CHAPTER 2

Nephrite/Jade: The Preeminent Celt Stone of the Pacific Northwest

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Nephrite/jade is rather different from all the other toolstones discussed in this volume, as it was exclusively used for making ground, rather than flaked stone artifacts in the Pacific Northwest. While most toolstone was selected for its property of being able to fracture it in a controlled manner, nephrite was selected for the exact opposite reason – namely it is exceedingly difficult to fracture at all. Because of its extreme toughness, nephrite was a very desirable material for the production of stone celts (adzes, chisels, and axes). Nephrite from the Pacific Northwest is dominated by shades of green, but can occur in a myriad of colors. Being a semi-precious gemstone, polished nephrite also has remarkable aesthetic qualities – namely translucency and luster. The combination of incredible toughness, durability and unique aesthetic properties make nephrite a remarkably singular toolstone. Besides celts, there are very few other artifact types aside from production debris (e.g., knives, pendants, scrapers, points) made of nephrite in the Pacific Northwest. Despite its general rarity in the environment, nephrite was the most commonly used toolstone, or more specifically 'celt stone', for the production of stone celts in the Pacific Northwest. This paper first briefly describes the cultural context of indigenous nephrite use, second describes the petrology and petrogenesis of nephrite, and third reviews the distribution and occurrence of *in situ* and secondary nephrite deposits.

These sections are not intended to either: provide a definitive description of the geology of nephrite in the region (for interested readers see Adams et al. 2007; Fraser 1972; Harlow and Sorensen 2005; Iizuka and Hung 2005; Leaming 1978; Simandl et al. 2000; Wen and Jing 1992), a summary of the prehistoric use of nephrite technology in the Pacific Northwest (see Emmons 1923; Darwent 1998; Mackie 1995; Morin 2012), nor an introduction to a nephrite sourcing study (see Morin 2012). Rather, my intention is to provide the geophysical contexts for assessing the accessibility of nephrite as a celt stone by indigenous peoples in the Pacific Northwest. I suggest that indigenous utilization of alluvial nephrite from the Fraser and Bridge Rivers, rather than from discrete quarry sites, has significant implications for understanding the social relations of nephrite procurement and ownership. Namely, I suggest that the contexts of nephrite procurement – primarily targeted chance encounters of nephrite cobbles/boulders in river gravels – limited the potential for either individual or corporate ownership or domination of nephrite source areas, and did not require any form of hierarchical organization of labor to meet local and distant demands for nephrite celt stone. Instead, I suggest that local nephrite procurement was largely individualized and open to all local inhabitants. Procurement likely occurred primarily by individuals or small groups regularly scouring Fraser and Bridge River gravel beds during winter months proximate to their winter villages.

The Salish Nephrite Industry

Based on my extensive inventory of all major museum repositories and archives holding pre-contact material culture from the Pacific Northwest (Morin 2012), I can confidently state that the traditional territories of Interior and Coast Salish peoples of the Fraser River drainage and Salish Sea regions were the centers of nephrite celt production and use in the Pacific Northwest (PNW). There are literally thousands of celts reported from this

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region, and based on my mineralogical analysis of a sample of over 1000 celts and celt fragments from here (Morin 2012), nephrite was definitely the most commonly used raw material. I refer to this distinctive technological tradition as the 'Salish Nephrite Industry'. Nephrite celts do indeed occur outside of these regions at very low rates, and other rocks, such as chlorite, were used for producing celts in some areas. The earliest evidence for nephrite celt use dates to about 3500 B.P., but such evidence is sparse until 2500 B.P. when there is a veritable explosion of nephrite celt use associated with the Marpole Phase (2500-1000 B.P.).

As nephrite cannot be flaked in a controlled manner, celt blanks were instead laboriously sawn from alluvial pebbles, cobbles and boulders. Estimates for producing a single sawn nephrite celt range from about 40-100 hours, exclusive of times spent in raw material acquisition (Darwent 1998; Morin 2012), thus making these tools very valuable. Sawn cores are distinctive, very rare artifacts, with fewer than 140 examples reported for the entire PNW, of which only 65 of 131 analyzed examples have been confirmed to be nephrite (Morin 2012). Remarkably, nearly all of these sawn cores are from two relatively restricted locales along the Fraser River: the Hope vicinity at the entrance to the Fraser Canyon, and the Lytton-Lillooet locality in the Mid-Fraser region. I refer to these locales as the primary nephrite celt production zones. The Lytton-Lillooet locality in particular has both the most numerous and largest sawn nephrite cores in all of Cascadia. Communities in these two locales clearly specialized in the production of nephrite celts beyond their own requirements, as the greatest number of celts are found on the Lower Fraser River and the Salish Sea – regions containing absolutely no evidence of nephrite working. I refer to these later regions as the primary nephrite celt consumption region. Importantly, there are very few nephrite sawn cores from outside these two locales, indicating that unworked nephrite celt stone was neither commonly exchanged, nor regularly obtained by long-distance quarrying forays from other regions. Nephrite celt stone was fashioned into finished or largely finished celts in the locations along the Fraser River where alluvial nephrite was most abundant and exchanged to the adjacent Coast and Canadian Plateau regions.

Late Prehistoric Period (3500 B.P. to contact) sites on the Lower Fraser River and Salish Sea typically contain nephrite celts, and in some cases they are very numerous. Over 300 celts are reported from various excavations and surface collections of the Marpole site (on the Fraser River in modern Vancouver) alone, for example. In coastal assemblages celt size varies markedly from 10-300 mm in length, but typically are small (median length ~50 mm), heavily worn, and have been extensively reworked through continual resharpening and occasionally have been bisected into two smaller celts (Mackie 1995; Morin 2012). It is probable that the larger celts were hafted as adzes and the smaller ones as chisels and were used in a variety of heavy and fine woodworking tasks. The extreme toughness of nephrite (Bradt et al. 1977; Leaming 1978; Harlow 1993) would probably make nephrite celts more durable, that is, requiring less frequent resharpening, being less liable to fracture, and thus with longer use-lives, than celts made of other materials (e.g., semi-nephrite, quartzite, serpentine, bone, antler, mussel shell). These celts were probably highly curated and valued tools because: they were non-local, they were time consuming to produce, and they were very functional in woodworking. In Coastal sites, assemblages containing celts are mainly found in shell middens, especially large shell middens associated with major winter village sites (e.g., Beach Grove, Katz, Port Hammond, False Narrows, Marpole, Musqueam), and rarely found in association with burials (for rare exceptions see Burley 1989 and Curtin 2002). I think it is near certain that large increase in the use of these artifacts is associated with the origins of an indigenous material culture reliant on heavy woodworking (e.g., canoes, plank houses, boxes) and may be related to the origins of carving specialists such as canoe makers and carvers.

Nephrite celts were also used throughout the adjacent Canadian Plateau, approximately concurrently with the Coast. On the Plateau, celts are nearly all made of nephrite, are typically larger (median length ~133 mm) than those on the Coast, and consist of two types: small functional celts, and large non-functional celts ranging up to 500 mm in length. While nephrite celts larger than about 150 mm long are quite rare on the coast (N=11), they are rather more common on the Canadian Plateau (N=48), especially around the town of Lytton (N=15). Similar examples are reported from as distant as northern Idaho on the Columbia Plateau (Morin 2012; Smith 1910). Indeed, there is direct historic evidence that these large celts were non-functional valuable 'property', not tools as such, but rather used in high value transactions (James Teit quoted in Emmons 1923). Nearly all of these large celts are made of very high-quality and often beautiful nephrite, as only pure and homogeneous bodies of nephrite can be used as cores from which to saw out such large objects. Based on traditional production times of nephrite *mere* clubs in New Zealand (Beck 1912), these large nephrite 'property celts' would have taken upwards of one thousand hours to saw from a large boulder core, and procurement of suitable nephrite boulders would have also been no trivial task. Because of the rarity, beauty and especially the enormous labor costs, large property celts would have been exceedingly valuable. 'Property celts' are exclusively recovered from invariably poorly reported mortuary contexts on the Plateau, and are probably all more recent than 1200 B.P. (Morin 2012; Sanger 1969). I suggest that they were amongst the most valuable property and most emphatic symbols of wealth among elites on the Canadian Plateau (see Hayden 1998).

The sections above provide a brief synopsis of the Salish Nephrite Industry, a widespread and long-lasting technological tradition. I highlighted key aspects of nephrite celt production, and the Plateau-Coast dichotomy in celt form to emphasize the diversity of this technological tradition, and to hint at the complexity of the economies that functioned to circulate such objects. Having provided this cultural context for nephrite celt stone use, I now shift the discussion to a detailed geological description of nephrite and its occurrence in Cascadia.

Petrology of Nephrite in the Pacific Northwest

Nephrite is one of two unrelated rocks (the other being jadeite) commonly referred to as 'jade'. Although locations in British Columbia have the appropriate geological conditions for occurrence of jadeite (Leaming 1978:6), it has not been identified north of California (Harlow and Sorensen 2005). Nephrite, however, has been identified at over 50 *in situ* bedrock locations and as placer or gravel deposits over broad areas in Western North America, and especially, in British Columbia (see Figure 2-1). Nephrite in Western North America is a metasomatic hydrous monomineralic rock that is noted for both its visual properties and extreme toughness; nephrites from other parts of the world, such as China, are derived from different processes and parent rocks. Briefly, nephrite is a rock composed of tremolite/actinolite with a distinctive 'nephritic' or felted texture (Leaming 1978:8) and often contains other trace minerals such as serpentine, talc, chrome garnet, chlorite, vesuvinite and diopside (Harlow and Sorensen 2005; Leaming 1978:11). Tremolite-actinolite is an amphibole mineral series that makes up over 90 percent of nephrite rocks. Amphiboles are long double chains of silica tetrahedrons and attached cations (e.g., iron and magnesium) (Blatt et al. 2006: 27). Tremolite and actinolite differ from each other only in the proportion of iron to magnesium, with tremolite ($Ca_2Mg_5Si_8O_{22}(OH)_2$) containing only magnesium and no iron (theoretically it contains no iron, in the real world, some iron is always present), and actinolite ($Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$) containing magnesium and iron (Leaming 1978:8).

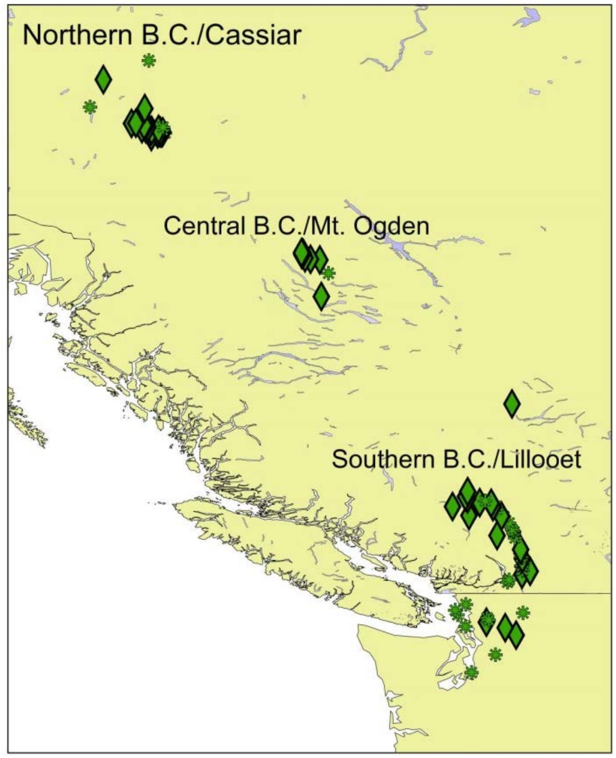

Figure 2-1. Nephrite sources in the Pacific Northwest. Diamonds are *in situ* nephrite sources, and asterisks are 'float' (colluvial or alluvial) nephrite sources.

The minerals that make up nephrite are described by Leaming (1978:11) as “characterized by a peculiar texture in which microfibrous tremolite occurs as twisted and felted bundles, tufts, and sheaf-like aggregates in interlocking random orientation.” Tremolite crystals lacking completely felted or nephritic textures but having acicular crystals or large sheaves are described as semi-nephrite (Beck 1984:7). Thus, while there are no chemical differences between tremolite/actinolite, semi-nephrite, and nephrite, there are significant differences in the textures of these rocks, and these differences in texture have profound implications for the physical properties of these materials. The felted or nephritic texture of nephrite makes it extremely tough (Bradt et al. 1973:727: Rowcliffe and Fruhauf 1977). Toughness can be described as resistance to breakage. While nephrite is not a particularly hard rock (Moh = 6.5-7), it is the toughest naturally occurring material in the world (Brandt et al. 1973; Harlow 1993). The extreme toughness and relative hardness of nephrite causes it to be particularly resistant to physical weathering. Because of these properties, it is therefore able to be transported notable distances from its bedrock sources by natural forces. The toughness of nephrite is also its most desirable property as a celt stone.

While no single element determines the color of nephrite (Wilkens et al. 2003), the proportion of iron to magnesium and the inclusion of other minerals in nephrite have a marked effect on its visual properties. Primarily, greater concentrations of iron in nephrite tend toward green (Wen and Jing 1992). Nephrite made of pure tremolite (i.e., with very low iron content and) tends to be white; nephrite containing more actinolite-ferroactinolite (i.e., contain more iron) tends towards green – often vibrant green; and nephrite extremely rich in ferroactinolite tends towards black (Harlow and Sorensen 2005; Wen and Jing 1992). Green nephrite is most common in British Columbia, while white nephrite is rarest (Fraser 1972:82). Nevertheless, there is a remarkably wide range of ‘greens’ within B.C. nephrites. Leaming (1978:7), for example, required 16 different Munsell color designations to adequately describe 47 bedrock specimens of B.C. nephrite. Some of this variability probably relates to the formation of nephrite deposits, iron/magnesium ratios described above, and perhaps post-formation oxidation processes

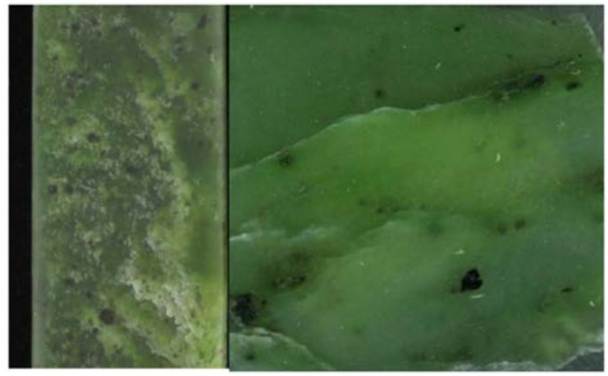

Figure 2-2. Black chromium spinel (pictotite) inclusions in nephrite.

(see Beck and Mason 2010).

Nephrites from British Columbia often contain inclusions. To the naked eye, inclusions within nephrite tend to be irregularly shaped small spots, flecks (~0.5 to 2 mm in diameter), or short streaks. These inclusions are often spinels or chrome garnets (Iizuka and Hung 2005; Leaming 1978). There are two distinctive types of inclusions common to B.C. nephrite. The larger of the two types of inclusions are chromium spinels, are black, and can occur as semi-spheres or as thin flat tiny sheets (Iizuka and Hung 2005), and are often immediately recognizable with the naked eye (see Figure 2-2). The second common type of inclusion in B.C. nephrite is bright green, spherical, and typically much smaller than the black inclusions. These green inclusions are chromium-calcium garnets called uvarovite (Iizuka and Hung 2005: 50), and are also visible to the naked eye if the artifact or hand sample is examined closely (see Figure 2-3). Experts with 2-4 decades experience mining, working, and handling nephrites can recognize material from Cassiar, for example, by the size, shape and arrangement of these green inclusions that are very common to nephrite from the famous Cassiar source.

Nephrite in British Columbia is thought to develop in a metasomatic reaction – that is, a chemical reaction between rocks of very different chemistries with the presence of water (Harlow and Sorensen 2005; Harlow et al. 2007; Leaming 1978). In British Columbia, nephrite was formed hundreds of millions of years ago in the Triassic and Jurassic periods (Gabrielse 1990; 1998a, 1998b; Monger 1989; Simandl et al. 2000), at the zone of contact between ultramafic serpentine rocks and siliceous

Figure 2-3. Green chromium garnet (uvarovite) inclusions in nephrite.

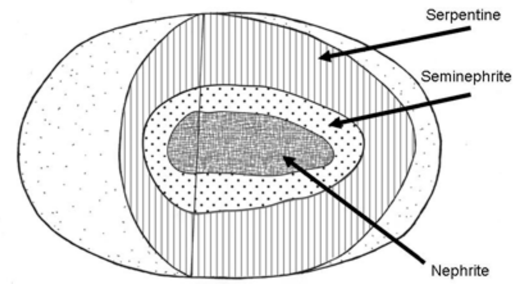

Figure 2-4. Hypothetical nephrite lode.

sedimentary rocks (or their metamorphosed equivalent) (Leaming 1978:14). In this ‘reaction zone’ serpentine bodies and sedimentary bodies exchange material, that is, a chemical reaction, in a liquid matrix and recrystalize dependent on the local pressures and temperatures. Under such conditions actinolite/tremolite is formed. For this actinolite/tremolite to develop into nephrite, that is crystallize with a nephritic texture, requires “a stress free environment and rapid crystal growth from innumerable centers. Further, the growth of the fibers must be entirely random” (Leaming and Hudson 2005:173). This random structure may be inherited from the parent serpentine rock (Leaming and Hudson 2005:173). If this material is particularly pure, then it is nephrite.

Nephrite tends to form in small deposits called lodes that range from tens of centimeters in diameter (see Simandl et al. 2000: 344), to lenticular bodies up to 10 m high, by 100 m long by 50 m wide (Leaming 1978:17). The bodies of nephrite are typically surrounded by ‘seminephrite’ and serpentine (Figure 2-4). Seminephrite is actinolite/tremolite with a partially developed nephritic or felted texture, and usually contains notable amounts of serpentine and talc (Beck and Mason 2010; Simandl et al. 2000). The major factors that cause nephrite to form in Cascadia are then: 1) tectonic uplift along an orogenic belt – represented by the Cordilleran Mountains, and 2) contact between serpentine and siliceous sedimentary rock bodies or their metamorphic equivalents.

Nephrite Occurrences in Cascadia

The richest nephrite deposits in North America, and indeed some of the richest deposits in the world, occur in British Columbia, but can also be found in California, Wyoming, Alaska, Washington State, Oregon, and the Yukon. The following discussion reviews nephrite sources in three major regions of British Columbia, Northern Central and South, and Washington State. Each of these four major ‘source regions’ actually contains numerous geologically distinct bedrock occurrences of nephrite, and many secondary sources. As Southwestern British Columbia was clearly the primary region of indigenous use of nephrite, greater detail will be devoted to describing deposits there.

British Columbia

There are three major regions in British Columbia where *in situ* or bedrock nephrite is found. These all fall along a roughly north-northwest running nephrite-bearing belt (Leaming 1978:19) (see Figure 2-5). The most northerly source is in the Cassiar Segment around Dease Lake and Cassiar. Second, there is a major nephrite bearing region in Omineca Segment northwest of Prince George near Mt. Ogden (alternatively Ogden Mountain). Finally, in the Lillooet Segment there are a number of nephrite source locations west and south of Lillooet, west of Lytton, and east of Hope. I devote particular attention to them because they were definitely the most intensively utilized by indigenous peoples in the past.

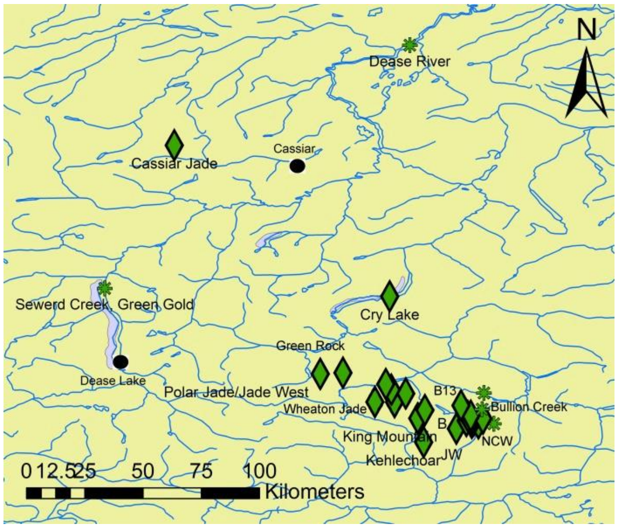

Figure 2-5. Nephrite sources in Northern B.C. Diamonds are *in situ* nephrite sources, and asterisks are 'float' (colluvial or alluvial) nephrite sources.

Northern B.C.: The Cassiar/Dease Lake Region

Nephrite was first identified by Euro-Canadians in Northern B.C. in 1938, but it was not until about the 1980's, that the Northern B.C. Group around Cassiar began to be intensively quarried, and subsequently has been the centre of the B.C. nephrite industry (Leaming and Hudson 2005: 39). Indeed, Dease Lake claims to be the 'jade capital of the world' (Leaming and Hudson 2005: 38) (see Figure 2-5). There are large bodies of *in situ* bedrock nephrite here and innumerable 'float' or colluvial/alluvial/glaciofluvial deposits (see Figure 2-5). Within this region there are three main loci of nephrite occurrences.

The first, and perhaps most well known, deposit is at Cassiar (see Figure 2-5). When this nephrite deposit was encountered, it was blasted through, and discarded in enormous quantities during the course of an asbestos mining operation (Leaming 1978:35-36). It is reported that upwards of a thousand tons of nephrite was dumped in tailings of this mining operation before anyone had realized that the nephrite was in fact far more valuable than the asbestos (Leaming and Hudson 2005:54). According to provincial records, 1,700 metric tons of nephrite have been extracted from this source (MINFILE 104P 005). Leaming (1978:9, 36) notes that this material is chemically distinguishable from other varieties given this high chromium content (within the chrome garnets). However, from the data presented, it appears that Cassiar nephrite is only marginally more chromium rich than Seyward/Dease Lake or Noel Creek nephrite (Leaming 1978:9). Specimens I have obtained from this source likely represent several of the many lodes of nephrite encountered accidentally in the course of asbestos mining. Here the nephrite deposit was below ground, and was not likely available for indigenous exploitation.

A second major *in situ* deposit of nephrite in this region occurs near Seyward Creek immediately northeast of Dease Lake (Gabrielse 1990; Leaming 1978:36) (see Figure 2-5). This source is associated with the Kedahda Formation and is part of the Cache Creek Terrane, and was formed between late Mississippian and Triassic periods about 325 – 200 million years ago (m.y.a.) (Gabrielse 1998a:49, 54). Alluvial nephrite presumably from this source can be recovered from Thibert and Delure creeks, and from Dease River (Leaming 1978:35). While only 5 metric tons of nephrite has been extracted from the Seward Creek source (MINFILE 104J057), the fact that it occurs in comparatively widespread alluvial contexts suggests that it would have been readily accessible for tool production in the past by indigenous peoples (K. Makepeace, Personal Communication, 2009). My samples from Dease River are from alluvial contexts and are visually distinctive from the Seyward Creek material. I submit that some of this material is from an entirely different source than Seyward Creek/Dease Lake.

The third and most widespread group of nephrite sources in the Northern B.C. or Cassiar group occurs east of Dease Lake and south of Cry Lake (see Figure 2-5). The potential nephrite deposits associated with this area are amongst the largest in the world at about 50,000 metric tons (Leaming 1978:38). Bedrock or *in situ* deposits here include the famous Polar deposit, Kutcho, Wheaton Creek, King Mountain, Provencher Lake, Letain Creek, Two Mile Creek, Greenrock Creek, King Kong, Baggins, and the Kehlechoa River (B.C. Ministry of Energy, Mines, and Petroleum Resources; Gabrielse 1998; Leaming 1978:33; Leaming and Hudson 2005). Similar to Cassiar, some of these deposits have produced very large quantities of nephrite, such as the approximately 2,500 metric tons removed from Kutcho (MINFILE 104I 78). As with the Seward Creek deposits, these deposits are also associated with the Cache Creek

Terrane and date from about 325 – 200 mya (Gabrielse 1998: 54). There are extensive quantities of 'float' nephrite in alluvial and colluvial contexts surrounding several of these sources (Leaming 1978:30-35). Representative sampling of all of these sources and 'float' deposits would be a major undertaking. This area would have had significant quantities of nephrite boulders and cobbles that could have been exploited in the past by indigenous peoples.

Overall, the Northern B.C. nephrite sources in the Cassiar district are extremely rich by global standards. The plentiful 'float' nephrite in particular would have been accessible during summer to indigenous peoples living in the region throughout the Holocene. The absolute dearth of reported nephrite artifacts from archaeological sites in this region, however, suggests that this material was not utilized here, but it may have been traded to the Coast. My samples of nephrite in this region can only be considered representative of four of the many *in situ* sources here. Of the three major source regions in B.C., the Northern or Cassiar region has the lowest likelihood of indigenous exploitation.

Central B.C. Group – Omenica

This region is approximately located in the centre of British Columbia, northwest of the city of Prince George. There are two major *in situ* nephrite bedrock outcrops in this region, and both have extensive associated boulder fields or 'float' deposits (see Figure 2-6). Nephrite has been extracted on an industrial scale near the upper reaches of the Omenica River around Mount Ogden at both Lee and Ogden creeks, and other nearby claims (Fraser 1972; Leaming 1978:26-28; Simandl et al. 2000). The claim at Ogden Creek near Mount Ogden has been a major global producer with records of over 1,400 metric tons extracted (MINFILE 093N 165). Individual talus boulders identified in this vicinity weigh 70 - 150 metric tons (Leaming 1978:32; Leaming and Hudson 2005: 50). Such individual boulders dwarf entire *in situ* nephrite deposits in some areas (Oregon and Washington). Nephrite has also been recovered in small quantities from Vital, Silver, Quartz, Kelly, Teegee and Kwanika creeks (Fraser 1972:12). All of these sources occur at the margin of the Cache Creek Terrane where it abuts a local serpentinite body (Leaming 1978:31). As with the Northern Region deposits, the Mount Ogden sources date between about 325 – 200 m.y.a. (Pennsylvanian to Jurassic, Simandl et al. 2000: 341). This source has undergone much more extensive geological research than any other nephrite deposit in B.C. and is the best described and understood (Fraser 1972; Simandl et al. 2000).

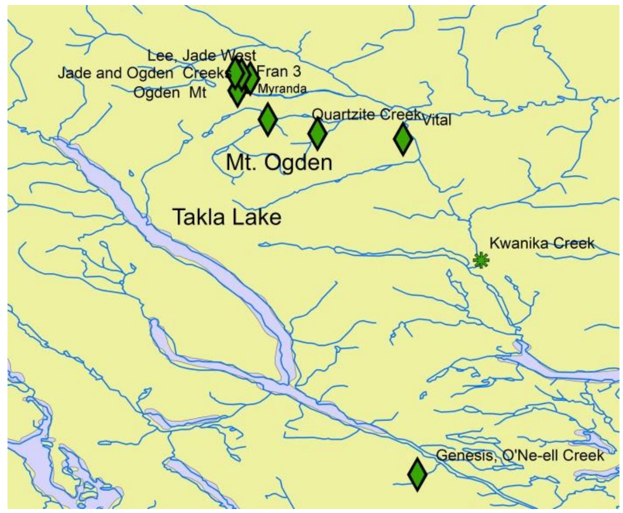

Figure 2-6. Nephrite sources in Central B.C. Diamonds are *in situ* nephrite sources, and asterisks are 'float' (colluvial or alluvial) nephrite sources.

The other major *in situ* nephrite source in the Central Region is near Mount Sidney Williams at O'ne-ell Creek (see Figure 2-6) (Fraser 1972; Leaming 1978). This deposit is again occurs at the margin of the Cache Creek Terrane and dates to about 325 – 200 m.y.a. (Leaming 1978). Although the production records are incomplete for this source, extraction appears to have been a small fraction of that removed from Mount Ogden.

In summary, 'float' nephrite cobbles and boulders in Central British Columbia in the vicinity of Mount Ogden occur in quantities that would have been available for indigenous use. However, the general paucity, but not absolute absence, of nephrite artifacts in this region, suggests that it was not locally utilized. Instead of nephrite, indigenous peoples in this region utilized flaked and ground basaltic materials, or less commonly, a pale green chlorite slate for ground celts (Morin 2012). Further, given that this region is a part of the Fraser River watershed, and that glacial processes appear to have moved large (multi-ton) boulders some distance from their original location, some nephrite from this region may have been carried by the Fraser River to locations far to the south. An intensive geoprospection and provenancing study of origin of nephrite boulders and cobbles in the Fraser River would be the only way to investigate this issue.

Southern B.C. – Lillooet Group

The nephrite deposits in Southern British Columbia along the Lillooet Segment should be of primary interest to archaeologists because: 1) there are many relatively abundant *in situ* and alluvial nephrite sources, 2) there is substantial archaeological evidence for manufacturing of nephrite implements, and 3) there are thousands of nephrite artifacts recovered from archaeological sites in and around this region. For these reasons, I devote particular attention to the distribution of nephrite in Southern B.C. below. In the following sections, I first describe the distribution of known *in situ* nephrite sources, then discuss the important sources of alluvial nephrite boulders and cobbles along the Fraser River.

The first *in situ* nephrite deposits in Canada were discovered in the Shulaps range (Leaming and Hudson 2005: 19; G. Vanderwolf, Personal Communication, 2008). *In situ* nephrite deposits occur in a number of known sources in the Shulaps Mountain range immediately northwest of the town of Lillooet (see Figure 2-7). These source locations include Hell, Hog, Brett, Jim, Blue and Marshall Creeks and Lac La Mar (Leaming 1978:21-27, see Figure 2-7). Most of these sources occur at the headwaters of such creeks in the range of 2000 m elevation. Alluvial nephrite can be found along the streambeds of these sources and is common in the Yalakom and Bridge Rivers that drain the region. Within these river systems, boulders weighing up to 20 tons are reported (Leaming and Hudson 2005:16), and smaller boulders and cobbles are of course much more common.

All of these sources occur at the contact margin between the Shulaps Ultramafic Body (or Mission Ridge Pluton) and the Bridge River Terrane (Journeay and Monger 1994; Leaming 1978:21). Many of these sources appear to have been rather productive and were quarried on an industrial scale, but production records are rare to non-existent. For a brief period in the 1960's, the Lillooet area was the world's largest nephrite producing region (Leaming 1978). Some 100 metric tons were removed from the Hell Creek source in 1973 alone (MINFILE 092 JNE 063). The 6-ton nephrite boulder in the Simon Fraser University Academic Quadrangle pond is also from the Hell Creek source (Leaming and Hudson 2005:24). The Brett Creek source appears to have been entirely mined out well before 2006 (Joseph Morin, Personal Communication, 2006). Much of the alluvial nephrite within the Bridge River is likely derived from these sources, and it is quite probable that the Bridge River conveys considerable quantities of nephrite into the Fraser River (Morin 2012). Indigenous collection of materials derived from these sources along streambeds, or the Bridge, Yalakom, or Fraser Rivers is near certain.

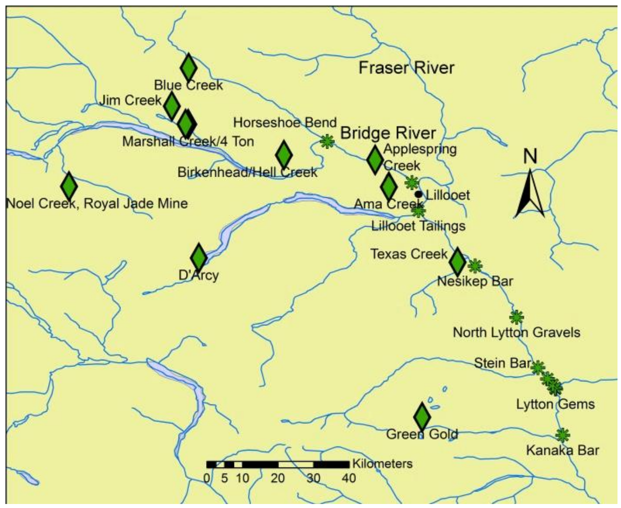

Figure 2-7. Nephrite sources in Southern B.C. Diamonds are *in situ* nephrite sources, and asterisks are 'float' (colluvial or alluvial) nephrite sources.

There are three other *in situ* nephrite sources along the Bridge River, but not associated with the Shulaps Range formation: 1) the Ama Creek or Moon Creek (both names are applied to this single creek) source about 3 km north west of the junction of the Bridge and Fraser Rivers, 2) the Applespring Creek source located adjacent to the Bridge River road approximately 5 km west of the bridge over Bridge River, and 3) at the Horseshoe Bend 400 m downstream from the confluence of the Bridge and Yalakom Rivers (Leaming 1978:21-22) (see Figure 2-7). The nephrite from all of these sources appears to be of low quality and none have seen any industrial quarrying. Some of the alluvial nephrite that is and certainly was commonly collected from the Bridge River is likely derived from these sources, and the Bridge River almost certainly transports this material into the Fraser River. Again, indigenous collection of materials derived from these sources along streambeds, or the Bridge, Yalakom, or Fraser Rivers is highly probable.

South of the Shulaps Range in the Cadwallader Range, there are two further important *in situ* nephrite bedrock sources at D'Arcy at the west end of Anderson Lake, and at Noel Creek south of Gold Bridge at the west end of Carpenter Lake (Figure 2-7). The D'Arcy nephrite source has not been recently exploited to any degree (Leaming and Hudson 2005:18; Leaming 1978:28). This source appears to lie on the contact margin of a small ultramafic body and the Cayoosh Assemblage (Journeay and Monger 1994; Leaming 1978:21). The Noel Creek source was at one point a major producer, with records of over 500 metric tons extracted (MINFILE 092 JNE 118). The Noel Creek source appears to lie at the contact between the Bridge River Terrane and the Caldwallader Terrane (Journeay and Monger 1994). There are no reports of alluvial or 'float' nephrite in the vicinity of these locations, but some 'float' nephrite would be expected. As float nephrite appears to be comparatively rare around these two sources, I would expect a moderate to low probability of indigenous exploitation of these sources.

There are two well documented and two poorly documented *in situ* nephrite sources in the mountains on the west bank of the Mid-Fraser (see Figure 2-7). One is near the headwaters of Texas Creek/Molybdenite Creek (Leaming 1978:21). This source has not seen industrial scale quarrying. Another small *in situ* nephrite source is reported about 40 km further downstream the Fraser near the headwaters of Kwoiek Creek west of Lytton (Leaming 1978:21). While nephrite not has been quarried here on an industrial scale, vesuvianite, which according to Darwent (1998) is commonly misidentified as nephrite, occurs in large quantities here (Leaming 1978:21). Slightly further downstream, between Boston Bar and Spuzzum there are two further poorly documented *in situ* sources of nephrite also associated with the Kwoiek fault. Although the geology is discontinuous, both the Kwoiek Creek/Skihist, and the Texas Creek sources are found at the contact margins of the Bridge River Terrane (sedimentary) and the Scuzzy Pluton (ultramafic) (Journeay and Monger 1994). Nephrite from these four sources would almost certainly be carried downhill by alluvial or colluvial processes and enter the Fraser River system. If this material was transported via alluvial action in any quantities, it would probably have been collected and utilized in the past.

There is one final known source of *in situ* nephrite on the Coquihalla River about 20 km east of Hope, just 100 m south of the Coquihalla Highway (see Figure 2-7) (Leaming 1978:19; Monger 1989). This nephrite deposit occurs at the contact margin of the Bridge River Terrane (sedimentary) and the Methow Terrane (serpentinized ultramafics) (Journeay and Monger 1994). This source is located near Sowaqua Creek and was encountered during highway construction in the early 1980's. In the following seasons following its discovery, this source was completely mined out. Previous to the complete quarrying of this source, float nephrite on the Coquihalla River was perhaps more plentiful, while now it is found only very rarely. This material would have been carried down the Coquihalla River and entered the Fraser River near Hope. Given the proximity of this source to the Lower Fraser Valley with archaeological sites containing large numbers of nephrite tools, it is possible that this source was heavily utilized in the past.

Finally, there are unconfirmed reports of a nephrite source on the east side of Harrison Lake near Cogburn Creek (Leaming 1978: 20). Here, the Bridge River Terrane (sedimentary) contacts the Spuzzum Pluton (ultramafic), thus providing the appropriate conditions for nephrite formation (Journeay and Monger 1994). If nephrite does occur at this location, it would be the most proximate location within British Columbia to the major centers of prehistoric nephrite tool use near the mouth of the Fraser River.

Fraser River Gravels. With regards to the context of aboriginal procurement of nephrite toolstone, the exact *in situ* location of sources is probably not particularly relevant. I suggest that the primary contexts of indigenous nephrite collection were the gravel bars of the Fraser River rather than bedrock or colluvial sources. I state this with some confidence as all of the 131 sawn boulders/cobbles/pebbles I have analyzed have some portion of cortex that is consistent with alluvial transport (i.e., rounding and smoothing). And, as described above, most nephrite from Southern B.C. sources ends up being carried downstream in the Fraser River. Mackie (1995:46) provides an excellent account of the distribution of nephrite in the gravels of the Fraser River and much of this discussion overlaps considerably and inevitably with his.

First, most of the *in situ* sources of nephrite in this region are located at elevations approaching 2000 m in very rough terrain. Hell Creek is apparently named so in reference to its particularly rugged terrain (G. Vanderwolf, Personal Communication, 2008). At such high elevations, bedrock is usually only exposed for a month or two every year around August, and occasionally remains snow covered throughout the year (*ibid*). George Vanderwolf describes himself as nearly dying of hypothermia while staking the Hell Creek claim (~2200 m) during a blizzard in the late summer (Tenove 2005). Once the nephrite deposit has been located, it needs to be cut out of the bedrock using a diamond saw. Due to its extreme toughness, modern diamond saws can only cut nephrite at a rate of about a half meter per hour. I suspect that prehistoric indigenous technology would have been practically useless for extracting bedrock nephrite. If prehistoric peoples could extract nephrite from the bedrock, or collect colluvial or float material in the immediate vicinity, there remains the daunting problem of transporting it back home. Some of these sources are so remote even today that helicopter and horseback are the only options for carrying out nephrite (Leaming and Hudson 2005; G. Vanderwolf, Personal Communication, 2008). If prehistoric people did carry nephrite out of the alpine zone on their backs, it was probably only in limited quantities.

Second, the Fraser is a very powerful river and has the ability to transport very large boulders and cobbles considerable distances. The terminus of most gravel in the Fraser River is in the vicinity of Chillwack (Leaming 1978). Beyond this point, the Fraser River only has enough force to transport sand and silt (see Smith and Ferguson 1995). The annual Fraser River flood cycles seasonally deposit nephrite boulders and cobbles along the gravel bars of the Mid-Fraser, the Fraser Canyon, terminating in the Chilliwack gravels (see Church and Jones 1982). However, the distribution of alluvial nephrite from Lillooet to Chilliwack is by no means uniform in terms of the quantity or size of nephrite boulders, cobbles and pebbles.

Alluvial nephrite is most common and occurs in the largest clast sizes most proximate to *in situ* or bedrock outcrops. Near the major *in situ* nephrite sources along the Bridge and Yalakom rivers, where nephrite miners extracted hundreds of tons of nephrite per year at the peak of their operations (Leaming 1978; Leaming and Hudson 2005), alluvial boulders individually weighing from 10-20 tons were occasionally located. An example of such massive alluvial boulders can be seen in the Academic Quadrangle pond at Simon Fraser University – a 6 ton nephrite boulder from Hell Creek (Leaming and Hudson 2003:24). Smaller, and more manageable, nephrite boulders (~2-10 kg) and cobbles were also relatively plentiful along the Bridge, Yalakom and Fraser Rivers in the vicinity of Lillooet and Lytton. All reports agree that while alluvial nephrite can occasionally be found from Lytton to Hope, it is much less frequently encountered than from Lillooet to Lytton (Emmons 1923; Leaming 1978). There is, or was, an *in situ* nephrite source on the Coquilhalla River about 20 km upstream from Hope, and alluvial nephrite from this source likely could also have been procured along the banks and gravel bars of the Coquilhalla and around Hope. Nephrite is much more rarely found around Chilliwack than it is farther upstream, and the size of the cobbles or pebbles is much smaller than further up the Fraser River (Leaming 1978). Leaming (1978:19) describes such deposits of alluvial nephrite as typically being neither abundant nor very large, and "(g)enerally, the largest boulders are found farthest from Lillooet" (21).

At periods of low water levels, especially between October and April, the gravel bars along the Fraser River would be exposed to the greatest extent, and freshly deposited nephrite could be procured (Environment Canada 2009; Morrison et al. 2008). Note that contrary to opinions held amongst many archaeologists, this is not coincidental with the late summer sockeye salmon fishery. Rather this is coincident with the period of winter sedentism in large villages practiced by all groups along the Mid-Fraser and Fraser Canyon during the Late Prehistoric Period (3500 B.P. to contact). Such winter villages are invariably located with 3 km, and usually much closer, to the Fraser River, and short mid-winter excursions from these villages down to the Fraser gravel bars would have been by far the most cost-effective way to procure nephrite toolstone.

Another important reason to believe that nephrite toolstone was procured from the Fraser gravels rather than *in situ* sources is the Fraser's ability to naturally 'test' the quality of the material. When quarrying bedrock nephrite, a rather high percentage of the material is discarded because of flaws, fissures and other impurities (Leaming 1978). Such imperfections would have also made such nephrite useless for making celts. Nephrite or any stone washed down the Fraser River is continually sandblasted, bumped and battered many thousands of times during its journey. Because nephrite is far tougher than nearly every other rock in the world, rocks of pure flawless nephrite are gently rounded and polished by this process and can be transported hundreds of kilometers (see also Beck 1984 for New Zealand). Flawed and imperfect nephrite transported by the Fraser River will break apart much more rapidly. This is the reason that so many of the alluvial boulders collected along the Fraser River are of such exceptionally high quality material (Leaming 1978). The sandblasting of nephrite boulders by the sands suspended in the Fraser River remove any oxidized cortex from nephrite, making it readily identifiable (Leaming 1978:19). Of the prehistorically sawn nephrite boulders I have examined, all that display cortex are consistent with such alluvial transport. Thus, I think the gravel beds of the Fraser River would have been by far the most attractive locations for past peoples to collect nephrite celt stone.

The Fraser River from the Bridge River in the north to the Chilliwack River in the south has hundreds or thousands of gravel bars of various sizes. The larger of these gravel bars are named, such as Boston Bar, Sailor's Bar, and American Bar (see Forsythe and Dickson 2007: 37; Hudson 2006: 162-3). In the Mid-Fraser and Fraser Canyon sections, these bars are relatively permanent due to the highly entrenched nature of the Fraser River there. Further downstream, approximately from Hope to Chilliwack, the large gravel bars are probably more dynamic and occasionally form moderate sized islands within the river. All of these gravel bars would be seasonally modified by floodwaters and would have new boulders and cobbles deposited on them. With regards to nephrite occurrences, alluvial cobbles and boulders are more common and larger upstream towards the Bridge River, and smaller and less common downstream towards Chilliwack (Leaming 1978). The areas richest in alluvial nephrite – from Lillooet to Hope – have been set aside as a 'jade preserve' by the provincial government and alluvial nephrite can be quarried by anyone. No stakes or claims can be made on gravel bars within this preserve (Hudson 2006:162). I propose these alluvial sources of nephrite would have been the primary contexts for indigenous quarrying of nephrite toolstone in the Pacific Northwest.

A single local rock hound (Arn Homelin, Personal Communication, 2011) with several decades experience looking for nephrite on the Fraser River has provided me with the most detailed description of how to locate alluvial nephrite in Fraser River gravel bars. As this is the most precise and detailed description of procuring alluvial nephrite that I have encountered, I report his comments here in some detail. Homelin, (Personal Communication, .2011) has collected nephrite on many Fraser River gravel bars, but has spent most of his effort on bars around Hope and Yale, and has found the bars around Hope to have generally been the most productive. While he could not comment on the general abundance or average size of nephrite in general areas of the Fraser (beyond his favorite bar at Hope), he did note that his largest find was at Kanaka Bar (downstream from Lytton), where he recovered a nephrite boulder weighing about 100 kg. When specifically questioned regarding gravel bars between Lytton and Lillooet, Homelin (Personal Communication, 2011) indicated that there were few bars in this region (likely due to the steepness of the topography), but that those regions were generally viewed as 'rich' in alluvial nephrite. The following two paragraphs briefly describe some of Homelin's (pers. comm. 2011) strategies and tricks for successfully identifying alluvial nephrite in the Fraser River.

First, nephrite occurs on both the 'high bars' (those commonly above the water level) and the 'low bars' (those that are usually inundated), but is more plentiful and larger on the 'low bars'. This is the case for two reasons: 1) nephrite is dense and is not transported by the Fraser as readily as other rocks of comparable size, and 2) the 'high bars' are scoured more often by rock collectors than the 'low bars'. Additionally, knowledge of the anatomy of individual gravel bars is important for identifying the most likely place to find nephrite. Alluvial nephrite is most often found at the upstream side (or top end) of such bars, at the transition zone between alluvial deposits of larger and smaller clasts (rocks). Nephrite and other dense rocks are preferentially deposited on the 'river side' of these transition zones, while less dense rocks are deposited on the 'outside' margin of these transition lines. The best strategy to locate nephrite is then to literally crawl on ones knees along these transition zones on the 'top end' of these grave bars.

The Fraser River carries a considerable quantity of suspended sand, clay and silt, as evinced by its brown 'chocolate milk' color. As the Fraser River water levels recede towards winter, the rocks in the gravel bars are covered by perhaps millimeter-thick fine coating of brown clay-silt. This greatly impairs visual identification of any rocks. As the fall-winter rains become more incessant, this layer of clay-silt begins to wash off of these rocks. Because of the smooth and finely polished cortex on alluvial nephrite (from natural sandblasting in the Fraser) compared to other rocks, the clay-silt layer washes off it somewhat earlier than off of the other rocks. Therefore if one times one's search for alluvial nephrite with the onset of the rainy season correctly, you can increase your probability of locating nephrite by closely inspecting all rocks that are washed clean by the rain. Homelin (Personal Communication, 2011) suggests that it takes approximately three years of experience to be able to 'read' the gravel bars and identify alluvial nephrite with any level of success.

The terraces immediately adjacent to the banks of the Fraser River are also composed of materials washed down the Fraser system. These terraces were specifically targeted by early placer miners looking for gold from about A.D.1858 to about 1900. Using techniques perfected in the California gold fields, American and Chinese miners systematically washed and sorted millions of tons of such sediments along the Fraser (Forsythe and Dickson 2007:27-69; Kennedy 2008). Green rocks were ignored by the Californian miners, but were recognized as jade by acute Chinese miners and were apparently smuggled back to China in coffins with deceased countrymen (Hudson 2006: 92). While nephrite can be recovered from these large gravel terraces, it is unlikely that these deposits were utilized to any significant degree before contact. Overall, I have seen more visual diversity in the nephrites from the Lillooet locality alone than in any other nephrite bearing region in the Pacific Northwest.

Glaciers

The present distribution of quaternary materials (sediments such as gravels, silts, and glacial tills) near the surface and the rocks found within such deposits in British Columbia is largely not the result of slow steady processes. Rather the dominant factor behind the distribution of such materials is punctuated by past glacial activity. During the Pleistocene, most of British Columbia, and all of the nephrite bearing regions therein were heavily glaciated by the Cordilleran Ice Sheet (Clague 1989; Clague and James 2002; Clague et al. 1980). Such ice sheets and melt waters derived from them transported and deposited enormous quantities of gravels, silts, sands throughout B.C. and Washington (Clague 1989a; Clague and James 2002). The movement of such ice sheets is complex and was occasionally marked by reversals in direction (Clague 1989), but generally the direction of such flows was away from the high elevation mountains of the Canadian Cordillera. The nephrite deposits near the peaks of the Shulaps and Caldwader Ranges west of Lillooet for example would have experienced intense glacial scouring and nephrite bearing rocks would have become dislodged and embedded in massive glaciers slowly flowing downhill. From this location, the glaciers and embedded nephrite may have flowed west towards the coast, east towards the interior, or southwards through the Fraser Canyon, depending on the height of adjacent glaciers (Clague 1989). Because of the extreme toughness of nephrite compared to almost all other rocks, it would be more likely to survive complete disintegration before being deposited by glacial action. For these reasons, glacially transported nephrite from the alpine sources in Southern British Columbia could potentially occur as small 'erratics' many hundreds of kilometers from the *in situ* source. In particular, 'float' nephrite found on Orcas, Vashon and Whidbey Islands in Puget Sound is probably derived from *in situ* sources in B.C. that was transported to Puget Sound with the 'Puget Lobe' extension of the Cordilleran Ice Sheet around 17, 000 B.P. (Porter and Swanson 1998). It is presently unclear how much nephrite throughout British Columbia and Washington was redistributed through glacial activity, and how often such secondarily deposited material was utilized in the past.

Washington State

Washington State contains has both *in situ* bedrock and Quaternary (fluvial, colluvial or glacially derived) or 'float' deposits of nephrite. Leaming and Hudson (2005:79) report four *in situ* deposits: Mount Higgins and Helena Ridge near Darrington, Cultus Mountain near Mt. Vernon, and at Mount Stuart about 100 km east of Seattle (see Figure 2-8). Some of these sources have been quarried on an industrial scale, removing up to five tons of nephrite (Leaming and Hudson 2005:79). Float nephrite is reported from Orcas, Vashon and Whidbey Islands, along the Nooksack, Skagit, and Stillaguamish Rivers, around Deer Creek near Oso, and around Darrington (Ames and Maschner 1999:171; J. Aylor, Personal Communication, 2009; Leaming and Hudson 2005: 79; B. Meirendorf, Personal Communication, 2009) (see Figure 2-8). Harlan Smith (1907:368) reported finding nephrite cobbles and boulders on the beach at Mareitta, and indicated that this material looked similar to the nephrite he was familiar with from Lytton.

Briefly, this float nephrite is probably derived from glacial transport during the Pleistocene (Porter and Swanson 1998). George Mustoe indicated to me (Personal Communication, 2009) that this float nephrite appears to be eroding from Late Pleistocene deposits. Leaming suggests that it was deposited there by the Fraser River (Leaming and Hudson 2005:79). Both the Nooksack and Skagit Rivers may have *in situ* bedrock nephrite sources within their drainages that are carried downstream by fluvial transport (J. Aylor, Personal Communication, 2009). All of the sources above were potentially available for indigenous quarrying or collection for tool production. George Mustoe indicated to me (Personal Communication, 2009) that Washington nephrite is greenish black, uniform in texture, and visually very different from the nephrites that are found in the Fraser River gravel bars around Hope.

While I have much less data for Washington State than for British Columbia, it appears that the indigenous use of nephrite is very similar or identical to much of Southern B.C. and is essentially a part of the same Salishan nephrite working tradition or industry. Briefly, small nephrite celts are recovered from shell midden contexts from the San Juan Islands, the Southern Salish Sea, and Puget Sound – albeit at a much lower recovery rate than in the Gulf Islands, Southeastern Vancouver Island, and the Lower Fraser River. Larger nephrite celts rare, but occasionally recovered from mortuary contexts along the Mid- and Upper reaches of the Columbia River in eastern Washington (M. Collins, Personal Communication, 2009; Darwent 1998). Again, these large celts appear are much more rare here than on the Canadian Plateau. Nephrite production debris (sawn cores, debitage and saws) is very rare but occurs in at least two sites in Washington. By way of comparison, there are numerous individual sites in British Columbia with more evidence of nephrite celt production than is evident in all of Washington State.

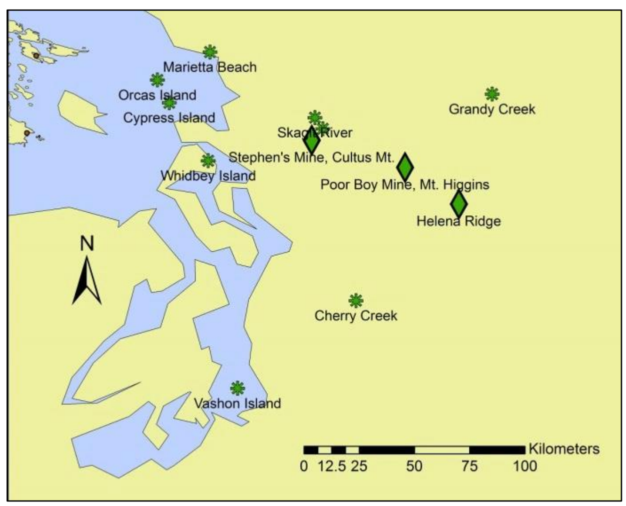

Figure 2-8. Nephrite sources in Washington State. Diamonds are *in situ* nephrite sources, and asterisks are 'float' (colluvial or alluvial) nephrite sources.

Conclusion

This chapter presents a brief review of non-nephrite celt stones, and a detailed overview of the petrology and petrogenesis of nephrite in British Columbia and Washington State. It highlights the geological contexts of nephrite, and the processes that have transported nephrite since its formation. Particular attention is drawn to the potential and apparent precontact utilization of nephrite from various sources. Three major source areas are identified (Northern, Central, and Southern B.C.), each of which contain many discrete outcrops and secondary deposits of nephrite. Additional potential sources are also identified in Washington State, but the majority of the nephrite that occurs there may originate from B.C.

Most importantly, I argue that the gravel bars of the Fraser River from Lillooet to Chilliwack provided the most plentiful and reliable context for nephrite quarrying during the prehistoric period. Alluvial nephrite is both naturally 'tested' for flaws and is more readily accessible from winter village locations near the Fraser River. The fact that alluvial, rather than bedrock nephrite was utilized by indigenous peoples has both important cultural implications, and implications for carrying out a traditional 'sourcing' study of matching artifacts to bedrock sources. First, as indigenous utilization of individual quarries or outcrops was very unlikely, and the fact that alluvial nephrite is rather diffusely distributed, it is improbable that a group or person could readily 'own' or control access to this material. Further, it is probable that nephrite procurement would be carried out by individuals or small groups; as such procurement would require virtually no organization of labor. Second, as the cultural context for nephrite procurement was at secondary deposition locations (river gravels), geochemical matching of artifacts to bedrock sources would at best describe the natural distribution of nephrite in the Fraser River. Instead, such a sourcing study should emphasize the cultural context of acquisition and production, and thus attempt to correlate nephrite artifacts with alluvial nephrite, and especially alluvial nephrite with evidence of cultural use (e.g., saw marks) (see Morin 2012). This provides the foundation for understanding the prehistoric utilization of nephrite in the Pacific Northwest.

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