Rocks of the Tagish Lake area record a long and complex geologic history. Sedimentation, volcanism, intrusion, deformation, metamorphism, mineralization, uplift and erosional events of various ages and extents were interwoven to produce the landscape seen today. Not all rocks of the same age are affected equally, and in a reaffirmation of the Terrane concept, Paleozoic rocks of the Yukon-Tanana and Cache Creek Terranes display disparate histories. On the other hand, Mesozoic strata conventionally thought to define the Stikine Terrane (ST; Stuhini and Laberge Groups) record a younger deformational history that shares some deformational events with the older terranes. Perhaps these Mesozoic strata should not be considered the Stikine Terrane fingerprint (see Chapter 8). To complicate matters further, the geologic histories recorded in the area vary not only between Terranes, but also according to structural level within Terranes. For example, brittle to ductile fabrics recorded within the Llewellyn-Tally-Ho fault system display this structural dichotomy well (see Chapter 13 and below). A synopsis of this geologic tapestry is shown schematically in the time-space-event chart of Figure TC-1 (in pocket).

Little data within the map area constrains the pre-Devonian history. Lisel Currie at Carleton University initiated a doctoral study under the auspices of this project with the goal of unraveling this early history. The Tagish area study focused on the Mesozoic and younger events which can be resolved by contemporary field mapping techniques.

The discussion that follows presents a west to east time-slice approach in describing the geologic history and explains footnote references on Figure TC-1. In order to limit discussion of Cordilleran-wide implications of the local geologic history presented here, a model-dependent approach is taken. The evolutionary model for the architecture of the northern Canadian Cordillera largely follows that detailed in Mihalynuk et al. (1994c). According to this model, orocline processes dominated the Mesozoic evolution of the Tagish area. A synopsis of this model is presented in Figure 15-1e to f. An extension of the model to incorporate the possible pre-Devonian origins of the Nisling assemblage is presented in Figure 15-1a. Stage names and absolute time scale references, adapted from Harland et al. (1990), are shown on Figure TC-1.

**Pre-Devonian**

The oldest strata in the map area are protoliths of the Florence Range metamorphic suite (Currie, 1990; part of the Nisling assemblage, Mortensen, 1992). These were probably deposited in a passive continental margin setting (Wheeler and McFeely, 1991) during Upper Proterozoic to Cambrian time. A predominance of quartz-rich clastic rocks suggests derivation from cratonic sources to the east, a contention supported (but not proven) by detrital zircon studies (Gehrels et al., 1991a, b; Mortensen, 1992). Detrital zircon U-Pb upper intercept ages are 2.17 to 2.2 Ga (Gehrels et al., 1989; Aleinikoff et al., 1981), and Nd and Sm-Nd model ages are between 2.09 and 2.4 Ga (Aleinikoff et al., 1990; McCulloch and Wasserburg, 1978; Samson et al., 1989). Thick carbonate layers are extensive, but there are no coexisting evaporites; this suggests deposition in a relatively shallow, open sea, but probably not in a sabkha-type environment such as is generally associated with intracontinental rift settings. Metamorphism destroyed any stromatolitic or delicate clastic structures that may once have been present. Hornblende-rich gneisses probably represent mafic dikes, sills and/or flows related to rifting or later magmatic events, however, geochemical data needed to test this suggestion are lacking.

**Regional Relations and Problems**

A lack of confirmed pre-Devonian oceanic crustal rocks supports the interpretation that deposition was on attenuated, but not isolated fragments of ensimatic crust (Figure 15-1a), analogous to the model proposed by Struik (1987). Pre-Devonian strata probably have miogeoclinal correlatives on cratonic North America: Upper Proterozoic quartz-rich clastic sediments, limestone, mafic flows and tuffs of the Windermere supergroup (Tempelman-Kluit, 1976); Eocambrian quartz-feldspathic grits and upper limestone of the Gog Group; and Cambrian to Devonian passive continental margin strata exposed in the Rocky Mountains. There are, to date, no direct indications of rocks as old as the middle Proterozoic Purcell Supergroup in the Tagish area. An indirect indication of protolith ages near the youngest limit of known Purcell strata is an 1150 Ma Rb-Sr model age (Werner, 1977), but lithologies of the samples analyzed are unlike those of the Purcell. This problem is not resolved; both oceanic crust and Purcell protoliths are notoriously difficult to date and, as a result,
Figure 15-1. Tectonic model time slices depicting the evolution of the Intermontane arc complex. See text for details.
may not yet have been recognized. Isotopic dating of detrital zircons is another approach to the protolith age problem. So far, however, none of the detrital zircon studies have isolated rocks that consistently yield zircons exclusively older than 1 Ga, the young limit of Purcell strata deposition.

Details of the pre-Devonian period are obscured by later deformation, metamorphism and intrusion. Only vestiges of this potentially long history have been recognized in the Tagish area, and those mainly through indirect isotopic dating techniques. Mortensen (1992) and Currie (1992) dated orthogneiss bodies within these old strata that are of Late Devonian and Early Mississippian age and establish a minimum age for deposition of the host rock protoliths. Further isotopic and perhaps geochemical characterization and careful search and study of relict protolith textures are required in order to distinguish component parts of Nisling assemblage rocks and enable correlation with strata deposited on the craton.

**Mineral potential considerations**

Correlative para-autochthonous strata of the North American miogeocline host economically important, and in some instances huge, sedimentary exhalative lead, zinc, silver deposits. Examples of these include the world class Sullivan (middle Proterozoic), Faro (Cambro-Ordovician) and Howard’s Pass (Early Silurian) deposits. To date only minor indications of lead-zinc-silver mineralization have been found within the Nisling assemblage (near the Nelson Lake occurrence 104M019) and Boundary Ranges suite rocks of the Tagish area (e.g. Big Thing, 104M071), and neither of these are classified as sedimentary exhalative. The Tagish area has not been seriously prospected for this type of deposit but comprehensive regional geochemical data to help delineate prospective regions have recently become available (Jackaman and Matyszek, 1993) and this offers an exploration opportunity.

**Devono-Mississippian**

Strata of this age are represented by the Boundary Ranges metamorphic suite, orthogneiss bodies within the older Nisling assemblage, and Early Mississippian oceanic crustal rocks within the Cache Creek Terrane.

Hallmarks of the Stikine Terrane in this time interval are Middle to Late Devonian carbonates and compositionally variable volcanic rocks (Anderson, 1989; Figure 15-1b), and widespread, Late? Mississippian micritic to platformal carbonates (Monger, 1977a; Figure 15-1c). These rocks were in part deposited flanking a fragment of old miogeocline, the Nisling assemblage, and may be partly incorporated in the Yukon-Tanana Terrane as the Boundary Ranges suite (Figure 15-1b, and following).

The oldest dated elements of the Cache Creek Terrane are Lower Mississippian carbonates of the “western facies belt” of the Atlin Terrane (Monger, 1975). These rocks were presumably deposited on an igneous oceanic crustal package now represented in part by basalts of the Nakina Formation and tectonized ultramafites (Monger, 1975). Not all parts of Nakina Formation shown on Figure GM97-1 are demonstrably correlative. Age data are almost completely lacking and some of the mafic and ultramafic units could be fragments of younger oceanic crustal material.

**Regional relations and problems**

Much of the margin of ancestral North America seems to have been affected by Devonian extension. During this event a continental sliver that appears to have been separated from ancestral North America formed in part the nucleus upon which an extraordinarily long-lived arc system developed. This feature is here termed the Intermontane arc complex (IAC).

Although the period is apparently dominated by extension, local compressional events are documented (e.g. Smith et al., 1993). Devono-Mississippian metaplutonic, metavolcanic and intercalated basin strata form a 340 to 370 million year old, continuous belt that extends 5000 km along the length of the Cordillera (Rubin et al., 1990). Currie (1994) reports that a granitic dike of Early Mississippian age cuts the Boundary Ranges suite in the Hobee Creek valley just outside of the map area (104M/1). Coeval felsic volcanic strata of apparent arc origin are reported in southern YTT (Mortensen, 1992). During this time, many granitoids were emplaced within the pericratonic strata (Mortenson, 1992) of the Kootenay and Yukon-Tanana Terranes.

Slide Mountain Terrane strata throughout central British Columbia and northwards to the Yukon probably developed in an extensional, back arc setting (Figure 15-1b, c; cf. Ferri, 1997). Syndepositional extension is recorded: grabens with clastic infillings, growth faults, exhalative deposits, rift-type alkalic volcanics (Nelson and Bradford, 1989) and intercalated felsic tuffs (Ferri and Melville, 1994) are examples. Miogeoclinal rocks are apparently affected by this same extensional event (Mortensen, 1982; Gordey et al., 1991) but lack a tuffaceous component. Several authors suggest that this lithologic arrangement indicates back-arc spreading (Ferri, 1997, and references therein). Local impingement of the arc on the North American miogeocline may explain predominantly compressional structures in areas such as the Kootenay arc of southeast British Columbia.

Boundary Ranges metamorphic suite rocks apparently correlate with parts of the Stikine Terrane. This is an extension of earlier ideas presented by Tempelman-Kluit (1976, 1979). Mortensen (1992) explicitly suggested such a correlation, and Currie (1992) presented isotopic
age data that strengthened this correlation in the Tagish area.

A problem with the proposed correlation is that carbonates, which are a conspicuous and commonly dominant constituent of the Stikine Terrane stratigraphy, are not as abundant within the Boundary Ranges suite. Difficulties also arise in distinguishing Stikine assemblage from non-Stikine parts of the Yukon-Tanana Terrane where the two have been juxtaposed then deformed and metamorphosed. In the Iskut area, McClelland (1992) reports Paleozoic Stikine strata resting unconformably on quartz-rich strata that probably correlate with older parts of the Yukon-Tanana Terrane. A similar relationship is reported in the Tulsequah area (Mihalynuk et al., 1994a). If this apparent relationship is correct then this is probably the oldest observed stratigraphic tie between the two terranes. It also supports isotopic data such as evolved Nd values (Jackson et al., 1991b) and old, inherited zircons (e.g. Sherlock et al., 1994) that indicate a spatially restricted older crustal component deep within the basement of northern Stikinia. Later, pre-Triassic deformation and metamorphism may have interleaved these strata to produce a composite terrane, the Yukon-Tanana Terrane. In light of this possibility, a more complete understanding of the evolution and composition of the Yukon-Tanana Terrane will require much more detailed geochronometric and isotopic characterization. Currently, one of the most productive avenues of inquiry is comparison of units that are less complexly metamorphosed, have relatively clear contact relations, and have been more fully characterized from an isotopic and geochemical standpoint, as for example, the work of J. Mortensen and others in the Yukon. Some sections of potentially correlative Yukon strata contain Paleozoic fossils (cf. Mortensen, 1992; Hart and Radloff, 1990) whereas most other sections are unfossiliferous.

Mineral potential considerations

As for pre-Devonian strata, Devono-Mississippian strata correlative with those of the North American miogeoclone host a spectrum of sedimentary-exhalative deposits. Cordilleran examples of these include the Stronsay, Jason and Tom deposits of the Earn Formation. Apparent restriction of this type of deposit to extensional environments in miogeoclinal and intracratonic basin settings (MacIntyre, 1992) may limit the possibility of finding deposits within accreted terranes west of the Cassiar platform. Instead, volcaniclastic massive sulphide deposits of Kuroko, Cypress and Besshi type are most important. For example, within Early Mississippian rocks of Stikinia, a variety of Kuroko-style deposits in the Tulsequah camp are now clearly established as syngenetic (Sherlock et al., 1994). In the Yukon, recently discovered volcanicogenic deposits that are of this age include the Kudz Ze Kayah, Wolverine and Frye Lake deposits, all within the Yukon-Tanana Terrane.

Numerous small podiform chromitite-nickel occurrences occur in ultramafic ophiolitic rocks of the Cache Creek Terrane, however, none discovered to date have been large enough to be of economic interest.

Pennsylvanian to Permian

Rocks of Pennsylvanian to Permian age are present in the map area, but their distribution is generally poorly constrained, except in the Cache Creek Terrane, where carbonate and pelagic sediments have yielded fossils representing most of the stages of these periods (Monger, 1975). The Early Permian is represented by the Wann River gneiss, which is believed to be metamorphosed mafic volcanic tuffs (Currie, 1994). However, the Mid-Permian volcanic and intrusive rocks which are part of an important magmatic pulse in the Yukon-Tanana Terrane of the Yukon, have yet to be recognized with certainty in the map area.

During the Pennsylvanian to Permian time interval the North American margin was probably oriented northeast-southwest with geologic elements in the Tagish area at about 30°N based on constraints provided by the paleotectonic reconstructions of Scotese et al. (1979).

Cache Creek sedimentation of this age is thought to have occurred mainly on well-oxygenated carbonate banks and shoals and locally restricted lagoons atop seamounts or oceanic plateaux (Monger et al., 1991). Chert and argillite were deposited on the flanks of the plateaux or on the adjacent abyssal plain. Yabeina fusilinids of Permian age indicate that carbonate deposition occurred within the Tethyan realm (Monger et al., 1972). Potentially uninterrupted fossiliferous carbonate and chert deposition occurred in a tectonically quiescent paleogeographic setting. Stratigraphic and fossil data indicate carbonate accumulation kept pace with slowly subsiding seamounts or plateaux (Monger, 1975). Consistent with this paleogeographic interpretation are rare earth element (REE) data from Cache Creek Terrane basalts that are either of MORB or ocean island character (C.H. Ash, personal communication, 1996). Near Graham Creek, the most westerly, and possibly the youngest oceanic crustal slivers include gabbro, disrupted basalt and serpentinized harzburgite tectonite. REE analyses of the Graham Creek basalts yield typical MORB patterns (Mihalynuk et al., 1991; see Chapter 6). Typical ophiolitic basalts do not have MORB REE signatures; they commonly display a supra-subduction zone signature. Thus, a geochemically isolated mid-oceanic ridge not coupled to a destructive plate margin is implied.

Tectonic settings are highly variable during this time interval. A period of magmatic quiescence spanned the Middle to Late Pennsylvanian. Limited Pennsylvanian and extensive Permian carbonate and quartz-rich or graphitic clastic sediments are depositionally interlayered...
with well-dated volcanic rocks in the Yukon-Tanana Terrane (Mortensen, 1992). Pelagic sedimentation dominated the Pennsylvanian to Permian deposition in the Slide Mountain basin and Quesnellia, although, in Quesnellia, small volumes of arc volcanics were deposited locally.

Early in this time interval, the Slide Mountain back arc basin continued to form behind an east-directed Quesnellian subduction zone. However, during earliest Permian time the subduction zone jumped to the foreland side of the Intermontane Arc Complex initiating consumption of the Slide Mountain basin (deformation within the Slide Mountain Terrane must have occurred by Early Permian because Harms (1986) describes a thrust plane that is cut by a 276 ± 16 Ma tonalite). Near the cusp of the arc complex, Permian subduction-related rocks with blueschist facies assemblages were emplaced along the inboard edge (Erdmer and Armstrong, 1988). Magmatism above a south-dipping Permian subduction zone was widespread in the Yukon-Tanana Terrane (Mortensen, 1992). Interpreted subduction polarity is based upon the position of the Permian magmatic front relative to the position of the high pressure rocks in the Yukon-Tanana Terrane that are dated at between 267 and 243 Ma (Erdmer and Armstrong, 1988).

A short, intraoceanic arc segment that may have been established on the Cache Creek oceanic crust in mid-Permian time is recorded by bimodal volcanism in both the French Range and Kutcho Formations, and in the Peninsula Mountain volcanic strata. In composition and setting these have analogues in the modern Izu-Bonin-Marianas forearc (e.g. Bloomer et al., 1995).

**Mineral potential considerations**

The only significant mineralizing event of this age in the Intermontane Arc Complex is the kuroko-style Kutcho Creek volcanogenic massive sulphide deposit. Zinc-lead-copper deposits in the Baldy and Bronson areas within metamorphic strata of the Yukon-Tanana Terrane in the Yukon may also be of this age.

**Lower to Middle Triassic**

Like the Pennsylvanian, few Lower to Middle Triassic rocks occur in the map area except within the Cache Creek Terrane. It also appears to be a time of subduction zone reconfiguration around the Intermontane Arc Complex (Figure 15-1f). Following the initial stage of collapse of the Slide Mountain basin due to east-verging contraction (Nelson, 1993) the subduction zone was re-established outboard of the Intermontane Arc Complex by Upper Triassic time (Figure 15-1e).

Middle Triassic (Ladinian) strata are common in the eastern Cache Creek Terrane (Jackson, 1992) and Mihalyruk and Mountjoy (1990) mapped deformed Middle to Upper Triassic chert bedded with quartz-rich wacke of the Peninsula Mountain suite. Chert and argillite of Lower to Middle Triassic age are regionally exposed in northern Stikinia in the Iskut area (Logan and Drobe, 1993; Logan et al., 1994), and Middle Triassic pelagic sediments are reported in the Quesnel Terrane in central and northern British Columbia (see Ferri, 1997). In the Yukon-Tanana Terrane, this time probably marks the end of a stage of ductile deformation that accompanied collision of the Cache Creek plateau with the Intermontane Arc Complex which caused initiation of rotation of Stikine Terrane and formation of the Intermontane Arc Complex orocline.

**Mineral potential considerations**

There is a little evidence for significant mineralization of this age.

**Upper Triassic**

Rocks in the Tagish area preserve a Late Triassic record that crosses terranes. This time slice is critical to our understanding of the Intermontane Arc Complex evolution. This time saw vigorous arc volcanism and plutonism in Stikinia that began in the Carnian and continued into the Late Norian. It is a time of loose terrane linkages: Nisling Assemblage with Stikine Terrane (Tempelman-Kluit, 1976; Bultman, 1979; Jackson et al., 1991b); Stikine Terrane with Cache Creek Terrane (Monger et al., 1992; Jackson, 1992); Cache Creek terrane with Quesnellia in southern British Columbia (Monger, 1984) and data in central and northern British Columbia that suggest probable Quesnellia - Slide Mountain ties (e.g. Ferri, 1997). Late Triassic magmatic rocks within the Intermontane Arc Complex host a variety of mineral deposits.

Arc strata of the Stuhini Group began to accumulate as early as the Carnian. These were deposited in a mainly submarine environment and were dominated by biadrate plagioclase and pyroxene-phryic pillow basalts and breccias and intercalated volcaniclastics, fetid carbonate and silty turbidites. The comagmatic, granitic to granodioritic Willison Bay pluton intruded to shallow levels and was chilled against these early Stuhini strata and a slightly older, comagmatic, foliated hornblende-pyroxene-rich gabbro. Both the gabbro and Willison Bay granite probably intruded along an old strand of the present Llewellyn fault. A moderate to locally strong synkinematic fabric in the gabbro may provide the oldest preserved evidence for movement along the Llewellyn fault. Although, emplacement of the intrusions may have been facilitated by the fault, the shape of the Willison Bay body does not show...
dissected by post-emplacement motion on the fault.

Dissection and exhumation of the Willson plutonic assemblage, and development of an extensive granite boulder conglomerate, which in part non-conformably overlies the pluton, demonstrates rapid uplift of the volcanic-plutonic arc complex. A return to fine clastic deposition and extrusion of pillow basalts records submergence of this part of the arc once again. Over 2000 metres of such submarine deposits accumulated. They consist of silty turbidites containing Carnian Halobia and pillow basalts with interpillow micrite from which Carnian conodonts have been recovered (Table AB2). A distinctive phreatomagmatic unit, which is overlain by quartz-rich epiclastic strata, hemitic tuff and intercalated carbonate marks a return to shallow water deposition. Capping the section are fossil poor, black to white, well to poorly-bedded carbonates of the Upper Norian Sinwa Formation.

Similar arc construction occurred in other parts of Stikinia and Quesnellia during this interval. In the Tulsequah area, Stuhini Group strata are particularly well exposed and are overlain by the type section of the Sinwa Formation. Details of arc architecture vary from place to place, since facies changes are common and rapid. In general, however, there is little difference between Upper Triassic sequences in the Quesnel and Stikine terrane segments of the Intermontane arc complex. Indeed, depositional character changes more along the strike of each of these arc segments than between the two. For example, both segments display a south to north transition from dominantly subalkaline volcanics to dominantly arc-derived clastics. This is illustrated in Stikinia by the transition from Stuhini Group volcanics in British Columbia to Lewes River Group clastics in the Yukon, and in Quesnellia by the transition from Nicola-Takla Group volcanics in southern and central British Columbia to Shonektaw Formation volcanics and finally Nazcha Formation arc clastics near the Yukon border (Gabrielse, 1969).

Within the Cache Creek Terrane Upper Triassic strata mark a change from dominantly pelagic to dominantly hemipelagic sedimentation. Abundant coarse clastics interbedded with chert provide clear evidence of the influence of extrabasinal sedimentary provenance. Granules to cobbles include quartz grains and plutonic clasts that are derived from Stuhini Group volcanics and comagmatic plutons of Stikinia (Jackson, 1992) and Shonektaw volcanic rocks of Quesnellia (Monger et al., 1991).

Evolution of the Intermontane Arc Complex at this time is interpreted to be dominated by continued closure of the Cache Creek ocean through orocline bending of the Quesnell-Stikine arc complex (Figure 15-1g). Structural and stratigraphic relations of rocks in the eastern and western parts of the Cache Creek Terrane suggest that they formed parts of a south-facing accretionary prism. Sediments ponded between the leading edges of thrust slices that constitute the accretionary prism may have been caught up in late movement that resulted in closely-spaced domains with contrasting structural styles, like those seen in the Graham Creek area. Deposition behind the forearc ridge probably occurred as a series of high-gradient submarine fans in an environment that persisted into the Jurassic and resulted in the reflection of east-flowing Laberge Group turbidites.

**Mineral potential considerations**

Upper Triassic rocks within the Stikine and Quesnell terranes host a variety of important deposit types. In the Late Triassic the most important of these are alkaline copper-gold porphyry deposits such as those at Copper Mountain, Afton and Mount Milligan and Cu-Mo±Au porphyry deposits like Brenda, Highland Valley and Stikine Copper. Volcanogenic massive sulphide deposits of this age include the Beshi-type Granduc deposit in Stikinia. No Upper Triassic deposits are known in the northern Cache Creek Terrane, and the restricted distribution of Upper Triassic Stuhini strata in the map area limit the potential for deposits of this age.

**Lower Jurassic**

Laberge Group clastic sedimentation spans most of the Lower Jurassic and is widespread in both the Cache Creek and Stikine Terranes in the Tagish area. These sediments mark a period of Stuhini arc dissection that occurs south of an interpreted orocline hinge zone within the Intermontane Arc Complex. Away from the hinge zone, in the Stikine and Quesnel segments, continued subduction of the Cache Creek Terrane (Figure 15-1g) resulted in a very voluminous pulse of calcalkaline magmatism: the Hazelton Group. Near the end of the Lower Jurassic, Quesnellia was emplaced against the margin of North America. Incipient emplacement of Quesnellia is well dated as 186 Ma (Early Jurassic) and rocks along the contact were metamorphosed and cooled by 181 Ma (Nixon et al., 1993).

Laberge Group strata presumably were deposited upon the Stuhini Group, yet no unequivocal contact with good age control has been found. North of Tutshi Lake, an apparently conformable contact exists between Sinwa Formation carbonates, that generally cap the Stuhini Group, and overlying argillite. This argillite is thought to be part of the lower Laberge Group, but no fossils have been recovered from it. Unfortunately, road construction obliterated the exposures reported by Mihalynuk and Rouse (1988a) in which the Sinwa-argillite contact was exposed. At most other localities a limestone cobble to boulder conglomerate occurs at the contact and oldest
fossils above the contact are Sinemurian. This suggests that the contact is generally an erosional unconformity.

Laberge Group strata were deposited as a series of high-gradient submarine fans (Dickie, 1989), probably in a forearc environment. In general, the strata coarsen upwards from dominantly argillite and siltstone of Sinemurian age at the base to wacke of Toarcian age at the top. Conglomerate sheets and lenses that occur at all stratigraphic positions contain Norian limestone cobbles as well as boulders of probable Upper Triassic granodiorite that resemble the Willison body. Local hornblende-rich sedimentary horizons may record unroofing of hornblende quartz diorite and granodiorite intrusions of the nearly coeval Aishihik plutonic suite and coeval volcanic rocks.

On the east side of the Whitehorse Trough, Laberge strata appear to grade imperceptibly downwards into wacke of Middle to Upper Triassic age. They probably onlapped a forearc ridge, and in places extended onto the fragmented oceanic plateau of the Cache Creek Terrane. Abundant slumps and intraformational conglomerate, as well as development of angular unconformities point to synsedimentary deformation at least as old as Sinemurian.

Intermediate to felsic volcanic flows and tuffs are believed to sit with stratigraphic continuity atop the Laberge strata, (Mihalynuk and Rouse, 1988a). Several hundred metres above the base of this unit is a thick conglomeratic horizon comprised of cobbles that are most likely derived from the Laberge Group. Considering that the youngest fossils obtained from the Laberge Group of the Tagish area are Toarcian, and that the volcanic strata appear to have been deposited rapidly, the volcanics are interpreted to be of Toarcian age. If this is true, then part of the Laberge basin was uplifted during the Toarcian to supply detritus for a conglomerate deposited atop it. Basin cannibalization may mark initiation of Whitehorse Trough collapse, interpreted as recording impingement of the inner and outer limbs of the Intermontane Arc Complex orocline. Interestingly, this timing corresponds to a sinistral, top-down-to-the-southwest fabric (Mihalynuk and Mountjoy, 1990) that was pervasively developed in the 185 ± 1 Ma (Currie, 1991) Hale Mountain granodiorite prior to the onset of brittle, dextral deformation at around 179 Ma (Table AA1) and peak metamorphism in the Florence Range metamorphic suite at around 177 Ma (Currie, 1994). Broadly synchronous ductile sinistral fabrics occur in the Tally-Ho shear zone in the Yukon (Hart and Radloff, 1990). Southwest-vergent motion of on the King Salmon thrust (e.g. Thorstad and Gabrielse, 1986) facilitated emplacement of the Cache Creek Terrane and formation of the clastic foredeep of the proto-Bowser Basin beginning in latest Toarcian to Aalenian time (Ricketts et al., 1992).

Southwest-vergent thrusts in front of the Cache Creek allochthon carried the western margin of the Laberge basin (and possibly parts of the basin floor and margin that consist of Peninsula Mountain volcanics and Graham Creek rocks) up and over Stuhini Group rocks and previously deformed Boundary Ranges and possibly Florence Ranges metamorphic strata (see Figure 13-8). Most of this overthrusting must have been restricted to the area south of Fantail Lake. Neither the 187 Ma hornblende at Teepe Peak nor the Boundary Ranges rocks in its thermal metamorphic halo appear to have been significantly involved in this event, in contrast to the strongly deformed 185 Ma Hale Mountain body a few tens of kilometres to the south. It appears that the Lower Jurassic overthrust may have been restricted to shallow crustal levels, mainly within the Laberge Group near the British Columbia - Yukon border. Thicker stacking, or stacking that involved deeper stratigraphic levels, might correspond to the limits of high pressure kyanite-bearing amphibolite-grade schists and gneisses of the Florence Range metamorphic suite, and may be genetically related. One possibility is that an accommodation zone between the King Salmon thrust and the Llewellyn fault may represent exposure of deep level rocks in the zone of transfer from overthrust to tear fault. Assuming that the King Salmon thrust follows the Sinwa Formation as it does in the Tulsequah area, it would merge with the Llewellyn Fault near the Engineer Mine. High pressure rocks of the Florence Range suite are limited to positions south of this juncture (see Structure for a complete discussion).

**Mineral potential considerations**

Assemblages of Early Jurassic age within the Intermontane Arc Complex are generally endowed with a broad range of arc-related mineral occurrences. Rocks of this age within the map area are, however, dominated by coarse, marine clastics of the Laberge Group. Since no syngenetic mineral occurrences are known within these rocks, they are not favourable exploration targets. Minor indications of synsedimentary volcanism do, however, point to potential for shallow hydrothermal deposits of Eskay type. There may be fault-related veins of this age, but none have been dated.

**Middle to Upper Jurassic**

Quesnel, Stikine and Cache Creek terranes were distinct tectonic elements separated by subduction or collision zones until Middle Jurassic time. The Middle Jurassic was a time of contractional deformation when Cordilleran terranes were assembled into their present relative longitudinal positions due to oroclinal collapse (Figure 15-1i). Quesnellia was thrust over the North American continental margin and the Cache Creek Terrane was emplaced over eastern Stikine Terrane. Sedimentation in the Cache Creek complex ceased prior to
Toarcian time at this latitude, but in the southern Cordilleran it continued into the Bajocian (Cordey et al., 1987). Plutons like the circa 177 Ma Bennett batholith (Mortensen and Hart, unpublished in Hart, 1995) and satellite bodies of the same age in the northern map area (Paddy Pass pluton, 176 Ma, Tables AA1, AA2) are only weakly foliated. Ductile deformation had all but ceased prior to emplacement of the 172 Ma, post-tectonic Fourth of July batholith, which pins the Cache Creek Terrane (Mihalynuk et al., 1992a). A metamorphic muscovite cooling age from the Boundary Ranges metamorphic suite also reveals a strong \( ^{40}\text{Ar}/^{39}\text{Ar} \) plateau at about 172 Ma (Smith and Mihalynuk, 1992).

Dextral motion dominates the major, long-lived structures, such as the Llewellyn and Teslin faults. In the Yukon-Tanana Terrane ductile deformation ceased at about this time, giving way to west-vergent brittle thrusting. A long period of cooling followed.

Within the map area, the Middle Jurassic also marks the termination of Laberge Group sedimentation. Both the Laberge Group and overlying Lower to Middle Jurassic volcanic strata were folded during the final stages of oroclinal collapse. Structural vergence in the deformed Laberge basin is mainly toward the west, but on its east margin vergence is locally eastward. Shortening in excess of 50 percent caused major synclines to be forced up and out of the Graham Inlet section (Figure GM97-1; see also Chapter 13).

In contrast, the Upper Jurassic was a period of relative tectonic quiescence - the beginning of a magmatic lull that persisted about 50 million years, through the Early Cretaceous. Perhaps this lull is equivalent to the time span required to rupture a new subduction zone outboard of the collapsed Intermontane Arc Complex, subduct the slab to a zone of melting below the new continental margin and deliver magma to the upper crust. In the case of the juvenile Izu-Bonin-Mariana arc, it appears that only 15 Ma elapsed between initiation of subduction and construction volcanic edifices that outline the arc (Bloomer et al., 1995), but only thin oceanic crust is involved. Plate velocity vectors for the time interval between 175 and 125 Ma display a strong convergence between North America and the Farallon oceanic plate (Engebretson et al., 1985). If this convergence is correct, a new subduction zone should have been rapidly established. The magmatic lull continues to be an enigma.

**Mineral potential considerations**

Late to post-orogenic mineralizing fluids related to lode gold mineralization have been well documented within the Atlin camp (Ash and Arksey, 1990a, b; Ash et al., 1992). Mineralization is coeval with the 172 Ma Fourth of July magmatism, which displays a mixed geochemical signature of syn-collisional and volcanic arc characters. No other mineralizing event within the Tagish area of this age are known. Although it is possible that auriferous veins at the Rupert and Ben-My-Chree occurrences are coeval, they are more likely related to metamorphic devolatilization of Early to Middle Jurassic age. Veins at the Engineer Mine could be of this age, but close association with Sloko Group volcanic strata suggests that they are coeval with Early Eocene volcanism. Regionally, significant deposits of this time period, such as the Golden Bear and Eskay Creek gold deposits, are situated in tectonic settings grossly similar to that of the map area.

**Cretaceous**

A magmatic lull affected most of the northern Cordilleran in the Early Cretaceous although the Mount Lawson pluton, with a cooling age of 133 Ma (K-Ar; Bultman, 1979), and a single Early Cretaceous pluton along the shores of south Tagish Lake dated at 127 Ma (U-Pb; Currie, 1994; Table AA5) appear to be exceptions. No strata of this age are known in the Tagish area.

By Late Cretaceous time both magmatism and strike-slip deformation were important. Strike-slip faults did not modify longitudinal terrane relationships significantly, however, their latitudinal positions may have been modified by hundreds of kilometres by mainly northward translation. Significant contractional deformation, like that recorded in the Bowser Basin (Evenchick, 1991, 1992), appears to be lacking in the Tagish area, although minor folding may have accompanied pluton emplacement (e.g. west of southern Tutshi Lake).

A widespread Early Cretaceous thermal event (Wilson et al., 1985; Pavlis et al., 1993) which has been attributed to uplift and unroofing of regional core complexes (Pavlis et al., 1993) set cooling ages in the Yukon-Tanana Terrane of Yukon and eastern Alaska. A 132 ±5 Ma K-Ar cooling age from sericite in the Llewellyn fault zone falls within the range of minimum \( ^{40}\text{Ar}/^{39}\text{Ar} \) cooling ages from Devonian-Mississippian orthogneisses exposed in core complexes in Alaska (Hansen et al., 1989; Hansen, 1990). However, evidence of a core complex in the Tagish area is lacking despite assumptions made early in the project that discovery of such evidence was highly probable.

Mid-Cretaceous magmatism is widespread in the Yukon and includes what may be the world’s largest collection of highly radiogenic plutons (Armstrong, 1988). These S-type granites are presumably the product of melting at mid-crustal levels in response to tectonic loading during the Middle Jurassic compressional event. This is well illustrated by intrusions inboard of the eroded edge of the Anvil-Nisutlin allochthon, where the plutons are concentrated in the thickest accumulations of pre-Cretaceous strata. Depositional thickening is partic-
ularly well displayed by the Devonian sequence (Fritz, et al., 1991).

Magmatism was renewed with vigor in Late Cretaceous time as a result of subduction beneath the new western Cordilleran margin. The oldest related plutons in the Tagish area are part of the 111 to 109 Ma Whitehorse magmatic epoch that is well dated north of the British Columbia border (Hart, 1994; Table AA5). These plutons are associated with copper + iron skarns (Tenney, 1980) developed in carbonate of the Upper Triassic Lewes River Group (Stuhini equivalent).

High-level plutons and coeval volcanic rocks with ages of about 83 Ma are the first widespread suite of Cretaceous magmatic rocks in the Tagish area. These intrusions are part of the Windy-Table intrusive suite and include small dioritic plutons that intrude the Whitehorse Trough and miarolitic and porphyritic quartz monzonite and alaskite of the Surprise Lake batholith that intrude western Atlin complex. Geochemically, the Surprise Lake batholith is an A or S-type granite (see section 14-12) with elevated tin, tungsten, fluorine, rubidium and unusual development of wrigglite (tin) skarn (Webster and Ray, 1992), but it lacks muscovite (Mihalynuk et al., 1992a). The batholith displays a slightly elevated initial strontium ratio of 0.706 calculated from a steep, two point isochron that is sensitive to small errors. This ratio may reflect the incorporation of some older, radiogenic crust, perhaps the edge of continental crust in the subsurface. However, when the initial strontium ratio is back calculated from the U-Pb age, it is geologically unreasonable, indicating isotopic disturbance. Thus, the unusual chemistry of the Surprise Lake body may be due to protracted cooling or refusion during a regional hydrothermal event and not crustal contamination (Mihalynuk et al., 1992a; see Chapter 12).

Volcanic rocks of this age are tilted and offset across minor and major faults, such as the Llewellyn and Nahlin faults. Closely spaced cleavage or even weak foliation is developed locally. However, no offsets greater than a few kilometres have been demonstrated. Regional cooling of the area between the Llewellyn and Nahlin faults to below 90°C followed this pulse of magmatism with final annealing of apatite fission tracks at about 50 Ma (Donelick, 1988).

**Mineral potential considerations**

Mainly high angle brittle faults of this age, with or without dextral offset, are common and may have provided conduits for mineralizing fluids. Widespread Late Cretaceous magmatism holds potential for regionally important hydrothermal events, and many of the meso- and epithermal veins and fault-related veins within the Tagish area may be Late Cretaceous or younger. Precious metal gold-silver-base metal sulphide veins of the Venus Mine and arsenical veins of the Ben claim group may be of this age. The setting of the copper-rich calcsilicate skarn at the Mill showing is similar to that of deposits of the Whitehorse Copper belt. It is hosted in Upper Triassic calcareous sediments of the Stuhini Group adjacent to the Late Cretaceous Jack Peak pluton (dated as 89.5 Ma ±2.6 Ma; K-Ar biotite may be reset; Bultman, 1979).

**Tertiary**

A spectacular widespread period of intermediate to felsic magmatism heralded onset of the Tertiary. Volcanic centres are particularly well displayed, each with intrusive and extrusive components. At 58.5 Ma a weakly foliated felsic volcanic unit was deposited adjacent to the Llewellyn fault near eastern Skelly Lake (Figure 11-1). At 56-55 Ma voluminous outpourings of Sloko Group volcanics blanketed the Tagish area; coeval semi-circular granitic plutons mark volcanic centres or the magmatic roots of Sloko volcanoes in the Coast Belt. At 54-53 Ma calderas along the east side of the Coast Belt were formed, including the Bennett and Skukum complexes. The huge volume of coeval plutonic rocks that dominate the Coast Belt is an anomaly of global scale. Plutonic emplacement in the Coast Belt occurred mainly in belts which young to the west at this latitude (e.g. Brew and Morrell, 1983).

Structures of this age are mainly high-angle and brittle. North-northwest to north-northeast-trending dike swarms probably fed the Sloko volcanic fields. Late, northeast to east-west-trending steep structures may in part be synvolcanic block faults that localized deposition of Sloko Group volcanic strata. Some of these faults appear to have focused mineralization - as between Atlin Lake and Tulsequah (Smith and Mihalynuk, 1992) and others are outlined by the loci of shallow, recent earthquakes (e.g. Brew et al., 1991) as in the Tulsequah area. However, most faults appear to be later, mainly vertical adjustments across major and minor fault strands (e.g. Llewellyn and Nahlin faults) that may have controlled epithermal deposition. Offsets of this age are generally less than a few hundred metres. The 55 ± 2 Ma Pennington Pluton (Hart, 1994) plugs the main strand of the Llewellyn fault; it is only locally affected by brittle deformation and shows no apparent offset.

Elevated crustal heat flow resulted in static Buchan-style, sillimanite-grade metamorphic overprinting of high P-T metamorphism within the Yukon-Tanana Terrane of the Coast Belt. Cooling to below 90°C mainly occurred in the 20 Ma following this magmatic pulse (50 to 30 Ma; Donelick, 1988).

**Mineral potential considerations**

Epithermal mineral potential of Sloko and related volcanic systems is well demonstrated by auriferous
veins at the Mt. Skukum deposit. Ore formation at the Engineer Mine is probably also of this age. Of historical importance, mineral deposits of this age will remain key exploration targets.