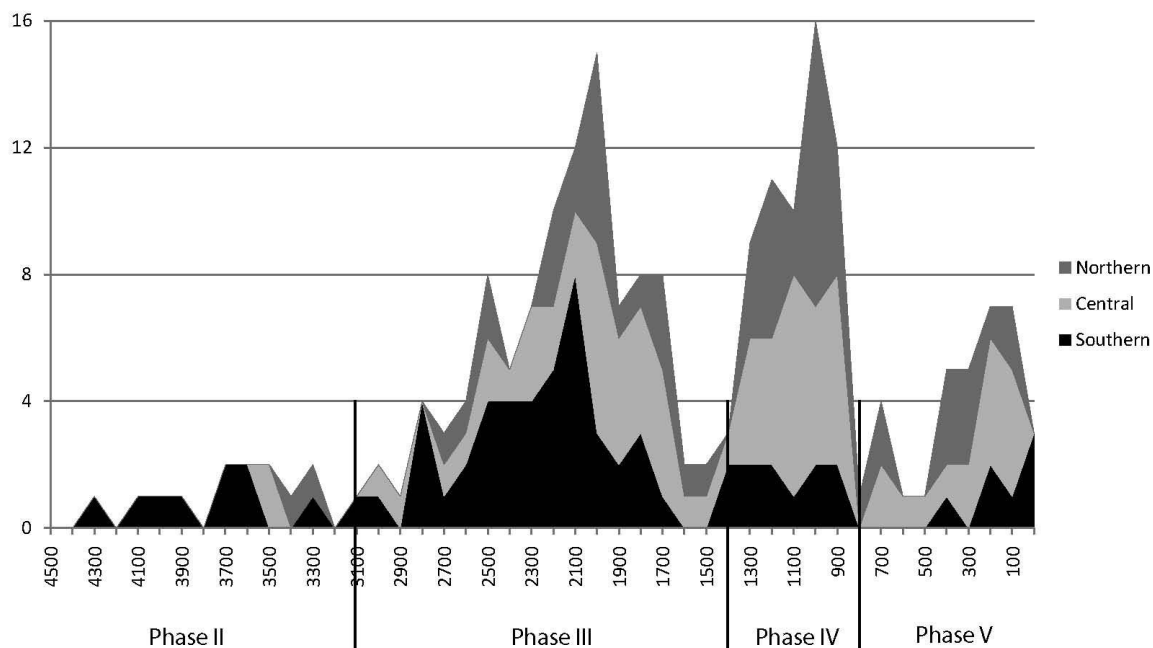


Fig. 4.2: Distribution of Kuril Island radiocarbon dates in 100-year bins (adapted from Brown and Fitzhugh in prep).

The geography of the Kurils has been mapped onto this plot by indicating how many of the radiocarbon dates come from the Southern, Central, and Northern parts of the Kuril chain for each 50 and 100 year bin. These graphs provide a way to visualize not only when, but where, the Kuril Islands were occupied and the intensity of the occupations based on the number of dates.

For the purposes of this graph, four dates between 7055 and 6895 BP are not shown on the distribution. All four of these dates come from the Yankito site on the southern island of Iturup, and there are no other dates for the period of time between 7100 and 4300 BP. This period is designated as the *Phase I* occupation of the Kuril Islands, represented by a dated single site and 2800 years of time. It is likely that there were similar sites elsewhere on Iturup and on Kunashir island which could be considered extensions of Early and Middle Jomon lifeways of Hokkaido projected into the southernmost Kuril Islands, and Middle Jomon pottery has been found at several sites on Iturup (Shubina and Samarin 2009). The climate in the southern Kurils during the Proto period was warmer and coincided with the Early Jomon warming and the rise in sea level during the Jomon

Transgression (Korotky et al. 2000; Razjigaeva et al. 2002, 2004). The southern Kurils were environmentally most like Hokkaido in terms of the terrestrial and marine subsistence resources that would have been available to colonizing groups primarily focused on hunting bear and deer, gathering plant foods, and fishing in island rivers and on the coast.

Based on the graphical distribution of radiocarbon dates in Figures 4.1 and 4.2, four different occupation sequences can be defined. The first is a period from 4300 – 3100 BP represented by 13 dates in both the 50- and 100-year bin distributions. These dates are predominantly from sites located in the southern Kurils, and correspond to Late Jomon occupations in Hokkaido. While this does not represent the absolute earliest human occupation in the Kuril Islands, it appears to be a prelude to more intensive occupation in the southern and central islands later on, and it is designated as the *Phase II* period. During Phase II, additional colonizing groups from Hokkaido may have migrated into the southern islands and for the first time, the central part of the island chain as far north as Rasshua Island. The climate began to cool during the Incipient period (Korotky et al. 2000; Razjigaeva et al. 2002, 2004), which may have been the beginning of improving conditions for sea mammal hunting in the southern and central Kuril Islands.

The second grouping of dates and the first major occupation sequence is designated as *Phase III* of Kuril occupation and extends from 3100 – 1400 BP. In Phase III there is a sharp increase in sites in the southern part of the island chain initially, and then in the central and northern regions later. A total of 118 dates make up the 50-year bin distribution, 99 dates in the 100-year bin distribution. This period roughly corresponds to the Epi-Jomon period in Hokkaido and the southern Kurils, and represents the first major occupation of the entire island chain, including consistent occupation of the northern Kurils beginning around 2300 BP. The climate during Phase III is characterized by several minor warming episodes but remained generally cooler than the preceding climate of the Jomon Transgression (Razjigaeva et al. 2002, 2004). Overall, Phase III represents the colonization and occupation of the entire archipelago, though sites in northern islands were occupied later than and not as intensively as the southern and central islands. Colonization of the islands chain took place over 1700 years as human groups slowly but methodically pushed northward. The expansion of sea mammal hunting that took place in Hokkaido during the Epi-Jomon period (Yamaura 1998) could have been a factor in the migration of people into

the interior of the Kuril chain, particularly if social changes in Hokkaido began to push Epi-Jomon groups towards an increasingly marine-adapted way of life.

*Phase IV* of Kuril occupation is assigned to the sequence that begins around 1400 BP and lasts for approximately 600 years until 800 BP. While this phase is shorter than Phase III, it represents the most intensive occupation in the Kuril Islands, particularly around 1000 BP. This period is made up of 78 radiocarbon dates in the 50-year bin distribution and 62 in the 100-year bin distribution. Based on the graphs presented here, the central and northern islands contribute the highest number of dates to the distribution, but this may be skewed by the fact that fewer sites were excavated in the southern islands than the central and northern islands during the 2007 and 2008 field seasons, and thus the southern island sites are underrepresented. Phase IV corresponds closely to the previously defined Okhotsk culture presence in Hokkaido and the Kuril Islands. Based on the shorter duration of Phase IV Kuril occupations, it appears the Okhotsk could have moved rapidly into the Kurils and established sites in the central and northern islands, apart from the Satsumon groups who replaced the Epi-Jomon in Hokkaido.

The final occupation of the Kuril Islands by indigenous people took place between 800 and 0 BP (with 0 BP corresponding to 1950 AD) and is designated as *Phase V*. Phase V corresponds to historically and ethnographically known occupation of the Kurils by the Ainu as well as Russian and Japanese explorers, settlers, and military detachments. The Ainu are described primarily in the southern and northern islands, but a significant portion of the dates for this period come from the central islands. Phase V is made up of 35 and 33 dates for the 50-year and 100-year bins respectively.

Table 4.1 summarizes the chronology of occupation sequences defined for the Kuril Islands which correspond roughly to the culture-historical periods developed in Hokkaido, and this framework provides the basis for constructing and interpreting the artifact assemblages analyzed for the current research. While the most basic changes in Kuril ceramic artifacts roughly correlate to the Epi-Jomon, Okhotsk, and Ainu culture history designations, it seems logical that the people who colonized and occupied the Kuril Islands, while having cultural connections to Hokkaido, left a distinct record of material culture that varied compared to the record of Hokkaido due to their unique adaptations to the Kuril environment. This assumption could be strengthened by the determination that people

occupied the Kurils on a year-round as opposed to seasonal basis, but this assertion cannot confidently be made based on current data.

<b>Time Period</b>	<b>Kuril Islands Chronological Designation</b>	<b>Corresponding Hokkaido Culture-Historical Period</b>
7100 - 4300 BP	Phase I	Early/Middle Jomon
4300 - 3100 BP	Phase II	Late Jomon
3100 - 1400 BP	Phase III	Final/Epi-Jomon
1400 - 800 BP	Phase IV	Okhotsk/Satsumon
800 - 0 BP	Phase V	Ainu

Table 4.1: Proposed chronological-historical framework for the Kuril Islands.

The range of behavioral variability within a particular cultural occupation sequence in terms of lithic resource procurement and consumption is not currently known in the Kuril Islands. The analysis of lithic assemblages from various geographic and chronological contexts may provide a way to differentiate instances of behavioral adaptation within a specific culture group from episodes of population replacement in the Kuril occupation sequence. The chronological sequence proposed here provides a culture-neutral framework within which artifact analysis can be placed for comparison and interpretation without the *a priori* assumptions of Hokkaido-based ceramic culture-historical sequences.

## Chapter 5: Analysis of Kuril Island Debitage Assemblages

### Introduction

Lithic artifacts represent not only the earliest record of human material culture, but also the most ubiquitous type of artifacts in the archaeological record. Distinguishing human-made from naturally-modified stone objects is one of the most fundamental types of analysis in the discipline of archaeology, and has played an important role in determining the integrity of entire sites and chronological periods. The analysis of lithic artifacts has the potential to answer questions not only about how the stone tools were made, but also provide input into the larger questions about prehistoric human behavior, lifestyle, economic systems, and social and organizational structures (Odell 2004).

Understanding how lithic raw materials were used for the production of stone tools allows for the development of inferences and explanations about raw material procurement strategies and activities, and how environmental and social factors may have impacted the consumption of lithic resources. Lithic raw material availability, abundance, form, and quality are all variable qualities or characteristics of the lithic resource base which act as factors that influenced the length of time and level of detail with which a stone tool was produced, used, and maintained (Andrefsky 2008).

There is no direct way to measure the lithic resources that were available in environments of the past as modern raw material surveys can be incomplete or inaccurate, particularly for environments that have experienced significant geomorphological change such as the Kuril Islands. However, the availability of lithic resources in the past can be inferred from artifact assemblages through the analysis of the consumption of raw materials represented in those assemblages (Dibble 1991).

The analysis of lithic assemblage reduction sequences and intensity provides a basis for not only identifying lithic reduction techniques, and technological traits and strategies, but also for developing higher-order interpretations and the evaluation of behavioral models based on archaeological data (Shott and Nelson 2008; Wenzel and Shelley 2001). This chapter focuses on the analysis of Kurildebitage assemblages with a focus on exploring lithic resource use in terms of the predictions for the conservation of raw materials based on Kuril Island environmental conditions as described in Chapter 2.

## **Debitage Analysis Overview**

Stone tool manufacturing is a reductive technology in the sense that a nodule of lithic raw material is reduced by the process(es) of removing individual flakes from it in the production of the tool. While in some instances individual flakes may represent a desired final product, they more often represent a record of the tool manufacturing process (Steffen et al. 1998). Debitage assemblages are created at the time of stone tool manufacturing, and are not likely to be transported away from the tool production site. While the analysis of completed tools is useful for addressing questions related to how the tools were used once they were made, issues of subsistence and mobility strategies, as well as functional and stylistic traits,debitage assemblages are more appropriate for understanding the consumption of lithic raw material and the techniques of stone tool manufacturing. In the 1970s and 1980s a number of archaeologists began trying to replicate examples of prehistoric artifacts with the goal of usingdebitage to recreate and understand the processes of stone tool production (Amick and Mauldin 1989; Amick et al. 1988; Crabtree 1982, Ingbar et al. 1989; Magne and Pokotylo 1981; Patterson and Sollberger 1978). A key component of this research was the investigation of flakedebitage variability and the sources and conditions associated with that variability (Andrefsky 2001). Analysis ofdebitage variability was then extended to make inferences about past human behavioral variability that accounts for the patterns that are seen in the archaeological record in terms of stone tool production (Andrefsky 2009; Carr and Bradbury 2001; Odell 1989). An ultimate goal for many of these studies is to establish causal relationships based on an understanding of the circumstantial factors that influence decision-making which has been transformed into archaeological patterns (Arnold 2004).

Reduction sequence stages provide an analytical platform for measuring lithic reduction intensity, which can be informative for exploring issues of stone tool manufacturing in the context of human decision making about the management of lithic raw material resources. Many archaeologists have used measures of reduction to test model predictions derived from human behavioral ecology (Clarkson and O'Connor 2005; Marwick 2008), which are often associated with issues of cost, risk, efficiency, and mobility (Bamforth 1986; Bamforth and Bleed 1997; Bleed 1996; Fitzhugh 2001; Jeske

1989; Myers 1989; Nelson 1991; Torrence 1989). Reduction stages usually do not represent real entities – they are abstractions placed on artifact assemblages by the archaeologist – but are a good analytical tool for dividing debitage assemblages into meaningful units of analysis. As long as the stages are well-defined, mutually exclusive, and linked to theory, they are useful for hypothesis testing (Bradbury and Carr 1999).

### **Research Questions**

The goal of the collection and analysis of debitage from Kuril Island sites is to ascertain how lithic raw material was being consumed in Kurils in the context of raw material curation/economy. Curation is defined as a form of economizing behavior with the goal of maximizing the ratio of yield to cost in terms of procuring and using lithic raw material (Jeske 1989). Curation can also be characterized as maximizing the potential use life of a tool before it is discarded (Andrefsky 2009; Shott 1996).

The concept of curation has a “property of significance” (Shott 1996:264) because it is useful for understanding the relationship between behavior and lithic assemblage formation. Curation can be seen as an adaptive response to the high cost of procuring lithic raw material (or the low availability of raw material) with an emphasis on maximizing the consumption of raw material through tool maintenance and recycling activities. The results of these activities should be seen as specific patterns in archaeological assemblages, specifically the debitage assemblages that represent the by-products of tool production, maintenance, and recycling. Depending on ways raw material is distributed and procured, curation activities may vary within a single culture group if the cost and availability of the raw material varies, resulting in differing assemblage characteristics for behaviorally and ethnically identical sites (Bamforth 1986).

Based on the expectations for raw material consumption outlined in Chapter 2, the varying levels of raw material availability in different Kuril Island environments should affect the level of lithic resource curation/economy detected in the artifact assemblages. Lithic assemblages from sites where high-quality raw material is widely available and the cost of procurement is low should demonstrate a low curation/economy strategy of raw material consumption. Assemblages from sites where lithic resources are less available and procurement costs of high should show evidence of high levels of curation/economy. In

order to measure curation, debitage analysis must be designed to be responsive to the intensity of raw material consumption through reduction activities.

The analytical techniques used to examine debitage assemblages span from the mass analysis of entire flake assemblages, to the classification of individual flakes based on flake attributes, and combinations of both approaches (Andrefsky 2007, 2009). Mass analysis is a method that segregates a debitage assemblage into size grades, often by sifting flakes through a series of nested screens. The segregated assemblage is then compared to a control experimental assemblage to make inferences about stone tool production techniques and activities (Ahler 1989; Andrefsky 2009). The advantage of this method is that it is fast and highly replicable, as well as objective since there is no human decision making involved after the size grades are established (Ahler 1989). However, debitage analysis based on flake size is compromised by the fact that there is overlap in the size distributions of flakes produced by different techniques and at different stages, and that it is difficult (if not impossible) to separate debitage from multiple reduction episodes present in a single archaeological assemblage (Mauldin and Amick 1989; Root 2004). Additionally, maximum flake size will be limited by the initial size of the raw material nodule or cobble, potentially making relative comparisons of assemblages based on flake size alone problematic.

At the opposite end of the debitage analysis spectrum, analysis of single debitage specimens provides a way to adding individual flakes to specific reduction stages and technologies (Andrefsky 2009). Recording flake attribute clusters as they co-occur on individual flakes allow for the creation of flake typologies that can be coordinated with the research questions at hand (Steffen et al. 1998). The typological classification of debitage may allow for the detection of specific trends in lithic reduction that are useful indicators of lithic technological behavior (Yohe 1998). Useful attributes include measurements of dorsal cortex, dorsal flake scars, flake termination, and striking platform morphology (Root 2004). The amount of dorsal cortex on a flake is useful as an indicator of the tool reduction stage based on the assumption that as core or biface is further reduced, the outer cortex of the stone is removed, and that assemblages formed through more extensive reduction will have a higher proportion of non-cortical flakes (Andrefsky 2005; Dibble et al. 2005). Similarly, as a piece of stone is reduced, the number of flake scars on the dorsal surface of debitage flakes will increase – flakes removed earlier in the reduction process should have fewer

dorsal flake scars a than flakes removed later (Andrefsky 2005; Lyons 1994). Flake termination can inform about the type of force used to detach a flake, such as hard hammer versus pressure flaking, which is important for interpreting the reduction techniques that were employed inferring the stage of reduction. Variation in striking platform morphology in terms of the number of facets also varies with reduction stages, with later reduction stage flakes generally having a higher number of striking platform facets (Andrefsky 2005; Magne and Pokotylo 1981). Utilizing combinations of individual attributes to define mutually exclusive typological classes is a way to overcome some of the complications and deficiencies of using either flake size or individual attributes alone.

Since bifacial tools, primarily in the form of projectile points, biface blanks, and scrapers, were the dominant tool classes observed in Kuril artifact assemblages, the flake categories used in this analysis were modeled after Yohe (1998) and Corn (n.d.) whose research was focused on the analysis of biface reduction stages. Their analyses consisted of the use of reduction stage flake categories based on multiple flake attributes, which agrees with Carr and Bradbury (2001) who found that no single flake attribute can be used to reliably classify an individual flake into a reduction stage category. Utilizing multiple lines of evidence in the form of multiple analytical techniques strengthens inferences made from the data (Bradbury and Carr 1999), and in addition to recording basic size measurements for each flake (weight and thickness), all flakes were classified to one of the ten attribute-based categories of the reduction typology described below.

1. First Flakes – These flakes are the first ones removed from a cobble or nodule in a reduction sequence and have 100% cortex covering the dorsal face, no dorsal flake scars, and a cortical platform (or platform missing).
2. Early Stage A – Flakes with 51-99% dorsal cortex, simple dorsal flake scar patterning (1 or 2 dorsal flake scars), and a striking platform with cortex, one or two facets (or platform missing).
3. Early Stage B – Flakes with 51-99% dorsal cortex, complex dorsal flake scar patterning (3 or more dorsal flake scars), and a striking platform with cortex, 1, 2, or 3 or more facets (or platform missing).
4. Middle Stage A – Flakes with 1-50% dorsal cortex, simple dorsal flake scar patterning, and a striking platform with cortex, one or two facets (or platform missing).
5. Middle Stage B – Flakes with 1-50% dorsal cortex, complex dorsal flake scar patterning, and a striking platform with cortex, 1, 2, or 3 or more facets (or platform missing).

6. Late Stage A – Flakes with no dorsal cortex, simple dorsal flake scar patterning, and a striking platform with one or two facets (or platform missing).
7. Late Stage B – Flakes with no dorsal cortex, complex dorsal flake scar patterning, and a striking platform with cortex, 1, 2, or 3 or more facets (or platform missing).

Biface reduction can be separated into any number of stages delineated by various combinations of flake attributes. In the analysis of Kuril Island debitage, the flakes categorized into seven attribute-based flake categories above can be collapsed into more general early, middle, and late stage of reduction classes, following the reduction outline of Morrow and Jefferies (1989). In early stage reduction, flake removal is aimed at removing cortex material and conducting initial piece shaping to create a crude biface blank, which results in the removal of large percussion flakes and angular fragments. The middle stage of biface reduction produces a more refined biface preform through the removal of biface thinning flakes from the lateral margins. The final late stage of reduction produces the finished tool or refreshes an existing tool through the removal of small edge modification flakes (re-sharpening or retouch flakes). The overall reduction trend can be characterized as a decrease in the proportion of flakes with cortex, an increase in dorsal flake scars and striking platform facets, and a decrease in flake size (Bradbury and Carr 1999).

Additionally, measures of flake mass in conjunction with flake counts can provide a simple measure of reduction intensity. Following the basic premise that flake size becomes smaller as the reduction process continues, assemblages of raw materials with fewer flakes but higher flake mass would be indicative of Early stage reduction – represented by large flakes that were removed in the initial stages. In comparison, raw material assemblages with a higher flake count but lower flake mass would indicate Late stage reduction – represented by many small flakes that were removed during final tool shaping and sharpening, and by tool resharpening and rejuvenation maintenance activities.

### **Sample Assemblage Description**

The flake artifacts that were analyzed for this study were recovered during archaeological excavations that took place over three field seasons from 2006 to 2008 as part of the larger Kuril Biocomplexity Project (KBP), a National Science Foundation-funded research project led by the University of Washington and aimed at examining the 5,000 year history of human-environmental interactions along the Kuril Island chain. The

KBP investigated over 60 archaeological sites across the entire archipelago and excavated more than 25,000 lithic artifacts. Of the total Kuril lithic assemblage, 4,947 unmodified flakes from excavation units and stratigraphic levels that were radiocarbon dated or could be assigned to a culture period based on ceramic analysis were included in the current study.

A brief overview of each of the sites with assemblages that were included in this study is given below. These sites were chosen to provide geographic as well as chronological coverage across the Southern, Central, and Northern Kuril Island groups. Due to various factors such as the limited time spent on some islands and field scheduling priorities, not all of the sites included in this study received the same amount of testing and excavation, as noted below. Detailed information on site location, excavation history, stratigraphy, and interpretations of site occupational sequences can be found in KBP archaeological field research reports (Fitzhugh et al. 2007, 2009a, 2009b).

### **Southern Island Sites**

#### *Ainu Creek 1 (AIC1), Urup Island*

The Ainu Creek 1 site, located on the southern end of Urup Island, was initially tested by the KBP over a period of six days in 2006, and excavated further for two weeks at the beginning of the 2007 field season. The site is located on a bluff 10 m above the beach on the Sea of Okhotsk side of the island. It consists of an unknown number of house pits and a large midden that is exposed by a road leading away from the beach that cuts through the site. Several WWII or Cold War-era military pits and trenches are also found within the archaeological site boundaries. During the 2007 field season, excavation units were placed in the road which had recently been widened by illegal construction activity and destroyed part of the upper layers of the site. The excavation of a 4 m by 10 m area removed much of the newly disturbed upper deposit by digging with shovels in thick arbitrary stratigraphic layers. Lower layers, interpreted as represented an undisturbed Epi-Jomon occupation, were dug at the very end of the excavation with hand trowels. The late excavation by trowel was focused on excavation units A1, A2, A3, B1, B2, and B3. These uphill units were believed to have been less disturbed by road plowing activity than other downhill units (see Fitzhugh et al. 2009a for a detailed description and interpretation of the site's stratigraphy). All of

the 1,145 flakes from the Ainu Creek 1 site analyzed for this study come from the contiguous lower levels of units A1, A2, and B2. Charcoal samples taken from unit A2, Levels 2 and 3 (OS-67619 and OS-67643) were radiocarbon dated to 2300 +/-60 and 2310 +/-60 radiocarbon years respectively, and this assemblage is assigned to Phase III.

### **Central Island Sites**

#### *Vodopodnaya 2 (VOD2), Simushir Island*

The Central Kuril site of Vodopodnaya 2, located on Simushir Island, was initially tested in two days by the KBP in 2006; in 2007 a seven-day excavation was conducted at the site. The site is located on the northwestern side of the island on a terrace approximately 40 m above the beach which overlooks the Sea of Okhotsk. In 2006, three 1 m by 1 m test pits were dug among 59 house pits identified at the site. In 2007, a 7 m by 2 m excavation area was dug adjacent to the 2006 Test Pit 3 unit, which had been placed between two house pit features. This excavation yielded a large number of stone and bone tools, ceramic sherds, lithic debitage, and faunal remains. A total of 17 wood charcoal samples from the 2006 Test Pit 3 and 2007 excavation units 1, 2, 3, and 4 were radiocarbon dated and returned dates that span from 1930 +/-30 to 1090 +/-25 radiocarbon years, and dating the occupation of the site to Phase III and Phase IV of the Kuril chronology.

A total of 722 flakes from unit/levels U2/L4, U3/L3, U3/L5, and U4/L10 were aggregated into one assemblage representing Phase III occupations. Unit U3/L3 contained charcoal samples dated to 1850 +/- 30 and 1930 +/-35; U3/L5 was dated to 1930 +/-30; U4/10 was dated to 1470 +/-30. There were no radiocarbon dates obtained for U2/L4, but it was assigned to Phase III based on the dates associated with the adjacent U3/L3 and U3/L5 layers. This assemblage represents approximately 500 years in time, and likely multiple occupations within the Phase III time period. Thus the behavioral signals drawn from this assemblage may be weaker because they potentially represent different lithic strategies from the middle and the end of Phase III.

There were 778 flakes from units/levels TP3/L2, U1/L2 and L3, U2/L2 and L3, U3/L2 that were aggregated into a second assemblage. All of these unit levels were designated as representing an “Upper Cultural Layer” (Fitzhugh et al. 2009a) in the site based on the presence of Okhotsk ceramic fragments, and two radiocarbon dates – one at

1090 +/-25 from TP3/L2, and one at 1100 +/-30 from U3/L2 – placing this assemblage in Phase IV.

*Rasshua 1 (RAS1), Rasshua Island*

On Rasshua Island, the Rasshua 1 site is located on the southwestern, Sea of Okhotsk-side of the island on a sloping terrace at the edge of an incised stream gully. The site was first visited by the KBP for one day in 2007, when several hours were spent testing two sections of an eroding bluff face. In 2008, a larger excavation lasting ten days was conducted and consisted of a 2 m by 4 m excavation unit Test Pit 1, which was sub-divided into two 2 m by 2 m units: Test Pits 1A and 1B; and Test Pit 2, a 2 m by 2 m unit dug 100 m to the southeast of Test Pit 1 A/B. The stratigraphy of Test Pit 1 is complex, and it is believed that site occupations spanning Phases III, IV, and V including 20<sup>th</sup> century activity are represented in the unit based on radiocarbon dating and diagnostic artifacts.

An assemblage composed of 952 flakes drawn from TP1A/L5, L6, and L7; and TP2/L3, L7A, L7C, L8A. Four different ethnostratigraphic layers have been defined for TP1A, including a top layer that represents military trenching activity across the site and redeposition of cultural materials from deeper in the unit and affects stratigraphic levels 1, 2, and 3A-3G. A second layer consisting of Levels 3H-J included intact cultural features with the remains of a wooden roof structure, interpreted as an Ainu house. Levels 3H and 3I are dated to 205 +/-35 and 214 +/-25 respectively, while 3J has a date of 2230 +/-30. Stratigraphically lower and beside the Ainu house depression, a third ethnostratigraphic layer is represented in a midden deposit in Level 4 of the unit. The fourth ethnostratigraphic layer is made up of the excavation layers below Level 4, and at the time of excavation was tentatively associated with an Epi-Jomon occupation. TP1A/L5 was dated to 1820 +/-25, and Level 7 was dated to 1700 +/-35, placing these levels in Phase III.

Test Pit two represents two occupation sequences; an initial house pit or other pit feature was dug prior to 2000 BP, and was subsequently covered by a layer of tephra from an Ushishir eruption. TP2/L7A is dated to 2040 +/-25 BP and L7B is dated to 2160 +/-35 BP. Cord-marked Epi-Jomon ceramics were found in TP2/L7B, 7C, 7D, and 8A. Following the Ushishir eruption, cultural materials from a nearby occupation were deposited on top of

the Ushishir tephra layers. TP2/L3 above the Ushishir tephra was dated to 1920 +/-25. Altogether, TP2 fits within last third of Phase III.

### **Northern Island Sites**

#### *Drobnyye 1 (DRO1), Shiashkotan Island*

The Drobnyye 1 site is located on the northern half of Shiashkotan Island on the Sea of Okhotsk coast. The site is situated on a terrace 30 m above the beach and on both sides of a deep stream-cut ravine. In 2006, two test pits were dug during several hours of island exploration and archaeological site testing. Test Pit 1, placed near a bluff-edge in the southern part of the site, was a 1 m by 1 m excavation unit excavated to 45 cm below surface. Test Pit 2 was located in the northern part of the site near a small point overlooking the beach. In 2007, the site was visited for six days to expand the original test pit excavations and test additional areas within the site, as well as to map the more than 40 house pit features identified at the site. The 2007 excavations included Unit 1, an expansion of the original Test Pit 1 on its northern side, Unit 2 located 40 m south of Unit 1, Unit 3 located 220 m NNW of Unit 1 in the far northern part of the site, and Unit 4 placed in a notch on a small isthmus leading to a point from the northern part of the site. All of the flakes analyzed in this study come from specific excavation levels in Test Pit 1, Unit 1, and Unit 3. The excavation levels from TP1 and U1 are roughly correlated as follows:

U1/L1 = TP1/L1

U1/L2 = TP1/L2 and top part of L3

U1/L3 and L4 = TP1 bottom of L3, L4, L5, and L6

One assemblage from this site is composed of 325 flakes drawn from Test Pit 1, Levels 4 and 5, and Unit 1 Level 4; TP1/L4 is dated to 1460 +/-35 and TP1/L5 is dated to 1470 +/-35. This assemblage is assigned to the end of Phase III based on the radiocarbon dates and the occurrence of cord-marked ceramics that may represent an Epi-Jomon occupation. A second lithic assemblage of 553 flakes comes from TP1/L2 and L3, U1/L1 and L2, and U3/L3 and L4. TP1/L2 is radiocarbon dated to 1110 +/-25, L3 is dated to 750 +/-30. By association, U1/L1 and L2 probably fall within this same date range. U3/L3 is dated to 870 +/-30 and L4 is dated to 1110 +/-25, with an additional date of 1720 +/-35 that

is anomalous or out of sequence. Based on these dates, this assemblage is assigned tightly to Phase IV.

*Ekarma 1 (EKA1), Ekarma Island*

The Ekarma 1 site was first identified during a KBP survey of the island in 2007, and was further tested during a ten day excavation in 2008. The site is located on the northern, Sea of Okhotsk side of the island and is situated on a terrace 20 m above the beach and 30 m to the west of a deeply incised stream valley. In 2008, a 2m by 2m unit labeled Test Pit 2 was dug using trowels and natural stratigraphic levels that were subdivided into arbitrary 10-20cm intervals for exceptionally deep natural layers. All of the flakes analyzed in this study come from Test Pit 2, which included two semi-diagnostic Okhotsk ceramic artifacts, a number of stone tools, several large sea mammal bones, and pockets of shell. Eleven charcoal samples from Test Pit 2 were dated to between 1180 +/- 25 and 845 +/- 25, and the stratigraphy of Test Pit 2 seems to match that of the 2006 Test Pit 1, from which three charcoal samples were analyzed returning radiocarbon dates between 1230 +/-25 and 835 +/-30, indicating a Phase IV context for the site.

*Savushkina 1 (SAV1), Paramushir Island*

The Savushkina 1 site is located on the Savushkina Peninsula on the northern end of Paramushir Island, the most northern island of the Kuril chain. The site is situated near a small terrace (3-5 m above the beach) and bisected by a 20<sup>th</sup> century road. During one day of site testing, two test pits were placed in the site by clearing off two erosion faces on the north side of the road. Test Pit 1 was 2 m long and 1.5 m deep and contained two cultural layers, an upper layer (Cultural Layer 1) that had iron and wire artifacts, and a lower layer (Cultural Layer 2) that included charcoal and lithics. Test Pit 2 was located 10 m east of Test Pit 1, was 2 m long and 2 m wide, and also contained two cultural layers. Cultural Layer 1 from the surface to 80 cmbs contained metal and some lithics; Cultural Layer 2 from 80 – 120 cmbs contained lithic debitage and several stone projectile points. The 200 analyzed flakes come from Test Pit 1/Cultural Layer 2 and Test Pit 2/Cultural Layer2. A single charcoal sample taken from Test Pit 1/Cultural Level 2 was dated to 1910 +/-30 radiocarbon years, placing it in Phase III of the Kuril chronology.

Artifact assemblages are useful as time-space units that aid in the interpretation of cultural behavior. The materialist view adopted here is that assemblages are not static types and fixed properties, but rather their compositions are influenced by sampling, size, and formation processes, and due to this variation, there is no one way to analyze assemblage data (Shott 2010). The approach taken in this analysis was to combine individual site assemblages from relevant excavation units and layers in order to create aggregated regional and chronological assemblages for analysis, comparison, and interpretation. Because this analysis is working at the broad scale of an entire island chain across roughly 2,500 years in time, the goal was to create assemblages that provided a snapshot of lithic technological behavior that was representative of a particular unit in the geo-chronological framework of the Kuril Islands. Five aggregate assemblages were created representing the Southern, Central, and Northern Kurils in Phase III of the Kuril Island occupation chronology outlined in Chapter 4, and the Central and Northern Kurils in Phase IV of the chronology (Table 5.1). Unfortunately, there were no assemblages with good contexts for Phase IV from the Southern islands that could be used in this comparative analysis.

<b>Aggregate Assemblage Geography and Chronology</b>	<b>Individual Site Assemblages Represented</b>
Southern Island Phase III	Ainu Creek Phase III
Central Island Phase III	Vodopodnaya 2 Phase III, Rasshua 1 Phase III
Northern Island Phase III	Drobnyye 1 Phase III, Savushkina 1 Phase III
Central Island Phase IV	Vodopodnaya 2 Phase IV
Northern Island Phase IV	Drobnyye 1 Phase IV, Ekarma Phase IV

Table 5.1: The aggregated lithic assemblages and their representative site assemblages included in this study.

There are several issues related to the dating and site formation contexts for these assemblages that are noted here in terms of potential effects these issues may have on interpretations or conclusions drawn from assemblage analysis. For the Phase III assemblages, the Southern island assemblage consists of an individual site assemblage that are dated tightly around 2300 – 2200 BP. The Central island assemblage includes site collections with a wider chronological spread, primarily from 2160 – 1700 BP. This may have the effect of combining several occupations over a span of 400 years which may represent different lithic resource consumption strategies within Phase III, though statistical

comparisons regarding lithic reduction intensity revealed no difference between the two assemblages. The Northern island assemblage includes flakes from the Drobnyye 1 site dated to the end of Phase III at 1470 BP, and from the Savushkina 1 site dated to 1910 BP, meaning this assemblage may also represent combined lithic strategies and weakening any distinct signal that may exist; likewise, statistical comparison turned up no significant differences. For the Phase IV assemblages, the Central island assemblage consists of flakes from the Vodopodnaya 2 site from contexts with Okhotsk pottery and two radiocarbon dates of 1090 +/-25 BP and 1100 +/-30 BP. The Northern island assemblage includes two sites (Drobnyye 1 and Ekarma 1) with strongly associated and confidently dated Phase IV contexts, and this assemblage should provide a consistent and clear view of lithic reduction behavior during Phase IV in the Northern islands.

Phase V occupations across the Kuril Islands by people associated with the Ainu culture are well documented historically and ethnographically (Kranshenenikov 1972; Snow 1897) but are the least represented in the Kuril archaeological record investigated by the KBP. IKIP and KBP research has documented Ainu artifacts and has dated charcoal samples to the Late period at sites on Kunashir, Chirpoi, Rasshua, Matua, and Paramushir islands (Fitzhugh et al. 2002, 2007, 2009a, 2009b), but unfortunately the lithic assemblages from these contexts were not sufficient to be included in the present study. Evaluating changes in Phase V lithic use and access to obsidian sources compared to the earlier occupation sequences would be of particular interest given the introduction of Japanese and Russian metal tools into the Kuril Islands during the 17<sup>th</sup>-19<sup>th</sup> centuries. Hopefully future field research will recover a richer Phase V artifact assemblage.

### **Kuril Tool Technology**

A wide variety of finished stone tools and stone tool fragments were recovered during the three KBP field seasons in moderate densities from sites across the Kurils. The tool types are representative of bifacial, blade, and core and flake reduction technologies, and primarily consist of biface blanks and bifacially flaked scrapers and projectile points, blade fragments, retouched and utilized flakes, as well as tools such as graters, drills, and adzes that occur less frequently. A tool typology has yet to be developed for Kuril Island stone tools and no attempt has been made to use stone tools as temporally or culturally

diagnostic artifacts, though there are a variety of tool morphologies that exist, particularly for projectile points (see Fitzhugh et al. 2007, 2009a, and 2009b for specific site tool assemblages).

While all of the finished stone tools are curated at the Sakhalin Regional Museum in Yuzhno-Sakhalinsk, Russia, a subset of the overall Kuril tool assemblage was briefly analyzed to provide context for the debitage analysis presented here. Table 5.2 represents a summary of the sample assemblages that match the same sites and excavation units and levels that were used for the debitage analysis for the Phase III and Phase IV Central and Phase III and Phase IV Northern assemblages. The Phase III assemblages from the Central and Northern island sites are dominated by retouched flakes, biface blanks, projectile points and scrapers. Projectile points, biface blanks, and scrapers are the most abundant tools in the Phase IV Central island assemblage, while three tool types – biface blanks, retouched flakes, and utilized flakes -- make up almost 60% of the Phase IV Northern island assemblage. Based on these small sample assemblages, there is little evidence for the frequent production of blade tools in the Central and Northern Kurils, though additional blade artifacts may be present from other sites not included in this analysis. This is consistent with overall lithic technological trends seen in Hokkaido, where blade and microblade production was common during the Paleolithic between 20,000 and 12,000 BP, then transitioned to biface tool production at the beginning of the Jomon period (Kimura 2006; Nakazawa et al. 2005, Sano 2006).

Tool Type	Central/Phase III		Northern/Phase III		Central/Phase IV		Northern/Phase IV	
	n	%	n	%	n	%	n	%
Adze	2	3.3					3	5.7
Anvil	2	3.3					1	1.9
Biface blank	9	14.8	2	15.4	6	10.5	14	26.4
Blade/blade fragment	1	1.6			1	1.8	3	5.7
Core	3	4.9			3	5.3		
Core fragment	7	11.5			1	1.8		
Drill			1	7.7			1	1.9
Flake -- retouched	14	23.0	4	30.8	2	3.5	12	22.6
Flake -- utilized	2	3.3	1	7.7			8	15.1
Graver	2	3.3						
Hammerstone	2	3.3			3	5.3		
Projectile point	8	13.1	2	15.4	15	26.3	6	11.3
Scraper - bifacial	8	13.1	2	15.4	3	5.3	5	9.4
Scraper - unifacial	1	1.6	1	7.7	1	1.8		
Total	61	100.0	13	100.0	35	61.4	53	100.0

Table 5.2: Distribution of stone tool types across geo-chronological assemblages.

Due to the small and inconsistent sample sizes across the assemblages, chi-square contingency table comparisons do not reveal any statistically significant differences in terms of individual tool type frequencies between the assemblages, either geographically across island groups or chronologically from Phase III to Phase IV. Aggregating specific tool types into reduction technology units (Table 5.3) does reveal a significant difference between the Central island assemblages from Phase III to Phase IV.

Tool Type	Central/Phase III		Northern/Phase III		Central/Phase IV		Northern/Phase IV	
	n	%	n	%	n	%	n	%
Bifacial tools	25	40.9	6	46	24	77.4	25	47.2
Blades	1	1.6			1	3.2	3	5.6
Cores/flakes	28	45.9	5	38.5	6	19.4	20	37.7

Table 5.3: Aggregation of tools into three comparative tool types across geo-chronological assemblages.

The bifacial tool category includes biface blanks, projectile points, and bifacial scrapers; the blade category is made up of blade or blade fragments; the core/flake category includes cores, core fragments, retouched and utilized flakes, and graters. Central island sites during Phase III contain an almost equal proportion of bifacial and core/flake tools (40.9% n=25, and 45.9% n=28 respectively), and only a single blade artifact. In Phase IV, bifacial tools make up over 75% of the assemblage (n=24), while core/flake tools fall to

just under 20% (n=6). This difference is statistically significant based on a chi-square comparison of the two assemblages ( $\chi^2=10.77$ , df=2, p=.005) and the nature of the change in tool technology is represented in the adjusted residuals (Table 5.4).

Tool Type	Central/Phase III	Central/Phase IV
Bifacial tools	-3.02	3.02
Blades	-0.62	0.62
Cores/flakes	3.28	-3.28

Table 5.4: Adjusted residuals for the chi-square comparison of tool types between Phase III and Phase IV assemblages in the Central islands.

This apparent difference in reduction technology could be based on a Phase III strategy that included the recycling of sufficiently-sized flakes into retouched tools as a way to maximize lithic material consumption in conjunction with the production of reliable and maintainable bifacially-flaked tools. By Phase IV, the level of lithic resource conservation was relaxed to some degree, perhaps due to increased knowledge of lithic resource availability in the environment or changing methods of raw material procurement.

A basic review of the different lithic raw materials associated with each tool type shows that basalt and chert make up the majority of the tools in each assemblage, consistent with the overall distribution of flakes in the debitage assemblages (Tables 5.5, 5.6, 5.7, and 5.8). Chert and basalt are represented in a range of bifacially-flaked tool types including biface blanks, projectile points, and scrapers. These are all tools that are highly maintainable when made from high-quality, fine-grained raw material. Obsidian makes up only 11.1% (n=18) of all the tools in these assemblages, and is primarily represented in the blade and retouched flake artifacts. Obsidian makes up 60% (n=3) of the five blade or blade fragments, and 19.3% (n=6) of the 31 retouched flakes. Though this sample size is too small to draw any concrete conclusions about specific tool raw material choices, it appears that obsidian was favored for cutting edge tools made through conservative lithic reduction practices such as blade production and flake retouch. This would suggest that obsidian was treated as valuable and potentially rare material in most Kuril environments, consistent with its nonlocal nature.

<b>Tool Type</b>	<b>Basalt</b>	<b>Chert</b>	<b>Chalced</b>	<b>Obsidian</b>	<b>Quartz</b>	<b>Unknown</b>	<b>Total</b>
Adze	1					1	2
Anvil						2	2
Biface blank	2	5	1	1			9
Blade/blade fragment				1			1
Core		3					3
Core fragment	1	5		1			7
Drill							
Flake -- retouched	4	7	1	2			14
Flake -- utilized	1	1					2
Graver	1		1				2
Hammerstone						2	2
Projectile point	3	3	2				8
Scraper - bifacial	2	3	1		1	1	8
Scraper - unifacial		1					1
<b>Total</b>	<b>15</b>	<b>28</b>	<b>6</b>	<b>5</b>	<b>1</b>	<b>6</b>	<b>61</b>

Table 5.5: Phase III Central island assemblage tool types and raw materials

<b>Tool Type</b>	<b>Basalt</b>	<b>Chert</b>	<b>Chalced</b>	<b>Obsidian</b>	<b>Quartz</b>	<b>Unknown</b>	<b>Total</b>
Adze							
Anvil							
Biface blank	5	1					6
Blade/blade fragment	1					1	2
Core	1	1				1	3
Core fragment		1					1
Drill							
Flake -- retouched	1			2			3
Flake -- utilized							
Graver							
Hammerstone						3	3
Projectile point	7	6		2			15
Scraper - bifacial	1	2					3
Scraper - unifacial	1						1
<b>Total</b>	<b>17</b>	<b>11</b>	<b>0</b>	<b>4</b>	<b>0</b>	<b>5</b>	<b>37</b>

Table 5.6: Phase IV Central island assemblage tool types and raw materials

<b>Tool Type</b>	<b>Basalt</b>	<b>Chert</b>	<b>Chalced</b>	<b>Obsidian</b>	<b>Quartz</b>	<b>Unknown</b>	<b>Total</b>
Adze							
Anvil							
Biface blank	2						2
Blade/blade fragment							
Core							
Core fragment							
Drill		1					1
Flake -- retouched		3		1			4
Flake -- utilized							
Graver							
Hammerstone							
Projectile point		1		1			2
Scraper - bifacial	1	1					2
Scraper - unifacial	1					1	2
<b>Total</b>	<b>4</b>	<b>6</b>	<b>0</b>	<b>2</b>	<b>0</b>	<b>1</b>	<b>13</b>

Table 5.7: Phase III Northern island assemblage tool types and raw materials

<b>Tool Type</b>	<b>Basalt</b>	<b>Chert</b>	<b>Chalced</b>	<b>Obsidian</b>	<b>Quartz</b>	<b>Unknown</b>	<b>Total</b>
Adze	3						3
Anvil						1	1
Biface blank	10	3			1		14
Blade/blade fragment	1			2			3
Core							
Core fragment							
Drill	1						
Flake -- retouched	7	2		2		1	12
Flake -- utilized	7			1			8
Graver							
Hammerstone							
Projectile point		5				1	6
Scraper - bifacial	2	1	1	1			5
Scraper - unifacial							
<b>Total</b>	<b>31</b>	<b>11</b>	<b>1</b>	<b>6</b>	<b>1</b>	<b>3</b>	<b>53</b>

Table 5.8: Phase IV Northern island assemblage tool types and raw materials

### Results of Debitage Analysis

The results reported here begin with a description of each geo-chronological assemblage, followed by a comparison of assemblages based on the debitage analysis. Each assemblage was initially separated and characterized based on six raw material groups –

basalt, chert, chalcedony, obsidian, quartz/quartzite, and an unknown/unidentified material type. The unknown/unidentified group represents flakes made from coarse-grained materials in a range of colors and structures that can be described as low-quality in terms of flintknapping characteristics associated with the production of finished stone tools (ease and predictability of flake removal, edge sharpness, internal material blemishes or fracture lines). The flakes in each raw material group were then analyzed per the debitage analysis criteria described above.

### *Southern Phase III Assemblage*

The Southern Phase III assemblage consisted of 1,145 flakes from the Ainu Creek 1 site in the southern Kurils. In terms of the proportions of raw materials in the assemblage based on flake count and mass, the unknown group, basalt, and chalcedony are the most abundant materials. Together they make up 78% of the assemblage by count and 92% by mass. The difference in the percentage that each raw material group makes up in the assemblage based count versus mass is directly related to the size of the flakes that are being created through the stone tool-making consumption of the material. Obsidian is represented in the assemblage at a much lower proportion by mass compared to count, and it is inferred that this is due to the extremely small size of the obsidian flakes -- over 89% of the obsidian flakes are Late stage reduction debitage with an average mass of 0.45 g. The unknown raw material category is actually represented by a much higher proportion by mass, with over 32% of unknown flakes categorized as Early stage reduction debitage with an average weight of 15.63 g.

By count, the majority of the flakes from each raw material group are present in the Late stage of lithic reduction except for chalcedony and quartz/quartzite, which are substantially represented as Early stage debitage (Fig. 5.1). For the entire assemblage, 19.7% by count and 36.6% by mass is composed of Early and Middle stage flakes, suggesting that a significant amount of tool production took place in this Phase III Southern Kuril site.

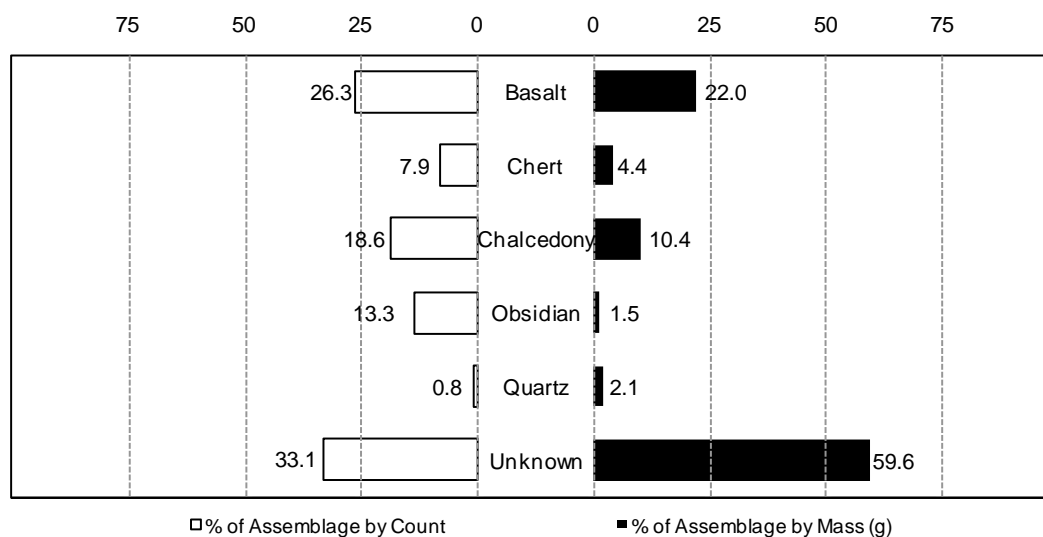


Figure 5.1: Distribution of raw material types in the Southern islands Phase III assemblage.

Average flake size represented by mass shows a general decrease in size from Early to Late stage reduction, and an analysis of variance of the differences in reduction stage flake mass are statistically significant ( $F_{crit}=0.06$ ,  $F_{stat}=3.02$ ,  $\alpha=.05$ ) for every raw material type except for basalt ( $p=0.94$ ). For obsidian, there was no difference between the Early and Late stages, though since only a single flake was categorized as Early stage debitage, a more useful comparison is between Middle and Late stage obsidian debitage, for which there is a significant difference. There are also differences in the percentage of size decrease from the Early to Late stage (Fig. 5.3). Chert flake size is reduced by 62% while basalt has the smallest percentage of size reduction from Early to Late stage, at just 6.6%. It is interesting to note that though the size of basalt flakes does not change significantly through the reduction stages, the majority of basalt flakes are categorized as Late stage debitage by count and by mass. This may indicate that the initial reduction of basalt material was done away from the occupation site, and that the final form of basalt tools was larger than tools made from other raw materials. The future study of tools from Southern Kuril sites may lend further insight into specific raw material utilization for tool production.

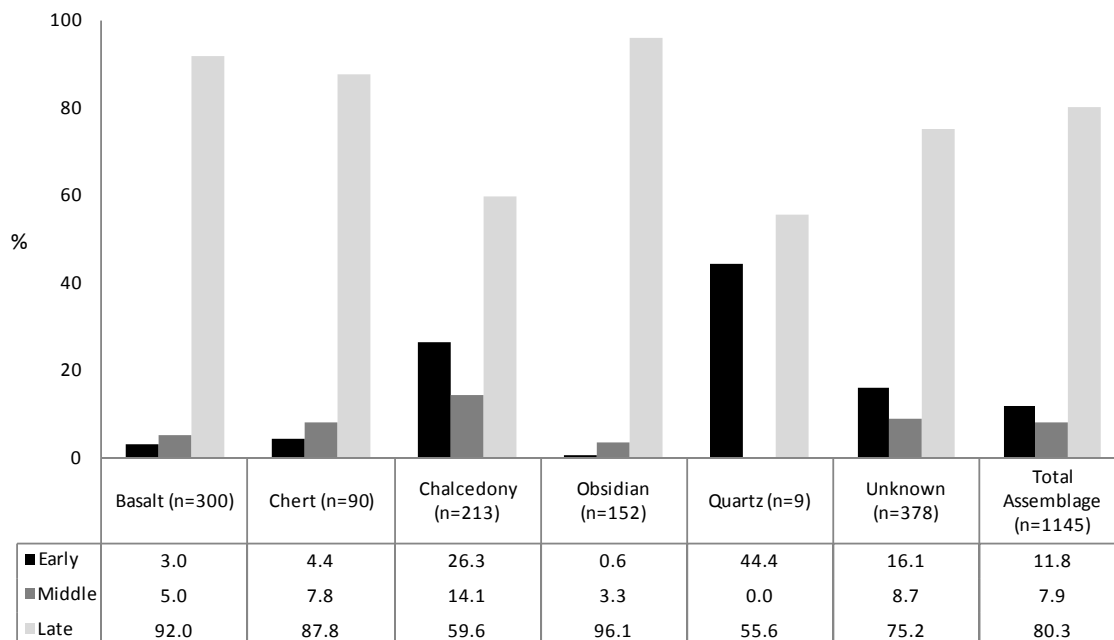


Fig. 5.2: Distribution of raw material types across lithic reduction stages in the Southern island Stage III assemblage by count. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

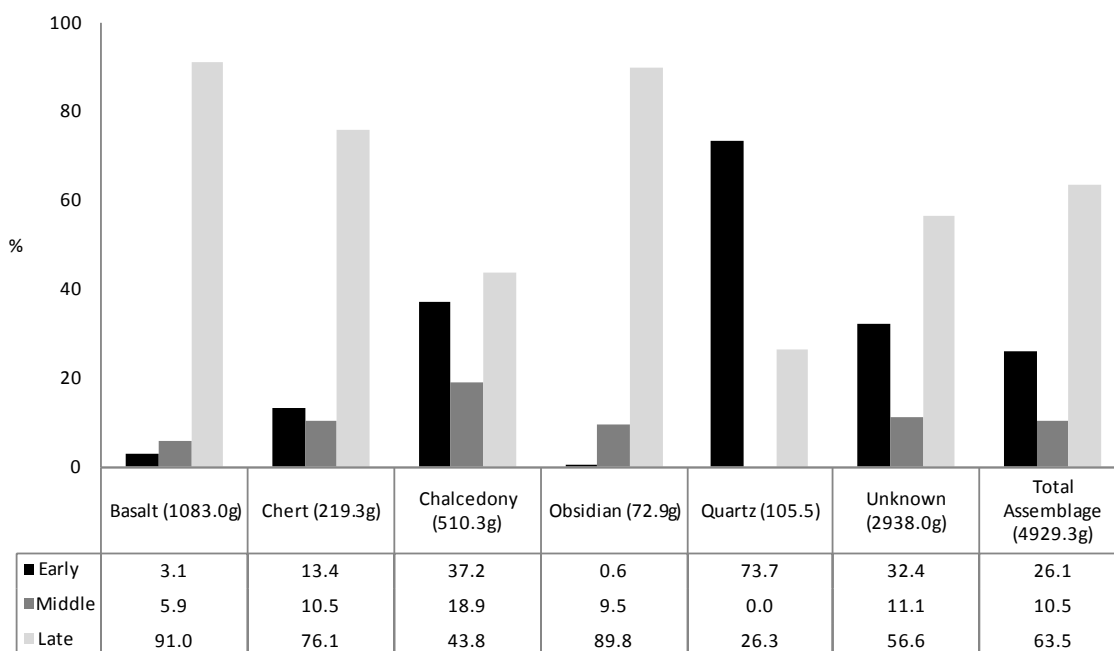


Fig. 5.3: Distribution of raw material types across lithic reduction stages in the Southern island Stage III assemblage by mass. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

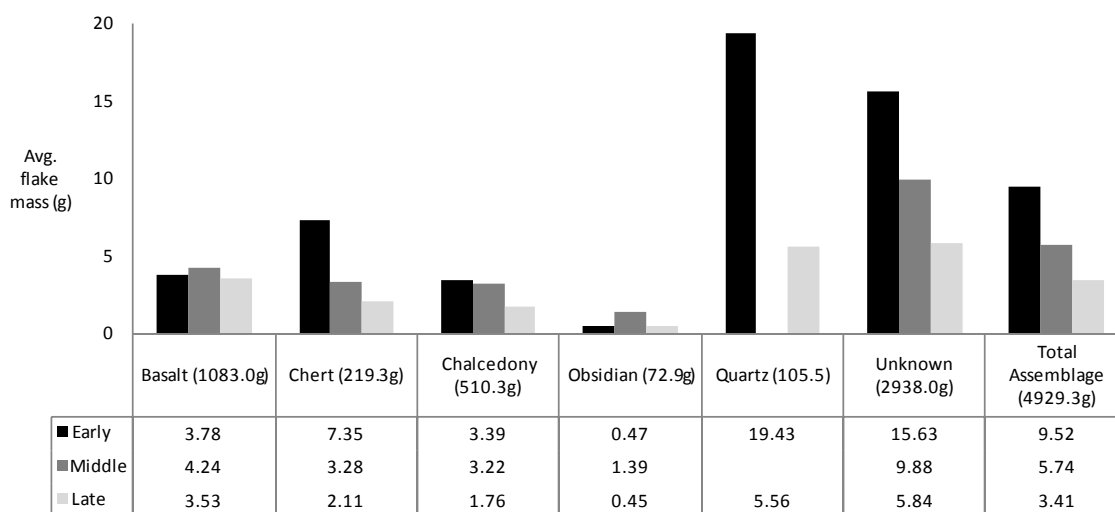


Fig. 5.4: Average mass of Southern island Phase III flakes in each lithic reduction stage. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

### *Central Phase III Assemblage*

The Central Phase III assemblage is made up of 1,557 flakes from the Vodopodnaya 2 and Rasshua 1 archaeological sites. Basalt and chert dominate this assemblage by count (87.8% of the assemblage) and by mass (88%) (Fig. 5.5) and given their abundance in the assemblage might indicate that these materials were widely available and accessible in the Central Kurils compared with chalcedony and obsidian which make up less than 3% of the overall assemblage. However, a substantial portion of chalcedony flakes are represented by mass in the Early and Middle stages of reduction (37.2% and 18.9% respectively) with a small Early stage size, indicating some local availability of small chalcedony nodules that are reduced at the site.

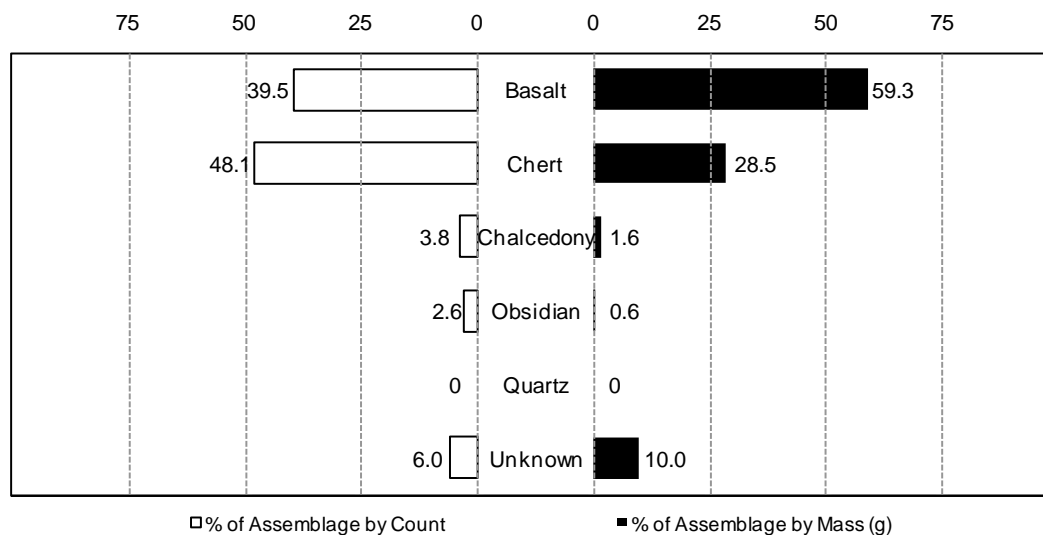


Figure 5.5: Distribution of raw material types in the Central islands Phase III assemblage.

In this assemblage, the difference in flake size from Early to Late reduction stages is only statistically significant ( $\alpha = .05$ ) for chert (which is reduced in size by 86%;  $p = .0001$ ) and chalcedony (reduced in size by 54%;  $p = .0001$ ) based on an analysis of variance across reduction stages. All of the obsidian flakes in this assemblage are Late stage flakes, and have a small average mass at 0.36 g (Fig. 5.8). It is interesting to note the very high proportion of basalt flakes that are assigned to the Late stage of lithic reduction. Although basalt was expected to be a locally available lithic resource based on its abundance in the assemblage, the dominance of Late stage flakes suggests this material was nonlocal. Alternatively, basalt may in fact be local to the Central islands, but is initially reduced at task sites, such as quarries, which may be located away from habitation sites.

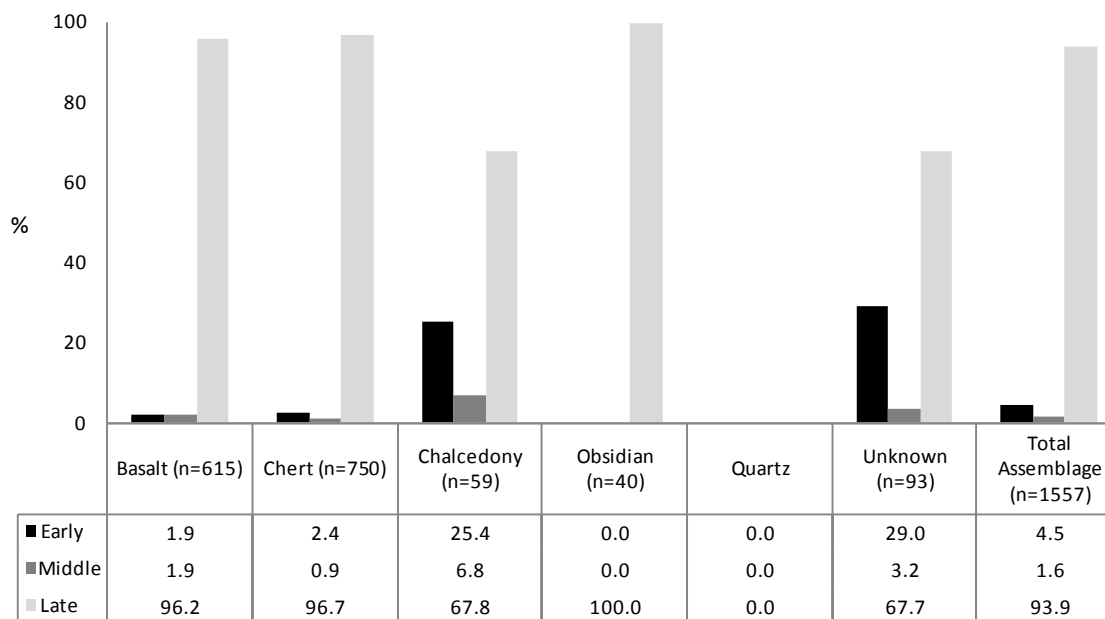


Fig. 5.6: Distribution of raw material types across lithic reduction stages in the Central island Stage III assemblage by count. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

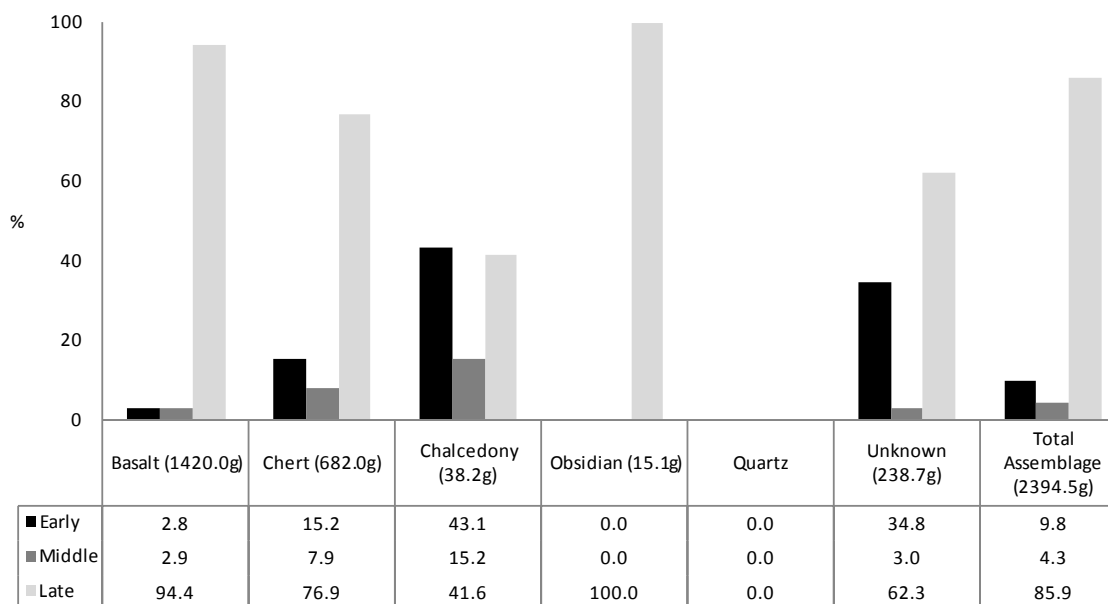


Fig. 5.7: Distribution of raw material types across lithic reduction stages in the Central island Stage III assemblage by mass. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

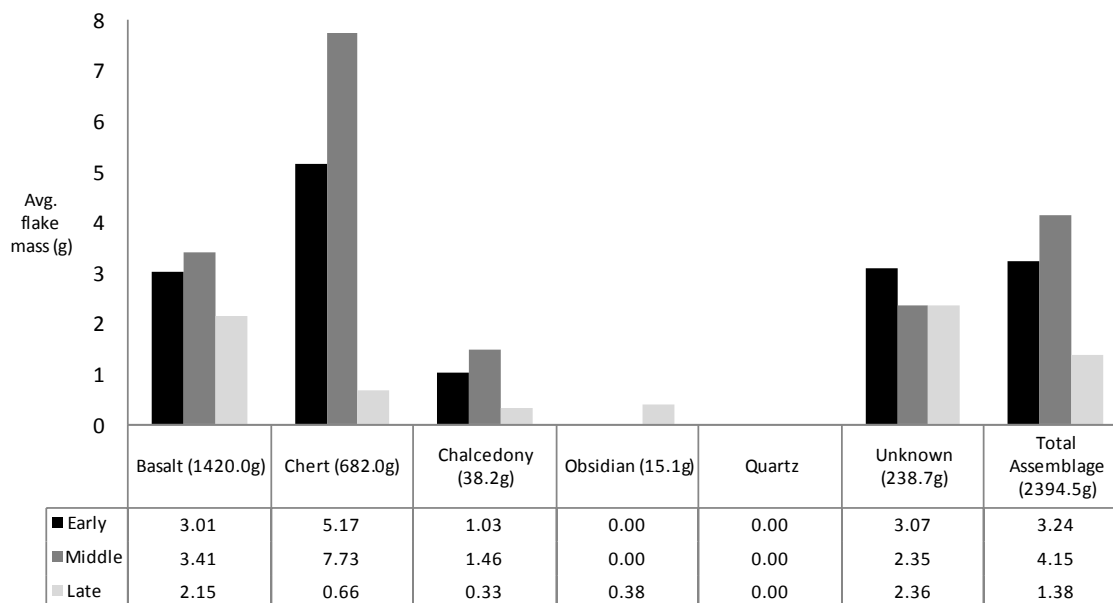


Fig. 5.8: Average mass of Central island Phase III flakes in each lithic reduction stage. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

### *Northern Phase III Assemblage*

The Northern/Early assemblage includes a total of 625 flakes from the Drobnyye 1 site on Shiashkotan Island and the Savushkina 1 site on Paramushir Island. A comparison of the percentage of raw materials represented in the assemblage by count and by mass shows that basalt is the dominant raw material in terms of the quantity of all the different materials present in the assemblage (Fig. 5.9). Obsidian makes up a substantially greater proportion of the assemblage (24.0% by count, 6.0% by mass) compared to the Central islands assemblage, and is more in line with the Southern assemblage proportion of obsidian, indicating greater social proximity to obsidian sources. The raw materials in this assemblage are primarily represented by Late stage flakes (Fig. 5.10 and Fig. 5.11), except for chalcedony which has 67% of flakes by mass in the Early stage. Over 23% of basalt flakes by mass are present in the Early and Middle stages of reduction, indicative of a greater amount of early reduction activity at the site compared to the Southern and Central island assemblages, which have only 9.0% and 5.7% respectively of basalt debitage represented in the Early and Middle stages by mass.

Late stage chert and obsidian flakes are very small, and there are no statistically significant differences in chert and obsidian flake size across the reduction stages ( $\alpha = .05$ ,

chert  $p=.94$ , obsidian  $p=.75$ ). This, combined with the fact that a higher percentage of these materials are represented by flake count rather than flake mass, is an indicator that mostly small flakes are being produced, probably through tool reshaping and resharpening.

Chalcedony makes up a small portion of the overall assemblage, and the high percentage of large, Early stage flakes is indicative of some local availability of this material. Basalt has the largest sized Late stage flakes which are 40% larger than the next closest raw material Late stage flake size (Fig. 5.12), indicating basalt was used less conservatively than the other materials.

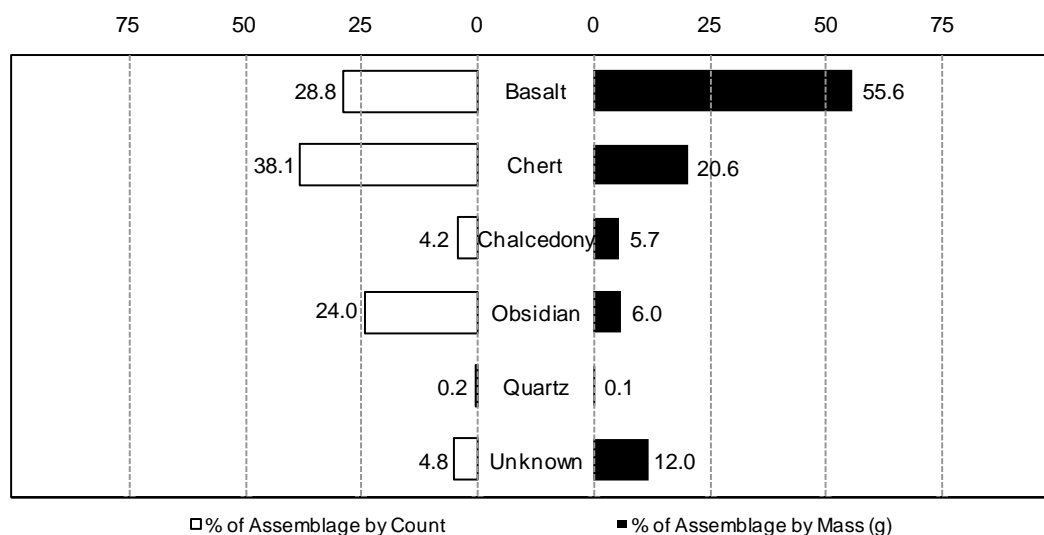


Figure 5.9: Distribution of raw material types in the Northern islands Phase III assemblage.

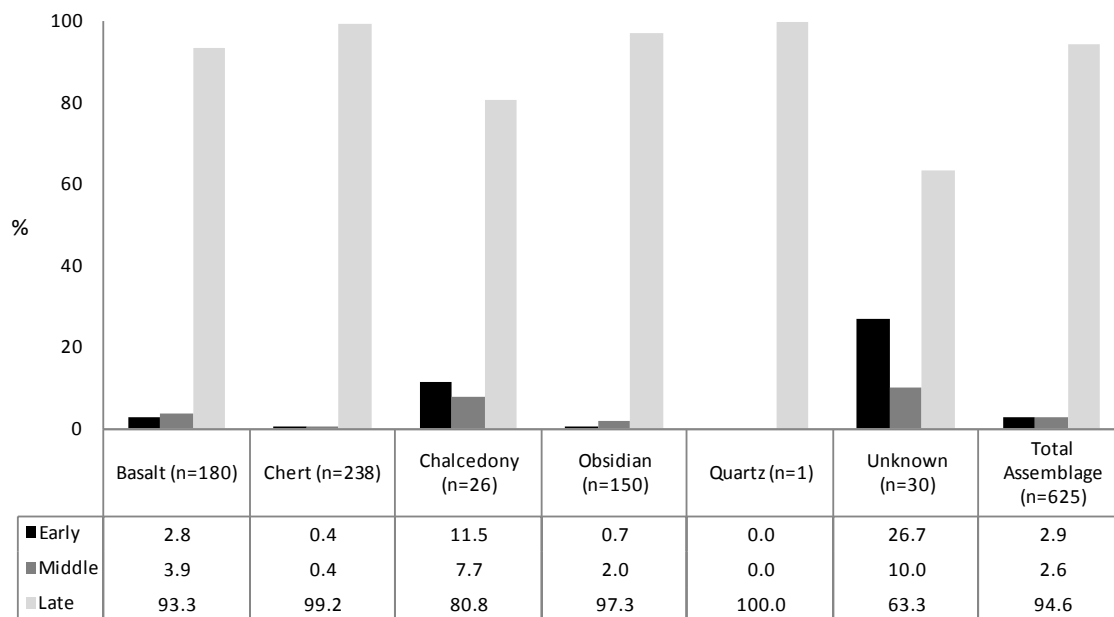


Fig. 5.10: Distribution of raw material types across lithic reduction stages in the Northern island Stage III assemblage by count. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

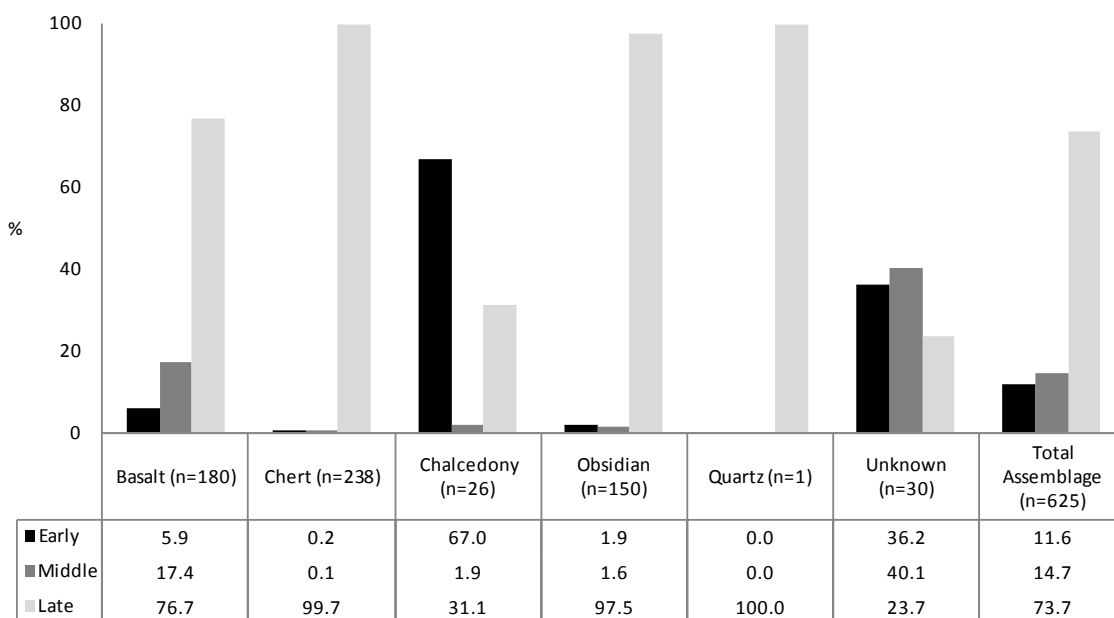


Fig. 5.11: Distribution of raw material types across lithic reduction stages in the Northern island Stage III assemblage by mass. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

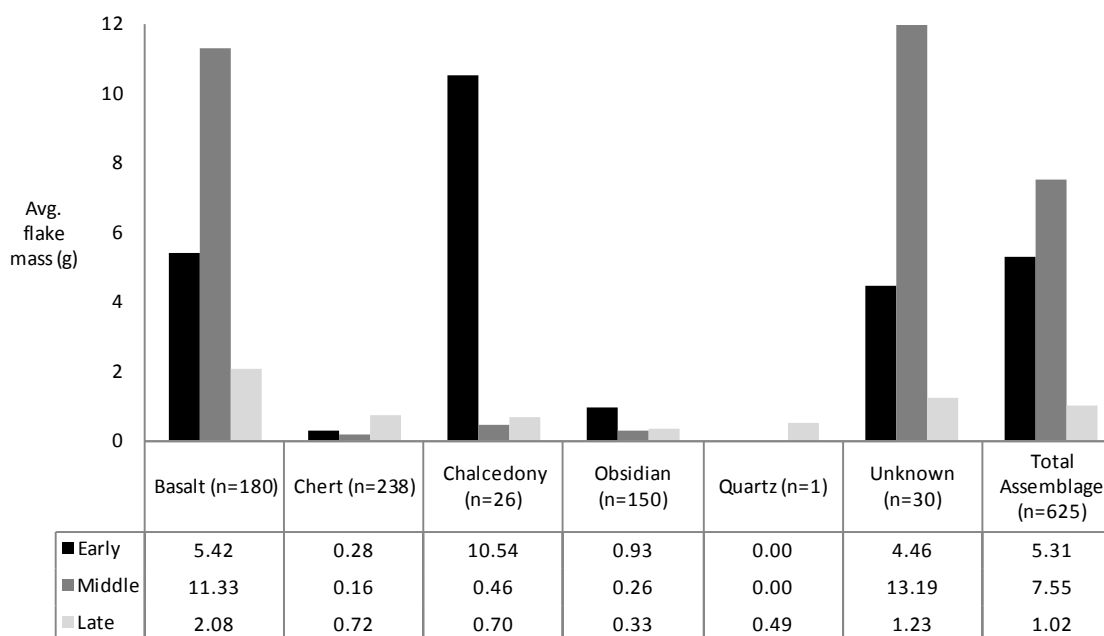


Fig. 5.12: Average mass of Northern island Phase III flakes in each lithic reduction stage. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

### *Central Phase IV Assemblage*

The Central island Phase IV assemblage is composed of 778 flakes from the Vodopodnaya 2 site. Basalt, chert, and the unknown group make up 88.1% of this assemblage by count, although by mass basalt and the unknown group make up 89.2% of the assemblage (Fig. 5.13). Chert is represented by a smaller proportion by mass, indicating a small size for the chert flakes in this assemblage. Similarly, obsidian is again present in a much smaller percentage by mass (1.9%) than by count (11.2%), indicating a very small flake size.

Each material type is dominated by Late stage flakes by count (Fig. 5.14), but there is some variability in reduction stage representation by mass (Fig. 5.15). Over 30% of basalt and unknown group flakes are Early or Middle stage flakes, as are almost 10% of the chert flakes. Almost 30% of the entire Central Phase IV assemblage is represented by Early and Middle stage flakes, indicating a higher level of initial reduction taking place at the site compared to the Central Phase III assemblage, with only 7.4% of the debitage by mass present in the Early and Middle stages. Chert, chalcedony, and obsidian are all reduced to

very small flake sizes by the Late stage, while basalt and the unknown group are reduced to a late stage size that is up to seven times larger than other materials (Fig. 5.16). Here, basalt is not being consumed at the same level of conservation or economy as the other fine-grained materials being utilized.

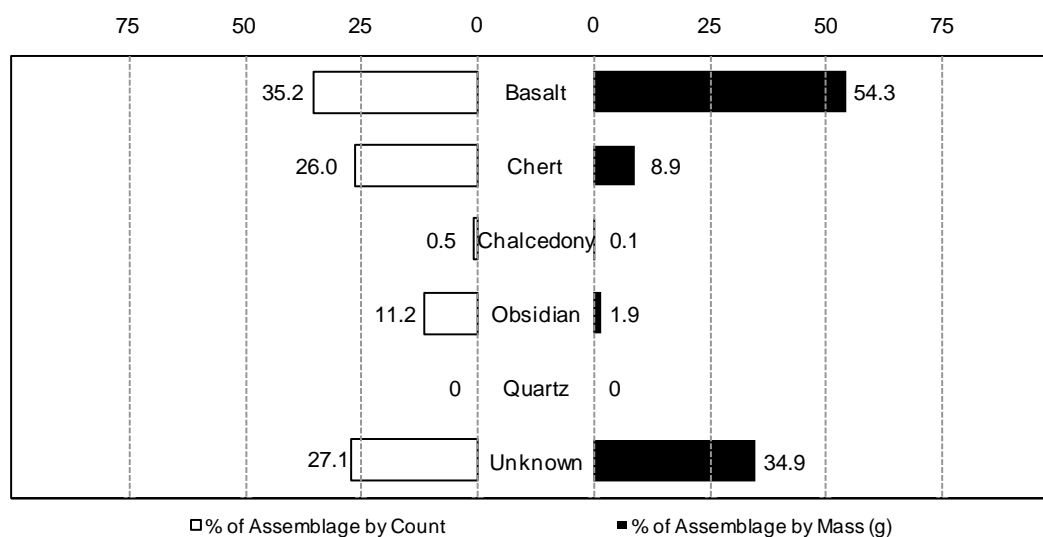


Figure 5.13: Distribution of raw material types in the Central islands Phase IV assemblage.

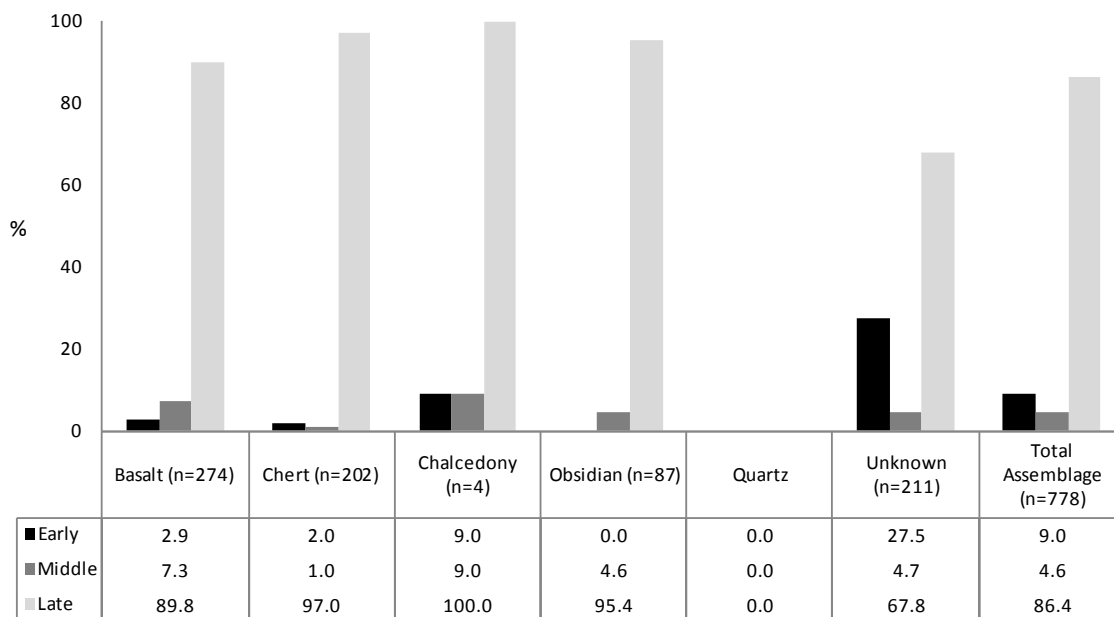


Fig. 5.14: Distribution of raw material types across lithic reduction stages in the Central island Stage IV assemblage by count. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

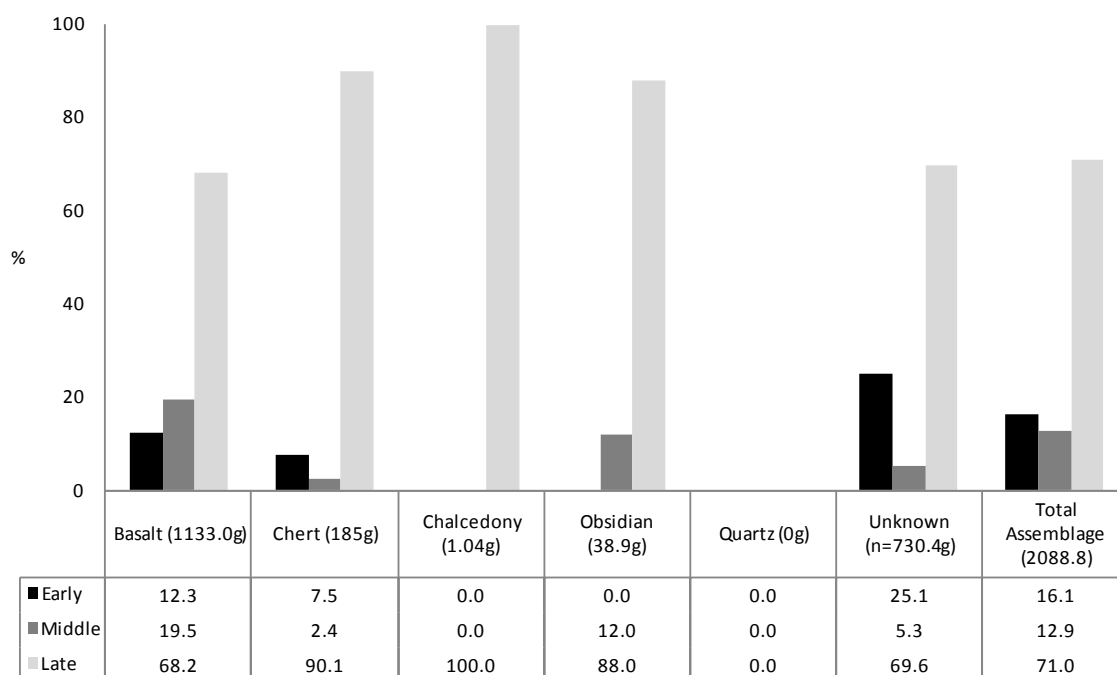


Fig. 5.15: Distribution of raw material types across lithic reduction stages in the Central island Stage IV assemblage by mass. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

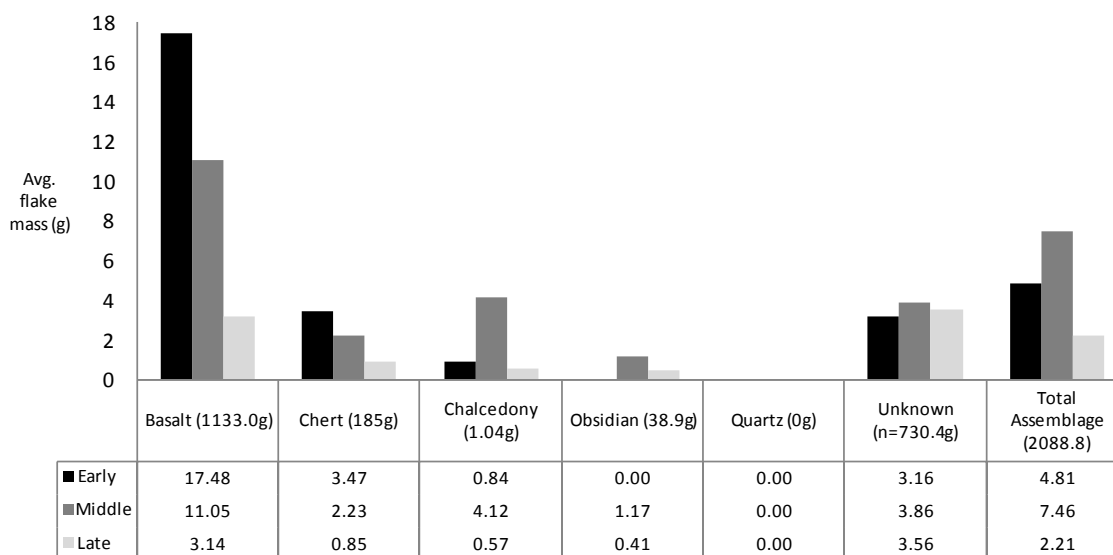


Fig. 5.16: Average mass of Central island Phase IV flakes in each lithic reduction stage. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

#### *Northern Phase IV Assemblage*

The Northern Phase IV assemblage consists of 842 flakes from the Drobnyye 1 and Ekarma 1 sites. The most striking aspect of this assemblage is the dominance of basalt, which makes up 79.2% of the assemblage by count and 75.9% by mass (Fig. 5.17). Chert, obsidian, and the unknown group make up the next three most abundant raw materials by count, though obsidian makes up a smaller proportion by mass in the assemblage while the unknown group represents a larger proportion. Basalt and chert flake sizes fall sharply from the Early to Late stages of reduction, by almost 73% for basalt and 95% for chert (Fig. 5.20). Although only 2.5% of the chert flakes are categorized as Early stage reduction by count, this represents 32.9% of the chert by mass, suggesting that only a small number of large Early stage chert flakes are present in the assemblage. Obsidian flakes fall 57% in size from the Middle to Late stages of reduction (statistically significant at  $\alpha = .05$ ;  $p = .007$ ). Obsidian material also starts and ends small, indicating that final shaping and sharpening, and/or the maintenance of obsidian tools is taking place in Northern Kuril sites during Phase IV as opposed to initial reduction.

The overall dominance of basalt in this assemblage would suggest that this was a highly abundant, locally available raw material. However, the fact that over 90% of the basalt flakes are categorized as Late stage reduction debitage by both count and mass confounds this suggestion, since much more Early and Middle stage debitage would be expected in an assemblage made up of locally available materials. In this case, basalt may in fact be available locally, but was reduced in the Early and Middle stages at task or workshop loci away from the sites. Alternatively, nonlocal basalt tools may have been brought to the sites and only maintained there.

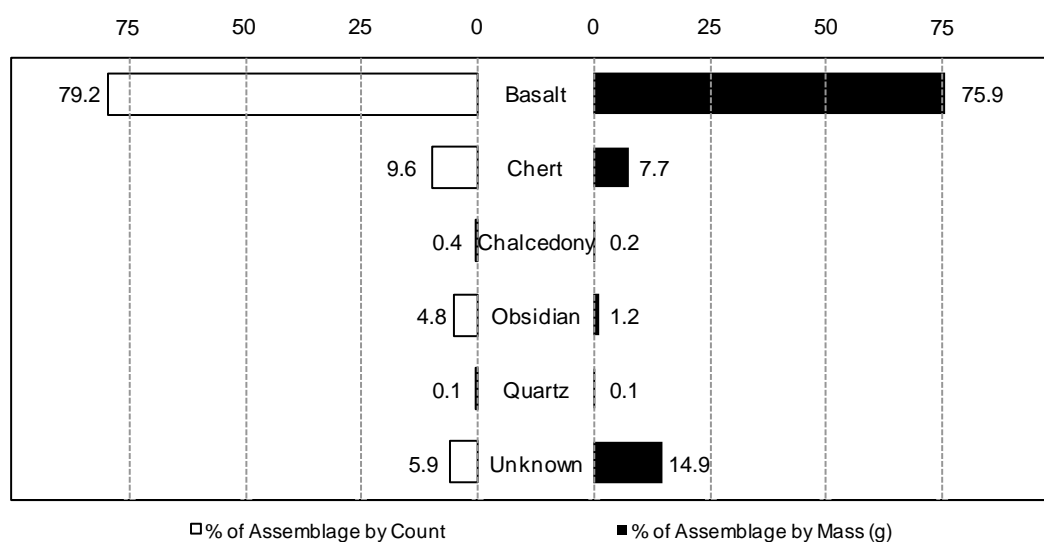


Figure 5.17: Distribution of raw material types in the Northern islands Phase IV assemblage.

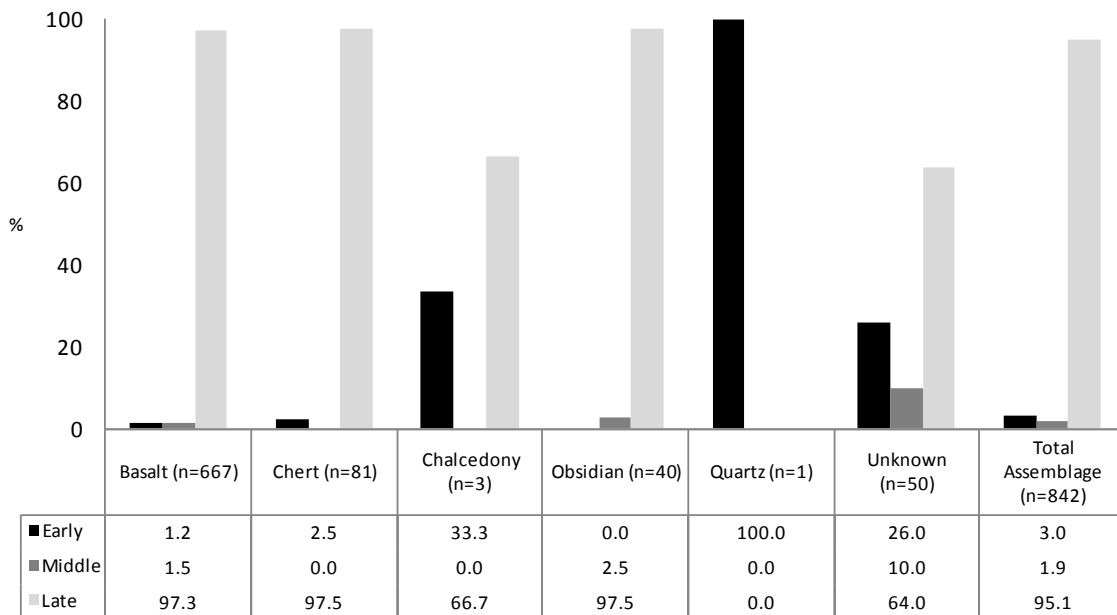


Fig. 5.18: Distribution of raw material types across lithic reduction stages in the Northern island Stage IV assemblage by count. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

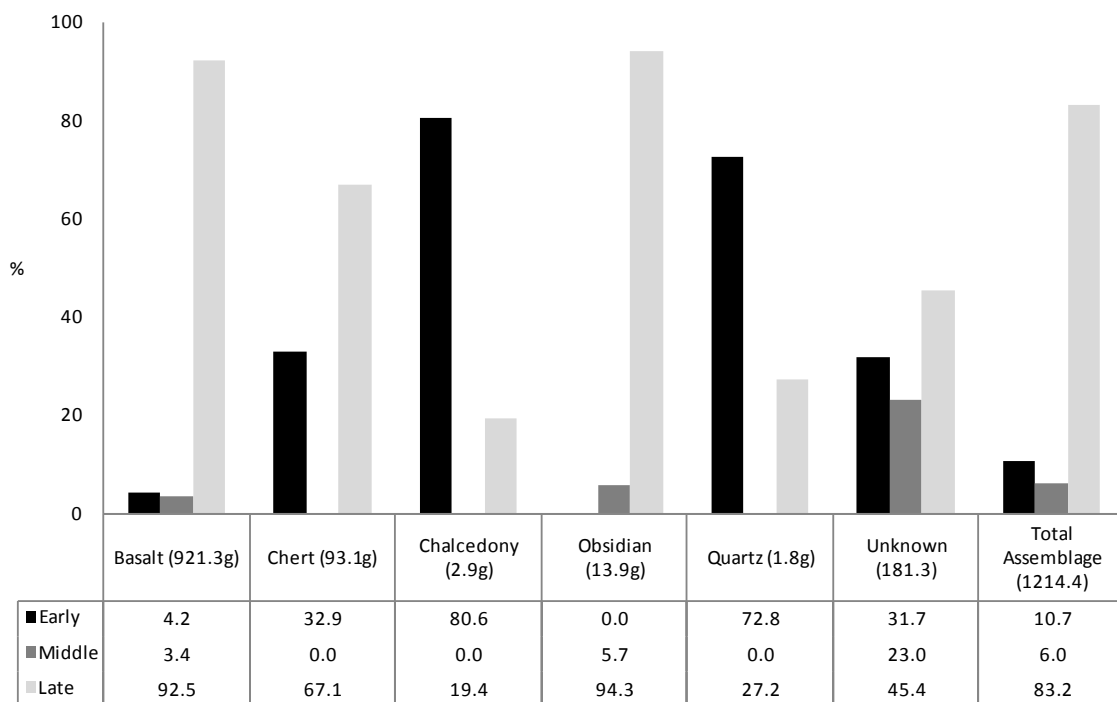


Fig. 5.19: Distribution of raw material types across lithic reduction stages in the Northern island Stage IV assemblage by mass. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

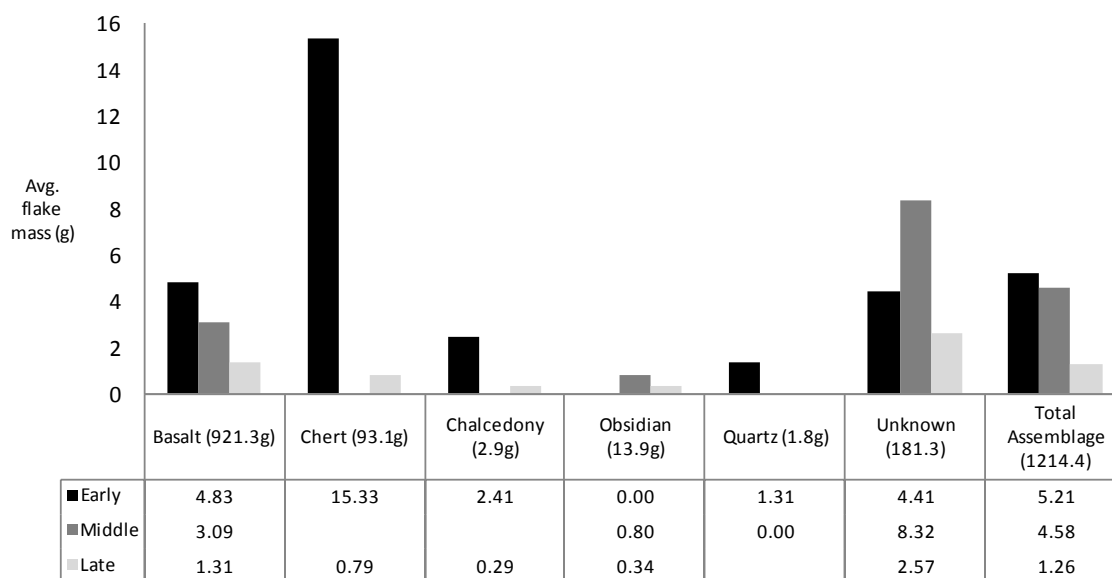


Fig. 5.20: Average mass of Northern island Phase IV flakes in each lithic reduction stage. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

### Overall Assemblage Comparisons

A comparison of the assemblages across space and time provides insight into the variability of lithic raw material use and reduction intensity across the Kuril Island chain. Geographic comparisons within Phase III show there are variations in the proportions of different raw materials present in the Southern, Central, and Northern island sites, as well as differences in the proportion of Late versus Early and Middle stage reduction flakes. Significant differences are present in Phase III between the Southern, Central, and Northern island site assemblages in terms of the proportions of raw material types measured by count ( $\chi^2=1149.78$ ,  $df=8$ ,  $p<.0001$ ) and by mass ( $\chi^2=2895.03$ ,  $df=8$ ,  $p<.0001$ ) (Tables 5.9 and 5.10) (quartz/quartzite is excluded from these analyses due to its extremely low abundance). The adjusted residuals indicate comparatively the raw materials that are dominant in each of the island group assemblages, with chalcedony, obsidian, and unknown types most represented in the Southern assemblage, basalt and chert in the Central assemblage when measured by count. When measured by mass, the same relationship is true except that obsidian is more substantially represented in the Northern island assemblage.

	Contingency Table (Count)				Adjusted Residuals		
	South	Central	North		South	Central	North
Basalt	300	616	180	Basalt	-7.919	8.804	-1.544
Chert	90	749	238	Chert	-23.752	20.222	3.524
Chalced	213	59	26	Chalced	13.456	-9.505	-4.570
Obsidian	152	40	150	Obsidian	11.466	-17.653	8.701
Unknown	378	93	30	Unknown	20.184	-13.848	-7.393

Table 5.9: Chi-square contingency table and adjusted residuals for raw material counts across Phase III geographic lithic assemblages.

	Contingency Table (Weight in g)				Adjusted Residuals		
	South	Central	North		South	Central	North
Basalt	1083.0	1420.0	456.6	Basalt	-32.195	26.448	12.153
Chert	219.3	682.4	169.2	Chert	-29.801	28.039	5.820
Chalced	510.3	38.2	46.8	Chalced	13.356	-12.901	-2.098
Obsidian	72.9	15.1	49.3	Obsidian	0.905	-6.282	8.108
Unknown	2938.0	238.7	98.6	Unknown	45.194	-36.970	-17.298

Table 5.10: Chi-square contingency table and adjusted residuals for raw material mass (g) across Phase III geographic lithic assemblages.

If it is assumed that these artifact assemblages can be used as proxies for the availability of specific raw material types in each island group, then there is clear variability in the lithic environments across the Kuril Islands. The Southern islands show the highest usage of unknown materials which are generally characterized as coarser-grained, lower-quality materials. Given that this material type dominates the Southern assemblage by count and by weight, and is present in a high proportion of Early reduction stage debitage (Figures 5.2 and 5.3), it was likely highly available locally at Southern island sites. The large size at each stage in the reduction process suggests this material was used much less conservatively than the other material types (Table 5.4). Similarly, while chalcedony makes up much less of the assemblage, it is present in a large amount of Early stage debitage (37% by mass), though flake size is much smaller than the unknown material, indicating a smaller beginning nodule size. Southern island tool makers had access to obsidian, but consumed it much differently than the other materials. Based on the presence of obsidian primarily in

the Late stage of reduction and at a small flake size in each stage, it is inferred that obsidian was a non-local material brought to the sites in mostly or completely finished tool form, with little initial reduction taking place on site. It is inferred that most of the obsidian reduction activity was related to tool sharpening and maintenance aimed at extending tool use life and conserving a relatively rare material.

The production of stone tools in the Central islands during Phase III is restricted to two primary raw materials, basalt and chert, supporting a finding originally described by Fitzhugh et al. (2004) based on their analysis of a smaller assemblage from the Central islands. The dominance of these two raw material types suggests that other raw materials were either not readily available or not of high enough quality to meet the functional needs of the stone tool technology. In an environment of restricted access to lithic raw materials, the use of fine-grained, high-quality materials would be a strategic choice for producing easily maintainable tools. This is supported by the low abundance of the lower quality unknown group in the assemblage overall.

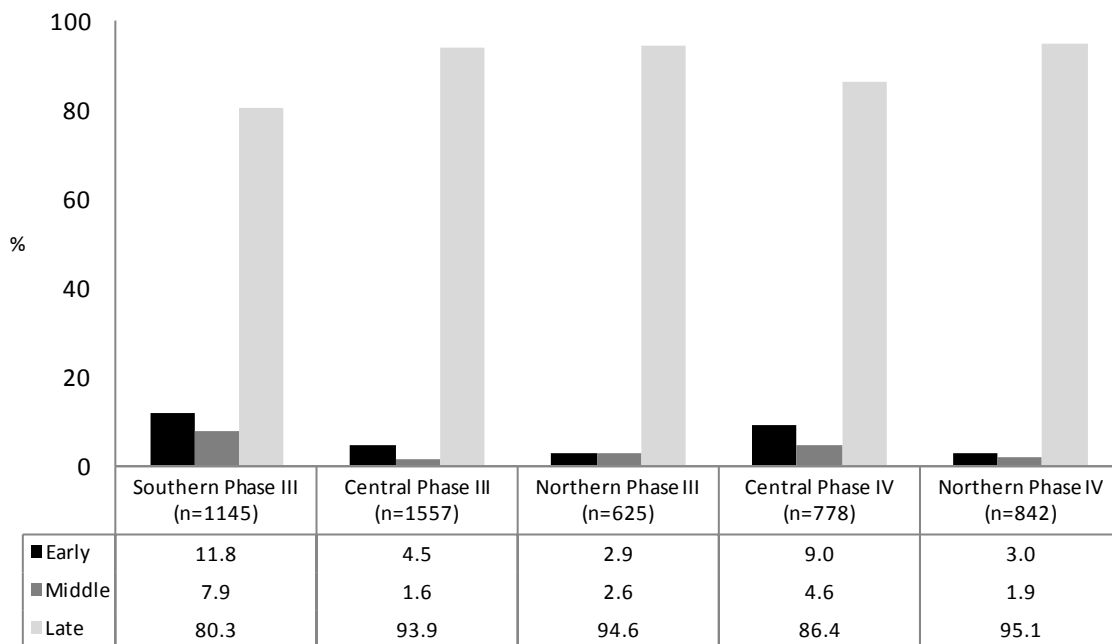


Fig. 5.21: Distribution of debitage by count in each lithic reduction stage across geo-chronological assemblages. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

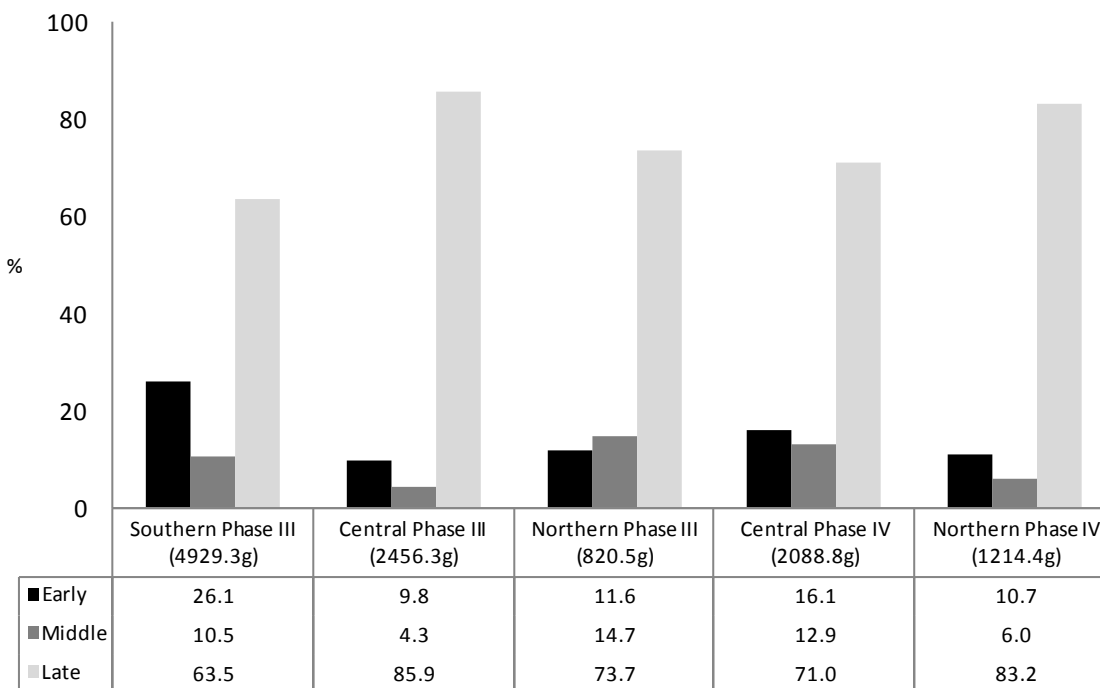


Fig. 5.22: Distribution of debitage by mass in each lithic reduction stage across geo-chronological assemblages. The values below the bars represent the percentages of each raw material type distributed across reduction stages.

Obsidian makes up a very small contribution to the overall Phase III Central island assemblage, only 2.6% by count and 0.6% by mass. The presence of only a few, Late stage obsidian flakes indicates this material was brought to the Central Kurils in small amounts in the form of completed tools that were maintained through reshaping and resharpening, but that no actual obsidian tool production took place in Central island sites at this time. While obsidian does not play a significant role in the lithic technological organization at Central island sites, it provides evidence of long distance connections maintained to obsidian source areas (Hokkaido and/or Kamchatka), which may represent social and exchange networks that were important for the successful colonization and continued occupation of the Central Kurils. Though the sample of finished tools made from obsidian analyzed here (Table 5.5) is very small, a range tool types including biface, blade, core, and retouched flakes were made from obsidian, suggesting the use of obsidian was not restricted to a specific tool type or function. Further analysis of a larger sample of finished tools may provide alternative interpretations.

Obsidian makes up a greater proportion of the Phase III Northern assemblage by count and by mass (Fig. 5.9) than it does for either the Southern or Central assemblages, indicating greater access and use of this non-local material, most likely from Kamchatkan obsidian sources. The high proportion of Late stage obsidian flakes (Figs. 5.10 and 5.11) suggest that obsidian was consumed primarily through tool maintenance activities; obsidian tools are present in the Northern island assemblage as a retouched flake and a projectile point. Interestingly, the Northern assemblage has a higher proportion of flakes by mass assigned to the Middle stage of reduction (Fig. 5.22, Table 5.12). This could indicate that some raw materials, particularly basalt, are entering Northern sites in a *less* reduced state compared to Southern and Central island sites, and that more tool forming and shaping is taking place.

The variation in reduction intensity across the Phase III geographic assemblages is significant by count ( $\chi^2=155.98$ ,  $df=4$ ,  $p<.0001$ ) and mass ( $\chi^2=462.08$ ,  $df=4$ ,  $p<.0001$ ). Using the adjusted residuals from the chi-square contingency tables as a guide for the directions of these differences (Tables 5.11 and 5.12), comparatively, Early and Middle stage reduction is more highly represented in the Southern assemblage while Late stage reduction is representative of the Central assemblage. By flake mass, Middle stage reduction has the greatest representation in the Northern assemblage.

Given the apparent restricted availability of high-quality raw material in the Central islands, the expectation for increased curation and economic consumption of lithic material is met.

	Contingency Table (Count)				Adjusted Residuals		
	South	Central	North		South	Central	North
Early	135	70	18	Early	7.625	-4.364	-3.947
Middle	91	25	16	Middle	7.551	-6.071	-1.601
Late	919	1462	591	Late	-10.918	7.340	4.211

Table 5.11: Chi-square contingency table and adjusted residuals for flake counts in lithic reduction stages across Phase III geographic lithic assemblages.

	Contingency Table (Mass in g)				Adjusted Residuals		
	South	Central	North		South	Central	North
Early	1286.51	234.66	95.27	Early	17.330	-14.578	-6.075
Middle	517.5	102.91	120.77	Middle	5.292	-9.642	6.079
Late	3130.1	2056.87	605.26	Late	-18.575	18.907	1.495

Table 5.12: Chi-square contingency table and adjusted residuals for flake mass in lithic reduction stages across Phase III geographic lithic assemblages.

In Phase IV, there are significant differences in the raw material composition and reduction intensity of the assemblages compared to Phase III, suggesting changing social or technological adaptations over time, or the presence of a different culture groups employing different lithic reduction strategies. One statistically significant difference is between the proportions of raw material types that compose the Phase III and Phase IV Central island assemblages as measured by count ( $\chi^2=165.0$ ,  $df=4$ ,  $p<.0001$ ) and by mass ( $\chi^2=392.8$ ,  $df=4$ ,  $p<.0001$ ). Although basalt and chert still make up the majority of the Phase IV assemblage, there is an increase in the amount of Unknown material that was utilized, suggesting that lower quality materials which were not used during Phase III, entered the lithic material “diet” in Phase IV (Tables 5.13 and 5.14). This could be interpreted as a less strict adherence to the use of high-quality raw materials for the production of easily maintainable tools, suggesting an overall relaxation in the need to maximize raw material resources.

	Contingency Table (Counts)			Adjusted Residual	
	Central Phase III	Central Phase IV		Central Phase III	Central Phase IV
Basalt	616	274	Basalt	2.038	-2.038
Chert	749	202	Chert	10.264	-10.264
Chalced	59	4	Chalced	4.604	-4.604
Obsidian	40	87	Obsidian	-8.651	8.651
Unknown	93	211	Unknown	-14.314	14.314

Table 5.13: Chi-square contingency table and adjusted residuals for raw material counts across Phase III and Phase IV Central islands lithic assemblages.

	Contingency Table (Mass in g)			Adjusted Residuals	
	Central Phase III	Central Phase IV		Central Phase III	Central Phase IV
Basalt	1420.0	1133.0	Basalt	3.399	-3.399
Chert	682.4	185.0	Chert	16.602	-16.602
Chalced	38.2	1.0	Chalced	5.544	-5.544
Obsidian	15.1	38.9	Obsidian	-3.774	3.774
Unknown	238.7	730.0	Unknown	-20.279	20.279

Table 5.14: Chi-square contingency table and adjusted residuals for raw material mass (g) across Phase III and Phase IV Central islands lithic assemblages.

The proportions of debitage in the Early, Middle, and Late lithic reduction stages also changes significantly by count ( $\chi^2=38.9$ ,  $df=2$ ,  $p<.0001$ ) and by mass ( $\chi^2=165.5$ ,  $df=2$ ,  $p<.0001$ ) (Tables 5.15 and 5.16). The increase in Early and Middle stage debitage is interpreted as an overall increase in tool production, and less tool maintenance resulting in fewer Late stage flakes. Analysis of variance of flake size between the Phase III and Phase IV assemblages confirms a significant difference between an overall average flake mass of 1.52 g in the Phase III assemblage versus 2.69 g in the Phase IV assemblage ( $F_{stat} = 28.8$ ,  $F_{crit} = 3.84$ ,  $p < 0.0001$ ), as well as for differences in average Late stage flake mass of 1.36 g in Phase III and 2.21 g in Phase IV ( $F_{stat} = 20.1$ ,  $F_{crit} = 3.84$ ,  $p < 0.0001$ ).

	Contingency Table (Counts)			Adjusted Residuals	
	Central Phase III	Central Phase IV		Central Phase III	Central Phase IV
Early	70	70	Early	-4.319	4.319
Middle	25	36	Middle	-4.315	4.315
Late	1462	672	Late	6.109	-6.109

Table 5.15: Chi-square contingency table and adjusted residuals for flake counts in lithic reduction stages across Phase III and Phase IV Central islands lithic assemblages.

	Contingency Table (Mass in g)			Adjusted Residuals	
	Central Phase III	Central Phase IV		Central Phase III	Central Phase IV
Early	234.66	336.3	Early	-6.312	6.312
Middle	102.91	269.45	Middle	-10.411	10.411
Late	2056.87	1483	Late	12.212	-12.212

Table 5.16: Chi-square contingency table and adjusted residuals for flake mass in lithic reduction stages across Phase III and Phase IV Central islands lithic assemblages.

Although obsidian still makes up a small portion of the Phase IV assemblage by count (11.2%) and mass (1.9%), it shows growth over the Phase III period by both measurements (2.6% by count and 0.6% by mass). This may suggest greater access to obsidian overall, potentially through expanded social networks, and which might predict an increase in the number of different obsidian source groups represented in the Phase IV assemblage over the Phase III assemblage. Obsidian is still represented in a range of tool types in Phase IV, including biface, blade, and retouched flake tools.

For the Northern island assemblages, there are significant differences in the proportions of raw materials that make up the Phase III and Phase IV assemblages by count ( $\chi^2=421.3$ ,  $df=4$ ,  $p<.0001$ ) and by mass ( $\chi^2=193.8$ ,  $df=4$ ,  $p<.0001$ ) (Tables 5.17 and 5.18). Basalt becomes the dominant raw material in Phase IV, making up almost 80% of the assemblage by count and by mass (Fig. 5.17) with a marked decrease in the proportions of chert and obsidian.

	Contingency Table (Counts)			Adjusted Residual	
	Northern Phase III	Northern Phase IV		Northern Phase III	Northern Phase IV
Basalt	180	667	Basalt	-19.340	19.340
Chert	238	81	Chert	13.074	-13.074
Chalced	26	3	Chalced	5.177	-5.177
Obsidian	150	40	Obsidian	10.863	-10.863
Unknown	30	50	Unknown	-0.948	0.948

Table 5.17: Chi-square contingency table and adjusted residuals for raw material counts across Phase III and Phase IV Northern islands lithic assemblages.

	Contingency Table (Mass in g)			Adjusted Residual	
	Northern Phase III	Northern Phase IV		Northern Phase III	Northern Phase IV
Basalt	456.62	921.3	Basalt	-9.623	9.623
Chert	169.18	93.1	Chert	8.540	-8.540
Chalced	46.8	2.9	Chalced	7.828	-7.828
Obsidian	49.3	13.9	Obsidian	6.198	-6.198
Unknown	98.55	181.3	Unknown	-1.888	1.888

Table 5.18: Chi-square contingency table and adjusted residuals for raw material mass (g) across Phase III and Phase IV Northern islands lithic assemblages.

The inferred decrease in the use of obsidian in Northern sites during Phase IV is interesting and quite surprising to find in this analysis. Given that the Northern sites are located closer to Kamchatkan obsidian sources, it is not clear why obsidian use should decrease in Northern sites but increase in Central island sites in Phase IV. Central island sites by their location in the island chain should have access to both Hokkaido and Kamchatkan obsidian sources, and the specific nature of Central island obsidian source use, which is explored in the next chapter, may provide some insight into this issue.

In the Northern islands, there is no statistically significant change in the proportion of flakes distributed across lithic reduction stages measured by count ( $\chi^2=0.73$ ,  $df=2$ ,  $p=0.693$ ) from Phase III to Phase IV, though there is weak difference when measured by mass ( $\chi^2=44.98$ ,  $df=2$ ,  $p=.000$ ). Similarly, there is only a slight difference between the assemblages in the average size of Late stage debitage, which rises from 1.02 g in Phase III to 1.26 g in Phase IV ( $F_{stat} = 4.14$ ,  $F_{crit} = 3.84$ ,  $p = 0.042$ ). So while there is a significant change in the raw material types that are chosen in Phase IV, the level of economy with which it is consumed is essentially unchanged. This might be inferred as a narrowing of the lithic diet breadth and a focus on specific stone tool types for which basalt was considered the most appropriate material. Yet of the 53 finished stone tools in the Northern island Phase IV tool assemblage (Table 5.7), 31 are made from basalt across a broad range of tool types including bifaces, projectile points, scrapers, retouched flakes, utilized flakes, and a blade. While this small sample is inadequate for use in drawing firm conclusions, the breadth of basalt tool types and the dominance of basalt in the debitage assemblage seems

to point a decrease in the availability of other raw material types, perhaps through social or territorial changes that have limited their procurement.

The results of the analyses presented here demonstrate some real differences between raw material and lithic reduction stage distributions between the Central islands Phase III and Phase IV assemblages. Given that the Central island Phase IV assemblage includes a mixed deposit from the Rasshua 1 site that is potentially composed of artifacts from multiple chronological phases (Phase III, IV, and V), we might expect a Phase IV assemblage with higher artifact contextual fidelity to provide an even sharper vision of the chronological variability. Likewise, the Northern islands Phase III assemblage includes artifacts from the Drobnyye 1 site that are dated to the very end of the Phase III chronology and potentially represent lithic technological behavior that could be attributed to an early Phase IV occupation. The differences in time between this and the Phase IV assemblage may reflect changes at a finer temporal resolution that are not detected in the aggregated assemblages, and may be contributing to the insignificant differences seen in lithic reduction stages between the Phase III and Phase IV assemblages.

### **Discussion and Conclusions**

There are two key findings from the analysis of Kuril Island site debitage assemblages that provide insight into the technological and social organization of Kuril inhabitants. The first is that there are clearly geographic differences in lithic reduction intensity and conservation of raw materials across the island chain. Relative to other Phase III assemblages, the Southern island site assemblage exhibited less conservative consumption of lithic material and use of a greater proportion of lower quality material, indicating that tool maintainability was not as great of a concern. Although the less efficient use of lithic raw material was predicted for the Southern site, the Southern islands may not be as rich in high-quality raw materials as initially believed. The Southern islands are geologically more diverse than the Central and Northern islands, but the distribution of high-quality raw materials may be restricted in certain areas, such as the southern end of Urup Island where the Ainu Creek site is located. Overall, the less efficient use of lower quality raw materials would characterize the Ainu Creek site as being located in an environment of low lithic resource availability and high subsistence resource predictability.

In comparison, the Central islands site assemblage of Phase III demonstrates a greater intensity of lithic reduction, and an almost exclusive use of high-quality raw materials. Though the higher level of lithic resource conservation was predicted, the dominance of high-quality raw materials was not. Given that basalt and chert make up the majority of the assemblage, it is inferred that these material types are available in the Central Kurils, as noted by Fitzhugh et al. (2004) and observed by the author in the field. However, the natural abundance of these materials may be low enough that a technological strategy aimed at maximizing tools and raw material resources was optimal in this environment. Strong social relationships among sites locally may have allowed for regular access to these materials, making them the most available of all the material types present. The very limited presence of nonlocal obsidian indicates that long-distance networks were not as strong in the Central Kurils during this phase of island occupation.

The Phase III Northern island sites assemblage falls in between the Southern and Central islands in terms of lithic reduction intensity, though the assemblage is made up of larger proportions of different high-quality raw materials than the other assemblages. Similar to the Central islands assemblage, the Northern assemblage was predicted to be mixed in terms of raw material quality, reflecting a lower availability of lithic resources. The Northern assemblage is composed of a higher proportion of obsidian than the other two assemblages, likely a product of its closer proximity to Kamchatkan obsidian sources, but also indicating stronger connections to obsidian sources than were present in the Southern islands.

That the inhabitants of the Kuril Islands engaged in appropriate lithic technological behavior relative to the conditions and constraints of their specific island environments during Phase III seems logical, and fits a model of adaptive variability. It is the second change in behavior that is detected in Phase IV that raises several interesting questions. For this period, the goal is to explain the apparent adoption of less conservative, less efficient use of lithic resources in the Central and Northern island sites. The Central island site assemblage of Phase IV shows a lower level of reduction intensity and the use of a greater proportion of lower quality raw materials, indicating less concern for maximizing materials and time.

Based on the model and predictions for lithic raw material consumption, less intensive reduction would be indicative of a change in lithic resource availability or subsistence resource predictability that allowed for a relaxation in efficiency. There are not indications of a dramatic change in the Kuril Island geological environment that would have significantly altered lithic raw material sources and their distribution across the island chain. While a significant cooling event took place between 1700 to 1300 BP followed by a warmer period around 1000 BP, but it is unclear if these climatic changes had significant effects on subsistence resource availability or predictability in the Central islands during Phase IV. Information derived from faunal assemblages from Central Kuril sites dating to Phase III and Phase IV could be insightful in terms of characterizing changes in the availability of Central Kuril prey species, but these data are currently not available for consideration here. Further investigation of the migration and colonization history of the island chain may be more fruitful.

Adopting a strategy of being over-conservative initially in a new environment makes sense as a risk-reduction strategy where information/knowledge about available resources is limited, and where there is low experience in dealing with new environments. This is precisely the situation that the first/early colonizers may have found themselves in during Phase III in the Central Kurils. As noted by Fitzhugh:

*“Colonization becomes more difficult and entails greater uncertainty as distances between habitable environments increases, as barriers between them become more impenetrable, and as potential habitats decrease in size and biodiversity,”* (Fitzhugh 2004:17).

As described earlier, there are distinct environmental and ecological differences between the Southern and Central Kuril Islands, with Central Kurils having only one-third of the ecological diversity of the Southern Kurils, being much smaller in island area size, and lying at the northern end of the Bussol Strait, which would have been a significant barrier to movement and communication.

Facing the need to balance investments of time and resources in tool technological activities and the pursuit of subsistence resources, as well as the need to learn about their new environment, the earliest colonists of the Central Kurils may have adopted a strategy based on a high level of conservation of lithic raw material and time spent managing their stone tool kit. Given a sufficient amount of time between 3100 BP and 1400 BP, occupants

of the Central Kurils could have become more familiar with their environment in terms of not only knowing where to find a suitable supply of lithic raw materials for use in stone tool production, but also in gaining information about the predictability and availability of subsistence resources. It is likely that they did, and that the differences in lithic reduction intensity between the beginning and the end of Phase III are obscured by the aggregated nature of the artifact assemblages used in this analysis. The occupants of the Central Kurils at the end of Phase III, currently believed to be Epi-Jomon groups, could have become integrated with people bearing the Okhotsk culture who entered the Kuril Islands around 1400-1300 BP. A resulting transfer of local environmental knowledge subsequently allowed Phase IV Central Kuril groups to be less conservative with their lithic resources.

This path of reasoning would argue for a long period of cultural continuity in the Kuril Islands by the first people to colonize the Central and Northern Kurils, ostensibly Jomon and Epi-Jomon groups moving northward out of the Southern Kurils, or potentially Hokkaido. However, based on the distribution of radiocarbon dates associated with Epi-Jomon and Okhotsk occupations, there appears to be a significant discontinuity in the occupation of the island chain around 1400 BP. Additionally, stylistic and technological analysis of ceramic artifacts from the Kuril Islands, which is currently still in the early phases, suggests that a completely different group of people representing the Okhotsk culture occupied the Kuril Islands during Phase IV than had occupied the islands during Phase III (Erik Gjesfjeld, personal communication 2010). This would lend support for the hypothesis that there was a “changing of the guard,” as the population density of the initial Epi-Jomon colonizers of the Central and Northern Kurils declined, and they were replaced by Okhotsk groups who brought with them a different set of adaptations.

Like the Epi-Jomon Phase III inhabitants of the Kurils before them, the Okhotsk Phase IV groups entered a Central Kuril environment that would have been unknown to them in terms of lithic raw material distributions and subsistence resource predictability. They had a similar focus on using high-quality lithic raw materials that could be easily maintained as the Epi-Jomon did, but practiced a more relaxed level of reduction intensity and conservation of materials and time related to their stone tool industry. The adaptive differences of the Okhotsk may have had less to do with changes in lithic technological strategies compared to the Epi-Jomon, and be more related to other cultural adaptations

such as greater mobility and networking that together allowed them to be less concerned with maximizing raw material efficiency.

With more advanced boating technology and navigation capabilities, Okhotsk groups may have been more adept at moving around the islands to obtain raw materials were regionally available, but unevenly distributed. The increased presence of obsidian in the Phase IV Central islands site assemblage indicates that the Okhotsk had greater access to nonlocal resources, which may have supplemented what was available locally to a greater extent than the Epi-Jomon were able to maintain in Phase III. These adaptations may have allowed Okhotsk groups to be more self-sufficient in acquiring local as well as nonlocal resources, and in mitigating the effects of local stochastic events that might have negatively impacted subsistence resources predictability.

Finally, the potential impact of occupation of the Northern Kuril Islands by culture and population groups from southern Kamchatka on the behavioral signal represented in the Northern islands lithic assemblages must also be considered. Very little is currently known about how far people living in Kamchatka may have ventured into the Kurils from the north, or how they might have influenced colonizing groups from Hokkaido and the Southern Kurils through trade and interaction. Given the relatively short distances from the southern tip of Kamchatka to Shumshu and Paramushir islands, it is probable that Kamchatkan hunter-gatherers traveled to at least these islands in pursuit of subsistence or other resources. There is currently very little in the Northern Kuril archaeological record such as lithic tool types or ceramics that have been useful in identifying Kamchatkan groups in the Kuril Islands, but this will be an important future avenue of study that could add new interpretations of the Kuril archaeological record.

Conclusions about the extent of Epi-Jomon and Okhotsk social networks represented by access to non-local obsidian during Phase III and Phase IV may provide further insight into the nature of these occupation and the changes or differences in cultural and technological adaptation that occurred across the Kurils. This will be developed in the following chapters on obsidian source provenance and social network analysis based on the obsidian sources present in Kuril lithic assemblages.

## **Chapter 6: Source Provenance Analysis of Obsidian Debitage from the Kuril Islands**

### **Introduction**

The physical and chemical properties of obsidian are such that as a lithic raw material it was as equally attractive to prehistoric stone tool makers as it is to archaeologists studying prehistoric lithic technology. The isotropic glass structure of obsidian makes it easy to flake predictably and creates extremely sharp-edged stone tools, and wherever it is available in the world people have incorporated it into their lithic technology. The homogenous chemical composition within specific obsidian flows and the low-frequency distribution of obsidian outcrops allows for the attribution of obsidian artifacts to their geologic sources with a high degree of certainty (Eerkens et al. 2007; Tykot and Chia 1997). Archaeologists over the last 40 years have increasingly exploited this property through provenance studies used to reconstruct past population movements, trade relationships, and subsistence and settlement patterns (Hughes and Smith 1993; Shackley 2008).

This chapter explores the provenance analysis of obsidian artifacts from Kuril Island lithic assemblages, and the patterns of obsidian source distribution across the Kuril archipelago. A key focus of this analysis is on determining the likely strategies and methods of obsidian procurement, both direct and indirect, given the geographic and social factors that may have influenced how Kuril islanders obtained this particular material resource.

### **Obsidian Formation and Physical Characteristics**

Obsidian is a natural glass that forms when silicic or rhyolitic magma from a deep volcanic source is extruded to the earth's surface and supercooled into glass through its contact with air, water, or cooler rocks (Hughes and Smith 1993; Shackley 2005). Virtually all rhyolitic lava flows and domes have a crystalline interior with several outer "zones" of glass material (Figure 6.1). The outermost zone is composed of porous glass formed due to the expulsion of gas during cooling. Below the porous glass zone is where a layer of artifact-quality obsidian may form, overlying the greater mass of the crystallized interior of the flow or dome. This obsidian may be exposed in spines where it has penetrated through

the porous glass zone, but for the most part it is not exposed until the outer porous layer has been eroded. By this time, the obsidian has most likely been transformed into hydrated glass (e.g. perlite) (Hughes and Smith 1993).

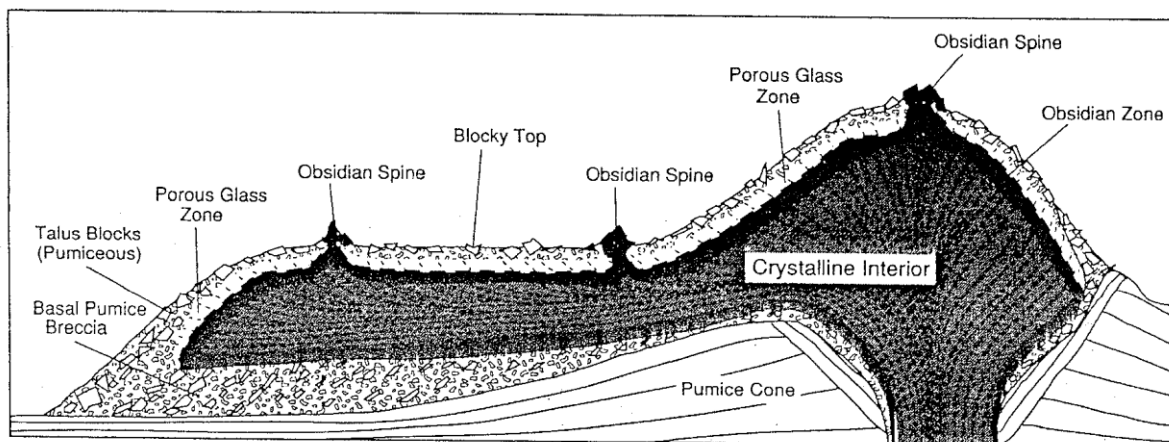


Figure 6.1: Schematic of obsidian zones in rhyolite domes and flows (from Hughes and Smith 1993, courtesy of the Geological Society of America).

Obsidian is not stable at ambient temperatures and pressures, and absorbs water inwardly through cracks formed in obsidian flows (Hughes and Smith 1993). As obsidian absorbs water, it naturally devitrifies into other forms of hydrated glass including perlite and pitchstone which are of much lower flaking quality. The absorption of water and increase in natural cracking and fracturing degrades obsidian outcrops over time and is the reason that obsidian is not present among rocks older than the Cretaceous Period (145–65 Ma); the specific rate of obsidian breakdown is governed by the exposed surface area and the crack network in the outcrop (Dietrich and Skinner 1979; Hughes and Smith 1993). For this reason, it is believed that most obsidian artifacts were made from obsidian found in relatively young formations from a geological perspective (Hughes and Smith 1993).

Because it is a glass, obsidian has a disordered atomic structure making it completely isotropic and with no preferred direction of fracture (Shackley 2005). Obsidian has a hardness of 5.0 – 5.5 on the Mohs scale and is also very brittle making it easy to knap and to create flakes with extremely sharp edges as thin as 0.000003 mm thick, sharper than surgical steel (Buck 1982; Cotterell and Kamminga 1990). Though the distribution of high-

quality obsidian is limited, it was widely exploited wherever it was available to stone tool makers as a result of its superior flaking characteristics (Glascock et al. 1998).

### **Obsidian Chemical Characterization**

Obsidian lava is formed from molten or partially molten rock and dissolved gases, and the melted rock is most commonly crustal material in which silicate minerals are the most abundant (Dietrich and Skinner 1979; Shackley 2005). Obsidian is composed primarily of 70-75% silicon oxide ( $\text{SiO}_2$ ), 10-15% aluminum oxide ( $\text{Al}_2\text{O}_3$ ), 3-5% sodium oxide ( $\text{Na}_2\text{O}$ ), 2-5% potassium oxide ( $\text{K}_2\text{O}$ ), .3-5% iron oxide ( $\text{FeO}$  and  $\text{Fe}_2\text{O}_3$ ), and 0.1-0.5% water. The elemental composition of the lava includes elements such as chromium (Cr), cobalt (Co), and nickel (Ni) that are absorbed into the solid material, and are called *compatible* elements. *Incompatible* elements such as rubidium (Rb), strontium (Sr), cesium (Cs), barium (Ba), and zirconium (Zr), have ions that are too large to fit into the crystal structure of the solid materials, and remain present in the liquid phase (Shackley 2005). These remaining elements typically are present in trace amounts of less than 1% (Glascock et al. 1998), and it is the unique concentrations of these trace elements that provide the geochemical “fingerprint” for each individual obsidian source (and sometimes individual flows within sources).

Obsidian magmas can become contaminated through mixing with adjacent magmas with different compositions, and creating multiple obsidian flows with detectable differences in trace element composition at the same volcanic source (Hughes and Smith 1993). Obsidian is usually present as a primary deposit (the original specific volcanic flow or outcrop) that can be geographically pinpointed, and also as a more widely distributed secondary deposit, such as in a river bed over many miles from the primary deposits for which the boundaries are not well-documented (Church 2000). Because of these issues, it is important for geologic sources of obsidian to be widely sampled in order to characterize them for comparison with archaeological samples.

A number of approaches have been taken by archaeologists and geochemists to differentiate among obsidian sources. The original and simplest method is through macroscopic visual analysis, used to describe obsidian in terms of color, light refraction, translucence, and luster among other visual characteristics (Fuller 1927; Glascock et al.

1998). However, visual identification is subjective, and obsidian from the same source may (and often does) differ in color or appearance based on the size and thickness of the artifacts, natural weathering, and use-wear, making this method useful only when supported by other forms of analysis. Other methods such as density measurements, and measurements of natural magnetic and radioactive properties were only partially successful in differentiating among sources (Glascock et al. 1998).

The most successful approaches for obsidian source identification have been through the geochemical analysis of trace elements, for which several different methods have been developed and refined including neutron activation analysis (NAA), inductively-coupled plasma mass-spectrometry (ICP-MS), particle-induced X-ray emission spectroscopy (PIXE), and X-ray fluorescence spectrometry (XRF). These methods have in common the ability to provide a quantitative measure of source composition, measuring multiple elements simultaneously independent of sample matrix and morphology (Glascock et al. 1998). Differentiation among sources based on trace element analysis is possible because the trace element amounts vary, sometimes by one to two orders of magnitude, providing a sensitive spatial and temporal indicator of origin (Glascock et al. 1998; Shackley 2005). Of the various analytical methods and instruments that are available for use in obsidian provenance studies, XRF and ICP-MS with laser ablation were used in the current study and are described in more detail below.

### *X-ray Fluorescence*

By the late 1950s and early 1960s, XRF was a well-established method for elemental analysis in science and industry, but was just beginning to be applied to archaeological research, primarily for the analysis of metals such as gold and silver coins (Banks and Hall 1963; Hall 1958, 1960; Harold 1961). The application of XRF methods for obsidian research began in the mid-1960s with provenance studies in the New World, primarily in California and Mesoamerica (Heizer et al. 1965; Parks and Tieh 1966; Weaver and Stross 1965), and since then it has been utilized throughout the world in hundreds of obsidian sourcing studies.

The basic principle behind XRF is the measurement of energy given off from an obsidian sample that has been irradiated with X-rays. When primary X-ray photons from an

X-ray source (such as an X-ray tube or a radioactive source) strike atoms in a sample, electrons from one of the atom's inner orbital shells (K, L, and M levels) are dislodged (Figure 2). As electrons from higher energy shells move to the inner/lower energy shells to replace the original dislodged electrons, energy is released in the form of secondary fluorescent X-rays, and this energy is measured in electron volts (eV). The amount of energy that is given off by each element is unique, and the energy that is measured can be compared with the known energies of individual elements to identify the element (Pollard et al. 2007).

There are two forms of XRF instrumentation, wavelength dispersive XRF (WDXRF), and energy dispersive XRF (EDXRF). WDXRF measures the wavelengths of the electromagnetic waves of secondary fluorescent X-ray energy that is given off by an element in the sample (Pollard et al. 2007). A crystal in the WDXRF instrument separates the various elemental wavelengths, sending only the wavelength of one element at a time to the detector. By changing the angle of the crystal, different elements can be chosen for analysis. Because the detector in the WDXRF unit is positioned behind a beryllium (Be) window, lighter elements that have weaker energy cannot pass through it, and so only heavier elements above Be can be detected (Pollard et al. 2007). WDXRF provides a high level of sensitivity for detecting elements (0.01%), but the analysis is slower and the instruments are more expensive and not portable, and thus are not used as commonly for obsidian studies as EDXRF instruments.

EDXRF instruments use a solid state semiconductor diode to detect and measure the secondary fluorescent X-ray energy that is emitted from sample elements. Since the energy that is given off by each element appears as a peak in an energy spectrum, the height of the peak can be used to indicate the concentration of a particular element in an obsidian sample. This is usually given in units of parts per million (PPM), which typically are converted from the energy peak spectrum through a regression calibration of well-characterized standards (Glascok et al. 1998). EDXRF systems can detect elements on the periodic table between sodium (Na, atomic number 11) and uranium (U, atomic number 92). XRF measurements are sensitive to the shape of the surface of the sample being measured, and flat, smooth surfaces are preferred because primary fluorescent X-rays dissipate in air at a rate equal to the inverse square of the distance between the X-ray source and the detector

(Pollard et al. 2007). Since the elements below sulfur (S, atomic number 16) have energies less than 2 eV which are absorbed by air within a short distance of the sample surface, detection of those elements must be aided with a vacuum pump or a helium purge. For obsidian studies using XRF, the most commonly used elements are rubidium (Rb), strontium (Sr), zirconium (Zr), niobium (Nb), barium (Ba), yttrium (Y), titanium (Ti), manganese (Mn), sodium (Na), potassium (K), and iron (Fe). These are the incompatible trace elements that provide unique obsidian chemical signatures, and are the elements that fall within the energy ranges that are easily detectible with XRF. Although EDXRF instruments provide less detection resolution (0.1%) than WDXRF, they are faster and can measure all elements simultaneously (Pollard et al. 2007).

XRF has become popular for archaeological applications because of its overall speed, precision, availability, and relatively low cost. Several of the advantages XRF has over other instrument technologies are that it is non-destructive, and requires little if any sample preparation. XRF is also fast – samples can be measured in several minutes – and easy to use with instruments that are integrated with computers and analysis software. XRF technology is also becoming smaller and more portable, with a new class of portable EDXRF (pXRF) instruments. These battery-powered instruments with miniaturized X-ray tubes and thermoelectrically-cooled detectors can be paired with laptop computers to create a totally-portable, low-cost instrument that provides a way for archaeologists to take the analysis technology into the field or to artifact collections in museums, and generate results that are comparable to larger, more expensive lab-based XRF systems (Craig et al. 2007; Nazaroff et al. 2010; Phillips and Speakman 2009).

For this study, XRF analysis was conducted with a Bruker Tracer III-V portable EDXRF unit (Figure 6.2). All of the obsidian flakes were analyzed as unmodified samples, placing the flattest part of the flake face-down on the instrument. Since the spot size for this instrument is ca. 4 mm in diameter, flakes larger than 5 mm in diameter were selected for analysis. XRF analyses permitted the quantification of the following ten elements: potassium (K), manganese (Mn), iron (Fe), gallium (Ga), thorium (Th), rubidium (Ru), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). The instrument was equipped with a rhodium tube and silicon PIN (p-type, intrinsic, n-type) detector with a resolution of ca. 170 eV FWHM (full width at half maximum) for 5.9 keV X-rays (at 1000

counts per second) in an area of  $7\text{mm}^2$ . All analyses were conducted at 40 keV, 15  $\mu\text{A}$  using a 0.076 mm copper filter and 0.0305 aluminum filter in the X-ray path for a 200 second live-time count. Peak intensities for the above listed elements were calculated as ratios to the Compton peak of rhodium, and converted to parts-per-million (ppm) using linear regressions derived from 15 well-characterized obsidian samples that previously had been analyzed with NAA and XRF which were incorporated into an instrument calibration created by Jeff Speakman at the Smithsonian Institution.

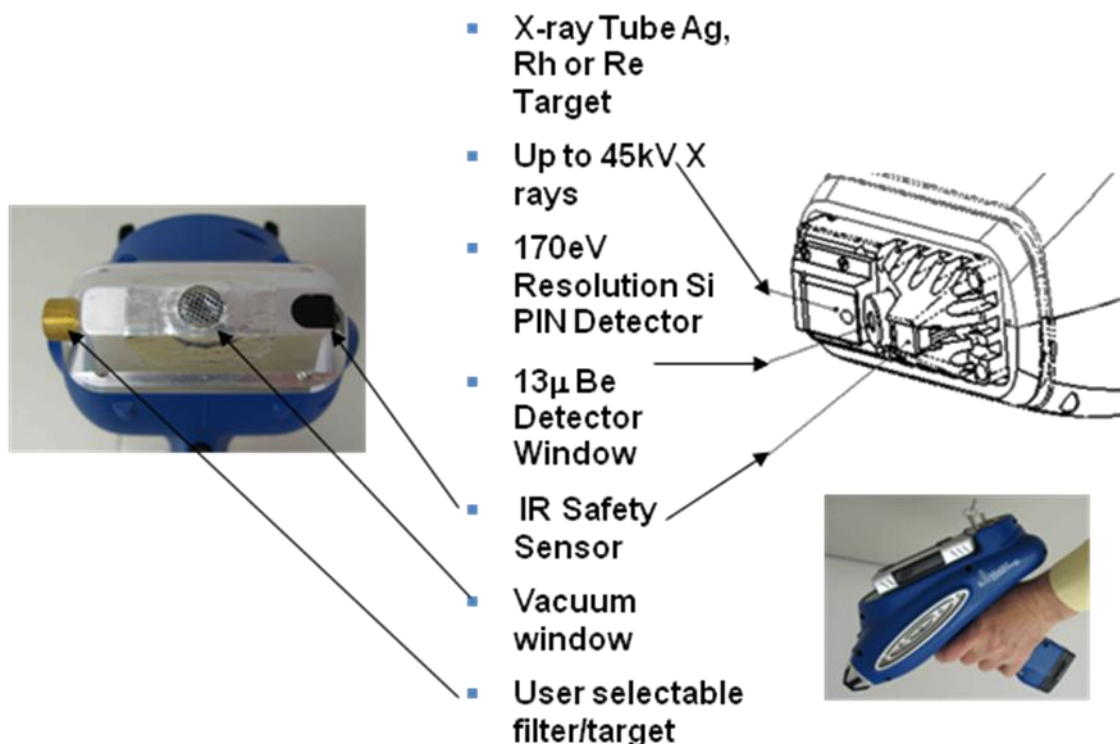


Figure 6.2 Bruker Tracer III-V portable XRF instrument.

### *Laser Ablation Inductively-Coupled Plasma Mass Spectrometry*

The application of ICP-MS in archaeological research began in the 1980s with the elemental characterization of pottery for the purpose of identifying the source of clays used in ceramic production (Hart and Adams 1983; Hart et al. 1987). Since then, it has become a standard analytical instrument for the generation of bulk compositional data for a range of archaeological materials, including obsidian (Devos et al. 1999, 2000; Gratuze 1999;

Gratuze et al. 2001; James and Dahlin 2005; Kennett et al., 2001; Mallory-Greenough et al., 1999; Speakman and Neff 2005; Speakman et al. 2002, 2007).

During analysis, sample material that has been digested (with either heat or in acid solution or ablated with a laser) is introduced into a plasma torch which ionizes the material. The ions then pass into a vacuum chamber in the mass spectrometer, where they are energized and accelerated through ion optics and filtered by an electrostatic analyzer to separate high and low-kinetic energy ions. A magnet separates the ions according to their mass-to-charge ratio, and they are counted by a detector, which identifies elements by translating the number of ions striking the detector into an electrical signal that is compared to the known electrical signal of atoms in each element (Speakman and Neff 2005). One of the advantages of ICP-MS is that it can detect elements to the low parts-per-million (ppm) to parts-per-trillion (ppt) levels for most elements on the periodic table. The ICP-MS method is minimally destructive (only a very small amount of sample material is necessary for analysis) and fairly quick, but the instruments are expensive and confined to laboratory environments. Additionally, data quantification, especially for laser ablation, can be difficult due to the need to manage instrument drift and the requirement of more complex data calibration calculations (Speakman and Neff 2005).

In recent years, laser ablation (LA) systems used in tandem with ICP-MS systems have gained increasing popularity as a tool for elemental analyses of both organic and inorganic matrices. Samples are placed in a chamber where a video camera projects a digital image of the sample on a computer screen. Computer software allows the instrument operator to map out a series of spots, lines, or raster patterns for the laser to follow. During ablation, the laser is focused on a sample area and removes a small amount of surface material by vaporization at a set repetition rate (measured in Hz) and with a specific amount of laser intensity (Speakman and Neff 2005). LA-ICP-MS offers several advantages over other analytical methods, including high accuracy and precision, low detection limits, rapid analytical time, low cost per sample, and high sample throughput. (Cochrane and Neff 2006; Speakman and Neff 2005; Speakman et al. 2002). The laser ablates an area of only 100-200 microns in diameter and 10-20 microns deep on the surface of the artifact, making it minimally destructive and ideally suited for the analysis of very small artifacts such as lithic flake debitage.

The obsidian flakes in this study determined to be too small, thin, or too morphologically irregular for XRF analysis were analyzed by LA-ICP-MS. This analysis took place at the Smithsonian Institution's Museum Conservation Institute (Suitland, MD, USA) using a Perkin Elmer Elan 6000 ICP-MS and CETAC LSX 266 nm laser ablation unit (Figure 6.3). Flakes were mounted to a glass slide so that the flattest face (dorsal or ventral) was exposed to the laser, and were pre-ablated to remove any surface contaminants with the laser operated at 70% power using a 200-micron diameter spot size running at a 20 Hz pulse rate over a computer generated raster at a speed of 100 micron/sec. For the actual analysis, the pre-ablated region was then ablated at 70% power using a 100 micron in diameter spot size operating at a 20 Hz pulse rate over a computer generated raster at a speed of 30 micron/sec (Figure 6.4) to generate elemental abundance data. Argon served as the transport gas from the laser ablation unit to the ICP-MS. At the beginning and end of each daily analysis session, a series of blanks, the NIST SRM 612 glass standard, and six well-characterized obsidian samples that previously had been analyzed by Neutron Activation Analysis (NAA) were analyzed to develop a set of calibration parameters and to monitor instrumental drift of the ICP-MS.



Figure 6.3: LA-ICP-MS system at the Smithsonian Institution Museum Conservation Institute used in this analysis (Photo: S.C. Phillips).



Figure 6.4: Microscope camera screen shot of laser ablation path on an obsidian flake. The ablation channel is approximately 10 microns wide (Photo: S.C. Phillips).

Source matching, via any method of geochemical analysis, is essentially an exercise in probability matching, where the chemical characterization of artifacts can provide a likely, but not absolute, match to known geologic sources. The ability to match obsidian artifacts to their geologic sources depends not only on the validity and reliability of the instrumentation used for the geochemical analysis, but also on the amount of source characterization that has been done to create a geochemical baseline dataset to measure artifacts against (Shackley 2008). Ward (1977, pg. 193) proposes geochemical similarity alone is not sufficient for assigning an artifact to a source, and that “characterizational dissimilarity” provides an additional level of confidence in the tentative identification of sources within a sometimes unknown universe of possibilities. Source provenance studies can be compromised by a failure to identify all possible sources within a region, and using only a few elements to assign artifacts to sources. Glascock et al. (1998) have laid out a systematic approach to obsidian source characterization that includes obtaining a representative sample of all sources in a given area, demonstrating that flakeable-quality obsidian is available at the geologic source, verifying that the source was available prehistorically, analyzing source specimens thoroughly, correlating source chemical

signatures to specific locations, and demonstrating that artifacts assigned to a source cannot also be assigned to a different source. Through this type of approach it is possible to make reliable connections between obsidian artifacts from archaeological contexts and natural geologic sources of obsidian.

It is also worth clarifying the term obsidian “source”. In the past, obsidian sources have been defined as spatial units, based on the geographic areal extent of an obsidian flow, as well as geochemical units (often referred to as geochemical groups), based on the chemical composition of the obsidian (Hughes 1998). There is an important distinction to be made because the same geographic location may include multiple chemically differentiated obsidian flows or outcrops, and in many parts of the world where obsidian provenance studies are conducted, the geochemical characterization of all of the obsidian flows or outcrops in a specific geographic region are incomplete. The overarching challenge in obsidian provenance research is to match the geochemical units to the spatial units (Neff 1998). The use of geochemical group as a definition for source then allows for the spatial definition of a source to be updated as new research on geology of a region is conducted (Hughes 1998). For the present study, the term “obsidian source” specifically denotes a geochemically differentiated group of obsidian raw material. In some cases, these geochemical groups have been confidently assigned to geographic space through geological surveys and sample analysis. In other cases, while the sources have been geochemically differentiated, they have only loosely (or not at all) been connected with geographic locales.

### **Relevant Obsidian Source Characterization Studies in Northeast Asia**

Over the past decade, regional studies in the northeast Asian portion of the Pacific Rim have developed information and ideas about the prehistoric use of obsidian as an important raw material for the manufacture of stone tools. Research conducted specifically on Hokkaido Island (Japan) and the Primorye and Kamchatka regions of the Russian Far East, have provided detailed accounts of the location of primary and secondary obsidian sources, the movement of obsidian over long distances, and the differential use of various sources based on location and quality (Glascock et al., 2000, 2006; Hall and Kimura 2002; Izhuo and Sato 2007; Kimura 2006; Kuzmin 2006a, 2006b; Kuzmin and Glascock 2007; Kuzmin et al., 2000, 2002a; Speakman et al. 2005; Suzuki and Naoe 2006; Wada et al.

2003, 2006). Several of these studies have provided the geochemical baseline data that are used in this study for matching Kuril obsidian artifacts to source geochemical groups. These baseline datasets are represented as tables in the text below.

### *Hokkaido*

The northern Japanese island of Hokkaido is located at the intersection of the northeast Japan and Kuril volcanic arc geologic systems, on a plate subduction zone of active volcanism that has formed the geology of the island (Izuho and Sato 2007). Hokkaido contains 21 different geological sources of obsidian, including the large Shirataki and Oketo volcanic complexes which include several sub-sources. Prehistoric procurement and use of obsidian from Hokkaido sources began during the Upper Paleolithic in Japan (ca. 30,000 BP), and a number of studies have shown that obsidian from these sources was transported up to 1000 km to locations across Japan, as well as Sakhalin Island and the Kuril Islands of Far Eastern Russia (Glascock et al., 2000, 2006; Hall and Kimura 2002; Izuho and Sato 2007; Kimura 2006; Kuzmin 2006a, 2006b; Kuzmin and Glascock 2007; Kuzmin et al., 2000, 2002a; Phillips and Speakman 2009; Suzuki and Naoe 2006; Wada et al. 2003, 2006).

Of the 21 different obsidian sources that have been differentiated geochemically, the primary sources for 11 have been located geographically (Table 6.1); the remaining ten sources have only been located in secondary or archaeological contexts (Izuho and Sato 2007). A number of obsidian provenance studies have focused on differentiating Hokkaido sources among stone tool and flake assemblages from Japan and Far Eastern Russia. Glascock et al. (2000) conducted NAA analysis on 73 obsidian artifact samples from archaeological sites on Sakhalin Island that were matched to two main Hokkaido obsidian sources, the Oketo and Shirataki volcanic groups (Table 6.2). Hall and Kimura (2002) utilized XRF to differentiate between two different Shirataki primary sources (Akaishiyama and Tokachiishikawa) and two other primary sources Oketo, and Tokachimitsumata (Table 6.3). Wada et al. (2003) used electron probe micro-analysis EPMA analysis to assign artifacts from an archaeological site at the mouth of the Tokoro River in eastern Hokkaido to different obsidian sources, but showing that the Shirataki and Oketo sources represented almost the entire assemblage. Obsidian artifacts from Rishiri

Island north of Hokkaido also were analyzed with EPMA and 96% of them were assigned to either Shirataki or Oketo (Wada et al. 2006). An initial pilot project that analyzed obsidian artifacts from the Kuril Islands found the Shirataki and Oketo sources were heavily represented in the flake assemblage (Phillips and Speakman 2009).

Source	Primary Locality	Latitude	Longitude
Shirataki	Akashiyama	43°56'	143°08'
Shirataki	Tokachiishikawa	43°54'	143°10'
Tokachimitsumata	Jyusan'nosawa	43°29'	143°10'
Oketo	Tokoryama	43°41'	143°33'
Oketo	Oketoyama	43°40'	143°30'
Akaigawa	Dobokuzawa	43°00'	140°49'
Chikabumidai	unknown	43°00'	142°23'
Ubundai	unknown	43°50'	142°17'
Hokuryu	unknown	43°46'	141°52'
Chippubetsu	unknown	43°46'	141°58'
Shikaribetsu	unknown	43°46'	142°59'
Toyoizumi	unknown	42°36'	140°39'
Nayoro	unknown	44°15'	132°34'
Monbetsu	Kamimobetsu	44°10'	143°22'
Keshomappu	Michikozawa	43°45'	143°18'
Okushiri	Katsumayama	42°11'	139°27'
Kushiro	unknown	42°59'	144°09'
Abashiri	Ponmoimisaki	44°01'	144°16'
Ikutahara	Nitappugawa	43°58'	143°29'
Oumu	unknown	44°33'	142°49'
Engaru	unknown	44°03'	143°28'

Table 6.1: Hokkaido obsidian source locations (from Izuho and Sato 2007).

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
Shirataki-A	Akashiyama	149.7	2.1	28.2	7.7	91.1	8.4	38
Shirataki-B	Akashiyama	172.8	2.7	-	-	84.7	14.5	20
Oketo	Tokoroyama	134.3	2.2	74.1	28.6	120.8	10.3	16
Oketo	Tokoroyama	136.6	-	61.8	-	116.3	-	1
Oketo	Oketoyama	97.4	-	53.2	-	128.4	-	1
Tokachimitsumata	Jyusan'nosawa	139.4	1.0	41.9	3.8	103.9	10.1	2
Akaigawa	Dobokuzawa	127.5	2.2	48.7	21.2	144.3	38.4	2

Table 6.2: Hokkaido obsidian source characterization (from Glascock et al. 2000).

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
Shirataki (Akashiyama Summit)	Akashiyama	188.0	7.0	32.0	2.0	91.0	4.0	31
Shirataki (Akashiyama Valley)	Akashiyama	185.0	6.0	31.0	2.0	89.0	3.0	30
Shirataki (Tokachiishikawa)	Tokachiishikawa	209.0	11.0	-	-	76.0	4.0	20
Oketo (Tokoro)	Tokoryama	171.0	9.0	80.0	5.0	127.0	5.0	20
Oketo	Oketoyama	127.0	5.0	97.0	4.0	160.0	6.0	31
Tokachimitsumata	Jyusan'nosawa	185.0	8.0	58.0	4.0	100.0	5.0	5

Table 6.3: Hokkaido obsidian source characterization (from Hall and Kimura 2002).

These analyses of Hokkaido obsidian sources and obsidian artifacts that have been traced to Hokkaido sources indicate that the Shirataki and Oketo sources, among others, have significant time depth in their use and wide distribution in transport and/or trade beyond the Japanese islands. The presence of these sources in archaeological sites on Sakhalin Island provides evidence of the long-distance transport of obsidian that included the use of boat technology to cross the La Perouse Strait between Hokkaido and Sakhalin. These findings are important in terms of the expectation of the Hokkaido sources used by occupants of the Kuril Islands, and the potential for developing trade/exchange networks from the Kuril Islands back to Hokkaido for continued access to these obsidian sources.

### *Kamchatka*

The Kamchatka peninsula of Far Eastern Russia is a highly volcanic region, with several mountain ranges containing active volcanoes, and with a number of geologically known and unknown obsidian sources. While obsidian artifacts have been recognized in archaeological contexts in Kamchatka since the beginning of the 20<sup>th</sup> century, no systematic source geochemical characterization studies were conducted before 2003 (Glascock et al. 2006; Speakman et al. 2005). An initial sourcing project was undertaken by Speakman et al. (2005) from 2003 – 2005 by the University of Missouri and the Russian Academy of Sciences to collect and analyze geological samples and obsidian artifacts from a number of Kamchatka archaeological sites (Table 6.4).

The results of this project identified a total of 13 different obsidian sources, eight that could be specifically located, and five others that were differentiated geochemically,

but remain unknown geographically except for speculation based on the location of archaeological sites that contain those sources. Four sources, Itkavayam (KAM-03), Payalpan (KAM-05), Ichinsky (KAM-07), and Khangar (KAM-12) are located in the Central Range, a belt of mountains running through the center of the Kamchatka peninsula. These sources are often open-area scatters with obsidian of varying color and structure in the form of large blocks and chunks (Glascoock et al. 2006). Three sources are located in southern Kamchatka, the Nachiki (KAM-06), Tolmachev Dol (KAM-11), and Bannaya River (KAM-13) sources. The Karimsky source (KAM-9) is the only obsidian source located in the Eastern Range of mountains, which includes the Krasheninnikov, Karymskaya Sopka, and Avachinskaya Sopka active volcanoes. The remaining sources have only been roughly oriented to the general regions of the archaeological sites from which samples were analyzed for the study: KAM-01 in the southwestern peninsula; KAM-02 in the south; KAM-04 in the area around the city of Petropavlosk-Kamchatskiy; KAM-08 to the northern peninsula; and KAM-10 to the eastern slopes of the Central Range (Glascoock et al. 2006).

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
KAM-01	unknown	60.0	2.0	205.0	20.0	131.0	9.0	11
KAM-02	unknown	105.0	1.0	84.0	41.0	282.0	10.0	8
KAM-03	Itkavayam (Central Range)	74.0	2.0	114.0	22.0	125.0	8.0	7
KAM-04	unknown	67.0	1.0	157.0	7.0	145.0	8.0	8
KAM-05	Payalpan (Central Range)	92.0	1.0	54.0	5.0	96.0	5.0	8
KAM-06	Nachiki	100.0	2.0	77.0	10.0	114.0	6.0	8
KAM-07	Ichinsky (Central Range)	70.0	1.0	371.0	68.0	133.0	10.0	13
KAM-08	unknown	114.0	4.0	155.0	19.0	104.0	15.0	7
KAM-09	unknown	51.0	1.0	142.0	24.0	155.0	12.0	5
KAM-10	unknown	62.0	1.0	288.0	16.0	136.0	11.0	7
KAM-11	Tolmachev Plateau	76.0	1.0	188.0	16.0	89.0	1.0	5
KAM-12	Khangar (Central Range)	71.0	3.0	205.0	4.0	151.0	7.0	2
KAM-13	Bannaya River	127.0	3.0	38.0	0.0	141.0	5.0	2

Table 6.4: Kamchatka obsidian source characterization (from Glascock et al. 2006).

Analysis of 62 obsidian artifacts from late Pleistocene and Holocene contexts at the Ushki Lake sites in Kamchatka indicated that the KAM-01, KAM-03, KAM-04, KAM-05,

KAM-07, and KAM-10 sources were present at the site. Additionally, two new previously unknown sources were differentiated geochemically, KAM-14 and KAM-15 (Table 6.5). Though these sources have not been geographically located, they may be geochemically related to the Ichinsky (KAM-07) source in the Central Range, roughly 200 km from Ushki Lake (Kuzmin et al. 2008).

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
KAM-01	unknown	60.0	2.2	206.0	20.0	131.0	9.0	12
KAM-03	Itkavayam (Central Range)	74.2	1.5	111.0	17.0	126.0	6.0	15
KAM-04	unknown	66.6	1.4	157.0	7.0	145.0	8.0	8
KAM-05	Payalpan (Central Range)	92.2	1.5	53.0	6.0	97.0	5.0	9
KAM-07	Ichinsky (Central Range)	70.8	1.4	354.0	54.0	133.0	10.0	24
KAM-10	unknown	63.1	2.9	282.0	21.0	134.0	12.0	11
KAM-14	unknown	56.5	0.3	219.0	25.0	107.0	15.0	2
KAM-15	unknown	78.9	1.4	276.0	25.0	120.0	6.0	7

Table 6.5: Kamchatka obsidian source characterization (from Kuzmin et al. 2008).

From preliminary research on Kamchatka's obsidian sources and artifacts, it is evident that obsidian was used since the late Pleistocene at least at the Ushki Lake sites (and potentially others), and was distributed widely around the Kamchatkan Peninsula. Distances from archaeological sites to obsidian sources range from just a few kilometers up to over 500 km, suggesting long-distance transport, and potentially trade, of this raw material resource (Glascock et al. 2006; Kuzmin et al. 2008).

#### *Korea, China, and Primorye*

Several studies have characterized obsidian sources and artifacts from the northeast Asian mainland, suggesting the wide-scale procurement and transport or trade of obsidian from sources in Korea, China, and the Primorye region of Far Eastern Russia. The Paektusan volcano is the only obsidian source known on the Korean peninsula, but it is a significant source of obsidian found in archaeological sites across North and South Korea, northeastern China, and the Primorye province of Far Eastern Russia. Located on the modern border between North Korea and China, the Paektusan volcano contains a large summit caldera and erupted most recently in 1898 (Popov et al. 2005). Initial

characterization of geologic samples of obsidian collected from the Chinese side of the volcano and analyzed by the Russian Far East Geological Institute and the Missouri University Research Reactor identified three geochemical groups, (PNK1, PNK2, and PNK3) (Table 6.6), two of which are associated with obsidian artifacts (Popov et al. 2005). In 2007, additional analysis of Paektusan geologic samples identified a fourth group (PNK4) (Kim 2009).

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
PNK-1	Paektusan (North Korea)	232.5	9.2	-	-	256.5	9.2	2
PNK-2	Paektusan (North Korea)	305.3	63.6	-	-	1749.7	244.8	3
PNK-3	Paektusan (North Korea)	132.0	4.6	-	-	505.7	18.9	3

Table 6.6: Kamchatka obsidian source characterization (from Popov et al. 2005).

Kim et al. (2007) traced 64 of 75 obsidian artifacts from six different archaeological sites on the Korean peninsula to the Paektusan source, including 19 artifacts from the Sangmuyongri site on the southernmost part of the peninsula 800 km from the volcano (Table 6.7). Using portable XRF (PXRF) to analyze 440 obsidian artifacts from 18 Late Paleolithic sites in the Changbaishan mountains of northeastern China, Jia et al. (2010) found that more than 93% of the artifacts could be attributed to the Paektusan source (Table 6.8). This included artifacts from a site located 320 km northeast of the volcano, the furthest distant site in their study.

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
PNK-1	Paektusan (North Korea)	251.0	27.1	14.9	14.6	247.7	33.7	21
PNK-2	Paektusan (North Korea)	301.5	42.0	-	-	1372.2	114.5	10

Table 6.7: North Korean obsidian source characterization (from Kim et al. 2007).

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
Group A	Paektusan (North Korea)	108.7	9.1	25.2	6.7	120.8	29.6	413
Group B	Basaltic Plateau	15.7	3.3	133.9	69.1	23.6	30.9	7
Group C	unknown	31.1	18.4	33.7	54.3	2.3	37.7	12
Group D	unknown	202.7	15.9	19.2	0.4	1485.0	125.6	3

Table 6.8: Source characterization for obsidian artifacts from northeastern China (Jia et al. 2010)

Jia et al. (2010) also identified artifacts in northeast China from two obsidian sources in the Primorye region of Far Eastern Russia. The Primorye province stretches from Vladivostok 1200 km north along the Sea of Japan, and includes several volcanic regions including the Sikhote-Alin mountains along the eastern coast, the Shkotovo and Shufan basaltic plateaus, the Krabbe Peninsula and the Gladkaya River Basin. Obsidian is found in these regions as basaltic or rhyolitic glass, or perlites, and occurring in extrusive lava domes, dikes, or flows (Doelman et al. 2004; Kuzmin et al. 2002b). An initial study of geological and archaeological obsidian samples using NAA and XRF identified sources on the Shkotovo and Shufan plateaus and the Gladkaya River basin associated with archaeological contexts, while obsidian perlites from the Zerkalnaya River in the Sikhote-Alin range were not found to have been used prehistorically (Table 6.9) (Kuzmin et al. 2002b). Continued geoarchaeological analysis of obsidian sources and obsidian artifacts from archaeological sites in southern Primorye has refined the characterization of the prehistoric use of obsidian from primary and secondary sources on the Shkotovo plateau and the Gladkaya River Basin, indicating prehistoric use of these sources from the Late Paleolithic (ca. 20,000 BP) through the Bronze Age (ca. 3500 BP) in this region (Doelman et al. 2004, 2008; Kluyev and Sleptsov 2007). Additionally, obsidian artifacts from the Paektusan source in North Korea/China have been identified in Primorye archaeological assemblages (Table 6.10) (Doelman et al. 2004, 2008; Kuzmin et al. 2002b), indicating the movement of obsidian from sources in North Korea/China and the Far Eastern Russia within and between those regions, though the specific mechanisms movement and spatio-temporal temporal patterns of source distribution are still being explored.

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
Basaltic Plateau	Basaltic Plateau	11.0	3.0	381.0	93.0	94.0	20.0	97
PNK-1	Paektusan (North Korea)	236.0	8.0	28.0	6.0	252.0	11.0	32
PNK-2	Paektusan (North Korea)	342.0	5.9	-	-	1886.0	5.0	2
Gladkaya-1	Gladkaya River	97.3	2.1	19.9	1.5	106.0	10.0	2
Gladkaya-2	Gladkaya River	59.3	0.1	485.0	28.0	156.0	8.0	6
Gladkaya-3	Gladkaya River	89.0	1.0	39.0	33.0	115.0	2.0	2
Krabbe Peninsula	Krabbe Peninsula	92.0	1.0	83.0	21.0	149.0	1.0	2
Sadovy	Sikhote-Alin Mountains	146.0	30.0	224.0	65.0	369.0	19.0	4
Chernaya Rechka	Sikhote-Alin Mountains	180.0	8.0	58.0	10.0	488.0	69.0	2
Samarga	unknown	102.0	2.0	250.0	17.0	132.0	3.0	5

Table 6.9: Primorye obsidian source characterization (from Kuzmin et al. 2002).

Source	Primary Locality	Rb		Sr		Zr		n
		mean	sd	mean	sd	mean	sd	
Basaltic Plateau	Basaltic Plateau	13	5	313	40	87	13	62
PNK	Paektusan (North Korea)	247	57	31	58	244	40	20
Gladkaya	Gladkaya River	101	13	11	3	80	19	4
Krabbe Peninsula	Krabbe Peninsula	149	65	57	49	195	23	2

Table 6.10: Primorye obsidian source characterization (from Doelman et al. 2004).

### Kuril Island Obsidian Artifacts

The obsidian provenance studies mentioned above have demonstrated the long-term procurement, transport, and use of obsidian from several key source areas in northeast Asia, and suggest that systems or networks for moving obsidian over distances up to 1000 km existed for at least 20,000 years. While virtually all of the areas surrounding the Kuril Islands (Japan, Kamchatka, and Primorye) have been characterized in terms of their obsidian sources and prehistoric use of obsidian, until recently the Kuril Islands were an archaeological blank spot in terms of lithic raw material, and specifically obsidian, studies. However, new research on the distribution of nonlocal obsidian throughout the Kuril Islands has created a data set useful for addressing questions about human migration, movement, and resource exchange within the archipelago, and in turn characterizing the nature of social relationships that existed among the island chain's inhabitants.

Although few studies of Kuril Island lithic assemblages have been published, Fitzhugh et al. (2004) used a small sample collected during the 2000 International Kuril Island Project (IKIP) expedition to investigate geographic constraints on mobility, trade, and access to raw material sources. Their working hypothesis was that geographic location and insularity affected lithic raw material procurement in ways that could be detected in the archaeological record. They conducted an analysis of flake assemblages with the goal of examining the variability of raw material distribution across the island chain and on Sakhalin Island. The distribution of different raw materials on each island was expected to be a function of local availability and the degree of access through cultural interaction (migration or exchange).

Based on a sample assemblage of 1,004 flakes, Fitzhugh et al. (2004) encountered only small amounts of obsidian in the northern and central Kurils (12 and 20 flakes respectively) which they suggested may have originated from different geographic locations in Kamchatka based on variable translucence and texture qualities. Other types of raw materials in the assemblage (chert, dacite, basalt, and chalcedony) were believed to have come from local island sources. Given that the distribution of different raw materials were centered at either end of the island chain, they concluded that the Kuril Islands were sufficiently isolated to constrain the spread of non-local raw materials throughout the islands via mobility or exchange, and that the Kurils were settled permanently enough to support the development of in-situ systems of local raw material utilization.

Native geological sources of high-quality obsidian in the Kuril Islands are currently unknown, and the limited surveys that have been conducted by the KBP have only located sparse outcrops of fractured perlite and pitchstone on Ketoi and Yankicha islands in the central part of the Kurils (M. Nakagawa, personal communication 2007; A. Rybin, personal communication 2006). However, recent archaeological excavations by the KBP at sites in the southern, central, and northern parts of the island chain, and work by Russian archaeologists Olga Shubina and Igor Samarin in the southern islands, have recovered obsidian artifacts from contexts associated with Phase III and Phase IV site occupations spanning roughly 1750 years from ca. 2500-750 BP. This work greatly expanded the lithic artifact assemblage beyond what was available to Fitzhugh et al. through the IKIP

excavations, and provides the basis for exploring patterns of obsidian distribution in the Kuril Islands.

In 2007 an initial pilot project conducted XRF trace element analysis of 131 obsidian flakes from 18 sites on eight islands, and identified nine different source groups that could be matched to geological sources of obsidian located in Hokkaido and Kamchatka (Phillips and Speakman 2009). Obsidian from four Hokkaido sources was found to be present primarily in the southern Kurils, with only three flakes excavated from central or northern island sites. Conversely, all of the obsidian from five different Kamchatka sources was present only in the central and northern islands. This study concluded that the Bussol Strait, a 109 km-wide open-water strait that separates the southern and central island groups, may have been a significant barrier to the long-term access to Hokkaido obsidian by inhabitants of the central and northern islands, who sought less costly obsidian from Kamchatka. A follow-up study analyzed an additional 774 obsidian flakes with laser-ablation inductively coupled mass-spectrometry (LA-ICP-MS) and confirmed a similar pattern of distribution, though also found obsidian from Hokkaido sources present in Central and Northern sites, and for the first time, Kamchatkan obsidian in Southern sites (Phillips 2010).

In order to explore ideas about the obsidian procurement activities and relate those activities to socially meaningful ties between participants in a network of human relationships, it is necessary to develop an archaeologically-derived data set based on the distribution of obsidian artifacts across the Kuril Islands. The following section describes the results of provenance analysis of the Kuril Island obsidian artifact assemblage which provides the foundation for characterizing the Kuril obsidian procurement activities.

### **Kuril Island Obsidian Artifact Source Provenance Analysis**

A total of 1,433 obsidian flakes were analyzed with XRF or LA-ICP-MS representing all of the unmodified obsidian flake artifacts recovered by the Kuril Biocomplexity Project excavations in 2006, 2007, and 2008, as well as several obsidian flakes excavated during the International Kuril Island Project (IKIP) in 1999 and 2000, and flakes provided by Russian archaeologist Olga Shubina from her work in the southern Kuril Islands. These obsidian flakes are part of the larger lithic assemblage of unmodified flakes

that was brought from the Kuril Islands to the University of Washington for analysis and are inclusive of the obsidian flakes analyzed in the Phillips and Speakman (2009) and Phillips (2010) studies mentioned above. Formal lithic tools and flakes with evidence of retouch were not brought back to the United States and are curated at the Sakhalin State Regional Museum in Yuzhno-Sakhalinsk, Russia, and were not included in the source provenance analysis.

Figures 6.5 and 6.6 show the two-axis plots created with the Gauss MURRAP software program of the obsidian source groups represented in the sample. Of the eleven common elements that were measured by both XRF and LA-ICP-MS analyses, plotting rubidium (Rb)/strontium (Sr), and rubidium (Rb)/zirconium (Zr) provides the greatest and most consistent amount of obsidian source group separation for this assemblage. Each obsidian flake was assigned to a known source group based on visual cluster analysis and comparison with the published baseline data for obsidian source groups in northeastern Asia that were previously geochemically characterized (Tables 6.2-6.10).

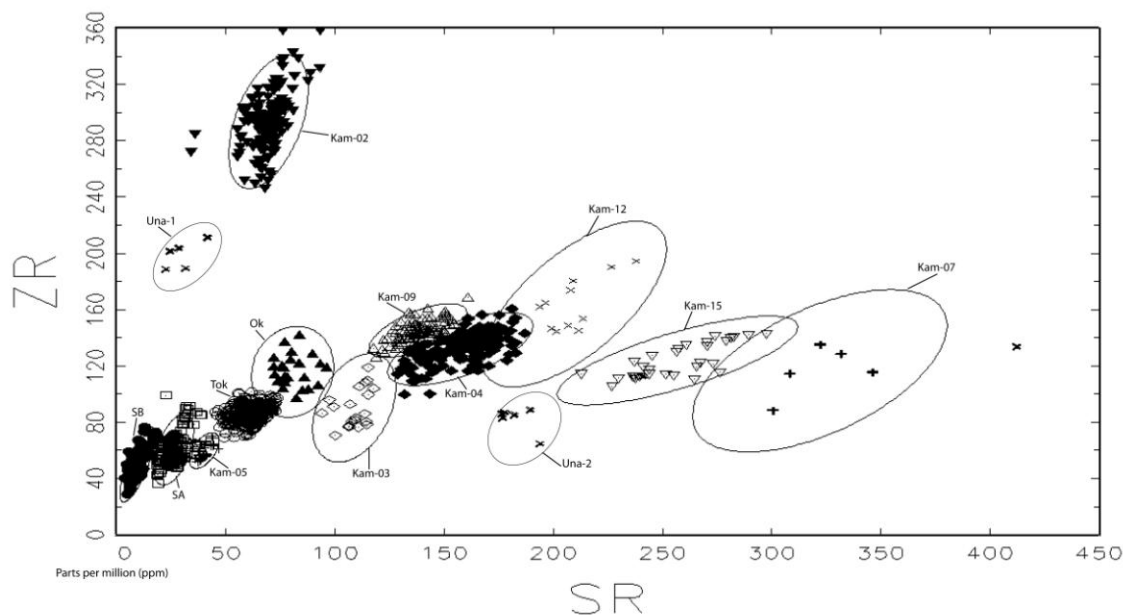


Figure 6.5: Strontium-Zirconium plot of obsidian flake trace element compositions (ppm) from the Kuril Islands. The ellipses surrounding each source group drawn at a 95% confidence level.

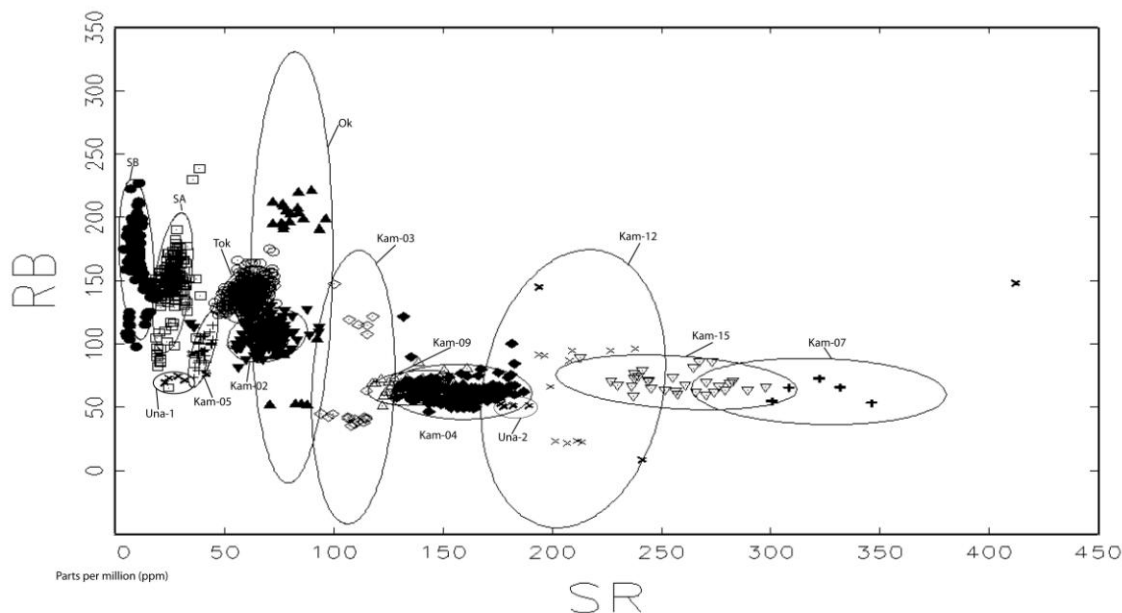


Figure 6.6: Strontium-Rubidium plot of obsidian flake trace element compositions (ppm) from the Kuril Islands. The ellipses surrounding each source group drawn at a 95% confidence level.

Obsidian flakes from the Kuril Island assemblage were matched with 13 different obsidian source groups. Four source groups from Hokkaido are represented, Shirataki-A (SA), Shirataki-B (SB), Oketo (Ok), and Tokachimitsumata (Tok). Nine source groups from Kamchatka are represented, Kam-02, Kam-03, Kam-04, Kam-05, Kam-07, Kam-09, and Kam-15. Eleven flakes could not be assigned to a previously characterized source group from either Hokkaido or Kamchatka, but plot into two groupings named “Unassigned 1” and “Unassigned 2”. Additionally, two small obsidian cobbles recovered from island surveys, one sample from Kunashir and one from Ketoi, were believed to represent samples of obsidian that naturally occurs in the Kuril Islands. These purported Kuril source samples, which appear to be low-quality perlite or pitchstone and are quite different visually from the rest of the obsidian artifact assemblage, were plotted but not matched to any other artifacts or Hokkaido or Kamchatka source groups.

In order to study potential changes in patterns of obsidian source distribution in the Kuril Islands through time, a sub-sample of chronologically defined obsidian flakes was selected. This sample (n=469) represents all of the obsidian flakes that come from archaeological sites with stratigraphic unit or level contexts that could be assigned to a specific chronological period (Phase III, IV, or V) through radiocarbon dating, ceramic

analysis, or both (Appendix VI.B). The overall distribution of obsidian artifacts from different sources across the Kuril Islands can be described based on several different variables, including by geography and chronological phase.

### **Overall Pattern of Obsidian Source Group Distribution**

Under a set of neutral assumptions about raw material availability and procurement, a neutral model would predict that obsidian from the closest sources will occur in the greatest quantities in a site compared to the most distant sources that will be represented in the smallest quantities (Brantingham 2003). This is an example of the distance-decay family of models that predicts the amount of a raw material present in an archaeological assemblage varies inversely with the distance from the source. Based on the results of initial pilot studies of Kuril obsidian assemblages, this relationship can be represented in a geography-based model for source group patterning that predicts Hokkaido sources to be most abundant in Southern island sites and Kamchatkan sources to be most abundant in Northern island sites.

The expectations for the Central island assemblages are less clear. The Central island sites in this study lie closer to Kamchatka than to Hokkaido, and the Bussol Strait which separates the Southern and Central islands may have acted as a significant barrier to the movement of people and materials. Two factors are important to consider here, one related to the colonization history of the island chain, and one to the linear geography of the Kuril archipelago. It is generally believed that initial migration into, and colonization of, the Kuril Islands happened in a unidirectional sequence, from south to north out of Hokkaido. For some period of time, likely early in Phase III, Hokkaido would have been the only known source of obsidian for Kuril colonists, until contact with human groups from Kamchatka and knowledge of Kamchatkan obsidian sources was established. In this case, the expectations of the neutral model may not be met, at least for some portion of the Phase III Central island occupation.

The Central islands are also a bridge between the southern and northern parts of the island chain, and any individuals or groups traversing the archipelago would have passed through the Central islands, potentially providing inhabitants of Central island sites with access to obsidian from more geographically distant sources. Thus the expectation for

Central site assemblages is that they should be more “mixed” than Southern or Northern assemblages in their composition of artifacts made from Hokkaido and Kamchatka source groups. Also, the amount of source mixing should increase through time, with initial Phase III assemblages in the Central Kurils having lower source diversity and a stronger connection to Hokkaido sources representing social network connections towards the south by the early colonists of the Central islands. By Phase IV, if relationships have been developed towards the north, Kamchatka sources may begin to make up more of the Central island obsidian assemblage in place of Hokkaido obsidian, and the Central island assemblage should have an overall higher level of source diversity. At this point, assemblage obsidian source composition would be more in line with neutral model expectations.

The flake assemblages constructed for obsidian source group analysis below are the obsidian subset of the aggregated assemblages used in the lithic analysis chapter, representing separate assemblages for the Southern, Central, and Northern islands in Phase III, and assemblages for the Central and Northern islands in Phase IV. The Central islands Phase III assemblage includes artifacts from Rasshua 1 site contexts that span 400 years in time, representing the aggregation of obsidian source procurement and use behavior. Similarly, the Phase III Northern islands assemblage is composed of obsidian flakes from the Savushkina 1 site dated to 1900 BP and the Drobnyye 1 site dated to the very end of Phase III at 1470 BP, and potentially represents an early Phase IV occupation. These issues will be further addressed later in the results analysis section of this chapter.

The assemblages were examined first to develop a general pattern of obsidian source group distribution across the island chain (Table 6.11). During Phase III, the obsidian assemblage for the Southern island sites is exclusively composed of Hokkaido source groups. The Tokachimisumata group is the most abundant making up over 68% (n=104) of the Hokkaido-sourced obsidian, followed by the Shirataki-A and Shirataki-B groups (18.4% n=28, and 11.2% n=17 respectively), and three flakes from the Oketo group.

The Central island site assemblage during Phase III includes eight different source groups, three Hokkaido groups and five Kamchatka groups. This assemblage is almost evenly split, with Hokkaido source groups making up 47.5% of the assemblage, Kamchatka

groups 52.5%. The Tokachimisumata group again makes up the majority of the Hokkaido obsidian flakes (73.7%, n=14).

The Northern island site assemblage is composed almost exclusively of Kamchatka source groups which represent 99.4% of the overall assemblage (n=150). Only a single flake from the Oketo source group is representative of Hokkaido obsidian. The Kamchatka-sourced obsidian is made up of three main groups, Kam-02 (34%, n=51), Kam-04 (33%, n=49), and Kam-09 (31%, n=46).

Sources	Southern Phase III		Central Phase III		Northern Phase III		Central Phase IV		Northern Phase IV		Total	
	n	%	n	%	n	%	n	%	n	%	n	%
SA	28	18.4	4	10.0			1	1.1			33	7.0
SB	17	11.2							1	2.5	18	3.8
Ok	3	2.0	1	2.5	1	0.7					5	1.1
Tok	104	68.4	14	35.0			2	2.3			120	25.6
Kam-02			2	5.0	51	34.0	33	37.9	26	65.0	112	23.9
Kam-03							4	4.6	1	2.5	5	1.1
Kam-04			2	5.0	49	32.7	8	9.2	9	22.5	68	14.5
Kam-05			1	2.5	2	1.3	9	10.3	2	5.0	14	3.0
Kam-07							3	3.4			3	0.6
Kam-09			10	25.0	46	30.7	8	9.2			64	13.6
Kam-15			6	15.0	1	0.7	15	17.2			22	4.7
Unx1									1	2.5	1	0.2
Unx2							4	4.6			4	0.9
Total	152	100.0	40	100.0	150	100.0	87	100.0	40	100.0	469	100.0

Table 6.11: Frequency distribution of obsidian source groups in Kuril Island obsidian flake assemblages.

The overall pattern of obsidian source distribution confirms that the Southern island site utilized obsidian raw material from Hokkaido, Northern sites almost exclusively from Kamchatka, and that the Central islands drew from both Hokkaido and Kamchatka source areas, either via direct access or through trade (Fig. 6.7). A chi-square comparison of the Southern, Central, and Northern island site assemblages from Phase III shows a statistically significant difference between the islands groups in terms of their regional source use ( $\chi^2 = 272.39$ ,  $p < .0001$ ,  $df = 2$ ); a review of the adjusted residuals confirms the direction of the distribution pattern (Table 6.12).

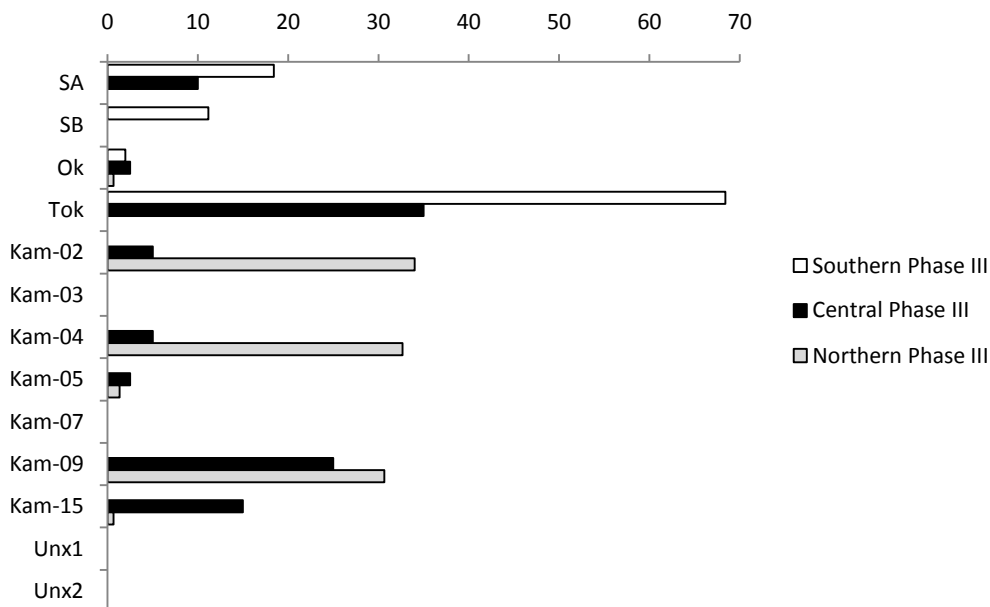


Fig. 6.7: Frequency distribution of obsidian sources during Phase III.

Island Group	Source Group	
	Hokkaido	Kamchatka
Southern	15.7325	-15.7325
Central	-0.3551	0.3551
Northern	-15.5362	15.5362

Table 6.12: Adjusted residuals for chi-square comparison of differences between Kuril Island obsidian assemblages from Phase III.

There are two obsidian flake assemblages to consider for Phase IV, one for the Central island sites and one for the Northern island sites. Over 91% (n=80) of the Central assemblage is made up of obsidian flakes from all seven Kamchatka source groups. Of these seven source groups, the Kam-02 group makes up 37.9% (n=33); the next most abundant Kamchatka source groups are Kam-15 (17.2%, n=15) and Kam-05 (10.3%, n=9). Just three flakes (3.5%) in the overall assemblage are made from two Hokkaido source groups, Shirataki-A (n=1) and Tokachimisumata (n=2). Four flakes of the total assemblage are currently grouped into the Unassigned 2 source group.

The Northern island site assemblage also is dominated by Kamchatka obsidian, with 95% (n=38) represented in four Kamchatka source groups and dominated by the Kam-02 source group which contributes 65% (n=26) of the flakes to the entire assemblage. Nine flakes from the Kam-04 group represent 22.5% of the assemblage. There is one flake each from the Hokkaido Shirataki-B and the Unassigned 1 group.

During Phase IV, both the Central and Northern sites are highly oriented toward using obsidian from Kamchatka source groups (Fig. 6.8). The Central assemblage has only a slightly more southern leaning but there is statistically no significant difference between Central and Northern island site use of Kamchatka versus Hokkaido obsidian ( $\chi^2=0.058$ ,  $df=1$ ,  $p=0.809$ ).

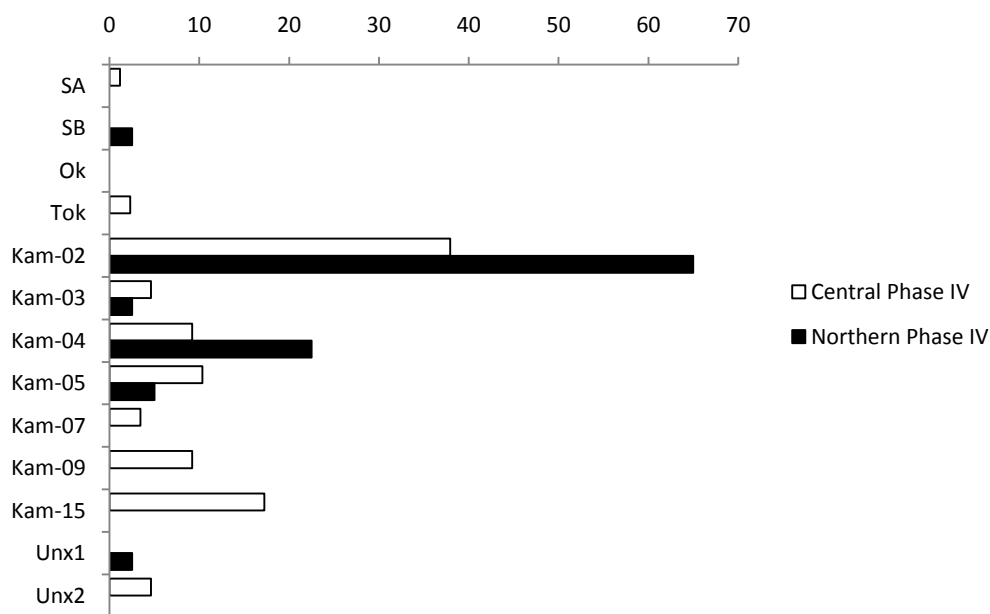


Fig. 6.8: Frequency distribution of obsidian sources during Phase IV.

What is significant is the change in the distribution of obsidian source groups present in the Central island site assemblages between Phase III and Phase IV ( $\chi^2 = 35.40$ ,  $p < .0001$ ,  $df = 1$ ; Table 6.13). Figure 6.9 shows that the Tokachimisumata source from Hokkaido is the single most abundant group during Phase III making up 35% of the

assemblage (n=14), while during Phase IV the Kam-02 group is the most abundant (37.9%, n=33).

Assemblage	Source Group	
	Hokkaido	Kamchatka
Central Phase III	5.9494	-5.9494
Central Phase IV	-5.9494	5.9494

Table 6.13: Chi-square adjusted residuals for Central island Phase III and Phase IV obsidian distribution.

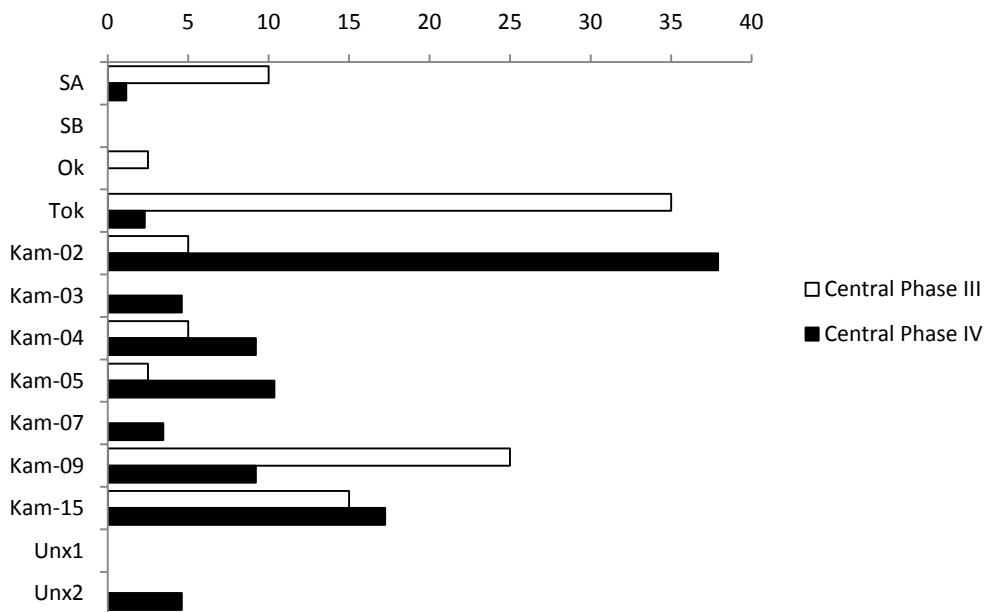


Fig. 6.9: Central island frequency distribution of obsidian sources during Phase III and Phase IV.

There is no difference between the Northern island site Phase III and Phase IV assemblages (Fig. 6.10) in their orientation towards using Kamchatkan as opposed to Hokkaido source groups ( $\chi^2=0.024$ ,  $df=1$ ,  $p=0.876$ ).

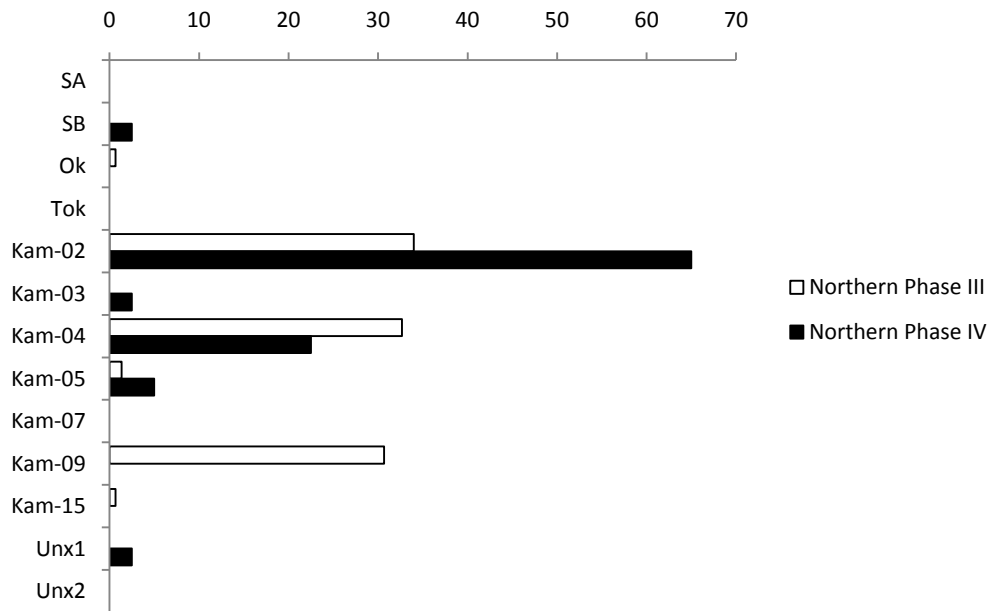


Fig. 6.10: Northern island frequency distribution of obsidian sources during Phase III and Phase IV.

A further review of these assemblages indicates there is a significant difference between Phase III and Phase IV in the selection of specific Hokkaido and Kamchatkan obsidian source groups. Table 6.14 is a table of the frequencies and rank orderings of all 13 obsidian source groups for each phase. These two ranks are not highly correlated (Spearman's  $\rho$ ,  $r_s = 0.24$ ,  $df = 11$ ,  $p = .214$ ), demonstrating that obsidian source selection in Phase III does not carry over into Phase IV.

Source	Phase III	Rank	Phase IV	Rank
SA	32	9	1	3
SB	17	8	1	3
Ok	5	6	0	1
Tok	118	13	2	5
Kam-02	53	11	59	13
Kam-03	0	2.5	5	8
Kam-04	51	10	17	12
Kam-05	3	5	11	10
Kam-07	0	2.5	3	6
Kam-09	56	12	8	9
Kam-15	7	7	15	11
Unx-1	0	2.5	1	3
Unx-2	0	2.5	4	7

Table 6.14: Rank order of overall obsidian source group frequency in Phase III and Phase IV.

The above results suggest that on the whole, the expectations of the geographic model for obsidian source distribution are met with Southern and Northern island sites primarily utilizing obsidian from sources that are geographically closest to them, and Central island sites accessing a mix of different obsidian source groups. But, this simple model does not provide any insight into the *specific* obsidian sources that were used or the *number* of different sources that were used (diversity). For the obsidian assemblages being considered here, based on macroscopic lithic analysis and an overall perception of material quality in terms of flakeability, all of the obsidian sources present in Kuril assemblages, whether from Hokkaido or Kamchatka source groups, are of equal quality (though this does not take into account any *perceived* differences in quality that Kuril stone tool makers may have attached to obsidian from different sources). The only samples with an obvious difference in quality are the Kunashir and Ketoi samples, which are not identified in the assemblage as artifacts based on macroscopic or geochemical analysis. Given that all the obsidian artifacts were manufactured from materials equal in quality, a null model would posit that each obsidian source group had an equal chance of being used, but clearly that was not the case in the Kurils. Thus, specific obsidian source usage should be based on other factors besides source quality.

## Obsidian Source Diversity Measurement and Results

There are two basic dimensions to measuring diversity, *richness* (the number of different groups or classes of artifacts, fauna, etc.) and *evenness* (the proportional distribution of individual samples across those groups or classes). As a diversity measure, the richness of an assemblage increases as the number of discreet classes or groups contained within the assemblage increases. Richness is a simple yet powerful indicator of archaeological variability, though it is inherently affected by the size of the sample assemblage and thus sample-size effects must be considered (Jones et al. 1989). Evenness (as measured by the Shannon evenness statistic) ranges from 0 to 1, where minimum evenness occurs when all individuals of an assemblage are represented in a single group, and maximum evenness when the individuals of an assemblage are represented in all groups in equal proportions.

There are also a number of diversity indices that attempt to capture both components of richness and evenness in a single measure (Browbowsky and Ball 1989; Rothschild 1989). The Simpson's D index measures the probability that two individuals randomly selected from a sample will belong to different groups; the greater the value of D, the greater the sample diversity. The Shannon H (or Shannon-Weaver) index is another measure of diversity that takes into account group richness and the proportion of each group in the assemblage; larger numbers indicate a greater amount of diversity in the assemblage. Because each of these diversity measures can be affected in different ways by sample size (see Browbowsky and Ball 1989 for a detailed account), all were included in this analysis to demonstrate consistency of results regardless of the specific measure used.

A comparison of diversity measures for each obsidian source group assemblage indicates that there is greater diversity among the Central island assemblages during both Phase III and Phase IV, and that obsidian source diversity in the Central islands increases from Phase III to Phase IV (Table 6.15). Compared to the Southern and the Northern island sites, Central island sites appear to be using a wider variety of obsidian sources from Hokkaido and Kamchatka, consistent with source diversity expectations outlined above. A rank order comparison of the number of flakes and the number of difference sources represented in an assemblage shows no correlation between sample size and richness

(Spearman's  $\rho r_s = -0.553$ ,  $df = 3$ ,  $p > .10$ ), indicating there is no sample-size effect acting on these data.

Assemblage	n	R	Shannon E	Simpson's D	Shannon H
Southern Phase III	152	4	0.645	0.488	0.894
Central Phase III	40	8	0.824	0.796	1.713
Northern Phase III	150	6	0.680	0.688	1.219
Central Phase IV	87	10	0.817	0.802	1.882
Northern Phase IV	40	6	0.582	0.536	1.042

Table 6.15: Diversity values for geo-chronographic obsidian assemblages.

A common problem that is encountered when comparing assemblage diversity measures is determining if one assemblage is significantly more or less diverse than another assemblage. This is made more complex when the assemblages are of different sample sizes (Kintigh 1984). Kintigh's (1984, 1989) model of creating simulated assemblages provides a way to compare measured diversity values with the expected diversity values for each assemblage given its specific sample size.

This model is built on the assumption that for a given set of artifacts, there is a culturally determined pattern of artifact distribution across a set of defined classes (typological, compositional, etc.). The simulated assemblages are constructed by selecting individual specimens at random and placing them into the defined classes based on the probabilities observed in the underlying culturally derived assemblage. The model is applied by creating a large number of simulated assemblages for each of the different empirical assemblages being considered based on their different sample sizes, using the probabilities given by the original aggregated artifact assemblage frequency distribution. The outcome is a distribution that can be described graphically and with summary statistics, which provides a way for the diversity measures of different assemblages to be compared relative to each other taking sample size into account (Kintigh 1984, 1989).

In the present study, this model was implemented using the R statistical programming language. For the Phase III assemblages, an underlying frequency distribution of obsidian flakes across the thirteen sources present was taken as the distribution of obsidian source groups in the three island group assemblages (Southern, Central, and

Northern) combined. For the Phase IV assemblages, the same type of distribution was created for the two island group assemblages (Central and Northern) combined. A number of simulated assemblages (n=1000) were then generated using re-sampling with replacement for each of the different island group assemblage sample sizes. This created a simulated frequency distribution of expected diversity values for each assemblage given the sample size of the specific assemblage. A results table showing the mean, standard deviation, and 95% confidence interval values as well as plots of the distributions for each of the diversity measures was generated for each assemblage simulation (Table 6.16, Figures 6.11-6.18).

		Measured Values		Simulated Values	
<b>Southern/Phase III</b>		mean	sd	2.5% and 97.5% CI	
Richness R	4	8.613	0.555	7	9
Shannon E	0.645	0.822	0.028	0.766	0.878
Simpson's D	0.488	0.792	0.017	0.754	0.821
Shannon H	0.894	1.767	0.061	1.640	1.873
<b>Central/Phase III</b>		mean	sd	2.5% and 97.5% CI	
Richness R	8	7.146	0.912	6	9
Shannon E	0.824	0.861	0.047	0.758	0.948
Simpson's D	0.796	0.776	0.036	0.688	0.831
Shannon H	1.713	1.684	0.121	1.437	1.898
<b>Northern/Phase III</b>		mean	sd	2.5% and 97.5% CI	
Richness R	6	8.580	0.583	7	9
Shannon E	0.680	0.823	0.029	0.769	0.885
Simpson's D	0.683	0.792	0.018	0.753	0.825
Shannon H	1.219	1.766	0.062	1.644	1.888
<b>Central/Phase IV</b>		mean	sd	2.5% and 97.5% CI	
Richness R	10	10.039	1.066	8	12
Shannon E	0.817	0.740	0.042	0.653	0.820
Simpson's D	0.802	0.729	0.039	0.643	0.798
Shannon H	1.882	1.703	0.115	1.481	1.911
<b>Northern/Phase IV</b>		mean	sd	2.5% and 97.5% CI	
Richness R	6	8.295	1.162	6	10
Shannon E	0.582	0.772	0.059	0.648	0.873
Simpson's D	0.536	0.720	0.060	0.583	0.813
Shannon H	1.042	1.626	0.172	1.276	1.941

Table 6.16: Diversity values for simulated obsidian assemblages.

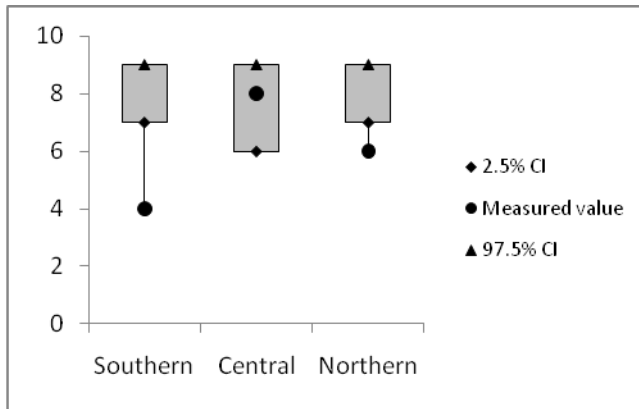


Figure 6.11: Plot of richness values for Phase III assemblages.

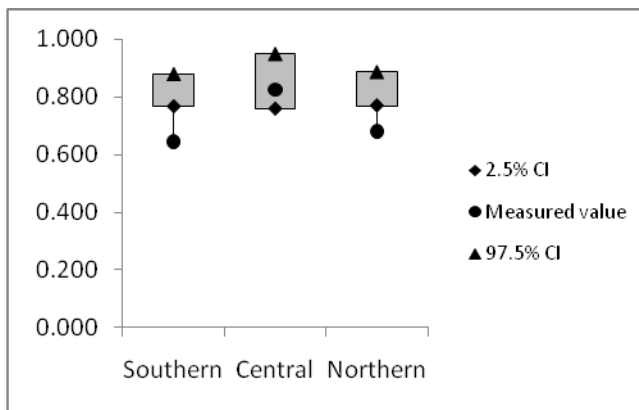


Figure 6.12: Plot of Shannon E values for Phase III assemblages.

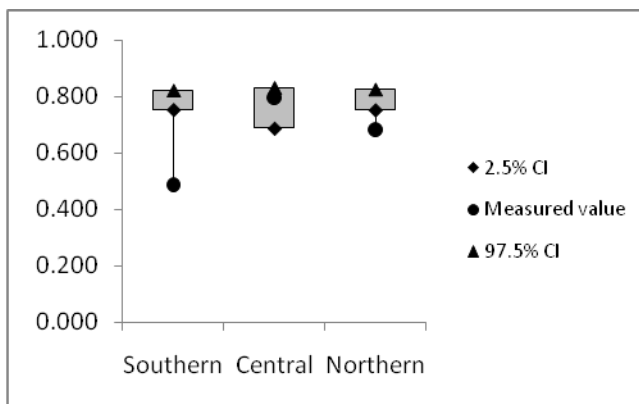


Figure 6.13: Plot of Simpson's D values for Phase III assemblages.

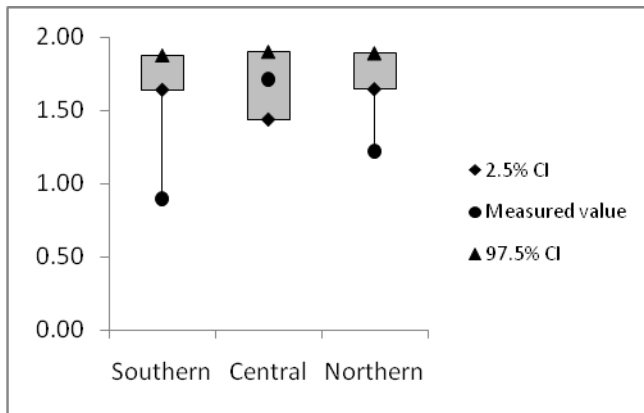


Figure 6.14: Plot of Shannon H values for Phase III assemblages.

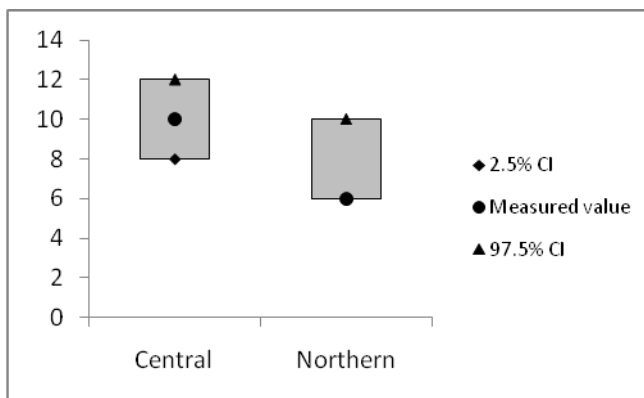


Figure 6.15: Plot of richness values for Phase IV assemblages.

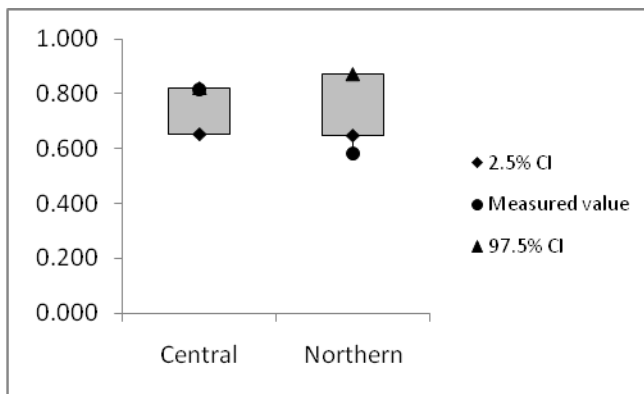


Figure 6.16: Plot of Shannon E values for Phase IV assemblages.

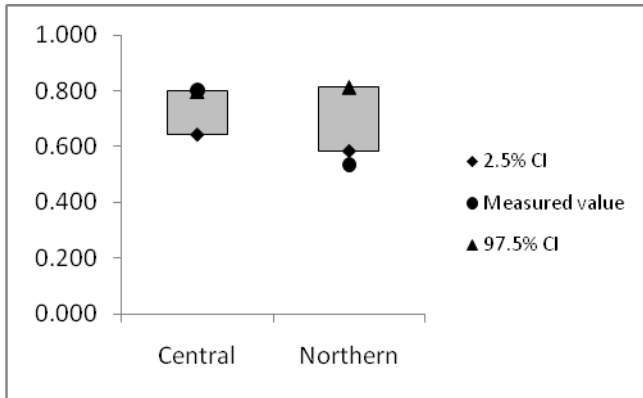


Figure 6.17: Plot of Simpson's D values for Phase IV assemblages.

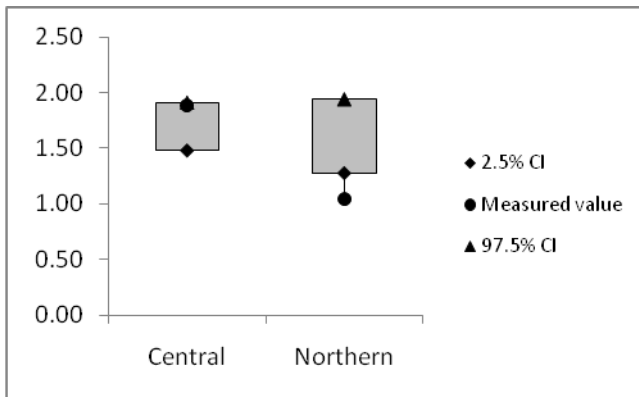


Figure 6.18: Plot of Shannon H values for Phase IV assemblages.

When the measured diversity values of each assemblage are compared to the expected diversity values of the simulated assemblages, the results indicate that during Phase III the Central island site assemblage falls within the expectations for obsidian source group diversity given the size of the assemblage, while the Southern and Northern island site obsidian assemblages are less diverse than expected (Table 6.16, Figs. 6.6.11 – 6.14). Figure 6.11 depicts this graphically with box plots that represent the boundaries of the 2.5% and 97.5% confidence interval of the distribution and showing where the measured value for source group richness falls in relation to the simulated values. The low diversity value of the Southern island site assemblage is likely being driven by the fact that of the four source groups represented in the assemblage, the Tokachimisumata source makes up almost 70% (n=104) of all obsidian flakes in the Southern island sites. Six sources are present in

the Northern assemblage but three of them – Kam-02, Kam-04, and Kam-09 – account for more than 97% of all obsidian flakes.

During Phase IV, the Central island site assemblage again falls within the expectations for obsidian source group diversity, while the Northern assemblage is right at or below the lower limit given by the simulated diversity measures (Table 6.16, Figs. 6.15 - 6.18). In the Northern islands sites, two sources – Kam-02 and Kam-04 – make up 87.5% of the obsidian flake assemblage.

### **Discussion and Conclusions**

Based on the distribution of obsidian source groups in Kuril assemblages and the measures of assemblage source group diversity, it is possible to develop scenarios that might explain the obsidian artifact portion of the Kuril Island archaeological record. During Phase III, the expectations for obsidian source group diversity based on distance appear to be met for the Southern assemblage. The Southern islands sites are geographically closer to the Hokkaido obsidian source areas, but are still located anywhere from tens to several hundred kilometers from the actual volcanic sources of obsidian in Hokkaido. Southern sites would have maintained a strong affinity to Hokkaido sources with procurement access embedded within the regional networks that extended from Hokkaido into the southern Kurils.

At the opposite end of the island chain, the Northern site assemblages also demonstrate the use of obsidian primarily obtained from the adjacent geographic source region in Kamchatka. During both Phase III and Phase IV, southern-oriented connections to Hokkaido obsidian were very weak, evidenced by only a few flakes from Hokkaido source groups in Northern islands assemblages. The source group diversity present in the Northern assemblages is based on the use of a variety of Kamchatka source groups. Similar to Southern island sites, Northern sites are located hundreds of kilometers from the actual obsidian quarries on Kamchatka, necessitating long-distance transport of obsidian across the Kamchatka peninsula and then through the Northern islands. Interestingly, even though overall source group richness is the same in the Northern assemblage during Phase III and Phase IV (six sources) the evenness of the Phase IV assemblage is lower, with most of the Kamchatka obsidian represented by two sources (Kam-02 and Kam-04) compared to three

(Kam-02, Kam-04, and Kam-09) in Phase III. The Kam-09 source drops out of the Northern assemblage altogether during Phase IV, potentially indicating some loss of access to this source group. Hokkaido obsidian was likely obtained through relationships with specialists or travelers moving independently through the Kuril chain, though the Phase III period presence of obsidian from the Oketo source may represent Hokkaido obsidian that was brought northward during an early migration or colonizing event.

The changes in Northern island site obsidian source use from Phase III to Phase IV are subtle compared to the shifts observed in the Central islands across the two time periods. For the Central islands sites Phase III assemblage, the expectation was that there should be low obsidian source group diversity representative of early colonizing groups bringing obsidian from a few sources with them to the newly occupied Central Kurils, and which would be primarily Hokkaido source groups. However, it appears that connections or travel to Kamchatkan obsidian sources were already in place by Phase III in the Central Kurils, suggesting a more rapid and wide-spread migration by the early occupiers of the Kuril Islands. Eight different obsidian source groups are represented in the Phase III assemblage, three Hokkaido and five Kamchatka groups. This gives the Central assemblage higher diversity relative to the Southern and Northern assemblages, the distribution of obsidian flakes between Hokkaido and Kamchatka sources is almost perfectly even with 47.5% of the flakes made from Hokkaido obsidian and 52.5% made from Kamchatka obsidian. As mentioned earlier, this would seem to support the null prediction of a mix (in this case an almost perfect mix) of Hokkaido and Kamchatka sources in the Central islands based on the linear south-north geographic orientation of the Kuril archipelago.

However, this explanation would require a set of “all else being equal” assumptions about the direction of human migration into the Kuril Islands, the motivation for the movement of people and obsidian through the chain, and ease of movement through the archipelago across physical or geographical barriers. Based on radiocarbon chronologies and ceramic typologies discussed in Chapter 4, it is currently believed that the movement of people into the Kuril Islands was initially directed from Hokkaido northward, first into the Southern islands as early as 7000 BP, and then into the Central and Northern islands. There is no current evidence for large human migrations from Kamchatka southward, though it is likely that residents of the southern Kamchatka peninsula traveled to and perhaps occupied

some of the northern islands such as Paramushir and Shumshu at least seasonally. Anecdotally, a large obsidian biface of a morphology not found anywhere else in the Kuril Islands was found on northern Paramushir Island, and may represent a type of artifact common to southern Kamchatka.

In the Central Kurils, long distances to obsidian source areas and the dominance of Late stage debitage argues for indirect procurement of heavily reduced obsidian tools though trade or exchange relationship. In Phase III, these relationships were still strongly oriented to the south and Hokkaido sources. As mentioned earlier, the very small obsidian sample from the earliest context at the Rasshua 1 site is represented by Hokkaido sources exclusively, 80% of which is assigned to the Tokachimisumata source group. During Phase III, the Tokachimisumata source group makes up 68.5% of the Southern island site assemblage, and 73% of the Hokkaido obsidian in the Central site assemblage. The Tokachimisumata source has a strong representation in Southern and Central Kurils, and may represent a strong legacy relationship based on cultural continuity that persisted in the Central islands into Phase III. Given the relative geographic isolation of the Central Kurils and the lower level of resource predictability, maintaining strong relationships to Hokkaido and/or the Southern Kurils may have been important for Epi-Jomon groups that were still in the process of adapting to a new and different environment in the central islands. Hokkaido obsidian could also have been “re-supplied” to sites in the central part of the island chain by new groups that passed through the Central Kurils in a continued expansion northward.

At the same time, new relationships were being developed to the north and access to Kamchatka obsidian was achieved during Phase III. It has been argued that this represents a need to reduce the risks and/or costs of obtaining Hokkaido obsidian across the Bussol Strait (Phillips and Speakman 2009). While this conclusion makes some sense in terms of optimality models, it is harder to evaluate with the current data set given that Hokkaido sources make up a significant portion of the obsidian assemblage. Obsidian from Kamchatka may have been obtained from specialized traders or individuals moving southward, who either originated from Kamchatka, or were making a return trip to the south after having visited the Northern Kurils or Kamchatka. Alternatively, this level of source diversity in terms of the mixture of Hokkaido and Kamchatkan obsidian source groups may be a result of the span of time – over 400 years – that the Central islands sites Phase III

assemblage represents. Thus, specific obsidian source access and use signals in the early part of Phase III may be obscured by the later inclusion of Kamchatkan sources.

By Phase IV, the composition of the Central island site obsidian assemblage had changed markedly, indicating a shift in the orientation of obsidian procurement networks, and potentially a break in the cultural continuity that may have existed for over two thousand years. As in the Phase III assemblage, the Phase IV assemblage has high obsidian source group diversity and an even higher richness, with ten different sources present. However, the diversity of the two assemblages is quite different in the specific sources that are represented. The Phase IV assemblage is dominated by obsidian from Kamchatka sources, which make up 92% of the obsidian flakes and is composed primarily of just two of the eight Kamchatka source groups, Kam-02 and Kam-04. Additionally, the change in source use comes at a time of increased access to and use of nonlocal obsidian overall in the Central islands, as noted in Chapter 5, as well as the less intensive level of lithic reduction of obsidian material, as evidenced by the increase in obsidian flake size and presence of Middle reduction stage debitage in Phase IV. These data do not support a null geographic model expectation of a more or less even mix of obsidian source groups from Hokkaido and Kamchatka present in the Central islands during Phase IV. Nor do they support a distance decay model that predicts obsidian artifacts should become smaller as the distance from the obsidian source and the site increases.

Echoing the conclusions of population replacement and culture change based on the lithic analysis of Chapter 5, the obsidian data supports an interpretation of the occupation of the Central Kurils by a group of people with decidedly different access to nonlocal obsidian in Phase IV. Given their relative marginalization in Hokkaido by Satsumon groups which may have prevented them from settling in the interior of the island, Okhotsk groups entering the Central Kurils would have had less concern for maintaining a network of relationships tethered to Hokkaido. Thus, once established in the Central and Northern Kurils, they were more inclined to develop relationships for the procurement of Kamchatkan obsidian. Their social relationships may have been more opportunistic rather than legacy-oriented, allowing them to obtain obsidian from multiple trading partners, as evidenced by the highest source richness of any assemblage.

Overall, the obsidian assemblage analysis provides a closer look at a narrow but important aspect of lithic technological organization in the Kuril Islands. While obsidian makes up only a small portion of the overall Kuril lithic assemblage, the nature and meaning of its presence provides an inordinate amount of information about the history of human migration and occupation in the Kuril Islands, and the structure of human interactions across the island chain. The procurement of nonlocal resources over long distances is inherently linked to social relationships through trade and exchange activities. Thus, the obsidian raw material present in Kuril Island assemblages provides an empirical basis for reconstructing past social networks that allow for a different level of analysis of human interaction across the island chain. This idea is explored in the next chapter through the use of social network analysis concepts and methods.

## Chapter 7: Social Network Analysis of Kuril Island Obsidian

### Introduction

Personal relationships provide humans with the ability to share information, ideas, and resources, whether it is informally with a next-door neighbor, or professionally with colleagues on the other side of the globe. Establishing and maintaining inter- as well as intra-group social ties is one way that hunter-gatherer groups have adapted to living in the face of environmental unpredictability where assistance or outside resources may be required (Alexander 2000; Binford 2006; Grattan 2006; Hofman et al 2007; Kirch 1988; Reycraft and Bawden 2000; Sheets and Grayson 1979; Torrence 1999, 2002; Whallon 1989, 2006; Wiessner 1982). Such networks then should be a prerequisite for colonizing and maintaining a long-term presence in insular and unpredictable environments, enabling a form of adaptive flexibility to deal with events that cause environmental and/or social uncertainties (Fitzhugh 2004; Kirch 1988). However, network participation may also place constraints on individuals or groups in the form of social obligations that must be honored and maintained. The concept of exchange among hunter-gatherers is interesting not only as an optimal behavioral strategy for procuring material resources, but also because participation in exchange relationships can be linked to more anthropological issues of human interaction such as cultural transmission and integration over long distances. This chapter will explore the nature of Kuril Island social networks based on the distribution of obsidian sources across the island chain as an additional form of analysis of the past relationships that Kuril Island occupants may have maintained as part of their adaptive strategy for island colonization and occupation.

### Social Network Analysis

Lithic artifact assemblages represent the proximal results of raw material procurement and exchange behavior, and provide a basis for conceptualizing the structure of exchange-based social relationships. In many cases, archaeological networks are constructed “by eye” and are inferred superficially from lines drawn on maps that connect archaeological sites. This is especially true of provenance studies that trace artifacts and/or their raw materials to their locations of manufacture or natural sources (e.g. Kuzmin 1996).

While some basic relationships may be fairly obvious, there may or may not also exist latent structure and form in the data which more rigorous methods of relationship analysis might reveal (Shennan 1997).

Social network analysis (SNA) is a systematic approach that utilizes empirical data sets, mathematical and statistical models, and visualization to explore network structure and the effects of that structure on participants in a network (Freeman 2004; Mizruchi and Marquis 2006). Social network analysis focuses on *actors* and their social *ties*: actors are defined as network nodes representing individuals, communities, corporations, nations, etc. which are linked by network ties based on communication, economic transactions, kinship, etc. (Thompson 2003). Where conventional analysis of social science data compares actors based on their attributes, SNA compares actors based on their relationships (Hanneman and Riddle 2005). The SNA perspective views actors and their behavior as interdependent, with ties between actors acting as channels for the flow of resources (material and immaterial). Network ties both enable and constrain actor behavior, and network structure is seen as the “enduring pattern of actor relationships” (Freeman 2004). At the heart of SNA is *graph theory*, the use of graphs to display and model the formal properties of social networks.

Important to SNA is the idea that a network is not a metaphor for human interaction, it is a precise mathematical construct that is used to represent, analyze, and model those interactions which for this study, are viewed as relevant to the ability of hunter-gatherer groups to survive and thrive in the Kuril Islands. Analytically, this technique provides a tool for measuring the characteristics of regional systems quantitatively, and in turn, for objectively comparing systems with one another. Because networks are dynamic, and the types of interactions that produced network ties may shift over time, it is necessary to incorporate a diachronic element to the analysis and compare network structures as they changed through time (Nietzel 2000). Additionally, SNA provides a way to superimpose a measure of non-Cartesian social geography represented by human relationships on top of cartographic space to make comparisons between geographic and social space (Mackie 2001; Thomas 2001).

### *Structuralist and Individualistic Approaches to SNA*

SNA approaches the study of networks from both the structuralist and the individualistic perspectives. The structuralist perspective focuses on the description and analysis of the larger network and all of its components, including the actors, their ties, and the patterns of the relationships that are present in the network. The structuralist perspective ignores the agency of individual actors and is concerned with elucidating the structures of relationships within which the actors and their actions are embedded (Kilduff and Tsai 2003).

The most basic structural property measurement of a network is graph *density*. Density is a measure of the number of connections between actors in a network given the total number of possible connections. An analogy to graph density is that of a piece of woven fabric; the density represents how tightly the fibers are woven together. If all possible network connections are present in a network, it is described as a complete graph; conversely if no connections are present, it is an empty graph. Another network structural property focuses on the presence of *triads*, or ties between three actors, in the network. Connections between three actors are different from connections between two actors in that triads are a bridge from local to global structure. The measurement of triads is related to the analysis of balance in a network and transitivity between actors – if actor A is connected to actor B and actor C, actors B and C are also likely to be connected. If actors B and C are not connected, actor A may broker transactions between actors B and C and may derive power from this position. Structural balance theory proposes that connections between all three members of a triad can lead to greater interpersonal trust, cooperation, and enforcement of social norms (Kitts and Huang 2010; Simmel 1950).

The individual perspective focuses on measuring the role and position of individual actors in a network. The actor may be an individual person, or an aggregation of individuals in some corporate organization; in either case, the methods and techniques of network analysis are applied in the same way. Social network studies assume that basic network principles, such as homophily, apply equally to individual people and entire organizations.

Actor-level indices (also called node-level indices) measure the properties of an actors' position in the network as a way to describe the variability of the actors. Actor

*centrality* measures are the most prominent node-level indices. Actors that are measured as being more “central” in one way or another are perceived to have differential access to information or resources, and may have differential control over the flow of those resources through the network and between other actors (Freeman et al. 1991; Hanneman and Riddle 2005). There are several different types of centrality measures. *Degree* centrality measures the number of ties that an individual actor has to other actors, and is a measure of the actor’s level of participation in the network. *Betweenness* centrality is a measure of the actor’s position between third party actors, and is related to an actor potentially being a bridge between two subgroups of actors and participating as a broker of information or resources between groups of actors. *Closeness* centrality measures how close an actor is to other actors and is measured by the shortest path distance between actors. *Eigenvector* centrality summarizes the other measures of individual centrality and reflects an actor’s overall position within the network; higher scores are indicative of a more central position (Mizoguchi 2009). Social network theory assumes that the structure of a network impacts the behavior of its actors, and centrality measures provide a key metric for identifying and quantifying the most important actors in a network based on their position and distance to other actors (Mizruchi and Marquis 2006; Wasserman and Faust 1994).

### **Applying SNA to Archaeological Cases**

At its core, SNA a collection of analytical methods for studying relationships, and does not yet have a substantive body of theory aimed at delineating specific approaches for networks of individuals versus organizations. This is a weakness for archaeologists working at a level in between these perspectives of network analysis – we often want to understand the actions of individuals (or small groups of individuals) at specific points in time, but we can only analyze the remnant network structures that are reconstructed from aggregated materials that have lost their personal identity in the archaeological record. For archaeologists, the concept of the site provides a boundary definition for a unit of analysis pertaining to a specific portion of the archaeological record. Sites are useful because they are real-world locations and represent places of comparative interest in a network context (Hunt 1991), and several archaeologists utilizing SNA techniques have relied on the site as the network analytical unit. In his study of the development of hierarchies in early Japanese

state formation, Mizoguchi (2009) analyzed network relationships between sites from two different culture-historical periods representing three hundred years of time. Knappett et al. (2008) modeled regional connections in a single network of sites in the Aegean Sea during the Middle Bronze Age (ca. 2000-1600 BC); similarly Hunt (1991) used Lapita archaeological sites to model Lapita Cultural Complex exchange networks.

However, using sites for analysis and comparison often requires creating aggregated artifact assemblages that represent the actions of multiple individuals over long periods of time. Social network analysis is a way to extract and visualize evident relationships in the underlying artifact data (Terrell 2010), and the accuracy of those relationships is directly based on the fidelity of the assemblages that were used to constitute the network in the first place. Network models based on aggregated assemblages are oversimplified, and mask specific relationships that may have existed among individual people. They also collapse changes in network structure over time, essentially removing the dynamic nature of human relationships and making the network a static entity for the purpose of analysis.

Efforts to minimize distortions or oversimplifications of the network can be made by trying to segment assemblages to the smallest site and chronological units possible. This requires strict control over site and assemblage chronologies, and also requires a significant number of artifacts in each of the segmented assemblages to enable statistically valid comparisons.

The focus of the current network study is to model the generalized connections that may have existed in two chronological phases between sites located in the main geographic groupings of islands (Southern, Central, and Northern) based on their access to nonlocal obsidian. To that end, site assemblages were constructed by aggregating obsidian flakes from multiple excavation units and levels within each broad chronological phase (Phase III and Phase IV). This was necessary due to the small number of obsidian flakes found in any single dated excavation context. It is acknowledged that these aggregated assemblages represent the deposition of obsidian flakes into the site by multiple individuals and different points in time during each phase. Phase III represents site assemblage contexts that span roughly 900 years, though the largest span of time in any one site is 500 years, and with several sites that have multiple assemblages from coexistent contexts; Phase IV assemblages span about 350 years. It is assumed that the primary factors that influenced

obsidian access at each island site, such as geographic location and distance to sources, and the social conditions that facilitated or retarded exchange relationships, affected each individual in a given site more or less equally; this may be a more tenuous assumption for Phase III with its longer spread of time. The patterns of obsidian distribution, and by extension the network ties that are modeled, are representative of the overall pattern of relationships during the particular phase, even though it must be kept in mind that specific deviations from the overall pattern were possible (and probable). While those deviations may be inherently interesting, it is not possible to detect explore them further with the current data.

### **Network Construction and Description**

There are several qualitative and quantitative approaches to developing a proposed network structure. One way to analyze the relationships between actors in a network is through affiliation networks. Affiliation networks contain two sets of nodes, actors (individuals, corporations, countries) in one set, and affiliations (country clubs, industry trade groups, international alliances) in another set. An important idea behind affiliation networks is that actors are brought together through a joint affiliation which increases the chance the actors will have a social relationship (Wasserman and Faust 1994). This is based on the concept of *homophily*, where actors form ties to other actors who are similar to them in some way (also known as “birds of a feather flock together”), though the similarity may be in the form of some unobserved characteristic. Overlap in actors’ affiliations may also allow for the flow of information or materials between groups of actors (Wasserman and Faust 1994). For this study, specific obsidian source groups represent entities that people living in various Kuril Island sites could have affiliations with through their procurement and use of obsidian raw material from those sources. People using the same obsidian sources may have participated in the same obsidian procurement networks, increasing the chances that there were social relationships between them. Affiliation networks are constructed from an affiliation network matrix and depicted in a special type of graph called a bipartite graph. As an example, Table 7.1 is an affiliation network matrix of corporate CEOs who belong to a set of different country clubs; a “1” in the matrix represents membership in the club, a “0” represents no membership.

CEOs	Country Clubs		
	A	B	C
1	1	0	0
2	0	0	1
3	1	1	0
4	0	1	0

Table 7.1: A basic affiliation network matrix.

This network matrix and the relationships that are present in it are represented in the bipartite graph in Figure 7.1 which matches the CEOs with their memberships in the country clubs.

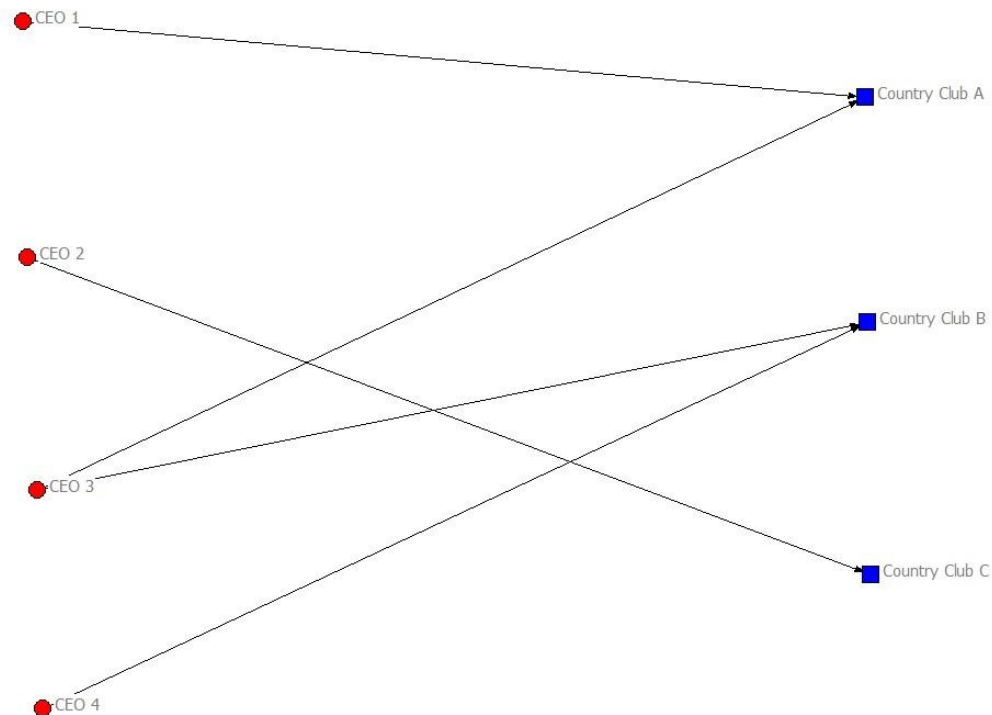


Fig. 7.1: A bipartite graph based on an affiliation network matrix.

In this example, CEO #1 and CEO #3 are both members of country club A; they may have a relationship and can be considered a subgroup of the overall group of CEOs.

Similarly, CEO #3 and CEO #4 are members of country club B, and may have a relationship and also are considered a subgroup. Because CEO #3 is a member of two different subgroups, he or she may facilitate the flow of information or materials between the two subgroups. CEO #2 in this network is considered an isolate, because he or she has no relationships with any other CEOs based on country club membership (Fig. 7.2).

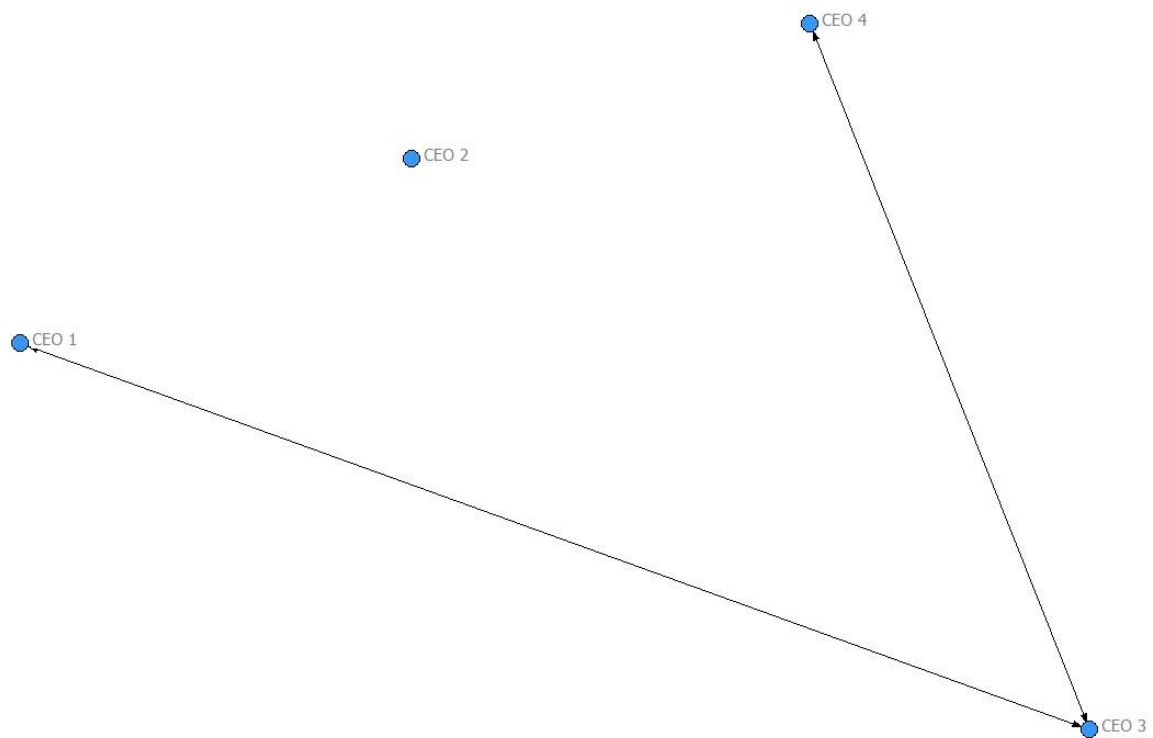


Fig. 7.2: A network graph based on an affiliation network matrix.

### **Kuril Island Networks**

Using obsidian source data, an affiliation network matrix can be created for the archaeological sites used in this study. Table 7.2 is a binary matrix of sites and obsidian sources during Phase III, and Figure 7.3 is the resulting bipartite graph; Table 7.3 and Figure 7.4 are the matrix and bipartite graph for Phase IV.

	SA	SB	Ok	Tok	K2	K3	K4	K5	K7	K9	K15	U1	U2
Ainu Creek	1	1	1	1	0	0	0	0	0	0	0	0	0
Vodopodnaya 2	1	0	1	1	1	0	0	1	0	1	1	0	0
Rasshua 1	1	0	0	1	1	0	1	0	0	1	0	0	0
Drobnyye 1	0	0	0	0	1	0	1	1	0	1	1	0	0
Savushkina 1	0	0	1	0	1	0	1	0	0	1	0	0	0

Table 7.2: A Phase III affiliation network matrix.

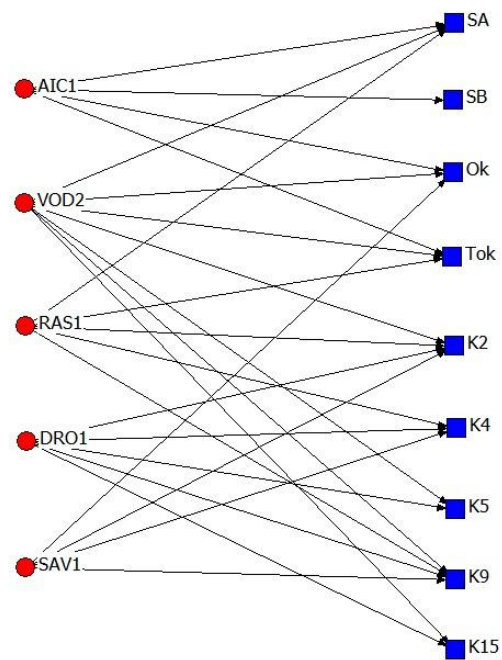


Fig. 7.3: A bipartite graph based on Phase III affiliation network matrix.

	SA	SB	Tok	K2	K3	K4	K5	K7	K9	K15	U1	U2
Vodopodnaya 2	1	0	1	1	1	1	1	1	1	1	0	1
Drobnyye 1	0	1	0	1	0	1	1	0	0	0	0	0
Ekarma 1	0	0	0	1	1	1	1	0	0	0	1	0

Table 7.3: A Phase IV affiliation network matrix.

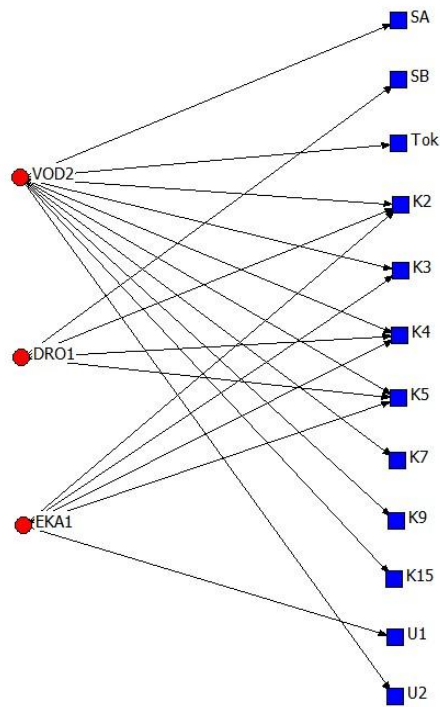


Fig. 7.4: A bipartite graph based on Phase III affiliation network matrix.

Based on the number of lines connecting sites to obsidian sources in these bipartite graphs, it is easy to see the inherent complexity in trying determine social ties between even a small number of sites. While the creation of affiliation networks is a first step in determining where ties between sites may exist, the application of additional analytical methods is necessary in order to propose the structure of the social network. The affiliation network would predict that Kuril sites that share the same obsidian sources are more likely

to share a social relationship, and that the network structure should be based on these relationships. Correspondence analysis provides one method for placing actors in spatial arrangement in order to view potential relationships between them (Wasserman and Faust 1994), and for analyzing the relationships between actors and their affiliations at the same time (Shennan 1997). Correspondence analysis is an exploratory technique for data analysis designed to analyze simple two-way and multi-way tables and determine some measure of association between row and column variables. An important feature of correspondence analysis is the ability to represent the row and column points in biplots. Points that are similar will be located close together on the plot, points that are dissimilar will be positioned far apart (Clausen 1998). It is also well suited for working with binary data sets such as the matrices constructed based the Kuril Island obsidian source assemblages (Tables 7.2 and 7.3).

Figure 7.5 is a plot of the correspondence analysis scores for the archaeological sites and obsidian sources of Phase III based on the affiliation network matrix (Table 7.2). Expectedly, the southern sites tend to be located with the Hokkaido obsidian source groups, while the central and northern sites are located with the Kamchatka source groups. In terms of locating sites together that may be indicative of a network relationship, it may be proposed that the Rasshua 1 (RAS1) and Savushkina 1 (SAV1) have a tie, Vodopodnaya 2 (VOD2) and Drobnyee 1 (DRO1) have a tie, and Vodopodnaya 2 (VOD2) and Rasshua 1 (RAS1) also have a tie.

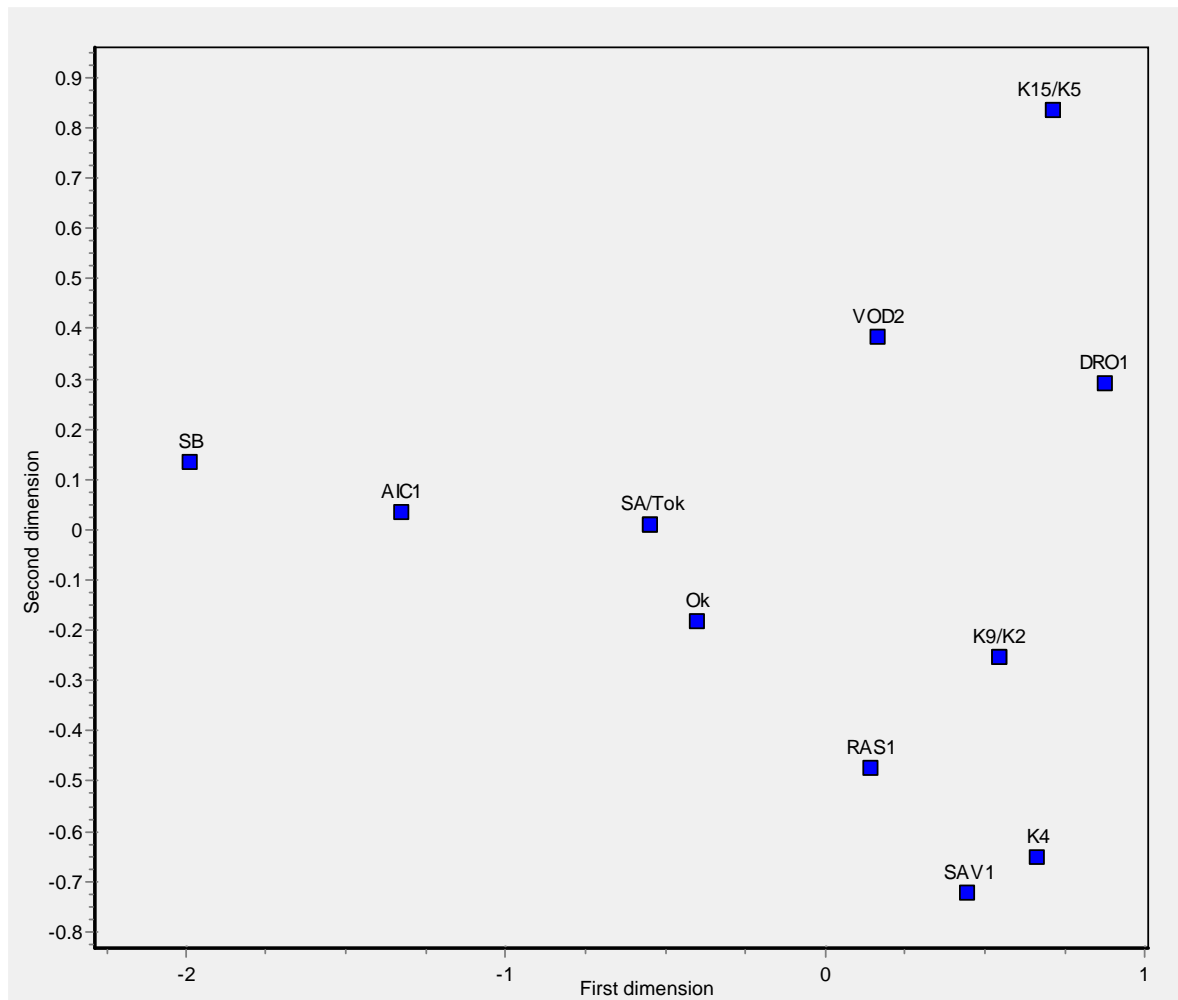


Fig. 7.5: A correspondence analysis plot of the Phase III affiliation matrix.

For Phase IV, the correspondence analysis plot (Fig. 7.6) contains only three sites and is less informative, but indicates that the Drobynee 1 (DRO1) and Ekarma 1 (EKA1) have a tie.

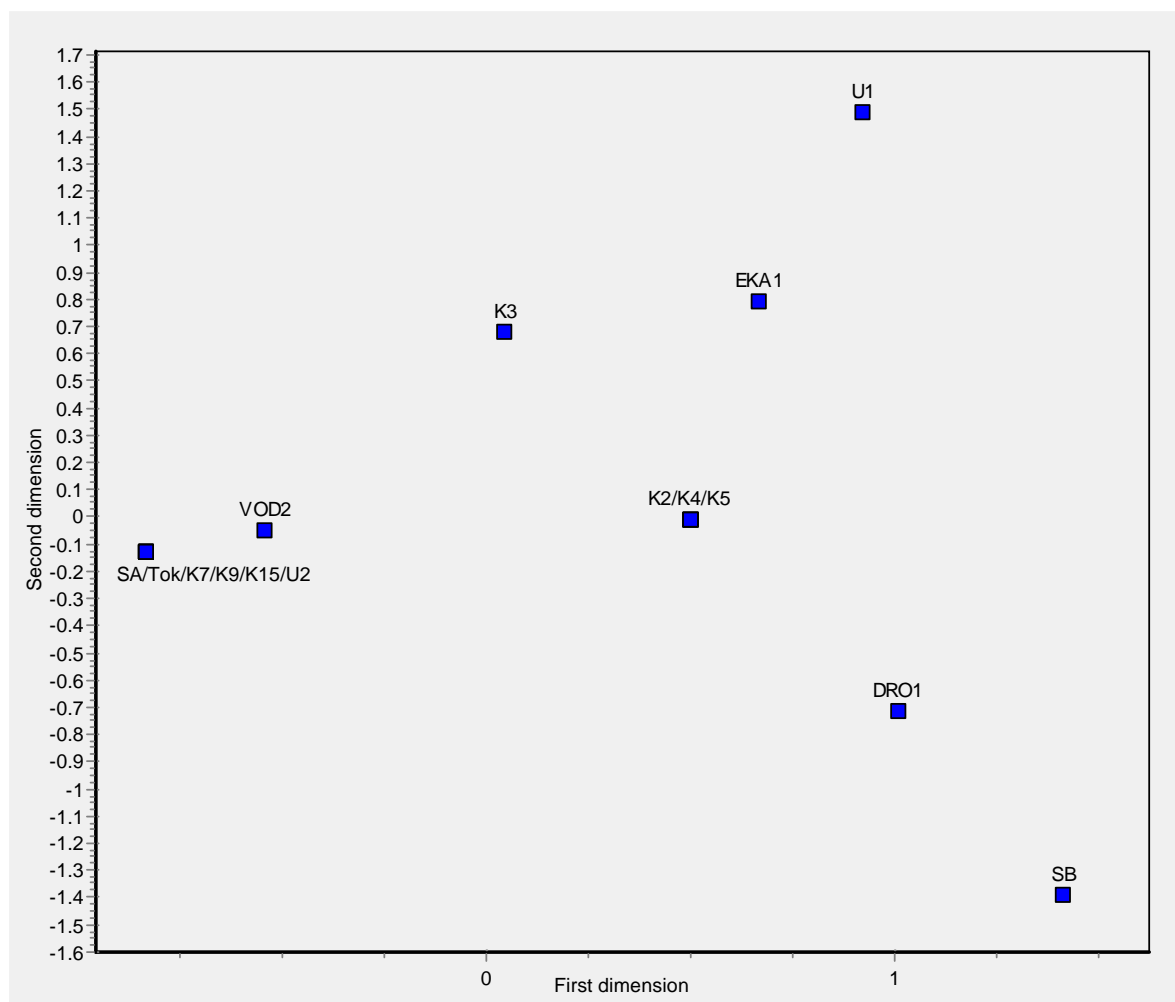


Fig. 7.6: A correspondence analysis plot of the Phase IV affiliation matrix.

Correspondence analysis is one exploratory technique for analyzing simple binary tables containing some measure of relationship between sites based on connections between sites and obsidian sources. Another way to develop network relationships based on binary presence-absence data is through cluster analysis. Cluster analysis provides a way of looking for archaeologically similar groupings and relating these patterns to some other factors believed to be relevant to accounting for them, in this case, social relationships that provided access to obsidian raw material. Cluster analysis similarity measures express the relationships between archaeological sites based on a similarity coefficient, which represents a score, or definition, of how similar two sites are, and can be entered into a matrix that is used to generate a proposed network. This provides a way to further refine

the presence or absence of relationships between sites based on a measure of how similar the sites are based on the number of common sources between them (i.e. two sites that share five different sources should be considered more similar in their obsidian procurement network participation and more likely to have a tie than two sites that share only one obsidian source). Tables 7.4 and 7.5 are matrices of Jaccard similarity coefficient values based on the original binary matrix of sites and sources for Phase III and Phase IV (Tables 7.2 and 7.3). For each pair of sites, the Jaccard coefficient compares their scores for the presence of each obsidian source and expresses the number of matches as a proportion of the total number of sources (see Shennan 1997 for a review of matching coefficient mechanics). Jaccard coefficient values range from 0 to 1, with 0 meaning there is no similarity between the sites, and 1 meaning there is perfect similarity.

	Jaccard Measure				
	AIC1	VOD2	RAS1	DRO1	SAV1
AIC1	1.000	.375	.286	.000	.143
VOD2		1.000	.500	.500	.375
RAS1			1.000	.429	.500
DRO1				1.000	.500
SAV1					1.000

Table 7.4: A Phase III Jaccard similarity coefficient network matrix.

	Jaccard Measure		
	VOD2	DRO1	EKA1
VOD2	1.000	.273	.364
DRO1		1.000	.500
EKA1			1.000

Table 7.5: A Phase IV Jaccard similarity coefficient network matrix.

Choosing an appropriate Jaccard coefficient cutoff value that will be the basis for establishing ties between sites is the next step in building the network structure. Here, network density is an important and related characteristic of the networks being generated. Network density is calculated as a proportion of the ties present based on the total number of possible ties. Density values range from 0 for a network with zero ties between actors, and 1 for a network where every actor has a tie to every other actor (this is considered a

complete network) (Wasserman and Faust 1994). In the present case, network structures at either extreme of the network density value range are considered unrealistic (as well as unhelpful in terms of exploring social network data). Given that this process is a method of data exploration, any number of approaches might be taken to choosing a similarity coefficient cutoff value. The approach used here is to measure network density for a range of Jaccard coefficient values, and plot the density values to determine where an inflection point in the distribution might exist. Table 6 shows the averaged network density values for Phase III and Phase IV affiliation networks at each coefficient value between 0.0 and 0.6 and the amount of difference in network density at each change in coefficient at .025 intervals; Figure 7.7 is a plot of the coefficient and network density values.

Jaccard Coefficient	Network Density	Density Change	Density % Change
0.000	1.000		
0.025	1.000	0.000	0
0.050	0.950	0.050	5.0
0.075	0.950	0.000	0.0
0.100	0.950	0.000	0.0
0.125	0.950	0.000	0.0
0.150	0.900	0.050	5.3
0.175	0.900	0.000	0.0
0.200	0.900	0.000	0.0
0.225	0.900	0.000	0.0
0.250	0.900	0.000	0.0
0.275	0.733	0.167	18.6
0.300	0.683	0.050	6.8
0.325	0.683	0.000	0.0
0.350	0.683	0.000	0.0
0.375	0.517	0.167	24.4
0.400	0.417	0.100	19.4
0.425	0.417	0.000	0.0
0.450	0.367	0.050	12.0
0.475	0.367	0.000	0.0
0.500	0.367	0.000	0.0
0.525	0.000	0.367	100.0
0.550	0.000	0.000	0.0
0.575	0.000	0.000	0.0
0.600	0.000	0.000	0.0

Table 7.6: Jaccard coefficient and network density values.

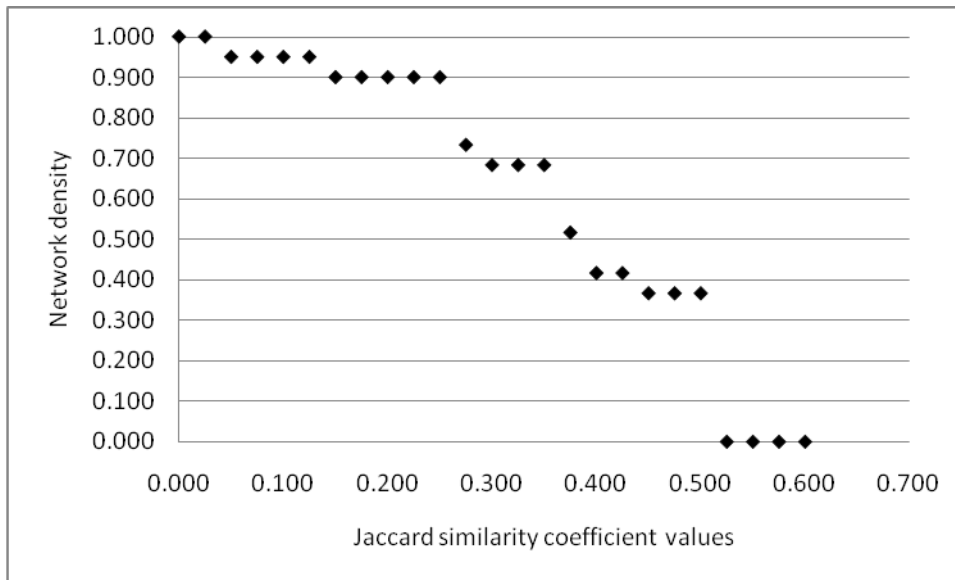


Fig. 7.7: Plot of Jaccard coefficient and network density values.

Based on the distribution of similarity coefficient and network density values given in Table 7.6 and Figure 7.7, the most significant changes in network density are generated from changes in coefficient values from 0.250 to 0.400, which represents 69.2% of the change in network density (the change from 0.500 to 0.525 is too close to the minimum density to be relevant). Given that the coefficient value of 0.325 falls exactly in between 0.250 and 0.400, 0.325 is chosen as the coefficient cutoff, and only pairs of sites with Jaccard coefficient values greater than or equal to 0.325 will be assigned a tie. Figures 8 and 9 are the resulting social network graphs created by the UCInet and NetDraw network analysis software packages (Borgatti et al. 2002) for the Early and Middle period sites respectively<sup>1</sup>.

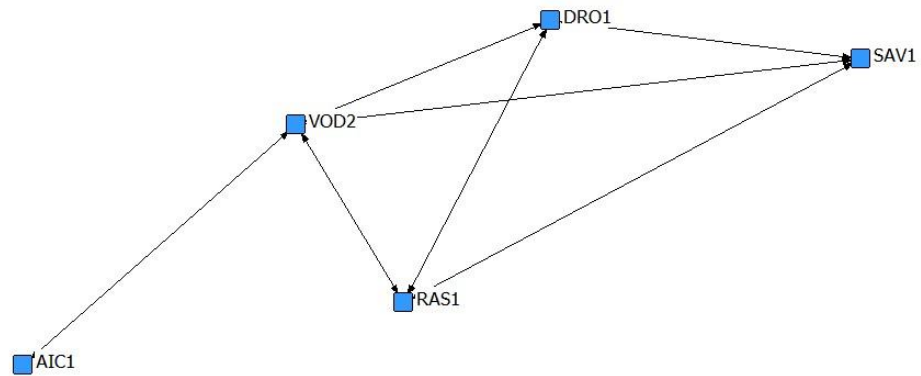


Fig. 7.8: Phase III network graph.

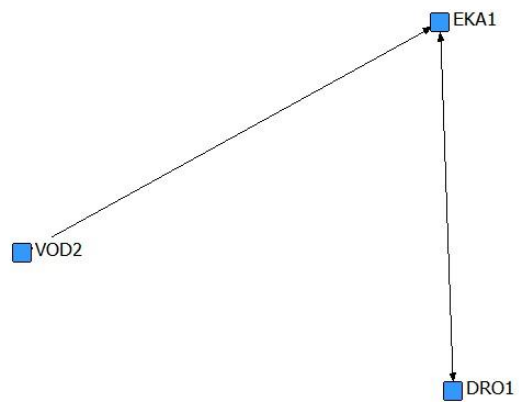


Fig. 7.9: Phase IV network graph.

<sup>1</sup> UCInet places actor nodes randomly in the network graph; the actors have been re-arranged manually to depict general geographic orientation.

## Kuril Island Network Measurements

Graph-level measurements provide a description of some of the overall characteristics of the Phase III and Phase IV networks. The density of the Phase III network is 0.700, meaning that 70% of all possible network connections between sites are present. For the Phase IV network, the density is 0.667, though because there are only three sites and two ties, this statistic is less informative. The networks for both periods are fairly well-connected, and there is essentially no change in the density of network ties given the maximum number of ties possible from Phase III to Phase IV. A triad census, or count of triangles present in the network, describes some of the substantive implications for group dynamics based on triad relationships (Coleman 1990; Kitts and Huang 2010). Here, the triad census reveals a major difference between the Phase III and Phase IV networks -- there are four triads present in the Phase III graph compared to none in Phase IV.

Measures of actor position in these networks are represented by the centrality measures in Tables 7.7 (Phase III) and 7.8 (Phase IV). During Phase III, the Vodopodnaya 2 (VOD2) site is the most central by all of the centrality measures. This site has the highest degree or number of ties, lies between the greatest number of other sites, is the closest to all other sites, and is most central to the overall pattern of the network. This is not unexpected given the geographic orientation of the site, with Vodopodnaya 2 on Simushir Island in the central part of the island chain. In this network, the Ainu Creek (AIC1) site is the least central; the position of this site towards the end of the island chain would dictate that it has fewer network connections into the archipelago.

Site	Degree	Between	Closeness	Eigenvector
AIC1	1	0	12	0.17
VOD2	4	3	9	0.524
RAS1	3	0	10	0.482
DRO1	3	0	10	0.482
SAV1	3	0	10	0.482

Table 7.7: Actor centrality measures for each site in the Phase III network.

During Phase IV, the Ekarma 1 (EKA1) site is the most central by all measures; the Vodopodnaya 2 and Rasshua 1 sites are equally the least central to the overall network

pattern. During this period, the “center” of the network has shifted northward and site centrality is no longer correlated with the geography of the Kuril Islands, although this conclusion is not well-supported because of the small size of the network. Future analyses of additional Phase IV sites may provide additional data that allows for the construction of a larger and more interesting network.

Site	Degree	Between	Closeness	Eigenvector
VOD2	1	0	6	1.5
DRO1	1	0	6	1.5
EKA1	2	1	5	2

Table 7.8: Actor centrality measures for each site in the Phase IV network.

### Network Modeling

In addition to describing network structures and the centrality of actors within networks, SNA provides several methods for statistically testing network hypotheses and for modeling the processes that lead to a network’s particular configuration and allow for the prediction of structured relationships. Null hypothesis testing provides a way to compare observed properties of a network against properties obtained from a distribution of randomly generated networks using a baseline model (Butts 2008a). The conditioned uniform graph (CUG) test procedure is one of the most useful for detecting structural biases in networks. The CUG test utilizes a baseline model of random social structure given some set of fixed constraints, such as the size of the network (number of actors) or density of the network (proportion of ties among actors present), which acts as the null hypothesis (Butts 2008a). A statistic from the observed network is compared against a distribution of values generated by the baseline model to determine if the observed statistic is significantly different from the random distribution. This is an initial step used to isolate bias in the network structure which can be used to model the stochastic processes that generated the network (Robins et al. 2007).

One of the most powerful uses of SNA is in modeling network structures, and in predicting the structure of unknown networks (Butts 2008b). A class of models called p-star or exponential random graph (ERG) models can provide detailed quantitative analysis of

how stochastic processes and biases interact to form networks. These models allow for parameterizing the social processes of interest that may be related to the network structure (Butts 2008a; Robins et al. 2007). ERG modeling is based on the concept that the network we observe is only one particular configuration out of a universe of network configurations that are possible. The use of ERG models is a complex method for creating a probability distribution for all network configurations, and for exploring what factors make the observed network the most likely configuration (Robins et al. 2007). The exponential parameterization modeling framework can also be extended to comparing different networks based on graph permutation techniques or by modeling multiple networks from the same set of statistics (Butts 2008a).

For this study, a CUG test was generated using the `statnet` package in the R statistical software program for both the Phase III and Phase IV networks to determine their usefulness for further network modeling. As outlined above, a test statistic is chosen and obtained for the observed network, and then 1000 random graphs of the same size are generated to obtain a distribution for the test statistic. This represents the baseline model and the null hypothesis that the observed statistic value will fall within the distribution of values for the randomly generated networks. The test results are presented graphically in a histogram of the distribution and showing the position of the observed value. Here, the test statistic is graph density, the proportion of ties present given the maximum number of ties possible in a network. The attribute that was held constant was network size.

Figure 7.10 shows the results of the CUG test for the Phase III network based on the observed graph density value of 0.7. The probability of obtaining value as large as the one calculated for the observed network is 0.147, meaning that there is a 14.7 percent chance of obtaining the observed value in the random distribution. In this case we cannot reject the null hypothesis.

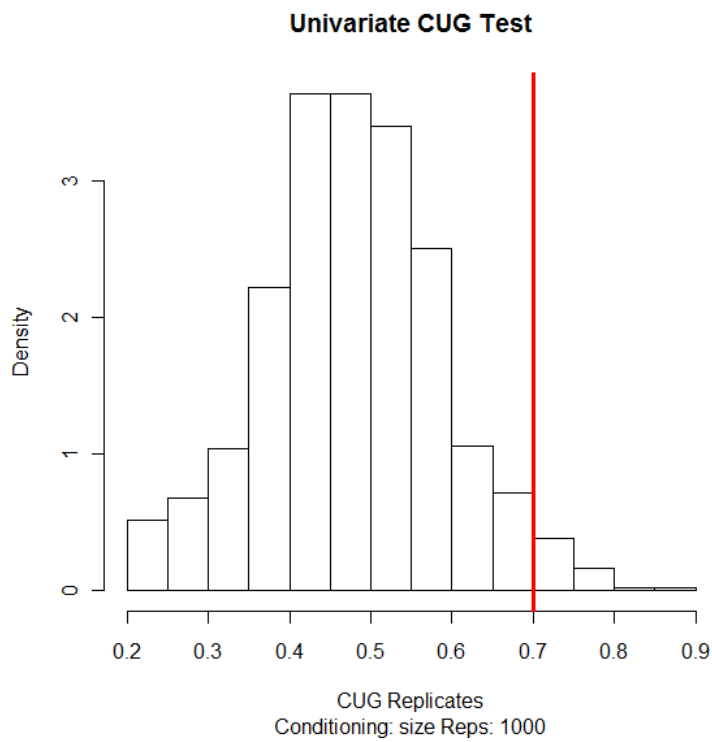


Fig. 7.10: Phase III CUG test distribution.

Similarly, the results of the CUG test for the Phase IV network also indicate that the null hypothesis cannot be rejected – there is a 35.3 percent chance ( $\Pr \geq X = 0.353$ ) of obtaining the observed value of 0.6 in the random distribution (Figure 7.11).

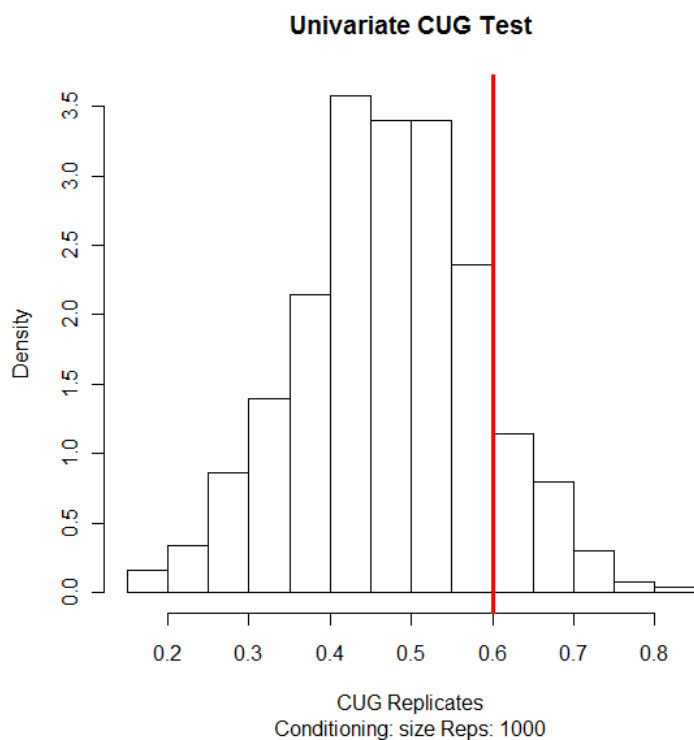


Fig. 7.11: Phase IV CUG test distribution.

While the Phase III network provides a meaningful way to describe the social ties between archaeological sites in the Kuril Islands based on obsidian source use, neither it nor the Phase IV network are suited for use in random graph-based models focused on predicting network structures. The size of these networks is likely the primary limiting factor. Because there are only five actors in the Phase III network and three in the Phase IV network, the solution space for the generation of random graph distributions is very limited. For any network, there are only  $n(n-1)/2$  possible ties between actors; for a five-actor network the maximum number of ties is 10, for a three-actor network the maximum number of ties is 3. In comparison, a 20-actor network has a maximum of 190 possible ties, creating a much larger space for random graph distributions. Many network studies have the problem of trying to work with too many nodes – a 250-actor network has a maximum of 31,125 ties, which makes computational modeling and display of large networks problematic. Future work on the Kuril materials to develop a larger number of dated artifact assemblages will be useful in constructing larger networks with more actors, which should

be more suitable for employing random graph modeling techniques with real predictive power.

### **Discussion and Conclusions**

The Kuril Island networks analyzed in this study were constructed from the empirical obsidian provenance data, which provided a way to infer relationships between sites given the assumption that obsidian was procured through some type of trade or exchange network. This resource procurement network is just one dimension of the likely multidimensional network of relationships that people in the Kurils would have participated in, including networks based on friendship and affiliation, ascribed kinship, task group, and other frameworks for social ties. As determined from the results above, the Kuril networks as currently structured are not appropriate for use in predicting the social processes that are important to network formation. But they are quite useful for illuminating and characterizing the nature of relational patterns that are not easily identified in the obsidian site-source data alone.

The Phase III and Phase IV networks are described in terms of graph-level and actor-level indices which quantify specific characteristics of the networks and the sites that are included in them. Both networks are similar in their graph density measurements – the Phase III network has a density of 0.700; the Phase IV network density is 0.667, meaning that both networks contain over two-thirds of all possible network ties. Based on graph density alone, there appears to be some continuity in the overall level of “connectedness” among sites between the two phases. More interesting are differences in the internal structure of the two networks and the orientation of site centrality as measured by actor centralization indices.

The count of triads in a network is used to identify the structural balance of the relationships, which has implications for personal cooperation, the flow of information and resources, and the reinforcement of cultural characteristics (Coleman 1990; Kitts and Huang 2010). The Phase III network contains four of nine possible triads. By this measure, the Phase III network is highly integrated, and potentially fosters a high level of interaction and communication. Highly integrated information networks are likely to transfer an increased diversity of information more quickly and with a higher level of confidence in its

fidelity (Fitzhugh et al. in press). Generalizing triad relationships to the larger network predicts a higher level of cooperation within the Phase III network overall (Kitts and Huang 2010).

Conversely, networks with few triads are considered to be less integrated and represent a generally lower level of “connectedness” in the network. The transmission of information through these types of network may be slower, and with less redundancy and confidence in the accuracy of the information (Fitzhugh et al. in press). Less integrated networks may generate lower levels of cooperation and reduced enforcement of cultural norms compared to more integrated networks. Future work on the long-term reproduction and cohesion of ceramic styles during Phase III and Phase IV in the Kurils may provide evidence to further differentiate the effects of network structure on the dominant cultural characteristics of these occupation periods.

In the Phase III network, the central Kuril site of Vodopodnaya 2 on Simushir Island has the highest values for the degree, betweenness, closeness, and eigenvector centrality measures (Table 7.7). This suggests that the Central island sites are the path center, or backbone, of the overall Kuril Island network during this time, and are important in tying together the larger systems of social relationships extending from the Southern to the Northern islands. Alternatively, the high centrality of these sites may be influenced primarily by the linear geographic orientation of the Kuril Islands and the location of these sites in the middle of the island chain, representing a geographic null model for the number of ties a site will have. It is also relevant to consider the social network ties to sites on Hokkaido and Kamchatka that likely existed, and which may have provided sites located at the extreme southern and northern ends of the Kuril archipelago with a high measure of connectivity. Those connections are impossible to evaluate here based on the Kuril Island data alone, but linking the archaeological record of the Kurils to the records of Hokkaido and Kamchatka are an obvious next step in the future study of Kuril networks.

However, the construction of network relationships for the Phase III occupation of the Kuril Islands is productive in terms of contextualizing the potential role of these networks. During Phase III, the Southern island sites have a strong connection to Hokkaido based on the dominance of Hokkaido obsidian source groups in Southern island site lithic assemblages. The Central islands sites have a strong southern orientation through the use of

Hokkaido source groups, yet also have connections to the north and Kamchatkan source groups as evidenced by the nearly 50/50 split in the frequency of Hokkaido and Kamchatka obsidian in the Central islands assemblage. Given the higher obsidian source group diversity of the Central island sites and their resulting high centrality measures, the originally predicted positive relationship between diversity and centrality is upheld.

Northern island sites maintain a much weaker southern relationship, and northern lithic assemblages are dominated by Kamchatka obsidian. This scenario can be characterized as one of incremental network building during Phase III with Epi-Jomon people maintaining strong network ties to the south, and potentially Hokkaido, while new sites and network links are established to the north. Maintaining strong network ties could have been important early in the Kuril colonization process as small groups of people tried to establish themselves in an unfamiliar and isolated environment with low resource predictability. The result was the formation of a well-integrated network (represented by the number of triads) that facilitated the flow of information and resources through the network, and reinforced cooperation and the enforcement of cultural norms. Due to the long time span of the Phase III occupation, this network might be characterized as “mature” in terms of having had a sufficient amount of time to establish many ties that made the network fabric tightly woven. Even though the distances from the central islands to the Hokkaido and Kamchatka source areas are great, the flow of material resources such as obsidian was made possible by a tightly integrated cultural network.

During Phase IV, there is a dramatic shift towards the use of Kamchatkan obsidian source groups in the Central islands, which may signal a shift in the orientation of the social network to the north. This could be evidence of a different group of people, presumably the Okhotsk who had no or very weak legacy ties to Hokkaido who replaced the Epi-Jomon groups in the islands and established a more northern orientation and affiliation. If the Okhotsk culture represents a more effective adaptation to the environment of the central Kurils, perhaps migrating and colonizing Okhotsk groups were not as dependent on social relationships, resulting in a network that was less integrated and potentially representing a higher level of cultural independence of Okhotsk groups compared to the Epi-Jomon populations that preceded them. Archaeologically, this cultural independence might be seen in a less-strict adherence to normative artifact styles in ceramics and/or lithics, resulting in a

wider variety of artifact stylistic or morphological types. Alternatively, the lesser integration seen in the Okhotsk network could be due to the fact that the Phase IV Kuril occupation was much shorter than Phase III, which stunted the maturation process of the Phase IV network and prevented it from becoming a system of tightly woven connections. Also, the increased mobility of Okhotsk groups in Phase IV may have resulted in reduced clarity in the SNA depiction of the network structure, which implies some level of stability in residential affiliation. This interpretation is only tenuously supported by the obsidian assemblage data and requires further lines of evidence and “cables of inference” in order to be considered more seriously, but it provides a scenario against which future research questions might be framed.

SNA provides an additional tool to the archaeologist’s kit of analytical methods, and one that is packaged in theory drawn from sociological and anthropological studies of human relationships, making it inherently complementary to anthropological archaeology. One perspective that network analysts must keep in mind when utilizing SNA is that any specific set of network relationships is only a subset of the larger universe of networks within which individual actors are embedded. Any one actor may be present in a number of networks of physical, material exchange, friendship, kinship, professional, and communication relationships to name a few. Ascribing a single set of social relationships as “the” social network is overly simplistic and probably inaccurate, as Butts notes:

*“An individual to whom no one comes for professional advice may nevertheless have many friends and vice versa – it is unwise to jump to the conclusion that an individual is generally socially isolated on the basis of isolation in one relation, just as it is similarly unwise to presume that an individual who is highly central in one setting is highly central in all settings,”* (Butts 2008a).

For archaeologists especially, who often use networks constructed from relations based on material artifacts as a proxy for unobserved relationships, it is important to embed conclusions drawn from SNA studies within a larger and richer context of empirical findings. The current study has shown that the use of SNA has some interpretive power for the investigation of human social structure in the Kuril Islands. Future work to expand the size and complexity of Kuril networks through the use of additional and different data sets, combined with the ongoing analysis of island occupation sequences, should allow for the

creation of a deeper and more detailed account of the role social relationships played in the ability of people to survive and thrive in the Kuril Islands.

## Chapter 8: Summary and Conclusions

### Introduction

The purpose of this study was to evaluate predictions derived from a model of lithic resource consumption in varying environmental settings, and to explore the extent to which a nonlocal resource could act as a proxy for prehistoric network structures in the Kuril Islands of Far Eastern Russia. My approach was to consider the consumption of stone tool raw material and the human relationships that provide access to material resources through social networks as two equal components of adaptive human behavior in a dynamic and unpredictable environment. The concepts of the plasticity of human behavior and forager decision-making that is oriented towards choosing optimal strategies provided a framework for deriving predictions from a simple behavioral model.

Due to their relative geographic isolation, vulnerability to dynamic natural events, and range of environmental conditions which would have challenged the technological and social strategies employed by low-density foraging groups, the Kuril Islands provided a unique case for studying adaptive human behavior. The primary analytical component of this study was the measurement of lithic reduction intensity across geographic and chronological assemblages to test predictions about behavioral responses to different island environments. A source provenance analysis of obsidian artifacts traced the movement of a nonlocal material resource through the island chain, and provided the basis for deriving connections among archaeological sites that were visualized and quantified in terms of network structures representing nature and level of human social behavior that existed in the Kuril Islands.

Lithic debitage from radiocarbon-dated contexts from six different archaeological sites in the Kuril Islands formed the material assemblage for this research. These site-specific lithic assemblages consisting of a total of 4,947 flakes were aggregated into Southern, Central, and Northern island geographic assemblages for use in making spatial comparisons of lithic resource use. A chronological framework for the mid- to late-Holocene occupation of the Kuril Islands was also developed in order to place these geographic assemblages in a temporal context that is complementary, but not specifically tied to the pottery-based culture-historical sequences currently used in the region. All of

the lithic materials and radiocarbon dates used in this study were obtained through fieldwork and analysis conducted by the Kuril Biocomplexity Project from 2006 through 2010.

### **Significant Results and their Importance**

Predictions for Kuril Island lithic assemblage characteristics were guided by a model that incorporated the environmental factors of lithic resource availability and subsistence resource predictability, and the assumption of basic optimizing behavior among foragers who seek a high return on their investments in procuring resources. Obsidian source diversity and network centrality predictions were tied to island colonization sequences and geographic location. The varied environmental and geographic conditions in the Southern, Central, and Northern Kuril Islands were used to specify predictions for island group assemblages during each chronological phase.

In the Southern islands, which have the widest variety and abundance of lithic raw materials and the highest diversity and predictability of subsistence resources, flake debitage assemblages were predicted to demonstrate a relatively lower amount of lithic resource conservation. Southern island obsidian artifacts were expected to be dominated by Hokkaido obsidian source groups, and networks were expected to be focused on local rather than regional relationships. The Central Kurils by comparison have a narrower variety of lithic resources and lower subsistence resource predictability; lithic assemblages were predicted to show a greater amount of stone tool raw material conservation and curation. Based on the inferred direction of the colonization of the Kuril archipelago, the early periods of Central island occupation should be dominated by Hokkaido obsidian source groups, followed by the presence of a mix of Hokkaido and Kamchatka sources in later periods as northern-oriented relationships are established. In the Northern islands, which are intermediary between the Southern and Central islands in terms of lithic and subsistence resources, the level of lithic reduction intensity was expected to fall between those of the Southern and Central assemblages. Kamchatkan obsidian source groups should have dominated the obsidian artifact assemblages, and networks were expected to be locally oriented.

*Lithic reduction intensity and assemblage raw material composition*

In Chapter 5 I demonstrated that variation in lithic reduction behavior exists in the lithic assemblages from occupation sites in different parts of the Kuril Island chain. This supports the expectation of inherent plasticity in human behavior in the context of lithic technological organization, a behavioral response to the variation in island environments across the archipelago. During Phase III (3100 – 1400 BP), the Central islands debitage assemblage had the highest proportion of Late stage flakes and the smallest proportion of Early stage flakes by count and mass compared to the Southern and Northern islands assemblages. These results fit the predictions given the assumptions made about the nature of lithic resource availability and subsistence resource predictability for the Southern, Central, and Northern islands. It is inferred that the greater amount of tool maintenance activity used to extend tool use life and conserve lithic raw material resources in the Central islands was a form of optimal lithic reduction behavior, and represents the abilities of the Kuril Islands' human occupants to choose behavioral strategies that favored their technological goals given the environmental constraints that they encountered.

It is difficult to draw strong conclusions about lithic resource consumption from the finished stone tools alone due to the small sample that was examined in this study. The initial view provided by the tool assemblage suggests a great deal of biface and flake tool artifacts were used across the Kurils. Utilized and retouched flakes were particularly abundant in the Central islands assemblage, an indication that sufficiently-sized flakes were recycled as a way to maximize lithic resource use. This is apparent for obsidian raw material specifically; utilized flake is the most frequent obsidian tool type, and at least one retouched obsidian flake is present in each assemblage. Several obsidian blades and bifacially flakes tools such as projectile points and scrapers were also present, suggesting that the use of obsidian was not restricted to a particular tool type or function. This would meet the prediction of a broad range of obsidian tool forms proposed for the Phase III Central island assemblage, but not for the prediction of specific obsidian tool types in other assemblages. Further analysis of a larger sample of finished stone tools will be necessary in order to develop more specific conclusions about specific tool functionality and raw material choices across the Kuril Islands.

The quality of the lithic raw material types in each assemblage was predicted to be influenced by the type and abundance of raw materials present in each island environment. The outcomes of these predictions were less clear, and may re-shape some of our ideas about the different lithic environments of the Kuril Islands.

The Southern islands, which were believed to have the highest diversity and abundance of lithic raw material types, contained an assemblage which consisted of a majority of flakes assigned to a lower quality unknown group of raw material. While higher quality materials such as fine-grained basalt, chert, chalcedony, and some obsidian were present in this assemblage, they were all reduced much more intensively and to a smaller size than the unknown group. The use of such a large proportion of lower quality raw material suggests this material was highly abundant and easy to procure locally, and that it met the technological needs of the tool makers. While the Southern islands are more geologically diverse than the other parts of the island chain, high-quality raw materials there may not have been as easy to access for stone tool makers, requiring them to employ an opportunistic strategy of lithic raw material procurement. This brings into question the overall characterization of the Southern islands as a high-availability lithic environment in terms of high-quality materials such as chert and fine-grained basalt. Data on assemblage raw material composition from a wider selection of sites in Southern islands could help to clarify this issue.

Higher quality raw materials, primarily fine-grained basalt and chert, were heavily used in the Central islands indicating they were available in adequate abundance. This resulted in assemblages that are less mixed with low quality raw materials than originally anticipated. But higher quality raw materials were consumed more conservatively compared to other parts of the island chain, suggesting that either it was ultimately more costly to procure basalt and chert, or that concerns for efficient time budgeting made extending the use life of tools important. Here, a more selective strategy of raw material procurement was employed in conjunction with resource maximization. The Northern islands assemblage mirrored the Central assemblage with a heavy reliance on basalt and chert material, but also included a much higher proportion of nonlocal obsidian, an indication of stronger ties to obsidian source areas or greater movement of people from Kamchatka into the northern parts of the archipelago.

The use of transportation technology, such as pack animals or boats, has been cited as a mechanism for decreasing the costs associated with moving nonlocal lithic raw materials from their source locations to the sites where they are ultimately consumed (Close 1996, 1999; Ames 2002). While the case can certainly be made that boats transported people and materials such as obsidian through the Kuril Islands, I do not believe that their use had a great impact on making nonlocal obsidian more available, particularly to the inhabitants of the Central Kurils. Boat voyages to Hokkaido or Kamchatka mainland areas would have been intermittent or perhaps seasonal, and could have been particularly risky during most times of the year due to storminess or water current conditions in the straits that separate the islands. These trips would have lasted days if not weeks depending on the traveling conditions, and during longer trips or periods when travel was restricted, island inhabitants would have been reliant on raw material that had been brought to the islands previously. The efficient use of those lithic stockpiles would have been an important strategy for ensuring that tool production and use needs were able to be met, and this is the overwhelming signal of lithic reduction that is detected in Kuril Island assemblages.

I believe that these data and results of analysis support the basic predictions of the resource consumption model given the context of behavioral choices that are made based on the variation of environmental conditions and constraints geographically across the Kuril archipelago. A potentially more interesting result from Chapter 5 was the detection of differences in lithic reduction behavior across time, and the implications this finding has on interpretations of Kuril Island occupation history and cultural evolution. Overall, but particularly in the Central islands assemblages, lithic reduction intensity decreases from Phase III to Phase IV, as indicated by increases in the relative proportions of Early and Middle stage debitage compared to Late stage debitage. Assemblage raw material composition also changed with a marked increase in the use of lower quality materials in the Central islands. The use of nonlocal obsidian also increased in Phase IV, suggesting a different set of relationships that facilitated access to obsidian were in place.

It was suggested in the conclusion of Chapter 5 that the changes detected in the lithic assemblages represent a change in population groups, with people bearing the Okhotsk culture replacing the Epi-Jomon groups. Within the Phase III assemblage, comparisons between individual site assemblages from earlier in the phase with those from

later in the phase did not reveal any differences in lithic reduction behavior. At present, it is a statistically significant difference in lithic reduction intensity between the Phase III and Phase IV assemblages as they are currently constructed that supports a “changing of the guard,” hypothesis for the re-colonization of the island chain by a completely different group of people carrying with them a set of behavioral adaptations.

Newly arriving Okhotsk groups would have been faced with a similar unfamiliarity of lithic resource availability and subsistence resource predictability in the Central Kurils that the initial Jomon/Epi-Jomon colonizers experienced before them more than 1600 years earlier. Phase IV in the Kuril chronology is 900 years shorter than Phase III, and it seems unlikely that the Okhotsk people attained a hyper-awareness of the lithic resources in the region that allowed them to somehow accelerate their behavioral adaptations towards a less efficient use of these resources. Their ability to extract more resources from the environment, travel or trade more effectively, or perhaps supplement their lithic toolkit with bone tools and thus not have to rely as heavily on stone resource could have contributed to a different set of lithic procurement and consumption strategies compared to the Epi-Jomon.

#### *Obsidian source diversity*

The results of the obsidian source provenance study in Chapter 6 suggest that in the Phase III lithic assemblages, the predictions for assemblage source use and diversity were largely met based on a neutral model of distance decay from the obsidian source location to the site. As a proxy for social network relationships, assemblage obsidian source composition provides insight into the strength and direction of trade or exchange relationships. The Southern island site had relationships clearly oriented to Hokkaido, and potentially to a specific trading partner or group that provided access to a specific source, the Tokachimisumata source group. The Central islands assemblage contained a mix of eight Hokkaido and Kamchatka source groups, and the obsidian flakes were distributed almost equally between these two source regions resulting in the highest diversity values for this phase. In the Northern islands, three Kamchatka source groups represented 97.4% of all obsidian flakes.

While the Southern and Northern assemblages met the expectations of obsidian source group patterning based on the linear geography of the Kuril Island chain and basic distance decay models, the Central island assemblage was more diverse than predicted. It was initially believed that obsidian from both Hokkaido and Kamchatka would be found in the Central islands in Phase III, but that Hokkaido source groups would be dominant, indicating a strong southern network orientation.

The equal presence of Hokkaido and Kamchatkan source groups suggests that during this phase relationships to the north were already established and provided significant access to obsidian from Kamchatka. This could be interpreted as evidence of the evolution of relationship-based procurement behavior by Epi-Jomon groups that may or may not have had a strong presence in the Northern Kurils, but cultivated access to Kamchatkan obsidian sources. These additional sources of non-Hokkaido obsidian may have been an important buffer for times when travel between Hokkaido and the Central Kurils was disrupted due to unfavorable conditions, or the risk and costs of traveling across the Bussol Strait were judged to be too great.

The obsidian distribution pattern shifted in Phase IV, when over 94% of the Central island assemblage was composed of obsidian from seven different Kamchatkan source groups. This pattern does not support a neutral model based on distance decay relationships. The abundance of obsidian in the Central island assemblage overall also grew, suggesting that a different set of network relationships was bringing more obsidian almost exclusively from Kamchatka to the Central islands. To build on the conclusions of the lithic debitage analysis, this abrupt and distinct change in obsidian consumption and source use is viewed as a completely different set of adaptive behaviors of the Okhotsk culture, as opposed to the continued evolution of Epi-Jomon obsidian use behavior. The re-orientation of obsidian source use in the Central Kurils suggests that the Epi-Jomon network connections to the south were no longer in place, having been supplanted by an Okhotsk network with no strong history or legacy of relationships to Hokkaido.

#### *Network centrality measure*

Quantification of an actor's position in a network was evaluated by centrality measures, and actor centrality was used to determine the level of "connectedness" of Kuril

Island sites. Since the actor centrality measures were based on the number of different sources a particular site shared with other sites, these results track closely to those of the obsidian assemblage diversity measures. In Phase III, Southern and Northern islands sites shared fewer obsidian sources with other sites, and had lower centrality measures than Central islands sites. As mentioned above, it was originally predicted that the Central islands sites would have low obsidian source diversity, and in relation low centrality measures. However the position of the Central island sites in the middle of the chain, specifically Vodopodnaya 2, provides more opportunities to be linked to sites to the south or north, and I believe the linear geography of the Kuril chain is influencing site centrality rather than distinct social processes.

Overall, the Phase III network is depicted as being highly interconnected, with a strong density measure and number of triangles present in the network structure. This can be described as a network that facilitates the flow of information, ideas, and cooperation. Based on the specific obsidian sources present in Kuril sites, the network was strongly oriented to the south and Hokkaido. An Epi-Jomon system of social relationships that is highly interconnected as a support system for colonizing populations, and with strong legacy ties to a southern homeland, seems to be an appropriate way to characterize this network.

The low number of sites available for constructing a social network for Phase IV makes the results of site centrality measures less useful for network analysis, though it is interesting to note that the Vodopodnaya 2 site has lower centrality measures and is connected to only one of two possible sites in this small network. The obsidian source group data suggest that during Phase IV, Central island sites' network connections would have been oriented towards the north and to other sites primarily using obsidian from Kamchatka. If access to Hokkaido obsidian sources, and by extension connections to Southern island sites, were not maintained, then it is possible that in Phase IV Central island sites may have had fewer network ties overall. This would represent a shift in network structure that was not necessarily being dictated by inherent geography of the island chain and the central geographic position of the sites.

## **Contributions and Broader Implications**

This study has first and foremost contributed to a small but expanding body of research on the history of the mid- to late-Holocene human occupation of the Kuril Islands. It comes at a time when interest in this island chain is growing, as evidenced by the continuation of studies begun by the Kuril Biocomplexity Project in 2006, and the initiation of new research by additional investigators in the region. The research presented here is focused on behavioral adaptations to environmental conditions, and represents the largest analysis of lithic artifacts from the Kuril Islands to date. It is also the first provenance study to address the distribution and use of nonlocal obsidian across the islands, which provides a link to issues of human interaction and trade over long distances.

Fitzhugh et al. (2004) were the first to examine lithic technological organization in the Kuril Islands in terms of the insularity and environmental heterogeneity of the island chain, and how those factors may have affected human mobility, trade, and the use of raw material resources. Their initial findings that selective systems of raw material utilization were developed across the Kurils, and that the curation and intensity of lithic reduction intensified with increased isolation, are supported and expanded upon by my research. Added here is not only a finer-grained view of the differences in lithic resource use across the major geographic regions of the archipelago, but also a temporal component that documents how raw material use changed in conjunction with a purported transition in the ethnic or culture-group occupation of the Kurils that took place around 1400 BP.

Similar to the initial studies conducted on Kuril lithic assemblages, previous work tracing the movement of obsidian from sources to sites in northeast Asia provided a foundation for the current analysis of Kuril obsidian artifacts. The determination that obsidian from Hokkaido was transported up to 1000 km to sites on Sakhalin Island beginning ca. 20,000 BP firmly established long-distance procurement networks in the Sea of Okhotsk region (Glascock et al. 2000; Kuzmin 2006b; Kuzmin et al. 2002a). Although less research has been conducted to date on obsidian procurement networks in Kamchatka, many of the Kamchatkan source groups have been identified archaeologically or geologically in the last decade (Glascock et al. 2006; Kuzmin et al. 2008; Speakman et al. 2005). The work presented here to assign obsidian artifacts to specific source groups within the Hokkaido and Kamchatka has established a link between these source areas and raw

material use in the Kuril Islands. This study has also contributed additional tests of predictions derived from optimization models that are a part of the larger suite of human behavioral ecology concepts aimed at understanding variation in human behavior. In many cases, expectations for the conservation and efficient use of raw material resources were met, particularly in the Southern and Central island assemblages which indicated lithic reduction strategies were shaped by specific environmental conditions. However, the obsidian provenance data demonstrated a strong departure from the expected source group composition of the Central island assemblages based on the geographic null model of a distance-to-source relationship between Central island sites and obsidian source locations. The nearly complete dominance of Kamchatkan obsidian in the Phase IV Central island assemblage suggests that in the Central Kurils, social rather than distance factors influenced the use of nonlocal obsidian raw material. Obsidian flake assemblages have proved useful as markers of the extent and longevity of a nonlocal resource procurement network, demonstrating that obsidian source use in the Central Kurils shifted through time and may be related to a shift in the orientation of social network relationships.

At a broader level, this research has contributed to the understanding that prehistoric social networks represent an additional dimension of human behaviors that can be evaluated under the premises of HBE optimization models. While the results presented here are preliminary in nature, they were generated by placing social networks into the context of the archaeological record, providing an additional link between the material traces of the past and the behavior that created them. Personal relationships provide humans with a range of behavioral options far beyond any single individual's personal ability, and understanding the links between social networks and behavior should be an important anthropological goal.

### **Future Research**

The research reported here into the human prehistory of the Kuril Islands has been broad but not deep, a consequence of trying to synthesize the 5000-year archaeological record of an entire 1200 km-long island chain. The current study, which was based on a sub-sample of the catalog of Kuril archaeological materials recovered by the Kuril Biocomplexity Project (itself a limited survey project), could benefit from analysis of larger

lithic assemblages from additional dated site contexts from all parts of the island chain. Expanding the radiocarbon database with more dates from excavation units and stratigraphic levels that are determined to be unmixed/undisturbed will allow for the generation of larger and a greater number of assemblages that can be used for comparisons within, as well as between, geographic island groups and chronological phases. I am specifically interested in identifying artifact assemblages that correspond to Phase V of the Kuril Island chronological sequence, and site occupations that may be related to the Ainu who inhabited the Kurils up until the 20<sup>th</sup> century. Historic and ethnographic accounts provide the earliest information about the Ainu groups that participated in exchange systems with Japanese and Russian traders. But the origin of the Ainu is not well understood, nor is their initial migration and occupation of the Kuril Islands, particularly the Central Kurils. Specific attention to archaeological sites that can be dated to Phase V will provide a more complete understanding of the final phase of the Kuril chronology. Other interests I have for future research in the Kurils and northeast Asia build on several components of the current study.

The obsidian source provenance study conducted as part of this research has contributed new information about lithic resource use in the archipelago, but much of the additional work that will help clarify obsidian procurement and use in the Kuril Islands needs to take place outside of the island chain, specifically in Kamchatka. I plan to extend source provenance studies for obsidian artifacts from archaeological sites in Southern Kamchatka in order to establish the extent of native Kamchatkan obsidian source use. We know very little about the influence of Kamchatkan cultures on the Northern Kurils, either through the actual migration into and occupation of the islands by people from Kamchatka, or through trade and other social relationships they had with Kuril Island colonizers who came from the south. Relatively few problem-oriented studies have been conducted in southern Kamchatka, and new research there will have the extra reward of enhancing research on the human occupation history of the northern part of the Kuril archipelago.

I also plan to continue refining the analysis of Kuril Island social networks through the integration of additional archaeological sites and network variables, and the use of more advanced network modeling techniques. While the results presented here are preliminary in nature, they were generated by placing social networks into the context of the

archaeological record, providing an additional link between the material traces of the past and the behavior that created them. The network analysis conducted in this study was based on a single network tie variable, obsidian source groups, and provided an initial yet one-dimensional view of the structure of human social relationship in the Kurils. Incorporating additional tie variables based on the analysis of other artifact classes, such as ceramic provenance and stylistic analysis, will provide a much richer context for the creation of network structures. Likewise, while network topology and actor centrality measures provide basic quantification of the network, the statistical testing and modeling of these networks will allow us to go beyond network description begin to identify structural biases that can be used to predict the formation and structure of social networks under various conditions. This will provide an additional avenue for testing hypotheses about optimal human networking behavior under a range of environmental and social conditions.

In the last few decades, archaeological research on islands has moved from the margins to a more central position of anthropological studies of human evolution, migration, and cultural change (Erlandson and Fitzpatrick 2006: 21), and has expanded our ideas about human adaptive capabilities. The current study has lent support to the notion that communication and interaction were important strategies for human groups living in isolated and challenging environments, and this finding reinforces the idea that island environments actually encourage rather than retard social networking. A focus on the contexts and conditions that influence human relationships, and how those relationships shape cultural change, will be fruitful avenues for future studies of island societies.

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## Appendix A: Lithic Analysis Coding Sheet

### Artifact Type

- 1 Complete flake
- 2 Proximal flake
- 3 Distal flake
- 4 Medial flake
- 5 Split flake Left
- 6 Split flake Right
- 7 Chip

### Material

- 1 Basalt
- 2 Chert
- 3 Chalcedony
- 4 Obsidian
- 5 Quartz/quartzite
- 99 Unknown

### Color

- 1 Black
- 2 Brown
- 3 Grey
- 4 Green
- 5 Red
- 6 Tan
- 7 Orange
- 8 Pink
- 9 Clear
- 11 Yellow
- 12 White

### Structure

- 1 Uniform
- 2 Banded
- 3 Mottled
- 4 Spotted
- 5 Dendritic
- 6 Crystal
- 7 Veined/Fractured

**Texture**

- 1 Phaneritic/large crystals
- 2 Aphanitic/small crystals
- 3 Porphyritic/phaneritic
- 4 Porphyritic/aphanitic
- 5 Glassy
- 99 Undetermined

**Cortex %**

- 1 0%
- 2 1-10%
- 3 11-20%
- 4 21-30%
- 5 31-40%
- 6 41-50%
- 7 51-60%
- 8 61-70%
- 9 71-80%
- 11 81-90%
- 12 91-99%
- 13 100%

**Cortex Type**

- 1 Natural/Flat
- 2 Alluvial/Rounded
- 99 None

**Cortex Location**

- 1 Dorsal only
- 2 Dorsal and platform
- 3 Dorsal and termination
- 4 Dorsal/platform/termination
- 99 None

**Dorsal Scar Termination**

- 1 Abrupt
- 2 Non-abrupt
- 3 Both
- 99 Undetermined

**Dorsal Scar Orientation**

- 1 Unidirectional/proximal
- 2 Unidirectional/distal
- 3 Bi-directional/proximal and distal
- 4 Multidirectional
- 5 Unidirectional medial
- 6 Bi-directional/medial
- 99 Undetermined

**Curve**

- 1 Pronounced
- 2 Slight
- 3 None

**Termination**

- 1 Feather
- 2 Hinge
- 3 Step
- 4 Plunging
- 5 Crushed
- 99 Unidentifiable/termination missing

**Bulb**

- 1 Pronounced
- 2 Diffuse
- 3 Flat
- 4 Negative
- 99 None/missing

**Platform**

- 1 Single/Flat
- 2 Double
- 3 Multiple/Complex
- 4 Cortical
- 5 Crushed
- 6 Undetermined
- 7 Abraded
- 99 None/missing

**Platform Lip**

- 0 Absent
- 1 Present

**OHR**

- 0 Absent
- 1 Present

**Thermal Alteration**

- 0 Absent
- 1 Potlidding
- 2 Waxy luster
- 3 Fracturing
- 4 Crazing

**Appendix B: Obsidian Source Diversity Simulation R Code**

```
### Simpson's D diversity index
D<-function (x) {
p<-x/sum(x)
1-sum(p^2)
}
```

```
### Shannon H diversity index
H<- function (x) {
x<- x[x>0]
p<- x/sum(x)
-sum(p*log(p))
}
```

```
### Richness diversity index
R<-function (x){
n<- specnumber(x)
sum(n)
}
```

```
### ALSO
R<-function (x) {
sum(x>0)
}
```

```
### Shannon E evenness index
E <- function(x) {
h<- H(x)
r<-specnumber(x)
rs<-sum(r)
rl<-log(rs)
h/rl
}
```

```
### ALSO
E <- function (x) {
h<- H(x)
r<-sum(x>0)
rl<-log(r)
h/rl
}
```

```
### Combined Diversity Index Simulation
set.seed=(1234)
N<-1000
RR.res <- rep(0,N)
E.res <- rep(0,N)
D.res <- rep(0,N)
H.res <- rep(0,N)
freq <- rep(0,15)

for (i in 1:N) {
  freq <- rep(0,13)
  raw<-sample(1:13, 150, prob=prb3,replace=TRUE)
  temp <- table(raw)
  index <- as.numeric(names(temp))
  freq[index] <- temp

  RR.res[i] <- RR(freq)
  E.res[i] <- E(freq)
  D.res[i] <- D(freq)
  H.res[i] <- H(freq)
}
```

### **Vita**

Stephen Colby Phillips was born in Houston, Texas and grew up outside of Atlanta, Georgia. In 1990, Colby graduated with a Bachelor of Science in Communications degree from the University of Tennessee. Following ten years of working as a public relations and marketing executive in the computer and networking technology industries, Colby switched careers to archaeology. He earned his Bachelor of Science in Anthropology degree from the University of New Mexico in 2003. He earned his Master of Arts in Anthropology in 2006 and Doctor of Philosophy in Anthropology in 2011, both at the University of Washington.