2 Nephrite

Nephrite is one of two minerals commonly referred to as jade. The other material, jadeite, is chemically unrelated to nephrite and has a completely different petrogenesis (Leaming 1978). In this chapter there will be a brief description of the physical and chemical properties of nephrite and its sources in British Columbia.

Chemical and Physical Properties

Nephrite is classified as a dense, compact, micro-fibrous form of tremolite-actinolite with the following chemical formula: ($Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$ (Fraser 1972:21; Leaming 1978:8). The specific gravity of nephrite averages between 2.97-2.99 and ranges between 2.95 - 3.04, depending on the source (Fraser 1972:43; Leaming 1978:7). In its purer forms, nephrite has randomly interlocked bundles of crystalline fibers that produce a characteristic 'nephritic' structure (Turner 1935 cited in Fraser 1972:21). These fiber bundles are the source of nephrite's strong physical characteristics (Brandt et al. 1973:731). When applying force to a piece of nephrite, the interwoven fiber bundles act to hinder breakage through increased fracture surface area and dispersion of fracture energy (Brandt et al. 1973:731). Nephrite does not break in a concoidal manner and fractures tend to be very irregular.

Nephrite is probably one of the best natural materials to use for groundstone cutting tools because it is both a hard and tough mineral. The estimated hardness of nephrite ranges between 6-6.5 on the Mho hardness scale (Turner 1935; Brandt et al. 1973). On polished surfaces, however, a range of 6.5-7 was recorded on some nephrite specimens (Fraser 1972:46-51) whereas values as low as 5-6 were also listed (Hurlbut 1973). Again, the toughness of nephrite, or its resistance to breakage, is also high (Brandt et al. 1973:729). When compared to other materials, such as jadeite, corundum, quartzite and quartz (Table 2.1), nephrite is clearly the most resistant material. Furthermore, in terms of crushing strength, nephrite has values greater than those for steel (Kolesnik 1970 cited in Leaming 1978:7). These qualities make nephrite an excellent material for the creation of stone tools because of the durability of its working edges.

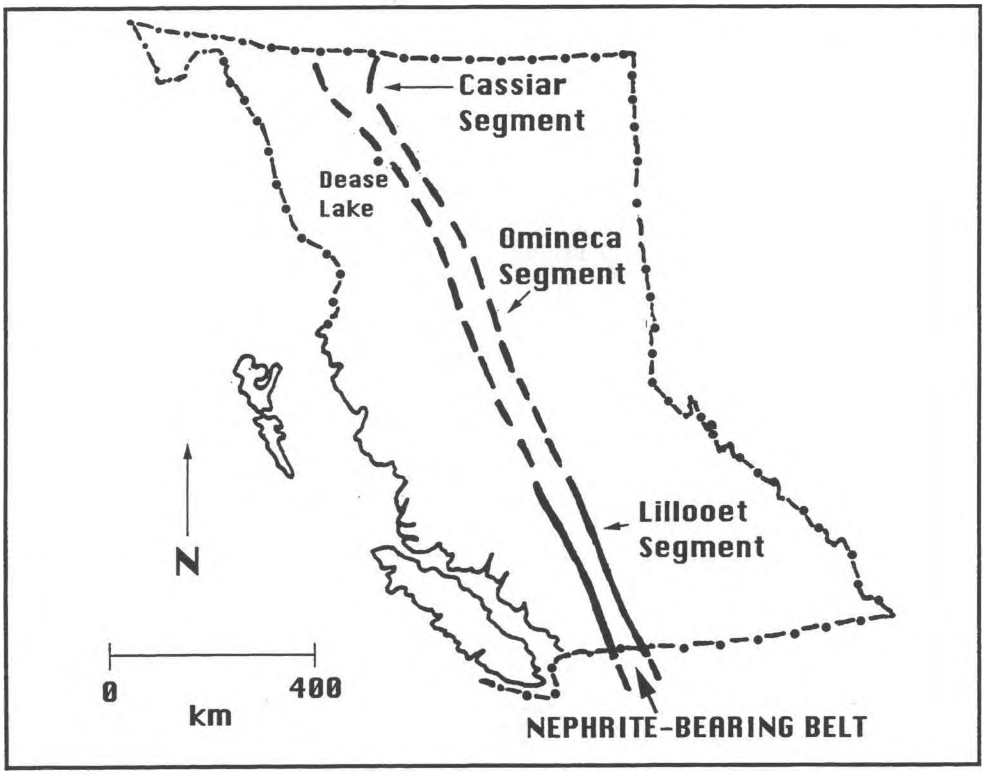
Nephrite is also a gem stone. In its higher grades, nephrite can be finely polished and is highly aesthetic. Nephrite is usually green in color but can take on black, white or purple hues (Fraser 1972:45-46; Leaming 1978:7). Impurities and variations in nephrite's mineral content often make it mottled in color. This variation can also affect the hardness and strength of nephrite specimens. For modern gemstone production and carving, nephrite appraisal involves assessing uniformity of color, structural soundness, translucency, hardness and the level to which a specimen can be polished (Leaming 1978:18). High grades of nephrite have uniform color, structural integrity, translucency, the ability to hold a high polish and have greater hardness. Lower grades are more mottled, highly fractured, opaque, less polishable and softer.

Sources in the Pacific Northwest and Adjacent Regions

Nephrite deposits occur in a number of locations in the Pacific Northwestern Region. The most accessible source of nephrite to prehistoric interior cultural groups occurs along the Fraser River in the area between Lillooet and Hope in southern British Columbia. Other nephrite bearing formations occur in Northern and Central British Columbia, Washington and Oregon. Peripheral to the Interior Culture area, nephrite appears in the Yukon, Alaska and Wyoming (Leaming 1978:55). Source locations of nephrite in these regions are described in this section..

Sources in British Columbia

The formation of nephrite deposits in British Columbia resulted from a metasomatic intrusion of serpentinites into Paleozoic deposits of greenstone, chert, pelite and limestone during tectonic events in the Mesozoic (Leaming 1978:18). In a band of ultra-mafic rock formations that begin in the Hope area, a belt of nephrite bearing rock stretches into the Yukon and Alaska (Figure 2.1; Fraser 1972:8; Leaming 1978:18-9). In British Columbia, three major segments of the belt contain sub-



stantial *in situ* deposits of nephrite: the Lillooet Segment, the Omineca Segment and the Cass iar segment.

The Lillooet Segment. The deposits in the Lillooet Segment (Figure 2.2) extend from Yakalom River, north of Lillooet, to the Coquihalla River near Hope (Leaming 1978:20). In the northern part of the segment, *in situ* deposits exist in the Shulap Mountain Range along Hell Creek, Hog Creek, Jim Creek and Blue Creek (Leaming 1978:25-27). In the Cadwallader range, Nephrite deposits are found along Noel Creek and Anderson Lake (Leaming 1978:27-8). Additionally, *in situ* nephrite formations out-crop along the "Horseshoe Bend" of the Bridge River and along the Ama and Applespring Creeks (Leaming 1978:21-2). In this area, large deposits of ultra-mafic rocks are present (Holland 1962; Fraser 1972; Leaming 1978:19-22). In the central part of the segment, *in situ* deposits appear along Texas Creek and in the Skihist area. In the south, *in situ* deposits occur near Harrison Lake on Cogburn Creek and the Coquihalla River.

Alluvial deposits of nephrite appear throughout the creeks and rivers of the Lillooet segment area (Holland 1962; Leaming 1978). These specimens range in size from small pebbles to 20 ton (18,200 kg) boulders (Holland 1962:121). Deposits of alluvial nephrite are particularly abundant in the area north of Lillooet because of the large number of *in situ* deposits in the Shulap and Cadwallader Ranges (Holland 1962:119). Alluvial pebbles also occur in the Hope area in the Fraser and the Coquihalla rivers, but are less extensive in quantity than in the north (Leaming 1978:19). Colluvial deposits of nephrite are also present in talus slopes in the Shulap Range (Leaming 1978:17).

Omineca Segment. The Omineca segment occurs in Central British Columbia (Figure 2.1). *In situ* deposits of nephrite are only found in a few locations in the Omineca segment and glacial action has transported some material considerable distances from any known source areas (Leaming 1978:29). The main nephrite bearing formations in the segment occur in the Mount Sidney Williams and Mount Ogden areas (Leaming 1978:28-29). Large deposits of alluvial and colluvial nephrite boulders are known in the Axegold Mountain Range.

Cassiar Segment. In the Cassiar Segment,

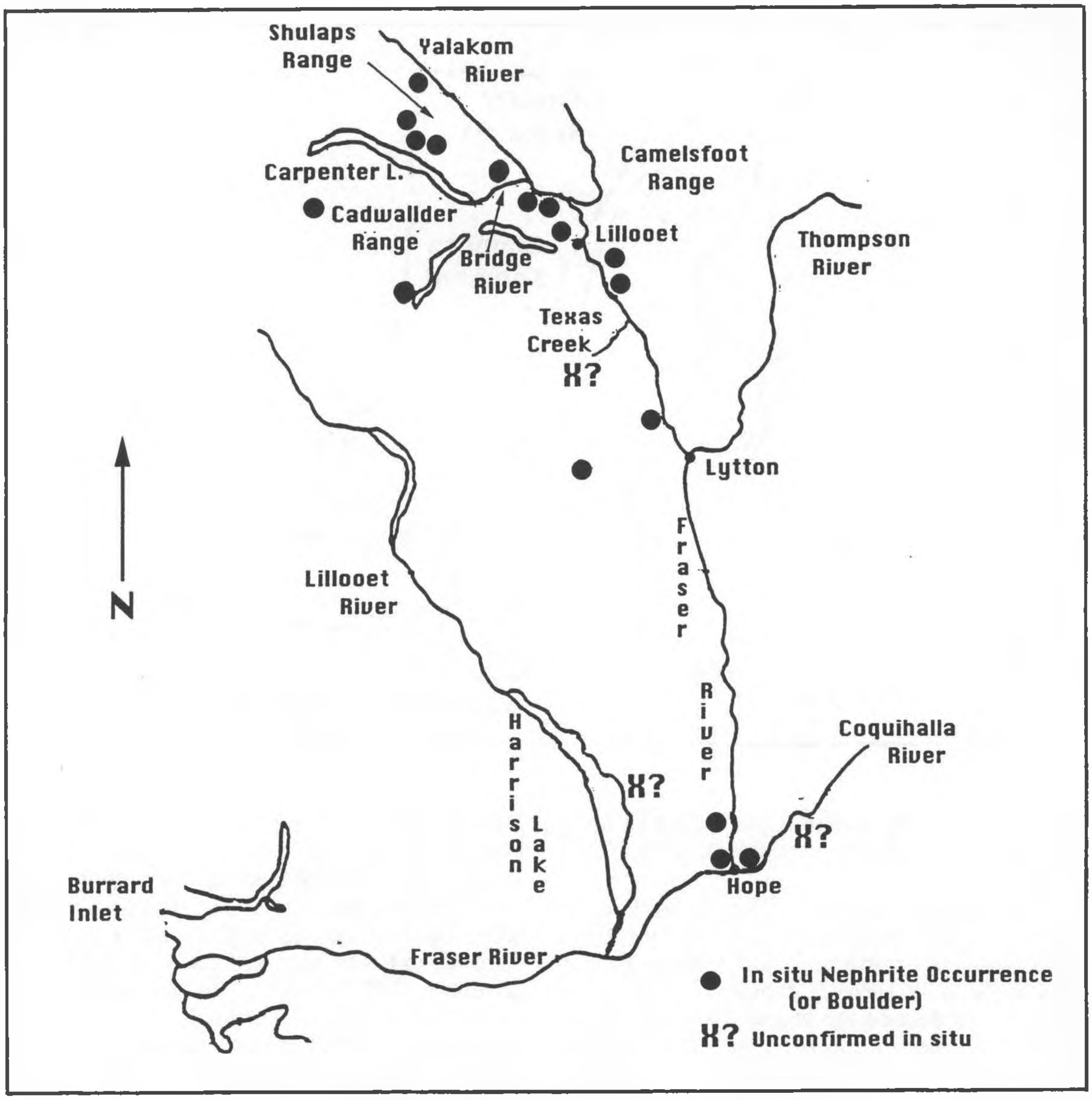


Figure 2.2. The Lillooet Segment (Modified from Leaming 1978:18).

extensive *in situ* nephrite deposits exist in the Cry Lake, Dease Lake, Wheaton Creek, King Mountain, Provencher Lake and McDame areas (Leaming 1978:33-5)

Yukon and Alaska Nephrite Sources

Nephrite deposits occur in several locations throughout the Yukon and Alaska. In the Yukon, deposits are principally in the Frances Lake area and may occur in other areas (Leaming 1978:39). In Alaska, nephrite occurs in the northwestern part of the state in the Upper Kobuk River area (Leaming 1978:55).

Washington and Oregon Sources

There are very limited nephrite deposits in Washington State including near Puget Sound in the Mount Higgins and Cultus Mountain areas (Leaming 1978:55). There is also a possibility of other sources of nephrite being in the Upper Skagit River drainage, because the British Columbia nephrite-bearing belt crosses into northern Washington (Leaming 1978:19). Other than these areas, there are no other locations in Washington State with known nephrite deposits (Galm 1994).

Nephrite deposits in Oregon are also very limited. Leaming (1978:35) cites only one example in the southeastern part of the state in Curry County and the possibility of other sources in additional areas.

Wyoming Sources

Wyoming is the only other location where nephrite could be obtained easily by interior groups. In south-central Wyoming alluvial deposits of metamorphic nephrite were abundant in early post-contact times (Leaming 1978:55).

Prehistoric Source Usage

The main type of nephrite source used prior to European contact was alluvial deposits of pebbles and cobbles. This is evident from artifacts and early records (Dawson 1887; Emmons 1923; Teit 1900). It is also quite possible that collection of suitable pieces also occurred on talus slopes and other colluvial deposits. Although important for modern commercial mining, the amount of effort needed to quarry *in situ* deposits probably deterred prehistoric use of such deposits. Modern mining of *in situ* jade deposits entails the use of explosives, large diamond saws, hydraulic wedges and heavy machinery (Fraser 1972:18; Leaming 1978:34). Most of the historic commercial nephrite mining in British Columbia, however, took place as part of the placer mining of alluvial gravels (Holland 1962; Fraser 1972).

For the purpose of this report, the alluvial deposits of nephrite in the northern and central Lillooet Segment will be considered to be the prime source of nephrite for prehistoric Interior Plateau groups. This is primarily based on the lack of any other centrally located source and the lack of ethnographic information relating to the import trade of nephrite from the Yukon or Wyoming. As will be discussed in Chapter 3, ethnographic informants reported that prehistoric nephrite gathering primarily occurred in the rivers and creeks of the Lillooet segment.

Although deposits of nephrite exist in Washington, their distant location and small size would probably preclude them from being utilized by Plateau occupants. The location of the deposits near Puget Sound makes them more accessible to coastal populations than to interior groups, and is unlikely to have been a significant source for British Columbia.

Although the Omineca and Cassiar segments are major focuses of the modern nephrite industry in British Columbia, their prehistoric exploitation is unknown. These areas were traditionally occupied by Athapaskan speakers and early ethnographic work among these groups does not indicate nephrite was used, processed, mined or traded historically (Morice 1897). The ultra-mafic deposits associated with the Omineca Segment border on the northern extent of the Canadian Plateau cultural sub-area (Richards and Rousseau 1987:3). It is thus possible that alluvial and glacial deposits of nephrite were available to northern Plateau groups. As will be discussed in a future section, however, very few nephrite artifacts have been recovered in archaeological excavations north of Kamloops. This probably indicates that use of Omineca nephrite was limited and it will be assumed that its contribution was negligible to the overall Plateau distribution of the material. The Cassiar segment, being farther north, is even more removed from contact with the plateau culture area. Northern Coastal groups probably utilized this segment for their nephrite requirements (Emmons 1923:18) but interior exploitation or distribution is unlikely.

It is almost impossible to determine the precise source areas within the Lillooet Segment from which prehistoric artifacts were derived because of the large number of possible *in situ* origins for alluvial nephrite deposits. The physical toughness of nephrite creates a problem for source identification. Thus, because of the distance cobbles of nephrite can be transported before disintegrating, boulders from a number of sources can accumulate in one placer deposit. To complicate this, specimens from any *in situ* location within the Lillooet segment usually appear virtually the same in color and structure -- including in thin sections (Holland 1962:123). The only practical method to finding the source of nephrite in the area would be to define chemical 'fingerprints' unique to particular *in situ* locations (Erle Nelson, 1994: personal communication). The value of this type of study, however, would be limited because it still would not identify the exact locations where alluvial cobbles could be collected. Geographically, the source of nephrite for the study will encompass the area along the Fraser River between the Big Dog Mountain on the Yalakom River to the end of the plateau culture area south of Lytton. Although nephrite deposits do occur in the Hope area, the historic and ethnographic associations of this region are more closely tied to

Table 2.1 Comparison of Hardness and Toughness Values for Various Stone Minerals.

	Hardness	Fracture Surface Energy (ergs/cm2)	Fracture Toughness Kc (dyne cm-3/2)	
Nephrite	6 - 6.5	226,000	77 x 107	Brandt et al. 1973
Jadeite	6.5 - 7	121,000	71 x 107	"
Hornblende	5-6	-	34 x 107	Wu et al. 1990
Glass	5.5	5,000	7 x 107	Wiederhorn 1969 *
Quartzite	7	4,320	7 x 107	Wiederhorn 1969 *
Quartz	7	1,030	5 x 107	Brace & Walsh 1962*
Corundum	9	600	7 x 107	Wiederhorn 1969 *

* Cited in Brandt et al. 1973

the coast (Richards and Rousseau 1987:21; Von Krogh 1980). It is more likely that nephrite from this locality would be distributed to the Coast rather than through the almost impassable Fraser Canyon.

Alternate Materials to Nephrite

Materials other than nephrite were also used for groundstone tools in the interior. The following section will briefly review some of the possible alternative materials that could have been used for groundstone celts.

Serpentine. Serpentine is often mistaken as a form of jade. As a related form of rock, serpentine frequently occurs in the same geological locations as nephrite and in greater quantity (Holland 1962:125). Due to its green color, serpentine is often brought home erroneously as jade by novice rock-hounds. Serpentine ranges between 2.5-4 on the Mho Hardness scale and has a specific gravity between 2.5 and 2.8 (Foshag 1957:32). It does not have a 'nephritic' texture and will not polish to the same degree as jade. Serpentine is a very common rock type and occurs in many different locations throughout the province of British Columbia (Holland 1962:125).

Greenstone. Greenstone is a "general field term for fine grained, chloritic, altered volcanic rocks." (Leaming 1978:54) On the Central Coast, greenstone is the predominate type of (Damkjar 1981; Philip Hobler 1994: personal communication) stone used for celt production where sources of the material exist in the Bella Coola Valley. Other sources of greenstone appear in the Shulap Ranges and are common in other areas of the Fraser Valley in the Carrier area of the plateau (Leaming 1978:22).

In New Zealand, the term greenstone describes a whole series of rock types that include both nephrite and serpentine (Beck 1970:20).

Jadeite. Jadeite is the other material referred to as jade. Jadeite originates in different geological contexts than nephrite and is "in general . . . a tough, hard, heavy, equigranular aggregate of prismatic pyroxene crystals" (Leaming 1978:4). As a material, jadeite is harder than nephrite but has less fracture toughness (i.e., it is more brittle (Brandt et al. 1973). It has long been used in other areas of the world for groundstone (see Digby 1972; Foshag 1957; Hansford 1968; Huang 1992; Leighton 1989,1992).

The chances of jadeite being used by prehistoric interior groups are negligible. In British Columbia, jadeite only occurs in the northwestern section of the province in the Pinchi Lake area (Patterson 1973 cited in Leaming 1978). Other locations in the Pacific Northwest where jadeite deposits exist include the Yukon and California (Leaming 1978:55).

Vesuvianite. Vesuvianite is a material that can be mistaken for jadeite because of a similar specific gravity, and it has some surficial and physical characteristics similar to jade (Holland 1962:121). It is often green in color and relatively hard (Foshag 1957). It also has a greater specific gravity than nephrite that ranges between 3.35-3.45. A source of the material is located on Kwoiek Creek in the Lillooet segment (Holland 1962:121). There is the possibility that some celts identified as being made of jade could be manufactured from this material.