A Geochemical Approach to Understanding Raw Material Use and Stone Tool Production at the Richardson Island Archaeological Site, Haida Gwaii, British Columbia

by

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ABSTRACT

Archaeologists often base their classifications of rock type on informal visual assessments of the material which, unfortunately, can be erroneous. At the Richardson Island archaeological site in Haida Gwaii the raw material assemblage is diverse, and accurate rock type classifications can be used to explain possible behavioural relationships between raw material and selected stone tool types, and determine whether these relationships change through time. Thus, in this thesis, classifications for the most commonly occurring raw materials are established using macroscopic visual assessment of the lithic materials, major element compositions as determined through Electron Microprobe Analysis (EMPA), trace element compositions as determined through Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS), and geological discrimination diagrams. Correlation matrices are used to show that both raw material and tool types vary through time. Bifaces, scraperplanes, scrapers, unimarginal tools, and microblades are then examined more closely for significant trends in raw material use. Analysis shows that patterns of raw material use vary between tool classes and through time, but that the patterns are not the same for all rock types. From this evidence we can postulate that formal tool categories have strict raw material requirements which influence the raw material used to manufacture less formalized tools.

Examiners:

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CHAPTER 1

Introduction

In recent years the early human occupation of the Northwest Coast of North America, particularly in relation to a coastal migration route for the peopling of the Americas, has become a subject of increasing interest and study. Archaeological research in the Queen Charlotte Islands, or Haida Gwaii as this archipelago is locally known, is essential to understanding the degree of human movement and antiquity of settlement along this northwestern coastal route. Knowledge of peoples' activities, not only throughout the vast regions of Beringia and the northwest coast, but also within smaller localized areas, is needed to substantiate such a hypothesis. The possibility of an early coastal migration has added fuel to the quest to identify and interpret late Pleistocene and early Holocene archaeological sites within Haida Gwaii. Analysis of archaeological materials and interpretations of carefully compiled data not only address encompassing questions of migration, but encourage inquiry into the ancient inhabitants' behaviours and experiences at specific locations. Richardson Island, located near the northern boundary of the Gwaii Haanas National Park Reserve and Haida Heritage Site, is a site that in particular has much to add to our understanding of the early Holocene way of life.

In the incipient days of Haida Gwaii archaeology, researchers focused on establishing a culture-history sequence for the Northwest coast culture region as a whole. These pioneers of research recognized that changes in the archaeological record of Haida Gwaii were similar to transitions noted for other regions of coastal British Columbia. They also noted that shifts in technology appeared to occur earlier in Haida Gwaii than in locations further south. Likewise, studies indicated similar technological shifts in tool assemblages had occurred at an earlier date in Alaska. Gradually an image of population movement originating in Beringia and spreading through Alaska, into Haida Gwaii and down the BC coast emerged as a plausible explanation of the patterns of migration and settlement. Only recently has archaeological research focused attention on a regionalized culture history sequence for Haida Gwaii itself.

In the 1990s, paleoenvironmental reconstruction started to solidify images of how an early Holocene landscape would have looked to the early Haida Gwaii inhabitants.

Pollen analysis revealed an ecosystem that shifted from herb/shrub tundra to forests of pine, spruce, and hemlock (Mathewes 1989), and a refined sea-level curve illuminated the shifting boundaries between ocean and land (Fedje and Josenhans 2000; Josenhans et al. 1995; Josenhans et al. 1997). The enhanced paleoenvironmental knowledge, especially that of sea-level history, had an immediate impact on archaeological investigations as subtidal, intertidal and raised beach sites were confirmed and identified. Specifically, the raised beach site of Richardson Island, coupled with other sites of similar ages, added numerous lithic artifacts from the early Holocene period which allowed for a refinement of the typologies and technological transitions within the archipelago (Fedje and Christensen 1999). Of these, the most significant contribution was solidifying the emergence of microblades at around 8,900 BP.

While these archaeological and paleoenvironmental pursuits have produced laudable and significant results, there is a way to further our understanding of stone tool assemblages in Haida Gwaii. It involves examining the petrologic character of lithic assemblages. To date there has been little focus on the character of stone in these northwest coast archaeological sites. Yet specific analysis of the geology and the petrographic attributes of raw material can encourage more detailed interpretations of trends in stone tool technologies. Such knowledge can illuminate possible motives behind technological stability and change, resource procurement strategies, and tool manufacturing behaviours at a local level. Additionally, accurate assessments of rock types can enhance comparability between archaeological data sets and foster connections between contemporaneous sites that may otherwise go unnoticed. Thus, the goal of this thesis is to attain a better understanding of the raw material assemblage at the Richardson Island site, and to initiate a preliminary exploration into the relationships between raw material and stone tool types at this locale.

Within the broader discipline of archaeology, raw material studies have proven fruitful avenues of inquiry. The constraints of raw material have been highlighted as a key influence in stone tool manufacture. The form of a stone tool can be affected by the type of raw material, the original size of the nodule, flake or quarried piece of stone, as well as the proximity and availability of the raw material source. While cultural and environmental factors undoubtedly influenced the character of a stone tool assemblage, they are the raw material constraints that can be analyzed and measured most directly by the archaeologists of today. These issues are discussed at greater length in Chapter 2. Additionally, when engaging in discussions of raw material one must be confident that the classifications are accurate. Thus, Chapter 2 also discusses the difficulties of establishing accurate rock classifications when relying solely on macroscopic visual analysis which is common practice in archaeological reporting.

To date, the northwest coast of North America, and in particular the Haida Gwaii region, has seen little in the way of formal raw material analyses. The Richardson Island site is an ideal setting from which to begin exploring the prehistoric use of raw materials in Haida Gwaii. Chapter 3 discusses the specifics of the Richardson Island site including an overview of the culture-history sequence for Haida Gwaii, previous excavations at the Richardson Island site, its stratigraphic profile and site formation processes, and highlights those features that make Richardson Island appealing for a study of raw material.

To avoid errors of misclassification such as those mentioned in Chapter 2, Chapter 4 describes the methods employed to characterize the commonly used raw materials at the Richardson Island site. Macroscopic visual assessment, microprobe analysis (EMPA), laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and geological discrimination diagrams are used to establish accurate classifications of the rock types. The chemical data generated here are used for classificatory purposes only; however, they will provide a useful point of reference should formal sourcing studies in Haida Gwaii take place in the future. In the meantime, Chapter 5 provides a brief examination of possible source locations for some of the more common material types identified in Chapter 4.

Chapter 6 returns to site specifics and provides an overview of the Parks Canada archaeological typology and tool definitions used to classify the most recently excavated artifacts from Richardson Island.

Chapter 7 examines the relationships between raw material use and tool manufacturing behaviour. Previous studies of the Richardson assemblage (Fedje and Christensen 1999, Fedje et al. in press, Magne 2004) had demonstrated that both raw material and tool use do vary temporally. Those established trends are confirmed in this chapter by applying tests of correlation to the newly classified materials. A preliminary investigation into the relationships between flaked formed stone tools and raw material use is also presented. Five tool types (bifaces, scraperplanes, unimarginal tools, scrapers, and microblades) have been selected to examine how raw material use changes through time within each of the tool classes. Raw material preferences are first established for each of the tool types by way of chi-square tests which compare proportions of raw material used for specific tools with the proportions of the same raw material as it appears in the assemblage as a whole. Raw material use is then shown to vary between the Kinggi Complex component of the site (identified by an absence of microblades) and the period associated with the Early Moresby Tradition (addition of microblades). Another series of chi-square tests demonstrates that the proportions of raw material used in each time period varies significantly for some tool types but not for others. In the case of microblades, which only occur in the Early Moresby component of the site, chi-square tests and correlation matrices are used to demonstrate that the initial microblades were manufactured out of materials in common use for the manufacture of other tools, but that in the later stages of microblade manufacture the Richardson inhabitants began experimenting with new materials for this microlithic technology. The compiled data from this chapter are used to argue that the raw material requirements of formalized tools, such as bifaces and microblades, influence the raw material use among less-formalized implements, such as unimarginal tools.

Chapter 8 summarizes the results and situates them in terms of the cultural historical sequence for Haida Gwaii and the broader archaeological discussion concerning some aspects of raw material and tool typology. The benefits of applying LA-ICP-MS and microprobe analysis to studies of raw material are discussed, and avenues for future research are presented.

Intertidal locations and raised beach terraces have revealed that the late Pleistocene, early Holocene peoples of the area had an intimate and well-established knowledge of their environment. Locations such as Kilgii Gwaay, an intertidal wet site situated near the southern tip of the archipelago, has demonstrated that these ancient peoples maintained highly developed technological strategies for exploiting marine resources both near and far off shore (Fedje et al. 2001). Their resource use was diverse and their technological ingenuity, which incorporated stone, bone and wooden tools, was well suited for both marine and terrestrial landscapes. Such investigations have encouraged a move from interpretations based on the simple presence of humans and their generalized movement in a large area, to more specific knowledge of how the people may have lived, hunted and fished. The Richardson Island site, the locale around which this thesis revolves, also has much to add to our understanding of human occupation in Haida Gwaii 10,000 years ago. Thus far this site has been instrumental in confirming that microblades were added to an existing bifacial complex. It is the only site in Haida Gwaii where the emergence of the microblade technology is clear. The highly developed stratigraphic sequence at the Richardson Island site not only resolved the enigma of the microblade emergence but allowed for their introduction to be dated. The Richardson Island site promises to reveal even more about how these individuals organized themselves in a camp setting, the activities they carried out, how their resources were procured and varied with the seasons, how they interacted with and moved about the landscape, and what economic strategies they employed for resource procurement. The work presented in the following pages takes another step towards answering these larger questions.

CHAPTER 2

Raw Material Studies in Archaeology and the Classification of Stone in British Columbia

Raw Material Studies in Archaeology

The influence of raw material is one of the most important factors to consider in an analysis of a lithic assemblage. Quite simply, without stone there are no stone tools, and without flakeable stone there are no flaked stone tools. Certainly factors in addition to raw material such as differential transport, patterns of site use, tool function (Kuhn 1991; Rolland and Dibble 1990), environmental change, settlement types (Rolland and Dibble 1990) and mobility, will all affect the characteristics of a tool assemblage, yet of all these factors raw material is the only tangible element that can be analyzed directly. In some extreme cases, such as witnessed in the Quebec subarctic, even formed stone tools may be lacking in archaeological sites leaving raw material as one of few elements on which to base cultural historical sequences (Denton and McCaffrey 1988).

Within archaeology, raw material has assumed two very important roles: as a means for connecting material to source, and as a key variable influencing tool form and by extension, tool typologies. The sourcing of raw material will be addressed briefly throughout this chapter and more specifically in Chapter 5. The discussion presented in this first section of the chapter will outline the constraining effects of raw material on tool manufacture, with later discussion identifying the benefits of petrological and chemical analysis in the study of raw material types.

Effects of Raw Material on Tool Typology

The influences on stone tool assemblages of group mobility, resharpening and reuse, and raw material have received much attention. Initially differences between formal or curated tools, and informal or expedient tools were explained by the degree of sedentism assumed by the toolmakers (Binford 1980). 'Curated', while recognized to be a particularly loaded term (Shott 1996), can be used to refer to those tools that have received considerable effort in their manufacture. They have been reduced by multiple flaking impacts in their initial manufacture and throughout their use-life. Bifaces, scrapers, spokeshaves, drills and even retouched flakes (Andrefsky 1994) have been assigned to this formal category for stone tools. Expedient, or informal tools, on the other hand, reflect those tools that have been created for rapid, often one time use. They are the flake and shatter tools that show little evidence of modification or reuse. Until recently the formal tools were associated with mobile hunter-gatherer populations. It was argued that transient populations would require a transportable tool kit and would expend considerable effort to manufacture formed implements in anticipation of future use. Conversely, more sedentary populations would be able to store resources and materials thus manufacturing tools as needed. These expedient tools were disposable and showed little sign of modification.

While the degree of mobility is likely to account for some of the tool variation present in an assemblage, it is not the only driving force behind tool forms (Andrefsky 1994; Bamforth 1986;1990). Bamforth (1990), for example, demonstrated that prehistoric stone workers in the Central Mojave Desert "chose the same kinds of stone and manufactured the same kinds of products for transport and use elsewhere for 12,000 years" (1990:96) despite changes in mobility and settlement patterns during this period. Additionally, Dibble (1987), and Rolland and Dibble (1990), have pointed out that tool forms are not necessarily static constructs but represent a continuum of resharpening events. Instead of all tools being end products of one desired mental template, they are likely to be reused and resharpened. These rejuvenation processes not only change the morphology of a tool, but possibly its function as well. A tool, at any stage of its use-life, can be discarded and appear in the archaeological record. While Rolland and Dibble (1990) suggest that mobility patterns will affect the reduction intensity of a tool to some degree, they do not highlight it as a primary factor influencing the use-life of tools, and hence, Middle Paleolithic variability. They reserve this distinction for raw material constraints. Two features of raw material have been shown to affect assemblage variability are: 1) the availability, or accessibility, of raw material (Rolland and Dibble 1990; Dibble 1987; Kuhn 1991; Holdaway et al. 1996; Roth and Dibble 1998; Bamforth 1986; Andrefsky 1994; Munday 1976), and 2) the physical characteristics of the material itself (Dibble 1985; Jones 1984; Kuhn 1991,1992; Ashton and White 2003; Jones 1978; Moloney 1988; Moloney et al. 1988).

Availability of Raw Material

The availability, or accessibility, of raw material (the two terms are viewed here as synonymous and will be discussed at greater length towards the conclusion of this chapter) refers to both the cultural/behavioural (Bamforth 1986) and geological aspects which constrain access to raw material. Cultural factors which influence raw material acquisition, (such as social status, wealth (Bamforth 1986), property rights, politics, spiritual beliefs, etc.), are difficult to isolate in the archaeological record and, as such, many publications addressing the effects of raw material availability on tool assemblages concentrate on the proximity of raw material source. Specifically, whether a material is local or non-local will determine the degree to which a tool is resharpened (Rolland and Dibble 1990; Dibble 1987; Kuhn 1991; Holdaway et al. 1996; Roth and Dibble 1998; Bamforth 1986; Andrefsky 1994; Munday 1976). It has been found that the retouch frequencies will be higher on tools such as scrapers and notches if they are manufactured from materials from distant sources, whereas local materials will show lesser retouch (Roth and Dibble 1998; Holdaway et al. 1996; Bamforth 1986). Bamforth (1986) also notes that broken tools tend to be from non-local sources while unbroken tools are from local sources. In sum, a scarcity of raw material encourages the re-use or resharpening, of tools (Kuhn 1991).

Physical Characteristics of Raw Material

For many sites, however, the proximity of material is not enough to explain assemblage characteristics. The physical characteristics of stone, such as shape and size of the raw material nodule or blank (Dibble 1985; Jones 1984; Kuhn 1991,1992; Ashton and White 2003; Jones 1978) affect the overall morphology of the tool as well. Jones (1984) argued convincingly that the physical form in which raw material is found is a key influence on tool form and typology. He suggested that eroded tablets of argillite were used opportunistically by Polynesian axe makers who exploited the naturally occurring angles of the material as striking platforms, thereby reducing the stages of manufacture which eventually resulted in a distinctive style of hand axe. In a study of Early British Paleolithic bifaces, Ashton and White (2003) found that ovate bifaces were formed on large nodules of high quality flint, whereas point bifaces were made on smaller, poor quality flint gravel.

As alluded to in the last sentence, physical characteristics are not limited to shape or size of the nodule but include the quality or texture of material as well. Different raw materials have been found to exhibit unique flaking characteristics which can limit the morphological outcomes of a tool and influence the degree to which a tool will be retouched (Jones 1978; Moloney 1988; Moloney et al. 1988). Moloney et al. (1988) found that coarser grained materials such as basalt and quartzite frequently succumbed to step fracturing which prevented further flaking of the material. Jones (1978) also noted that among materials such as quartzite, basalt and trachyandesite the coarser grain size inhibited the use of fine retouch. In the case of basalt and trachyandesite he found the unretouched edge of a primary flake was sharper than that of a retouched edge, and once a primary flake edge became blunted after use it could not be resharpened effectively. On the other hand, phonolite, a very fine-grained material, was easily flaked and dulled edges could be resharpened easily. In a more controlled experiment, Moloney (1988) found that different material types used in biface manufacture affected the amount of material removed during manufacture, the length of the tool's working edge, manufacturing time, form or morphology of the biface, the amount of cortex showing on the finished piece, and the symmetry of the object. He noted that flint underwent more reduction than the other materials, while flint, tuff, and basalt produced the longest working edges. It took approximately two times longer to manufacture bifaces out of flint and tuff than other materials, but the greatest variety of biface forms was achieved with flint. Fewer blows were required to remove a flake from flint and tuff than it did from basalt, but the finer grained materials were more susceptible to shattering and breakage. "Of all lithic types, granite and flint produced the highest numbers and greatest weight of usable flakes, while basalt produced the least" (Moloney 1988:58). Of the detached flakes over 90% of the flint flakes were recognizable as being byproducts of human activity while only 40% of volcanic tuff, granite and dolerite flakes were recognizable as human made. Only 30% or less of the diorite, Bunter quartzite, basalt and limestone flakes were obvious byproducts of human activity (Moloney 1988:58). Given that the mechanical properties, quality of cutting edge, and number of usable flakes vary according to raw material type, there is a need to consider the role of raw material when analyzing the characteristics of a tool assemblage. This is especially true if there are multiple material types present at a site.

In assemblages of mixed raw materials it would appear that peoples relied on certain materials for specific tool types. In the European Paleolithic quartz, quartzite and other coarse materials were not used for Levallois flaking but for denticulates, notches (Geneste 1989, cited in Rolland and Dibble 1990 and elsewhere) and other "ad hoc" tools (Rolland and Dibble 1990). Handaxes, racloirs, points, and Levallois preforms on the other hand were manufactured from fine grained, high quality materials (Rolland and Dibble 1990; Geneste 1989). It has been suggested that flaked tool technology is best served by homogenous and isotropic microcrystalline fine grained siliceous rock that fractures easily and predictably (Andrefsky 1998; Kooyman 2000).

Common igneous rocks used for flaked artifacts are typically those with high silica (SiO2) content such as dacite, rhyolite, felsite and phonolite (Bakewell and Irving 1994; Mallory Greenough et al. 2002a; Rapp 2002) and vitreous volcanic glass such as obsidian (Erlandson et al. 1992; Hutchings 1996; Kooyman 2000; Rapp 2002). Porphyritic rocks in which the mass of the rock is fine grained with inclusions of crystals (phenocrysts) were not uncommonly used for flaked tools. Tuff, a pyroclastic rock formed by very small (< 4mm) lithified volcanic fragments could also maintain ideal flaking properties (Rapp 2002:44). Fine grained clastic sedimentary rocks such as shale have appeared in the archaeological record in carved (Kooyman 2000), flaked (Fladmark 1990) and ground capacities. Siliceous shales (ranging from 60 – 85% silica) were very conducive to flaking or ground tool technologies (Rapp 2002). Chemical and biochemical/biogenic rocks with interlocking textures, such as chert (Carozzi 1993), were widely used in flake tools (Fedje 1996; Fladmark 1996; Kooyman 2002; Rapp 2002; Wilson 1996). Metamorphic rocks also appear in the archaeological record but tend to be limited to those that originated as sedimentary rocks. Argillite, a weakly metamorphosed shale, siltstone, or mudstone, was often used for ground stone tools but could also be flaked (Ackerman 1996; Kooyman 2000).

Given the numerous ways in which raw material can affect tool morphology it is an important variable to consider and document in tool typologies. Bisson suggests that:

> Because of the importance of the type and quality of lithic raw material to hypotheses that stress reduction history and raw material economy (Dibble and Rolland 1992 and elsewhere) and/or the influence of blank form on assemblage

> composition (Kuhn 1991,1992), recording the specific type and characteristics of the raw material of each tool is essential. Raw material should be characterized both mineralogically and, if possible, by geological source. The texture of the raw material types represented in the site should also be described (2000:32).

Despite an awareness of the ideal classificatory standards described above, raw materials do not always receive thorough investigation and description in archaeological reporting. As will be outlined in the following section, the degree to which raw materials have been described and recorded along the coast of northwest North America has varied.

Commonly used Raw Materials in British Columbia and Surrounding Area

Along the northwest coast and in parts of interior British Columbia there was a scarcity of high grade, fine grained, siliceous rock such as obsidian and chert. This resulted in a widespread reliance on coarser igneous materials such as dacite, andesite, and basalt (Bakewell and Irving 1994; Mallory-Greenough, Baker and Greenough 2002; Mason and Aigner 1987) which, nonetheless, retain predictable flaking qualities. This is not to say, however, that high grade materials did not exist. In fact, obsidian, chert, quartzite, and chalcedony have appeared in sites throughout British Columbia, but the quantity has usually been limited. Most people would have had to travel great distances to acquire obsidian, for example, which was available in isolated locations such as Suemez Island in the Alexander Archipelago, Alaska (Erlandson et al. 1992), the Rainbow Mountain region, Mt. Edziza (Fladmark 1984) or Oregon (Ackerman 1996; Carlson 1994, 1996). Other obsidian sources have been observed (Fedje et al. 1996) but they have not been associated with artifacts. Despite its geographic restriction, obsidian has been uncovered in small quantities at coastal sites in Alaska (Ackerman 1996; Erlandson et al. 1992), at Namu (Carlson 1996; Hutchings 1996) and other locations along the central coast (Apland 1982), on northern Vancouver Island (Chapman 1982) and in Barkley Sound (McMillan and St.Claire 2003). Such far-reaching occurrence suggests that obsidian was highly desired and obtained through exchange networks or long distance acquisition trips to source locations (Pokotylo 1988:3; James et al. 1996; Carlson 1994). The same could be said for nephrite which has localized sources along the central Fraser River in southern British Columbia but is spread throughout northern and central coast Salishan territory in southwestern British Columbia (Mackie 1995).

Chert and quartzite appear to be quite common in Rocky Mountain areas such as Banff National Park, where artifacts of these materials dominate the lithic assemblages (Fedje 1996). Chert is also fairly well established in northeastern British Columbia (Fladmark 1996; Wilson 1996) and is widespread in Alaska as well (Ackerman 1996; Malyk-Selivanova et al. 1998). In southeast Alaska the manufacture of microblades from obsidian, chert, and argillite has been documented (Ackerman 1996).

Most assemblages in British Columbia and Alaska, however, are dominated by flaked tools of igneous rocks in the basalt, andesite, and dacite range (Apland 1982; Bakewell and Irving 1994;Carlson 1996; Fedje et al. 1996; Fedje et al. 2001; Hayden et al. 1996; Mallory-Greenough, Baker and Greenough 2002; Mason and Aigner 1987). Reports from sites near Haida Gwaii, such as Namu on the central coast, have also emphasized the use of andesite, trachyte, and basalt, as well as slate and quartzite in the formation of macroliths but emphasize minimal evidence of chalcedony or black chert (Carlson 1996).

The majority of artifacts from Haida Gwaii have been classified as basalt or andesite believed to originate from local sources (Fedje et al. in press; Severs 1974). During the 1993 survey for the Gwaii Haanas Archaeological Project, archaeologists stated that the majority of flakes from sites at Arrow Creek 1 and 2, Richardson Island, Echo Bay, Hoya Passage, and Lyell Bay were basalt (Mackie and Wilson 1994). Occasional chert flakes were noted and at Arrow Creek 2 an agate microblade core was discovered (Fedje et al. 1996). Recent reports from the Kilgii Gwaay site stated that 95% of the flakes and tools excavated were of a high quality "basalt" and that cobbles and boulders of that material were available in the intertidal zone about ten kilometers from the site (Fedje et al. 2001). Similarly the artifact dredged from Werner Bay was classified as vitreous basalt (Fedje and Josenhans 2000).

Andesite has also been identified in intertidal sites on Moresby Island (Hobler 1978: Ackerman 1996). A recent summary of raised beach sites in southern Haida Gwaii states that lithic materials appear to be local examples of basalt, rhyolite, andesite and agate (Fedje et al. in press). Hobler noted that many artifacts discovered during his surveys of 1974 and 1975 were "large andesite cores and flakes many of which show evidence of Levallois-like core reduction techniques" (Hobler 1978:11). Ackerman concurred with Hobler's findings and added that some flakes and cores were manufactured of argillite (1996). Fladmark also noted the presence of argillaceous materials used in pebble and flake tools at Skoglund's Landing (1990).

On Richardson Island, Fedje and Christensen found tools made of a "tabular bedrock material" (1999). Magne presented preliminary classifications of Richardson Island materials on "the basis of gross macroscopic characteristics" (2004:105). He identified metamorphic and igneous materials in the assemblage such as basalt, argillite, rhyolite, quartzite, and rare materials such as chalcedony, agate, and chert.

While numerous materials have been identified throughout British Columbia, only a few reports outline the techniques for classifying the material and/or provide detailed mineralogical or chemical descriptions (Bakewell 1996; Bakewell and Irving 1994; Commisso 1999; Hayden et al. 1996; Mallory-Greenough, Baker and Greenough 2002; Magne 2004; Mason and Aigner 1987). Fewer still discuss the impact of raw material on tool morphology (Mackie 1995, Ackerman 1996). The majority of reports, especially those considering sites in Haida Gwaii, do not indicate means for classifying material and in the absence of published accounts of rock assessments, it is assumed that the majority of the above mentioned raw material classifications were based on informal visual assessment.

Yet, in many cases, raw material type is not pertinent to the question at hand. Often the studies are focused on establishing dominant technological trends and changes in the area, or are concerned with morphology, reduction strategies or use life of the artifact, leaving cursory references to raw material. At times, naming lithic raw materials may not be as important as identifying tool properties and characteristics (Andrefsky 1998) and to engage in a more detailed raw material analysis may seem an ill-placed allocation of effort and resources. In his analysis of chipped stone assemblages from beach sites on the central coast of British Columbia, Brian Apland (1982) found that about 95% of the assemblages were of fine grained igneous rock from the basalt-andesite range. However, he articulated "it would require a chemical and/or mineral analysis to distinguish between these two types, a procedure not performed since it was apparent that the material was chosen for its accessibility and fine-grained nature rather than its chemical composition" (1982:29). In this instance Apland found that a chemical analysis would not have enhanced his study more specifically related to tool classification and description. Additionally, he raises an important point: if people of the past were not employing chemical methodologies to distinguish rock types why should archaeologists concern themselves with such techniques? As will be demonstrated in the next section of this chapter, chemical analyses can be extremely useful in archaeology to avoid problems of misclassification, to allow for comparisons between sites, and to establish provenance to source.

Chemical Analysis of Lithic material in Northwest Coast Region

To generalize, it is the easily identifiable material with a restricted geological occurrence that is typically subjected to chemical analysis as the resultant data can help to identify the source of material. In British Columbia and Alaska the most widely characterized material has been obsidian due to the unique chemical signatures of its outcrops, restricted abundance, and identifiability (Ackerman 1996; Carlson 1994, 1996; Erlandson et al.; Fladmark 1984; James et al. 1996). As with most projects employing chemical analyses of stone, the intended outcome of the obsidian analysis was to link the material to source. Recently researchers have attempted geochemical analyses and sourcing of archaeological material with less chemical variation and wider geographic distribution than obsidian and have met with successful results (Bakewell and Irving 1994; Commisso 1999; Hayden et al. 1996; Mallory-Greenough, Baker and Greenough 2002, 2002b;).

Commisso (1999) used x-ray florescence (XRF) techniques to establish the uniqueness of the Arrowstone Rhyolite Quarry in central British Columbia on the basis of major and minor elements. Mallory-Greenough et al. (2002a) and Bakewell and Irving (1994) also exemplified the usefulness (and relative low cost) of inductively coupled plasma- emission spectrometry (ICP-ES) and inductively coupled plasma-mass spectrometry (ICP-MS) to source dacite artifacts in British Columbia. ICP-ES and ICP-MS are fairly recent applications to archaeology, although their potential usefulness has been cited in publications dealing with stone tool analysis (Kempe and Harvey 1983:43; Kooyman 2000:41; Kennett et al. 2001).

In an attempt to differentiate the types of chert, chalcedony and quartzite at Keatley Creek, Hayden et al. (1996) employed progressively more sophisticated petrographic analyses before establishing five distinct rock types. This was a necessary procedure as the chert and chalcedony appeared to have a patterned existence from house to house at that site. Initial differentiation was conducted on a macroscopic level with artifacts distinguished on the basis of visual and textural properties. One author (Hayden et al. 1996) differentiated 34 types according to colour and texture. A geologist then established two major chert types and several minor types, a chalcedony, and a quartzite while another co-author distinguished 32 varieties. The discrepancies between classifications were attributed to "differences in texture, colour, and luster . . . apparently created by weathering or cortical surfaces, post depositional alterations of debitage, and culturally induced changes in colour and luster, especially due to heating, whether by accident or part of manufacturing techniques" (1996:346). Thin section analysis allowed the researchers to narrow the classification to three chert-like materials (jasperoid, pisolotic chert, and vitric tuff), plus a chalcedony and a quartzite. This classification was confirmed by subsequent Inductively Coupled Plasma Emission Spectrometry (ICP-ES) which aided in the discovery of nearby sources for some of the materials (Hayden et al.1996).

While Bakewell and Irving, and Mallory-Greenough et al. have demonstrated the usefulness of chemical analysis for sourcing materials such as basalt and dacite, their research also came with a warning for archaeologists and geologists using non-chemical petrographic methods to establish artifact rock types. Mallory-Greenough et al. (2002a) noted that artifacts often described as basalt in archaeological reports were in fact dacite, trachydacites, or rhyolites. Similar conclusions had been reached by Bakewell and Irving (1994) who stressed that "failure to combine geochemical analysis with petrographic examinations of lithic remains [had] led to widespread error and confusion in the classification and sourcing of stone used in the manufacture of projectile points, knives, scrapers, and other chipped stone artifacts" (1994:29). Petrographic analyses alone had led to classification errors in the San Juan Islands, the Aleutian Islands, the Canadian Plateau, and the Olympic Mountains. In the San Juan Islands artifacts classified as basalt were primarily dacite (Bakewell and Irving 1994). In the Aleutian Islands the artifacts classified by Mason and Aigner (1987) as basalt on the basis of thin-sections were more correctly identified as specimens of andesite by Bakewell and Irving (1994). On the Canadian Plateau artifacts of vitreous basalt and felsite basalt (Magne 1979, cited in

Bakewell and Irving 1994) were more accurately classified within the dacite to rhyolite range according to their high silica content (Bakewell and Irving 1994). And in the Olympic Mountains artifacts established of basalt/andesite were better classified as dacite (Bakewell and Irving 1994).

For many these distinctions are not a concern, yet for researchers interested the material itself, comparisons between sites and potential sources are difficult to establish when classificatory methods are not consistent. In fairness, geologists, like archaeologists, often face difficulties distinguishing between rock types when using visual assessment alone. In speaking with a geologist recently (Nelles 2004), he articulated the difficulty he faces when his children pick rocks up off of the beach and ask him to identify them. The pebbles, usually well rounded from battering on the shore, show little or no trace of the distinguishing features of the geological formation from which the rock originated. Out of context, assigning an accurate name to the rock can be complicated, especially if the material is fine grained. Archaeologists face similar problems.

Issues Associated with Raw Material Classifications

Most archaeological lithic materials used for flaking are fine grained, microcrystalline, or cryptocrystalline in texture. While the fine grain size allows for controlled and predictable flaking for the flintknapper, this quality can make rock identification for an archaeologist complex, especially when relying on macroscopic qualities alone. To assign such rocks to a generic rock category (e.g. igneous, metamorphic, or sedimentary) much less a specific rock within that group, becomes very difficult. Without knowledge of the geological context from which a lithic material originates, a piece of fine grained darkish rock could be a chemical precipitate (thus sedimentary), a siltstone or mudstone subjected to intense heat and pressure such as slate or argillite (metamorphic), or an extrusive volcanic rock that cooled rapidly thus inhibiting crystal growth such as a basalt (igneous). Perhaps if the rock were found in its original geological setting amidst contact margins, outcrops or exposed banks, we could assign it to a group with more confidence. But, a flaked artifact bearing scars and bulbar fissures of previous reduction events which may have blurred the visible signs of bedding planes and cortex, makes our task of rock identification all the more difficult. Thus, petrological (thin sections) and chemical analyses add a degree of confidence in interpretations of rock type, with geochemical data potentially being the most useful in an archaeological setting.

Mallory-Greenough et al. (2002a) cite two important advantages of using geochemical data over petrographic descriptions. First, great skill is required for "accurate petrographic descriptions of rock samples – skills that most archaeologists (or for that matter, geologists) do not posses" (2002a:54). Second, "geochemical data are much more definitive in their source characterizations" (2002a:54) should the archaeologist wish to extend the utility of the chemical data beyond pure classification.

However, a sole reliance on chemical techniques for raw material classifications is not yet possible. While igneous rocks are well understood and easily classified on the basis of elemental data (Le Bas et al. 1986; Le Maitre 2002; Pearce 1996), sedimentary and metamorphic rocks have more variable chemical compositions as they originate from igneous, sedimentary or metamorphic parentage. While both sedimentary and metamorphic rocks have been subjected to a barrage of chemical tests there have been fewer attempts to create classification schemes for these materials based on chemical composition alone. An exception would be among clastic[1] sedimentary rocks, for which such diagrams have been established according to major element compositions (Pettijohn et al 1972; Herron 1988).

Given the highly variable chemical compositions of the three major rock types, they are best differentiated on combined textural and compositional properties. Texture refers to the size, shape, porosity, and spatial distribution of minerals within the rock mass and can be assessed visually (macroscopically), while composition reflects the mineral, and hence chemical, makeup of the rock. Combining these features allows the overall rock type classification to be established. However, as with divisions between stone tool morphologies, the boundaries between rock types are not absolute, and subclasses form continua within each major rock type. For example, within the igneous designation, a basalt grades into andesitic basalt, which grades into andesite, then dacite and so forth as the silica percent increases. The classification of sedimentary rocks changes with grain size, and the type of metamorphic rock depends on how much it was

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[1] Clastic sedimentary rocks are composed of pre-existing rock fragments. When consolidated clastic rocks can be broadly categorized as conglomerates, sandstones and shales.

subjected to altering mechanisms of temperature and pressure. Thus, a shale will become an argillite, then a slate, then schist followed by gneiss, as temperature and pressure increase.

Similarly, when texture and composition are considered independently of one another, the igneous, sedimentary, and metamorphic attributes have potential to overlap. A flake of aphanitic basalt when examined with the naked eye may resemble a flake of shale or argillite, which is also fine grained. Similarly, the chemical compositions of some lutites[2] and volcanic rocks may also overlap (Garrels and MacKenzie 1971). In sum, the classification of rock is not straightforward and the informal macroscopic approaches that archaeologists rely upon can result in contradictory categorizations.

Given that archaeological raw materials are found out of their original geological contexts, and that thin sections require specialized skill to be effective, chemical analysis may be the most useful tool for establishing rocks types from an archaeological assemblage. The use of chemical techniques ensures classifications are replicable and consistent among researchers, which in turn allows for raw material comparisons between sites.

Benefits of Chemical Analysis to Archaeology

In summation, while the peoples of prehistory may not have selected materials according to chemical composition, we as archaeologists have much to gain from such knowledge. At the most basic of levels we can achieve consistency in our classificatory methods. Additionally, the chemical fingerprint of the rock itself can allow us to trace these materials to their point of origin. Archaeologists are not able to witness activities of the past, but there are clues which do help us to see the most general of movements throughout the landscape. Sourcing, for example, has allowed us to reconstruct trade networks of exotic materials such as obsidian (Tykot 2003). Yet, conceivably, we may be able to source more commonly occurring materials as well. Such information would enable us to test our assumptions that materials were collected for reasons of proximity or determine whether other social practices were influencing material use. By way of example we return once again to the statement, "it was apparent that the material was

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[2] Lutites are a group of rocks that include claystone, mudstone, shale, argillite and slate (Garrels and MacKenzie 1971).

chosen for its accessibility and fine-grained nature rather than its chemical composition" (Apland 1982:29). At an interpretive level, to assume archaeological materials were collected for their accessibility (assumed to reflect close proximity) and superior qualities, imposes our ideals of economic efficiency and optimality onto the archaeological record. This assumption may mask cultural preferences and social activities that could have influenced material acquisition, use, and finally deposition.

Ironically, the ideals of optimal rationality we expect to see in the archaeological record are not well practiced in our own society. Ownership rights, property restrictions, and cost are but a few factors that affect resource use in our market economy. Frequently individuals will endure a lengthy journey to the grocery store to acquire provisions (commonly originating from out of country) when there may be produce of exceptional quality in their neighbour's yard. Yet to extract these resources from the nearer location could garner social stigma. Definitively speaking, buying produce at the grocery store is more accessible than thieving from the neighbour's yard, thus *accessibility* becomes a culturally determined term.

What does accessible mean to the peoples of another culture? Does ease of procurement always determine material use in a foreign context? In an Australian ethnoarchaeological project, Gould (1980) documented the aborigine's use of a white chert for adze manufacture 60.7% of the time. White chert was located at five quarries between 23 and 32 kilometers away from the base site and was used predominantly in adze manufacture even though suitable, albeit less durable, materials, existed closer by. In addition, 26.7% of adzes were manufactured from exotic materials (from distances greater than 40km from the base site). These materials did hold a flaked edge more readily than the other materials nearby but "their edge-holding abilities [were] so much poorer than white chert, and their efficiency in relation to procurement [was] so low, that the fact that 26.7 percent of the adzes at Puntutjarpa were made from this kind of stone [had to be] regarded as a significant anomaly" (Gould 1980:149). Such intense use of these exotic materials could not be explained by ease of procurement or efficiency of use but was attributed to risk-minimization and maintenance of family ties over the desert landscape. Adzes of exotic materials symbolized the connectedness to distant locations that could be drawn upon in times of stress. Social factors, as opposed to immediate economic efficiency, guided the material use.

These contemporary examples demonstrate the complexities of resource use. We cannot hope to generate easily an emic understanding of the motivations for material use in the archaeological record, but chemical analysis can illuminate patterns in the archaeological record that contradict economically optimal uses of stone. To refer again to the Keatley Creek site, Hayden et al. (1996) provide a cogent example of how raw materials were patterned differently between house pits. The authors suggested that residents of these separate houses maintained distinct resource exploitation patterns between corporate, and possibly family, groups. This example considers economic motivations but other cultural factors such as familial relationships, politics, and even spirituality cannot be ignored as forces driving material patterning. Rapp and Hill (1998) also cite an excellent example from Egypt in which the quartzite used to construct the Colossi of Memnon was sourced using instrumental neutron activation analysis (INAA) to a quarry 676 kilometers downstream. Macroscopic assessment of the quartzite had resulted in the identification of six potential source locations, one of which was located only 200 kilometers upstream. Thus, while peoples of the past did not collect materials according to their chemical composition, archaeology can benefit greatly by applying chemical methodologies to studies of raw material.

Implications for Richardson Island

Raw material has the potential to influence the archaeological record in many ways and there are multiple methods available for exploring the effects of raw material on tool assemblages. To date, artifacts in Haida Gwaii have been described as being manufactured from basalt, andesite, chert, agate, tabular bedrock, vitreous basalt, argillite and argillaceous material (Ackerman 1996; Fedje et al. 1996, 2001, in press; Fedje and Christensen 1999; Fedje and Josenhans 2000; Fladmark 1990, Hobler 1978; Magne 2004; Severs 1974), yet the techniques employed for classifying these material types have not been formally presented. Given the positive results and interpretive depth raw material has added to archaeological investigations worldwide, it could be a fruitful avenue of inquiry in Haida Gwaii where archaeological research is still relatively recent. As will be discussed in the following chapter, Richardson Island is an excellent location from which to begin enquiry into raw material use in this region. Unfortunately not all aspects of raw material outlined in this chapter can be studied in the context of this thesis. Thus, research here is limited to a classification of raw material types using macroscopic assessments of stone, electron microprobe analysis (EMPA), laser ablation-inductively coupled-plasma mass spectrometry (LA-ICP-MS) and geological discrimination diagrams. The established rock classifications are then used to comment on potential source locations on and surrounding Richardson Island, and a preliminary exploration into the relationships between raw material and tool types is conducted on five artifact types; bifaces, scraperplanes, microblades, unimarginal tools and scrapers.

CHAPTER 3

Richardson Island: Context and Site Description

Archaeological Context of Haida Gwaii

Haida Gwaii has been relatively untouched by the advances of urbanization. In recent years this unspoiled land has been identified as a zone of exceptional archaeological significance and promises to reveal much about the ancestral Haida's[3] way of life. Paleoenvironmental reconstructive efforts in the Gwaii Haanas National Park Reserve and Haida Heritage Site (henceforth 'Gwaii Haanas') have pointed to the existence of archaeological sites older than 9,000 BP[4] in the Queen Charlotte Islands.

By 13,000 BP much of the British Columbia coast was ice free (Fedje and Christensen, 1999), yet with the retreat of the glaciers came another significant environmental change, that of prolonged sea-level fluctuation. At 12,400 BP in Haida Gwaii, sea level was approximately 150 meters lower than it is today due to the lingering glacial isostatic and eustatic changes (Fedje and Josenhans 2000). Between 12,200 and 10,800 BP sea level began to ascend at a rate of almost two centimetres per year. At about 10,800 BP, however, marine transgression became more rapid, and sea levels escalated at a rate of greater than five centimeters per year for the next 2,000 years (Fedje and Josenhans 2000). At that point sea level stabilized for a brief period before beginning a very slow regression over the next 4,000 years. It then embarked on a slightly more rapid descent which continued until the sea reached present day levels about 1,000 BP (Fedje and Josenhans 2000). See figure 3.1.

Thus at around 9,000 BP sea level reached heights of up to 16m above present day levels in the Queen Charlotte Islands. As sea level passed the modern high tide line at circa 9,400BP, there is potential to find archaeological sites of this age and younger on

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[3] At present it is unknown as to whether all archaeological sites in Haida Gwaii were inhabited by ancestral Haida or pre-Haida peoples. However, Haida mythology and oral history refer to a period before the great flood and Haida members identify with being in the area since the beginning of time. Additionally, the geographic isolation of the archipelago in post glacial times would have dissuaded visitation from less adept sea-faring peoples. In lieu of evidence suggesting otherwise, my predilection is to associate the archaeological record in this area with the Haida Nation.

[4] Dates are given in uncalibrated C^{14} years before present.

land, while older coastal settlements are likely to be submerged. Yet, even those sites below sea level may be within reach as Fedje and Josenhans have demonstrated with their discovery of a stone tool and two in-situ tree stumps on a drowned delta flood plain at depths of 53m and 143m (2000).

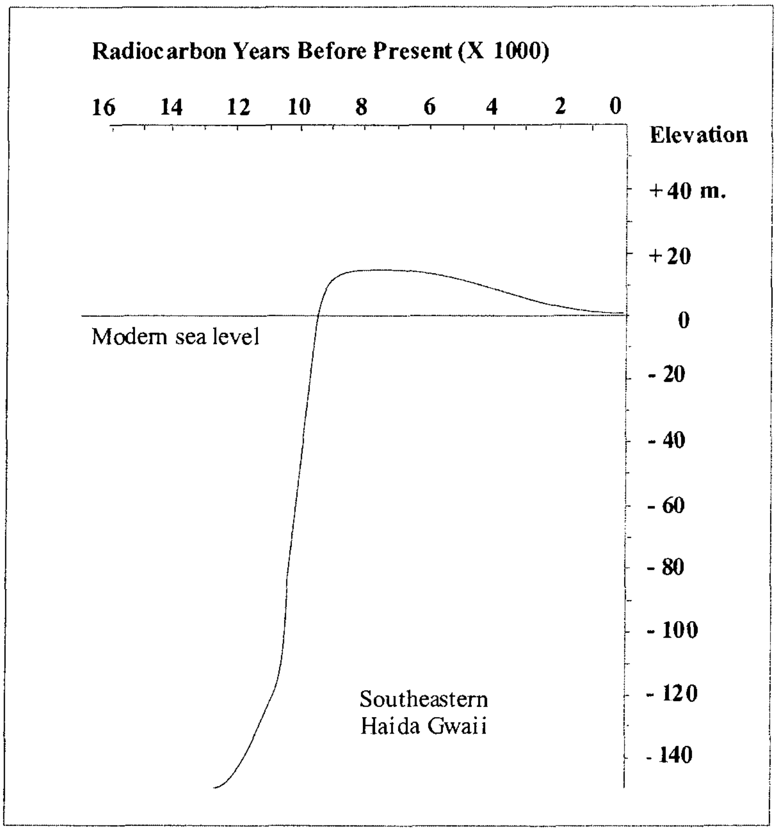


Figure 3.1 Gwaii Haanas relative sea-level curve. (Modification of image in Fedje and Josenhans 2000)

Paleoenvironmental reconstruction such as that mentioned above has allowed for the identification of numerous archaeological sites in Haida Gwaii. While most of these locations have not yet been excavated, knowledge of their locations high above and far below the modern tide line, as well as within intertidal locations, strengthens the proposition that the coast acted as the primary conduit for peoples migrating into the Americas. The oldest known archaeological site in Haida Gwaii is that of K1 cave which dates to 10,500 BP (Fedje et al. 2004). Additionally, the Richardson Island raised beach site dating to 9,300 BP and the intertidal site Kilgii Gwaay which dates to 9, 450 BP

(Fedje et al. 2001), both indicate that the people were well adapted to their environment and had likely been self-sufficient within the archipelago for thousands of years.

Culture History

The cultural historical sequence for Haida Gwaii can be divided into five phases based on current archaeological evidence: Pre-9500 BP, Kinggi Complex (circa 9,500 to 8,900 BP), Early Moresby Tradition (8,900 to circa 8,000 BP), Late Moresby Tradition (8,000 to 5,000 BP), and the Graham Tradition (5,000 BP to historic times) (Table 3.1 and Figure 3.2). At present, there are two sites that date to pre-9,500 BP. As mentioned above, K1 cave located in north eastern Haida Gwaii is the oldest site in the area. At this location two basally ground, bifacially flaked projectile points have been found in association with faunal remains dating to 10,500 BP (Fedje et al. 2004). In Juan Perez Sound, Fedje and Josenhans (2000) dredged a flake stone tool from 53 meters below present day sea-level and was assigned an age of 10,000 BP on the basis of the established sea-level curve for the area. Given the sparse number of artifacts from this time period it is not yet possible to identify technological characteristics within the archaeological record that may identify a distinct pre-9,500 BP cultural historical phase. Additionally, the unique contextual settings of these artifacts preclude them from being assigned to the established Kinggi Complex. Much more is known, however, about the post 9,500 BP deposits.

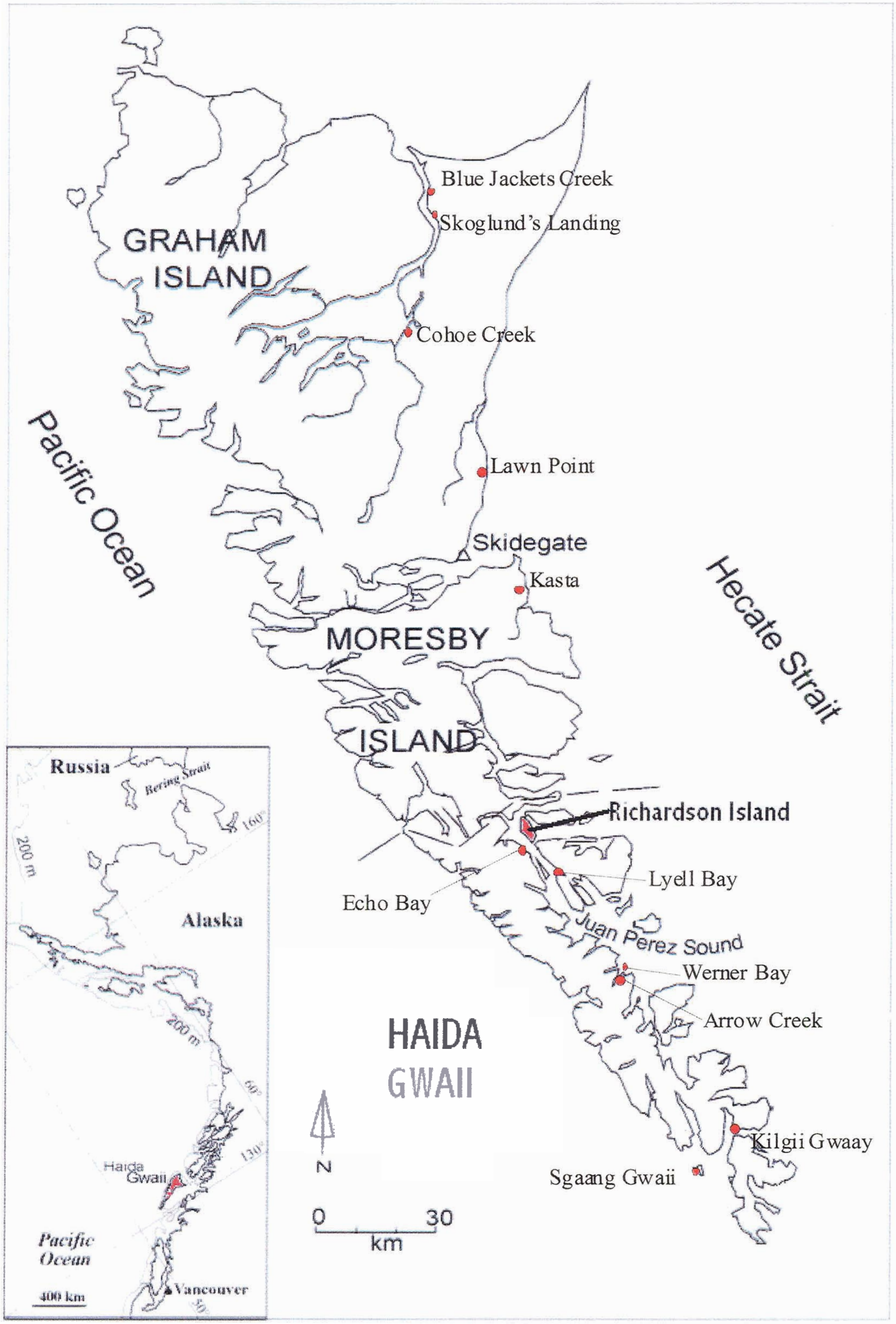
Thus far it appears that technological trends in Haida Gwaii resemble those traditions established for the rest of coastal British Columbia. The Old Cordilleran Tradition, recognizable in B.C. for its prevalence of bifaces and large stone tools (Matson and Coupland 1995), is mirrored in Haida Gwaii from before 9,500 BP-8,900 BP in what has been termed the Kinggi Complex (Fedje and Christensen 1999). The Kinggi Complex is found in the Richardson Island (Fedje and Christensen 1999; Magne 2004; Fedje et al., in press; Mackie et al. in prep.) and Kilgii Gwaay sites (Fedje et al. 2001) located on Moresby Island.

From 8,900 BP-8,000 BP in Haida Gwaii there is the emergence of microblades in the archaeological record. This addition of microblade technology to the Kinggi Complex has been termed the Early Moresby Tradition (Fedje and Christensen 1999) and

Table 3.1 Culture-Historical Sequence for Haida Gwaii (after Mackie n.d)

C-14 YEARS BEFORE PRESENT AND ENVIRONMENTAL CHARACTERISTICS	ARCHAEOLOGICAL TIME PERIOD AND CHARACTERISTICS	IMPORTANT SITES.
5000 - historic Sea level falling slowly towards present from high stand of about 15m above current. Environment similar to today; cedar climax forests develop around 3000 BP	**Graham Tradition** Large and small shell middens, emphasis on bone and antler tools, simple flaked stone, ground stone tools, houses; strongly marine focused economy especially salmon, halibut, rockfish, seals and sea birds. Way of life leads towards Historic Haida culture. (Notable references: Fladmark 1990; Mackie and Acheson, in press; Severs 1974)	Blue Jackets Creek, Skoglunds Landing, Honna River, Historic Towns such as Sgan'gwaii, Hiellen
8000-5000 Sea level stable at ca. 15 m above present therefore most known sites are on "raised beach terraces" in the forest. Spruce-Hemlock forest well established but little or no cedar.	**Late Moresby Tradition** Microblade technology, large scrapers. Cohoe Creek midden shows marine focus and maritime capable adaptation. Bone technology known, including slotted antler points. (Notable references: Fladmark 1986; Magne 2004; Christensen and Stafford 1999, in press; Fedje et al. in press)	Lawn Point, Kasta, Arrow Creek, Cohoe Creek, Lyell Bay
9000-8000 Sea level achieves maximum around 9000 years ago, stabilizes at ca. 15 metres above current. Slightly warmer and drier than today.	**Early Moresby Tradition** Mixed microblade and biface technology, large scrapers, spokeshaves, etc. Fauna from Echo Harbour and Richardson beaches shows use of sea otter and marine species. A poorly known period, with the mixture of bifacial and microblade technologies still to be explained. (Notable references: Fedje and Christensen 1999; Fedje et al. in press; Magne 2004)	Richardson Island, Echo Harbour, Lyell Bay
>9500 to 9000 Sea level rapidly rising from ca. 12500 BP to 9000 BP; total rise around 150 metres. Dynamic landscape change especially shoreline location and resources.	**Kinggi Complex** Bifacial technology, large scrapers, bone tools, wooden wedges, twine, basketry?, diverse marine-focused economy plus black bear exploitation. Period when sea level was rapidly rising. (Notable references: Fedje and Christensen 1999; Fedje et al. 2001; Fedje et al in press)	Richardson Island, Kilgii Gwaay, Arrow Creek 2
Pre-9500 Rapidly rising sea levels. Glacial period ends ca. 15000 years ago. Haida Gwaii incompletely glaciated. Tundra like environment, first trees are pines around 12500 years ago. Rooted pine tree known from 143 m below modern sea level.	Little known archaeologically, except for stone tool found on sea floor in Werner Bay, Juan Perez Sound and two bifacially flaked projectile point fragments found in K1 cave. Environmental data suggests Haida Gwaii was larger than present, and available to large mammals by 14000 BP. It is known SE Alaska occupied by 10,300 BP at least, and Americas by 12,500. People could have arrived very soon after the last ice age or spent the last ice age in a locally unglaciated area: the Hecate Refugium.	Werner Bay, K1 Cave (Notable References: Fedje and Josenhans 2000; Fedje et al. 2004).

Figure 3.2 Selected archaeological sites in Haida Gwaii. Modification of image created by Daryl Fedje, Parks Canada.



continues until 8,000 BP. The Richardson Island and Lyell Bay sites (Fedje and Christensen 1999, Fedje et al. in press, Magne 2004) represent this period in the culture-historical sequence. It was during the Early Moresby Tradition that sea-level stabilized.

At 8,000 BP, artifacts from Haida Gwaii sites indicate yet another shift in technology may have occurred. While further archaeological evidence is required, it appears that the number of bifaces begins to dwindle towards disappearance while microblades and unifacially flaked stone tools dominate the archaeological record. This phase, termed the Late Moresby Tradition, persists until about 5,000 BP (Fedje and Christensen 1999, Fladmark 1982) and closely resembles the Early Coast Microblade Tradition of the wider Northwest coast region which is known for its absence of bifaces. Sites assigned to the Late Moresby Tradition include Lawn Point, Kasta (Fladmark 1986), Arrow Creek, Lyell Bay (Fedje et al. in press; Magne 2004), and Cohoe Creek (Christensen and Stafford 1999).

The more recent Graham Tradition which spans 5,000 BP to historic times sees an emphasis on bone and antler tools. The role of stone in the assemblage is restricted to ground tools and simply flaked pieces of stone. Blue Jackets Creek (Severs 1974) and Skoglund's Landing (Fladmark 1990) are two important sites assigned to the Graham Tradition as are more recently occupied villages such as Tanu and Sgan'Gwaii (Mackie and Acheson in press).

The Transition from Kinggi Complex to Early Moresby Tradition

In Alaska a similar technological phase to the Kinggi Complex has been established where assemblages composed of bifacial projectile points and larger stone implements, yet free of microblades, has been termed the Nenana Complex. This northern tool tradition spans 11,800 BP-10,600 BP and appears to be succeeded by the Denali Complex. The Denali Complex is identified by the introduction of a microblade technology, of which small wedge-shaped microblade cores are the most distinctive form. Like the Early Moresby Tradition in Haida Gwaii, the Denali Complex is a mixed assemblage as it also contains macroblades, burins, bifacial knives and scrapers (Powers and Hoffecker 1989; West 1996). It is still unresolved as to whether the technological shift towards microblades in both Alaska and Haida Gwaii is due to differences in site function or is representative of preference for a new tool kit. If indeed representative of a new tool kit, it is unclear whether the shift was instigated by the diffusion of other peoples or whether it developed in situ (Fedje et al. in press; Magne 2004).

In the Queen Charlotte Islands the shift from Kinggi Complex to the Early Moresby Tradition has been well documented at the Richardson Island archaeological site, 1127T (Fedje and Christensen, 1999; Fedje et al. in press; Magne 2004). This unique locale encompasses a remarkable stratigraphic sequence (to be discussed in more detail in a later section of this chapter) that has allowed archaeologists to date the microblade emergence to 8900BP. Additionally the volume of artifacts recovered is allowing trends in artifact morphology to be refined (McLaren et al. n.d.) so that questions such as the ones above can be addressed. Yet despite the amount of research focused on stone tool traditions in Haida Gwaii, few studies have considered the role of raw material in the production of these artifacts. Some researchers have suggested that microblade development could be a response to raw material scarcity initiated by a rise in sea level and increased floral cover (Fedje et al. in press) but as sourcing studies in Haida Gwaii have been absent thus far, such hypotheses remain tentative. At the site level, raw material has been little considered. One exception is the recent work at the Richardson Island site by Magne (2004) who uses raw material as one possible line of evidence for in-situ microblade development. The scarcity of raw material study in Haida Gwaii is understandable as intense research in the region is relatively recent and, like so much of the British Columbia coast, is relatively free of high grade flaking materials. However, as discussed in the previous chapter raw material has proven a fruitful field of inquiry in the broader discipline of archaeology and has the potential to be an insightful field of inquiry in Haida Gwaii.

Richardson Island Site Location

Richardson Island is located in the southern half of Haida Gwaii on the east coast of Darwin Sound (see Figure 3.3), and is near the northern boundary of the Gwaii Haanas National Park Reserve and Haida Heritage Site. The islands of Haida Gwaii are the traditional lands of the Haida Nation and archaeological sites ranging from recent to those exceeding

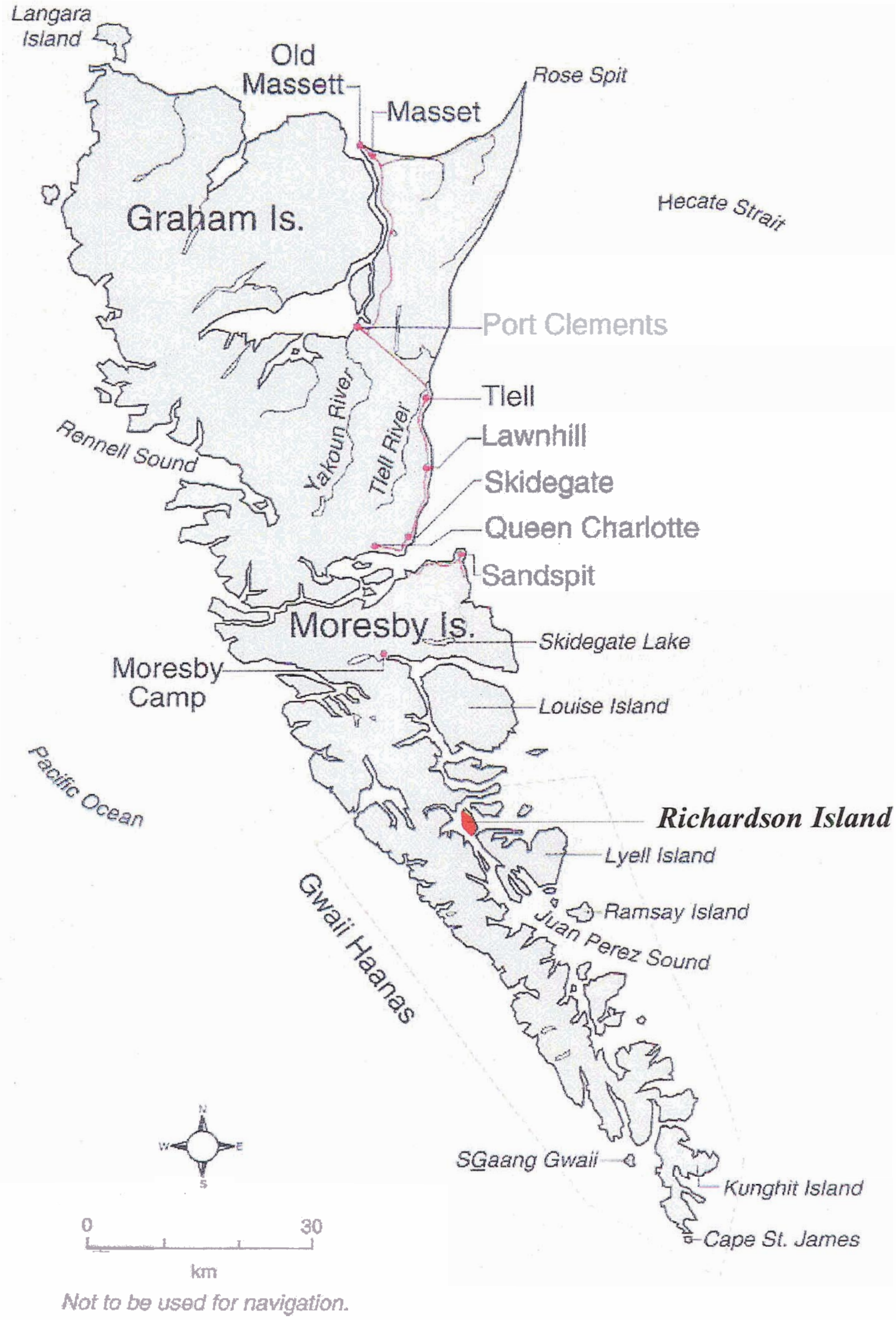


Figure 3.3 Map of Haida Gwaii showing location of Richardson Island. (Modification of image in Gwaii Haanas National Park Reserve and Haida Heritage Site: Visitor Handbook, P. 5)

10,000 years old, dot the landscape. The Richardson Island site, 1127T[5], is located about 17m above present day sea level and is on the west side of the island. As with much of the surrounding landscape of Haida Gwaii, the area immediately surrounding the Richardson Island site supports a healthy second growth temperate rain forest of alder, cedar, and hemlock. At the time in which the site was inhabited the area would have been newly forested with spruce and hemlock after being an herb-shrub tundra prior to 12,500 BP (Fedje and Josenhans 2000).

History of research at 1127T

The site was found in 1993 during an archaeological inventory survey for the newly proposed National Park. Numerous artifacts in the intertidal zone directed archaeologists to a small stream course. They followed the eroding artifacts upstream and found the site approximately 17 meters above sea-level. Initial 1m x 1.25m excavations by Parks Canada archaeologists in 1995 and a 1m x 1m excavation in 1997 indicated that the site was occupied from circa 9,300 – 8,500 BP (Table 3.2) (Fedje and Christensen 1999). In 2001 and 2002 a University of Victoria/Parks Canada team continued exploration in the area and opened a 3m x 2m unit (Mackie et al. in prep; Mackie and Smith 2003; Mackie et al. 2004). A test excavation also conducted in 2001, 20 m south on the raised terrace has yielded a date of circa 5,000 BP, thus indicating that a longer continuous occupation at this location is possible.

Site Formation Processes and Stratigraphy

Figure 3.4 presents a map of the site area and the location of the excavation units in relation to the present day shoreline. At the time of habitation, however, sea-level was approximately 15 meters higher and people would have been living at or near the water's edge. The earliest deposits at Richardson span the final centuries of sea-level rise in southern Haida Gwaii. At its most rapid, waters were rising 5-10 cm per year. The excavated portion of the site has also captured the onset of sea-level stabilization at about 8,900BP (Figure 3.5) which opens a unique window into how people not only lived in a dynamic environment but also how they coped with a major environmental change, in this case sea-level stabilization. In addition, the rapid rise in sea-level seems to have co-

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[5] 1127T is the archaeological site identifier which is assigned according to the Parks Canada designation scheme. The standard Borden unit system is not used within Gwaii Haanas, however, Richardson Island falls within unit FeTw.

Table 3.2 Radiocarbon Dates from Operations 10 and 12 at Richardson Island site, 1127T

CAMS #	Sample #	Material	Elevation[1] m (aht)	Depth[2] cm	Age	+/-
26262	1127T10J3-61	charcoal	18	61	8470	60
26263	1127T10N-108	charcoal	18	108	8640	60
26264	1127T10N-251	charcoal	18	251	8850	60
26265	1127T10S-325	charcoal	18	325	8700	60
26266	1127T10S-329	charcoal	18	329	8980	60
26267	1127T10S-347	charcoal	18	347	8960	60
26268	1127T10S-354	charcoal	18	354	9080	60
26269	1127T10S-374	charcoal	18	374	9160	60
39875	1127T12T18	charcoal	18	404	9290	50
39876	1127T12T20	charcoal	18	421	9290	50
39877	1127T12R21	charcoal	18	434	9590[3]	50

Note: Modification of Table 2 in Fedje and Christensen (1999:642)
[1] m (aht) = meters above high tide
[2] sample depth below sediment surface
[3] underlies raised beach, not associated with cultural material

occurred with a period of significant sediment accumulation thus creating a unique archaeological setting in which 800 years of human occupation have been stretched over 4.5 meters of deposits (Figure 3.6).

A total of 51 distinct layers were excavated in the four field seasons at Richardson. In 1995 the unit was initially excavated in arbitrary levels and concluded with excavation in natural layers. Those artifacts excavated in arbitrary levels were assignable to natural layers, or grouped layers for subsequent analysis. The excavations in 1997, 2001, and 2002 followed natural layers.

The site is underlain by a massive diamicton or debris flow (Fedje et al. in press) (Figure 3.7) above which a number of marine, terrestrial, and cultural events have deposited alternating layers of sediment. In Figure 3.6, the layers emphasized in red are likely upward tosses of beach gravel. The gravel is well rounded, well sorted, and consistently sized (roughly 30-50 mm in diameter). The north and south wall profiles (not seen here) also indicate a decreasing thickness in these gravel layers from east to west; that is as one moves further inland. Additionally, the few artifacts that are found in

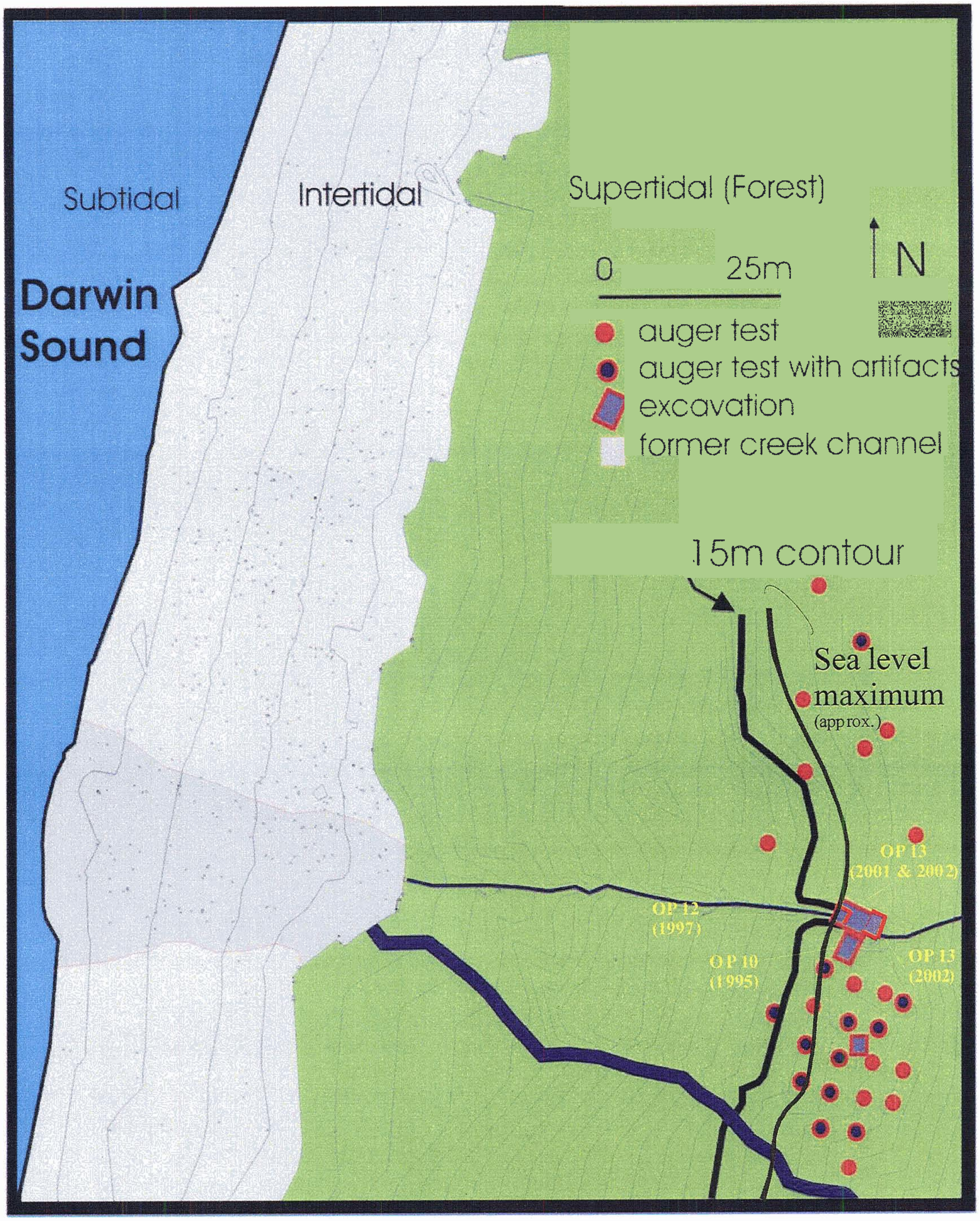


Figure 3.4 Map of 1127T Site Area
(Modification of original image created by Daryl Fedje, Parks Canada)

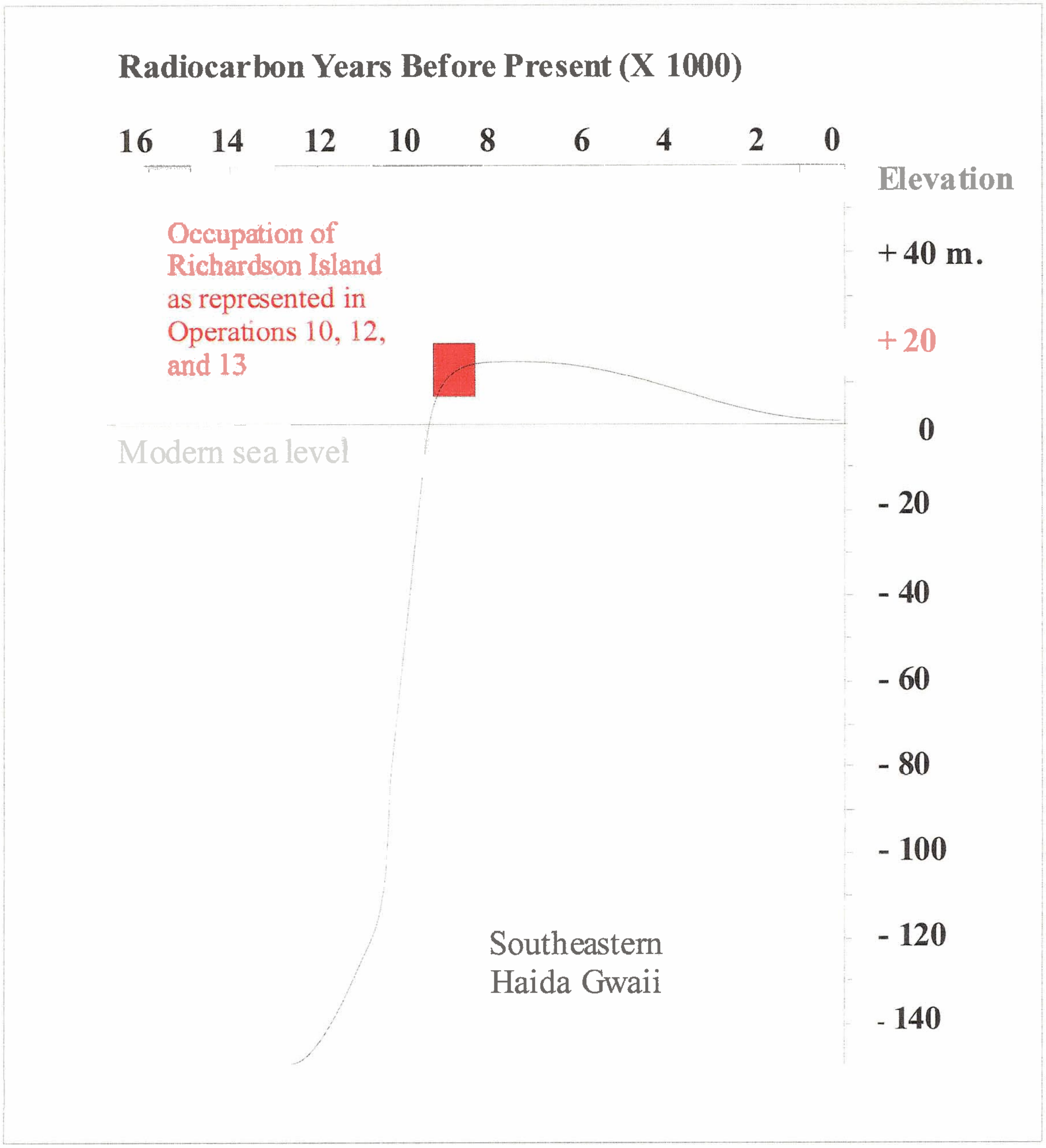
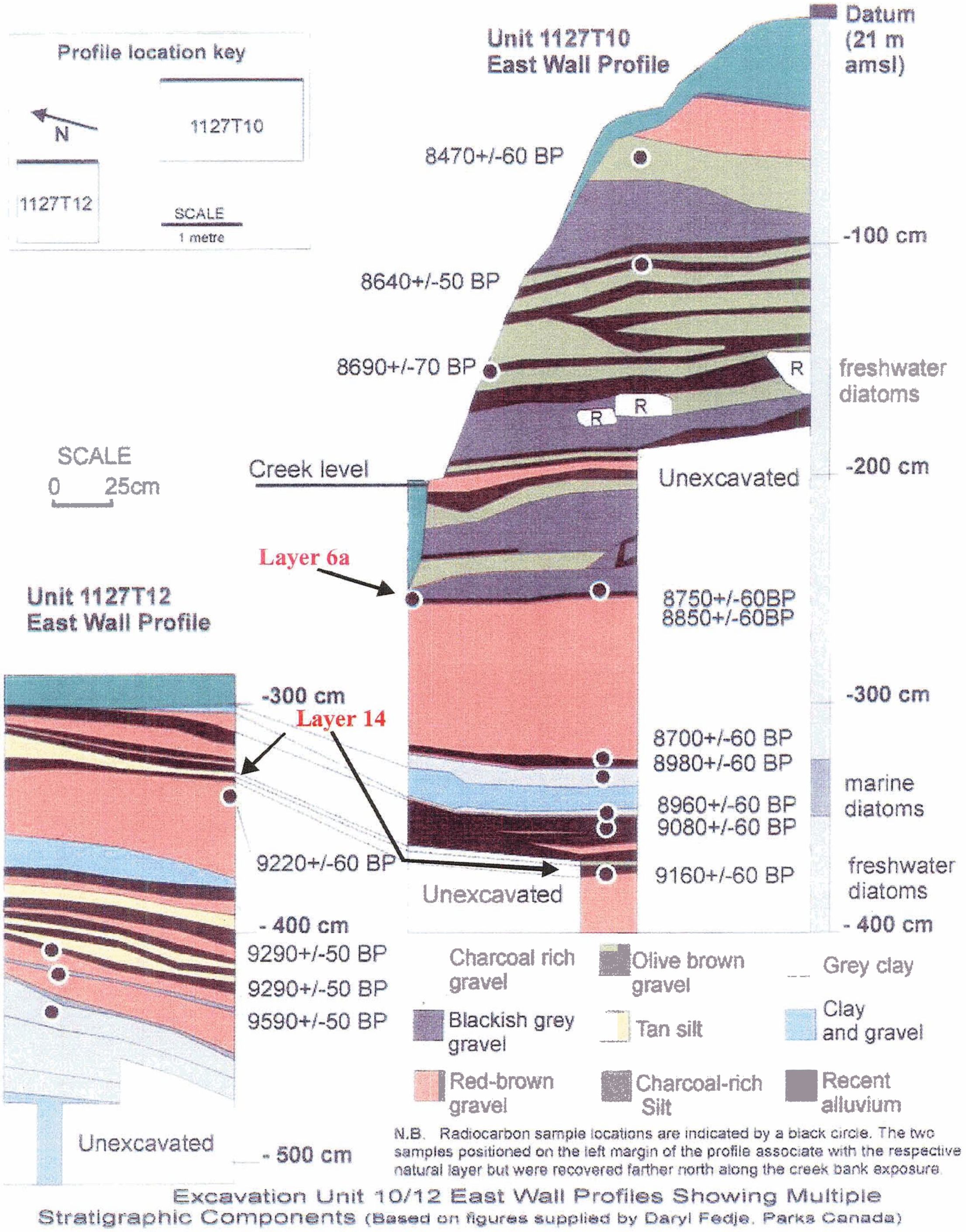


Figure 3.5 Gwaii Haanas Relative Sea-Level Curve and the Occupation of Richardson Island (Modification of image in Fedje and Josenhans 2000)



N.B. Radiocarbon sample locations are indicated by a black circle. The two samples positioned on the left margin of the profile associate with the respective natural layer but were recovered farther north along the creek bank exposure.

Excavation Unit 10/12 East Wall Profiles Showing Multiple Stratigraphic Components (Based on figures supplied by Daryl Fedje, Parks Canada)

Figure 3.6 Stratigraphic Profile of Operations 10 and 12, East Wall, at Richardson Island Archaeological Site 1127T. (Modification of image created by Daryl Fedje, Parks Canada).

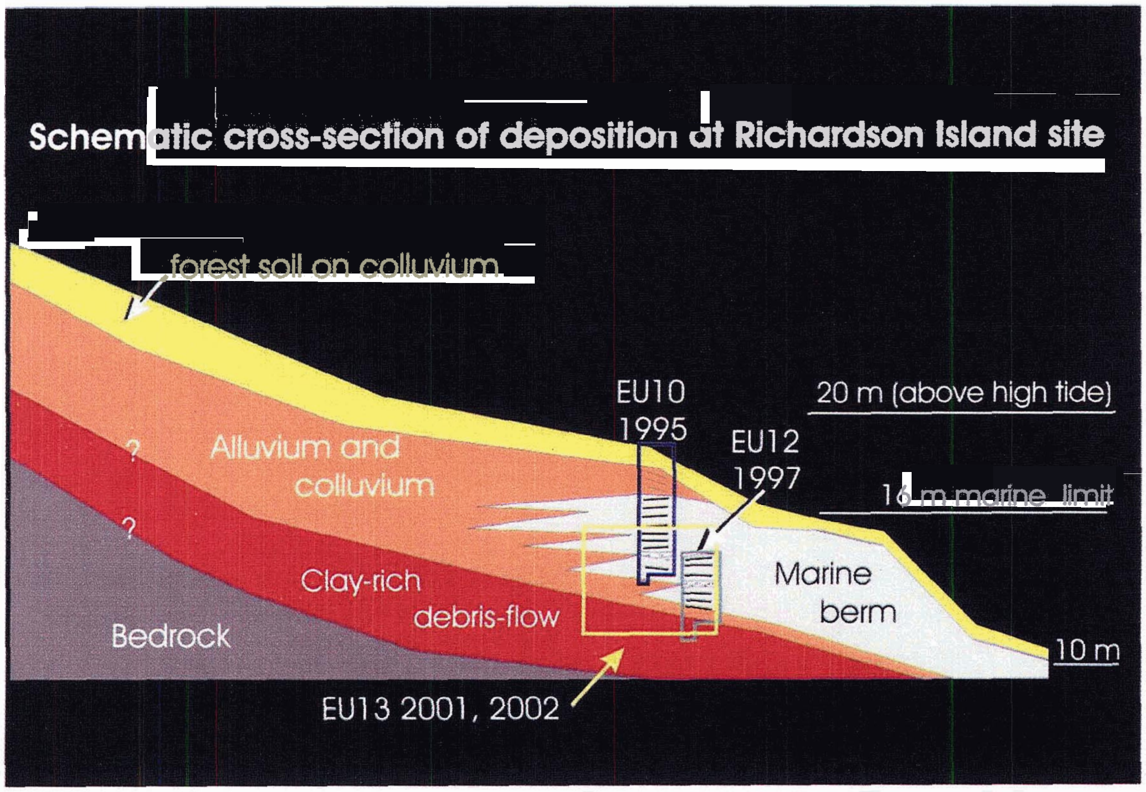


Figure 3.7 1127T site formation diagram. Image created by Daryl Fedje, Parks Canada. Reproduced with permission.

these gravel deposits are highly waterworn. These features argue for marine deposition and it is felt that the largest of these gravel deposits which occurred near the time of sea-level maximum, are examples of supra-tidal berm features (Fedje 2003). Flat topped berm features would have been (as they are today) desirable camp settings as they lack vegetation and are well drained. The yellow and grey layers in Figure 3.5 are likely resultant from terrestrial depositional processes. The silty layers above layer 6a are probably back of berm accumulations of sediment, whereas the silty and clay layers below appear to be downslope washes of clay, silt and mud. The exception would be at layer 14 where there does appear to be another back of berm accumulation present (not visible on this stratigraphic profile). Twenty-four cultural layers (shown in black on profile) were defined by greasy, charcoal and artifact rich soils and are interspersed throughout the terrestrial and marine depositions.

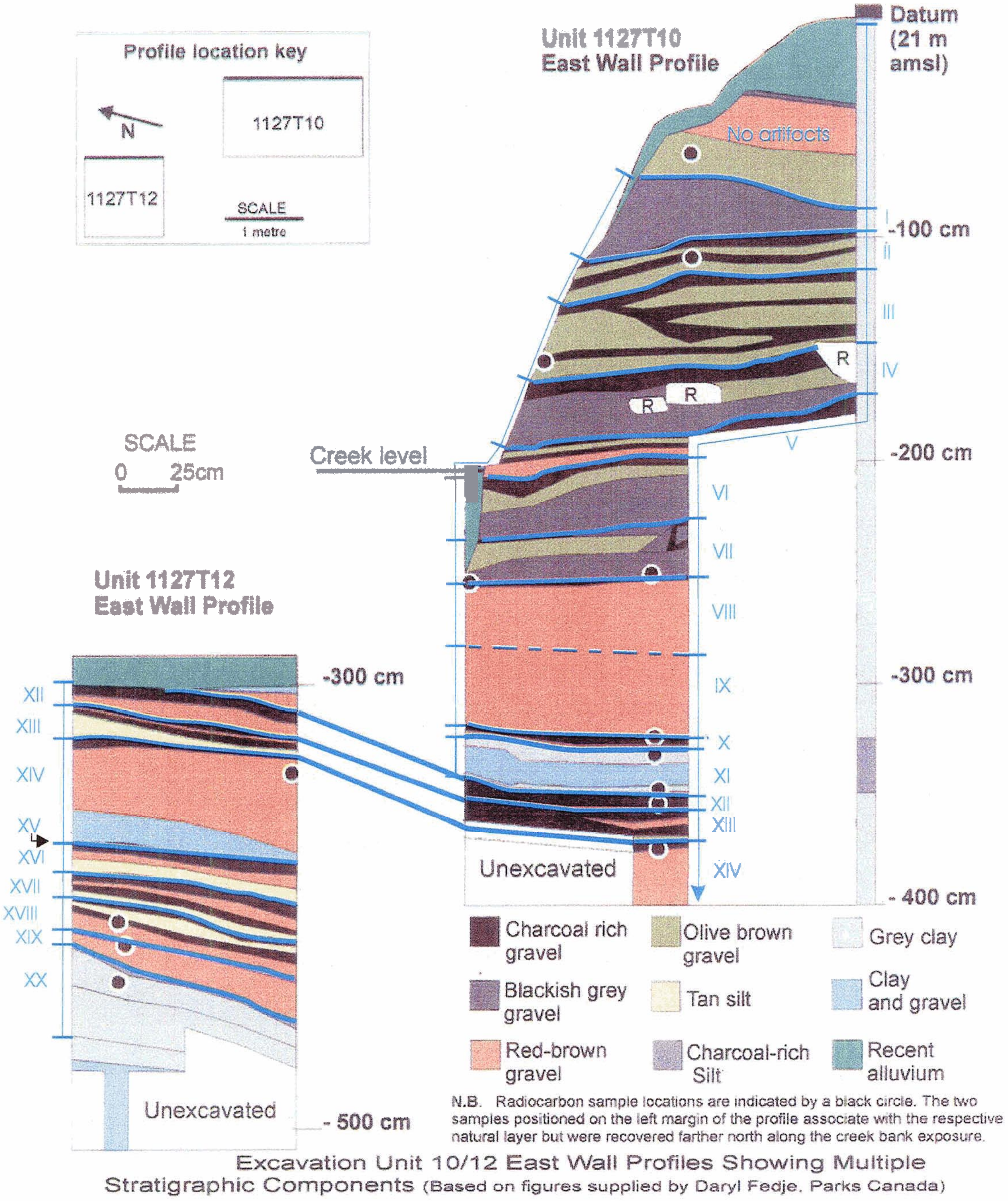
Each of the culturally and naturally deposited layers were interpreted as A, B, and C soil horizons. 'A' refers to the surface horizon and contains organic and mineral components (Tarbuck and Lutgens 1990). It is a former land surface with some vegetal and humic development, which may also have been anthropogenically altered. The cultural layers from the Richardson site were interpreted as the A horizons. In pedology, the 'B' horizon, positioned below A, and is often referred to as "the zone of accumulation" as it absorbs particles leached out of A; it is a transitional horizon (Tarbuck and Lutgens 1990). At Richardson, the B horizons also contain cultural material. It is believed that the artifacts appear within these horizons for various reason: 1) they are intrusive from A horizons in which trampling and anthropogenic activities have depressed artifacts into the underlying horizon, 2) some of the B horizons were briefly exposed surfaces that did not develop into distinct A horizons and 3) some of the B horizons contain marine deposited artifacts which are waterworn.

A typical 'C' horizon is characterized by slightly altered rock debris and very little organic material (Tarbuck and Lutgens 1990). The C horizons within the Richardson stratigraphy also contain artifacts which are redeposited from the beach or upslope. The majority of the stratigraphic layers were interpreted as A or B horizons, however, in a few instances a C horizon was also present. In the subsequent tool analysis, the 51 layers have been interpreted as A, B and C horizons in order to combine them into twenty independent depositional units (Fig 3.8) so that distinctly cultural surfaces and their subsurfaces are combined. While some stratigraphic resolution is lost, the depositional units still present detailed temporal resolution and the distinctions between strongly cultural layers are maintained.

The mention of storm tosses and mud washes conjures up images of destruction, however, these events were actually quite gentle and have sealed and protected the living surfaces from damage. Within these paleosols, hearth features, post moulds, structural features and artifact distributions do not seem drastically altered. Charcoal and calcine bone remain within hearth centers and numerous broken artifacts within layers can be refitted, as can some flakes and cores. Additionally, tools and flakes have retained their sharp edges. Preliminary analysis of three occupation layers revealed that well preserved living floors will allow us to separate functional differences between layers. For example, a "workshop" characterized by large tools, has been differentiated from what appears to be a food processing area in an earlier layer (Mackie et al. in prep). Such analyses are on going and full interpretation of all layers cannot be incorporated in this thesis.

Study Sample

As previously mentioned, the Richardson Island site has been excavated in three episodes; by Parks Canada in 1995 and 1997, and by a University of Victoria/Parks Canada team in 2001/2002. The excavation units were designated as Operations 1127T10 (1995 season), 1127T12 (1997 season), and 1127T13 (2001/2002 seasons) respectively, according to Parks Canada site designation requirements. The first excavation in 1995 sectioned the bank of the gully in which the site was found and was approximately 1.25m x 1m to a depth of 4m. It was possible to achieve this depth as the unit extended in from the edge of the gully. As this excavation failed to reach the bottom of the deposits, the excavation in 1997 opened a 1m x 1m unit to the north of 1127T10 and continued down to sterile deposits; a depth of about 1m. The stratigraphic and dating sequences developed during these two excavations were used as guides for the excavation of 1127T13 at which time a 3m x 2m unit was excavated. As in previous years, we were able to follow natural layers and were guided by the stratigraphy of previous excavations.



N.B. Radiocarbon sample locations are indicated by a black circle. The two samples positioned on the left margin of the profile associate with the respective natural layer but were recovered farther north along the creek bank exposure.

Excavation Unit 10/12 East Wall Profiles Showing Multiple Stratigraphic Components (Based on figures supplied by Daryl Fedje, Parks Canada)

Figure 3.8 Richardson Island stratigraphy divided into twenty depositional units (represented by roman numerals). Modification of image created by Daryl Fedje, Parks Canada.

The larger unit enabled us to further differentiate between layers that were compressed and indistinguishable in 1127T10 and 12, and to more efficiently guard against contamination. In total, 16m^3 were excavated yielding tens of thousands (and possibly hundreds of thousands) of artifacts, of which 3,156 are formed tools, cores and utilized flakes, 2 pieces of worked of bone, and the remainder debitage. Tool types are summarized in Table 7.5. Additionally, seventeen hearth features and 11 post mould features were discovered. There is no organic preservation at the site aside from calcine bone deposits localized within the hearth features. The combined raw material and tool analysis presented in later chapters will only consider 2,050 flaked stone tools originating from Operations 10, 12 and 13. At times it was difficult to reconcile differences in natural layer designations between excavation units. To retain maximum stratigraphic resolution, some materials from Operations 10 and 12 were omitted. Additionally, the utilized flake category was not applied consistently between Operations and was omitted from this analysis. A fuller explanation of the sample selection process is presented in Chapter 7.

Suitability of Richardson Island Site for a Study of Raw Material

The Richardson Island site ignites the imagination with potential research questions that could take a lifetime to explore. Yet for a site in the early days of analysis it is most logical to start with the known, or at least the knowable. Raw material is one factor that we can analyze directly at the Richardson Island site. The Richardson assemblage is amenable to a study of raw material for various reasons. First, the volume of lithic artifacts excavated from the 1127T location is immense. In the future, it is likely that at least some, if not all, tool classes and debitage from the site will be analyzed in detail. At present an analysis of the bifacial technology is nearing completion (McLaren et al. in prep). In light of the discussion presented in Chapter 2, raw material is an important variable to consider in the discussion of tool forms and characteristics. Second, when one examines the lithic assemblage for the first time there is an apparent diversity of raw material. Some of these materials are clearly distinct from one another but a number of the material types have succumbed to the effects of weathering which adds to the impression of raw material diversity. Whether these patinated and visually distinct material types are in fact different rock types could affect our interpretation of raw material use by the Richardson inhabitants. Accurate raw material classifications will help in resolving classificatory issues. Third, the stratigraphy at Richardson Island creates a unique setting for the study of raw material. The majority of reports that discuss the influence of raw material factors on assemblage variability often base conclusions on palimpsests in which hundreds if not thousands of years are compressed. This can be avoided at Richardson. Also at Richardson there is a known environmental change that could have impacted raw material acquisition; sea-level rise and its subsequent still stand. Were there any materials whose use was discontinued at any point during sea-level encroachment? Understanding the patterns of raw material use during times of sea-level rise and the eras of the sea-level stabilization could also shed light on the questions surrounding microblade development. Is there any evidence in the raw material record that would suggest that microblade development was a strategy to deal with resource shortages? Or if microblade emergence was attributable to outside populations, are there any examples of foreign or exotic materials that accompany their arrival? Finally are there any raw material characteristics that distinguish Kinggi Complex and Early Moresby Tradition. While there are undoubtedly many more questions that could be asked of raw material at Richardson Island, these are a few of the more obvious that will be addressed in the following pages and which make raw material at Richardson Island an interesting variable to study.

CHAPTER 4

Raw Material Characterization

Introduction

For the archaeologist, lithic artifacts are among the most important of finds. Stone is the only naturally occurring material modified by prehistoric people that survives almost all depositional environments encountered in archaeology. The manner in which these materials have been modified in the past, is key to our understanding of how our ancestors survived, and how we as archaeologists interpret their actions. Along the Northwest coast fauna is often lacking in the earliest sites, and thus our knowledge of cultural horizons and traditions is often based on the presence, absence, or relative proportions of stone tools. Yet despite the importance of stone tools in formulating the temporal and spatial phases of prehistory, the specific material of manufacture is a variable that has received inconsistent attention.

Within archaeological reporting along the northwest coast it is not uncommon to limit the discussion of raw material to a sentence or two. For example, at the important Kilgii Gwaay site "more than 95% of the material is a high-quality basalt" (Fedje et al. 2001:105). Some researchers may add possible source locations for these materials, "Abundant cobbles and boulders of, apparently identical, fine-grained rock are available in the intertidal zone at Benjamin Point" (Fedje et al. 2001:105). These are logical deductions based on a visual assessment of the material. Such classifications based on macroscopic analysis serve a purpose in classifying the material and, in some cases, establish possible local sources. The process is also quick and inexpensive. Such classifications form the most basic of raw material assessments.

However, as discussed in Chapter 2, the properties of raw materials have the potential to enhance our understanding of social processes beyond that which can be attained through macroscopic analysis alone. Specifically, thin-section and chemical analyses reveal unique mineralogical and chemical characteristics within the rock that can allow for accurate provenancing to source. An unexpected outcome of these more sophisticated raw material analyses has been the recognition that within archaeological reports the rock classifications based solely on informal, macroscopic visual criteria are often incorrect (Bakewell and Irving 1994: Bakewell 1996; Mallory-Greenough et al. 2002). Fortunately, researchers such as Mallory-Greenough et al. (2002) offer some suggestions as to how to avoid misclassifications. They suggest that given the high level of skill required to establish accurate petrographic descriptions of rock, geochemical data may be a practical alternative for archaeology. Granted Mallory-Greenough et al. are referring to sourcing studies in particular, but one cannot help but wonder if chemical analysis is a feasible alternative to visual raw material classification itself.

Hence the research presented in this chapter attempts to avoid the problems of raw material misclassification by combining macroscopic visual assessment with chemical analysis. To date there have been no geochemical or thin section analyses of archaeological raw materials from Haida Gwaii. The materials at the Richardson Island site represent a wide range of visual characteristics giving the impression of extreme raw material diversity. In addition the complex stratigraphic layers which reflect differing chemical micro-environments, have encouraged some of the materials to weather post-depositionally, adding to the difficulties of ascribing a raw material classification based on their surficial characteristics.

The following sections describe the analytical process employed to establish rock type, beginning with a visual differentiation of material types in the Richardson assemblage. The 30 most frequently occurring specimens are selected for geochemical analysis via electron microprobe (EMPA) and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). The EMPA provides the major element concentrations of the Richardson samples from which general rock classifications are established. The major elements allow for the separation of igneous from non-igneous materials which are then further divided into more specific classifications within the igneous, sedimentary and metamorphic fields. Trace and rare earth element concentrations, established through LA-ICP-MS, are used to confirm the classifications based on major elements and to discuss the chemical variability among rocks assigned to the same group. Finally, the applicability of the methods presented here is considered within the wider realm of material studies in archaeology.

Petrography: Visual Differentiation of Materials

The first stage of raw material characterization was to separate the materials according to visual distinctiveness. As alluded to in the introduction, the appearance of the Richardson Island materials was varied. In addition to colour and textural differences, many of the materials were weathered and donned mild to thick patinas which enhanced the appearance of diversity. Material types were separated according to grain size, texture[6], degree of homogeneity and colour (see Appendix A for textural definitions).

The grain size of the materials varied from coarse grained to cryptocrystalline. Textures included aphanitic, porphyritic, pyroclastic, and clastic materials. The abundance of phenocrysts to matrix was expressed as a percentage among porphyritic specimens, and crystal habit was noted. Materials were also divided according to visible accessory minerals. A more tactile assessment of the surface was also noted in that the materials felt smooth or rough to the touch. The degree of homogeneity, which refers to any observable structure in the rock specimen, was recorded. A homogenous material displayed a uniform matrix whereas a non-homogenous material exhibited evidence of layering, lamination, vesicles, inclusions of foreign materials, or flowbanding created during petrogenesis (rock creation). Rocks of differing colour were also separated using the Munsell Soil Color Chart. The division on the basis of colour also separated the fresh from weathered materials and allowed for the subtleties among patinas to be observed.

Conceivably, the textural properties listed above could be interpreted differently by independent researchers. In separating the Richardson Island materials I came to recognize my splitting tendencies, and only grouped together those materials that were similar on the accounts mentioned above. This resulted in a spread of 97 visually distinct specimens (Table 4.1), many of which occurred only once. Also, given that weathered and non-weathered specimens were separated, the same raw material may have been divided into two or more categories. This could not be avoided as many pieces were entirely surrounded by a patina and it was not possible to see what a fresh surface looked like on the inside. Raw material distinctions were assessed for stone tools only.

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[6] In discussing the textural properties of a rock, the terminology varies slightly according to igneous, sedimentary of metamorphic origin. Given the potential for overlap in rock types in the Richardson assemblage, and that rock types were unknown at the visual differentiation stage, the terminology here used for textural attributes is not meant to imply one major type over another and a combination of textural features is considered.

Debitage, which likely numbers over 100,000 pieces,[7] would have been too extensive to analyze for this project. The frequencies of visually distinct materials were tabulated and the results also appear in Table 4.1.

Table 4.1Visually Distinct Materials

Material Code	# of tools	Chemical Analysis #	Material Cod	# of tools	Chemical Analysis #	Material Code	# of tools	Chemical Analysis #
N13-1	494	1	T9-6	11	6	1127T10P14-7	2	
N14a-9	204	9	A24*	11		1127T10S25-7	2 .	
K29c/F24b	201	20	L29	10		1127T10T35-21	2	
J24/F24	196	23	K24*	5		1127T13U7-4	2	
A23-13	173	13	G21	8		B24	1	
K29b/A23	142	22	1127T10F17-2	8		E23	1	
1127T10CC35-42 /H24/M14	144	17	1127T10P11-1	7		K25x	1	
N13-2	99	2	K25a*	6		I27	1	
P16	75	29	v. variety	5		J24a	1	
1127T10D8-6	65	27	N13*	3		C24x	1	
E21a	63	21	R24a	6		F24a	1	
1127T10L10-8	62	28	R24	6		1127T13L6-5	1	
K29-12	56	12	?	11		1127T13N8-1	1	
L23-8	52	8	F24-11	5	11	1127T13K9-1	1	
COMBO	52		K25d	5		1127T10N15-4	1	
K23-10	44	10	P12	5		1127T10S17-8	1	
A25-7	42	7	I27T10J1710	5		1127T10F19-7	1	
K25	39	16	1127T10X26-1	5		J23	1	
M7-4	34	4	AGATE	5		K24b	1	
I24a	32	18	I22/23	4		1127T1035-21	1	
J27a	30	19	1127T13T9-6	4		1127T10A2-10	1	
I24-14	28	14	L25	4		1127T10F12-2	1	
1127T10H12-4	27	30	R21	4		1127T10X19-1	1	
P13-3	27	3	?N13-2	5		1127T13M6c-9	1	
ANDESITE	26		D24	3		1127T13U10-9	1	
1127T10R17-5	25	25	J27	3		khaki chert	1	
S108-1	24		S13	3		**TOTAL**	**2801**	
E21-5	24	5	C23	3				
E21*	23	24	1127T12A2-10	4				
1127T10K15-7	21	26	I24	3		Skudas Point Rhyolite		31
BEACHCOBBL	18		J25	2		Richardson Foliation		32
F22-15	14	15	H29	2		1127T10C13-6		33
(T23)	14		1127T13Q8-20	2				
I21	12		1127T13H6-36	2				
F24c	12		1127T13L6-13	2				

Note: Total tool count does not include abraders or hammerstones

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[7] This is a conservative estimate. The debitage count is currently underway.

Sample selection for chemical analysis

Thirty of the visually distinct materials were selected for chemical analysis. The first fifteen samples were chosen prior to the completion of the visual assessment but it was felt at the time that these were among the most frequently occurring materials at the site. Only two samples (#6 and #11 in Table 4.2) of the initial fifteen were not among the most frequently occurring samples at the site. The second suite of fifteen was selected according to frequency so that 28 most commonly occurring materials, plus samples #6 and #11, would be analyzed chemically. Omitted from this selection process were those materials designated as *COMBO* (exhibited characteristics of 2 or 3 visually distinct types and was thus a varied group), *ANDESITE* (medium-coarse grained material typical of bedrock surrounding the site; likely picked up and used in an expedient fashion), *BEACH COBBLE/PEBBLE* (retained rounded or waterworn cortex) and *S108-1* (had been grouped with sample #22 at the time of chemical analysis but upon subsequent inspection was designated as its own material type due to a greenish-purple hue that distinguished it from the other #22 specimens). Textural descriptions of the thirty samples selected for chemical analysis are presented in Table 4.2. Images of these samples appear in Appendix D.

In addition to these 30 samples, three additional specimens were included for chemical analysis. Sample #31 was a piece of rhyolite that was collected from a dyke located at Skudas Point, Lyell Island, approximately 7 km southeast of the Richardson site. This rhyolite was visually very similar to archaeological sample #4 and was collected during a preliminary raw material survey of the Darwin Sound area in 2003. This dyke had been analysed by Jack Souther of the Geological Survey of Canada in 1988 (Souther 1988-personal field notes; Souther and Jessop 1991) and its chemical composition matched very closely with the preliminary chemical analysis of sample #4. The Skudas Point Rhyolite was included here to see how closely the chemical composition would be to sample #4 and as a comparison to the elemental composition recorded by Souther and Jessop (1991). Sample #32 was also collected during the 2003 survey and is a piece of argillite or slate. It originates from a foliated exposure about 500m south of the archaeological site on Richardson Island, which I have called the

Table 4.2 Visual characteristics of materials selected for chemical analysis

Sample	Colour (fresh)	Colour (weathered)	Grain size	Texture	Accessory minerals and phenocrysts	Degree of homogeneity	Other
#1 N13-1	Black 2.5YR 2.5/0	Black w/ white banding	Micro/crypto-crystalline	Aphanitic Smooth	Metallic minerals visible in fresh exposure – pyrite? = <1%. Visible under 4x magnification	Very homogenous, weathers in bands which are linear	Banding = 50% of surface
#2 N13-2	Black 2.5Y 2/0	Grey 2.5Y 5/0	Very fine grained/micro-crystalline	Aphanitic Smooth	Metallic minerals visible in fresh exposure – very small Visible under 4x magnification	Very homogenous weathers grey	
#3 P13-3	Light brownish grey 2.5Y 6/2	(Cortex) Brownish yellow 10YR 5.5/6	Very fine grained	Aphanitic Slightly rough		Very homogenous	Not weathered-cortex often visible
#4 M7-4	White 10YR 8/2	N/A	Fine grained	Aphanitic Rough	Very small black minerals = 2% of matrix Visible under 4x magnification	Very homogenous	
#5 E21-5	Greenish grey 5G 5/1	Light greenish grey 5G 7/1	Micro/crypto-crystalline	Porphyritic Smooth	Black, 4-sided, euhedral, vitreous = <1% of matrix **Pyroxene?** Visible to naked eye	Very homogenous	
#6 T9-6	Dark grey 2.5Y 4/0	Grey 2.5Y 5.5/0	Very fine grained/micro-crystalline	Porphyritic Slightly rough	Clear/white anhedral minerals, glassy/vitreous, minerals with twinning? = 7% of matrix. Visible to naked eye. **Feldspar?** Sparse black, glassy, anhedral phenocrysts visible under 4x magnification. **Garnet?**	Homogenous, weathers grey	This comparative sample, also used for chemical analysis appears to be weathered almost all way through. Appears as though was previously black.
#7 A25-7	Grey 2.5Y 5/0 Greenish grey 5BG 5/1	White 2.5Y 8/2	Micro/crpto-crystalline matrix	Pyroclastic Smooth to rough – depends on specimen	Contains angular shards of clear minerals – glass like Black and dark coloured minerals present too. Can make out a few black minerals but none exposed to see surface adequately at 4x mag. Matrix is greasy, almost glassy.	Very homogenous	Very dense weathering rind
#8 L23-8	Black 2.5Y 2/0	Black with large white spots	Micro-cryptocrystalline Black matrix and white spots are the same consistency	Aphanitic Very rough-seems to fracture around the white bubbles/spots'. On fresh surface can see outline of where spot will appear. Coprolites? Ash?		Homogenous although spots are stretched/ elongated in same direction, aligned linearly into bands.	Most black of all materials

Sample	Colour (fresh)	Colour (weathered)	Grain size	Texture	Accessory minerals and phenocrysts	Degree of homogeneity	Other
#9 N14a-9	Very dark grey to black	Dark grey with white speckles = 5% of surface	Micro/crypto-crystalline White spots similar to L23-8 but not as large.	Aphanitic Smooth	Too fine grained to see distinct minerals	Laminated. Rock fractures/breaks along laminar planes	
#10 K23-10	Grey 2.5Y6/0		Very fine grained	Aphanitic Rough	Felsic-can't make out individual grains	homogenous	
#11 F24-11	Very dark grey 2.5Y 3/0		Very fine grained	Aphanitic with calcite veins	Occasional black minerals present, visible at 4x mag.	Homogenous with possible lamination	
#12 K29-12	Black 2.5YR 2.5/0	Surface is heavily grey/banded. Banding is warped.	cryptocrystalline	Aphanitic Smooth, weathered surface feels almost waxy.	Metallic minerals = 2% of composition visible in fresh exposure	The imp Can see outline of where the banding will become weathered	
#13 A23-13	Black 2.5Y 2/0	Not fresh (not weathered as others) Very dark grey with very tiny white dots, pinpricks 2.5Y 3/0	Micro/crypto-crystalline	Aphanitic Smooth	Metallic minerals = 2% of matrix, copper coloured	Very homogenous	This material often appears water worn or waxy
#14 I24-14	Grey 2.5Y 5/0		Microcrystalline-very fine grained	Aphanitic smooth	Some black minerals visible at 4x but same size as matrix	Homogenous	
#15 F22-15		Light greenish grey 5G 7/1	Very fine grained	Porphyritic A bit rough	Holes where larger crystals have fallen out. Anhedral clear grains and greeny minerals. All vis. at 4x	Fairly homogenous – some patches of white crystals seen with naked eye	Chalky-like weathering rind
	Greenish grey 5BG 5/1		Very fine grained	Aphanitic smooth	Some white-grey opaque, anhedral minerals present. Visible at 4x mag.	Homogenous although there seem to be patches where white minerals cluster	
#16 K25-16	Greenish grey 5BG 4/1	Light greenish grey 5G7/1	Very fine grained	Aphanitic Weathered surface a bit rough, unaltered surface is smooth	About 10% darkish black anheadral crystals visible under 4x magnification	Homogenous – no white crystal patches	Very similar to F22-15 Chalky-like weathering rind, just slightly different from F22-15 due to lack of white crystal patches
#17 M14-17	Greenish grey 5BG5/1	Light grey 5Y 7/1 to 5GY 7/1	Microcrystalline	Weathered surface is porphyritic smooth. Fresh is aphanitic, smooth	Euhedral to anhedral green crystals, depends on specimen. Usually anhedral. Occasionally fibrous. Visible to naked eye.	Weathering rind is homogenous except for patches of fine grained green minerals. Rind is slightly chalky. Fresh surface is homogenous	Uncertain as to how these patches look in unweathered portions of rock; seem to occur along planes of weakness in rock

Sample	Colour (fresh)	Colour (weathered)	Grain size	Texture	Accessory minerals and phenocrysts	Degree of homogeneity	Other
#18 I24a-18	Very dark grey 2.5Y 3/2	Light brownish grey 10YR 6/2	Microcrystalline – very fine grained	Aphanitic smooth	Unweathered is About 10% anhedral white crystals visible at 4x magnification embedded in sea of black	Very homogenous	
#19 J27a-19	Black 2.5Y 2/0		Microcrystalline	Aphanitic smooth		Mostly homogenous with very thin veins of white visible at 4x magnification. Calcite?	No weathering rind
#20 K29c/F24b-20		'Non-fresh' Dark grey 7.5YR 4/0 With white speckles	Matrix microcrystalline Inclusions vary from 3mm to <1mm		See next note over	Not very homogenous. Grey with white speckles and wisps of darker grey matrix mixed in. Often contains well rounded clasts ranging from 3mm-<1mm. Clasts are concentrated in bands. Gives impression of two/three differently coloured playdoughs being rolled and stretched together.	Doesn't appear to be a weathered surface. Was surprised when breaking this sample to find exterior was different from interior
#21 E21a-21	Black 2.5Y 2/0		Cryptocrystalline Almost glassy	Porphyritic	5-10% of matrix comprised of subhedral transparent – white crystals ranging from <1mm to 4mm. Vitreous, sometimes elongated with striations running parallel to length. **Zeolite group?** Some black minerals, and light brown to greeny crystals visible under 4x magnification but very sparse	Very homgenous	
#22 K29b-22	Very dark grey 2.5Y N3/0	Light grey 2.5Y N7/0	Very fine grained-micro crystalline	Aphanitic Rough Cackly textured weathering rind, rough appearance.		Homogenous. Rough weathering rind has a raised surface = grey (tiny black minerals apparent under magnification). Depressed areas are white.	Cackly weathering rind result of rough matrix
#23 J24/F24-23 (E21x)	Black	Light pinkish grey 5YR 7/1.5	Very fine grained to microcrystalline	Weathered =Slightly porphyritic smooth Dense rind Fresh = Aphanitic Smooth	Weathered =Under 4x magnification =5% Clear white crystals5% black crystals but too small to see characteristics. Some black crystals seem elongated and are aligned in the same direction Fresh surface = Under 4x magnification metallic minerals present, copper coloured – also presence of black crystals	Very homogenous	

Sample	Colour (fresh)	Colour (weathered)	Grain size	Texture	Accessory minerals and phenocrysts	Degree of homogeneity	Other
#24 E21-24	Pale yellow 2.5Y 7/4 to pale grey 2.5Y 7/2	(Cortex) Light yellowish brown 2.5Y 6/4	Fine grained	Aphanitic rough	~2% black minerals visible to naked eye. Under 4x mag. Appear sub to anhedral but quite small	Very homogenous	Does not form a weathering rind in these stratigraphic deposits
#25 1127T10 T17-6	Reddish brown 5YR 4/3		Cryptocrystalline Almost glassy	Aphanitic smooth	~5% dark inclusions/minerals visible throughout matrix but not clearly visible with magnification	Homogenous	Translucent
#26 1127T10 J15-5	Dark reddish grey 5YR 4/2		Matrix is crypto-crystalline Phenocrysts up to 3mm	Porphyritic smooth	Phenocrysts are clear-white, often elongated with striations running parallel to length, vitreous, subhedral	Homogenous	
#27 1127T10 A10-1	Very dark grey 2.5Y 3/0	Greyish brown 2.5Y 3/0	Micro/crypto-crystalline	Aphanitic Smooth Almost waxy		Very homogenuos	(Cannot help but wonder about heat treatment with this material)
#28 1127T10 N10-28	Greenish grey 5GY 5/1	Light brownish grey 10YR 6/2	Cryptocrystalline	Aphanitic smooth		Very homogenous	Surface often has a pinkish dusting Had to estimate colour through microscope as exposed surface so small.
#29 P16-29	Very dark grey 7.5YR N3/0	Pinkish grey 7.5YR 6/2	microcrystalline	Aphanitic Rough Weathering rind has a cackly texture.		Very homogenous Weathering rind is thick	Rind has a rough appearance especially at 4x mag. Raised = pinkish grey, depressed =white.
#30 1127T10 H12-4	Very dark grey – black 7.5YR 2.5/0		Microcrystalline	Aphanitic rough		Very homogenous	No weathering rind
#31 Skudas Pt. rhyolite	White 10YR 8/1 (not exact match with Munsel soil charts)	(Cortex) Brownish yellow 10YR 6/8	Fine grained	Aphanitic rough	Very small black minerals visible to the naked eye	Very homogenous	

Sample	Colour (fresh)	Colour (weathered)	Grain size	Texture	Accessory minerals and phenocrysts	Degree of homogeneity	Other
#32 Richardson foliation	Very dark grey-black 2.5Y 2/0		Micro/crypto-crystalline	Aphanitic smooth	~5% metallic minerals but too small to make out details at 4x mag. Copper coloured	Very homogenous between foliated laminations	
#33 1127T10 C13-6	Very dark grey 2.5Y 3/0		Matrix is cryptocrystalline, Almost glassy Phenocrysts are <1mm – 3mm in size	Porphyritic smooth	Phenocrysts b/wn 5-10% of matrix, clear/white euhedral to anhedral crystals, some elongate with striations parallel to length and another set of striations at about 80 degree angle to long striations, some crystals cubic. Other brown/green anhedral minerals present	Homogenous with thin veins of white mineral – calcite?	No weathering rind, resembles E21a

Richardson Foliation. This foliation exists within the Kunga Group (characterized by shale, calcareous shale, massive limestone, and fine-grained sandstone) and its orientation is documented on recently produced geological maps of the area (Haggart 2002b). The material flakes beautifully with predictable conchoidal fracture and appears to weather in a similar fashion to some of the material from the archaeological assemblage. Again, it was included to see how its composition would compare to the archaeological samples. Sample #33 was a piece of debitage[8] which was visually very similar to sample #21. However, these samples were separated by 36 natural layers, roughly 2.5m of deposits, and during the visual separation process I had a sense that this material was not present throughout the stratigraphic sequence. It seemed to disappear after a brief appearance in the initial cultural occupations of the site and then reappeared in the later years at which point it dominated the material classes. Inclusion of the samples #21 and #33 was a judgmental attempt to include intra-site variability, albeit based on a minute sample size.

Chemical Analysis

Commonly used techniques to establish the chemical compositions of artifacts include Atomic absorption spectroscopy (AAS), Optical emission spectroscopy (OES), X-ray fluorescence spectrometry (XRF), Inductively coupled plasma emission spectrometry (ICP-ES) and mass spectrometry (ICP-MS), Proton excited XRF (PIXE), Instrumental neutron activation analysis (INAA), and Electron microprobe analysis (EMPA). The most frequently used techniques in archaeology have been XRF, AAS, and INAA as they are common in university and commercial labs, require small sample size, and maintain low detection limits and high precision (Kempe and Harvey 1983). EMPA has also proven useful for analysis of individual minerals within Egyptian basalt vessels (Mallory-Greenough, Gorton and Greenough 2002), and for the examination of chemically and mineralogically homogenous archaeological materials such as obsidian, and flint/chert. It can also be used for whole rock analysis in which samples are powdered, fused, and hence homogenized, into glasses (Canil and Fedortchouk 2001). Since their emergence in the 1980's, ICP-MS and Laser ablation ICP-MS (LA-ICP-MS) have been gaining in

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[8] Artifact # 1127T10C13-6

popularity and may become the method of choice for many archaeologists in the future (Kennett et al. 2001).

ICP-MS is an extremely sensitive technique which offers low detection limits for many trace elements and rare earth elements. Its applications in the analytical sciences vary from the analysis of water samples to environmental samples, such as soils and sediments, to the study of wine and wheat in the food sciences, to nuclear applications with analyses of radioactive waste, as well as having wide applications within the fields of forensic science, biology, and geology. ICP-MS is a favoured method as it has the capability to detect multielemental compositions and allows for fast calibrations of materials. It has thus become a recommended procedure of governmental agencies such as the U.S. Environmental Protection Agency (Beauchemin 2000:3) and is widely available. LA-ICP-MS is an adaptation of the ICP-MS technology that allows for a direct analysis of solid samples versus the dissolution process typical of standard ICP-MS applications (Becker 2002). Not surprisingly ICP-MS and LA-ICP-MS have become welcome additions to archaeological investigations. Centers such as the Archaeometry Laboratory at California State University, Long Beach and the Research Reactor Center at the University of Missouri-Columbia have developed programs to explore the utility of these techniques in archaeology (Kennet et el. 2001)[9].

Sample Preparation

As the thirty visually dissimilar types had been based on formed tools, and given the analytical procedures are destructive, material analogues were selected from debitage[10]. This was not possible for samples 25, 26, and 28, however, as these materials were only present in microblade form. Thus one microblade from each material type (irregularly shaped or incomplete where possible) was selected for analysis. Documentation of these microblades appears in Appendix B.

Aside from the microblades which weighed between 0.10 and 0.18 grams, the remaining samples weighed between 4 and 12 grams, ensuring enough material for

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[9] A useful reference for ICP-MS and LA-ICP-MS publications with particular interest to archaeology can be found at http://www.missouri.edu/~rjse10/otherpub.htm

[10] I am confident that the debitage pieces selected for analysis are adequate representatives of the material types. It is not possible to analyze all artifacts chemically which would ensure that the visually similar materials are in fact the same. Yet, throughout the petrographic analysis I developed an eye for detecting the subtle differences between materials and it is upon this experience that I feel confident in the raw material groupings and the debitage selection for analysis.

chemical analysis was available, and allowing for an intact half of the specimen for further visual comparison and classification. Each sample was cut in half with a diamond saw so that one portion of the rock was less than 2.5 centimeters in diameter (but maintained a weight of >2g.) to allow for subsequent powdering of the sample. The other half of the rock remained as a comparative specimen. As the saw neared the completion of the cut, the sample was removed from the clamp and broken by hand where possible. This provided a fresh break that allowed for view of the natural rock matrix and fracture pattern as opposed to the smooth and artificial polish created by the diamond saw. The sectioned sample was placed in a steel mill and crushed until it was fine enough to be transferred to an agate mortar, where it was ground by hand to attain particle size of less than 200 microns.

Methods outlined by Canil and Fedortchouk (2001) were employed to transform the powdered samples into homogenous glass beads. For each sample approximately 0.10 grams of the powder was mixed with ethyl alcohol to create a slurry. This substance was pasted on a platinum wire and sintered with a propane torch. The wires were hung in a box furnace heated to 1500°C. Samples were removed after 24 hours and quenched in a stream of air. The heating process ensured that the samples reached a liquid state, thereby homogenizing the chemical composition throughout the glass.

Sample 25 was the only material that did not fuse into a bead. This is likely due to an extremely high silica content which is common among materials such as quartz, chalcedony, agate and some cherts. These materials require higher temperatures to reach a liquid state. Given the exceptional behaviour of sample 25 during the bead production phase, and given its unique visual attributes, this material was classified as chert or agate. Its chemical behaviour is distinctive from the other 32 samples analysed and, thus, was the first material type identified in this study. As this sample did not become a glass it was omitted from subsequent tests[11]. Once cooled the glass beads were sectioned, set in epoxy and polished.

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[11] Sample 25 was included in an experimental LA-ICP-MS run in which raw materials were lasered directly to see how the results would compare to regular solution ICP-MS and laser ablation conducted on the glass beads. Results will appear in a forthcoming report.

Results

EMPA analysis was conducted on the Cameca SX-50 instrument (including a Kevex 8000 energy-dispersive system, four wavelength dispersive spectrometers, and synthetic multilayer diffracting crystals) in the Department of Earth and Ocean Sciences at the University of British Columbia. The weight percents for the major element oxides (Mg, Na, Al, Si, K, Ca, Ti, Mn, Fe, and Ni) were established for the 32 samples and for the NIST 611 and 613 standards. The results are presented in Table 4.3.

The same samples and standards were analyzed for trace element[12] concentrations (Sc, Ti, V, Cr, Ni, Sr, Y, Zr, Nb, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, Th, U) using the LA-ICP-MS model Merchantek Geolase™ LUV266 Nd-YAG UV laser, coupled to a VG™ PlasmaQuad IIS ICP-MS quadrupole instrument housed in the Aqueous Geochemistry Lab at the University of Victoria. These results are presented in Table 4.4.

The weight of Ca as determined by the microprobe was used as the internal standard against which trace element and rare earth elements were calibrated. The same glass beads were used for both EMPA and LA-ICP-MS thus ensuring continuity between analyzed specimens. An early attempt to analyze the same samples via solution analysis was also performed[13], but as can be the case with geological specimens, some of the powdered rock did not go into solution (Robinson 2002; Taylor et al. 2002). This problem was avoided by using LA-ICP-MS.

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[12] A trace element occurs in minute quantities (less than 1%) in minerals and rocks. Rare earth elements are those trace elements that have an atomic number between 57 and 71, and have similar chemical properties to one another (Allaby and Allaby 1999).

[13] While the results are not presented here samples 1-15 were analyzed via solution ICP-MS and unprocessed rock samples 1-3, 6-9, 11-13, 15-23, 25-33 were lasered directly to see how the results of the three analytical methods compare (omitted samples were too large to fit in the cell of the ablation chamber). The prospects of lasering lithic materials directly, holds great appeal for archaeology. A laser hole is miniscule, a few microns wide, and barely detectable by the human eye, which is preferable to destroying even 2 grams of the artifact. The chemical signatures extracted from the very fine grained materials were comparable to those taken from the glass beads. The results are still being examined, and certainly issues of homogeneity, sample size, and quantification will need to be addressed, but nonetheless, offer another exciting exploration of how LA-ICP-MS can be applied to archaeology.

Table 4.3 Major element analysis for selected Richardson samples

Sample#	Ox%(Na)	Ox%(Mg)	Ox%(Al)	Ox%(Si)	Ox%(K)	Ox%(Ca)	Ox%(Ti)	Ox%(Mn)	Ox%(Fe)	total
Slide A 1	0.37	1.1	8.9	82.2	0.74	1.7	0.34	0.02	3.5	98.91
2	1.67	1.3	15.3	72.7	1.90	1.5	0.59	0.04	3.8	98.85
3	3.16	0.1	13.2	77.5	4.17	0.3	0.13	0.00	1.2	99.83
4	3.12	0.1	12.5	77.7	4.57	0.2	0.16	0.01	0.9	99.32
5	3.10	3.6	15.6	57.2	0.67	6.1	1.72	0.15	10.2	98.27
6	3.34	0.7	15.8	69.4	3.24	2.3	0.60	0.07	3.6	99.06
7	1.41	4.8	14.4	64.8	1.14	6.6	0.54	0.24	5.1	99.03
8	0.50	1.1	10.6	80.4	1.04	1.5	0.41	0.03	3.1	98.62
9	0.78	1.2	11	80.1	1.02	0.9	0.42	0.02	3.9	99.31
10	2.87	0.1	12.6	77.9	3.85	0.6	0.13	0.04	1.4	99.50
11	0.66	0.2	24.6	53.9	7.39	0.6	1.79	0.02	9.6	98.76
12	0.56	0.8	8.8	81	0.37	3.2	0.35	0.01	4.2	99.16
13	0.60	1.2	8.3	83.3	0.68	1.7	0.29	0.02	2.9	98.90
14	0.39	0.1	51.6	41.4	0.19	0.1	2.64	0.03	4.0	100.50
15	2.83	5.7	18.3	53.4	0.53	8.6	1.10	0.15	8.2	98.83
611	12.3	0.1	1.9	74.2	0.05	12.1	0.09	0.07	0.1	100.92
613	12.9	0.01	2.0	76.5	0.00	12.5	0.00	0.00	0.0	103.85
Slide B 16	1.23	1.4	12.3	75.5	1.63	1.5	0.49	0.03	5.0	99.06
17	0.78	0.3	24.9	53.3	6.79	0.9	1.77	0.00	9.8	98.47
18	1.67	2.1	15.7	63.8	2.60	5.5	0.89	0.06	6.1	98.56
19	1.92	2.5	18.9	59.6	4.14	3.7	1.01	0.12	6.3	98.09
20	1.69	6.1	19.5	50.8	0.69	10.5	1.18	0.12	8.1	98.74
21	3.16	0.6	14.8	72.1	3.62	1.7	0.56	0.04	3.0	99.53
22	1.40	2.0	22.8	60.9	1.32	1.9	0.91	0.02	7.3	98.56
23	1.99	3.6	20.2	56.9	2.27	2.5	1.08	0.22	9.5	98.21
24	3.08	0.1	12.8	77.5	4.34	0.3	0.12	0.02	1.4	99.58
26	2.24	0.2	12.6	75.7	3.70	1.5	0.38	0.05	2.5	98.93
27	0.99	1.0	14.1	72.5	6.14	1.3	0.35	0.06	2.8	99.26
28	1.24	0.9	13.0	75.1	4.59	1.9	0.34	0.04	2.2	99.23
29	2	3.1	20	59.7	2.59	2.1	1.22	0.24	8.0	98.86
30	3.35	1.9	16.2	64.6	1.47	4.9	1.07	0.09	5.5	99.23
31	3.41	0.2	13.1	77.1	3.55	0.5	0.20	0.01	1.5	99.70
32	2.28	1.8	17.7	60.5	2.18	6.7	0.91	0.04	6.4	98.54
33	3.07	1.0	15.0	69.8	1.75	2.9	0.89	0.10	4.4	98.99
613	12.9	0.01	2.0	76.6	0.00	12.5	0.00	0.02	0.0	104.02
611	12.2	0.1	1.8	74.8	0.08	12.1	0.08	0.05	0.1	101.34

Table 4.4 Trace and rare earth elements for Richardson samples (quantities expressed in ppm)

	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
45Sc	LD	3.8	LD	1.6	19.3	4.1	7.1	6.5	5.4	3.0	25.5
47Ti	1770	3103	418	414	7483	3000	2474	2136	2090	561	9317
51V	51	62	1	1	94	32	68	60	44	21	102
52Cr	2	2	1	1	1	1	1	3	<1	<1	7
60Ni	15	8	6	3	7	6	6	12	11	6	5
86Sr	46	233	21	14	214	99	150	66	97	13	116
89Y	4.8	11.4	7.2	12.0	22.5	20.8	7.4	5.7	5.8	16.5	23.8
90Zr	33	75	50	58	106	268	48	37	42	86	233
93Nb	2.9	5.8	4.9	4.7	3.7	16.3	3.0	3.2	3.2	6.2	10.9
137Ba	160	629	332	361	229	541	304	176	200	428	344
139La	2.60	7.82	5.85	8.71	7.55	18.12	7.03	4.02	4.21	11.18	9.35
140Ce	6.22	17.58	16.06	18.81	17.29	39.33	15.43	9.45	9.58	24.24	25.75
141Pr	0.70	2.02	1.31	1.90	2.23	4.17	1.68	1.10	1.03	2.43	2.61
146Nd	3.12	8.74	4.72	7.61	11.26	16.65	7.32	4.78	4.53	9.64	11.99
147Sm	0.80	2.01	0.93	1.68	3.14	3.56	1.55	1.10	0.99	2.13	3.56
153Eu	0.20	0.53	0.15	0.18	1.02	0.71	0.49	0.28	0.25	0.24	1.10
157Gd	0.76	1.89	0.98	1.68	3.57	3.28	1.36	1.05	0.92	2.19	3.68
159Tb	0.13	0.30	0.16	0.27	0.56	0.50	0.20	0.15	0.14	0.36	0.63
163Dy	0.90	2.07	1.26	1.99	4.09	3.44	1.32	1.05	1.02	2.60	4.64
165Ho	0.18	0.41	0.26	0.40	0.82	0.69	0.26	0.20	0.21	0.54	0.94
166Er	0.52	1.23	0.87	1.31	2.41	2.11	0.77	0.62	0.67	1.72	2.95
169Tm	0.08	0.17	0.14	0.21	0.35	0.32	0.11	0.10	0.10	0.27	0.46
172Yb	0.64	1.34	1.06	1.50	2.54	2.37	0.86	0.74	0.79	2.04	3.38
175Lu	0.10	0.19	0.14	0.23	0.35	0.34	0.13	0.12	0.11	0.31	0.49
178Hf	0.83	1.83	1.51	1.82	2.56	5.86	1.22	0.91	1.09	2.56	5.35
181Ta	0.18	0.39	0.45	0.49	0.25	1.04	0.20	0.20	0.23	0.59	0.82
232Th	1.52	2.23	3.21	4.12	1.17	4.54	0.94	1.52	1.60	5.77	4.36
238U	0.46	0.48	2.02	1.51	0.12	0.82	0.16	0.49	0.19	0.85	0.18

Table 4.4 Continued

	#12	#13	#14	#15	#16	#17	#18	#19	#20	#21	#22
45Sc	5.1	3.7	8.4	14.7	6.4	23.9	15.8	11.4	71.3	3.9	12.4
47Ti	1623	1448	9360	4820	2163	7411	3362	4305	21290	2247	3733
51V	43	50	24	97	37	47	49	67	343	25	42
52Cr	<1	4	33	1	<1	5	<1	<1	3	<1	<1
60Ni	11	16	10	10	5	4	5	8	36	2	5
86Sr	39	43	43	197	92	90	127	196	797	51	113
89Y	6.7	8.3	5.5	12.9	4.6	19.9	19.8	11.0	53.8	17.5	11.0
90Zr	35	24	168	86	40	171	56	95	367	209	91
93Nb	2.3	2.1	11.7	5.1	2.9	7.8	1.8	7.0	23.3	12.2	6.7
137Ba	40	191	63	134	160	298	538	1528	1366	386	214
139La	4.89	5.62	6.40	6.56	2.96	14.64	7.22	10.68	29.82	14.96	5.93
140Ce	11.39	10.58	11.54	14.88	6.97	37.05	11.48	27.51	74.23	30.36	14.87
141Pr	1.23	1.24	1.41	1.88	0.78	4.08	1.97	2.79	8.93	3.35	1.60
146Nd	5.33	5.32	5.64	8.74	3.44	18.86	9.99	11.67	40.81	13.71	7.39
147Sm	1.25	1.21	1.34	2.11	0.78	4.61	2.63	2.56	9.80	2.89	1.91
153Eu	0.45	0.37	0.33	0.67	0.21	1.31	0.69	0.72	3.17	0.46	0.46
157Gd	1.23	1.27	1.21	2.10	0.76	4.18	3.02	2.43	9.92	2.78	2.05
159Tb	0.18	0.19	0.21	0.32	0.11	0.62	0.46	0.35	1.49	0.42	0.33
163Dy	1.20	1.27	1.44	2.21	0.78	4.38	3.38	2.51	10.44	2.98	2.33
165Ho	0.23	0.27	0.27	0.43	0.16	0.85	0.68	0.46	1.98	0.60	0.47
166Er	0.66	0.78	0.75	1.27	0.52	2.58	2.07	1.39	5.83	1.85	1.43
169Tm	0.10	0.11	0.11	0.18	0.08	0.38	0.29	0.21	0.83	0.28	0.22
172Yb	0.67	0.85	0.81	1.33	0.64	2.81	2.18	1.66	6.26	2.12	1.68
175Lu	0.10	0.13	0.11	0.18	0.10	0.39	0.31	0.22	0.86	0.30	0.24
178Hf	0.81	0.62	3.76	1.63	0.96	4.39	1.63	2.68	7.75	5.14	2.68
181Ta	0.12	0.13	0.92	0.30	0.19	0.63	0.12	0.52	1.50	0.88	0.59
232Th	1.53	1.49	5.06	0.55	1.22	2.98	0.90	3.09	2.65	4.28	3.96
238U	0.08	0.79	0.03	0.10	0.10	0.03	0.04	0.04	0.17	0.46	0.07

Table 4.4 Continued

	#23	#24	#26	#27	#28	#29	#30	#31	#32	#33
45Sc	15.5	2.4	2.8	3.0	4.0	16.3	8.0	4.0	15.1	6.0
47Ti	4114	413	1502	1272	1448	4615	4094	757	3299	3292
51V	44	6	12	14	15	31	38	3	36	23
52Cr	<1	<1	1	1	1	<1	<1	<1	<1	<1
60Ni	13	2	3	2	4	9	4	3	7	3
86Sr	126	14	93	139	104	106	215	37	198	148
89Y	15.4	13.5	10.4	20.5	14.1	16.1	13.2	21.1	20.6	21.8
90Zr	85	72	191	156	105	92	94	119	59	192
93Nb	5.6	5.0	9.1	4.9	5.1	6.2	4.2	5.5	2.5	11.7
137Ba	620	426	590	752	683	590	391	478	544	566
139La	11.36	11.05	9.16	15.80	12.59	12.52	10.86	13.80	9.97	17.43
140Ce	26.33	24.57	18.59	26.55	27.53	28.64	22.98	30.64	14.66	33.37
141Pr	2.95	2.39	1.85	3.24	2.78	3.16	2.74	3.26	2.51	4.16
146Nd	13.67	9.51	7.33	14.30	11.38	14.45	12.67	13.65	12.25	18.67
147Sm	3.33	2.10	1.54	3.15	2.43	3.39	2.91	3.12	3.01	4.25
153Eu	0.86	0.21	0.68	0.57	0.49	0.88	0.83	0.43	0.80	0.97
157Gd	3.33	2.16	1.47	3.46	2.51	3.36	2.85	3.28	3.26	4.18
159Tb	0.50	0.35	0.24	0.54	0.37	0.51	0.41	0.54	0.49	0.65
163Dy	3.42	2.63	1.91	3.95	2.75	3.54	2.83	3.97	3.53	4.51
165Ho	0.66	0.54	0.42	0.80	0.55	0.69	0.54	0.82	0.72	0.87
166Er	2.01	1.76	1.47	2.52	1.77	2.08	1.58	2.59	2.23	2.66
169Tm	0.29	0.27	0.24	0.39	0.26	0.30	0.22	0.40	0.32	0.39
172Yb	2.19	2.13	1.92	2.93	2.04	2.29	1.67	3.01	2.49	2.91
175Lu	0.31	0.33	0.28	0.44	0.30	0.33	0.24	0.45	0.35	0.42
178Hf	2.49	2.73	5.06	4.68	3.10	2.80	2.57	3.82	1.85	5.05
181Ta	0.51	0.64	0.75	0.65	0.51	0.56	0.35	0.56	0.21	1.04
232Th	3.09	5.87	5.58	6.65	4.61	3.41	2.54	5.46	1.54	4.70
238U	0.04	1.55	1.77	0.37	0.94	0.03	0.04	1.71	0.04	0.17

What Kind of Rock? Separating Igneous from Non-Igneous Samples

Ranges of major elements in the average igneous rock

Igneous rocks have a restricted chemical composition (Brotzen 1966; Le Maitre 2002; Pearce 1996) and the weight percent of major elements tends to fall within expected ranges (Table 4.5).

Table 4.5 Range of major elements in average igneous rock

Oxide	Range
SiO2	35 - 80 wt %
Al2O3	8 - 22 wt %
Na2O	1.5 - 8 + wt%
K2O	0.5 - 8 + wt%

Note: Modification of table in Finn 2004

Bivariate plots of SiO2 versus the other major elements were generated for the Richardson samples. Some of the samples exceeded expected igneous ranges for Al, Na, K, and Si (Figure 4.1 a, b, and c). A series of volcanics from Haida Gwaii with known chemical concentrations were also plotted on bivariate plots for Al, Na, K versus SiO2 to ensure that rocks native to the area fell within the average igneous rock ranges (Figure 4.2 a, b, and c). Specifically, three samples from the Karmutsen Formation, one from the Yakoun Formation (Sutherland-Brown 1968), thirty-nine from the Masset Formation (Hickson 1991; Hyndman and Hamilton 1991; Sutherland-Brown 1968) and twenty-six samples from dyke swarms (Souther and Jessop 1991) were plotted. The Si, Al, and Na concentrations within the Haida Gwaii volcanics plot within the expected ranges for igneous rocks, save for one Masset basalt sample which registered a low Na content. The K seemed to be particularly low for basalt and basaltic-andesite and thus, K was not considered to be an accurate indicator of non-igneous environments in Haida Gwaii.

Among the Richardson Island samples, numbers 1, 8, 9, 12, and 13 were extremely high in silica and consistently plotted outside of the igneous realm. These plots provided the first line of evidence that samples 1, 8, 9, 11, 12, and 13 were non-igneous. The remaining samples fell within the range for an average igneous rock, or within range of the known Haida Gwaii volcanics, at least once. Thus, they could not be classified definitively as non-igneous at this stage.

Figure 4.1 Richardson samples

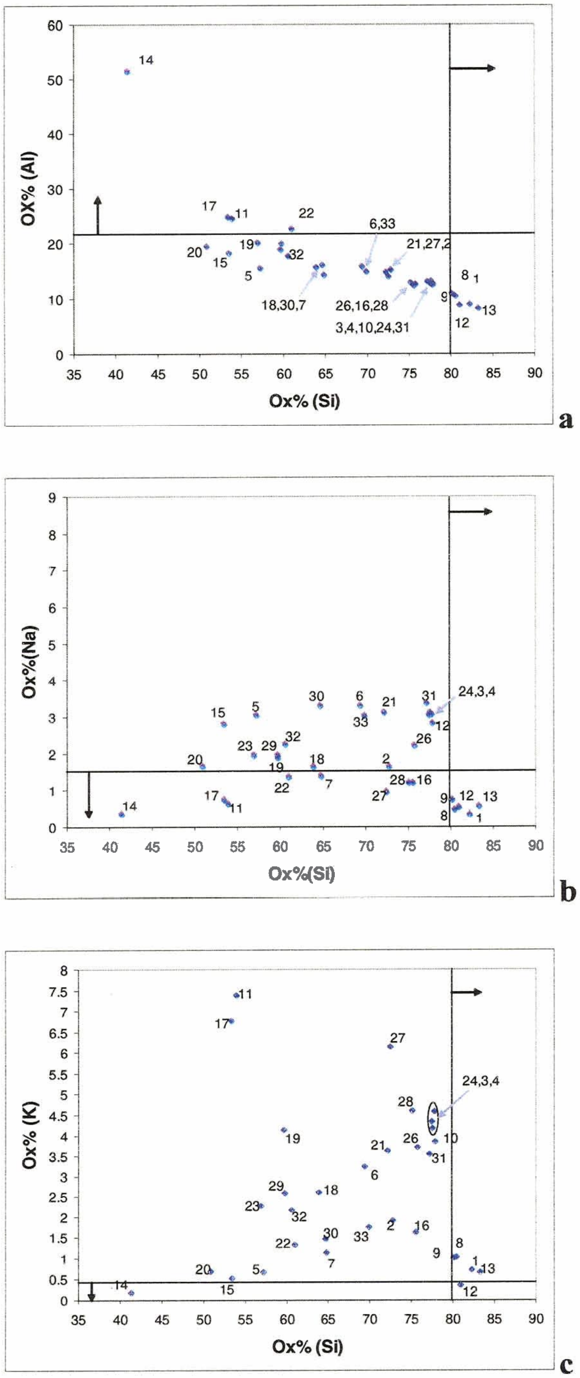
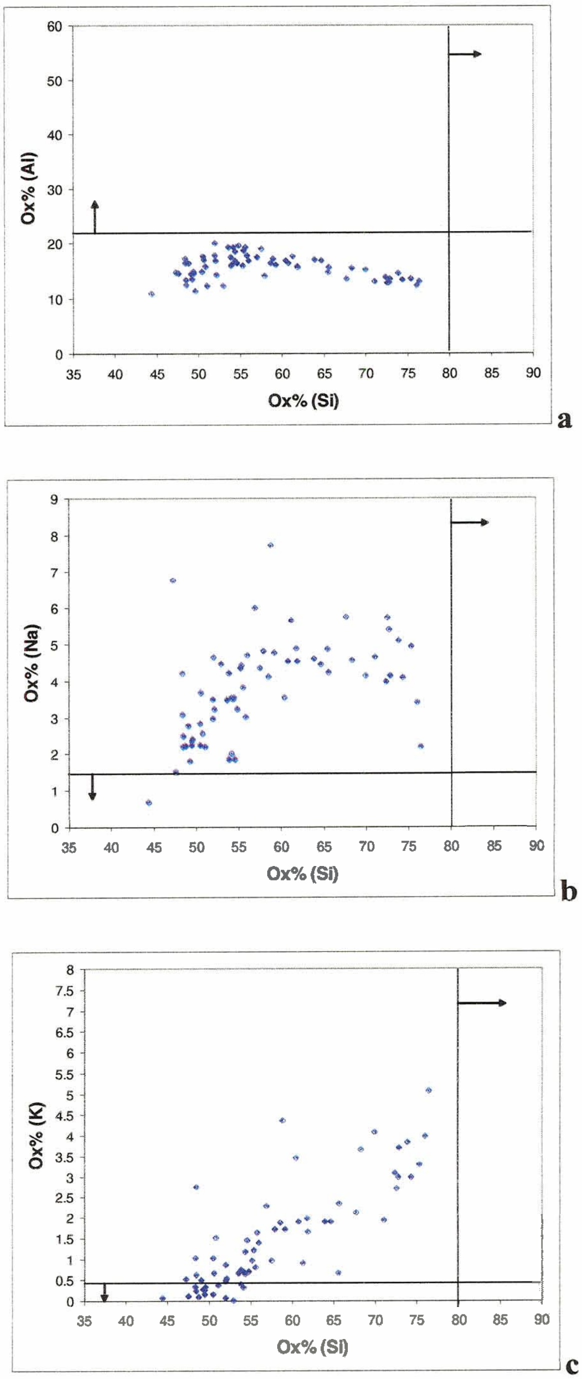


Figure 4.2 Haida Gwaii volcanics



Note: black arrows indicate zones outside of average igneous composition

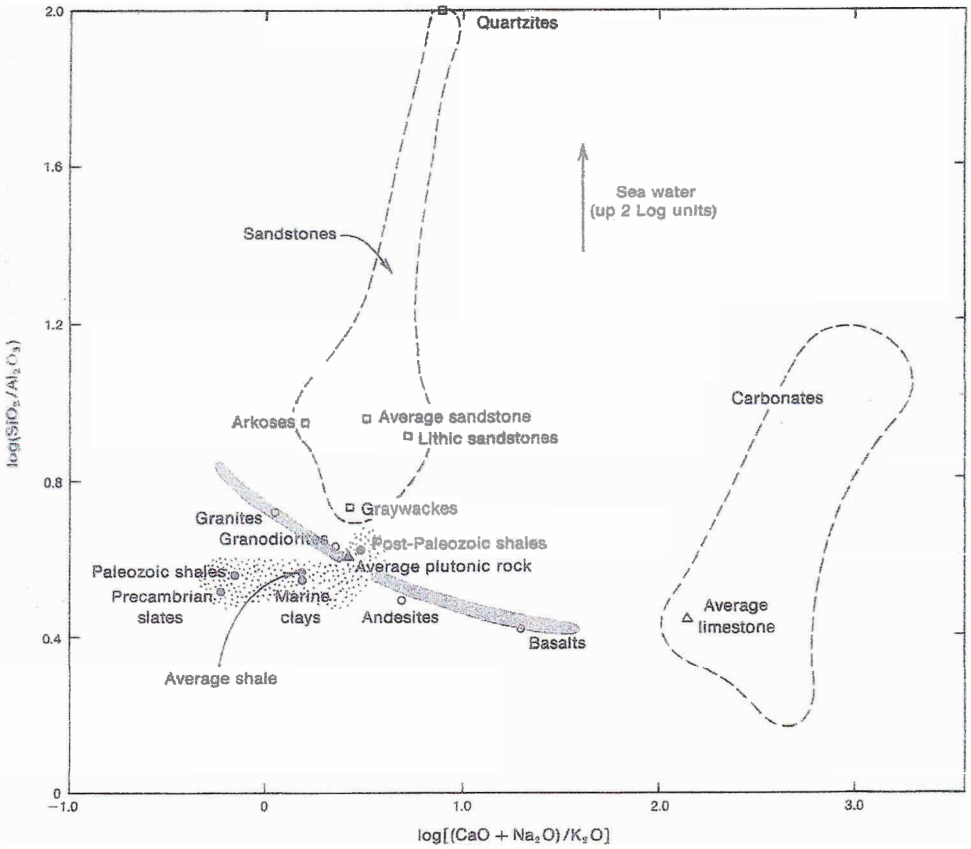
Both samples from known contexts, the Skudas Point rhyolite (# 31) and the Richardson foliation (#32), fell within normal igneous ranges. The sample from the Richardson foliation was of particular interest as it was known to be an argillite or slate and, thus, from a non-igneous context. Nonetheless it fell within the igneous fields on the bivariate plots. This indicated that overlap between the chemical compositions of igneous and non-igneous was possible among the archaeological samples and that a sole reliance on bivariate plots of major elements was not sufficient to distinguish between major rock types.

Igneous versus Non-igneous: log SiO2/Al2O3 vs. log (CaO+Na2O)/K2O

The overlap of compositions between igneous and clastic sedimentary rocks has been illustrated by Garrels and MacKenzie (1971) (Figure 4.3) who used a plot of log SiO_2/Al_2O_3 versus log $(CaO+Na_2O)/K_2O$ to display the chemical differences between these major rock divisions. Figure 4.3 depicts the restricted field of igneous compositions (in which highly siliceous volcanic rocks such as rhyolite plot to the left of the curve while basalts plot to the right) in relation to sedimentary rocks and slates. A zone of overlap between volcanic rocks in the dacite-andesite range and shaley sediments is visible. However, aside from this one overlapping zone, igneous and sedimentary fields are well divided. Among the sediments, shales tend to be low in Na and Ca, and limestones will be high in Ca with very low Na and K. Sandstones have high silica contents and lower alumina contents than lutites.

The igneous range depicted by Garrels and MacKenzie was adapted to accommodate the known Haida Gwaii volcanics (Sutherland-Brown 1968; Hickson 1991; Hyndman and Hamilton 1991; Souther and Jessop 1991). When added, these samples widen the igneous field depicted by Garrels and MacKenzie, but a smooth restricted curve is still maintained for igneous rocks (Figure 4.4). Seventeen additional argillite, sandstone and siliceous shale samples were plotted on the Garrels and MacKenzie diagram (compositional data from Pettijohn 1963, 1975). These samples indicate that the overlapping igneous and shale fields are broader than those originally depicted. Additionally, we see that siliceous shales and cherty shales have similar compositions to Graywackes (Figure 4.5). As whole rock chemistry of sedimentary rocks are not

Figure 4.3 The compositional fields of igneous and sedimentary rocks



Note: Image as it appears in Garrels and MacKenzie (1971: 227)

Figure 4.4 Comparison of known Haida Gwaii volcanics to igneous field as depicted by Garrels and MacKenzie (1971)

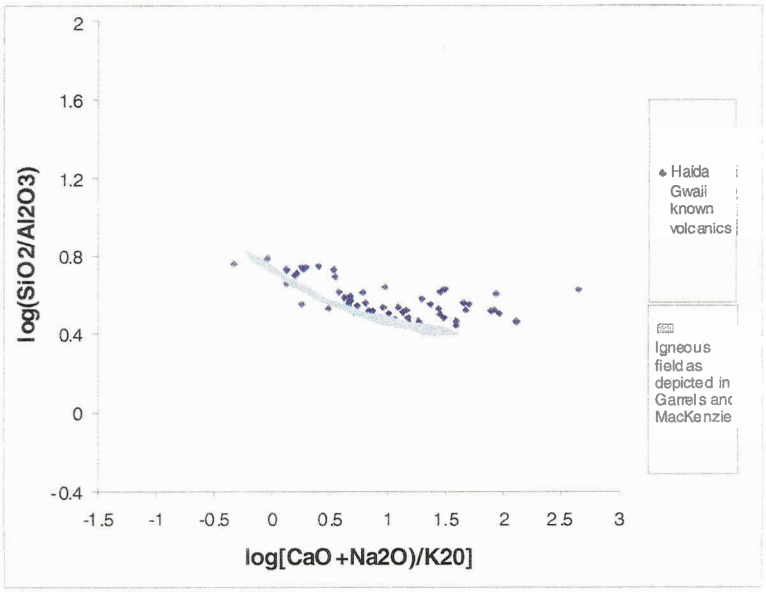


Figure 4.5 Plot of known Haida Gwaii volcanics and additional sedimentary samples from Pettijohn (1963 and 1975).

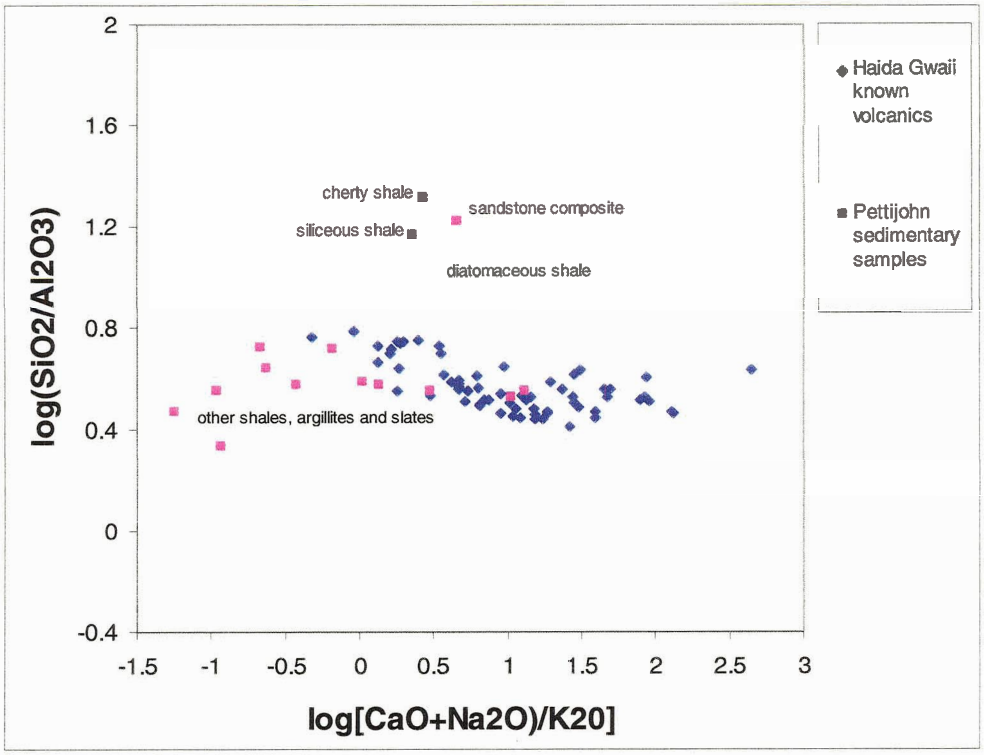
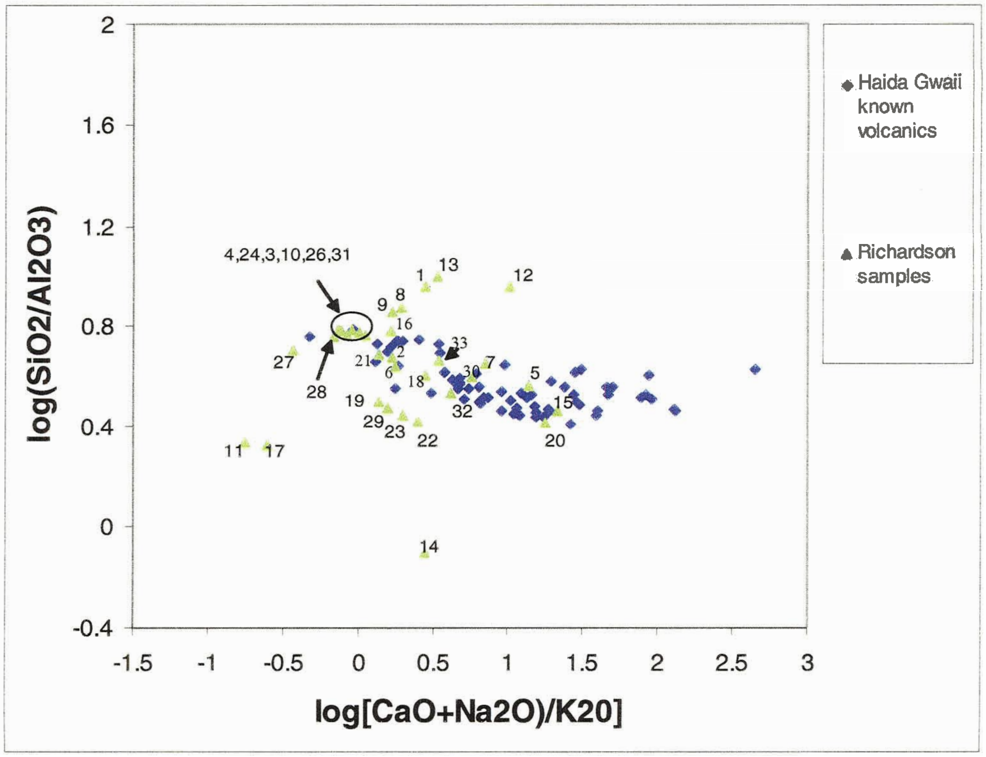


Figure 4.6 Plot of Richardson samples in comparison to known Haida Gwaii volcanics



currently available for the Queen Charlotte Islands, they could not be used for comparative purposes here.

The Richardson Island samples were then plotted (Figure 4.6). Once again, the samples 1, 8, 9, 12, and 13, which were outside of the normal igneous range in the previous section, were outside the igneous realm on this graph as well. In addition, samples 11, 14, 17, 19, 22, 23, and 29 plot convincingly outside of the igneous range, with sample 27 close to the end of the igneous band. The remaining samples, including 32 (Richardson Foliation), fall within the igneous zone, although many of these are within the section overlapped by lutitic[14] sediments.

Igneous vs. Lutites: Na2O/Al2O3 vs. K2O/Al2O3

In an effort to differentiate between overlapping volcanics and lutites, Garrels and MacKenzie also offer a comparison of Na2O/Al2O3 versus K2O/Al2O3 (Figure 4.7). The irregular line depicts the lower limit of most igneous rocks. (In Figure 4.7 a dashed straight line has been added to approximate the curved boundary between igneous rocks and lutites as depicted by Garrels and MacKenzie. This straight line is more easily replicated in subsequent plots than the original curved boundary). Lutites tend to fall below this line except for the Kitchi schists and Pelagic sediments. These sedimentary rocks are more sodic than normal igneous rocks and tend to plot above most igneous specimens. Garrels and MacKenzie suggest that there are "additional analyses available of similar materials that plot in the same general region or a little lower. They are the volcanogenic sediments [which] were originally basaltic or slightly more silicic lavas that were fragmented and altered but retained their original basaltic imprint" (1971: 229).

When the Haida Gwaii volcanics were added to this chart we see that some volcanics fall slightly below the dividing line (Figure 4.8). Finally, when the Richardson samples were added to this plot, the Richardson foliation (#32) did separate from the igneous samples (Figure 4.9) and a clear division between igneous and non-igneous materials appeared.

Despite the potential for the lower limits of igneous rocks to intertwine with the upper limit of the majority of lutites, this graph does resolve issues of affinity among the remaining Richardson samples. The Richardson samples that had been deemed non-

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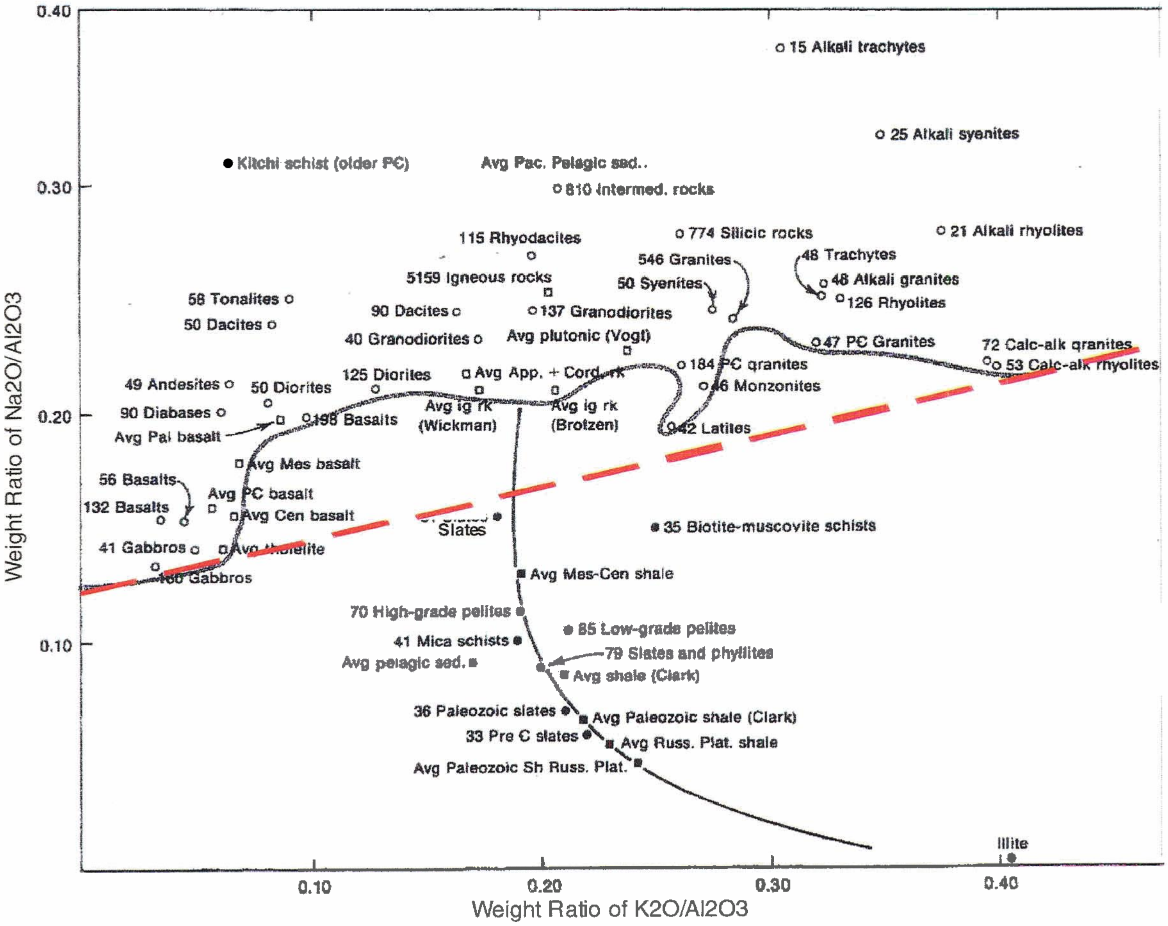
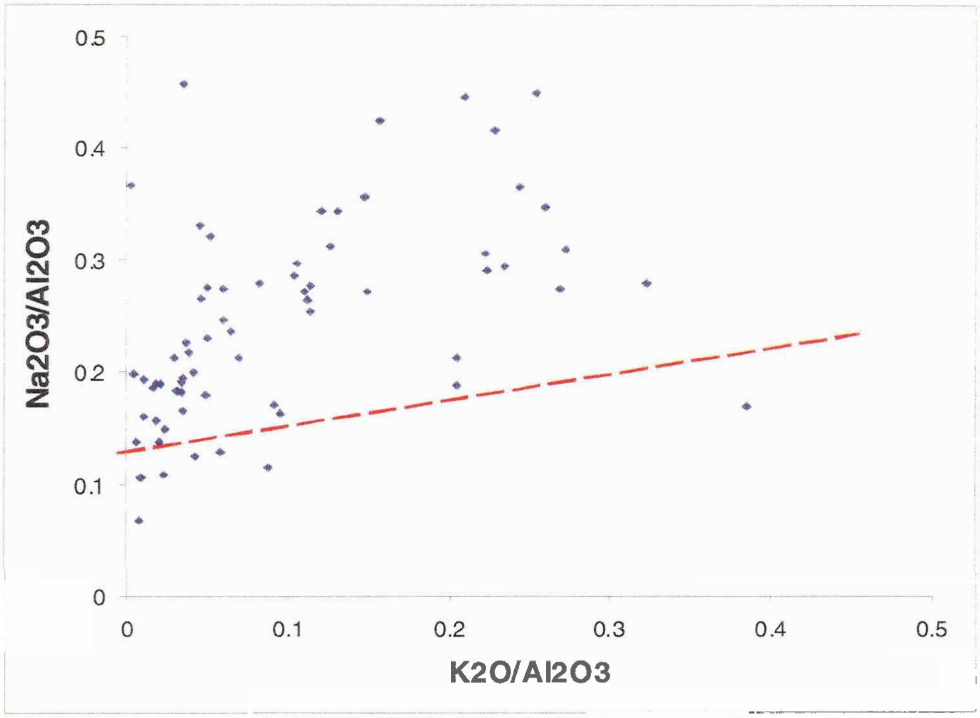
[14] A lutite is a sedimentary rock "composed of particles smaller than those of sandstone, commonly in the range of a few microns, and represent finer debris carried by the erosional agents of running water, ice, and wind" (Garrels and MacKenzie 1971: 39). Includes argillite and shale.

Figure 4.7 Comparison of lutites and igneous rocks according to Na2O and K2O compositions



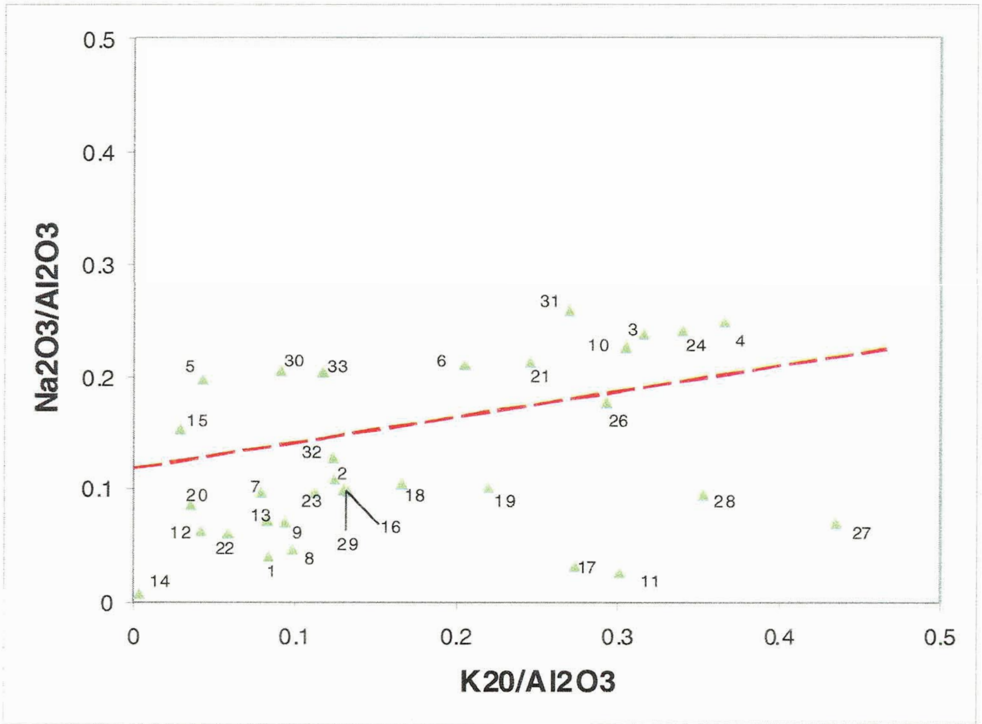
Note: Modification of Image from Garrels and MacKenzie 1971: 229. Dashed red line approximates the curved boundary depicted here in the original Garrels and MacKenzie image. The dashed line will be shown in subsequent plots as it is more easily replicated than the original boundary.

Figure 4.8 Known Haida Gwaii volcanics plotted according to Na2O and K20 compositions



Note: Dashed line indicates approximated boundary between lutites and igneous rocks as depicted by Garrels and MacKenzie (1971).

Figure 4.9 Plot of Richardson samples according to Na2O and K2O compositions



Note: Dashed line indicates approximated boundary between lutites and igneous rocks as depicted by Garrels and MacKenzie (1971). Samples 20 and 7 fall within the lower limits of the known Haida Gwaii volcanics as plotted in Figure 4.8 and were therefore examined carefully for visual characteristics that could argue for igneous or non-igneous origin.

igneous in the previous section were reconfirmed here. Of the samples that fell within the zone of overlap in the previous section, three samples (7, 20, and 26) plotted closely to the dividing line in Figure 4.9 or towards the lower limits of the known Haida Gwaii volcanics. As described below, a visual assessment of these samples confirmed their association within the igneous or non-igneous designations.

Sample # 7 plotted near the dividing line in Figure 4.9. However, a closer examination of its pyroclastic texture, in which shards of minerals and glass are visible, indicated that this material is a tuff. By definition tuffs fall into a grey zone between igneous and sedimentary rocks. They are formed from volcanic ash and pyroclasts measuring less than 2mm, which are consolidated by sedimentary processes. Yet, as their chemical compositions resemble those of other volcanic rocks originating from the same magmatic events, tuff, and hence sample 7, is best assigned to the igneous category.

Sample 20 was visually distinct as it maintained bands of clastic intrusions. This is likely a paraconglomerate, specifically a varvite. Varvites are "finely laminated shales or siltstones that periodically contain layers with scattered, sand-size, angular grains of quartz, feldspar, or lithic clasts" (Carrozi 1993:49). The material would have formed when grains dropped from floating glacial ice into the unconsolidated muds accumulating at a lake bottom. Its location near the igneous – sedimentary division in Figure 4.4d is not unusual given the Pettijohn varved argillite plots above the igneous border.

Sample 26 is most convincing as an igneous rock given its embodiment of phenocryts. As would be expected for igneous rocks, the three other samples containing phenocrysts (33, 21 and 6), plot in the igneous zone.

Summarizing Igneous and Non-Igneous separations

The three previous sections allowed for the separation of igneous and non-igneous materials among the Richardson samples. The distinctions are summarized in Table 4.6. Included in this table is sample 25. During the bead manufacturing stage this sample did not fuse into a glass due to exceptionally high silica content which suggests it is likely a chert or agate and, hence, non-igneous.

In addition to the igneous and non-igneous distinctions, a transitional category has been added to Table 4.6. This category contains samples 27 and 28. While these samples fall within the non-igneous zone in Figures 4.9, 4.1b, and, in the case of 27, in

Figure 4.6, the rare earth element plots (shown in the latter half of this chapter), indicate that these samples better resemble igneous materials. For this reason, 27 and 28 are denoted "transitional" in Table 4.6. They will appear in the upcoming igneous and non-igneous plots, and will be discussed separately towards the end of the chapter.

Table 4.6 Richardson samples divided according to igneous and non-igneous traits

Igneous samples	3, 4, 5, 6, 7, 10, 15, 21, 24, 26, 30, 31, 33
Non-Igneous samples	1, 2, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 20, 22, 23, 25, 29, 32
Transitional samples	27, 28

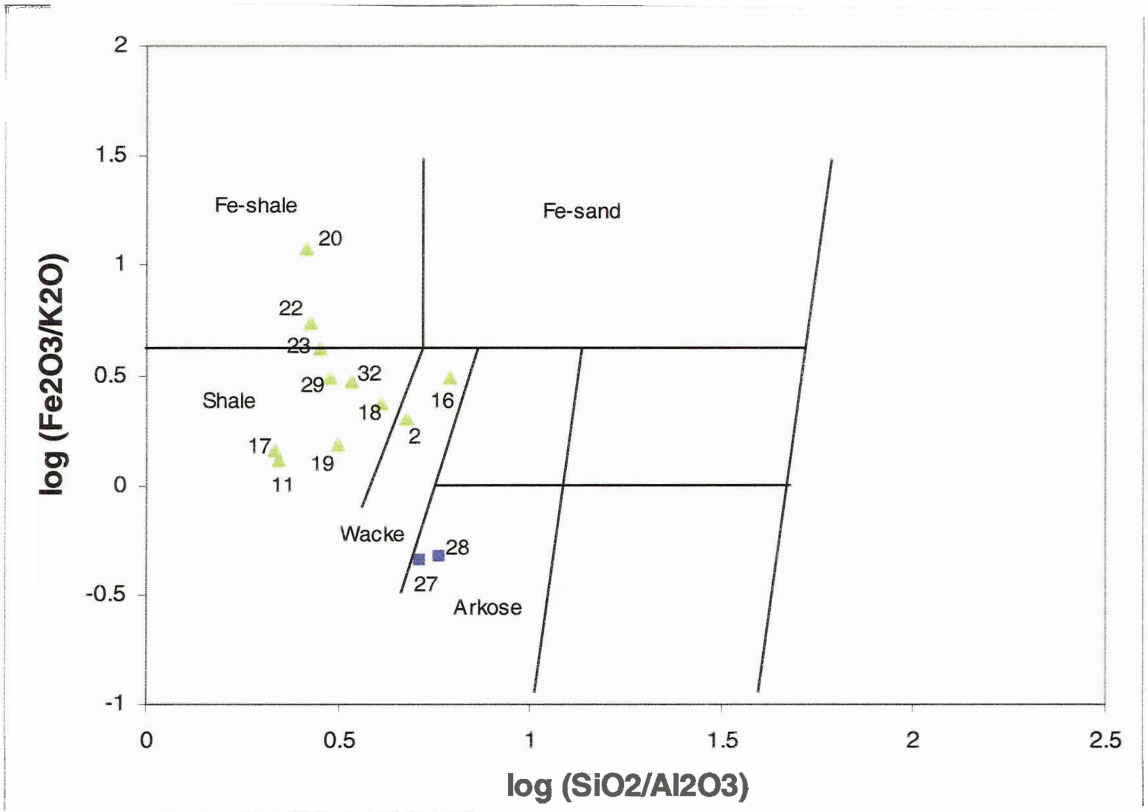
Establishing Non-Igneous Classifications

Sedimentary and metamorphic rocks are most commonly classified according to textural properties, although clastic sedimentary rocks can be differentiated according to major element data (Herron 1988; Pettijohn et al. 1972). These diagrams, however, are less rigorously tested than those for igneous rocks and are based on the premise that chemical composition changes with grain size (Argast and Donnelly 1987; Roser and Korsch 1986). Metamorphic classifications tend to be established on non-chemical traits such as texture, index minerals (formed by metamorphic processes only), and the type of metamorphism which is determined in the geological context (Robertson 1999). The composition of a metamorphosed rock varies significantly depending both on the degree of alteration it experiences and the composition of the parent rock. It is possible for a metamorphosed rock which is not subjected to high temperatures and pressures to maintain a chemical composition similar to that of the original protolith. Within each of the three major rock types one must keep in mind that the boundaries between classifications are not absolute but form a continuum in which one material grades into another.

Of the non-igneous samples identified in Table 4.6, it was possible to classify a number of materials according to their textural attributes and their locations in the plots in the previous sections. For reasons already mentioned #25 is likely a chert or agate, and #20 a varvite. An extremely high silica content also distinguished #1, 8, 9, 12, and 13 from the other samples. On the igneous versus sedimentary graph (Figure 4.3) these latter materials plotted above the igneous line in the general sandstone abscissa as identified by Garrels and MacKenzie. Yet, as we saw with the addition of the Pettijohn samples, siliceous shale and cherty shales will also plot in this realm. Given the exceptionally fine-grained nature of these materials it is unreasonable to classify them as sandstone, graywacke or arkose due to the comparatively larger grain size of these materials. A siliceous shale, however, is a reasonable classification. These materials are predominantly black with varying degrees of white speckling or spotting (refer to Table 4.2 for full descriptions). The speckled appearance of sample #13 is very subtle and could be mistaken for basalt. Two of the samples (#1 and #12) display obvious metamorphism and what would likely have been individual spots have been stretched and align in a banded pattern. Sample #12 displays advanced warping within the bands and within isolated planes of the material. Given the appearance of metamorphic alteration, a classification of siliceous argillite is offered for the group as argillite implies that the shale material has undergone mild metamorphism.

The remaining non-igneous samples (2, 11, 16, 17, 18, 19, 20, 22, 23, 29, 32) were plotted according to log Fe2O/K2O versus log SiO2/Al2O3 values (Figure 4.10) to determine their classifications (Herron 1988). The majority of these samples fall within the Fe-Shale/Shale designations. Given that shale is very fissile and able to split along thin laminations, it may be best to categorize these materials as mudrocks or argillites. Mudrocks are non- fissle with a blocky or massive texture while argillites are a more indurated mudrock (Tucker 1996:22). Aside from the shales/argillites that plot consistently in the shale fields in both Figures 4.6 and 4.10, there are a few samples that fall within contradictory fields. Sample #2 plots well below the sandstone (wacke) abscissa in Figure 4.6, but is classified as a wacke in Figure 4.10. It is visually very similar to the other materials classified as shale and it is possible that it is best assigned to that category. Given that the borders between classifications in Figure 4.10 are not absolute but form grading continuums, it will be classified as a 'wacke/shale'. A summary of the non-igneous classifications is presented in Table 4.7 at the end of the following section.

Figure 4.10 Richardson samples (non-igneous): logarithmic plot of Fe2O/K2O versus SiO2/Al2O3

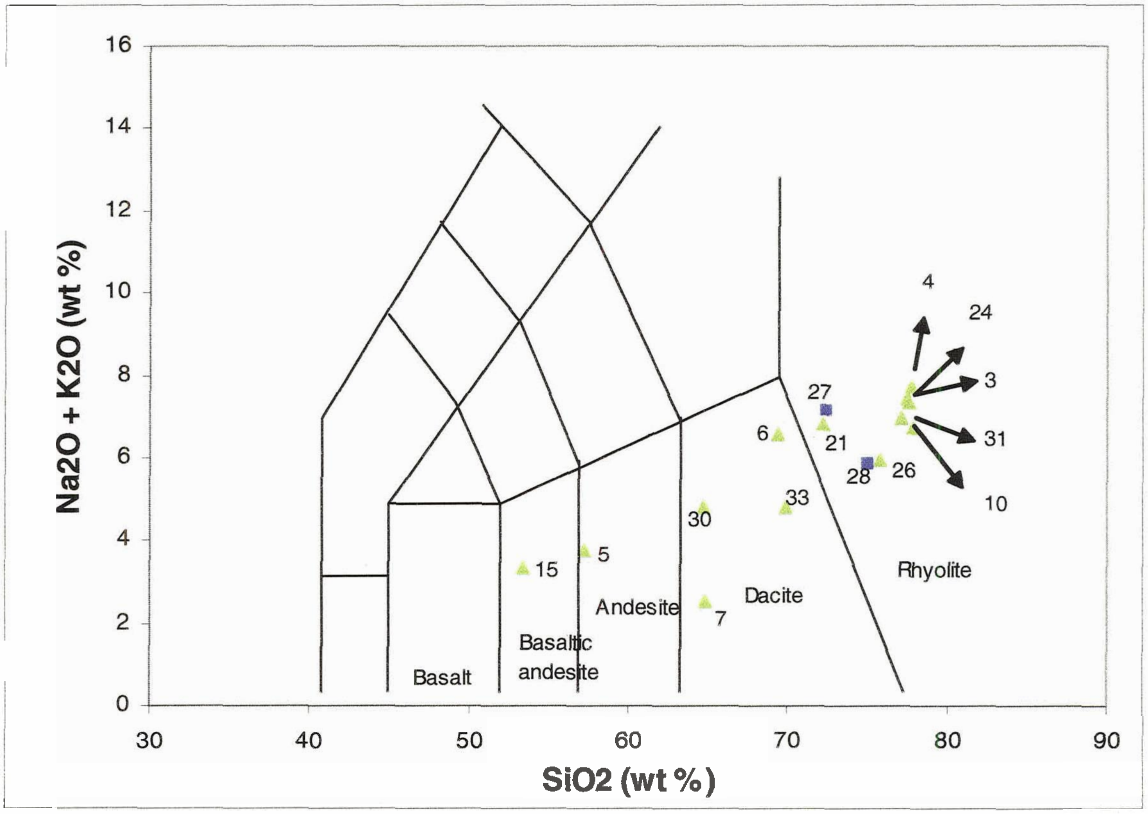


Note: This chemical classification of sedimentary rocks is after Herron 1988. Field co-ordinates also from Herron 1988.

4.6 Establishing Igneous Classifications

Major element oxides also allow for more specific classifications within the igneous rock types. The samples identified as igneous materials in Table 4.6 were plotted according to their total alkali (Na + K) and silica content (Figure 4.11). The majority of the igneous samples plot within the rhyolite and dacite fields while two materials appear in the basaltic-andesite to andesite range. A summary of the igneous and non-igneous classifications are presented in Table 4.7.

Figure 4.11 Richardson samples (Igneous) plotted according to SiO2 versus Na2O + K2O content



Note: This chemical classification of volcanic rocks using TAS (total alkali-silica diagram) is after Le Maitre 2002. Field co-ordinates also from Le Maitre 2002. The TAS diagram is an accepted and commonly used classification scheme for volcanic rocks.

Table 4.7 Summary of Richardson rock types

Sample	Rock Type	Sample	Rock Type	Sample	Rock Type
11	Shale/argillite	1	Siliceous argillite	3	Rhyolite
17	Shale/argillite	8	Siliceous argillite	4	Rhyolite
18	Shale/argillite	9	Siliceous argillite	10	Rhyolite
19	Shale/argillite	12	Siliceous argillite	24	Rhyolite
22	Shale/argillite	13	Siliceous argillite	26	Rhyolite
23	Shale/argillite	16	Wacke	31	Rhyolite
29	Shale/argillite	2	Wacke/Shale	21	Rhyolite
32	Shale/argillite	27	Rhyolite?	6	Dacite
25	Chert/Agate	28	Rhyolite?	30	Dacite
7	Tuff	14	Indeterminate[15]	33	Dacite
20	Varvite	5	Andesite	15	Basaltic-andesite

Confirming Igneous Classifications and Addressing Issues of Weathering and Mobility of Major Elements

In the discussion thus far, the Richardson samples have been differentiated according to major element concentrations. However, a further confirmation of rock types based on trace elements is required for two reasons. Firstly, during the sample preparation phase, weathering rinds were not removed and the elements Na, K, Ca, Mg, and to a slight degree Si, are mobile during weathering processes (i.e. concentrations of these elements may be depleted or enriched) (Rollinson 1993:72). Secondly, Na is volatile and thus, may have been depleted slightly during the sintering and glass fusion processes.

The degree to which these factors affected the rock classifications was examined by comparing the igneous assignments arrived at through the alkali-silica diagram (Figure 4.11) to a discrimination diagram for volcanic rocks based on the trace elements Zr, Ti, Nb, and Y (Figure 4.12) (Pearce 1996; Winchester and Floyd 1977). These elements are known to be immobile and hence are unaffected by weathering or heating

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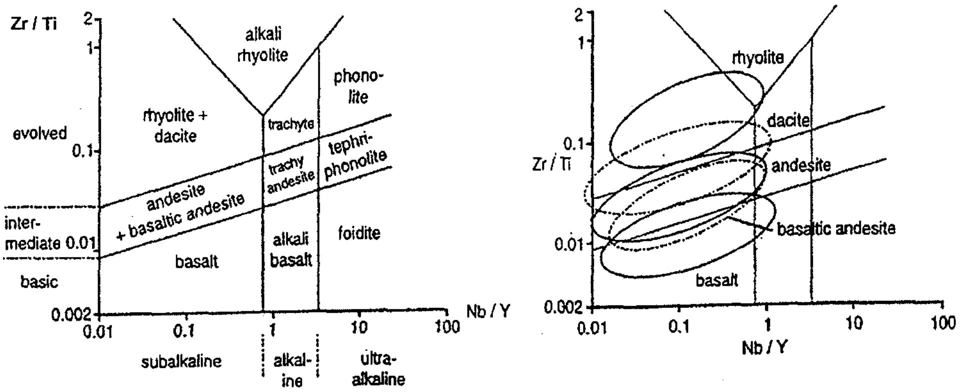
[15] Sample # 14 behaved strangely in the classification process as it frequently plotted off the scale in the discrimination diagrams. While a very high Aluminum content it could arguably be a shale, slate, or argillite. However, I believe there is an issue of contamination with this sample. I experienced some frustrating moments in the bead preparation phase when this sample became stuck in the steel mill and it is likely that contamination occurred at this time. Given the peculiar classifications offered by this sample it will be excluded from the remainder of the analysis. From this point on it will be known simply as material 14.

processes. Sedimentary discrimination diagrams based on trace elements are still in their infancy and were not applied here.

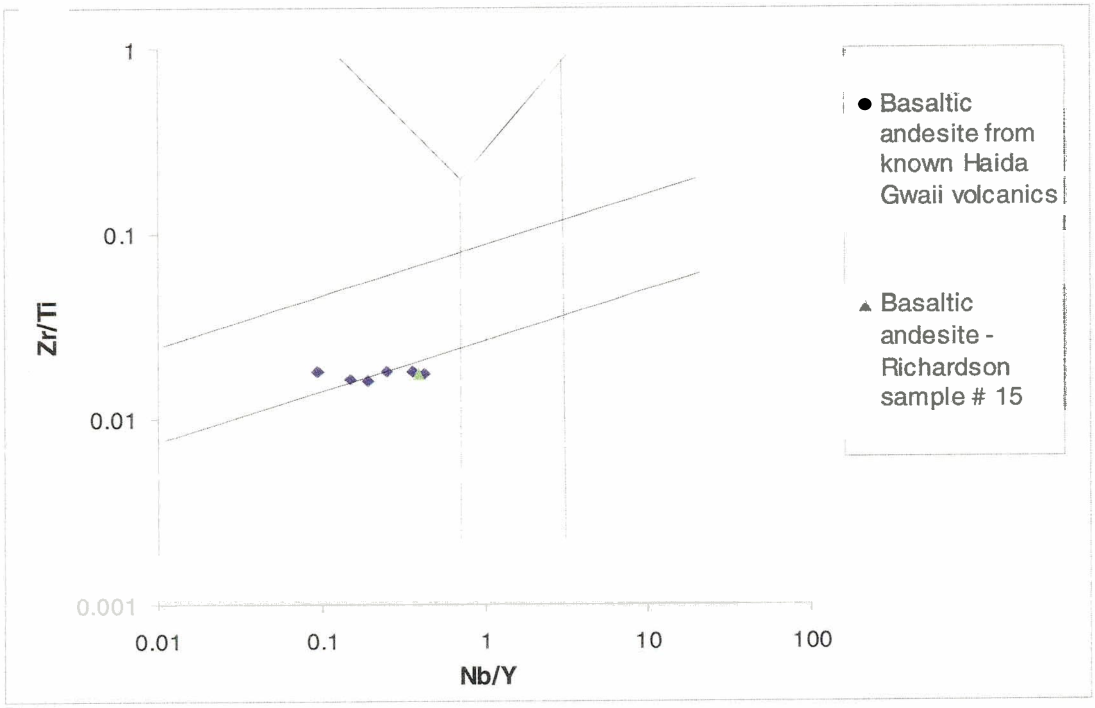
Figure 4.12 Zr/Ti vs. Nb/Y discrimination diagram for volcanic rocks



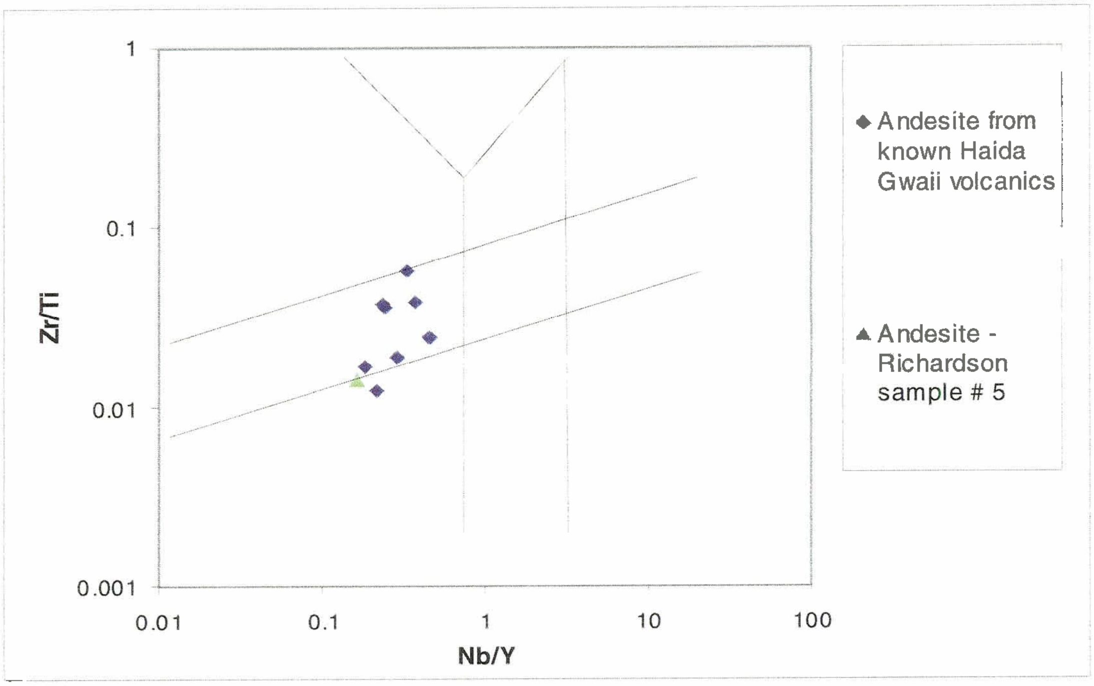
Note: Image as it appears in Pearce 1996: 101. Image on the left depicts revised fields of the Winchester-Floyd diagram (1977) established in Pearce (1996). Image on the right denotes the 10% probability ellipses which illustrate the potential for overlapping fields.

As in previous sections, the known Haida Gwaii volcanics were plotted on the Zr/Ti vs. Nb/Y diagram to observe local variability within the different igneous fields. The igneous Richardson samples were then plotted on the same diagram (see Figure 4.13 a-d). Aside from #21(which is visually more similar to the dacite sample 6 and 33 and will thus be considered dacite in the following discussions) the Richardson samples plot within comparable fields, indicating that the effects of weathering and the sample preparation process had minimal influence on major element composition and the classification schemes employed thus far.

Figure 4.13 Richardson samples (Igneous) and known Haida Gwaii volcanics plotted according to Zr/Ti versus Nb/Y ratios

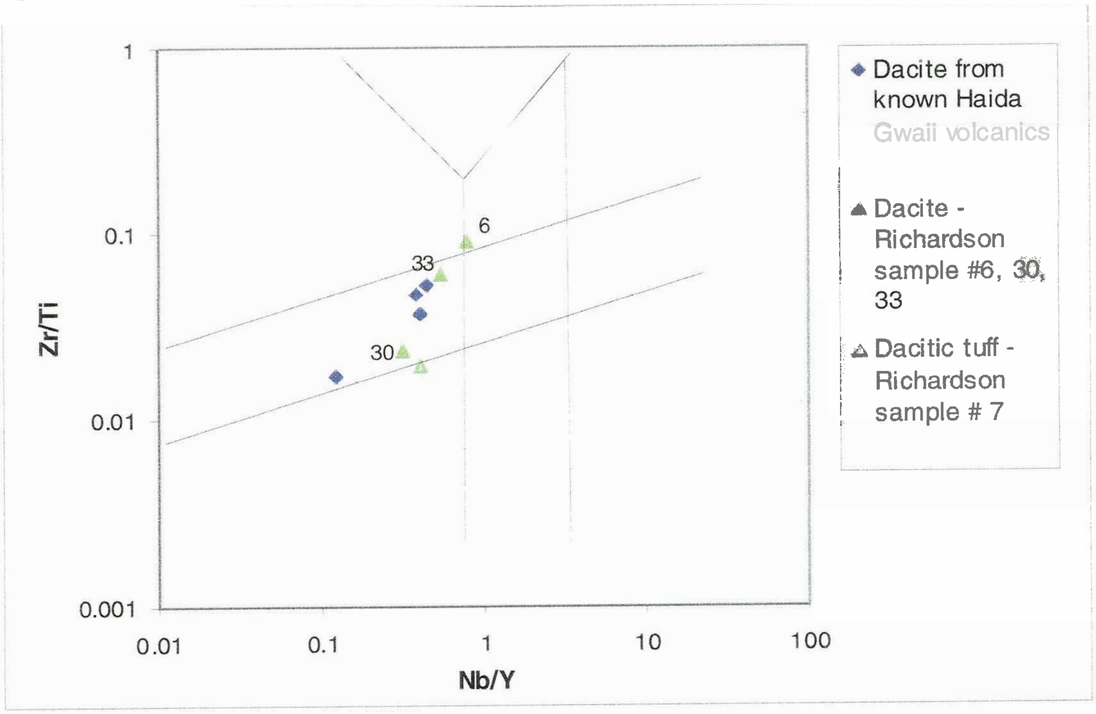


a) Basaltic andesite

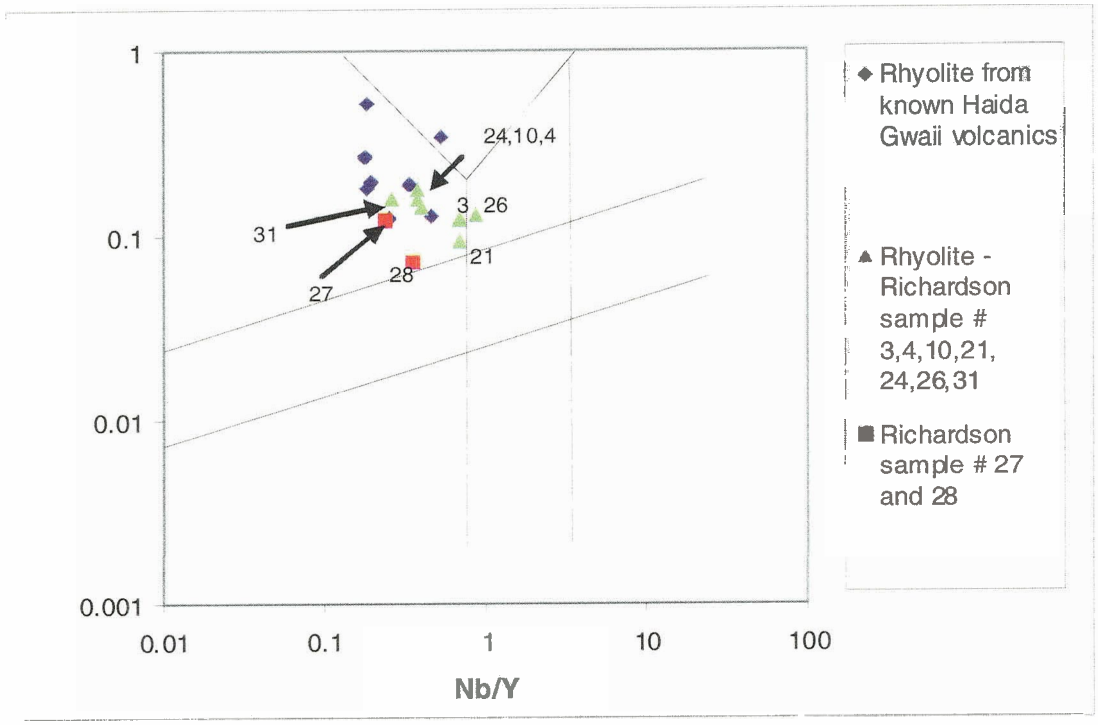


b. Andesite

Figure 4.13 continued



c. Dacite



d. Rhyolite

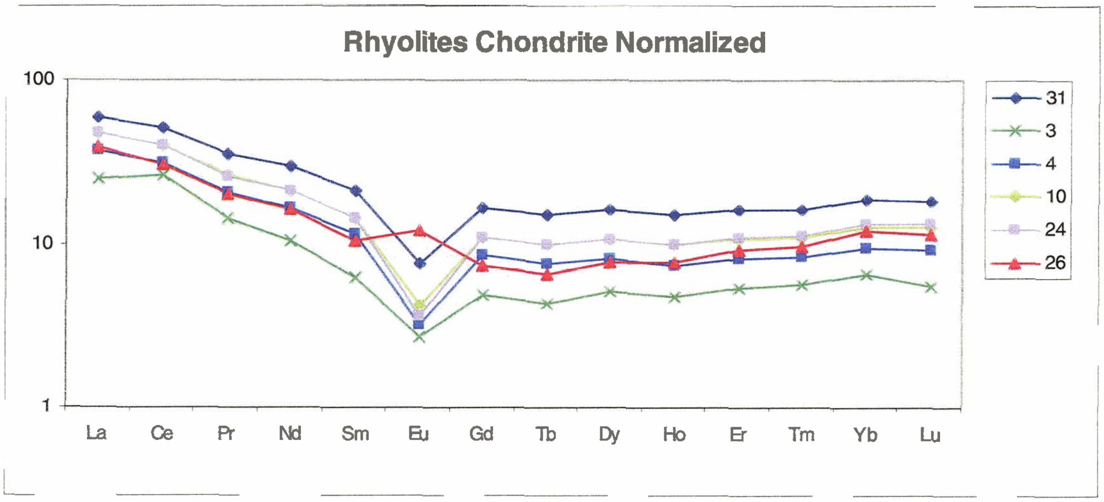
Compositional Variations within Rock Types

Rare earth elements (REE)

To this point we have identified twelve rock types among the thirty three samples tested, but how closely related are the materials within each group? Is it possible that they originated from the same source locations? In an attempt to answer these questions we must once again turn to the trace elements, specifically the rare earth elements (REE). As the REE are immobile, they resist the effects of weathering, hydrothermal alteration, and low-grade metamorphism. As such, this group of elements is particularly useful for distinguishing between rocks from different locations. Once normalized to chondritic meteorites (an accepted standard for REE believed to represent the average composition of primordial earth), the relative abundance of the lighter and heavier of these elements, and the presence of negative or positive Eu or Ce anomalies, reflect the unique environment in which the lithic material has formed (Rollinson 1993).

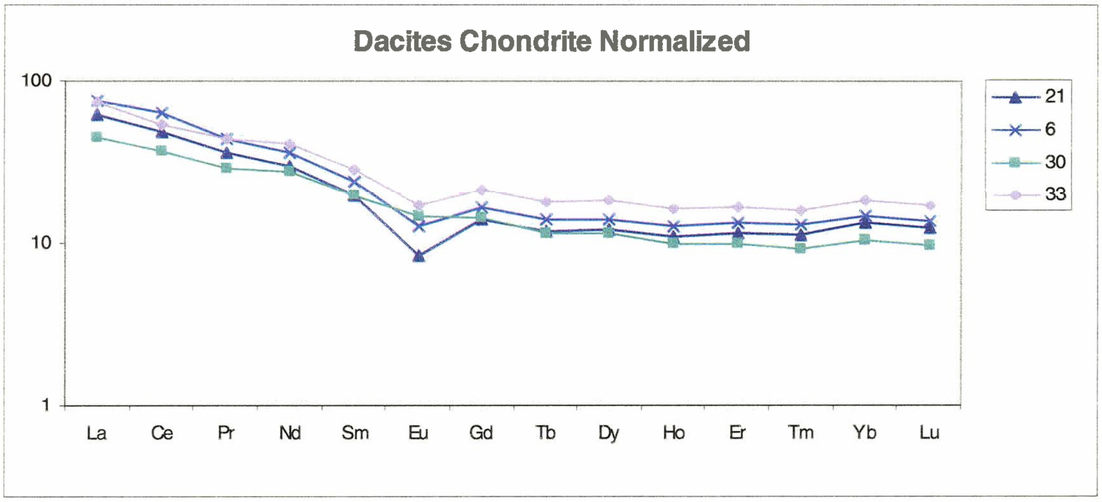
The REE for the Richardson samples were normalized to chondrite (Fig 4.14 a-f). These graphs indicate that some samples have quite unique REE patterns in comparison to other similarly classified rock types. But how much do these diagrams reflect the chemical variation within a single source versus the variation one might expect between distinct formations? Unfortunately, without multiple chemical analyses from within localized outcrops of the materials represented it is very difficult to know. At present chemical data are available for a small number of volcanic formations (Hyndman and Hamilton 1991; Hickson 1991; Sutherland-Brown 1968) and dykes (Souther and Jessop 1991) within Haida Gwaii but these limited analyses have been taken from diverse locations and rock types, and do not allow for sufficient comparisons. Nonetheless, the REE patterns presented here are useful for discriminating between samples to some extent. When we look at Fig 4.14a (Rhyolite chondrite norm), for example, we see that sample #26 exhibits a unique REE pattern due to a positive Europium anomaly. It is conceivable that it and the other rhyolite samples originated from the same volcanic magma, but that due to differential cooling within the magma and a process called fractionation, some minerals were concentrated in localized areas causing the depletion of elements in other locations (Rollinson 1993). Thus, we can say that #26 is spatially distinct from the other samples. However, whether they are removed by a meter within the same volcanic flow such as a dyke, or by hundreds of meters between different volcanic outcrops is hard to tell without more comprehensive chemical data from known locations. Similarly, whether variations in REE patterns among the shale samples represent exclusive sedimentary units or whether they reflect slightly different formational environments within the same sedimentary bed, is difficult to assess without a local chemical comparison. With this in mind we can look at the rare earth patterns within the rock type groupings to extract those samples that are most distinct in terms of their rare earth patterns. In addition to sample 26, sample 3 exhibits the next most distinctive patterning among rhyolites in that it has a more pronounced positive Ce anomaly. The remaining samples are very similar in their overall pattern. Among the dacites, sample 30 is the most distinctive due to a slight negative Eu anomaly. Sample 33 is distinct from the other two samples as it shows a slight negative Ce anomaly whereas the other two samples are slightly positive. Within the shale samples, sample 11 is the most distinct as it has a higher relative abundance of heavier REE. Samples 18 and 32 also maintain substantial negative Ce anomalies whereas the other samples have positive Ce anomalies. Among the siliceous argillite, sample 12 has a slight positive Eu anomaly and 13 has a slight negative Ce anomaly. As noted, these distinctly anomalous REE patterns suggest that the rocks could have originated from different source locations but in the absence of comparative data we cannot know for sure.

Figure 4.14 Rare earth elements for Richardson samples normalized to chondrite



a.

Figure 4.14 continued



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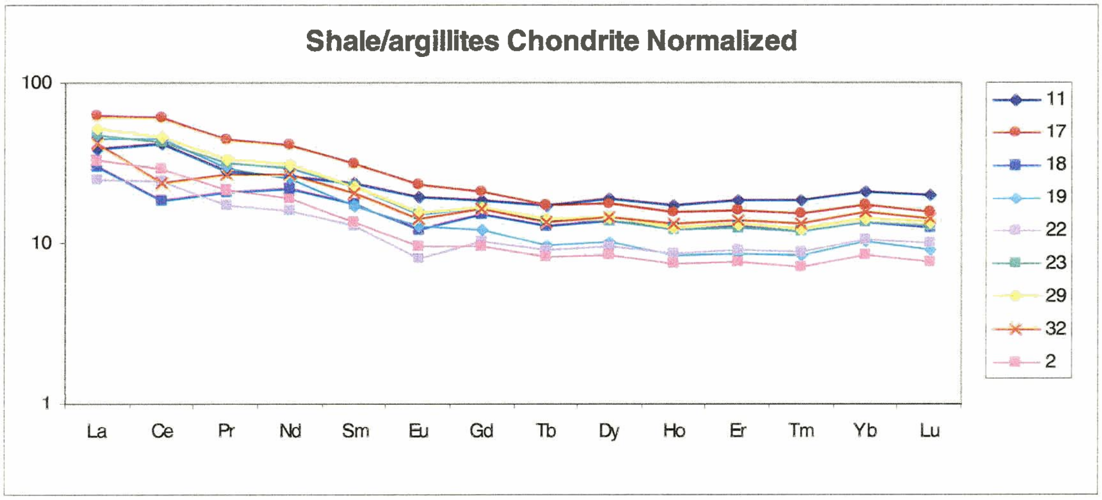

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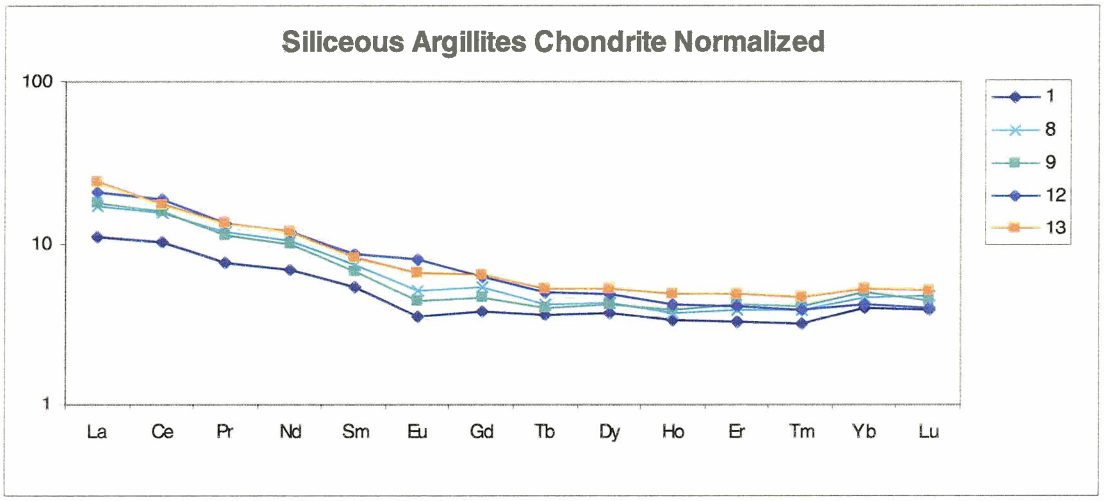
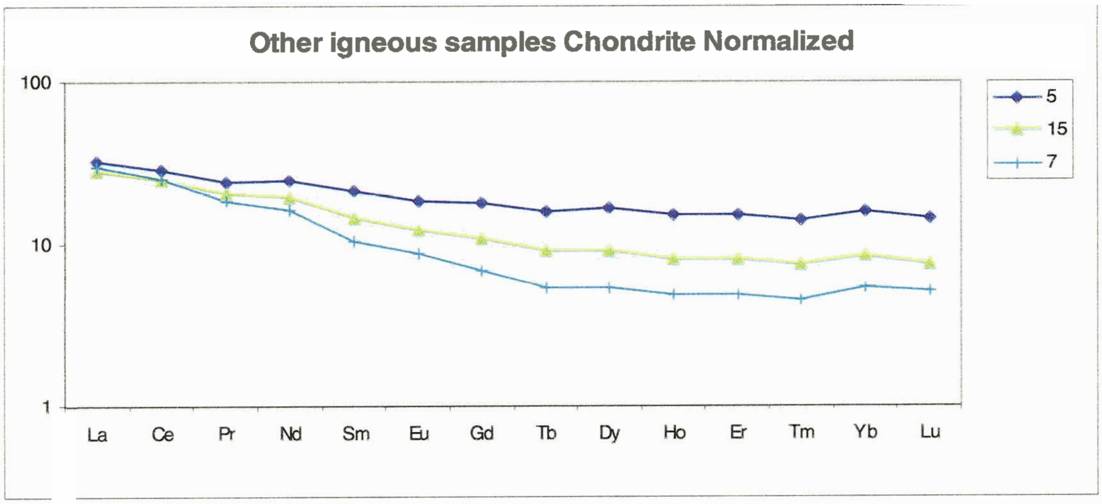


d.

Figure 4.14 continued



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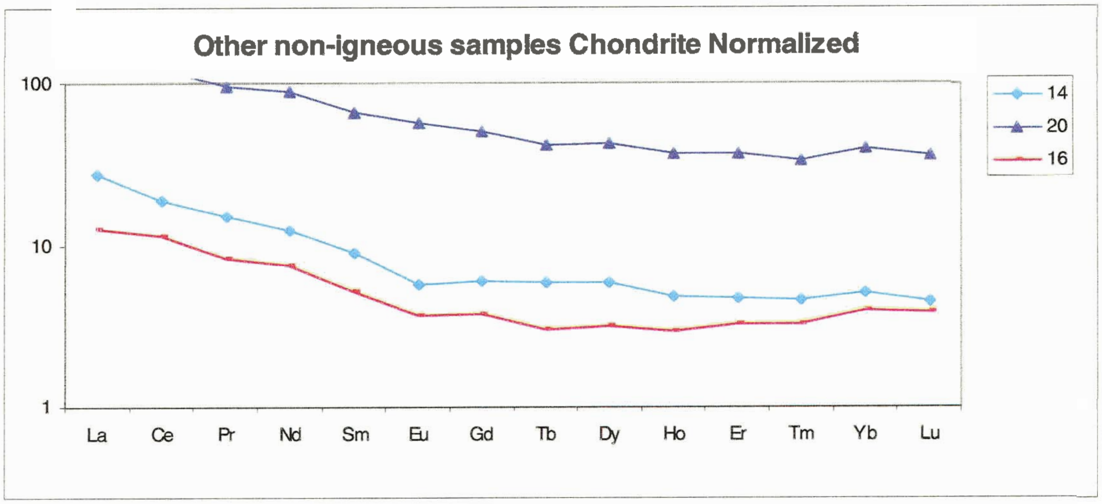
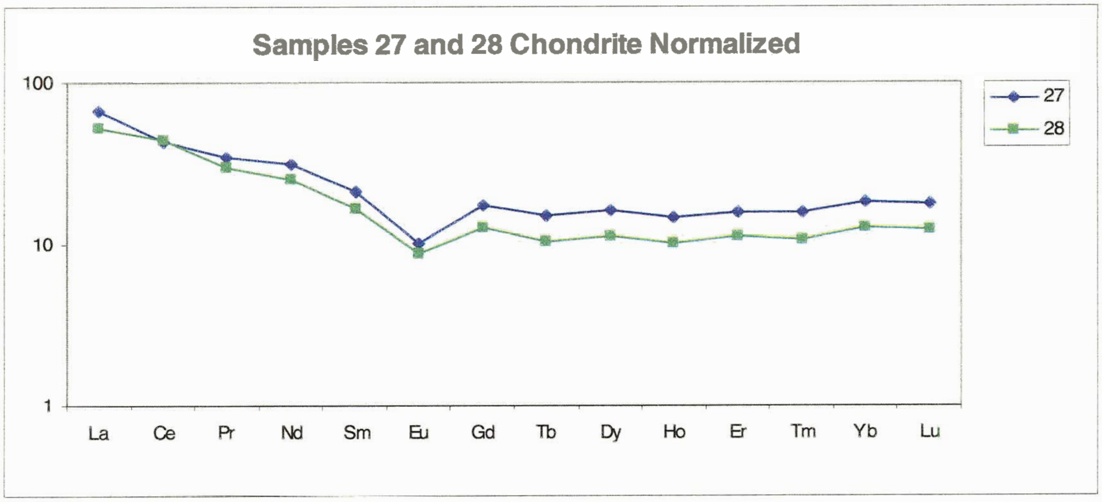


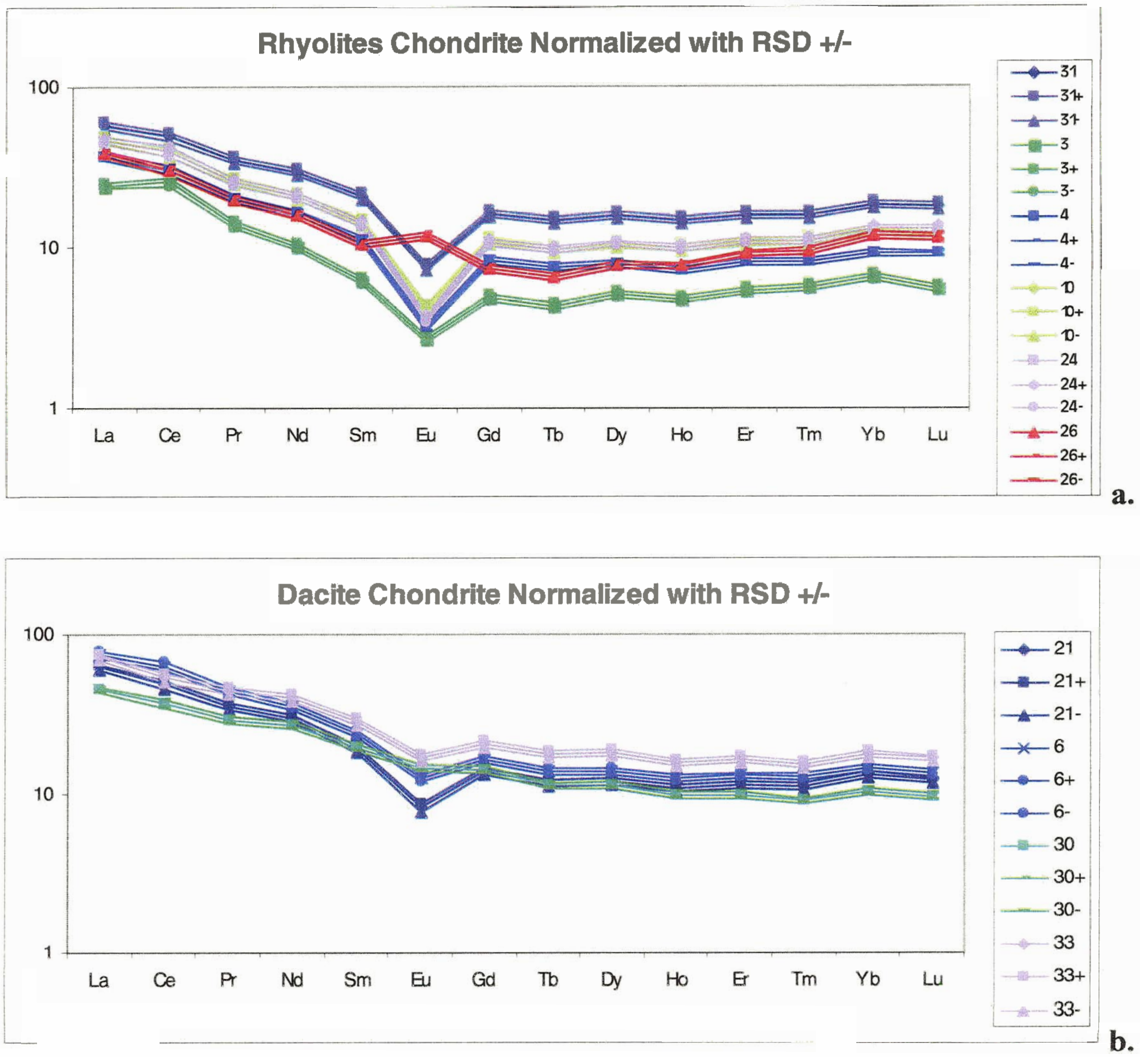
f.

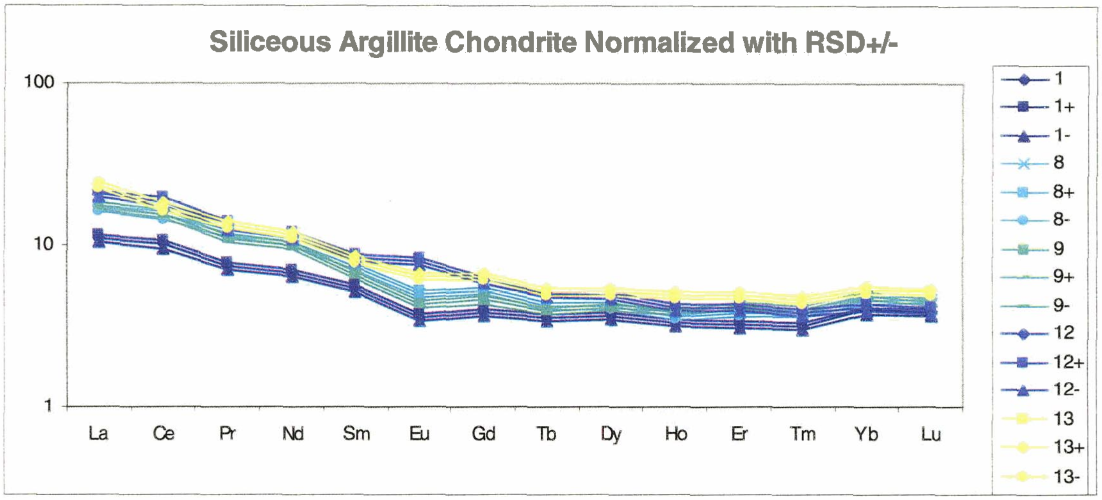


g.

And what of those samples that share similar REE patterns? Are any of them likely to be from the same source locations? To explore these question the relative standard deviation (%RSD) for each REE (as determined by analyses recorded for the NIST 613 standard - see Table 4.8), was applied to each sample to attain a pattern of deviation on either side of the detected concentrations. These were normalized to chondrite and plotted (see Figures 4.9a,b,c,d). In these figures we see that rhyolite samples 24 and 10, siliceous argillite samples 8 and 9, and shale 23 and 29 display overlapping deviation fields. None of the dacite samples overlap with one another. Samples displaying overlapping deviation fields were considered to be the same as their REE concentrations were within error of one another.

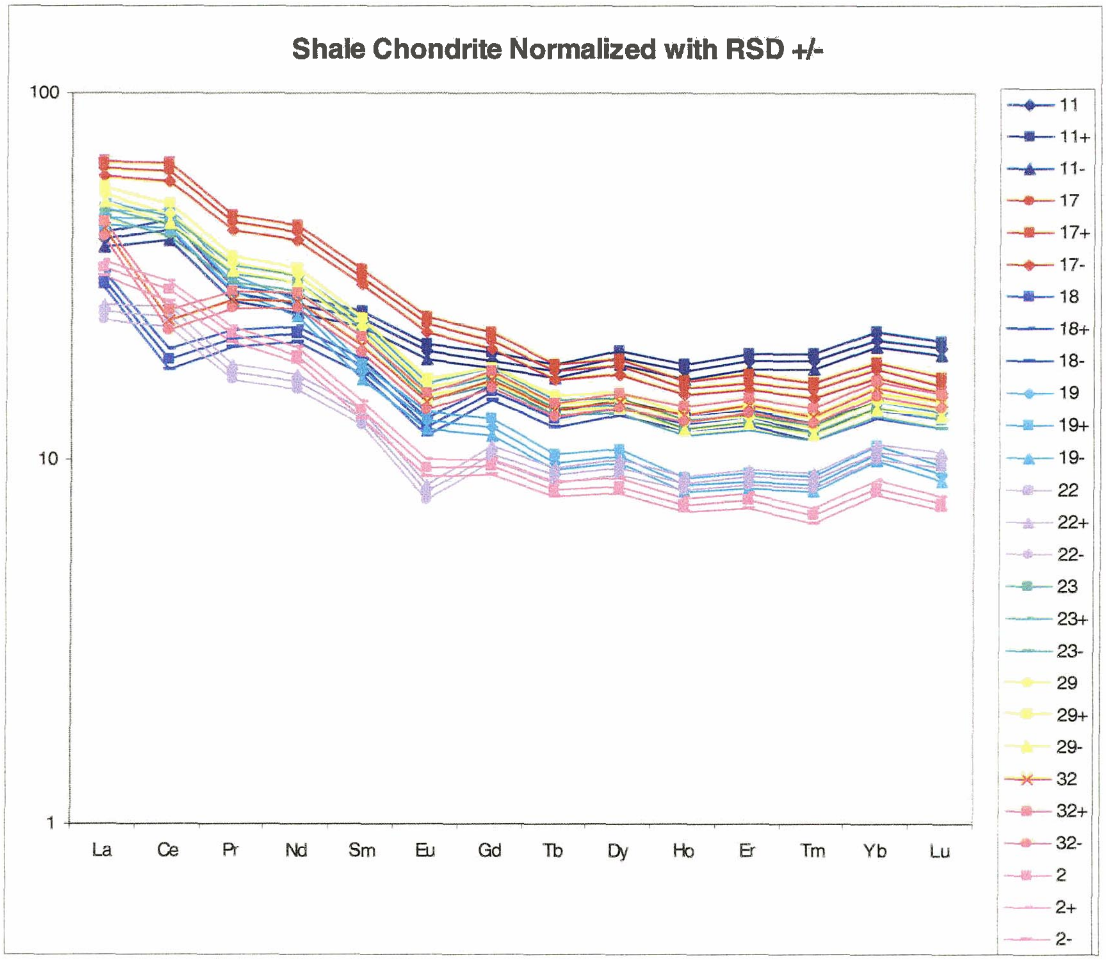
Figure 4.15 Rare earth element patterns for Richardson samples normalized to chondrite with relative standard deviations for each element plotted





c.

Figure 4.15 continued



d.

Table 4.8 NIST 613 Rare earth element concentrations

Sample Label	139La	140Ce	141Pr	146Nd	147Sm	153Eu	157Gd	159Tb	163Dy	165Ho	166Er	169Tm	172Yb	175Lu
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
nist613	38.74	42.49	40.18	37.78	39.9	37.37	40.19	38.97	38.82	40.86	40.4	40.4	43.43	40.27
nist613	32.83	34.53	33.91	31.97	33.52	31.24	33.63	33.07	33.12	34.83	34.22	34.18	36.69	34.74
nist613	35.81	38.76	37.21	35.07	36.71	34.42	37.08	35.99	35.86	37.75	37.39	37.66	40.05	37.81
nist613	35.73	37.95	37.11	35.43	36.73	34.46	36.79	35.83	36.13	38.03	37.48	37.42	39.84	37.6
nist613	36.75	40.23	38.52	36.31	37.58	35.61	38.11	36.97	37	38.82	38.42	38.55	41.18	38.8
nist613	34.69	36.06	35.4	33.99	35.5	33.02	35.86	34.85	34.88	36.8	36.36	36.48	38.76	36.5
nist613	35.94	38.25	37.33	35.77	37.28	34.76	37.38	36.26	36.41	38.54	38.26	38.32	40.67	38.7
nist613	35.59	38.44	36.97	34.56	36.15	34.14	36.58	35.58	35.44	37.17	36.76	36.73	39.21	36.55
AVERAGE	35.76	38.34	37.08	35.11	36.67	34.38	36.95	35.94	35.96	37.85	37.41	37.47	39.98	37.62
SD	1.68	2.42	1.88	1.71	1.82	1.79	1.87	1.69	1.65	1.74	1.79	1.81	1.95	1.70
%RSD	4.69	6.30	5.06	4.88	4.96	5.20	5.05	4.69	4.58	4.6	4.78	4.82	4.89	4.53
Reported	35.77	38.35	37.16	35.24	36.72	34.44	36.95	35.92	35.97	37.87	37.43	37.55	39.95	37.71
%Recovery	99.97	99.97	99.78	99.63	99.87	99.82	100.01	100.06	99.97	99.95	99.95	99.78	100.07	99.76

Comparison to Tholeiitic Basalt

Typically archaeological sourcing studies are conducted on archaeological samples and potential source materials. Rarely are questions aimed at predicting the locations of material acquisition on chemical evidence provided by the artifacts alone. A notable local exception is the work done by Edward Bakewell who employed a "source modeling" technique to identify the dacite sources utilized by inhabitants of the San Juan Islands (1996). When faced with questions of compositional variation among his dacite assemblage, he compared their means and standard deviations of selected major, trace, and rare earth elements with those of an Icelandic tholeiite. Tholeiitic basalts have been rigorously tested and the chemical variation within each flow is known to be exceptionally homogenous (Lindstrom and Haskin 1980). The dacites analyzed by Bakewell revealed less standard deviation among element concentrations than among the tholeiites. This was compelling evidence that the San Juan dacites were from the same source location especially given that volcanics such as andesite and dacite tend to exhibit more chemical variation than tholeiitic basalts. Of the igneous Richardson samples, only the rhyolite suite has a large enough sample size to have a similar method applied. When #4, 10, and 24 are averaged and the standard deviations calculated they fall within range of the tholeiitic basalt indicating that the chemical variation between them is what one would expect within a well-homogenized flow (Table 4.9). This is an interesting outcome given that these three rhyolite samples are visually distinct materials. While the grain size for each of these specimens is similar, the matrix colour varies from white (#4) to grey with purply hue (#10), to pale yellow (#24). None of these samples exhibit weathering rinds.

Table 4.9 Comparison of chemical variation among Richardson rhyolites to San Juan dacite and Icelandic tholeite

	Richardson Rhyolite samples 4,10,24		Richardson Rhyolite samples 4,10,24,3		San Juan Dacite		Icelandic Tholeite	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Ox%(Si)	77.68	0.21	77.65	0.18	65.39	0.5	47.91	0.3
Ox%(Ti)	0.13	0.02	0.13	0.02	0.47	0.01	1.95	0.1
Ox%(Al)	12.64	0.14	12.78	0.31	16.52	0.37	16.27	0.42
Ox%(Fe)	1.25	0.27	1.24	0.23	4.21	0.13	10.75	0.35
Ox%(Mn)	0.02	0.02	0.02	0.02	0.08	0.01	0.16	0.01
Ox%(Mg)	0.08	0.01	0.08	0.00	2.48	0.13	6.36	0.27
Ox%(Ca)	0.36	0.22	0.35	0.19	4.76	0.08	12.48	0.3
Ox%(Na)	3.02	0.14	3.06	0.13	4.38	0.11	2.4	0.13
Ox%(K)	4.25	0.37	4.23	0.30	1.67	0.11	0.36	0.06
Sr	14	1	15	4	637	34	293	35
Ba	405	38	387	48	660	18	87	22
Sc	2.3	1.3	2.5	1.2	9	1	33	1
Cr	<1	<1	1	<1	42	7	245	25
Ni	3.71	2.15	4.27	2.08	45	5	89	14
La	10.31	1.39	9.20	2.51	14	0.1	9.6	0.8
Ce	22.54	3.23	20.92	4.18	30.1	1.6	23.2	1.2
Sm	1.97	0.25	1.71	0.56	3.2	0.4	4.2	0.3
Eu	0.21	0.03	0.19	0.04	0.82	0.05	1.5	0.08
Yb	1.89	0.34	1.68	0.50	1.3	0	2	0.2
Lu	0.29	0.05	0.25	0.09	0.22	0.01	0.32	0.02

Note: San Juan Dacite and Icelandic Tholeite values from Bakewell 1996.
Trace and REE expressed in ppm.

Samples 27 and 28

Earlier in this chapter, samples 27 and 28 were identified as "Transitional samples" (Table 4.6). Initially, the discrimination diagrams which separated igneous from non-igneous materials on the basis of major element concentrations, revealed that samples 27 and 28 plotted well within the non-igneous realm. In Figure 4.9 the remaining igneous samples plotted above, or closer to, the boundary between igneous and non-igneous than did 27 and 28. Yet when these two samples were plotted on the sedimentary discrimination diagram (Figure 4.10), they received the unlikely classification of 'arkose'. Numbers 27 and 28 are somewhat unusual in the Richardson assemblage given that they are among the most fine-grained materials at the site. This quality is likely responsible for their restricted use in microblade technology. As arkoses are more coarsely grained, this is not a fitting classification. Also, in Figure 4.6 these samples did not plot within the general sandstone abscissa as may be expected of an arkose, but rather within or close to the igneous realm.

When plotted as igneous rocks on the total alkali silica diagram (Fig 4.11), both samples 27 and 28 received rhyolite designations. These classifications were confirmed by the Zr/Ti vs. Nb/Y discrimination diagram (Figure 4.13). The REE patterns, even more convincingly, indicate that samples 27 and 28 are igneous as their REE patterns match closely with those of the rhyolite and dacite samples. Thus, samples 27 and 28 are best classified as rhyolite.

Ultimately, samples 27 and 28 were not identified as igneous in the early discrimination diagrams as they are high in K/Na, low in Na/Al, and maintain low overall Na concentrations. These factors preclude them from being lumped with the other rhyolite samples in a generic rhyolite group. Additionally, the slightly different REE patterns, divergent locations in the Zr/Ti vs. Nb/Y diagram, and distinct visual characteristics encourage the separation of these materials from one another. Hence, for the remainder of this thesis they will be known as rhyolite 27 and rhyolite 28.

Why these samples presented such anomalous results is interesting to consider and a few explanations can be put forth. First, these simply could be rhyolites that fall outside of the average range for igneous rocks. Throughout this chapter we have seen examples of known Haida Gwaii volcanics that plot outside of the average chemical compositions for igneous rocks. There was one basalt sample (Hyndman and Hamilton 1991), for example, which was low in Na.

Second, the analyses could have been affected by the small samples used to prepare the glass beads. Both materials are used almost exclusively for microblade production and the samples selected for analysis included a microblade (used for #28) and a very small piece of debitage (for #27). As both specimens possessed weathering rinds it is possible that the proportion of weathered surface to fresh matrix was greater than among the other larger samples, causing a skewed result. Other samples with weathering rinds were much larger and the amount of unweathered matrix that became a bead would have been much higher than for the microblades. Also given that each of the samples was analyzed once only, it is not known what kind of range is to be expected within each of the visually dissimilar types. Samples 27 and 28 could be outliers.

Another explanation, which would warrant further testing, considers the mobility of Na during the heating process. As mentioned earlier, Na is volatile and its concentration in the rock could be affected by the sintering and glass fusion process. The trace element results indicated that the bead manufacturing process had not adversely affected the Na concentrations of the rocks and that the classifications were sound. However, if it were possible that the materials were heated in excess of the bead manufucaturing process, then perhaps the Na content would be affected. As the beads were not subjected to additional heating in the sample preparation phase, another possibility is that rhyolites 27 and 28 were heat treated[16] by the Richardson inhabitants. This idea is speculative, but the effects of heat treatment on the major element concentrations of Richardson materials could make for an interesting study.

Summary and Discussion

Through the combination of visual and chemical analysis it has been determined that the most frequently occurring materials at the Richardson Island site are siliceous argillite, shale/argillite, wacke, varvite, tuff, rhyolite, dacite, basaltic-andesite, andesite, and chert. The major elements deduced by the EMPA allowed for general rock classifications to be ascribed to the Richardson samples. Igneous and non-igneous materials that can be easily confused upon visual inspection were separated using major element diagrams provided

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[16] Heat treatment is a technique used by flintknappers to enhance the flaking quality of stone.

by Garrels and MacKenzie (1971). Specifically Richardson samples #2, 6, 11, 13, 18, 19, 21, 30, 33 which could be misclassified as basalt due to their mafic (dark) and in some cases, vitreous, appearance were found to be dacite, shale, wacke/shale and siliceous argillite. The rhyolite samples which are very light coloured with a grainy appearance could conceivably be confused with quartzite upon visual inspection. The discrimination diagrams used here show a clear distinction between these material types. Perusal of earlier catalogues of the Richardson artifacts also revealed that the chert sample #25 had previously received tentative assignment as a fine grained rhyolite.

The trace elements determined by LA-ICP-MS confirmed the classifications based on major elements and ensured that the sample preparation procedure and effects of weathering had not influenced the initial material distinctions. Additionally, the REE element patterns revealed that some of the materials were spatially distinct from similarly classed materials (although the spatial scale cannot be known) and that others were indistinguishable chemically. The documented trace and rare earth element data will be valuable for future raw material and sourcing studies in Haida Gwaii.

Of the igneous materials identified, dacite and rhyolite were the most common. These findings are in accordance with the conclusions drawn by Bakewell and Irving (1994) and Mallory-Greenough et al. (2002a), that volcanic materials used in British Columbia for lithic technologies tend to fall within the rhyolite/dacite/trachyte range as the high silica content in the rock makes it more amenable to flaking than materials such as basalt with a lower silica content.

It is important to note, however, that not all materials in this study were easily classified. Samples #27 and 28 did present some anomalous results but it is not unexpected that some ambiguity would emerge in a project where geological provenance is unknown. Rollinson reminds us that

> Geochemical investigations are most fruitful when a particular model of hypothesis is being tested . . . [and this] hinges upon a clear understanding of geological relationships. Thus, any successful geochemical investigation must be based upon a proper understanding of the geology of the area. It is not sufficient to carry out a ‘smash and grab raid’ returning to the laboratory with large numbers of samples if the regional geology is unclear. It is normal to use the geology to interpret the geochemistry.

> Rarely is the converse true for at best the results are ambiguous (Rollinson 1993:9)

Ironically, a prehistoric "smash and grab raid" is exactly what the archaeologist has to deal with, and if detailed information about the local environment is not readily available, some uncertainty regarding raw material classification can be expected. Thus I am aware that the interpretations here offered may change as the database of the region's geochemistry expands and as the character of the archaeological materials become better understood.

A major drawback of the presented methodology is that the analytical techniques are destructive. The conservation of material is an obvious concern for archaeologists as we are ethically responsible to protect finds of the past, many of which are limited in quantity. This concern makes the combination of EMPA and LA-ICP-MS preferable when chemical analysis is possible. Both applications require a solid material from which to extract a sample for testing, yet the overall amount that they require is very small. By creating a homogenous glass of the powdered specimen, the same bead was analyzed repeatedly by both techniques. This had the added advantage of ensuring continuity between data sets. Also, less material was needed than is required for techniques such as INAA or regular ICP-MS in which the powdered sample must endure a lengthy dissolution process before the solution is ready for a one time analysis. The preparation time for bead manufacture is much shorter as it can be accomplished in under thirty-six hours and the beads, which are presently housed at the University of Victoria, are available for future applications.

Overall, the combination of geochemical techniques with macroscopic assessment has many benefits. It has allowed for the most commonly occurring materials at the Richardson Island site to be classified and we can be confident that the classifications offered here are more accurate than what would have resulted had we relied solely on informal visual classification of the material. The process is also replicable and is not sensitive to operator error. Established classifications can not only be used to track material use through time at an archaeological site (as will be done in chapter 7) but allow archaeologists to look at the local geology in a more meaningful way. Most of the bedrock surrounding Richardson Island, for example, is basalt/basaltic-andesite while the outcroppings of dacite, rhyolite, and shale are much more restricted. As will be discussed in Chapter 5, the knowledge that basalt was not a commonly used material limits the potential source locations of raw material. This knowledge could shift an interpretation of tool manufacture from one based on an expedient almost habitual resource extraction process based on abundant material availability, to an extraction strategy that may warrant conscious planning given the more restricted distribution of material. There may be additional benefits of geochemical testing that are not immediately apparent. Tool typologies and traditions require comparable data between many local sites and it is not unreasonable to think the same may be true of raw material.

CHAPTER 5

Possible Raw Material Source Locations on Richardson Island and within the Darwin Sound Region

Introduction

Sourcing, or provenance studies, are based on the premise that the chemical, physical, and mineralogical properties of a raw material outcrop will be maintained in artifacts made of the same material (Malyk-Selivanova 1998; Rapp and Hill 1988). Connecting raw material to source has been an extremely useful tool in archaeology as knowledge of raw material distribution has aided in the reconstruction of trade and exchange networks, and understanding the movements of materials has helped archaeologists interpret the economic and social context of past populations (Tykot 2003).

Given the valuable insights that sourcing can provide, numerous materials have been subjected to provenance studies. Table 5.1 provides a list of materials from archaeological contexts that have been sourced.

Table 5.1 Archaeological materials that have been sourced

Stone	**Ceramics**	**Metals**	**Other Materials**
obsidian, chert (flint),jasper quartz, soapstone, nephrite, basalt, dacite, rhyolite, granite, turquoise, schist, sandstone, quartzite, limestone, marble, hematite, magnetite, alabaster	pottery, temper, other clay objects	native copper, copper alloys, tin, lead, gold, silver	amber, bitumen, ivory, bone, antler, horn, glass, jet

Modified version of similar table in Tykot (2003:61). This table includes materials highlighted in Rapp 1998; Pollard and Wolff (1997)

Of the lithic materials, obsidian has been the favoured material to source given its restricted geological appearance and easily identified chemical fingerprint (Rapp and Hill

1998). Chert has also been the subject of numerous sourcing studies (Luedtke 1992; Malyk-Selivanova 1998; Sieveking et al. 1972; Jarvis 1990; Cackler et al. 2000) as it is a commonly occurring material in stone tool assemblages world wide, yet it has proven to be a more difficult material to source than obsidian as outcrops often possess highly variable chemical compositions. Volcanic rocks such as basalt, dacite, and rhyolite have also been successfully provenanced to source as have intrusive igneous rocks such as granite.

The successful sourcing of lithic materials, however, is a very involved process and necessitates that a number of requirements be met. The first prerequisite is to identify the locations of all geological sources within in an area (Reeves and Brooks 1978; Tykot 2003). Samples must then be collected from each outcrop. As the homogeneity of each geological source may vary, it has been recommended that an absolute minimum of 15 samples from each source be collected to capture mineralogical and chemical variability within each outcrop (Malyk–Selivanova et al. 1998; Tykot 2003). The samples from each source are then chemically analyzed to establish the parameters that distinguish it from other sources. Trace elements provide the most effective discriminating features between sources as their concentrations reflect the 'fingerprint' acquired during petrogenesis. However, for some materials which can originate from more heterogeneous outcroppings, such as chert, petrographic microscopy (thin-sectioning) can also be helpful in distinguishing between sources (Leudtke 1992; Malyk–Selivanova et al. 1998).

The "success of trace-element measurements as a basis for identifying sources of [lithic materials] depends largely on two factors: (a) each source should be relatively homogenous; (b) variations of composition between different sources should be greater than the variations within each source" (Reeves and Brooks 1978:365). Thus, the chemical differences between sources must be measurable and statistically valid. The characterization of distinct sources can occasionally be based on a single-element concentration or a two-element concentration ratio, but is more commonly established with bivariate plots of element pairs or ternary diagrams in which three elements are considered (Reeves and Brooks 1978). If, however, the potential number of sources is large and compositions are somewhat inhomogeneous, then a multivariate statistical analysis, such as discriminant function analysis, is necessary as it considers data from multiple elements (Tykot 2003; Reeves and Brooks 1978). Once a set of chemical parameters is established for each source then the artifactual material can be analyzed and assigned to source. Tykot reminds us, however, that "we must avoid a tautological situation in which artifacts from 'unlikely' sources are never identified as such – often the exception to the rule is the most significant finding" (2003:63).

A comprehensive sourcing survey is beyond the scope of this thesis. However, on the basis of established material types in Chapter 4 it is possible to identify potential source locations on Richardson Island and in the Darwin Sound Region (inclusive of Darwin Sound, Crescent Inlet, Richardson Inlet, and Logan Inlet). Given that the tool assemblage at the Richardson site is poorly standardized, that there is little reuse of tools[17], and that there is an extremely high debitage to tool ratio (indicative of raw material abundance), it would seem that the raw material was available nearby and in high quantity. Thus, the aim of this chapter is to highlight areas of local sourcing potential in the Darwin Sound area according to established geological information. Observations recorded during a three day preliminary sourcing survey of the area conducted in the summer of 2003 (Appendix C) will also supplement the discussion.

Geology of Haida Gwaii

Haida Gwaii is located at the northern end of the Insular Tectonic Belt of the Canadian Cordillera. The exposed rocks within this region vary in age from Permian (possibly Carboniferous) (Hesthammer et al. 1991) to Miocene in formation. The majority of the visible rocks in the Queen Charlotte Islands are volcanic yet many of these formations are separated by distinct sedimentary units. Thus, a stratigraphic profile of alternating volcanic and sedimentary layers is recognizable throughout the Islands (Figure 5.1). In addition to the stratigraphic sequences, about one eighth of the exposed rocks in the QCI are metamorphic rocks or volcanic plutons in which molten lava has been expelled towards the surface, thus erupting through the established stratigraphy (Woodsworth and Tercier 1991).

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[17] Only a few tools appear to have been recycled. These specimens display more recent (unweathered) flake scars in addition to patinated scars. Presumably, the majority of tools would have been buried quickly after discard by the rapid sediment accumulations which created the deep stratigraphic profile we see today.

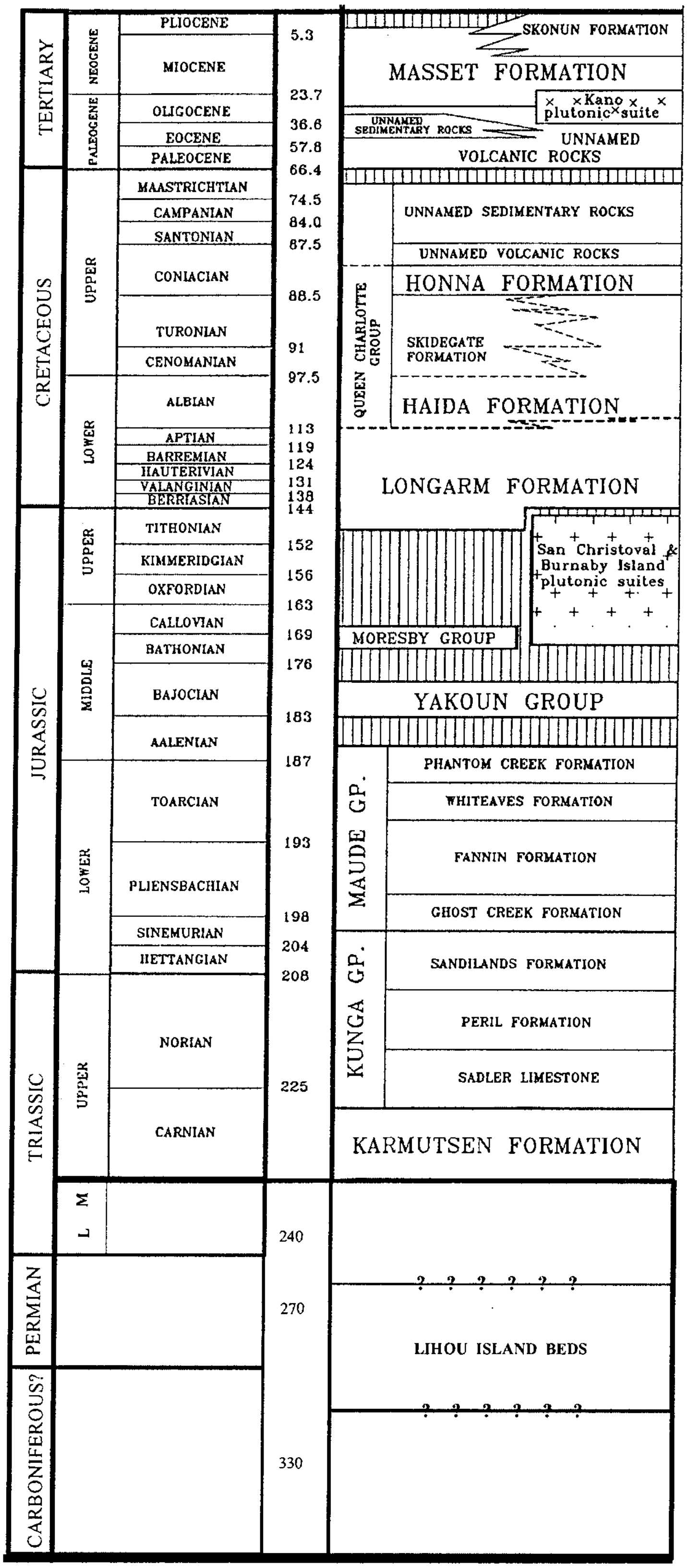


Figure 5.1 Geological Strata of Haida Gwaii (Modification of image in Thompson et al. 1991)

The oldest strata evident in the Queen Charlotte Islands are the Lihou Island Beds of limestone, dolomite and chert which date to the Permian period and possibly the Carboniferous period (Hesthammer et al. 1991). Exposures of this unit are restricted to Englefield Bay, Kitgoro Inlet, Hutton Point, and the southeast tip of Shuttle Island (Hesthammer et al. 1991; Haggart 2002b). The Karmutsen Formation is the oldest volcanic formation and was created when large amount of basalts were erupted at the beginning of the upper Triassic period. It is primarily composed of basaltic flows and pillow lavas but does also contain minor limestone and volcanic sandstone (Sutherland Brown 1968). The base of this formation is not visible except where the Lihou Island Beds are present and is generally regarded, in geological terms, as structural basement (Thompson et al. 1991). This basement rock was overlain by a thick limestone and deep sea sedimentary sequence that began at the end of the late Triassic (Desrochers and Orchard 1991) and continued through the early stages of the Jurassic period (Cameron and Tipper 1985). Known as the Kunga Group, this sedimentary sequence is identified by a massive grey limestone member (Sadler Limestone), a black limestone member with bedded shale (Peril Formation), and a black argillite member which is exposed throughout the Islands (Desrochers and Orchard 1991). Recently it has been argued that the upper argillite member, which also contains calcareous siltstone and tuff (Thompson et el. 1991), is only partially related to the Kunga Group. This upper argillite unit (the Sandilands Formation) represents a unique transitional sedimentary formation that encompasses the upper portion of the Kunga Group and extends to the more recent Maude Group (Cameron and Tipper 1985; Desrochers and Orchard 1991; Woodsworth and Tercier 1991). The Maude Group is a thin sedimentary unit composed of shale, argillite, lithic sandstone, limestone, siltstone and tuff deposited between the lower and middle Jurassic. Maude is similar to the Kunga Group but is distinguishable through fossil evidence and well exposed cross sections of the unit in which the sedimentary layers have been deposited in a stable shelf environment allowing for distinctive layering arrangements (Thompson et al. 1991; Tipper et al. 1991). The Yakoun Group overlies the Maude Group and is volcanic in origin. The majority of these rocks are pyroclastic in that they are composed of fragmented particles produced by explosive volcanic activity (Poulton et al. 1991). Porphyritic andesite, agglomerate, tuff, lapilli tuff, and sedimentary rocks derived from volcanic materials are indicative of this group (Cameron and Tipper 1985). The Yakoun is further divided into the Graham Island and Richardson Bay Formations. Above the Yakoun is a small sedimentary unit that was deposited in the middle Jurassic called the Moresby Group. Divided into three formations this group is identifiable by its combinations of siltstone, shale, sandstone, and pebble conglomerate (Cameron and Tipper 1985). The Lower Cretaceous saw the development of the Longarm Formation which combines sedimentary fine grained clastic rocks, such as siltstones, and greywackes, with volcanic beds of mafic pyroclastics. The Cretaceous Period was primarily a time of volcanic dormancy allowing for a lengthy period of sedimentation (Haggart 1991). The Longarm Formation and the successive sedimentary unit, the Queen Charlotte Group (deposited from the Middle Cretaceous into the first stages of the Upper Cretaceous), both accumulated in shallow marine environments at a time of rising sea level (Haggart 1991). The latter group has been divided into the Haida (primarily shale and sandstone) and Skidegate (primarily siltstone and sandstone) Formations which are overlain by the Honna Formation (Fogarassy and Barnes 1991). The latter formation may or may not be associated with the Queen Charlotte Group and is composed of conglomerate and sandstone.

The very end of the Cretaceous and beginning of the Tertiary was a period of uplift, erosion and volcanism. Thus a series of yet unnamed volcanics and sediments succeed the Honna Formation (Woodsworth and Tercier 1991). The final major volcanic formation was also laid during the Tertiary period. The Masset Formation, as it is known, is comprised of basalt, rhyolite, tuff, pyroclastic rock, dacite, porphyry, and volcanic sandstone (Hyndman and Hamilton 1991; Hickson 1991). A true definition of the Masset Formation, however, has yet to be established and there is uncertainty as to when this formation originated (Sutherland-Brown 1968; Woodsworth and Tercier 1991). Soon after the inception of the Masset Formation, the Skonun Formation started to accumulate with the erosion of volcanic materials. This sedimentary unit is composed of sandstone, mudstone, conglomerate, and lignite (Woodsworth and Tercier 1991). More recent accumulations of sediments remain unconsolidated while recent volcanic activity has resulted in the formation of sills (Sutherland-Brown 1968) and dykes (Souther and Jessop 1991) that have cut through the established stratigraphy.

As previously mentioned, one eighth of the exposed rocks in Haida Gwaii are plutonic in origin or metamorphic. Three major plutonic events have altered the established stratigraphic components: the San Cristoval Plutonic Suite which erupted in the middle Jurassic; the Burnaby Island Plutonic suite which erupted at the transition between middle and upper Jurassic; and the Kano Plutonic Suite which formed in the middle Tertiary (Woodsworth and Tercier 1991). As these magmatic units approached the surface the surrounding igneous and sedimentary rocks were metamorphosed by changes in temperature and pressure. Seismic activity in the region has also encouraged metamorphic transformations along faults and in areas of folding and thrusting.

Possible Source Locations

Of the strata listed in the previous section, the unnamed tertiary volcanic (Tv), a subvolcanic tertiary intrusion (Tvi), the Lihou Island Beds (CPL), the Kunga Group (TJK) (inclusive of the Sadler Limestone (TS), Peril Formation (TP), and Sandilands Formation (TJs)), the Maude Group (lJM), the Yakoun Group (mJY) (inclusive of the Richardson Bay Formation (mJR) and Graham Island Formation (mJG)) and the Moresby Group (mJM) (inclusive of the provisional Atli Inlet Formation, mJA (Haggart 2002a,b)) are located within the Darwin Sound region and are the most likely to contain sources of Richardson raw material. The characteristics of these strata are outlined in Table 5.2.

The materials identified in the Richardson assemblage are diverse, however, and it is not possible that they all originated from the same formation. Table 5.3 summarizes the groups and formations from which each of the Richardson materials could have originated. This table illustrates that the sedimentary and meta-sedimentary rocks could have originated from any number of strata while the volcanic materials are more restricted in potential sources. It is notable that the Karmutsen Formation, which dominates the exposed bedrock in the area, is an unlikely source for the Richardson materials as this formation is characterized by basaltic flows. As the Karmutsen Formation is so prevalent throughout Haida Gwaii, the area to be considered for potential source rock is greatly diminished.

Table 5.2 Characteristics of geological strata that could contain sources of Richardson archaeological raw materials

Symbol	Strata	Petrographic Characteristics
Tv	Unnamed volcanic	May contain Masset Formation, mafic to flesic lava flows and pyroclastic rocks
Tvi	Intrusive, subvolcanic intrusion	Andesite, basalt, some felsic rocks, fine to medium grained aphyric, diabasic texture; rare feldspar and/or hornblende phenocrysts; locally preserved country rocks
CPL	Lihou Island Beds	Hutton Point Beds, Kitgoro Inlet Beds, Chaatl Inlet: interlayered limestone, dolomite and chert
TS	Sadler Limestone (Kunga Group)	Massive, grey crystalline limestone, lesser secondary chert
TP	Peril Formation (Kunga Group)	Dark grey, medium bedded calcareous shale, minor grey limestone, rare peperite
TSP	Peril and Sadler Formations undivided (Kunga Group)	Massive limestone and medium bedded shale
TJs	Sandilands Formation (Kunga Group)	Shale, fine grained sandstone, locally tuffaceous
TJK	Kunga Group	Undifferentiated Sadler, Peril and Sandilands formations. Shale, calcareous shale, massive limestone, fine grained sandstone
IJM	Maude Group	Undifferentiated shale (IJG-IJP); fine-medium grained sandstone; conglomerate; minor calcareous shale
mJY	Yakoun Group	Undifferentiated (mJG-mJR) agglomerate flow breccias; sandstone; conglomerate; minor shale
mJR	Richardson Bay Formation	Porphyritic andesitic agglomerate and breccia, lapilli tuff, minor dark volcanic sandstone, siltstone and shalek
mJG	Graham Island Formation	Sandy shale, tuffaceous argillaceous siltstone; lapilli tuff, minor andesitic agglomerate
mJA	Atli Inlet Formation (provisional)	Black shale, thinly bedded siltstone, pebble conglomerate
mJM	Moresby Group	Concretionary sandstone; siltstone; conglomerate; minor agglomerate

Note: Petrographic descriptions from Haggart (2002a, b).

Table 5.3 Geological strata from which Richardson Island archaeological materials could have originated

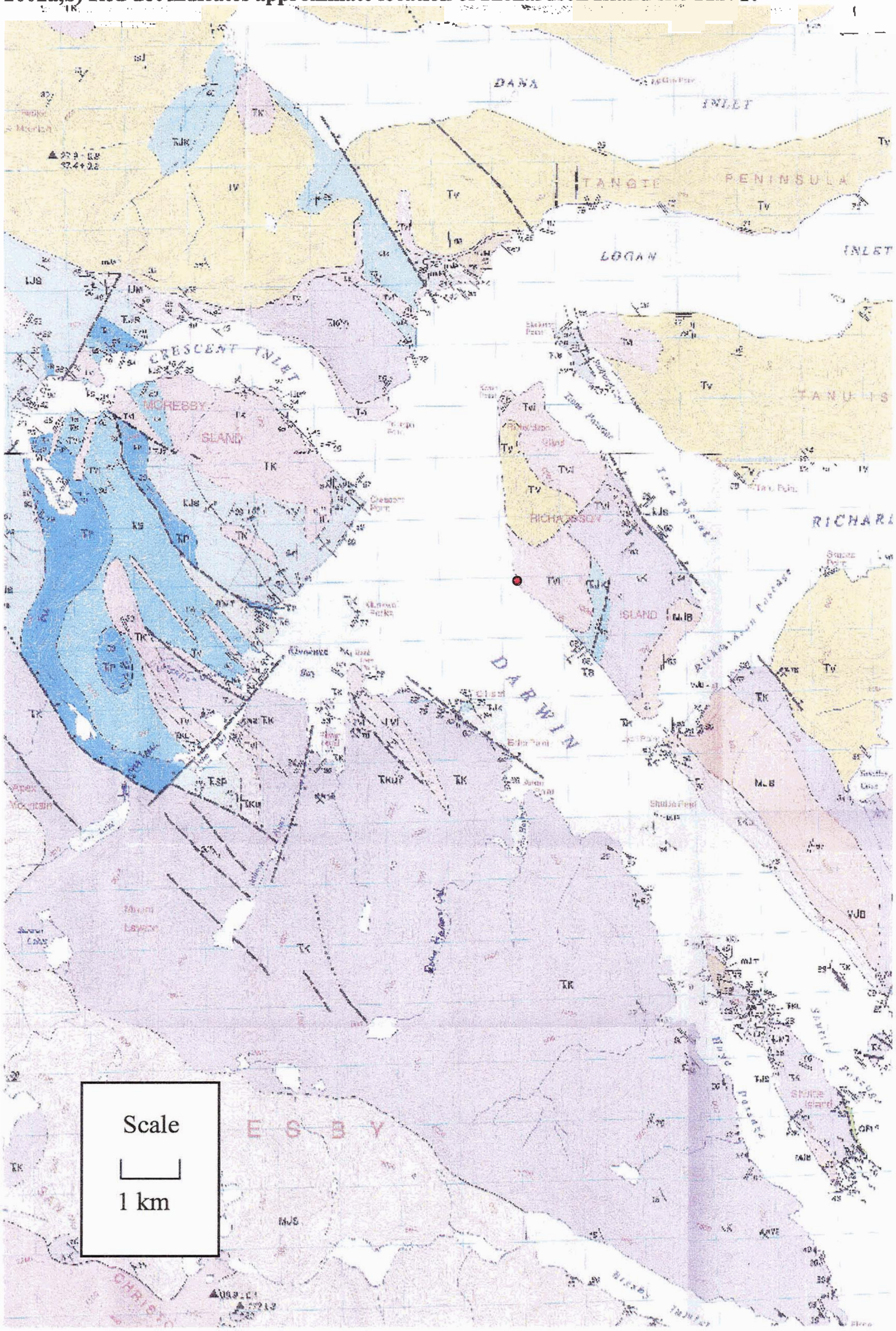
Shale/Argillite	Siliceous Argillite		Wacke	Varvite	Chert
TP	TP	especially near faults	TJK*	TJK*	CPL
TSP	TSP		TJS §	mJY	TS*
TJS §	TJS §		IJM	mJY	TJK
TJK*	TJK*		mJY	mJR	TSP
IJM	IJM		mJR	mJG	
mJY	mJY		mJM	mJM	
mJR	mJR				
mJG	mJG				
mJA	mJA				
TJK	TJK				
Basaltic-andesite	**Andesite**		**Rhyolite**	**Dacite**	**Tuff**
Tv*	Tv*		Tv*	Tv*	Tv*
Tvi*	Tvi*		Tvi*	Tvi*	TJS §
Dyke rocks	Dyke rocks		Dyke rocks	Dyke rocks	mJR
					mJG

Note:
§ indicates that stratum is present on Richardson Island but that it may have been submerged at sea-level maximum.
* indicates that stratum is present on Richardson Island and would have been above high tide at sea-level maximum

Local Sources: Richardson Island

Richardson Island is composed of seven geological units (Haggart 2002): A Tertiary subvolcanic intrusion (Tvi), an unnamed Tertiary volcanic (Tv), the Kunga Group (TJK), Sadler Limestone (TS), Karmutsen Formation (TK), Burnaby Island Plutonic suite (MJB), and the Sandilands Formation (TJs) (Figure 5.2). Of these strata MJB and TK are the least conducive to tool manufacture. The Burnaby Island Plutonic Suite is an intrusive rock with large grain size and the Karmutsen Formation, as previously mentioned, is primarily composed of basaltic flows. As indicated by Table 5.3, it is conceivable that all materials at the Richardson Island site originated on-island. However, during the survey in 2003, it was evident that much of the exposed bedrock on Richardson Island was ill-suited for flaking. According to descriptions offered by Haggart (2002a,b), it is plausible

Figure 5.2 Geology of Richardson Island and Darwin Sound Region (modification of Haggart 2002a,b) Red dot indicates approximate location of Richardson Island site 1127T.



that rhyolite, dacite, and the dacitic tuff could originate from the Tv volcanic. However, aside from an exposure of rhyolite in Tv, a traverse of the west side of Richardson Island did not reveal any material of exceptional flaking quality within these units. Nor were any materials found in this formation that resembled the white rhyolite, dacite or tuff encountered at the site. Similarly, Tvi, the formation in which the 1127T site is situated, did not present any materials resembling rhyolite, dacite or tuff. It did, however, contain comparable examples of andesite and basaltic-andesite indicating that these materials were readily available on site. Thus, while basaltic-andesite and andesite were available on site, rhyolite and dacite of decent flaking quality do not appear to have been available on Richardson Island in general. It is unlikely that tuff was acquired from an island location either. A slim exposure of TJS, which is locally tuffaceous, does exist along the east side of Richardson Island but this material was probably submerged at sea-level maximum. The Karmutsen Formation is also known to contain tuff, but it would be of basaltic, rather than dacitic, composition.

The sedimentary and metasedimentary materials from the Richardson site could all have originated the Sadler Limestone and Kunga Group formations located to the south of the site on the west side of Richardson Island. The Sadler Limestone is known to contain lesser secondary chert and the Kunga Group could provide shale, argillite, wacke and varvite. The siliceous shale with obvious metamorphic traits may be attributable to movement along the fault that separates the Sadler and Kunga units. During the preliminary sourcing survey in 2003, a foliated shale/argillite outcrop within the Kunga Group was located approximately 1.5 kilometers south of the 1127T site. This black, microcrystalline material flaked beautifully with predictable conchoidal fracture. Samples of this outcrop were collected and one piece of the material (#32) was analyzed with the archaeological samples in Chapter 4. While being below the fifteen sample minimum for source characterization, the chemical composition of this material provided encouraging results. Figure 4.11 displays the chemical composition of the Richardson shale formation in relation to the archaeological shale/argillite materials. Figures 4.14c and 4.15d reveal that the REE pattern of the Richardson foliation is very similar to that of sample #18. These results suggest that the foliated shale outcrop is a highly probable source of the shale/argillite that appears in the archaeological assemblage. Confirmation, however, would require a much more thorough investigation.

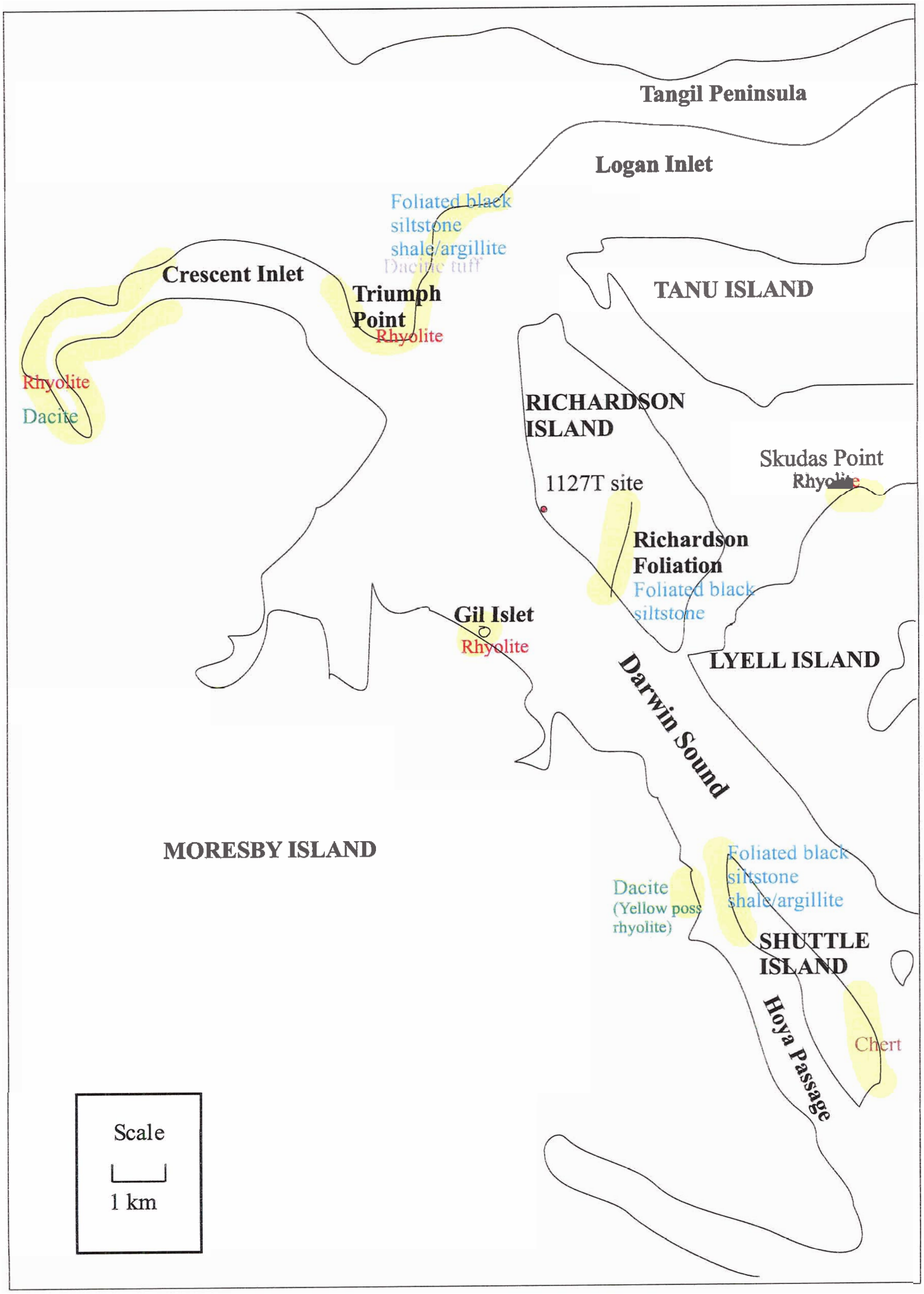
It is possible that shale/argillite, siliceous argillite, wacke, varvite, chert, andesite, and basaltic-andesite were collected on Richardson Island while rhyolite, dacite, and tuff originated off-island. Yet, locating a potential source location does not guarantee that the rocks in that area are amenable to flaking. Thus, while there is potential that the majority of materials originated on Richardson Island, we cannot assume that this is the case until all formations on Richardson have been surveyed for flakeable materials. Thus, the following section highlights some locations in the Darwin Sound region that could also offer high sourcing potential.

Regional Sources: Darwin Sound

There are many potential source locations throughout Darwin Sound, yet some locations seem more promising than others; specifically Crescent Inlet/Triumph Point and Shuttle Island (Figure 5.3). During a geological survey of Darwin Sound, Sanborn-Barrie (1991) noted that north of Crescent Inlet there was an abundance of dacite ash, dacitic tuff, and lapilli tuff, and to the northeast of Triumph Point there existed a foliated black siltstone similar to that found on the east side of Richardson Island. In his fieldnotes, Jack Souther also draws attention to a massive, structureless, light-coloured rhyolite exposure at Triumph Point at the head of Crescent Inlet (Souther 1987). At the end of Crescent Inlet he identified three dacite dykes cutting through rhyolitic or felsitic structures (Souther 1988). Geological maps of the area (Haggart 2002a,b) also indicate that the Kunga Group, inclusive of Sadler, Peril, and Sandilands Formations, are well represented in this restricted area. All material types in the Richardson assemblage are well represented throughout, and to the northeast of, Crescent Inlet.

On Shuttle Island Sanborn-Barrie again noted a foliated black siltstone and "andesitic lapilli tuff cemented by white weathering calcite" (1991). At the north end of Hoya Passage a fractured fine grained yellow white dacite dyke was found on Moresby Island (Souther 1988). The southeast side of Shuttle Island is also one of four locations in Haida Gwaii known to have bedded chert (Hesthammer et al. 1991; Sanborn-Barrie 1991). The majority of the Permian strata in which such chert is found, is concentrated within a small area on the northwest coast of Moresby Island. However, there are two

Figure 5.3 Areas with High Sourcing Potential



other locations on the east coast (the southeast tip of Shuttle Island and Hutton Point), about 12 and 25 km south of the Richardson Island site respectively. Descriptions of the chert indicate that "fresh surfaces are greenish and light grey, and weather to yellow or brownish-yellow" (Hesthammer et al. 1991: 323)

Overall rhyolite and dacite exposures are limited in the Darwin Sound region and dykes may offer the highest sourcing potential for these materials. Dykes are volcanic structures formed when lava pushes its way through fissures in existing country rock to the surface. The rapid cooling of the magma inhibits crystal growth commonly resulting in extremely fine grained rock. Researchers in New England, who long puzzled over a possible source location for their rock of rhyolitic-dacitic composition, were rewarded by the discovery of dykes that were saddle shaped and pockmarked from quarrying activities (Hermes et al. 2001). They suggest that "[archaeologists] seeking sources of raw materials from which stone tools were made might pay especially close attention to dikes and similar spatially restricted deposits" (Hermes et al. 2001:925). Their study indicates that these relatively small, localized anomalies within the surficial geology could be targeted for procurement. That they are potential sources of high quality raw material makes them of interest to archaeologists. As much of the southern Haida Gwaii bedrock geology is that of the Karmutsen Formation, restricted outcrops such as dykes may offer some of the best volcanic flaking material in the area (Table 5.4).

During the preliminary sourcing survey in 2003, a rhyolite dyke located just south of Richardson Island on northwestern Lyell Island (Skudas Point) was found to contain very fine grained material visually similar to the white rhyolite #4 of the archaeological assemblage. The height of the Skudas Point dyke was such that it would have been exposed in the intertidal zone during sea-level maximum. A comparison of the chemical compositions from the Richardson artifacts to a piece of material from this dyke, reveal that these rhyolites are quite similar (Figure 5.4). When trace element ratios from the artifactual data in Chapter 4 are compared to chemical compositions recorded for this dyke by Souther and Jessop (1991) of the Geological Survey of Canada, a similarity is also apparent. However, as with the shale foliation, to be confident that this rhyolite dyke

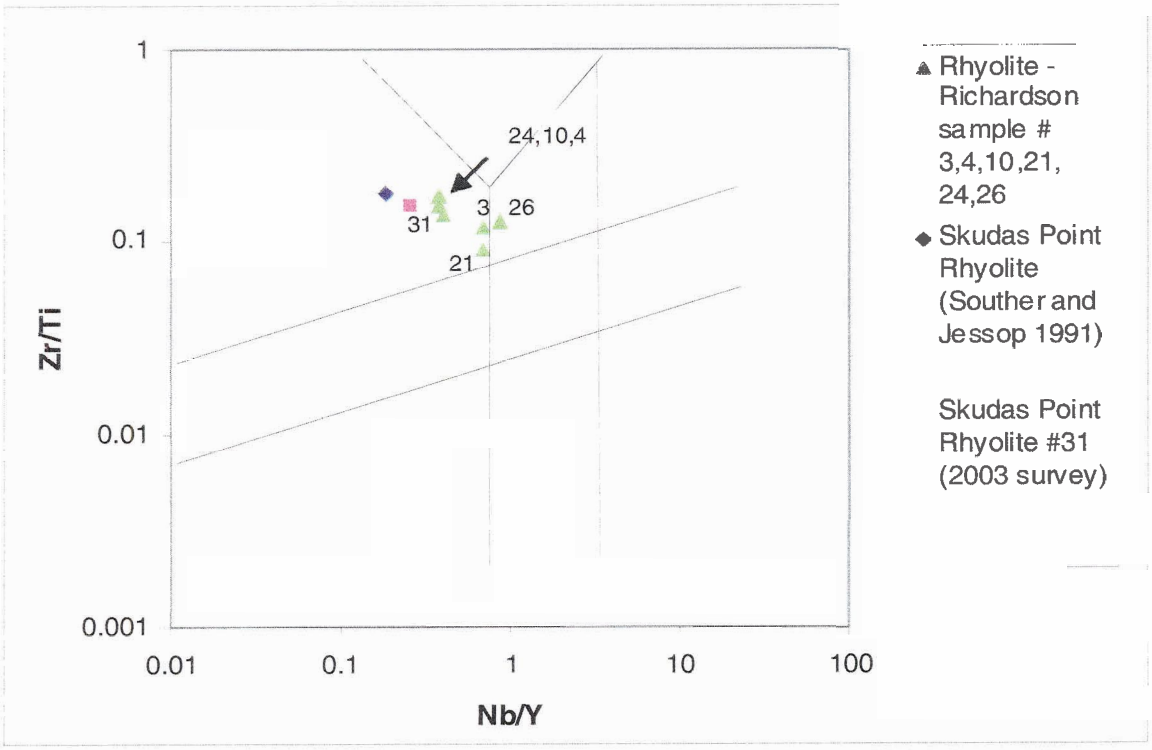
Table 5.4 Rhyolite and Dacite dykes of Northeastern Moresby Island identified by Jack Souther, 1987/88

Rhyolite Dykes	UTM	Location	Comments
SE 080687	n/a	Triumph Point-Head of Crescent Inlet	Massive light coloured structureless (sample collected during 2003 survey)
SE 081487	n/a	North Tanu Island	Notes a rhyolite dyke between Triumph Point and Flower Pot Island but coordinates not provided
#410988	E: 305150 N: 5867200	Entrance to Logan Inlet	(co-ordinates may not be exact)
#371088	E: 318650 N: 5845650	Skudas Point, Northern Lyell Island	Nice flaking material (sample collected during 2003 survey)
#121688	E: 330550 N: 5834550	Faraday Island (south of Lyell Island)	Aphanitic rhyolite
#331588	E: 330200 N: 5821800	Marco Island	Rhyolite
#320288	E: 312500 N:5843350	Gil Islet	Irregular outcrop of rhyolite
Dacite Dykes	**UTM**	**Location**	**Comments**
#311488	E: 315750 N: 5838850	North end Hoya Passage (near Shuttle Island) on Moresby Island	Fractured fine grained yellow white dacite
#031788	E: 315950 N: 5852650	North side of Tangil Peninsula	Pale grey dacite
#390188 390288 390388 390488 (3 dykes)	E: 324050 N: 5847650 to E: 323500 N: 5847350	South East Tanu Island	Fine grained dacite (visited during 2003 survey – not nice for flaking)
#390788	E: 321700 N: 5847450	South Tanu Island	Pale grey fine grained dacite, no veins (sample collected during 2003 survey-decent for flaking)
#400688	n/a	Near end of Crescent Inlet	Three dacite dykes cutting through rhyolitic or felsitic structure

Note: Data from Souther (1987, 1988).
Emboldened number identifies dyke of high archaeological interest.

was a source exploited by the Richardson inhabitants requires a more detailed sourcing study and analysis of a larger number of samples.

Figure 5.4 A comparison of chemical compositions: Richardson archaeological rhyolite samples, Skudas Point rhyolite (colleceted during survey in 2003), Skudas Point rhyolite (Souther and Jessop 1991)



Of those materials identified in the Richardson assemblage, rhyolite, dacite and chert are among the more geologically restricted materials and may offer the most success in future sourcing studies. However, foliated siltstones such as those recorded by Sanborn-Barrie may also be limited in exposure and could form the basis of such a study. According to the geological evidence there is no reason to suppose that the commonly occurring materials classified in Chapter 4 originated from sources outside of the Darwin Sound region. All of these rock types are available on Richardson Island or in the surrounding area. However, this is not to negate the possibility that materials from more distant locations exist in the Richardson assemblage. The chemical analysis presented earlier was restricted to those materials that occurred with frequency leaving infrequently occurring material types untested. Thus, it is possible that exotic materials from sources outside of the Darwin Sound region could exist in the Richardson assemblage.

Acquisition Strategies

Based on the previous discussion and characteristics of the Richardson assemblage, it is possible to make some tentative interpretations about the inhabitants' raw material acquisition strategies. Aside from basaltic-andesite and andesite which were available at the archaeological site location, all other commonly occurring materials originated at least one kilometer (approximation) from the site on Richardson Island and up to twelve kilometers away if the inhabitants were extracting materials off island. The rhyolite dyke at Skudas Point, for example, is approximately seven kilometers away from 1127T by boat. This suggests that the Richardson inhabitants were making a concerted effort to collect materials and transport them back to the 1127T location.

According to Gould who conducted ethnoarchaeological research among the Australian Aborigines (1980), material from distant locations that was found in high quantities within a habitation site, was often quarried. This material tended to be manufactured into reusable or curated tools. In contrast, expedient tools were made out of materials immediately available which could be picked up, manufactured, and discarded after very short use-lives. Thus, this material was not transported back to a base camp. The Richardson Island site was likely a habitation site as indicated by the multi-component hearths (Steffen n.d.), post holes, and possible structural features (Mackie et al. in prep; Mackie and Smith 2003, 2004), although the duration of occupation is unknown. The distance from which raw material was acquired may not have been great (as little as one kilometer away) but transport from the source back home still would have been necessary. Assuming people worldwide have a tendency to bring procured raw materials home, we may expect that quarried material would be present at the Richardson habitation site. A cursory inspection of the sedimentary and metasedimentary material types indicate quarrying activities could have occurred. Cores, core fragments, and shatter of siliceous argillite, shale/argillite and varvite are very blocky and angular, and do not exhibit waterworn cortex. During the summer of 2003, it was noted by the surveyors that in the shale foliation south of the site, material fresh from the outcrop flaked more predictably than tablets of the same material that had weathered in the surrounding vegetation or had fallen into the intertidal zone. Assuming the Richardson inhabitants did use material from this source, these qualities were likely observed by the tool makers. Thus, the lutitic materials were probably quarried above the intertidal zone as exposure to sea water would have emphasized the natural bedding planes in the rock making it less amenable to flaking.

Conversely, artifacts of volcanic origin in the assemblage often possess cortex or waterworn surfaces. This does not mean, however, that specific locations were not targeted for raw material acquisition. Also during the survey in 2003, it was noted that some rhyolite dykes (i.e. Skudas Point) and exposures (i.e. Triumph Point) exfoliated large tabular pieces of material due to weathering processes. The intertidal zone surrounding these outcrops was filled with potential raw material blanks which would have been ideal for flaking and raw material collection. Many rhyolite artifacts from the Richardson site possess cortex and slightly waterworn edges which suggests that the material could have been collected in the intertidal zone.

While a comprehensive sourcing study is beyond the scope of this thesis, knowledge of raw material types used at Richardson Island has allowed for the identification of potential source areas on Richardson Island and in the Darwin Sound region. While there are a number of geological structures that could have provided raw material, their locations are restricted. Conversely, formations such as the Karmutsen, which dominate the exposed bedrock in the area, would not have provided materials conducive to flaked tool technologies. In the remaining chapters, and particularly Chapter 7, which consider the interrelatedness of raw material and tool types, knowledge of the geology will help us to better understand the implications of raw material changes through time.

CHAPTER 6

Tool Classifications

Since the formation of the Gwaii Haanas National Park Reserve and Haida Heritage Site in 1993, all stone tools from the area have been classified according to the Parks Canada typology. This includes the Richardson Island artifacts excavated in 1995 and 1997. For consistency and standardization of tool classifications within the Richardson Island assemblage, but also within other Gwaii Haanas sites, the Operation 13 tools were classified according to the same typology.

At a theoretical level the Parks typology has the potential to generate much dialogue as its tool classes are based on morphological traits (e.g. notch), assumed functional traits (e.g. scraper, chopper), and traits related to methods of manufacture (e.g. biface, unimarginal tool), as opposed to being determined by only one of these traits classes. What constitutes an effective tool typology has been a subject of great debate since the mid-twentieth century (Adams and Adams 1991; Binford 1965; Bordes 1961; Dunnel 1971; Ford 1954; Read and Russel 1996; Shott 1996; Spaulding 1953; Bisson 2000). Should typologies distinguish between form/style (Bordes 1961) or function (Binford 1965); natural (Spaulding 1953) or artificial (Ford 1954) types; emic (Bordes 1961; Spaulding 1953) or etic (Ford 1954) categories; the objects themselves (Bordes 1961) or the attributes of tools (Bisson 2000)? Is it justifiable to use a system that combines a number of these factors as is exemplified by the Parks typology? Despite years of typological debate, primarily focused on assemblages from the European Paleolithic, it is still unresolved as to which typological constructs (form, function, style, attribute clusters, etc.) are more effective at capturing meaningful variability. And then, what has meaning to the tool makers of the past (an emic perspective) and what is meaningful to archaeologists today (etic) may be divergent. More recently the complexity of the topic has been exposed further by querying how factors such as raw material (Rolland 1981; Rolland and Dibble 1990; Kuhn 1991, 1992; Jones 1984), tool resharpening and reuse (Dibble 1987), and site use and mobility patterns (Kuhn 1991), affect tool production and are in turn considered in, or ignored by, the typologies that have been constructed.

To date there has been no effective solution to the typological debate. It is not the purpose of this thesis to try to offer a resolution, nor to reconstruct the intricacies of the discussion except to say that any typological system currently in practice is not safe from theoretical scrutiny. Thus, the concerns that plague all typologies are of course relevant to the Parks typology as well.

At a practical level, however, the Parks typology suffices. It has been suggested that a successful typological system must address the problem at hand and function at a practical level (Adams and Adams 1991; Dunnell 1971; Odell 1981). To this end a typology requires a clear purpose (Adams and Adams 1991; Dunnell 1971). One such purpose is to achieve a "general purpose" (Mackie 1995). The general purpose of the Parks typology as a classificatory tool for comparing multiple sites is obvious. The Gwaii Haanas area is still in the early phases of connecting archaeological data to an emerging culture-history sequence and the current typology is helping to understand the temporal and spatial trends in morphological variability and dominant reduction strategies (i.e. bifacial flaking, unimarginal, etc.) within the archipelago. It does not mask technological shifts in the cultural historical sequence such as the transition from the Kinggi Complex to Early Moresby Tradition. The typology provides a means for summarizing data that is comparable between sites, and different researchers can use the typology thus indicating that it is replicable.

In the context of the Richardson Island site the Parks typology has proven replicable and communicable between users. In addition to assigning classifications to the Operation 13 materials for this thesis, the classifications ascribed to the 879 tools excavated in 1995 and 1997 were reviewed and confirmed. In total there are 3,156 stone tools recorded for Operations 10, 12 and 13 from the Richardson Island archaeological site. As the Operation 10 and 12 materials were already catalogued, debitage and tools had been separated prior to their reexamination here. The tools were reviewed to ensure classifications were consistent between Operations. Only in a few instances was there disagreement with the prior tool classification from these earlier excavations. These tools were reclassified to ensure consistency with the Operation 13 materials.

The Operation 13 artifacts required cleaning, labeling and separation into debitage and tool divisions before tool designations could be determined. In a few instances it was difficult to classify the newly excavated artifacts from Richardson Island as some of the distinctions between tool categories were ambiguous and vaguely defined. For example, the division between a unifacial tool and unimarginal tool was based arbitrarily on flake scar length. However, it was not clear initially at what point the transition between the two tool types occurred. After a discussion with Parks' archaeologists it was confirmed that a flake scar length of 1 cm. would act as the dividing point between unifacial and unimarginal tools. Additionally, the definition of a utilized flake was interpreted differently between Operations 10/12 and Operation 13 resulting in higher number of these artifacts in Operation 13. There were also a number of multi-functional artifacts in the Richardson assemblage which were difficult to classify using the Parks typology. For example, one artifact could have a scraping edge, a spokeshave, and a graver and would receive three tool classifications. The typology did not offer a means for categorizing these multipurpose tools differently. Aside from the concerns mentioned above the typology functioned well as a classificatory tool and it is to be expected that typologies will be refined and altered while in use as the assemblages are better understood (Adams and Adams 1991).

Challenges to the Parks Canada typology and particular tool categories would be valid, yet it has proved itself to be a meaningful classificatory tool within Gwaii Haanas, and, as will be demonstrated in Chapter 7, produces results when combined with independent variables such as raw material. In addition to allowing comparison between sites, it has been suggested that a demonstration of a useful classification system is whether or not it produces a meaningful exploration of data which are unrelated to its construction (Mackie 1995). In the context of this thesis the typology has allowed for an exploration of raw material influence within five tool types, thus demonstrating itself as useful.

Definitions and descriptions of tool categories

The tool types and definitions that follow are based on Fedje et al. (in press) and Mackie et al. (in prep). Figure 6.1 provides illustrations of tools (bifaces, microblades, scrapers, unimarginal tools, scraperplanes) which will form the majority of analysis in Chapter 7.

Core: A mass of rock from which flakes have been detached. This category includes unidirectional cores (in which flake removal originates from one platform surface and all flakes are removed in the same direction), multidirectional cores (in which flake removal originates from more than one platform surface), bifacial cores and core fragments.

Microblade core: As with cores these are objective pieces of material from which microblades have been detached. Microblade cores are much smaller than the generic core and tend to be unidirectional, flat topped and display clear microblade scars. The overall morphology of microblade cores range from "boat-shaped to conical to bullet shaped" (Fedje et al. in press). (See Figure 6.1)

Microblade: These are small, specialized blade flakes removed from a prepared core. They have parallel lateral edges and are at least twice as long as they are wide. At Richardson the lengths range between 0.5-2.75 cm and width ranges between 0.2-0.8 cm (Fedje et al. in press). Microblades tend to have one or more ridges that run parallel to their length and maintain a trapezoidal, triangular, or prismatic cross-section (Bar-Yosef and Kuhn 1999). Microblades would have been set in slots of wood or bone at the end or along the sides of the shaft. These tools would have been used as projectile points, knives, or spears (See Figure 6.1).

Scraperplane: These are large planar to dome shaped tools with steep working edges of 80-90 degrees. Most are made on large tabular pieces of igneous or metamorphic rock with a natural laminar fracture plane of the rock left untouched as the ventral plane or platform of the tool[18]. Occasionally scraperplanes are made on large robust flakes. This tool may resemble a unidirectional core but is differentiated on the basis of intentional retouch, usewear, and edge rounding along the perimeter of the planar surface. Scraperplanes were probably used for heavy tasks such as coarse woodworking (Figure 6.1).

Denticulate scraperplane: similar to scraperplanes except for one or more pronounced projections along the working edge. These have been included in the generic scraperplane category in the forth coming analysis (Figure 6.1).

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[18] Given the correlation between the planar surface of raw material and the scraperplane category, it is possible that this tool class is typologically biased to this raw material; i.e. the tool category is biased by raw material attributes.

Scraper: These tools are usually made on a flake which displays continuous unimarginal retouch to produce a shaped edge. Side and end scrapers are included in this category although most Richardson scrapers are not well formed or standardized. Scrapers are shallow in thickness and the length of the flake scars along the scraping edge equal the thickness of the tool. This category includes denticulate scrapers. Scrapers were likely used for preparing hides, performing light wood or bone working tasks, and food processing (Figure 6.1).

Unimarginal tool: These artifacts possess marginal retouch on one side of a flake to produce a slightly dulled, steepened, or strengthened edge without changing the overall morphology of the flake. Unimarginal tools may exhibit one or more flake scars with the scar length measuring up to 1cm. Unimarginal fragments are included in this category. These tools are believed to be functionally similar to scrapers (Figure 6.1).

Unifacial tool: These flake tools also display retouch along one surface except that flake scars exceed 1cm in length. Unifacial tools may have been used as knives and are also functionally similar to scrapers.

Utilized flake: Consists of flakes or flake shatter that have not been intentionally modified by flaking but show evidence of use through step-fracturing, edge nibbling or edge rounding. This category is likely underrepresented as chemical weathering of some material types has obscured use wear patterns. Additionally, some examples of edge nibbling may be resultant of in-field screening, which may have damaged some of the edges. Utilized bifacial reduction flakes are included in this category. Utilized flakes were likely used briefly for cutting and then discarded.

Biface: A tool that has been flaked on both faces from the same edge. Usually the entire surface of each face is flaked, thus creating an edge around the circumference of the tool. The majority of Richardson bifaces are foliate shaped. Bifaces could have been used as chopping or cutting tools, while the more finished examples could have been hafted and used as projectile points or spears (Figure 6.1).

Bifacial preform: This is an artifact manufactured by bifacial flaking to produce a circumferential edge but maintain the appearance of an unfinished tool. The artifact does not show use-wear and maintains large, uneven flake scars. It is usually interpreted as a stage in the bifacial reduction strategy.

Bimarginal tool: A tool that displays marginal retouch on both faces originating from the same edge. Marginal retouch is identified by flake scars up to 1 cm in length. Its function was likely similar to that of a unimarginal tool.

Chopper: A large tool usually made on a large cobble or planar slab of raw material. Has rough unifacial or bifacial flaking on one edge to create a crude and very acutely angled working edge. Choppers were likely used for heavy duty chopping of wood and bone.

Spall tool: Large primary reduction flake bearing high proportion of cortex which may exhibit expedient retouch or use wear along one edge. Spall tools are a heavy duty variation of the utilized flake or scraper.

Wedge: A core fragment, heavy flake, or piece of shatter with a tapering end that shows obvious dulling at the angled edge and signs of battering at the opposite end. Wedges were used for splitting wood or bone.

Spokeshave/Notch: a tool with one or more unifacial or unimarginal concavities flaked into it. The concave working edge is formed by continual unifacial or unimarginal flaking. This tool is similar to a scraper but was likely used for scraping curved wood and bone.

Graver: A tool with one or more small projections created by unimarginal retouch. Gravers frequently display use wear (rounding, edge damage, polish) near the tip of the projection. Typically found on flake tools and scraperplanes. The projections are strong and durable and would have been used for scribing.

Burin: A flake tool produced by detaching a flake or two thus creating a chisel like, unretouched, projection. Burins are more delicate than gravers and were likely used for fine bone and woodworking and incising.

Hammerstone: Small cobbles or large pebbles with regular pitting on one or more surfaces resulting from percussion events. Used to detach flakes from the core.

Abrader: Small tabular pieces of sandstone with surface cavities or grooves from repeated grinding and polishing. On some of these samples it was difficult to identify the use wear, however, the size of these pieces were out of context for the well-sorted beach gravel deposits in which they were found indicating that they had been transported manually. Abraders were probably used for sharpening and smoothing bone, wood and shell as there is no evidence of ground stone at Richardson.

The definitions presented above represent tools that are products of both flaking and non-flaking techniques. In the analysis presented in Chapter 7 only those tools manufactured by means of flaking techniques are examined for temporal trends, while five tool types (microblades, bifaces, scraperplanes, unimarginal tools and scrapers) are further inspected for trends in raw material use.

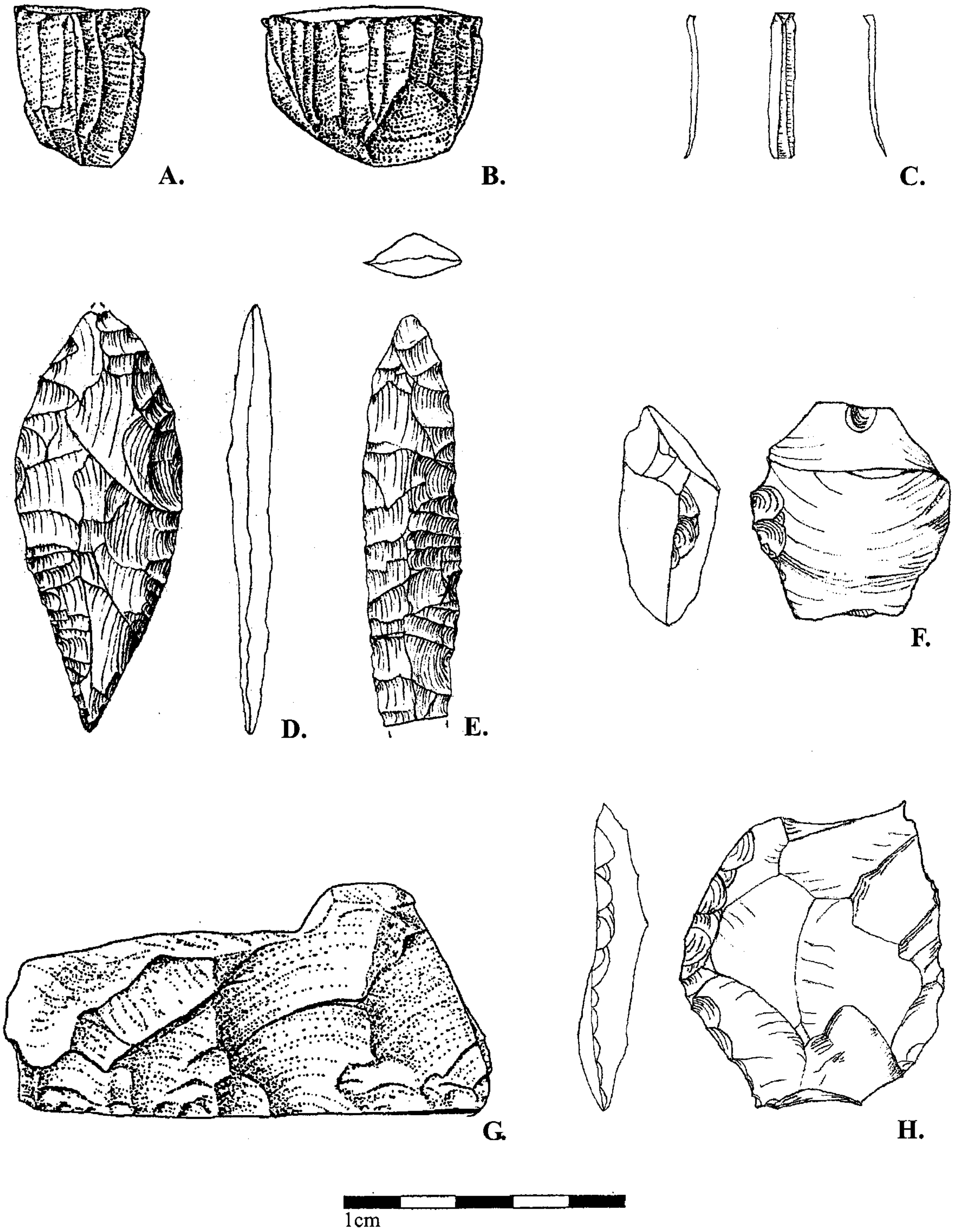


Figure 6.1 Images of selected stone tool types from the Richardson Island archaeological site: a. and b. Microblade cores; c. Microblade; d. and e. Bifaces; f. Unimarginal tool; g. Scraperplane; h. Scraper. (Images a, b, and g are by J. McSporran in Fedje and Christensen (1999:11), images d and e are by D. McLaren, images c, f, and h are by N. Smith.

CHAPTER 7

Raw Material Use and Tool Manufacturing Patterns

Introduction

The purpose of this chapter is fourfold: to analyze the trends of raw material use through time; to consider the distribution of tool classes through time; to explore the relationships between raw material and five tool classes thus determining which materials are preferred in biface, scraperplane, unimarginal, scraper and microblade production; and to explore the consistency of raw material use among these tool types between the Kinggi Complex and the Early Moresby Tradition.

The discussion will begin with a summary of the temporal designations, sample size, raw material and tool classifications. This will be followed by an examination of raw material use through time. In this section a descriptive analysis of the raw material data will be presented as a frequency table and selected trends will be graphed. The percentages of raw material abundance will also be analyzed in a correlation matrix to show that some materials, such as siliceous argillite, are associated with the older depositional units, while other materials, most notably shale/argillite, gain prominence in the Early Moresby period. A similar presentation and analysis of data will be conducted on the tools. The data presented here reconfirm the already established distinctions (Chapter 3) between the Kinggi Complex and Early Moresby Tradition tool complexes (Fedje and Christensen 1999).

In the next section raw material and tools will be considered together. First a discussion of how to apply raw material types and their subclasses to the bifaces, scraperplane, scraper, unimarginal, and microblade categories will be presented. A series of chi-square tests have been conducted on raw materials for each tool type to assess whether subclasses of material types are used for different tools. As a result of these tests, the preferred material for bifaces, scraperplane, scraper, and unimarginal tools can be identified.

The tool types have been examined internally for raw material variation between the Kinggi and Early Moresby periods. As can be demonstrated, bifaces are the least flexible category in terms of raw material variability as they exhibit little change in raw material use between the two periods, while conversely unimarginal tools are very flexible in raw material use between the two time periods. Since microblades are present in the Early Moresby Tradition only, they are examined differently from the other tool categories. The analysis of raw material use in microblade production involves a frequency table, correlation matrix and chi-square tests to reveal that the first microblades were manufactured out of material that was in common use at the site. In more recent occupations, there was a switch to new materials. Finally, it can be argued that changes in raw material use between the Kinggi and Early Moresby periods were initiated by rising sea-level and later encouraged and affected by the emergence of microblade technology.

Analytical Parameters

Temporal Distinctions

As mentioned in previous chapters the materials examined here date to between 9,300 and 8,500 BP. This period is stretched over more than 4 meters of vertical soil deposits, thus creating an exceptional archaeological setting in which 51 stratigraphic layers are distinguished. A series of dates collected during the 1995 and 1997 excavations confirmed a continuous temporal sequence throughout the stratigraphic profile. A number of these layers were cultural as evidenced by their greasy black, charcoal, and artifact rich matrices, while other layers were the result of natural depositional and pedalogical processes. Each of the 51 stratigraphic layers was interpreted as an A, B, or C soil horizon which enabled the stratigraphic layers to be compressed into 20 depositional units (represented by Roman Numerals in Figure 3.7). The depositional units do not represent equal time intervals and range from roughly thirty to more than one hundred radiocarbon years. These units are stratigraphically ordered; Layer I is the most recent and Layer XX is the oldest.

The emergence of microblades at 8,900BP (Fedje and Christensen 1999) provides another temporal distinction. This shift in technology allows us to divide the site into two components: The Kinggi Complex which is found in the older layers (9,300 to 8,900BP/ depositional units XI-XX) and the more recent Early Moresby Tradition (8,900-8,500BP/ depositional units I-X). In the analysis that follows artifacts are grouped according to the twenty depositional units, according to divisions between Kinggi and Early Moresby components, and/or for the site as a whole in which all depositional units are considered together.

Sample Size and Derivation

While the total number of tools for the 1127T site is 3156, only 2050 artifacts were considered for this chapter. Excluded from the analysis were 354 tools, the majority of which were not products of flaking technology (i.e. abraders and hammerstones), artifacts which had been recorded from the 1995/97 field seasons but are not currently housed with the collection at the University of Victoria, and a few samples that were too burnt or encrusted in oxidized sediment to assign a raw material classification. Also excluded from this analysis were 631 utilized flakes which had not been consistently recorded between Operations, and 96 artifacts from the 1995 and 1997 test excavations which were assigned to layers that spanned two depositional units. By omitting this latter set of artifacts the discrete temporal units were maintained.

Raw Material and Tool Classifications

In Chapter 4 it was concluded that the 30 most commonly occurring, visually distinct materials at the Richardson Island archaeological site, could be assigned to 14 raw material categories: Andesite, Basaltic-andesite, Chert, rhyolite 27, rhyolite 28, material 14, Dacite sum, Rhyolite sum, Shale/argillite sum, Siliceous argillite sum, Tuff, Varvite, Wacke, and Others. The categories with 'sum' are consolidations of 3 or more visually distinct subcategories. In the analysis that follows there are times when the raw material subcategories are distinguished and other occasions in which they are united with the larger raw material type. In instances when the subcategory is separated from its larger raw material group it will be denoted by sample number (i.e. siliceous argillite #13) instead of 'sum' (i.e. siliceous argillite sum). An artifact could only receive one rock type assignment.

Each artifact was also assigned a tool category. There are 14 tool classes: core, microblade technology, biface sum, bimarginal sum, unifacial sum, unimarginal sum, scraper, chopper, spall, spokeshave, graver, spokeshave/graver, scraperplane sum, and wedge. For ease of analysis, a number of the tool categories were consolidated. The categories with 'sum' are consolidations of 2 or more subcategories. In the original Parks

Canada database, whole tools are separated from fragments. As an initial step for this analysis, fragmented tools were joined with their complete counterparts; for example, scrapers and scraper fragments were united, as were unimarginal tools and unimarginal fragments, and so on. All artifacts indicative of microblade technology were consolidated (e.g. microblades, microblade cores, microblade core rejuvenation flakes). The bifacial category includes complete bifaces, biface fragments, bifacial performs and biface end fragments. The scraperplane category includes scraperplanes, scraperplane fragments, scraperplane rejuvenation flakes, denticulate scraperplanes, and denticulate scraperplane fragments. The association and positive correlation of scraperplanes and denticulate scraperplanes has been documented by Magne (2004) and was reconfirmed in tool correlation matrices run for this project, affirming that these categories could be united.

As outlined in Chapter 6, tools were assigned to a category on the basis of morphological characteristics, manufacturing techniques and/or assumed function. In some cases, however, one artifact could have multiple features and thus received multiple tool classifications. For example, one tool could possess a graver, a spokeshave, and exhibit separate unimarginal flaking, in which case the artifact would receive three tool classifications. Therefore, while there are only 2,050 individual artifacts, 2,292 tools are represented.

Raw Material Use through Time

To understand the raw material use through time at the Richardson Island site, a descriptive analysis of the data is presented and trends in the data are confirmed statistically. Interpretations of raw material use through time that appear towards the end of the chapter are based on statistically significant trends.

The raw material frequencies for the site are presented in Table 7.1. When the material types are considered for the site as a whole and the percent of raw materials are presented as a bar graph (Figure 7.1), we see that siliceous argillite is the most abundant material at the site (33%), followed by shale/argillite (25%), others (12%), varvite (6%), rhyolite (6%), and so on. However, when the material proportions are divided into Early Moresby Tradition (more recent deposits) and Kinggi Complex (older deposits) there is a

Table 7.1 Raw Material Frequencies per Depositional Unit

Depositional Unit	*Rhyolite 27*	*Rhyolite 28*	*Sample 14*	*Dacite sum*	*Rhyolite sum*	Andesite 5	Basaltic andesite 15	Tuff 7	Shale/argillite sum	Chert 25	Varvite 20	Wacke 16	Siliceous argillite sum	Others	Total Tools with Raw Material code
I	28	49	2	4	0	0	0	0	8	0	0	0	1	5	97
II	19	8	0	10	0	0	0	0	15	0	2	0	3	4	61
III	13	1	0	17	16	0	0	1	14	19	0	0	8	15	104
IV	3	0	0	16	5	0	0	0	29	6	2	0	3	11	75
V	0	1	0	11	0	1	0	0	17	0	0	0	1	2	33
VI	0	0	1	3	1	0	0	3	67	0	0	0	21	19	115
VII	1	0	0	6	5	0	0	5	23	0	2	0	8	22	72
VIII	0	1	0	2	16	0	0	2	52	0	8	0	42	16	139
IX	0	0	0	1	2	1	0	2	27	0	4	0	28	2	67
X	0	0	0	2	6	0	0	4	39	0	3	0	41	16	111
XI	0	0	4	0	19	5	1	5	37	0	22	2	51	26	172
XII	0	0	5	6	21	2	2	1	46	0	24	0	70	15	192
XIII	0	0	0	3	13	2	0	2	33	0	25	9	109	15	211
XIV	0	0	1	1	9	0	1	1	36	0	9	0	85	16	159
XV	0	0	0	1	0	0	0	0	0	0	0	0	3	3	7
XVI	0	0	1	2	1	1	2	0	40	0	6	16	103	30	202
XVII	0	2	6	4	9	0	1	1	30	0	12	8	45	30	148
XVIII	0	0	0	0	2	0	1	1	5	0	4	0	34	6	53
XIX	0	0	1	1	0	1	0	1	2	0	2	0	19	3	30
XX	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
EMC*	64	60	3	72	51	2	0	17	291	25	21	0	156	112	874
Kinggi*	0	2	18	18	74	11	8	12	230	0	104	35	520	144	1176
total	64	62	21	90	125	13	8	29	521	25	125	35	676	256	2050

*EMC = Early Moresby Component and is a sum of depositional units I-X
Kinggi = Kinggi Component and is a sum of depositional units XI-XX

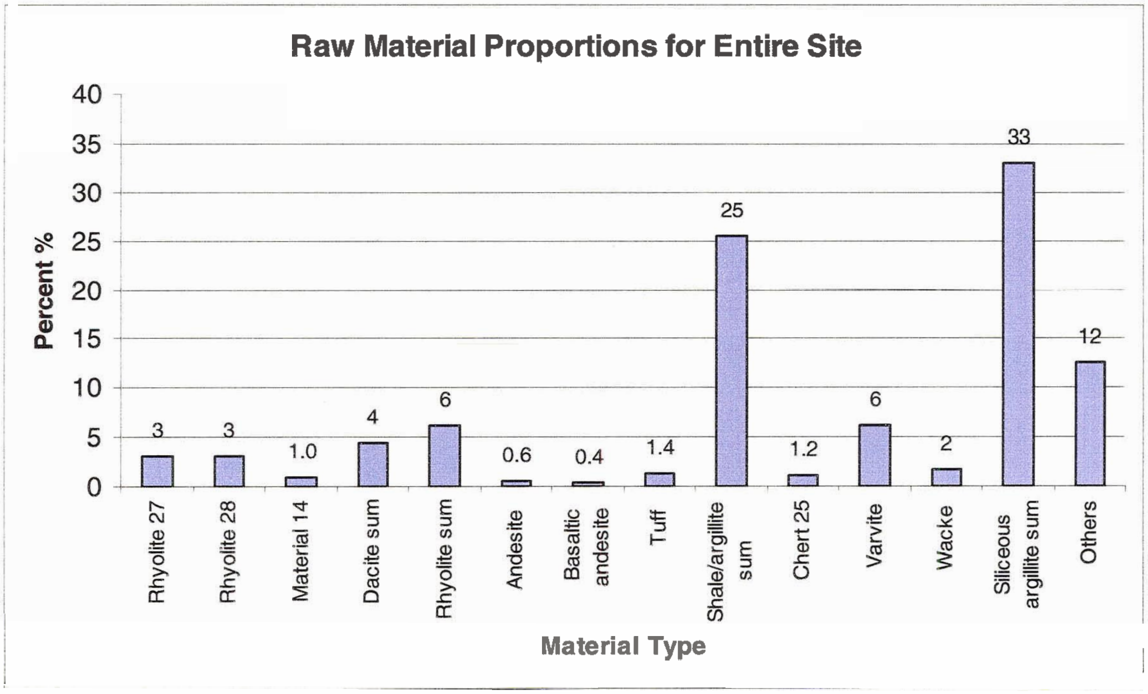


Figure 7.1 Total Raw Material Proportions for 1127T

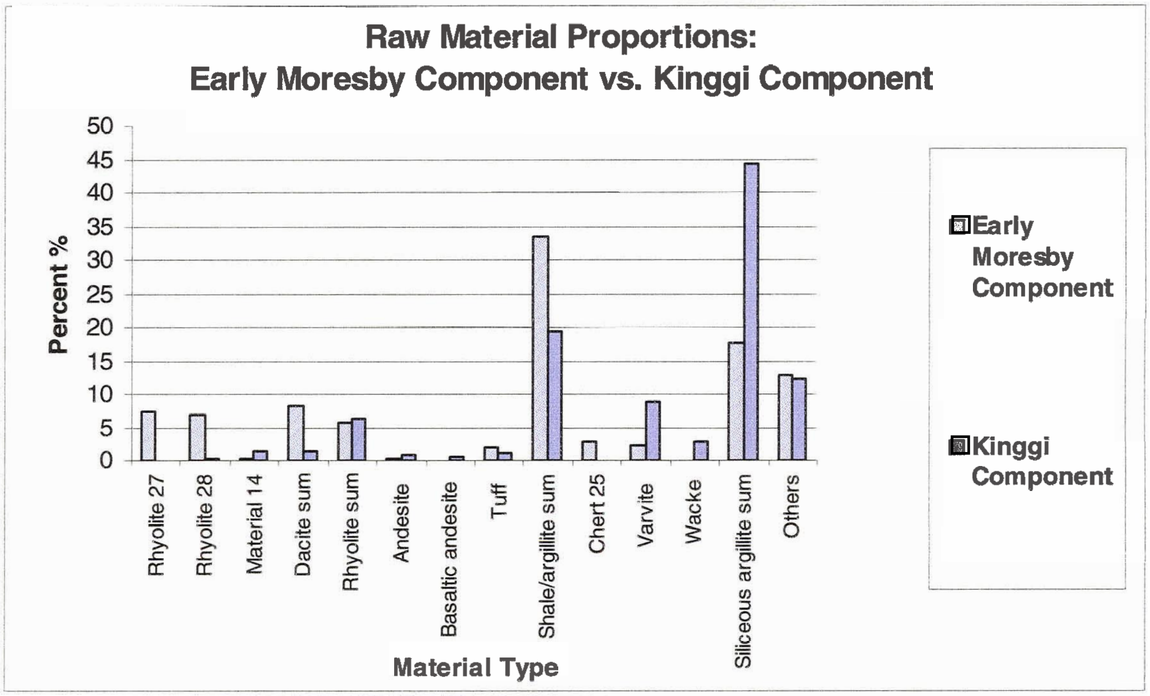


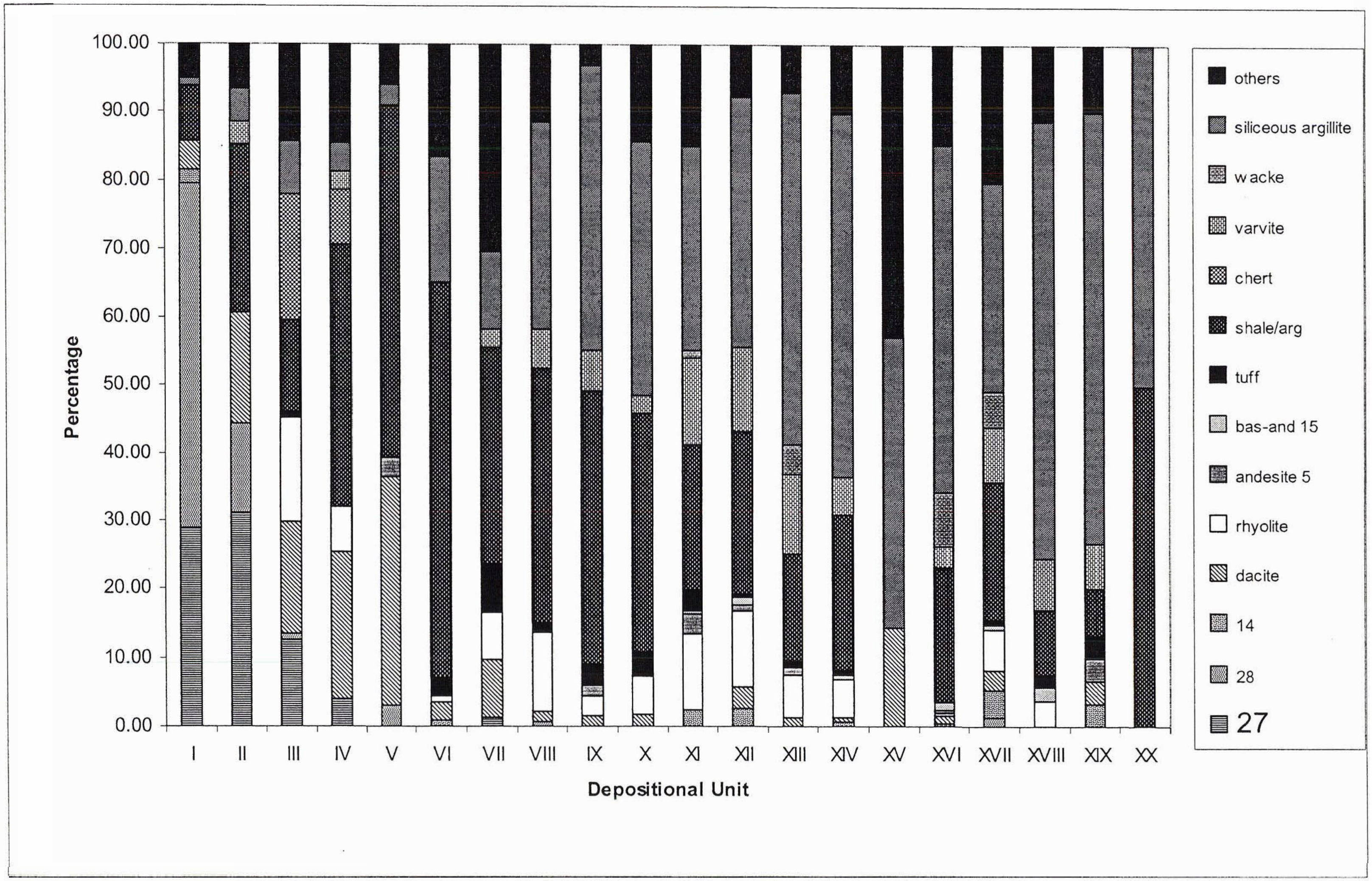
Figure 7.2 Raw Material Proportions: Early Moresby Component vs. Kinggi Component

dramatic shift in the material proportions between the two periods (see Figure 7.2). Most notably there is a decreased dependence on siliceous argillite from Kinggi to Early Moresby, coupled with an increased use of shale/argillite. There is also an increased reliance on rhyolite 27, rhyolite 28, and dacite in the Early Moresby period and a decrease in varvite, wacke, andesite and basaltic andesite.

In an attempt to examine further the shift in raw material use between the early and late periods, the proportions of raw material within each depositional unit were plotted on a stacked bar graph (Figure 7.3). This provided a visual indicator of trends through time and a means of associating the emergence and disappearance of some materials with specific depositional units. Figure 7.3 reveals that siliceous argillite declines steadily from the older to more recent depositions and is replaced by shale/argillite as the most commonly used material at depositional unit IX (8,850BP). Shale/argillite use increases until unit VI, at which point it decreases significantly. At depositional unit V we also see a marked increase in the use of material 27, followed by a rise in the utilization of material 28 shortly thereafter. In these later years, dacite use is enhanced and there is a brief occurrence of chert. Wacke and basaltic-andesite have long since disappeared by this point while the remaining materials appear to be used fairly consistently through time.

A test of the Pearson product-moment coefficient of linear correlation available in Microsoft Excel assessed the statistical significance of raw material proportional use through time. Within a correlation matrix, values of -1 indicate a negative correlation while +1 reflects a positive correlation. In this instance a positive correlation between materials would indicate a tendency to co-occur while a negative correlation between materials would suggest that the materials are not inclined to occur at the same time. A negative correlation with the depositional units suggests that the material occurs more recently while a positive correlation with depositional units confirms an association with the older units.

As shown by the correlation matrix in Table 7.2, the associations of dacite and materials 27 and 28 with the more recent depositional units, and siliceous argillite and basaltic-andesite with the earlier, are statistically significant. Materials 27 and 28 are



Note: Sea-level stabilization occurs at depositional unit X = 8900 BP. Depositional unit XX is oldest, depositional unit I is most recent.

Figure 7.3 Raw Material Percentages by Depositional Unit

Table 7.2 Correlation Matrix, Based on Raw Material Percentages and Depositional Units

	Depositional Unit	*Rhyolite 27*	*Rhyolite 28*	*Sample 14*	*Dacite sum*	*Rhyolite sum*	*Andesite 5*	*Basaltic andesite 15*	*Tuff 7*	*Shale/argillite sum*	*Chert 25*	*Varvite 20*	*Wacke 16*	*Siliceous argillite sum*	*Others*
Depositional Unit	1														
Rhyolite 27	**-0.629**	1													
Rhyolite 28	**-0.472**	**0.787**	1												
Sample 14	0.282	-0.018	0.186	1											
Dacite sum	**-0.537**	0.255	0.04	-0.304	1										
Rhyolite sum	-0.18	-0.163	-0.29	0.056	-0.099	1									
Andesite 5	0.138	-0.255	-0.15	0.357	0.159	-0.08	1								
Basaltic andesite 15	**0.48**	-0.244	-0.17	0.229	-0.363	0.125	-0.05	1							
Tuff 7	0.003	-0.289	-0.25	0.012	-0.282	0.188	0.153	-0.11	1						
Shale/argillite sum	-0.255	-0.242	-0.25	-0.316	0.169	-0.08	-0	-0.32	0.12	1					
Chert 25	-0.385	0.203	-0.08	-0.2	0.392	**0.538**	-0.18	-0.18	-0.141	-0.105	1				
Varvite 20	0.366	-0.31	-0.28	**0.449**	-0.47	0.439	0.362	**0.474**	0.144	-0.278	-0.275	1			
Wacke 16	0.36	-0.184	-0.12	0.241	-0.254	-0.061	-0.02	0.306	-0.217	-0.204	-0.133	0.259	1		
Siliceous argillite sum	**0.901**	**-0.575**	**-0.44**	0.112	**-0.651**	-0.137	0.138	**0.471**	0.061	-0.309	-0.378	**0.438**	0.26	1	
Others	0.078	-0.224	-0.24	-0.021	0.137	0.07	-0.25	-0.03	0.271	-0.318	0.0452	-0.17	0.071	-0.054	1

0.44 is significant for 95% confidence

also positively correlated with one another, while 27 is negatively correlated with siliceous argillite. Dacite and Rhyolite are positively correlated with Chert, and dacite is negatively correlated with siliceous argillite. Basaltic andesite is positively correlated with Varvite and Wacke.

Temporal Variability within Shale/argillite, Siliceous argillite, Dacite, and Rhyolite Raw Material Classes

It was established in Chapter 4 that the shale/argillite, siliceous argillite, dacite, and rhyolite categories were composed of multiple, visually dissimilar samples, some of which differed geochemically, i.e. maintained unique rare earth element (REE) patterns. While it was not possible to say that the chemically unique materials were from isolated source locations, it was reasonable to infer that these materials were spatially distinct, if even on a scale of but a few meters.

With this in mind, do differences in REE patterns and visual dissimilarity exhibit temporal variability within the four raw material classes mentioned above? To answer this question the siliceous argillites, shale/argillites, dacites, and rhyolites were examined separately. As in the previous section, the data within each of the raw material classes were examined via descriptive analysis and observed trends were confirmed statistically. Within each group the percentage of each visually distinct material for each depositional unit was plotted as a stacked bar graph (Figure 7.4 a-d). Correlation matrices were established and considered for those graphs producing a linear trend[19] (Table 7.3a-d). As in the previous section a positive correlation between materials indicates a tendency to co-occur whereas a negative correlation suggests they are temporally opposed. Again, a negative correlation with depositional units suggests the material occurred more recently, whereas a positive correlation indicates an association with the older depositional units.

Within the rhyolite class, sample 26 was noted for its distinctive REE patterns. When plotted (Figure 7.4a), 26 appears suddenly and briefly in depositional units III and IV while the other rhyolite samples have an earlier and more lengthy occurrence between units XVIII and VI. These trends are not deemed significant by the correlation

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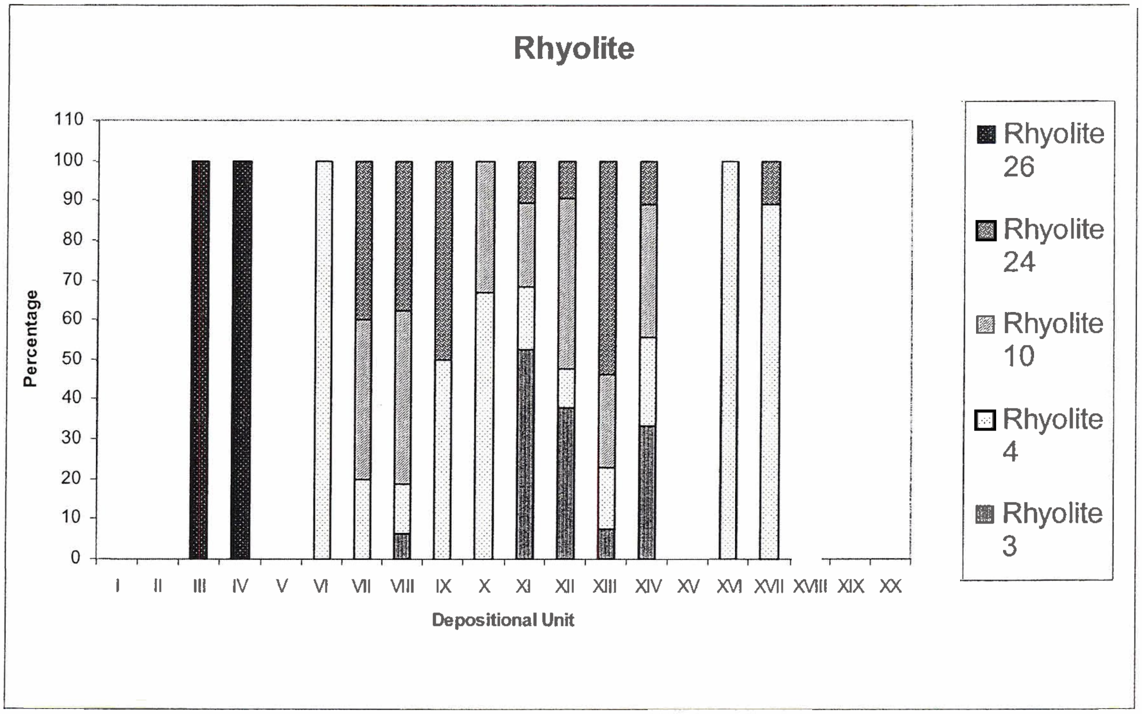
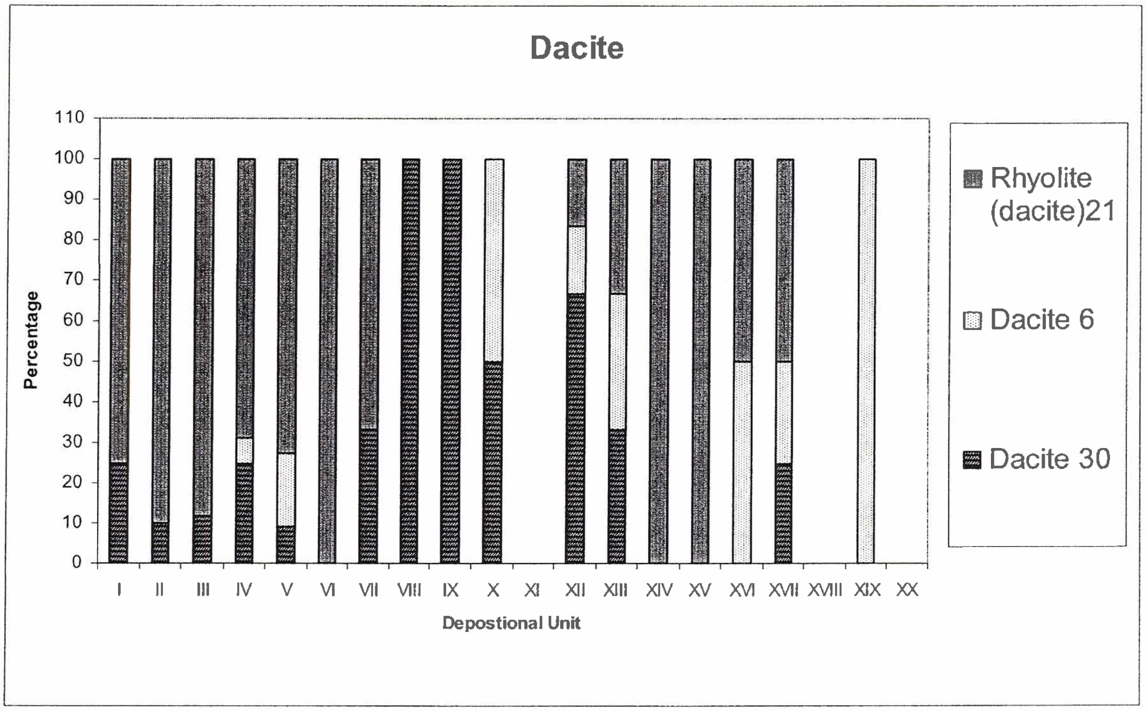
[19] A test of correlation can only be run on variables displaying a linear trend. Where a linear trend is not visible the graphic patterns are described.

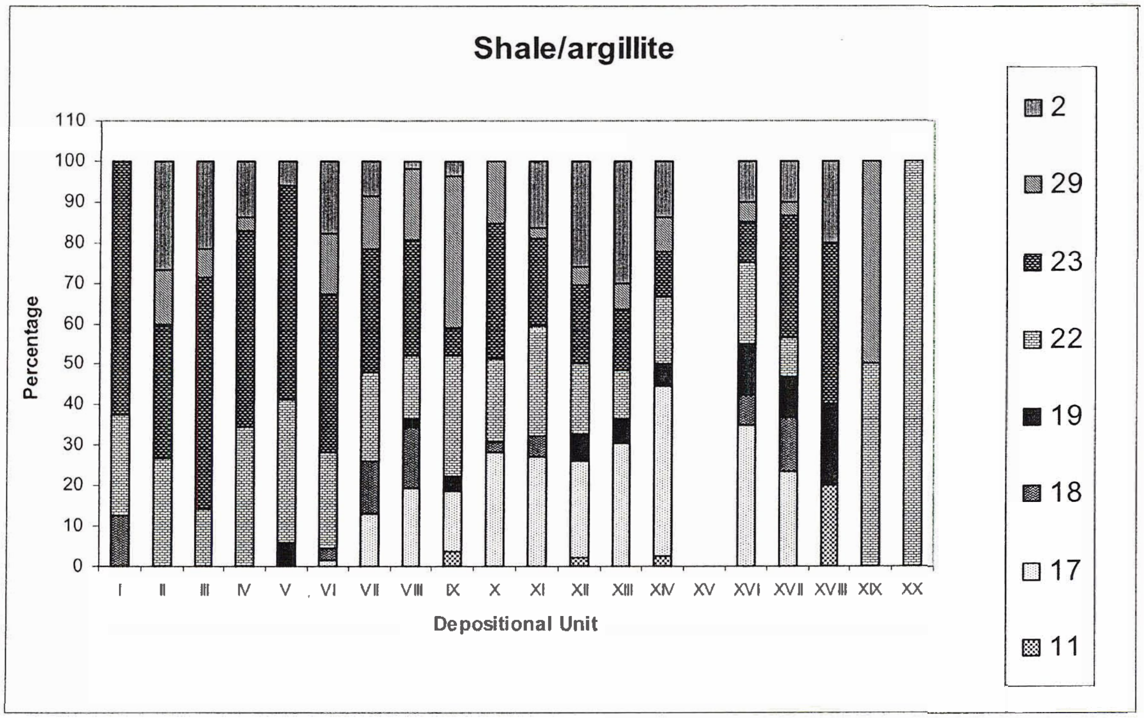


a.

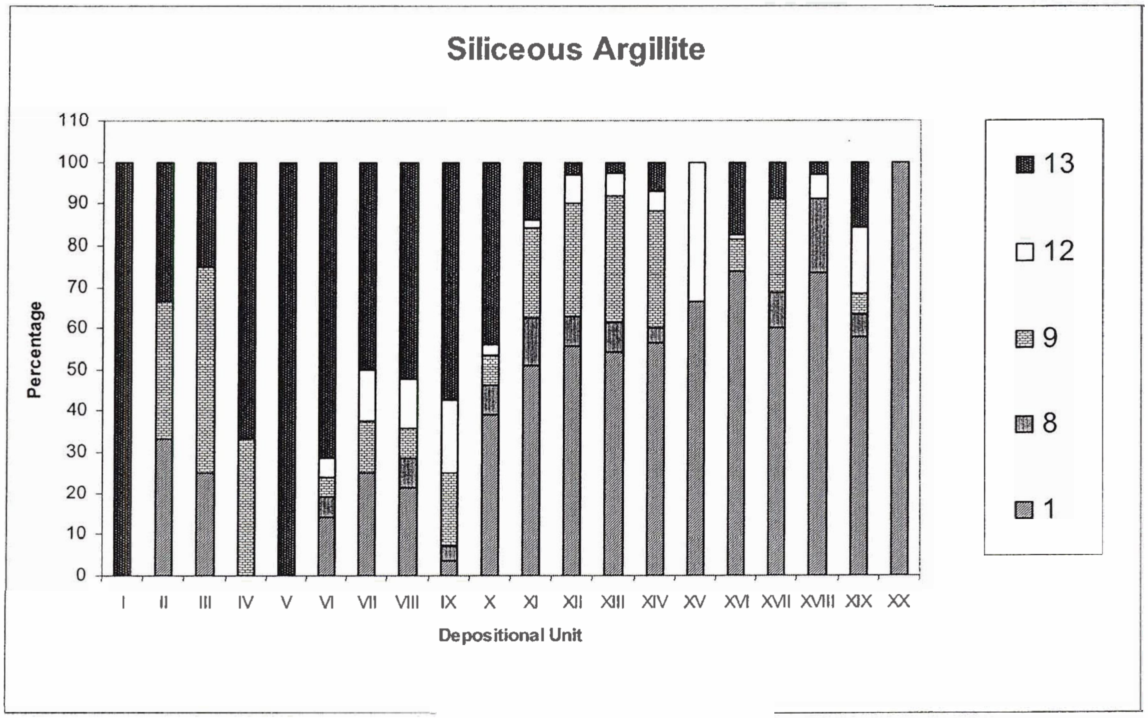


b.

Figure 7.4 Raw Material Percentages by Depositional Unit: a) Rhyolite, n = 125 b) Dacite, n = 90 c) Shale/argillite, n = 521 d) Siliceous argillite, n = 676



c.



d.

Figure 7.4 continued Raw Material Percentages by Depositional Unit: a) Rhyolite, n = 125 b) Dacite, n = 90 c) Shale/argillite, n = 521 d) Siliceous argillite, n = 676

Table 7.3 a) Correlation Matrix: Rhyolite

	Depositional Unit	*Rhyolite 3*	*Rhyolite 4*	*Rhyolite 10*	*Rhyolite 24*	*Rhyolite 26*
Depositional Unit	1					
Rhyolite 3	0.118	1				
Rhyolite 4	0.247	-0.16	1			
Rhyolite 10	0.167	0.417	-0.001	1		
Rhyolite 24	-0.021	0.074	-0.006	0.342	1	
Rhyolite 26	-0.405	-0.15	-0.266	-0.26	-0.21	1

.729 is significant for 95% confidence

Table 7.3 b) Correlation Matrix: Dacite

	Depositional Unit	*Dacite 30*	*Dacite 6*	*Rhyolite (dacite) 21*
Depositional Unit	1			
Dacite 30	-0.228	1		
Dacite 6	0.42	-0.105	1	
Rhyolite (dacite) 21	-0.477	-0.425	-0.339	1

.90 is significant for 95% confidence

Table 7.3 d) Correlation Matrix: Siliceous argillite

	Depositional Unit	*Siliceous argillite 1*	*Siliceous argillite 8*	*Siliceous argillite 9*	*Siliceous argillite 12*	*Siliceous argillite 13*
Depositional Unit	1					
Siliceous argillite 1	**0.8743**	1				
Siliceous argillite 8	0.4238	0.309	1			
Siliceous argillite 9	-0.323	-0.152	-0.086	1		
Siliceous argillite 12	0.2646	0.094	-0.024	-0.296	1	
Siliceous argillite 13	**-0.762**	**-0.889**	-0.38	-0.224	-0.208	1

.729 is significant for 95% confidence

Table 7.3 c) Correlation Matrix: Shale/argillite

	Dep. Unit	*Shale/ argillite 11*	*Shale/ argillite 17*	*Shale/ argillite 18*	*Shale/ argillite 19*	*Shale/ argillite 22*	*Shale/ argillite 23*	*Shale/ argillite 29*	*Wacke/ shale 2*
Depositional Unit	1								
Shale/ argillite 11	0.311	1							
Shale/ argillite 17	0.295	-0.119	1						
Shale/ argillite 18	-0.14	-0.221	0.215	1					
Shale/ argillite 19	0.468	**0.733**	0.271	-0.01	1				
Shale/ argillite 22	0.173	-0.289	-0.29	-0.19	-0.38	1			
Shale/ argillite 23	**-0.75**	0.077	-0.36	0.223	-0.02	-0.26	1		
Shale/ argillite 29	0.081	-0.107	-0.04	-0.09	-0.26	0.164	-0.36	1	
Wacke/ shale 2	-0.17	0.216	0.165	-0.32	0.283	-0.35	0.188	-0.258	1

.582 is significant for 95% confidence

matrix which requires a linear trend for statistical relevance, but the obvious presence and absence of 26 is noteworthy nonetheless. As will be highlighted later in this chapter rhyolite 26 was used exclusively in microblade manufacture thereby accounting for its restricted temporal presence.

The three dacite samples exhibit alternating appearances and disappearances (Figure 7.4b). Sample 30 exhibited the most unusual REE pattern of the three dacite samples, but it is difficult to establish trends on the basis of this graph. None of the dacite behaviours are significant according to the correlation matrix (Table 7.3b) which is to be expected as none of the samples exhibit a linear trend.

Among the shale/argillite group, sample 23 increases with a progression towards the more recent units (Figure 7.4c). This trend is also statistically significant (Table 7.3 c). However, sample 23 possessed a REE pattern that was very similar to that of 29, which has a much lower proportional use in the more recent depositional units. Had these materials been lumped together this trend may not have emerged.

Among siliceous argillites (Figure 7.4d), sample 1 shows a decreasing trend with time, while 13 appears to increase in the more recent units. According to the correlation matrix for siliceous argillite (Table 7.3d) these trends through time are statistically significant, as is the negative correlation of these materials with one another ($r = -.889$). As an overall pattern, sample 1 was the most commonly utilized siliceous argillite in the older depositional units while 13 was the most abundant in the later units. Type 1 appears to be replaced by 13 as most commonly used siliceous argillite at layer X (8,900 BP). In Chapter 4 siliceous argillites 13 and 12 had also been flagged as they maintain unique REE patterns in the siliceous argillite group.

The above exploration of data proves that the REE patterns may be useful in understanding raw material use through time. Whether these shifts are the result of an emerging tool type (microblades), the result of environmental pressure (sea-level rise and cessation) or other factors will be considered at the end of this chapter.

Distribution of Tool Classes Through Time

As with the raw material types, the tool class frequencies were tabulated for each depositional unit (Table 7.4) and proportions of tools within the Early Moresby and Kinggi components were expressed as a bar graph (Fig 7.5). These charts provide visual indicators of what one would expect to see within the two periods based on previous analysis at Richardson (Fedje and Christensen 1999; Magne 2004; Fedje et al. in press). The Kinggi Complex maintains a higher proportion of bifaces and scraperplanes than the Early Moresby period which is dominated by microblades. The percentages of unimarginal tools, however, are comparable between the two phases.

As in the previous section, the proportions of tools per depositional unit are also plotted (Figure 7.6). Again we see a decreasing trend in bifaces and scraperplane abundance from the older to more recent units, and a steady increase in microblade use. The most pronounced increase in microblade abundance begins at depositional unit VIII. A correlation matrix (Table 7.5) confirms the statistical significance of these trends as microblades are negatively correlated with depositional units (r = -.845), while bifaces and scraperplanes are positively correlated with depositional units (r = .8331 and .6301 respectively).

At the 95% confidence interval, we also see that microblades are negatively correlated with bifaces (-.705) and spokeshaves (-.642), and that bifaces are positively correlated with scraperplanes (.802). Spokeshaves and gravers are positively correlated (.6603), as are unimarginal tools with gravers (.691) and spokeshave/graver (.614). The positive correlations between unimarginal tools, spokeshaves, gravers, and spokeshave/gravers are not surprising as these tool classes can often be found in combination on one artifact.

The distinctions between Early Moresby Tradition and Kinggi Complex here noted are in accordance with previous tool analyses conducted on Richardson Island materials excavated in 1995 and 1997 (Fedje and Christensen 1999; Magne 2004, Fedje et al. in press). Comparable results between earlier studies and the ones offered here indicate that the tool classifications have been consistently applied between researchers.

Considering Tools and Raw Material Together

In the above two sections it was demonstrated that both tool and raw material use patterns differ between the Early Moresby and Kinggi periods. But how are the tools and raw materials themselves related to one another? And do the relationships between tool and

Table 7.4 Tool Class Frequencies per Depositional Units

DEPOSITIONAL UNIT	*CORE*	*MICROBLADE TECHNOLOGY*	*BIFACE SUM*	*BIMARGINAL SUM*	*UNIFACIAL TOOL SUM*	*UNIMARGINAL TOOL SUM*	*SCRAPER*	*CHOPPER*	*SPALL*	*SPOKESHAVE*	*GRAVER*	*SPOKESHAVE/GRAVER*	*SCRAPERPLANE SUM*	*WEDGE*	*TOTAL*
I	2	90	1	0	1	2	0	0	0	0	0	0	0	0	96
II	2	46	0	3	0	7	3	0	0	0	0	0	0	0	61
III	4	86	1	4	0	4	3	0	0	3	4	0	0	0	109
IV	3	58	2	0	1	8	1	1	0	1	3	1	2	0	81
V	0	23	1	1	0	4	2	0	0	1	5	0	0	0	37
VI	5	67	3	0	1	19	6	0	1	4	15	3	1	0	125
VII	16	16	5	0	1	15	6	1	0	7	5	1	7	0	80
VIII	13	2	11	1	1	56	10	1	0	18	27	4	16	1	161
IX	1	2	9	1	1	25	5	0	0	4	19	7	1	0	75
X	25	4	25	0	2	15	6	4	0	6	6	3	21	0	117
XI	38	2	14	1	3	29	24	1	0	24	35	3	32	1	207
XII	34	0	13	2	1	56	17	1	0	36	44	0	22	1	227
XIII	54	1	38	1	1	49	18	3	0	21	15	0	21	2	224
XIV	22	0	26	0	4	40	11	0	0	33	32	3	14	1	186
XV	1	0	1	0	0	0	3	0	0	1	1	0	1	0	8
XVI	41	0	35	2	0	44	19	0	0	12	25	3	39	1	221
XVII	36	0	19	3	1	33	17	2	0	13	33	1	21	3	182
XVIII	10	0	12	3	0	5	13	0	0	2	7	0	8	0	60
XIX	1	0	6	0	0	7	1	0	0	5	6	1	3	2	32
XX	0	0	1	0	0	0	0	0	0	0	0	0	2	0	3
Early Moresby	71	394	58	10	8	155	42	7	1	44	84	19	48	1	942
Kinggi	237	3	165	12	10	263	123	7	0	147	198	11	163	11	1350
TOTAL	**308**	**397**	**223**	**22**	**18**	**418**	**165**	**14**	**1**	**191**	**282**	**30**	**211**	**12**	**2292**

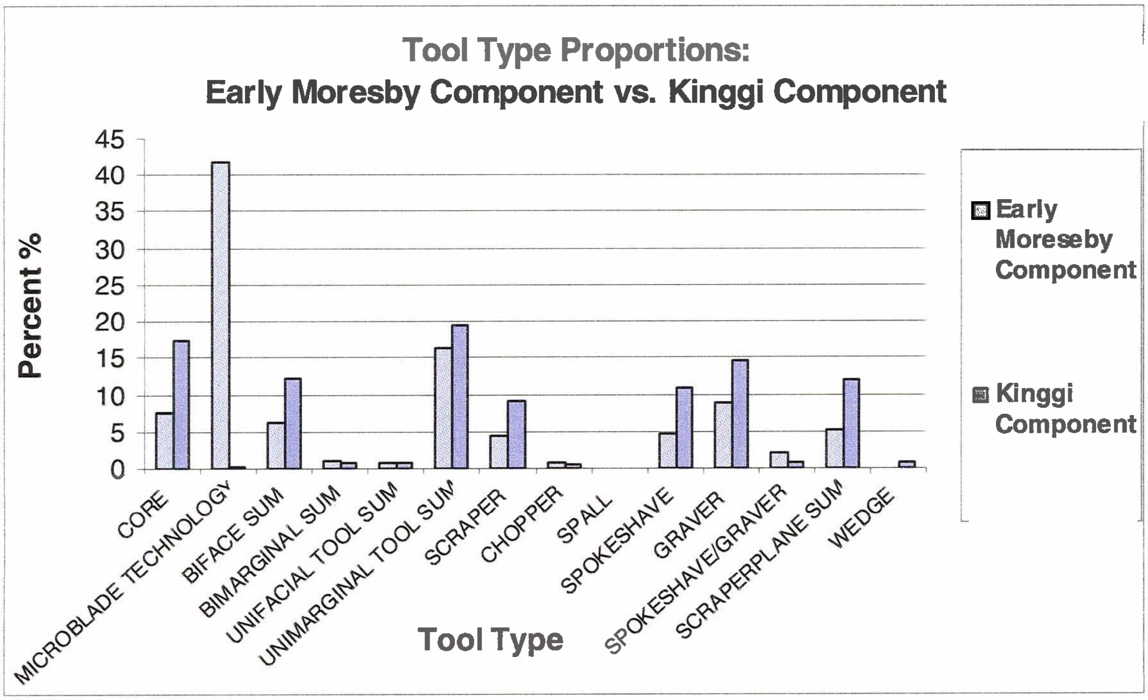
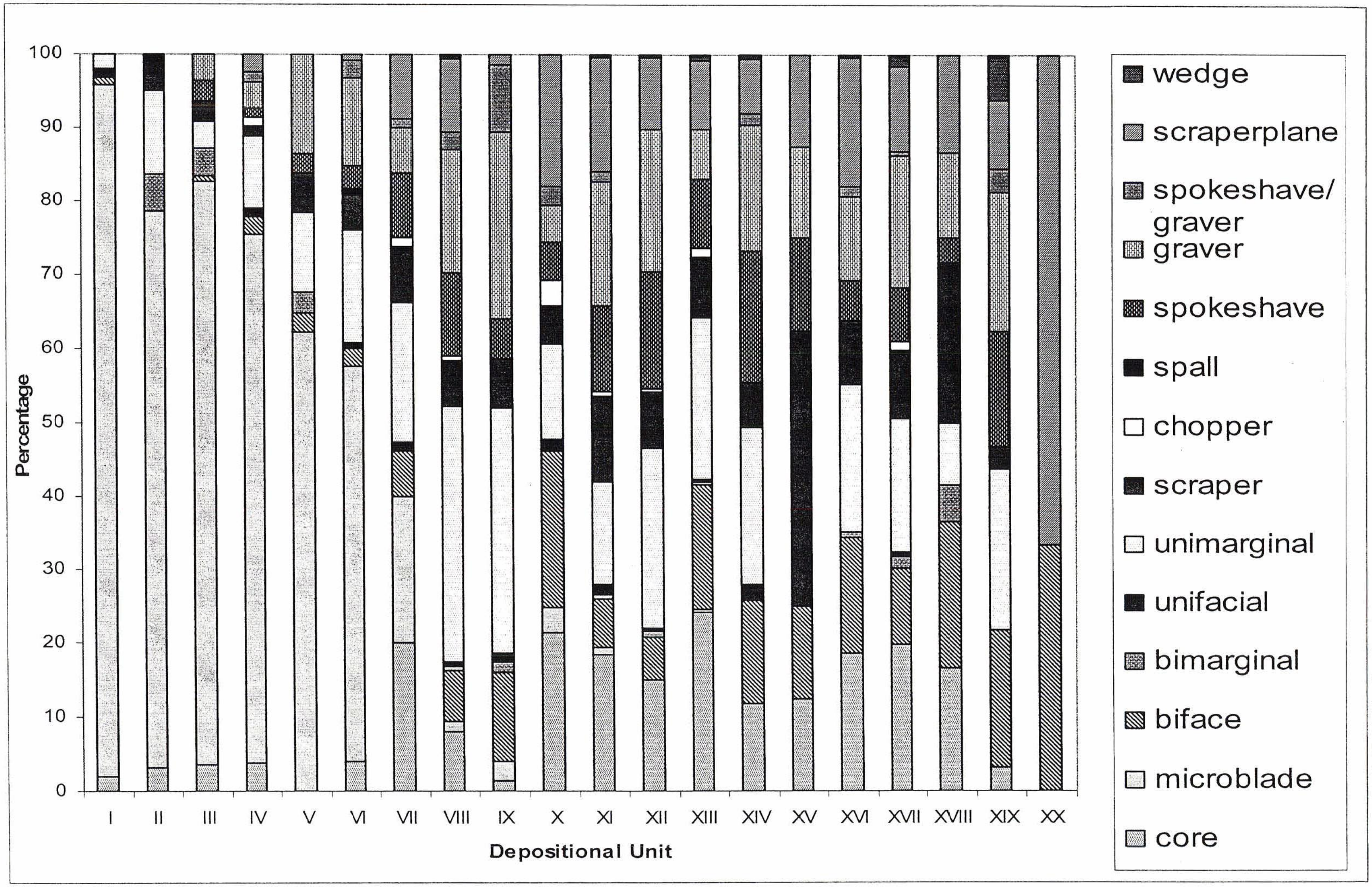


Figure 7.5 Tool Type Proportions: Early Moresby Component vs. Kinggi Component



Note: Sea-level stabilization occurs at depositional unit X = 8900 BP. Depositional unit XX is oldest, depositional unit I is most recent.

Figure 7.6 Tool Type Proportions by Depositional Units

Table 7.5 Correlation Matrix for Tool Classes and Depositional Unit

	DEPOSITIONAL UNIT	CORE	MICROBLADE TECHNOLOGY	BIFACE SUM	BIMARGINAL SUM	UNIFACIAL TOOL SUM	UNIMARGINAL TOOL SUM	SCRAPER	CHOPPER	SPALL	SPOKESHAVE	GRAVER	SPOKESHAVE/GRAVER	SCRAPERPLANE SUM	WEDGE
DEPOSITIONAL UNIT	1														
CORE	0.379	1													
MICROBLADE TECHNOLOGY	**-0.85**	**-0.58**	1												
BIFACE SUM	**0.833**	0.241	**-0.71**	1											
BIMARGINAL SUM	-0.17	-0.13	0.289	-0.22	1										
UNIFACIAL TOOL SUM	-0.22	0.219	-0.08	-0.09	-0.49	1									
UNIMARGINAL TOOL SUM	0.093	0.211	-0.45	-0.04	-0.16	0.294	1								
SCRAPER	0.368	0.383	-0.4	0.133	0.116	-0.23	-0.19	1							
CHOPPER	-0.04	**0.561**	-0.19	0.172	-0.29	0.452	0.113	-0.12	1						
SPALL	-0.18	-0.18	0.209	-0.22	-0.16	0.051	0.001	-0.09	-0.14	1					
SPOKESHAVE	0.441	0.407	**-0.64**	0.127	-0.39	0.24	0.511	0.308	0.014	-0.16	1				
GRAVER	0.375	0.131	**-0.58**	0.026	-0.11	0.159	**0.691**	0.259	-0.19	0.033	**0.66**	1			
SPOKESHAVE/GRAVER	-0	-0.2	-0.25	0.087	-0.21	0.41	**0.614**	-0.15	0.034	0.113	0.115	0.557	1		
SCRAPERPLANE SUM	**0.63**	0.06	-0.48	**0.802**	-0.25	-0.18	-0.27	-0.02	0.054	-0.16	-0.08	-0.22	-0.17	1	
WEDGE	0.442	-0.04	-0.29	0.238	-0.19	-0.2	0.282	-0.12	-0.08	-0.09	0.472	0.356	0.151	-0.01	1

0.441 is significant for 95% confidence

Note: highlighted values indicate a correlation stronger than 95% confidence raw material stay the same between the Early Moresby and Kinggi periods? These have proven to be complex questions to answer, especially given that some tools (bifaces, scraperplanes, microblades) and some materials (siliceous argillite, shale/argillite) are not consistently represented through time. In an effort to limit the scope of a potentially very large analysis, I decided to concentrate on five tool categories (bifaces, scraperplanes, microblades, unimarginal tools and scrapers) and to examine their associations with raw material on a case by case basis. Microblades, scraperplanes, and bifaces were selected because of their temporal patterning, while scrapers and unimarginal tools were chosen for their more uniform presence between the Early Moresby and Kinggi periods. Also, these five tool categories represent very distinct forms which required different reduction strategies to be created. Their difference in form must have been recognizable as distinct to the people who made them and likely represent different a priori intentions. While it is possible that unimarginal tools may be ancillary to the scraper form, the remainder of the tools types represented fall into mutually exclusive groups. The bifaces, scraperplanes, microblades and scrapers/unimarginal tools could not represent different stages of reduction for one tool type such as has been documented for tool categories elsewhere (Dibble 1987).

To lump or split?: the question of raw material

The first question to arise in the union of raw material and tools was whether or not to keep those materials with distinct REE patterns separate from the other samples in the larger raw material classes. As seen earlier, both siliceous argillite 13 (Figure 4.14d) and rhyolite 26 (Figure 4.14a) had unique REE patterns in comparison to the rest of their groups and the appearance of these materials in the archaeological record had obvious temporal associations/restrictions. But what does this mean? It is tempting to answer that the temporal variability indicates a dramatic shift in sourcing location, but we cannot assume that this is the case. Certainly there is a shift in source location, but without confirmation of source, based on chemical analysis, the scale on which this shift occurs remains unknown. A shift of a few meters may not matter if the material is being used for the same purposes and tool manufacturing behaviour is unchanged. Thus, in the absence of definitive source information, the more meaningful analysis is to focus on how those materials with distinct REE patterns are being used in tool manufacture. Is their use the same as the other materials in their class; i.e. is rhyolite 26 used in the same way as the other rhyolite samples; is the role of siliceous argillite 13 the same as the other siliceous argillites, and so on. Where the materials with distinct REE patterns differ in use from the other materials, we can ask why this occurs. Answers may vary and could reflect factors such as differing flaking properties of stone that were exploited for different tool types, a change in source location, changes in technology which have affected material use, etc. The following test can not confirm which of these factors did affect the material use but it will help us avoid the assumption that all of the material sub types from the same group were used in the same way. To determine whether distinctions in tool manufacturing behaviour were present in each of the rhyolite, dacite, siliceous argillite and shale/argillite classes, those samples with distinct REE patterns were compared to the other samples of their raw material class by means of a chi-square test (SPSS) for each tool (bifaces, scraperplane, microblade, unimarginal tools, scrapers). Within each raw material category, if the material with a distinctive REE pattern is shown to have the same proportional use as the other materials (a non-significant chi-square result) in the manufacturing of a particular tool type, then there is no need to separate it from the other material types in the subsequent analysis of that tool. If, however, a different proportional use of the material is established (a significant chi-square result), then the material types will be separated in the following analysis of that tool. As will be seen below, the distinction between materials with distinct REE patterns and those without is significant for some tool categories, but not for others.

Dacite

There are three dacite samples: 6, 21, and 30. Of these samples, dacite 30 maintains a distinct REE pattern (Figure 4.14b) while dacites 6 and 21 have similar REE patterns and, hence, are united for the chi-square analysis. Table 7.6 indicates the frequencies with which these two dacite categories occur within each tool class. A series of chi-square tests were run on the varying dacite frequencies within each tool class to determine whether or not dacite 30 and dacite 6, 21 exhibited significantly[20] different proportional uses within each tool category. As we can see in table 7.6, which summarizes the chi-square tests, there is no significant difference in proportional use between Dacite 30 and

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[20] A recorded p value less than .050 is considered significant.

Dacite 6, 21 among microblades, unimarginal tools, or scrapers. The same proportions of Dacite 30 and Dacite 6, 21 are used in the manufacturing of these tool types. Thus, in subsequent examination of these tool categories, all dacite will be lumped.

The bifaces and scraperplane categories present a different picture. There are ten bifaces made of dacite in the Richardson assemblage and all of them represent Dacite 6,21. A chi-square test could not be applied to this tool category given the 0 value associated with dacite 30. Thus we note that all bifaces made of dacite are made of 6 and 21 only. The one dacite scraperplane is representative of Dacite 30 but as there is only one case represented we cannot draw any meaningful conclusions from this occurrence.

Within Table 7.6 there also appears to be a substantial difference between the frequencies and percentages between dacite 30 and dacites 6 and 21 in the 'others' tool category. It is tempting to examine the inherent trends more closely, however, as the 'others' category is a consolidation of all remaining tools, it would need to be deconstructed into individual tool types to extract any meaningful assessment of trends.

Table 7.6 Comparison of chemically distinct Dacite samples per tool type: a summary table of chi-square results.

		Micro-blade	Biface	Scraper-plane	Unimarginal	Scraper	Others	Total
Dacite 30	**Frequency**	**9**	**0**	**1**	**2**	**3**	**10**	**25**
	Percentage	36%	n/a	4%	8%	12%	40%	
Dacite 6, 21	**Frequency**	**29**	**10**	**0**	**17**	**5**	**13**	**74**
	Percentage	39.2%	13.5%	n/a	23%	6.8%	17.6%	
Chi-square	**Significant Y/N**	N	notable n/a	n/a	N	N		
	p value	.777			.100	.406		

Note: In this table and those to follow, chi-square analyses are summarized within each column and are meant to be read from top to bottom.

Rhyolite

Within the rhyolite class there are 5 samples: 3, 4, 10, 24, and 26. Of these, rhyolites 4, 10, and 24 have very similar REE patterns and are lumped accordingly. Rhyolite 3 has a slightly different REE pattern while rhyolite 26 is very distinct (Figure 4.14a). Table 7.7 compares the frequencies of rhyolite 26 and 3 with the other rhyolites for each tool type.

An immediate distinction can be observed from this table in that rhyolite 26 appears exclusively in microblade form and is the only rhyolite to do so. Thus the separation of 26 from the other rhyolite samples is warranted.

Chi-square tests were then run to determine whether the use of rhyolite 3 was comparable to the other rhyolites (4,10,24) among bifaces, scraperplanes, unimarginal tools, and scrapers. No significant results emerged from these tests indicating that 3 could be joined with the larger rhyolite group.

Table 7.7 Comparison of chemically distinct Rhyolite samples per tool type: a summary table

		Micro-blade	Biface	Scraper-plane	Unimarginal	Scraper	Others	Total
Rhyolite 26	**Frequency**	**26**	**0**	**0**	**0**	**0**	**0**	**26**
	Percentage	100%	n/a	n/a	n/a	n/a	n/a	
Rhyolite 3	**Frequency**	**0**	**0**	**4**	**3**	**3**	**18**	**28**
	Percentage	n/a	n/a	14.3%	10.7%	10.7%	64.3%	
Rhyolite 4, 10, 24	**Frequency**	**0**	**1**	**18**	**13**	5	**58**	**95**
	Percentage	n/a	1%	18.9%	13.7%	5.3%	61.1%	
Chi-square (excluding26)	**Significant Y/N**	notable n/a	n/a	N	N	N		
	p value			.572	.681	.304		

Siliceous argillite

There are five samples within the siliceous argillite class: 1, 8, 9, 12, 13. Of these siliceous argillites 1, 8, and 9 showed very similar REE patterns and were lumped together. Siliceous argillites 12 and 13 exhibited unique REE patterns within this group (Figure 4.14d). Siliceous argillite 12 was first compared to 1, 8, and 9 as all of these materials occur together before the emergence of 13. The frequencies and chi-square results for this comparison are presented in Table 7.8a and reveal that there are no significant differences between siliceous argillites 1, 8, 9, and 12 and that they can be combined.

The combined siliceous argillites 1, 8, 9, and 12 were then compared to siliceous argillite 13. The frequencies per tool type and the results of the chi-square test appear in Table 7.8b. Here we see some significant and insignificant results. Both microblades and scraperplanes show a significant difference between the use of siliceous argillite 1,8,9,12 and siliceous argillite 13. A higher proportion of siliceous argillite 13 is manufactured into microblades while scraperplanes are made almost exclusively of siliceous argillite 1,8,9,12. These trends are to be expected, however, as scraperplanes and siliceous argillite 1,8,9,12 are more common in the older units of the site, while microblades and siliceous argillite 13 occurred more recently. Among bifaces, a tool class which also maintains a strong temporal correlation, there is no significant difference in the proportional use of siliceous argillite. Nor is there a difference between the siliceous argillite groups in scraper manufacture. Yet, among unimarginal tools there is a significant difference as a higher percentage of siliceous argillite 13 is associated with this tool class.

Table 7.8 a. Comparison of Siliceous argillite 1, 8, 9 to Siliceous argillite 12 per tool type: a summary table.

		Micro-blade	Biface	Scraper-plane	Unimarginal	Scraper	Others	Total
Siliceous argillite 1,8,9	**Frequency**	**8**	**92**	**76**	**98**	**44**	**270**	**588**
	Percentage	1.4%	15.6%	12.9%	16.7%	7.5%	45.9%	
Siliceous argillite 12	**Frequency**	**0**	**10**	**3**	**10**	**3**	**13**	39
	Percentage	n/a	25.6%	7.7%	25.6%	7.7%	33.3%	
Chi-square	**Significant Y/N**	n/a	N	N	N	N		
	p value		.101	.340	.151	.962		

Table 7.8 b. Comparison of Siliceous argillite 1, 8, 9, 12 to Siliceous argillite 13 per tool type: a summary table.

		Micro-blade	Biface	Scraper-plane	Unimarginal	Scraper	Others	Total
Siliceous argillite 1,8,9,12	**Frequency**	**11**	**102**	79	**108**	47	**280**	**627**
	Percentage	1.8%	16.3%	12.6%	17.2%	7.5%	44.6%	
Siliceous argillite 13	**Frequency**	**23**	**23**	**1**	**36**	**10**	40	**133**
	Percentage	17.3%	17.3%	.8%	27.1%	7.5%	30%	
Chi-square	**Significant Y/N**	Y	N	Y	Y	N		
	p value	.000	.772	.000	.009	.993		

Shale/argillite

Within the shale/argillite category there are 8 samples (11,17, 18, 19, 22, 23, 29, 2) and their REE patterns are difficult to tease apart. Shale/argillite 23 and 29 overlap but in the other samples the REE patterns are more variable and more difficult to group. Therefore, I refer back to Figure 4.11 which differentiates between the sedimentary samples on the basis of major element concentrations. In this diagram there appear to be two clusters within the Shale divisions. One combines 18, 22, 23, 29, and 2 and is called Shale/argillite A, and the other, composed of 17, 11, 19, will be referred to as Shale/argillite B. The frequencies and chi-square results for these groups are presented in Table 7.9. There is a significant difference between these two groups for microblades and scraperplanes.

Table 7.9 Comparison of Shale/argillite subclasses per tool type: a summary table.

		Micro-blade	Biface	Scraper-plane	Unimarginal	Scraper	Others	Total
Shale/ argillite A	**Frequency**	**107**	**35**	**27**	**102**	**45**	**137**	**453**
	Percentage	24.6%	8%	6.2%	23.4%	10.3%	30.2%	
Shale/ argillite B	**Frequency**	**1**	**7**	**19**	**24**	**12**	74	137
	Percentage	.7%	5%	13.9%	17.5%	8.8%	54%	
Chi-square	**Significant Y/N**	Y	N	Y	N	N		
	p value	.000	.297	.002	.211	.683		

The above analyses within raw material groupings demonstrate that for some tool categories the distinctions between raw material subclasses are significant. Thus, in the following analysis of individual tool types, raw material subclasses will be separated if a significant difference has been established in this discussion. Where there is no significant difference all material subclasses will be combined. The word ‘sum’ indicates that all sub categories within the material type have been lumped. Table 7.10 summarizes the raw material groupings per tool type which will be used in the upcoming analysis.

Table 7.10 Summary of significant raw material associations per tool type based on Chi-square tests

BIFACES	SCRAPER-PLANES	SCRAPERS	UNIMARGINALS	MICROBLADES
Dacite 6, 21	Dacite 30	Dacite sum (6,21,30)	Dacite sum (6,21,30)	Dacite sum (6,21,30)
Rhyolite 3,4,10,24	Rhyolite 3,4,10,24	Rhyolite 3,4,10,24	Rhyolite 3,4,10,24	Rhyolite 26
Siliceous argillite sum (1,8,9,12,13)	-Siliceous argillite 13	Siliceous argillite sum (1,8,9,12,13)	-Siliceous argillite 13	-Siliceous argillite 13
	-Siliceous argillite 1,8,9,12		-Siliceous argillite 1,8,9,12	-Siliceous argillite 1,8,9,12
Shale/argillite sum	-Shale/argillite A	Shale/argillite sum	Shale/argillite sum	-Shale/argillite A
	-Shale/argillite B			-Shale/argillite B

Examining Raw Material Trends within Individual Tool Types

Five tool types have been examined: bifaces, scraperplanes, unimarginal tools, scrapers and microblades. Microblades present a special case and will be discussed in more detail towards the end of the chapter.

Determining the preferred material

Within the biface, scraperplane, unimarginal and scraper categories, the preferred material for a tool is identified. For example, if material X makes up 35% of all material use at the site but it represents 55% of the material within the Y tool category, a preference for material X in manufacturing the Y tool is suspected. A preference for material X is confirmed by a significant chi-square result.

Identification of a preferred material for the Richardson Island tools considers the site as a whole and does not attempt to distinguish between Early Moresby and Kinggi components at this stage. The process represents a descriptive and exploratory phase of data analysis. Preferred materials are identified so that comment can be made about the properties inherent in the material, which make it desirable for the manufacture of a particular tool.

Determining the consistency of raw material use among individual tool types through time

Once the preferred material has been identified, its use within the Kinggi and Early Moresby components will then be compared. Thus far, it has been established that some materials are not consistently represented through time. Therefore, in the following section, the association of tool type and rock type through time is tested by means of a chi-square test.

A consistent association of raw material and tool type between the Kinggi component and Early Moresby component is represented by a non-significant chi-square result. This suggests that the proportional use of the material has not changed significantly through time and that the behaviour affecting the association between raw material and tool type has not changed.

Conversely, a significant chi-square result indicates that the association between raw material type and tool type has not been consistent through time. If the result is significant, then a change in the behavioural use of the material is supported.

In addition to the preferred material, other commonly used rock types for each tool class can be assessed to see if their proportional use changes between components.

Bifaces

Preferred material

There are 223 bifacial artifacts in the Richardson assemblage. Figure 7.7 illustrates the raw material percentages within this tool class. When compared to the raw material percents in all tools (Figure 7.7), we see that siliceous argillite and varvite occur as a higher percentage in bifaces than they do in all the other tools. A chi-square test was run to see if the greater representation was statistically significant, thus indicating a 'preference' for these material types (Table 7.12). The results of the chi-square test indicated that a greater use of siliceous argillite among bifaces was significant (.000) while varvite use was not significant (.368). Thus, siliceous argillite is the preferred material for biface manufacture.

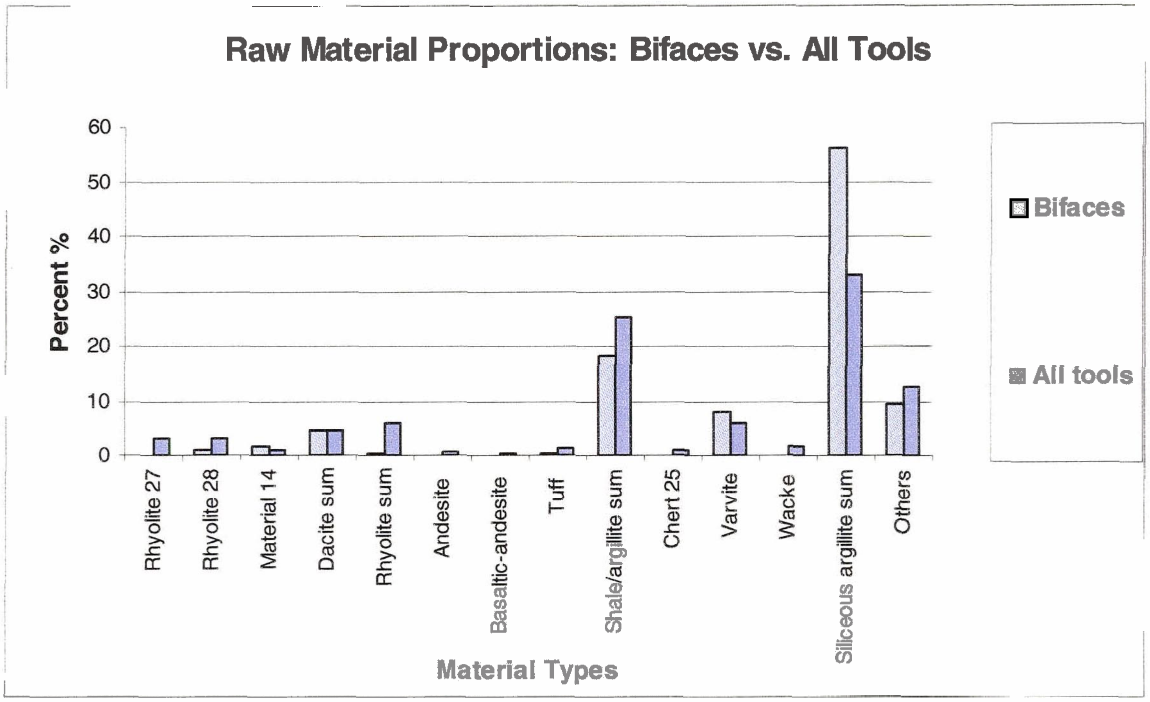

Figure 7.7 Raw Material Proportions: Bifaces vs. All Tools

Table 7.11 Test of significance (preference) for siliceous argillite and varvite in biface manufacture: a summary of results

		Siliceous argillite sum	Varvite
Bifaces	**Frequency**	**125**	**17**
	Percentage	56.1%	7.6%
Non-bifaces	**Frequency**	**635**	**126**
	Percentage	30.7%	6.1%
Chi-square	**Significant Y/N**	**Y**	**N**
	p value	.000	.368

Note: As in previous tables, chi-square results are summarized in each column and results are intended to be read from top to bottom. The total values, against which the above frequencies were compared, are not shown here but can be deduced from the percentages.

Consistency of raw material use through time (bifaces)

Siliceous argillite, as well as varvite, shale/argillite, and dacite (other commonly used materials in biface manufacture) were then selected to see if the proportional use of these materials changed between the Kinggi and Early Moresby periods. Figures 7.8 shows that the overall amount of siliceous argillite and varvite decreases from Kinggi to Early Moresby, while shale/argillite and dacite increase. A series of chi-square tests were run to determine whether these changes in material proportions were significant. The results are summarized in Table 7.12, and reveal that the only statistically significant change is among the shale/argillite group which increases in the Early Moresby period.

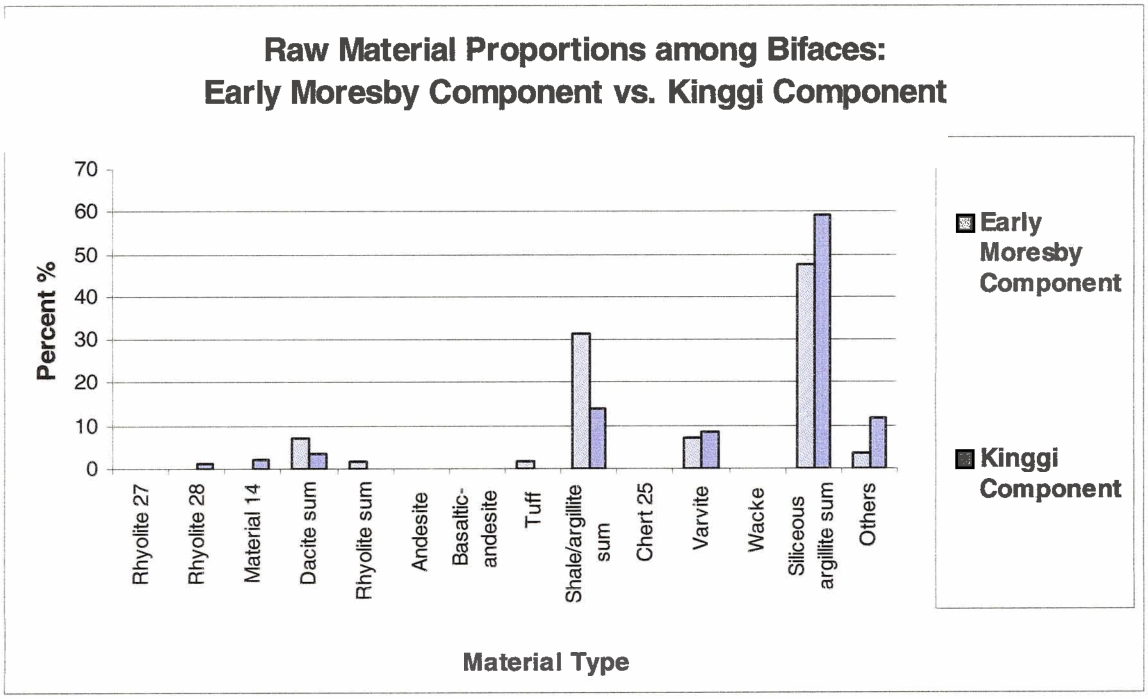

Figure 7.8 Raw material proportions among bifaces: Early Moresby Component vs. Kinggi Component

Table 7.12 BIFACES: Changes in raw material percentages between Kinggi and Early Moresby; a test of significance

		Siliceous argillite sum	Varvite	Shale/ Argillite sum	Dacite 6, 21	Others	Total
Early Moresby	**Frequency**	**27**	**4**	**18**	**4**	**4**	**57**
	Percentage	47.4%	7%	31.6%	7%	7%	
Kinggi	**Frequency**	**98**	**14**	**23**	**6**	**25**	**166**
	Percentage	59%	8.4%	13.9%	3.6%	15.1%	
Chi-square	**Significant Y/N**	**N**	**N**	**Y**	**N**		
	p value	.126	.735	.003	.284		

Scraperplanes

Preferred material

Both siliceous argillite 1-12 and rhyolite 3-24 are used in higher percentage among the 204 scraperplanes examined than among all others tools (see Figures 7.9). Chi square tests reveal that the greater use of these materials in scraperplane production is statistically significant (Table 7.13). Thus siliceous argillite 1-12 and rhyolite 3-24 are preferred materials for scraperplane manufacture.

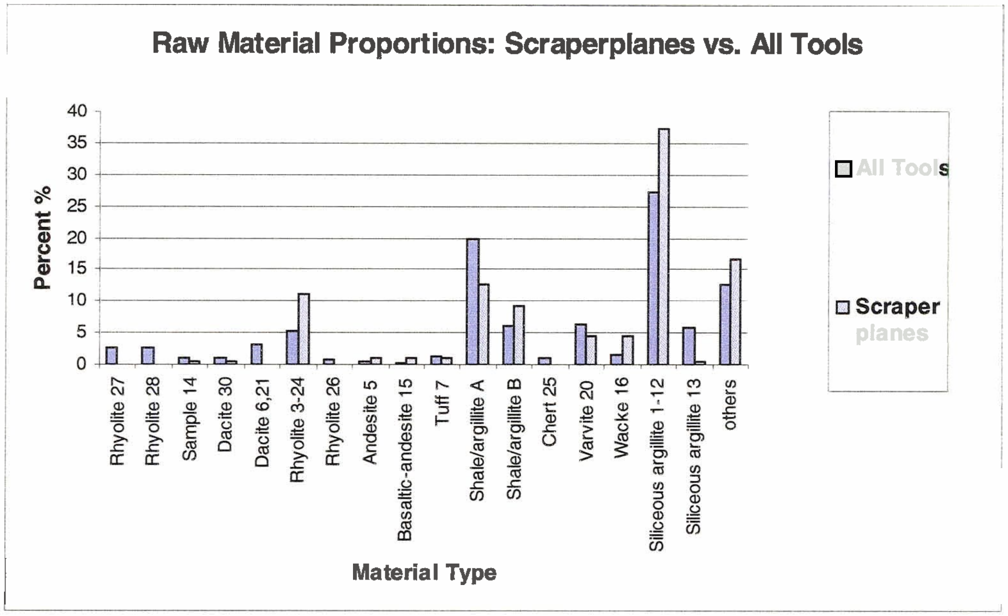

Figure 7.9 Raw Material Proportions: Scraperplanes vs. All Tools

Table 7.13 Test of significance (preference) for siliceous argillite (1-12) and rhyolite (3-24) in scraper plane manufacture: a summary of results

		Siliceous argillite 1-12	Rhyolite 3-24
Scraper planes	**Frequency**	**79**	**22**
	Percentage	37.4%	10.4%
Non-scraper planes	**Frequency**	**548**	**122**
	Percentage	26.3%	5.9%
Chi-square	**Significant Y/N**	Y	Y
	p value	.001	.009

Consistency of raw material use through time (scraperplanes)

The proportional use of these materials also changes significantly between the Kinggi and Early Moresby components (Table 7.14). Siliceous argillite decreases in the later period (chi-square value .003), while rhyolite increases (chi-square value .035). Shale A and B were also compared between the two periods but the changes in their proportions of use were not deemed significant by the chi-square test. A closer examination of Figure 7.10 also indicate that andesite, basaltic-andesite, varvite, wacke, and material 14 which are present in the Kinggi period disappear in Early Moresby. In this later period, dacite 30 does emerge in scraperplane form.

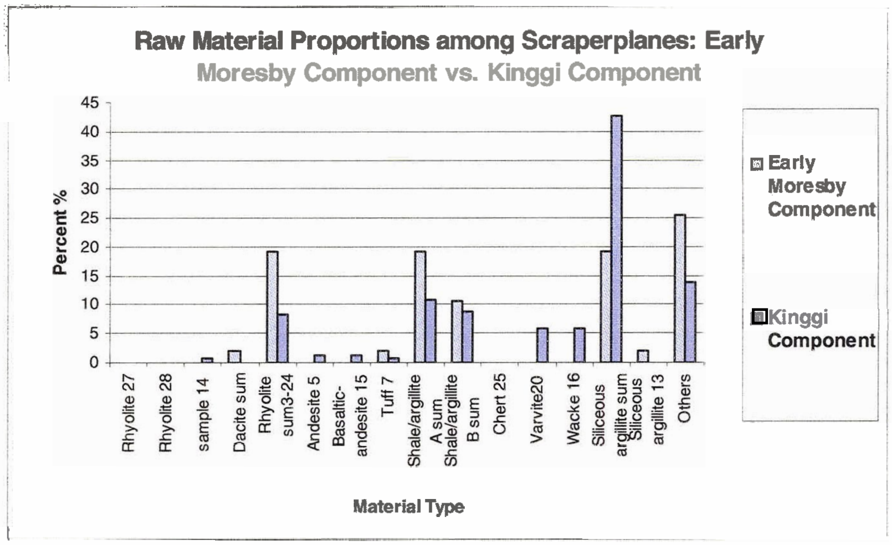

Figure 7.10 Raw Material Proportions among Scraperplanes: Early Moresby Component vs. Kinggi Component

Table 7.14 SCRAPER PLANES: Changes in raw material percentages between Kinggi and Early Moresby, a test of significance

		Siliceous argillite 1-12	Rhyolite 3-24	Shale/ Argillite A	Shale/ Argillite B	Others	Total
Early Moresby	**Frequency**	**9**	**9**	**9**	**5**	**15**	**47**
	Percentage	19.1%	19.1%	19.1%	10.6%	31.9%	
Kinggi	**Frequency**	**67**	**13**	**18**	**14**	**45**	**157**
	Percentage	42.7%	8.3%	11.5%	8.9%	28.7%	
Chi-square	**Significant Y/N**	**Y**	**Y**	**N**	**N**		
	p value	.003	.035	.173	.722		

Scrapers

Preferred material

There are 165 scrapers in total. The raw material percentages for this tool class are depicted in Figure 7.11. When compared to the raw material percentages for the site as a whole (Figure 7.11) we see that shale/argillite has a greater percentage of use among scrapers. Siliceous argillite and dacite also have a slightly higher percentage of use among scrapers. Chi-square tests revealed that the use of these materials was not significantly higher than the proportions exhibited among all tools. In the manufacture of scrapers, analysis indicated that shale/argillite was the material of preference. The chi-square results are summarized in Table 7.15.

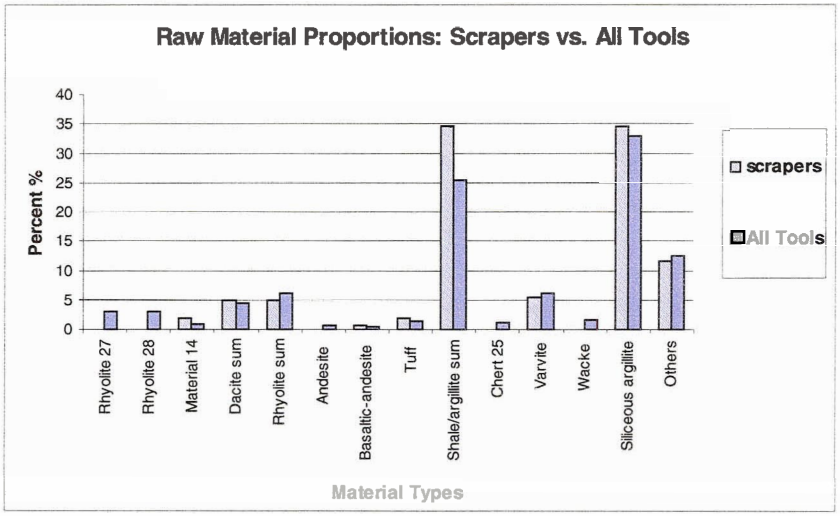

Figure 7.11 Raw Material Proportions: Scrapers vs. All Tools

Table 7.15 Test of significance (preference) for shale/ argillite sum, siliceous argillite sum and dacite sum in scraper manufacture: a summary of results

		Shale/ argillite sum	Siliceous argillite sum	Dacite sum
Scraper	**Frequency**	**57**	**57**	**8**
	Percentage	35.4%	35.4%	4.8%
Non-scraper	**Frequency**	**533**	**703**	**91**
	Percentage	25.1%	33.1%	4.3%
Chi-square	**Significant Y/N**	**Y**	**N**	**N**
	p value	.007	.695	.729

Consistency of raw material use through time (scrapers)

In addition to the preferred material (shale/argillite), siliceous argillite, rhyolite and dacite were also selected to see if proportional changes in their use occurred between the Kinggi and Early Moresby periods. As indicated in Table 7.16, rhyolite and dacite do not experience significant proportional changes between the two periods, whereas the patterns of siliceous argillite and shale/argillite use do change significantly. Specifically, siliceous argillite use decreases in the Early Moresby period while shale/argillite use increases greatly. Figures 7.12 also reveal that basaltic-andesite, tuff, varvite, and material 14 are only manufactured into scrapers in the older half of the site.

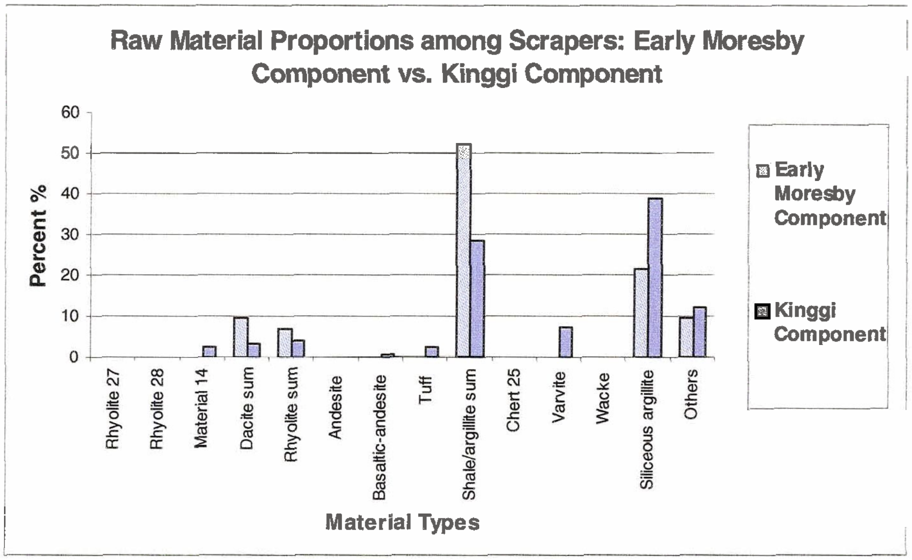

Figure 7.12 Raw Material Proportions among Scrapers: Early Moresby Component vs. Kinggi Component

Table 7.16 SCRAPERS: Changes in raw material percentages between Kinggi and Early Moresby, a test of significance

		Siliceous argillite sum	Rhyolite sum	Shale/ argillite sum	Dacite sum	Others	Total
Early Moresby	**Frequency**	**9**	**3**	**22**	**4**	**4**	**42**
	Percentage	21.4%	7.1%	52.4%	9.5%	9.5%	
Kinggi	**Frequency**	**48**	**5**	**35**	**4**	**31**	**123**
	Percentage	39%	4.1%	28.5%	3.3%	25.2%	
Chi-square	**Significant Y/N**	**Y**	**N**	**Y**	**N**		
	p value	.038	.423	.005	.102		

Unimarginal tools

Preferred material

There are 418 unimarginal tools in the assemblage. Siliceous argillite 13, Shale/argillite and varvite were selected to test for preference. As summarized in Table 7.17 all of these materials were used in significantly high percentages in the manufacture of unimarginal tools. Thus they are all preferred.

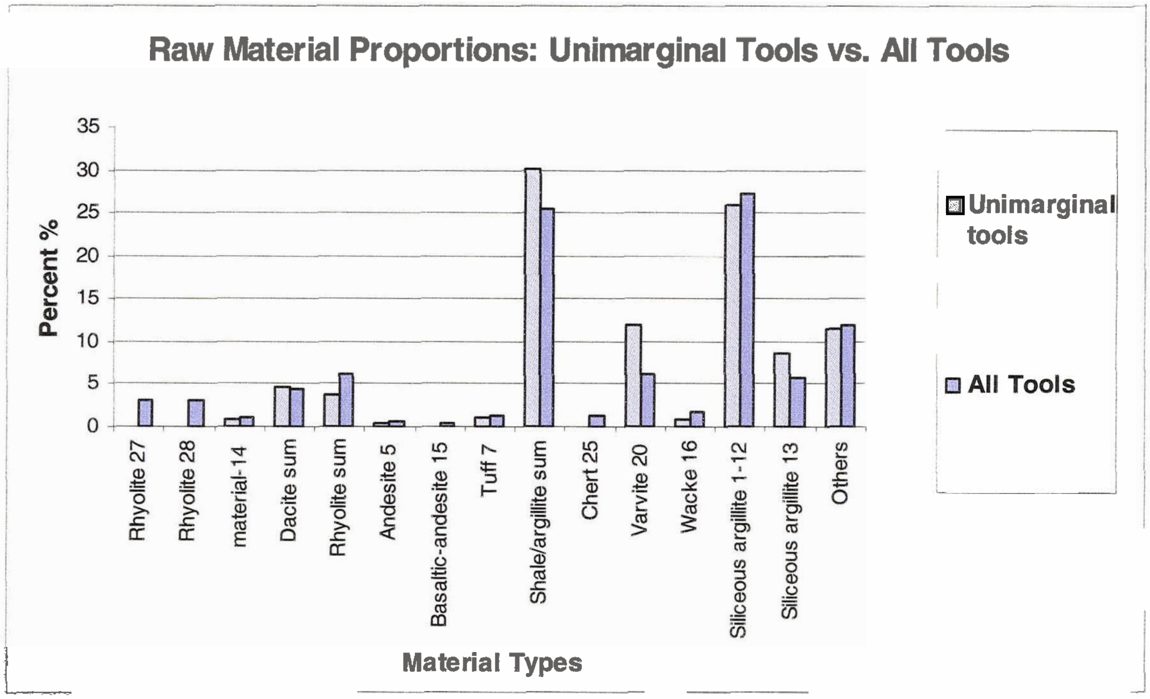

Figure 7.13 Raw Material Proportions: Unimarginal Tools vs. All Tools

Table 7.17 Test of significance (preference) for shale/ argillite sum, siliceous argillite 13 and varvite in unimarginal tool manufacture: a summary of results

		Shale/ Argillite sum	Siliceous argillite 13	Varvite
Unimarginal	**Frequency**	**126**	**36**	**50**
	Percentage	30.1%	8.6%	12%
Non-unimarginal	**Frequency**	**464**	**97**	**93**
	Percentage	24.8%	5.2%	5%
Chi-square	**Significant Y/N**	**Y**	**Y**	**Y**
	p value	.023	.007	.000

Consistency of raw material use through time (unimarginal tools)

In addition to the three materials mentioned above, dacite, rhyolite, siliceous argillite 1-12, and tuff were chosen to explore changes in proportional uses of rock types between the Kinggi and Early Moresby periods. An examination of figure 7.14 indicates that Dacite, rhyolite, tuff, shale/argillite, and siliceous argillite 13 all increase in proportional use in the Early Moresby period, whereas varvite and siliceous argillite 1-12 are more abundant in the Kinggi period. Chi-square tests revealed that rhyolite was the only material that registered an insignificant result. The changes among the other rock type categories were all significant (Table 7.18) thus indicating that raw material use among unimarginal tools is highly variable through time.

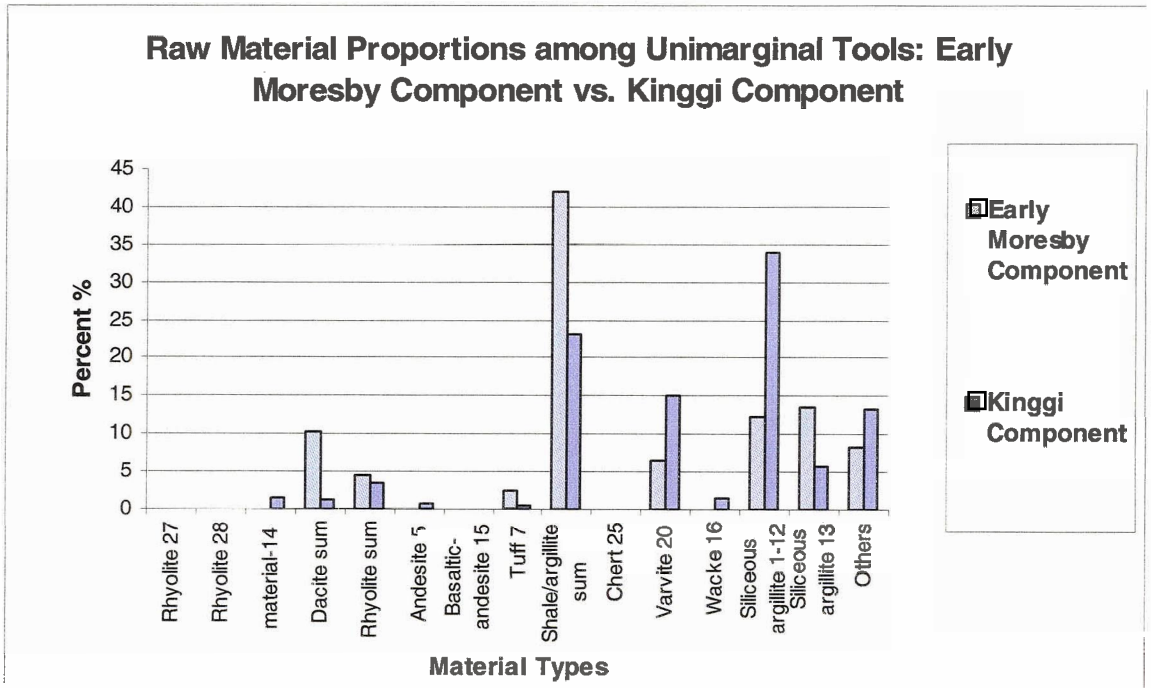

Figure 7.14 Raw Material Proportions among Unimarginal Tools: Early Moresby Component vs. Kinggi Component

Table 7.18 UNIMARGINAL TOOLS: Changes in raw material percentages between Kinggi and Early Moresby, a test of significance

		Siliceous argillite 1-12	Siliceous argillite 13	Rhyolite	Shale/ argillite sum	Dacite sum	Tuff	Varvite	Others	Total
Early Moresby	**Frequency**	**19**	**21**	**7**	**65**	**16**	**4**	**10**	**13**	**155**
	Percentage	12.3%	13.5%	4.5%	41.9%	10.3%	2.6%	6.5%	8.4%	
Kinggi	**Frequency**	**89**	**15**	**9**	**61**	**3**	**1**	**40**	**45**	**263**
	Percentage	33.8%	5.7%	3.4%	23.2%	1.1%	.4%	15.2%	17.1%	
Chi-square	**Significant Y/N**	Y	Y	N	Y	Y	Y/N	Y		
	p value	.000	.006	.573	.000	.000	.046	.008		

The changes in proportional uses of raw materials between the Kinggi and Early Moresby periods for each of the tool categories above, is summarized in Table 7.19. It would appear that bifaces are the tool category most resistant to changes in material use, whereas unimarginal tools are the most flexible. These shifts will be discussed at greater length in the final section of this chapter.

Table 7.19 Summary of changes in proportional use between Kinggi and Early Moresby periods for commonly used raw materials within each tool type

BIFACES	SCRAPER PLANES	SCRAPERS	UNIMARGINALS
Dacite 6, 21		Dacite sum (6,21,30)	Dacite sum(6,21,30)*
	Rhyolite 3,4,10,24*	Rhyolite 3,4,10,24	Rhyolite 3,4,10,24
Siliceous argillite sum	Siliceous argillite 1,8,9,12 [a]	Siliceous argillite sum [a]	Siliceous argillite 13* -Siliceous argillite 1,8,9,12[a]
Shale/argillite sum*	-Shale/argillite A -Shale/argillite B	Shale/argillite sum*	Shale/argillite sum*
			Varvite[a]
Varvite			
			Tuff*

Note: * Increases in proportional use from Kinggi to Early Moresby

[a] Decreases in proportional use from Kinggi to Early Moresby

Microblades

Microblades present a special case as they, by definition, first appear in the Early Moresby period. Why microblades emerged is still a topic of discussion. As suggested by Magne (2004), microblades in Haida Gwaii could have been a strategy developed in anticipation of material shortages, or they could represent functional changes in hunting and gathering as a response to growing or stabilizing fish populations. Others have suggested that the appearance of microblades can be attributed to population migration. In an analysis of tool assemblages from Richardson Island, Arrow Creek 2 and Lyell Bay (three sites in Gwaii Haanas with firmly dated microblade components), Magne suggests that the development of a microblade technology occurred in situ. He bases this conclusion on temporal trends in the tool assemblage which draws connections between the morphology of microblade cores and the scraperplane tool class that had been dominant in the earlier tool kit. He also notes that changes in raw material use through time, strengthens the proposal of in situ microblade development. He states,

> the rise in importance of basalt at the "cusp" of Level 10, the same level where microblades first appear, is interesting in that perhaps a strategy is revealed in shifting temporarily to the basalt when both argillite and the black/white metamorphic were not available. Another line of evidence is hinted at in the observation that scraperplanes and microblade cores, especially microblade core performs, share several morphological characteristics (2004:10).

While Magne's rock classifications differ from those established in this thesis, he does capture the major shift in material use from siliceous argillite to that of shale/argillite at the time of microblade development and uses this to support his idea of in situ development. The implication of this work is that microblades were unlikely to have been imported into Gwaii Haanas from outside of the archipelago. If this were the case we would expect to see specimens manufactured from foreign materials. Magne does not provide a direct analysis of the association of microblades and raw material at the archaeological sites. Therefore, by making such a comparison, as this thesis does here, we strengthen his argument for in situ development and provide further evidence against the proposal that microblades were imported.

The exploration of the microblade data begins with a presentation of the raw material frequencies per depositional unit (Table 7.20). The first microblade-like artifacts emerge in depositional unit XIII; however, it is not until unit IX that the first definitive microblade appears. After this layer the number of microblades increases dramatically. When the frequencies are converted to percent and plotted on a line graph (Figure 7.15) some interesting descriptive trends through time emerge. To test the significance of these observed trends through time a correlation matrix was created (Table 7.21). The matrix reveals that Rhyolite 27 and the 'others' category are negatively correlated with depositional units (r = -0.724, -0.611) indicating that their more recent occurrence is statistically significant. Varvite and siliceous argillite 13 occur in the earlier units of

Table 7.20 Frequency of Raw Material Types per Depositional Unit among Microblades

Depositional Unit	Rhyolite 27	Rhyolite 28	Rhyolite 26	Chert 25	Andesite 5	Basaltic-andesite 15	Tuff 7	Shale/argillite A	Shale/argillite B	Dacite sum	Varvite20	Material 14	Wacke 16	Siliceous argillite 1-12	Siliceous argillite 13	Others	Total
I	25	49						6		2		2			1	4	**89**
II	19	7						9		3	1			1	1	2	**43**
III	9	1	16	19			1	13		9				4		11	**83**
IV	2		5	6				19		11	1			1	1	9	**55**
V		1			1			10		7					1	2	**22**
VI							2	34	1	2		1		2	12	5	**59**
VII	1						3	3		2	1			1	2	1	**14**
VIII		1						1									**2**
IX								1							*1*		**2**
X														*1*	*3*		**4**
XI											*1*				*1*		**2**
XII																	**0**
XIII														*1*			**1**
XIV																	
XV																	
XVI																	
XVII																	
XVIII																	
XIX																	
XX																	
TOTAL	**56**	**59**	**21**	**25**	**1**	**0**	**6**	**96**	**1**	**36**	**4**	**3**	**0**	**11**	**23**	**34**	**376**

Italicized numbers indicate there is some question about the artifact's microblade status.

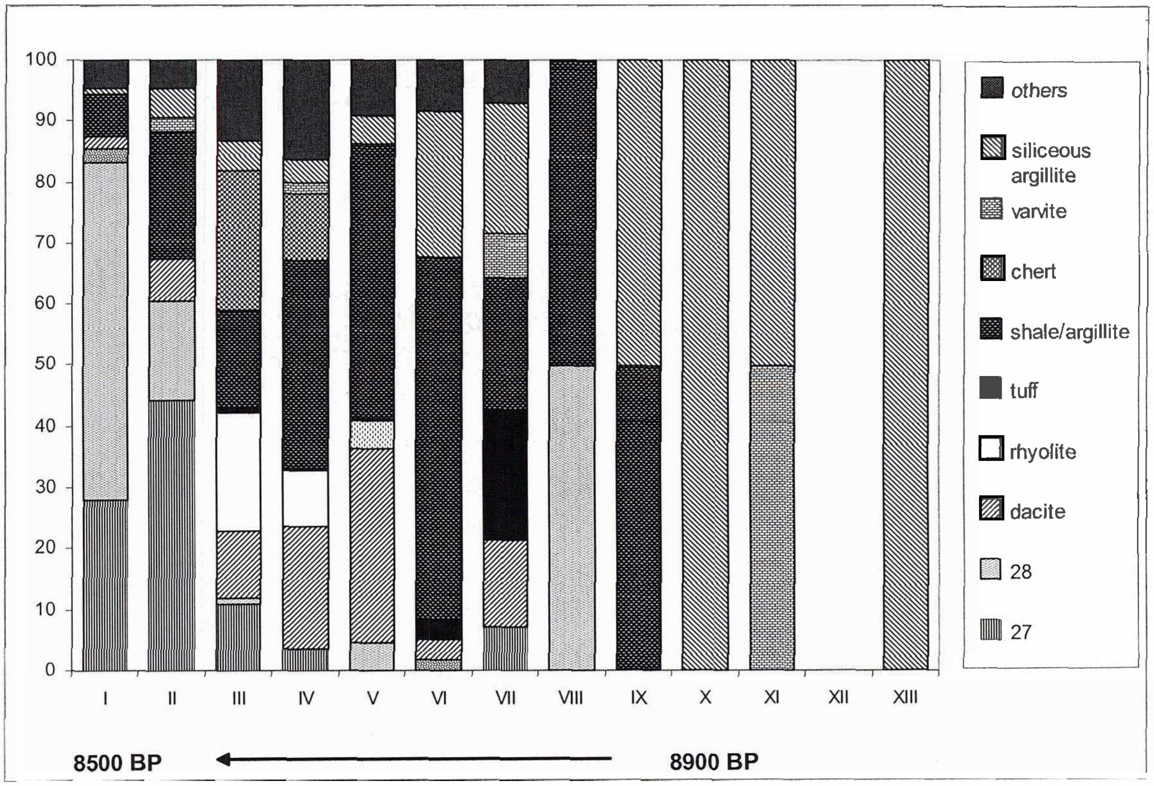

Figure 7.15 Microblade Raw Material Percent per Depositional Unit

Table 7.21 Correlation matrix for microblade raw material percent and depositional units

	Depositional Unit	***Rhyolite 27***	***Rhyolite 28***	***Material 14***	***Dacite sum***	***Rhyolite 26***	***Andesite 5***	***Tuff 7***	***Shale/argillite A***	***Shale/argillite B***	***Chert 25***	***Varvite20***	***Siliceous argillite 1-12***	***Siliceous argillite 13***	***Others***
Depositional Unit	1														
Rhyolite 27	**-0.724**	1													
Rhyolite 28	-0.359	0.393	1												
Material 14	-0.42	0.251	**0.465**	1											
Dacite sum	-0.377	-0.067	-0.297	-0.255	1										
Rhyolite 26	-0.371	0.00	-0.237	-0.204	0.25	1									
Andesite 5	-0.1	-0.194	-0.111	-0.147	**0.759**	-0.139	1								
Tuff 7	0.084	-0.06	-0.224	-0.069	0.179	-0.111	-0.122	1							
Shale/argillite A	-0.011	-0.331	-0.013	0.026	0.232	-0.126	0.282	-0.031	1						
Shale/argillite B	0.00	-0.194	-0.184	**0.549**	-0.152	-0.139	-0.1	0.053	**0.474**	1					
Chert 25	-0.372	0.00	-0.237	-0.204	0.252	1	-0.139	-0.111	-0.125	-0.139	1				
Varvite20	**0.494**	-0.167	-0.216	-0.183	-0.224	-0.154	-0.124	0.008	**-0.452**	-0.124	-0.154	1			
Siliceous argillite 1-12	0.327	-0.156	-0.307	-0.172	-0.189	-0.012	-0.183	0.138	**-0.444**	-0.03	-0.012	-0.172	1		
Siliceous argillite 13	**0.794**	-0.426	-0.441	-0.197	**-0.484**	-0.339	-0.195	-0.086	-0.312	0.005	-0.339	0.355	**0.605**	1	
Others	**-0.611**	0.053	-0.297	0.037	**0.707**	**0.684**	0.193	0.13	0.175	0.157	**0.686**	-0.309	-0.173	**-0.605**	1

.441 is significant for 95% confidence

microblade emergence as is demonstrated by their positive correlations (0.494 and 0.794 respectively). Of these four materials, siliceous argillite 13 is positively correlated with siliceous argillite 1-12 (0.605) indicating that these materials tend to co-occur, while siliceous argillite 13 is negatively correlated with dacite (-0.484). Varvite is negatively correlated with shale/argillite A (-0.452). The 'others' category is positively correlated with dacite (0.707), rhyolite 26 (0.684), and chert 25 (0.686), but is negatively correlated with siliceous argillite 13 (-0.605). The correlation results support the hypothesis that materials in use at the time of microblade introduction were used for the first microblades and that, with time, new materials were gradually introduced for use in microblade manufacture.

To further test this hypothesis the material types were divided into two groups: microblade materials and regular materials, and the depositional units bearing definitive microblades were also divided into to two units. The regular material group was defined as those materials in use prior to microblades and was composed of all siliceous argillite, all dacite, all shale/argillite, tuff, varvite, andesite and material 14. The microblade material class combined rhyolite 27, rhyolite 28, chert 25, and rhyolite 26. With the exception of 2 bifacial artifacts made of rhyolite 28 in depositional unit XVII, these materials are defined as those used exclusively in microblade production. The 'others' category was not assigned to either material grouping. The proportions of the microblade materials and regular materials within the two newly created temporal units were compared by means of a chi-square test. The results of these tests (summarized in Table 7.22) show that the increase of the microblade materials in the more recent component is statistically significant (chi-square result of .000) as is the decrease of regular materials in the more recent segment of the Early Moresby Period (chi-square result .000).

Table 7.22 Changes in raw material proportions in microblade manufacture between depositional units I-IV and V-VIII

		Regular Materials	Microblade materials	Others	Total
Depositional Units I-IV	**Frequency**	**86**	**158**	**26**	**270**
	Percentage	31.9%	58.5%	9.6%	
Depositional Units V-VIII	**Frequency**	**86**	**3**	**8**	**97**
	Percentage	88.7%	3.1%	8.2%	
Chi-square	**Significant Y/N**	**Y**	**Y**		
	p value	.000	.000		

Note: Once again chi-square results are summarized in each column and results are to be read from top to bottom.

Specifically, the first microblades are manufactured out of materials such as siliceous argillite 1-12, siliceous argillite 13, and varvite, which were in regular use for other tool types at the time. A high percentage of shale/argillite A is used in microblade manufacture until depositional unit VI at which point shale/argillite starts to decline while the use of other material types begins to increase. In depositional units III and IV a number of materials are in use at the same time, including rock types such as rhyolite 26, chert 25, rhyolite 27, which were unrecorded in older depositional units. Also, at this time, the 'others' category is inflated considerably. By depositional units I and II, microblade manufacture is dominated by the rhyolite 27 and 28 classes. Thus, the initial microblades were manufactured out of materials that were already in common use. This was followed by a period of experimentation in which known materials and previously unused materials at the site are manufactured into microblades. In the most recent units we may be beginning to observe the emergence of a preference for rhyolite 27 and 28 in microblade manufacture.

Summary and Discussion

The most abundant materials at the Richardson Island archaeological site are siliceous argillite and shale/argillite. These materials are not evenly distributed through time. The Kinggi component is dominated by siliceous argillite whereas the Early Moresby component maintains a higher proportion of shale/argillite. Also, in the older half of the site, basaltic-andesite, wacke, and andesite are used for flaked tools but they are not represented in the Early Moresby component. Instead, there is the appearance of four new materials, all of which are associated with microblade development. Also, at this time there is an increased reliance on dacite and a decrease in varvite. While the introduction of new materials is directly attributable to microblade emergence, this technological shift may also be partially responsible for the increasing reliance on shale/argillite over siliceous argillite. In the previous section it was demonstrated that the first microblades were manufactured out of known materials. Initially, siliceous argillite and varvite were employed, followed by a rapid switch to shale/argillite use which dominated microblade manufacture for most of the Early Moresby period. The discontinuation of siliceous argillite in microblade manufacture may have been due to its brittleness and tendency to fracture along planar laminations, which may have encouraged microblades to break both during production and use. The shale/argillite without obvious bedding planes and possessing a lower silica content would have been softer, less brittle and, hence, less susceptible to breakage.

Both siliceous argillite and shale/argillite were in use at the time of microblade introduction, although the former was in a phase of declining use while the latter was increasing. Prior to the new technology, people would have been experiencing rapid sea-level rise (Figure 2.1), an environmental consideration that they, and their ancestors, would have been experiencing for almost two and a half thousand years. Anticipating a continuous rise of the water's edge, the people may have been looking for an alternative to the siliceous argillite source if it were in danger of being submerged. Siliceous argillite was the preferred material for biface manufacture. Bifaces are among the most curated of tool types in the Richardson assemblage (McLaren et al., n.d.) and would have played an important and possibly versatile role in the Richardson toolkit. Shale/argillite, which was in use and preferred for scraper and unimarginal tool manufacture, but also capable of producing decent bifaces, may have been seen as an alternative raw material.

Interestingly, sea-level stopped rising by 8,900BP (Depositional unit X). As most of the materials exploited until that point continue to be in use after sea-level maximum, it is unlikely that any of the sources were submerged. The exceptions are basaltic-andesite and wacke, which cease to exist after depositional unit XI. As suggested in Chapter 5, basaltic-andesite is one of the most common rock types found in the local bedrock geology and it is thus more likely that its disappearance is attributable to cultural factors. The wacke is slightly more restricted geologically and a closer chemical analysis of the artifacts made of this material could determine the likelihood that all wackes originated from the same source. If it were shown that all specimens exhibited similar chemical signatures, it would be more likely that the source was submerged at sea-level maximum.

Why then does siliceous argillite continue to decline in use if sea-level ceased to rise? With the introduction of microblades and the experimentation of known materials, if it were discovered that siliceous argillite was not as effective in microblade manufacture as shale/argillite, then a continued reliance on shale/argillite would be justified. Thus, the downward trend in siliceous argillite use may have been initiated by an anticipated need for a new resource location, but after sea-level stabilized at 8,900BP its continuous decline may more adequately reflect the raw material requirements of the emergent microblade technology. Regardless of the motivation for the shifting dominance in raw material, the effects within the bifacial, scraperplane, scraper, and unimarginal tool categories are not alike, suggesting that some of these categories had more stringent raw material requirements than others.

Through experimental and lithic analysis, a number of generalizations have arisen about which rock types and properties are preferred in tool manufacture (Chapter 2). Past peoples were aware of the differing properties between rocks and were often selective when creating a certain type of tool. The inhabitants of Richardson Island are no different. Numerous material types exist at the Richardson Island site and there does appear to be a preferred material for the majority of tool classes studied here.

Siliceous argillite has the highest silica content of all of the materials. Cores, core fragments, and shatter of this material indicate that it is brittle and will fracture predictably, but overall it tends to be quite blocky and will exhibit laminar fracture along bedding planes. This trait is exacerbated by weathering. Hence, as mentioned in Chapter 5, fresh outcrops of this material were likely targeted as increased exposure to sea water and weathering processes encouraged the planes of weakness in the rock to be emphasized, causing reduced predictability during flaking. When flaked, this material would maintain a sharp edge. From cores that have undergone little reduction, it is apparent that siliceous argillite weathered in tabular, rhomboidal tablets which could have facilitated biface manufacture. All of these qualities likely warranted the preference of siliceous argillite in biface manufacture.

Siliceous argillite was also a preferred material in scraperplane production. Again a hard material with a sharp edge would be desirable for this tool category likely used for heavy woodworking activities. However, it is very likely the tendency of siliceous argillite to fracture along flat, straight bedding planes was the quality most exploited for scraperplane manufacture. This tool class is typified by a flat surface on the ventral plane of the tool, a feature that is extremely difficult to manufacture via flaking due to the concavity of a conchoidal fracture. If a flat surface is indeed a prerequisite for scraperplane manufacture, it would have been easier to take advantage of a natural planar surface than to create an artificial one. A natural planar surface is also typical of rhyolite, the other preferred material in scraperplane production. Rhyolite is also very high in silica content and has a slightly coarser grain than siliceous argillite which creates a sharp and durable edge when flaked.[21]As mentioned in Chapter 5, concentrations of rhyolite nodules are found in isolated locations within Darwin Sound. At a number of sources, rhyolite weathers out of the surrounding bedrock and dyke formations in tabular form. Frequently the planar surface of a scraperplane will possess cortex, suggesting that the natural surface has been left unmodified.

Both scrapers and unimarginal tools were manufactured out of a variety of materials. Shale/argillite appears to have been preferred in scraper manufacture. It is possible that a lower silica content would have created a slightly duller edge than siliceous argillite, thus decreasing the chances of tearing or cutting while performing scraping activities. Alternatively, shale/argillite may have held a resharpened edge better than flakes of other material types thus encouraging its reshaping into scrapers. Unimarginal tools are highly variable in terms of raw material use which is to be expected of an informal tool class. These artifacts were likely manufactured out of any material available at hand and thus show multiple material preferences.

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[21] The scraperplane category presents a typological problem. I am arguing that the bedding planes and naturally occurring planar surfaces were desirable for scraperplane manufacture. However, it could be argued that this tool category is an archaeological construct that is biased towards the fracturing characteristics of the rock as opposed to the true tool intentions of the people themselves. Given that scraperplanes are manufactured out of many material types and that those materials are represented in other categories as well, a typological issue is not well supported. Additionally, this tool class is represented in sites well away from Richardson Island (West 1996; Hoffecker et al. 1996; West et al. 1996)

When the proportions of preferred material and commonly used materials in each tool class were compared between Kinggi and Early Moresby, it would appear that bifaces have the strictest material requirements, unimarginal the least strict, while scraperplanes and scrapers have particular material needs that are served by certain material types.

Bifaces were stable in their raw material patterning. There was a significant increase in shale/argillite use in the Early Moresby component, but aside from this, the proportional use of siliceous argillite, dacite, and varvite was unchanging. After 8,900 BP, bifaces dominate the siliceous argillite use in the assemblage. Even though shale/argillite is increasing, people are still procuring siliceous argillite for biface manufacture while this material decreases in the other categories. Among scraperplanes the decrease in siliceous argillite compensates for an increase in rhyolite use. Material used in scraper manufacture is fairly consistent between the two components, although use of preferred material (shale/argillite) continues to increase. Unimarginal tools show multiple changes in material proportions through time indicating that the material needs of this tool class are not a factor in material exploitation.

Only five tool types have been considered here which presents a limited picture of the relationships between tools and raw materials. Thus, the interpretations offered could change with additional analysis of tool classes and sourcing studies. It appears that the raw material needs of more formalized tool classes can dictate the material used in other tool categories. The raw material requirements of bifaces were static and unchanging. Unimarginal tools, more expedient and less formalized in comparison to the other four material types, had no apparent requirements and could be made out of debitage produced from making the less flexible tools. It is intriguing that the emergent microblade technology could affect raw material behaviour so immediately. The value/benefits of this resource conserving technology must have been recognized instantly. The exploration of microblade data also reveals that while the microblade concept may have arrived from peoples further north, the development of the technology happened, as suggested by Magne, in situ. The first microblades were manufactured out of commonly used materials and, after a period of experimentation, preferred materials (rhyolite 27, 28) were identified. It would be interesting to track the raw material use in other Early

Moresby sites and throughout the more recent depositional units at Richardson to see if microblades become as inflexible in their raw material needs as bifaces appear to have become in the later years of their existence.

CHAPTER 8

Summary and Discussion

The archaeological setting at Richardson Island has much to add to our understanding of the early Holocene way of life in Haida Gwaii. This thesis offers a glimpse into the behavioural patterns of the Richardson inhabitants with respect to their raw material acquisition strategies and preferences for tool manufacture, and suggests that there are tools that dictate raw material procurement. It has been shown that the use of raw material is not consistent between tool types, or through time. These conclusions have been based upon raw material classifications established through geochemical and macroscopic analyses of stone.

Raw material characterization

The methodology presented in Chapter 4 fits into an area of lithic analysis that has received inconsistent attention by archaeologists. At present, rock type classifications are based on methods that vary from informal visual assessment to chemical analysis. Unfortunately, some classifications based on informal visual assessments can be incorrect. As people become more interested in sourcing materials such as dacite, which is less visually distinct than traditionally sourced materials like obsidian, a more reliable methodology for establishing rock types could be a useful tool. The methods outlined in Chapter 4 attempt to combat the problem of misidentification by combining macroscopic petrographic analysis, microprobe, LA-ICP-MS (a relatively new technique to be used in the field of archaeology) and geological discrimination diagrams to identify rock type. The combination of microprobe and LA-ICP-MS has advantages over other analytical techniques such as INAA and regular ICP-MS. Both of these latter techniques require lengthy dissolution processes for sample preparation and the dissolved sample can only be analyzed once. Additionally, there is the risk that heavy elements may not dissolve entirely. Conversely, the glass beads created here required little preparation time, are available for future analyses, and ensure a homogenous mix of elements. The microprobe complements the LA-ICP-MS very well in that the Ca concentration established by the microprobe could be used as the internal standard for the LA-ICP-MS analysis.

The result of the characterization process was the identification of 11 distinct material types (rhyolite, dacite, basaltic-andesite, andesite, dacitic tuff, siliceous argillite, shale/argillite, wacke, varvite, chert) among the 33 analyzed. Notably, basalt or quartzite were not among those visually distinct materials at the Richardson Island site, although these materials had been noted as frequently occurring rock types in previous studies of artifacts from this site. Additionally, chert 25, the material which did not fuse into a glass bead and appeared exclusively in microblade form, had been catalogued as rhyolite prior to this analysis. This evidence suggests that informal visual assessment can be erroneous.

The classification method offered here, however, is by no means perfect. The discrimination diagrams selected are biased towards igneous and sedimentary rocks, exclusive of chert, while metamorphic rocks, as is the case in geology, are still best classified visually (macroscopically and via thin section) as opposed to chemically. Moreover, classifying the rhyolite samples 27 and 28 was not a straightforward process. These would be prime candidates for future thin section analysis; a process avoided here given the large quantity of specimen and skill required to interpret the mineralogical textures. Nonetheless, thin sectioning may be the only method capable of resolving classificatory issues that arise when samples are not neatly categorized within discrimination diagrams. Additionally, it would have been advisable to run chemical analyses on more than one specimen per visually distinct material. Yet, for a preliminary characterization of materials, the methods outlined present some encouraging results, especially for discriminating between volcanics and lutites that can be difficult to differentiate macroscopically, and both of which are likely to appear in archaeological assemblages as flaked artifacts.

The use of geochemical techniques also allowed the heavily weathered materials to be classified. While not directly analyzed here, the strata may be correlated with particular weathering rinds. Of the established raw material categories, the shale/argillite class exhibited the most variable weathering characteristics. Specimens of this material type appeared to absorb characteristics of the surrounding stratigraphic matrix. Samples 23 and 29, for example, displayed a reddish tinge which is likely attributable to their placement in the compact and heavily oxidized iron layers of the stratigraphy. Conversely, the moist clay layers produced heavily weathered grey and greenish-grey patinas on the shale/argillite samples. A closer examination of the correlation between stratigraphic layers and weathering rinds would make for an interesting study.

Raw Material and Tool Types

It has been demonstrated that raw material use varies through time at the Richardson Island site. Some notable results include the steady decrease of siliceous argillite through time coupled with a steady increase in shale/argillite. The former category also showed an internal trend as siliceous argillite 1 decreased in the more recent depositional units while siliceous argillite 13 increased in the latter units. The Early Moresby component saw the emergence of new material types, such as chert, rhyolite 26, 27 and 28, while some materials common in the Kinggi component declined or disappeared (such as basaltic-andesite, andesite, wacke) .

Temporal trends were also evident among some of the tool categories. Bifaces and scraperplanes decreased through time while microblades emerged in the more recent component of the site. These trends are to be expected as they are notable characteristics which help define the Kinggi Complex and Early Moresby Tradition.

When raw material and tool types were brought together, chi-square results indicated that some materials were preferred for the manufacture of certain tools. Siliceous argillite was preferred in biface manufacture, siliceous argillite and rhyolite were preferred in scraperplane manufacture, shale/argillite was preferred in scraper manufacture, while multiple material types were used in the unimarginal tool category.

When the proportions of commonly used materials within each tool type were compared between the Kinggi and Early Moresby components, the bifacial category was the most static as shale/argillite was the only material to change in proportional use. Among scraperplanes, siliceous argillite decreased in the Early Moresby component while rhyolite increased. Among scrapers, siliceous argillite use also decreased while shale/argillite increased. Unimarginal tools were highly variable in terms of their raw material use between the two components suggesting that this category may not have had specific requirements of a raw material type. The unimarginal tools could be manufactured out of the byproducts created by the manufacture of other tools.

Culture history

The culture historical sequence for the early Holocene in Haida Gwaii is typified by the shift from Kinggi Complex to Early Moresby Tradition. These culture complexes are characterized by changes in the stone tool technology which are clearly present at the Richardson site. However, it may be that behavioural patterns in raw material use could warrant consideration in the culture history sequence as well. The data presented here suggest that, in addition to an abundance of bifaces, scraperplanes, and an absence of microblades, the Kinggi Complex has a predisposition to greater raw material diversity. The scraperplane, scraper, and unimarginal tool categories were made of more material types in the Kinggi component than in the Early Moresby component. This could be the result of people's anticipatory behaviour in times of rising sea level and an attempt to keep the raw material base broad. This conclusion would be strengthened by additional evidence from other tool types at Richardson, as well as from other sites in Haida Gwaii that contain Kinggi and/or Early Moresby components.

The results presented here also strongly support the hypothesis of in-situ microblade development suggested by Magne (2004). Within this tool category it was demonstrated that the original microblades were manufactured out of materials already in use for other tools. However, circa 200 years after the emergence of microblades, a period of experimentation involving multiple material types occurred, after which microblade manufacture was dominated by two new materials. This indicates that the people in the area developed and refined the microblade concept over a 400 year period. The materials were not exotic but could be found locally, therefore arguing against the arrival and influx of a microblade bearing peoples from faraway lands. While the idea may have arrived from contacts outside of the Haida Gwaii archipelago, the development of the technology was insular and gradual.

Coastal Migration

While the date of the Richardson site does not allow for direct comment on coastal migration, the archaeological evidence suggests that people had a very well established knowledge of their raw material resources; knowledge which would have taken time to develop. The most persuasive evidence in support of a coastal migration theory would come from the dating of archaeological sites. However, as many of the oldest sites in

Haida Gwaii are likely to be submerged, other forms of archaeological evidence from the early Holocene period do indicate that people had been living in the area much earlier than the dates at Richardson suggest. The ages of Kilgii Gwaay (9,450 BP) (Fedje et al. 2001) and K1 cave (10,400BP) (Fedje 2004) confirm this of course, but from the archaeological evidence one can draw a similar conclusion. At Kilgii Gwaay it would appear that the people had advanced sea-faring capabilities and comfort on the water given the diversity of marine fauna uncovered. Bone and wood technology is often thought to be essential for marine subsistence, and both of these organic materials are well represented at Kilgii Gwaay.

Burnt bone point tips have also been found in hearths at Richardson Island and fauna preserved in these hearth features indicate that the Richardson inhabitants were adept sea-faring peoples. Rockfish, dogfish, salmon, flounder, ling cod, herring, greenling, prickle back and sculpin are but a few of many aquatic species identified thus far (Steffen pers. com. 2004; Mackie et al. 2004). In addition to the faunal record, the behaviours emerging from raw material studies also indicate that people had a well-established knowledge of their lithic resource base. They were likely collecting material off island and would have been comfortable transporting it across the water. It appears the people anticipated the drowning of their resources and had generated adaptive strategies in the face of rising sea-level which would have started its upward encroachment ca. 12,380BP (Fedje and Josenhans 2000). How long it takes a group of people to develop such strategies is a question I do not feel comfortable tackling, however, Haida mythology also alludes to a time before the great flood (Reid and Bringhurst 1996; Swanton 1908; Boas 1932).

> In the beginning there was nothing but water and ice and a narrow strip of shoreline .. (Boas, 1932: Bella Bella Tales)

> Then he [Raven-Walking] told only the black bear, marten and land otter to be here [on Haida Gwaii]. And the strip of ocean between [the mainland and Haida Gwaii] was narrow. The tide flowed back and forth in this, and he pushed the islands apart with his feet ... at that time there was no tree to be seen. (Swanton, 1908: Haida Texts - Massett Dialect)

Thus, the oral traditions and archaeological evidence suggest that the people of Haida Gwaii and the inhabitants of Richardson Island were self sufficient, adaptable to rapid environment change, and had been established in the archipelago for a great length of time.

Insights into general raw material and tool manufacturing behaviours

The effect of raw material on tool assemblages is a multifaceted problem in archaeology but has proven to be an interesting avenue to explore within the Richardson assemblage. In return, the Richardson Island site could be of interest to researchers elsewhere concerned with affects of raw material on tool forms. Unlike many Paleolithic sites, Richardson Island does not suffer from a compressed stratigraphy. Given the palimpsestic nature of the most Paleolithic sites, Holdaway et al. (1996) have suggested that "it is probably best to interpret these patterns as the result of economizing behaviour built up from many separate behavioral episodes in prehistory" (1996:386). At Richardson it is possible to separate depositional units which span less than a human generation allowing us to escape interpretations based on purely economizing behaviour. We are able to see, as indicated by microblade development that the people considered the effects of raw material, searched and experimented with varieties of stone before relying on a few material types. Similarly, when faced with what is presumably a declining resource base, such as the case with siliceous argillite, the response was not to engage in resharpening or further curation of tools, but to increase utilization of an alternative raw material. These trends would not be visible in a compressed stratigraphy and interpretations of raw material use could alter drastically. Based on this evidence it could be postulated that in times of raw material scarcity an alternative source of material will be sought out before people will engage in resharpening efforts to conserve raw material. A test of this hypothesis could be conducted on the bifaces at Richardson Island by comparing the intensity of reduction seen through flake scar patterning and changes in width, thickness, and length (McLaren et al. n.d.) with raw material. At present it appears that the bifacial form at Richardson Island stays consistent until the most recent depositional units in which case two examples of more refined bifaces have been attributed to flaking techniques influenced by microblade manufacturing techniques (McLaren et al. n.d.)

These examples also ascribe agency to the peoples who made the tools and a reminder that people are active agents in raw material acquisition and use. It can be easy to assume that tool types are entirely determined by proximity of material and the differential flaking characteristics of stone, but we must not forget that people had a choice and would have been intimately attuned to variations in raw material.

Additionally, it is easy to assume that aspects of raw material such as accessibility (inclusive of behaviour and proximity to source) and the physical characteristics of stone will affect all tool categories evenly and in expected ways throughout the archaeological record and between cultures. Yet, given that other factors such as mobility, degree of sedentism, cultural differences, environmental factors, site function, etc., all influence tool form, and that these factors will vary from site to site, we should be wary of universal laws ascribed to raw material use and consider the dynamics of tools and raw materials in relation to one another. It is postulated on the basis of the prior analysis that those tools requiring more preparation (greater number of flake detachments) and standardization of form (i.e. microblade or Levallois technology) would represent formal categories whereas less standardized tools or those that require less flake detachment are informal. The formalized tools in an assemblage will have the most restricted raw material requirements and the debitage byproducts generated from formal tool manufacture will be used for informal categories. These effects will be more visible in assemblages with high raw material diversity.

Future avenues

The destruction of artifacts is not an ideal procedure and sometimes impossible to conduct. At Richardson we are fortunate to possess a plethora of debitage which makes the destructive element of chemical analysis less of a concern. Yet, had we been considering a site such as K1 cave in Haida Gwaii at which only two biface bases were discovered, we would be less inclined to transform them, or portions of them, into glass beads. LA-ICP-MS is capable of extracting trace element concentrations from solid materials leaving a hole only a few microns wide. It is appealing to think that artifacts could be lasered directly to extract chemical data. One problem is that the material must be very fine grained and devoid of phenocrysts, to ensure that the matrix is homogenous enough to provide an accurate chemical composition given the small sample size extracted. However, test ablations on fifteen of the materials analyzed in Chapter 4 indicated that when lasered directly, the very fine grained materials produced similar chemical output frequencies to those of the prepared glass beads. The results of these tests are currently being examined in more detail[22], but the potential to laser rocks directly is tantalizing, especially because it could offer a quick means of classifying rock type. Of course, there are issues that arise with such an approach. LA-ICP-MS is capable of ablating an unprepared solid material directly, yet this unaltered material, such as a piece of debitage, will not contain a known concentration of an element against which the chemical output can be standardized. This problem was avoided in Chapter 4 by using the Ca concentrations as determined by the microprobe as the internal standard to determine the absolute concentrations of trace elements in each sample. These absolute concentrations are needed if comparing results to other data generated by other analytical methods. Such a situation may occur if one wishes to compare the LA-ICP-MS data to published data in geological sources. However, if the absolute concentrations are not required, and one is interested in establishing material type only, the ratios between the key element concentrations may be all that is needed, thus nullifying the need for a known internal concentration.

In Chapter 4 the trace element ratios of Nb/Y and Zr/Ti were used to confirm igneous classifications attained on the basis of major element data and to prove that weathering had not affected the classifications. Theoretically, the igneous samples could have been classified on the basis of trace element ratios alone. The problem was establishing which samples were igneous versus non-igneous. If key trace-element ratios for discriminating between igneous and non-igneous rocks could be established, then categorization of rock types could be done solely with LA-ICP-MS data.

At present it is possible to separate the felsic igneous Richardson samples (rhyolite and dacite) from the remaining material types by experimenting with different trace element ratios. Yet just as Garrels and McKenzie (1971) found (Figure 4), the separation of mafic volcanics (basalts through andesites) from sediments is proving more difficult. The teasing apart of these rock types on the basis of trace elements (if not already done), requires the expertise of a geologist to establish the distinction. The result for archaeology would be extraordinary, for it makes the reality of "zapping" a rock and

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[22] The results of these tests feature in a methodological paper that is currently in preparation with R. Cox, D. Canil, and Q. Mackie. Upon completion it will be submitted to *Archaeometry* or the *Journal of Archaeological Science.*

classifying it with minimal destruction more plausible. Such a method could be a quick alternative to the more inaccurate and informal visual assessment that is commonplace in archaeological reporting. Just as one might send bones to a faunal analyst, lithic artifacts could be sent to a lab and *then returned intact* with a very quick turn around time and an accurate rock type classification. In comparison to other analytical techniques, LA-ICP-MS is also affordable (approximately $40 per sample for commercial rates at the University of Victoria).

More immediate and attainable avenues for future study that arise out of this thesis project are those that make use of the established raw material types for Richardson Island. With evidence that raw material preferences were in place for bifaces, scraperplanes, and microblades, but less so for scrapers and unimarginal tools, how the remaining tool classes fit into the picture is yet to be seen. Similarly, the excavated material from the Operation 14 location, which dates to circa 5,000 BP, represents a Late Moresby component which is close to the end of the known 4,000 year span of microblade use in Haida Gwaii. One cannot help but wonder how raw material preferences at this time compare to the older depositional units. Did microblades become as conservative in raw material requirements as bifaces were earlier?

Also, how are raw material frequencies reflected among debitage and how do these compare to the frequencies recorded for tool types? In his analysis of raw material frequencies between tools and debitage from Operations 10 and 12, Magne (2004) found that some materials had a high debitage to tool ratio which could indicate events of tool manufacture and removal, while other materials appeared to be manufactured into tools which were more readily left behind. The patterns were inconsistent between levels. Magne's analysis could be expanded to include raw material categories established here and the debitage from Operation 13. The emergent patterns could then be interpreted within the context of larger living surfaces exposed during the excavations of Operation 13. These larger living surfaces have revealed functional differences between layers such as tool workshops versus food processing/hearth areas (Mackie et al. in prep). The contextual setting could reveal possible task-specific motivations behind the procurement and manufacturing strategies of particular raw materials.

And finally, a logical avenue to pursue would be a sourcing study for selected materials identified here. Specifically, chert and rhyolite may prove to be the easiest materials to source given that exposures of these materials appear in restricted locations within Darwin Sound and southern Haida Gwaii. The chert is a very straight forward case as Lihou beds are only found in two locations in southern Haida Gwaii; Hutton Point and Shuttle Island. These outcrops require sampling and analysis, the results of which could be compared to the chemical data generated here. As for rhyolite it would first have to be determined whether the outcrops are chemically distinct enough to allow for specific fingerprinting. If so, then the archaeological materials could be compared to the outcrops. As part of this approach it would be advisable to test multiple rhyolite samples of archaeological origin so that the intrasite variability at Richardson is accounted for. The research presented here has focused on those materials that are visually distinct. Yet Mallory-Greenough et al. (2002) would remind us that even visually similar materials may have different chemical signatures and originate from different locations. A study to determine whether the shale and argillite materials of the Kunga Group are chemically distinguishable would also be intriguing.

The Richardson site presents numerous questions about which raw material forms one small branch of tool development, site use, occupation and culture history. Yet this variable has much to offer our understanding of the Richardson inhabitants' procurement strategies, preferences, habits, and movement about the landscape. While some of these questions could be explored through informal visual classifications of material types, chemical data has added an element of confidence, accuracy, and replicability. We are fortunate to have techniques such as microprobe analysis and LA-ICP-MS which add depth and dimension to our archaeological interpretations.

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APPENDIX A : TEXTURAL DEFINITIONS

Grain Size	Medium grained	average grain size 1-5mm, mineral crystals visible with hand lens.
	Fine grained	average grain size <1mm, few crystal boundaries visible with hand lens.
	Very fine grained	no crystal boundaries visible with hand lens but could be distinguished with 4x magnification.
	Microcrystalline	few crystal boundaries discernible at 4x magnification.
	Cryptocrystalline	no crystal boundaries visible at 4x magnification.
Texture	Aphanitic	Igneous rock texture with grains too small to be identified without a petrographic microscope. Common in dyke formations. In the visual assessment conducted in ch.4 aphanitic includes interlocking, extremely fine-grained sedimentary rocks.
	Porphyritic	Obvious phenocrysts set within a finer-grain size matrix.
	Pyroclastic	Volcanic rocks consisting of fragmented particles, shards and minerals.
	Clastic	Refers to the texture of sedimentary rocks composed of fragmental rock particles.
Phenocryst habit	Euhedral	Well-formed mineral crystals with regular well-defined shape.
	Subhedral	Only some of the mineral crystals display well formed crystal faces.
	Anhedral	Crystal grains in rock with no well defined crystal faces.
Homogeneity	Layering	
	Lamination	Very fine stratification of layers in a sedimentary unit
	Inclusions	
	Flowbanding	
Accessory mineral		A sparse visually distinct mineral which is the same size as the surrounding material but whose presence in the rock does not affect the rock name.

Definitions adapted from Thorpe and Brown (1985) and Allaby and Allaby (1999)

APPENDIX B: MICROBLADE DOCUMENTATION

Artifact #: 1127T10N10-28
Length: 1.90cm
Width: 0.74 cm
Thickness:
    Midflake: .12 cm
    Platform: .14 cm (at bulb)
Weight: 0.184 g.
Portion: complete,
Cortex: absent
Lateral Margins: irregular and converging
Ridge Count: 2
Dorsal Scar Count: 3
Direction of dorsal scar detachment: indeterminate
Dorsal arrises: triangular or single arrise
Retouch: absent
Usewear: absent
Comment: very irregular
Raw material type: rhyolite (sample #28)

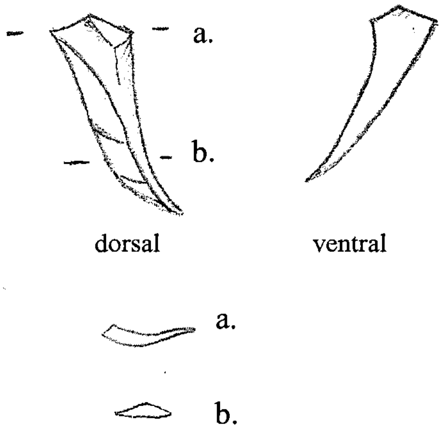


Image not to scale

Artifact #: 1127T10T17-6
Length: 1.21 cm
Width: 0.57 cm
Thickness:
    Midflake: 0.15cm
    Platform: 0.11cm
Weight: 0.113g.
Portion: proximal (partial medial)
Cortex: absent
Lateral Margins: roughly parallel – irregularity on right margin
Ridge Count: 2
Dorsal Scar Count: 3
Direction of dorsal scar detachment: same as blade
Dorsal arrises: roughly parallel
Retouch: absent
Usewear: absent
Comment: irregular, thick and lumpy in places
Raw material type: chert/agate (sample #25)

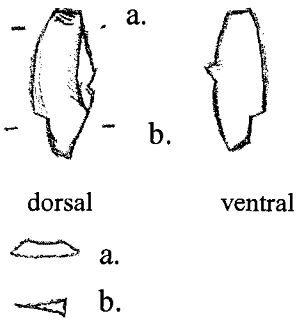
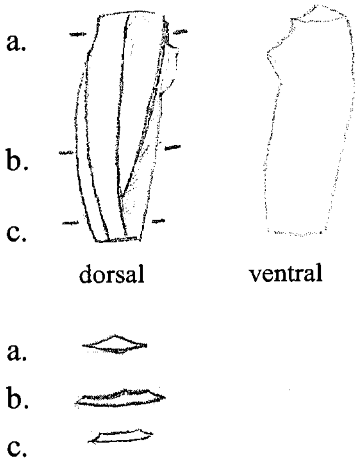


Image not to scale

Artifact #: 1127T10J15-5
Length: 1.90cm
Width: 0.49cm
Thickness:
 Midflake: 0.10cm
 Platform: 0.15cm
Weight: 0.105g
Portion: proximal
Cortex: absent
Lateral Margins: roughly parallel
Ridge Count: 3
Dorsal Scar Count: 4
Direction of dorsal scar detachment: same as blade
Dorsal arrises: 3; 2 converging, 2 parallel
Retouch: absent
Usewear: absent
Comment: no comment
Raw material type: rhyolite (sample #26)



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APPENDIX C: PRELIMINARY SOURCING SURVEY

Preliminary Sourcing Survey: July 31st, 2003 – August 2nd, 2003

From July 31st – August 2nd, 2003 a survey for archaeological lithic sources was conducted in the Northern region of the Gwaii Haanas National Park Reserve and Haida Heritage Site. This survey work was in support of an MA thesis project at the University of Victoria which involves an analysis of the lithic raw material use at the Richardson Island archaeological site, 1127T . The three day survey outlined here provided invaluable geological evidence which allowed for a refinement of the thesis research design and for the collection of rock samples to be used as comparative specimens for ongoing analysis of materials excavated at the Richardson Island archaeological site.

Research conducted prior to survey:
Prior to the survey in the summer of 2003, 15 visually dissimilar rock types from the Richardson Island archaeological site had been selected for chemical analysis involving Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) at the University of Victoria. The ICP-MS provided the trace element concentrations for each of the samples. The Zr/Ti and Nb/Y ratios provided igneous classifications for each of the samples; 3 of which were rhyolite, 1 dacite, 4 andesite to basaltic andesite, 3 basalt, 2 falling on the border between the later two types, and 2 alkali basalt. During a consultation with Jim Haggart at the Geological Survey of Canada (GSC) it was suggested that many of these fine-grained samples resembled dyke materials. Examination of dyke samples collected by Jack Souther of the GSC in 1987 and 1988 revealed that some of the Richardson samples did in fact resemble dyke samples, especially those of rhyolitic origin. Thus, a number of fine-grained dykes recorded in Jack Souther's field notes were visited during the 2003 survey.

Outcomes of survey
Samples from 33 locations within Darwin Sound, Richardson Inlet, and Logan Inlet were collected over the three day period. A summary of the locations visited and samples collected during the preliminary sourcing survey are presented in Table 1.

Initial survey efforts focused on locating dykes. While a number of these exposures revealed materials of decent flaking quality, the rhyolite dyke at Skudas Point, Northwest Lyell Island, was of particular interest as it was very similar to archaeological rhyolite samples from 1127T. Subsequent analysis of this rhyolite has indicated that the chemistry of the archaeological samples and the rhyolite from Skudas Point are very similar. However, to confirm this dyke as a definite source location would require additional sampling and testing of this location and other rhyolite exposures in the area.

In addition to sampling dyke rocks, a traverse of the west side of Richardson Island was also conducted to establish whether raw materials of exceptional flaking quality existed close to the 1127T site itself. At the north end of Richardson Island a fine-grained rhyolite in a Tertiary volcanic exposure (TV), which has yet to be named by the

Geological Survey, was encountered. This material is not of high flaking quality but does resemble some of the more uncommon rhyolite types represented archaeologically.

Roughly 500m south of the 1127T site, a slightly metamorphosed shale exposure was discovered. This extremely fine-grained material exists within the geological unit known as the Kunga Group (characterized by shale, calcareous shale, massive limestone, and fine-grained sandstone). The material flakes beautifully with predictable conchoidal fracture and appears to weather in a similar fashion to some of the material from the archaeological assemblage. The discovery of this possible raw material source was significant for two reasons. Firstly, it confirmed that high quality flaking material was immediately available to the inhabitants of the Richardson site. Secondly, the exposure was of sedimentary origin, not igneous. The initial rock classifications based on trace element concentrations (mentioned above) had been based on the assumption that the 15 archaeological samples were of igneous affinities. The discovery of this material in the Kunga Group indicated that such an assumption was unfounded. The thesis research design, which involves a geochemical classification of rock types at the 1127T site, was thus amended to include microprobe analysis. This has allowed for the separation of igneous and sedimentary materials based on major elements. Again, chemical analysis conducted subsequent to the sourcing study has revealed that the shale located to the south of 1127T is similar to a material found in the archaeological assemblage. Yet, once again, absolute confirmation of the exposure as a source location would require further testing.

The previous discussion has highlighted only two materials of interest that were collected during the preliminary sourcing survey. All samples, however, have been useful in considering the resource extraction efforts employed by the previous inhabitants of Richardson Island. The samples collected during the 2003 preliminary sourcing survey are currently housed at the University of Victoria and are being used as a comparative collection for the Richardson Island archaeological site 1127T.

References

Sanbourne-Barrie, M. 1993 Geology of the Darwin Sound Area, Queen Charlotte Islands, British Columbia: Geological Survey of Canada. Open File Map. O.F.2852, scale 1:30,000.

Souther, Jack 1998 Unpublished field notes. On file with Geological Survey of Canada, Vancouver Branch.

Table 2 Summary of locations visited between July 31st and August 2nd, 2003.

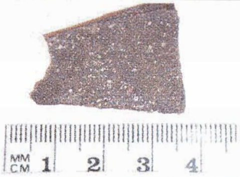
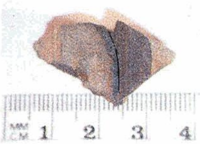
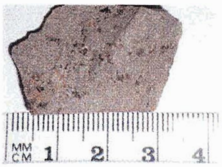
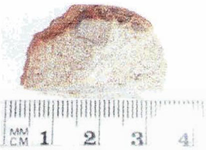
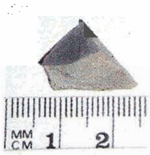
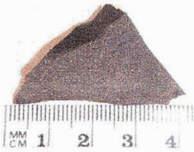
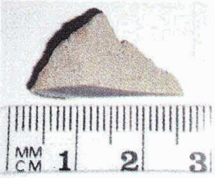
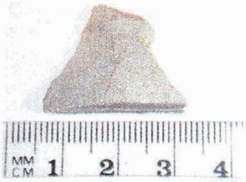
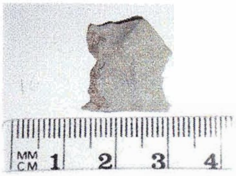
July 31st, 2003				
Location	**UTM**	**Formation visited**	**Observations**	**Samples collected**
East side, Shuttle Island	E: 0314599 N: 5850183	Karmutsen Formation (TK) Attempt to find andesitic lapilli tuff as described by Sanbourn-Barrie (1991).	Not much material of interest. Some large volcanic cobbles on beach, one with flakes removed.	Volcanic cobbles collected, Bag #1.
Northwest Lyell Island, bay to east of Lyell Point.	E: 0316279 N: 5843394	Dyke location (Souther 1988)	Green andesitic dyke, exfoliates in tabular slabs	Samples collected, Bag #2
Skudas Point, North Lyell Island	E: 0318638 N: 5845761	Dyke location #3710 (Souther 1988)	Bluff like point. Rhyolite present from shore level to 10m above sea-level. Exfoliates in tabular blanks.	Multiple samples collected. Bag #3= exfoliated material from beach. Bag #4= material removed from dyke. Bag #5&6= material from highest attainable points on dyke.
South Tanu Island	E: 0317470 N: 5847700	Unnamed volcanic rock (TV) Obsidian pebbles observed in this location during 1993 Archaeological inventory (Mackie, pers. comm.)	Rare scattered obsidian pebbles	A few pebbles collected. Bag #OB1
South Tanu Island		Dyke location #3915 (Souther 1988)	Two dykes visible. Arichika Type, not nice for flaking.	Sample collected. Bag #7
West of Tanu Point		Dyke location #3917 (Souther 1988)	Dyke material not nice for flaking, nice cobbles nearby are good flaking. Swamped at sea-level max.	Cobble material collected. Bag#8
August 1st, 2003				
South Tanu Island		Dyke location #3913 (Souther 1988)	Nothing of interest	Nothing collected
South Tanu Island	E: 0320323 N: 5847626	Dyke location #3911 (Souther 1988)	Fine grained andesite dyke. Weathers in tabular blanks. Excellent for flaking	Sample collected from shore. Bag #9. Samples collected 7m above sea- level, Bag #10

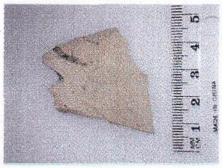
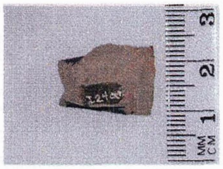
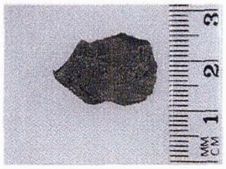
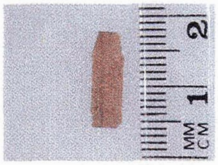
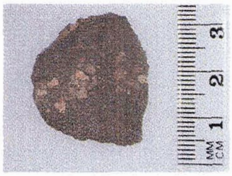
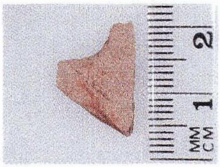
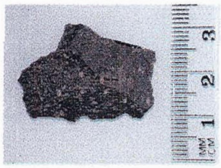
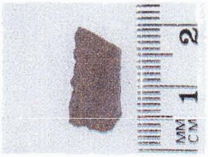
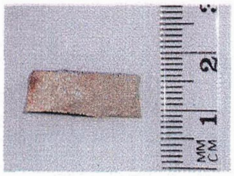
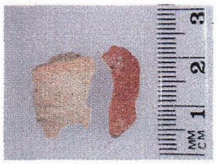
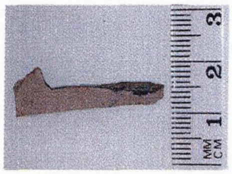
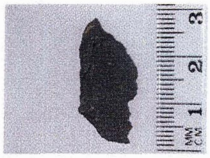
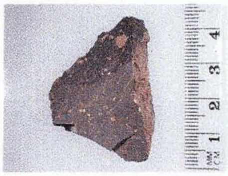
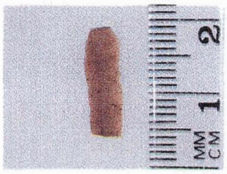
Location	**UTM**	**Formation visited**	**Observations**	**Samples collected**
South Tanu Island	E: 0320696 N: 5847533	Unnamed volcanic rocks (TV) Walking between dyke locations	Black basalt cobbles and very nice green striped rock with white spotting. Presumably eroding from bedrock.	Samples collected. Bag #11
South Tanu Island	E: 0321790 N: 5847486	Dyke location #3907 (Souther 1988)	Dyke described as fine-grained dacite, light grey. Cobbles on beach flakeable	Samples in Bag #12
North east, Atli Peninsula	E: 0325950 N: 544800	Dyke location (Souther 1988)	Not overly exciting, material not great	Sample collected anyway Bag # 13
Bay around corner from Tsinga Point	E: 325900 N: 544300	Sandilands Formation (TJS) Description of a metamorphosed siltstone (Sanbourne-Barrie 1991).	Very interesting material, unique, very flakeable. Does not resemble Richardson materials but sample collected nonetheless	Bag #14
South side Atli Peninsula	E: 0321468 N: 5843682	Dyke location (Souther 1988)	Very fine-grained aphyric andesite, semi-flakeable -200m west of this location second dike of fine-grained andesite	Samples collected Bag #15 - Bag #16
Lockport		Headed up Longfellow Creek to search for paleomarine sediments	Rhyolite cobble collected	Bag #17
Triumph Point, most westerly bay	E: 0310708 N: 5848715	Subvolcanic intrusions (TVi) Rhyolite exposure noted (Sanbourne-Barrie 1993; Souther 1988)	Beach composed of tabular rhyolite cobbles eroding from bedrock. Many textures and colours represented. Blue-green volcanic that flakes well also noted at this location. Very green material also noted. Can flake almost everything on this beach.	-Rhyolite samples from beach = Bag #18 -Rhyolite samples from bedrock = Bag #19 -Blue/green volcanic = Bag #20 -Green volcanic = Bag #21
August 2nd, 2003				
Traverse down west side of Richardson Island, North of 1127T	E: 0313179 N: 5847691	Unnamed Tertiary Volcanic (TV)	Large slide exposing bedrock. Rhyolite of varying textures and colours. Medium grained. Some black volcanic rock with thin calcite veining. Large flake found to north of slide but debris covers most of what could be intertidal site.	Assorted samples collected = Bag #22

Location	**UTM**	**Formation visited**	**Observations**	**Samples collected**
Continuation down west side of Richardson Island, north of 1127T	E: 0313237 N: 5846874	Unnamed Tertiary Volcanic (TV)	Survey between this and last point revealed little of interest. Cross section of materials common from this formation collected for comparative purposes	Assorted samples = Bag #23
West side of Richardson Island, north of 1127T	E: 0313234 N: 5846877	Unnamed Tertiary Volcanic (TV)	-Hammerstone found in intertidal -Some nice material available on this stretch of beach, but not abundant.	Artifact =Bag # 24 Material sample = Bag #25
West side of Richardson Island, north of 1127T	E: 0313219 N: 5846857 E: 0313245 N: 5846574	Subvolcanic intrusion (TVi)	-Have collected cross section of semi-flakeable material available between this UTM and the last. Assorted materials, some fine grained black rock becoming more common in beach matrix but not typical of surrounding bedrock. Nearing 1127T location	-A piece of black and white banded material commonly used for artifacts at Richardson = Bag #26 -assorted samples = Bag #27 -Fine grained black material becoming more apparent in beach complex. = Bag #28.
West side of Richardson Island, near to 1127T	E: 0313245 N: 5846532 E: 0313297 N: 5846261	Subvolcanic intrusion (TVi)	Continuing to collect black fine grained material from the intertidal. Material is becoming more common and seems to be originating from a local source.	-Bag #29 -Bag #30
Creek beside 1127T site location		Subvolcanic intrusion (TVi)	Sampling bedrock exposed in creek	-Bag #31
West side of Richardson Island, South of 1127T	Between E: 0313729 N:5845357 and E: 0313972 N: 5845141	Subvolcanic intrusion (TVi)	Selection of material common along this stretch of the island. Not very exciting.	Assorted samples collected – Bag #32

Location	**UTM**	**Formation visited**	**Observations**	**Samples collected**
West side of Richardson Island, South	E: 0314284 N: 5844887	Kunga Formation (TJK)	Large slide has exposed foliated shale outcrop. Slide has dislodged great amount of very fine-grained black rock, flakes beautifully. Outcrop extremely high, would be exposed at sea-level maximum. Top of slide/base of exposed foliation is ~25m above sea-level. Material weathers like arch. Material.	Assorted samples collected from this foliation – Bag#33

APPENDIX D: IMAGES OF RAW MATERIAL SAMPLES SELECTED FOR CHEMICAL ANALYSIS

	Sample # 1 Siliceous Argillite		Sample #9 Siliceous Argillite
	Sample # 2 Wacke/Shale		Sample # 10 Rhyolite
	Sample # 3 Rhyolite		Sample # 11 Shale/Argillite
	Sample # 4 Rhyolite		Sample # 12 Siliceous Argillite
	Sample # 5 Andesite		Sample # 13 Siliceous Argillite
	Sample # 6 Dacite		Sample # 14 Contaminated
	Sample # 7 Dacitic Tuff		Sample # 15 Basaltic-andesite
	Sample #8 Siliceous Argillite		Sample # 16 Wacke

	Sample # 17 Shale/argillite		Sample # 26 Rhyolite
	Sample # 18 Shale/argillite		Sample # 27 Chert/rhyolite ?
	Sample # 19 Shale/argillite		Sample # 28 Chert/rhyolite ?
	Sample # 20 Varvite		Sample # 29 Shale/argillite
	Sample # 21 Rhyolite/Dacite		Sample # 30 Dacite
	Sample # 22 Shale/argillite		Sample # 31 Rhyolite (Non-archaeological sample from Skudas Point, Lyell Island)
	Sample # 23 Shale/argillite		Sample # 17 Shale/argillite (Non-archaeological sample from Kunga Formation, Richardson Island)
	Sample # 24 Rhyolite		Sample # 33 Dacite
	Sample # 25 Chert/agate		