Rocks of the Graham Creek Suite crop out in series of tectonic lenses less than 2 kilometres wide within a northwest-trending belt extending from Atlin Mountain to Sunday Peak (Figure 6-1). This belt probably extends northward beyond the area mapped (cf. Hart and Orchard, 1996). Lithologic components include tectonized harzburgite, gabbro and pillow basalt that have a consistent spatial association. Usage of this nomenclature is, however, restricted to areas where rocks of the suite are bounded to the east by the Peninsula Mountain or Windy-Table suites. Their western extent is mainly coincident with the probable northern continuation of the Nahlin fault from where it is well defined in the southern Atlin map sheet (104N; Aitken, 1959). Graham Creek rocks are probably correlative with the Atlin Complex, but they are discussed separately here to underscore the possibility that they are potentially an unrelated ‘oceanic crustal assemblage’ that forms basement to the Whitehorse Trough. Internal stratigraphic continuity, only a moderate degree of internal deformation (exemplified by the well preserved pillow basalts), and an upper contact that is possibly gradational with overlying Laberge Group lithologies, serve to distinguish this package of rocks from the Atlin Complex elsewhere in the map area. Exact relations with adjacent strata are obscured due to the complex structural setting and poor exposure.

Figure 6-1. Distribution of the Graham Creek Igneous suite in the Tugish area.

Figure 6-2. Stylized facies interrelationships between the Graham Creek Igneous and Peninsula Mountain suites.
Rocks of this suite were named by Mihalynuk and Mountjoy (1990). Bultman (1979) recognized a gabbro body on the southwest flank of Table Mountain (see Figures 2-1, GM97-1), but otherwise included these rocks with his Peninsula Mountain Formation. Early reconnaissance mapping by Cairns (1911) shows parts of the belt and correlates the rocks with the now obsolete Perkins Group which was thought to range from Devonian to Jura-Cretaceous age.

**Tectonized Harzburgite and Serpentinite, MTGu**

Tectonized harzburgite and serpentinite are fanned along the western margin of the Graham Creek Suite (Figure GM97-1) where they apparently occupy the lowest structural position within it (Figure 6-2). Immediately to the west are wackes that, on the basis of field criteria, are indistinguishable from those of the Laberge Group.

Generally, harzburgites are intensely listwanitized to produce a rock consisting of quartz, iron and magnesium carbonate and mariposite (chrome mica). Such rocks weather a distinctive bright orange colour and have a hackly surface (Photo 6-1) with quartz and carbonate veins standing above the surrounding weathered carbonate matrix. Thin, irregular stringers (< 0.5 cm) have a random orientation, but straight quartz veins greater than about 0.5 centimetre thick may display an orientation that is typically at high angles to the bounding contacts of the harzburgite bodies. Other than these veins, no regular secondary fabric is developed within the harzburgite, but foliated cataclasites are developed at the faulted margins of these bodies (Photo 6-2c). Locally a pervasive internal fabric is preserved. This is thought to represent an early metamorphic fabric of mantle origin as described in the harzburgites near Atlin by Ash and Arksey (1990b, Photo 6b). Mantle tectonite fabrics are best preserved on the southern flank of Sunday Peak in rocks that are pyroxene rich (80%) and surprisingly fresh (Photo 6-3). Olivine is
generally replaced by serpentine (typically antigorite). Serpentinite forms lenses up to tens of metres long. Protoliths may be pods or tectonic slivers of dunite. Such pods are bright green and sparsely or non-vegetated. Chrysotile veinlets up to 1 centimetre thick, but normally less than 3 mm, crosscut the serpentinite; these account for less than 3% of the rock volume.

Varitextured gabbro and pillow basalt, MTGg

Cairnes (1913) and Bultman (1979) mapped medium-grained gabbro that crops out on the southwest flank of Table Mountain. Its rubbly outcrops are extensively altered to a chlorite - actinolite - prehnite (Photo 6-4)- calcite - biotite (or stilpnomelane?) assemblage and are crosscut by microfaults. Locally, pillow basalt relics are preserved within the gabbro. These are crosscut and assimilated by gabbro. On the eastern edge of the unit pillow basalt is well preserved (Photo 6-5).

Gabbro is comprised mainly of plagioclase (55%, andesine composition) with interstitial hornblende (40%, actinolite-altered). Plagioclase is relatively fresh with minor patches of prehnite, actinolite and chlorite alteration. In contrast to the mafic phases of the Fourth of July batholith, it contains only sparse apatite (euhedral, <1%) and no appreciable sphene.

Some fine-grained zones resemble mafic volcanics and may be disrupted flows or breccias. Gabbro may represent the slowly cooled interiors of massive flow units, or alternatively, dikes or sills within a basaltic sequence.

Massive pillow basalt is interbedded with pillow breccia. Both units are rubbly weathering and, where not covered by lichen, caramel coloured. Fresh surfaces are black with a bluish green tint. Microscopic examination shows the rocks are dominated by quenched feldspar in a devitrified groundmass and pyroxene is accessory (Photo 6-6). Metamorphic grade is subgreenschist with abun-

Photo 6-3. Photomicrographs showing (Left) the relatively unaltered state of harzburgites (here a pyroxene-rich portion) from Sunday Peak. Height represents 2.5mm of sample MMI91-21.5a. (Right) Relicts of a single pyroxene crystal (Px) in a matrix of serpentine(Srp) and tremolite (Tr). Scale: height represents approximately 2.5 mm of sample MMI91-7-3.
dant prehnite and rare pumpellyite as the most common authigenic minerals.

In Graham Creek valley, the southernmost outcrops of pillow basalt occur among outcrops of chert, cherty wackes, chert breccia and quartzose wackes. This mixed unit grades into pillow breccia with sparse, interlayered wacke. The zone could be a tectonic rather than a stratigraphic feature, but it is gradational in nature. Furthermore, the composition of wackes within the zone suggest derivation from Peninsula Mountain volcanics, requiring that the volcanic source rocks were not too far removed. Mixing of lithologies at the base of the pillow basalt unit may be the result of debris flow or fault scarp deposition. That major structural contacts exist within adjacent lithologies is unarguable as a significant fault zone crops out in cherty wackes in Graham Creek valley about 2.5 kilometres above its mouth, and there is definitely a fault contact, 5 kilometres northwest, between the harzburgite lenses and both porphyritic intrusions and sediments.

Geochemical signature

Rare earth element (REE) analyses indicate that pillow basalt and gabbro of the Graham Creek Suite are typi-

![Photo 6-4](image_url) Photomicrograph of gabbro east of Graham Creek is less altered than normal. It shows relatively pristine plagioclase (Pl) and hornblende (Hbl). Interstices are altered to Prehnite (Prh). Long dimension represents 2.5mm of sample MMI89-21-4.

![Photo 6-5](image_url) Pillow basalts of the Graham Creek Igneous Suite.

![Photo 6-6](image_url) Photomicrograph of plane polarized light view of quench feldspar growth in pillow basalt.

cal mid-ocean ridge basalts (MORB; Figure 6-3a). On the Zr-Zr/Y, Ti/100-Zr-Sr/2 and Ti/100-Ar-Y*3 plots (Figures 6b, c, d) the samples overlap or plot in fields of overlap between MORB and island arc basalts. However, the Ti-Cr diagram is designed to discriminate between island arc (low potassium) tholeiite and ocean floor basalt and the samples clearly fall within the latter field.

The MORB signature of Graham Creek suite basalt is consistent with the association with tectonized harzburgite. It is also consistent with REE data from the
Figure 6-3. Geochemistry of Graham Creek suite basalt: (a) normal MORB normalized rare earth element plot of samples from widely separated areas shows that they are MORB; (b) Zr-Y discrimination plot following the method of Pearce and Norry (1979) shows that the samples plot in the zone of overlap between MORB and island arc basalts; (c, d) trivariate plots of Ti/100-Zr-Sr/2 or Y*3 follow the method of Pearce and Cann (1973) and show that the samples plot in either ocean floor or low K (island arc) tholeiite fields; (e) Ti-Cr plot following the method of Pearce (1975) is used to discriminate between ocean floor and low K (island arc) tholeiites. Samples of this study clearly fall within the ocean floor field.
Atlin Complex near Atlin (Ash, 1994). However, MORB signatures from accreted oceanic terranes are relatively rare. An explanation for this has been that it is mechanically more feasible to obduct young, buoyant, supra-subduction zone oceanic crust (SSZ), than it is to obduct mature oceanic crust generated at a mid-ocean ridge (Dewey, 1976). A fundamental contribution of the Ocean Drilling Program within the last decade has been the recognition of non-accretionary forearcs as the best modern analog for the origin of large ophiolites (Bloomer et al., 1995). After initiation of a subduction zone, infant arc volcanism with exceptionally high production rates (equivalent to slow spreading ridges) replaces thinned, pre-existing oceanic crust during formation of a supra-subduction zone ophiolite (Figure 6-4). Thus, both MORB and depleted volcanic arc chemistry can be expected.

Age, Correlations and Tectonic Significance

Original structural and stratigraphic relationships between the Graham Creek suite and both the Cache Creek Complex and the Peninsula Mountain suite are difficult to establish. Syndepositional faulting, original facies complexities, Late Cretaceous and Early Eocene volcanic cover, intrusions of Jurassic to Eocene age, and late structural deformation all obscure original contact relationships. There are, however, lithologic ties between these three assemblages.

All major lithologies within the Graham Creek suite have potential correlative within the Atlin Complex. Associations of bedded chert, pillow basalt and quartzose wacke are recognized in the Kedahda Formation in the Carcross area (Hart and Pelletier, 1989a). Graham Creek gabbros are lithologically equivalent to the distinctive Nakina Formation, and particularly resemble the Conrad Member in southern Yukon (Hart and Radloff, 1990) which also displays the dual character of both hypabyssal intrusive and extrusive breccia. Interbedded chert and wacke occur in the Cache Creek Terrane near Atlin (see under Wacke in Chapter 5) and are also reported northwest of Dease Lake, in the French Range, where Norian chert is interbedded with hornblende-bearing wackes compositionally similar to the Lewes River Group (Mon- ger, 1969). Arguments against correlation include a lack of dated strata within the Graham Creek suite that are older than Middle Triassic, and a total lack of massive carbonate, a hallmark of the Atlin complex.

Linkages between the Graham Creek suite and the Peninsula Mountain suite are based upon: the occurrence of wacke with clasts derived from the Peninsula Mountain volcanics and also chert with pillow basalt clasts; an apparent upward transition from pillow basalt to hyaloclastite to subaerial volcanics of the Peninsula Mountain suite sensu stricto; the occurrence of pillow basalt and interbedded chert overlain directly by coarse intermediate to felsic pyroclastics (near Ear Mountain); and conglomeratic rocks at the base of the Peninsula Mountain succession that appear to be at least in part derived from the Graham Creek suite lithologies.

One possible explanation for the occurrence of the Graham Creek Suite is that it is part of a small, juvenile basin in which Laberge sedimentation was localized. If this was the case, a juvenile crustal REE signature would be expected in these rocks. In fact, samples from this suite that have been analyzed thus far display good MORB signatures - unusual, but not unexpected, in ophiolitic assemblages which normally show a supra-subduction zone signature as noted above. Basalts of the Atlin complex
display the same MORB signature (C. Ash, personal communication, 1998).

Temporal and lithologic ties between the Atlin Complex, the Graham Creek Suite and the Peninsula Mountain suite suggest that these tectonic elements were loosely associated by Late Triassic time. Contacts between them are disrupted and equivocal, probably reflecting a period of amalgamation that outlasted the Middle to Late Triassic and the initial juxtaposition of these lithologic suites.

On a regional scale, lithologic packages including the Peninsula Mountain suite and the Graham Creek suite resemble huge, fault-bounded lenses. However, the preservation of stratigraphic linkages between them suggests that the magnitude of displacement at their contacts is relatively small (i.e. less than tens of kilometres). Displacements between them and the Atlin Complex could, on the other hand, be much greater. It is possible that the Graham Creek suite represents old oceanic crust atop which the Peninsula Mountain suite was built in a forearc setting. Unfortunately, attempts at geochemical discrimination of the Peninsula Mountain suite (see next section) have led to inconclusive results. More work on geochemical characterization and isotopic age dating of both suites are necessary before more confident paleogeographic associations can be made.

**Mineral Potential**

Key elements of mesothermal gold belts are mantle-derived ultramafite and deep-rooted structures of crustal scale. The Graham Creek Suite, bounded by strands of the Nahlin fault, contains both of these elements. Graham Creek area is the westmost occurrence of ultramafic oceanic crustal rocks in the map area, and Graham Creek placer gravels mark the westernmost limit of the Atlin placer camp. However, relative to the immediate Atlin area, little placer production is recorded.

Although no lode occurrences are known from areas underlain by the Graham Creek rocks, an ultramafic association is supported by the presence of chromite (of presumed ultramafite origin) in auriferous heavy mineral concentrates from Graham Creek (S.B. Ballantyne, personal communication, 1989; see also Chapter 14). However, in ultramafites underlying the headwaters of more economically important streams of the central Atlin placer camp, no producing lode deposits have been discovered to date. Perhaps the large amount of placer gold near Atlin indicates a fully exhumed source area. Small amounts of placer gold in Graham Creek indicates either a largely uneroded lode source or one that was not well mineralized. Further exploration will be required to test these alternatives and the potential for mesothermal gold deposits in the Graham Creek area.