# Lower to Middle Jurassic stratigraphy, ammonoid fauna and sedimentary history of the Laberge Group in the Fish Lake syncline, northern Whitehorse Trough, Yukon, Canada

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## ABSTRACT

The Upper Triassic to Middle Jurassic Whitehorse Trough is a 500-km-long forearc basin developed on the eastern margin of the Stikine Terrane. Basin fill in the Fish Lake syncline consists of Early to Middle Jurassic strata of the Laberge Group. Re-examined fossil collections record all ammonite zones from the Upper Pliensbachian to lowest Bajocian (except for the recessive or volcanic Aalenian Stage), suggesting that the Laberge Group is a conformable sequence. Biostratigraphic dating of oldest conglomerates indicates that source area uplift occurred first in the north in the Early Pliensbachian, progressing southwards through the Late Pliensbachian. Periodic, basin-wide anoxia was prevalent during the Middle and Late Toarcian, indicated by abundant *Bositra*, a low-oxygen-tolerant bivalve. The final stage of basin-fill, Early Bajocian chert-pebble conglomerates, provides a maximum age constraint on the amalgamation of the Cache Creek and Stikine terranes.

## RÉSUMÉ

La bassin de Whitehorse, qui date du Trias supérieur au Jurassique moyen, est un bassin d'avant-arc de 500 km de longueur qui s'est formé sur la marge est du terrane de Stikine. Le synclinal de Fish Lake contient des strates du Groupe de Laberge datant du Jurassique précoce à moyen. Les collections de fossiles que l'on a réexaminées indiquent la présence de toutes les zones à ammonites du Pliensbachien supérieur au Bajocien basal (à l'exception de l'étage récessif ou volcanique aalénien), ce qui suggère que le Groupe de Laberge est une séquence conforme. La datation biostratigraphique des plus anciens conglomérats indique que le soulèvement régional a commencé au nord, pendant le Pliensbachien précoce, et qu'il a progressé vers le sud au cours du Pliensbachien tardif. Il y a eu anoxie périodique sur tout le bassin pendant le Toarcien moyen et le Toarcien tardif, comme l'indique l'abondance de Bositra, lamellibranches qui vivaient dans des eaux pauvres en oxygène. Des conglomérats à cailloux de chert, qui se sont déposés lors de la dernière étape de remplissage du bassin au Bajocien précoce, fournissent une limite d'âge maximale pour le fusionnement des terranes de Cache Creek et de Stikine.

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# INTRODUCTION

The Whitehorse Trough is a 500-km-long forearc basin on the eastern margin of the Stikine Terrane (Fig. 1) that was an active depocentre from the Late Triassic through Middle Jurassic (Hart, 1997). The Jurassic basin fill of the Laberge Group records a critical time in the evolution of the Whitehorse Trough and can be used to examine tectonic and environmental events affecting both the basin and the Stikine Terrane.

Previous sedimentological work (e.g., Wheeler, 1961) was conducted before the development of a precise North American ammonite biozonation. Hart and Radloff (1990) produced a refined geological study of the region in the context of modern plate tectonics, but did not update ammonite identifications. The biostratigraphy of the Laberge Group was investigated by Pálfy and Hart (1995) based on new fossil collections, but most previously collected specimens were not re-examined.

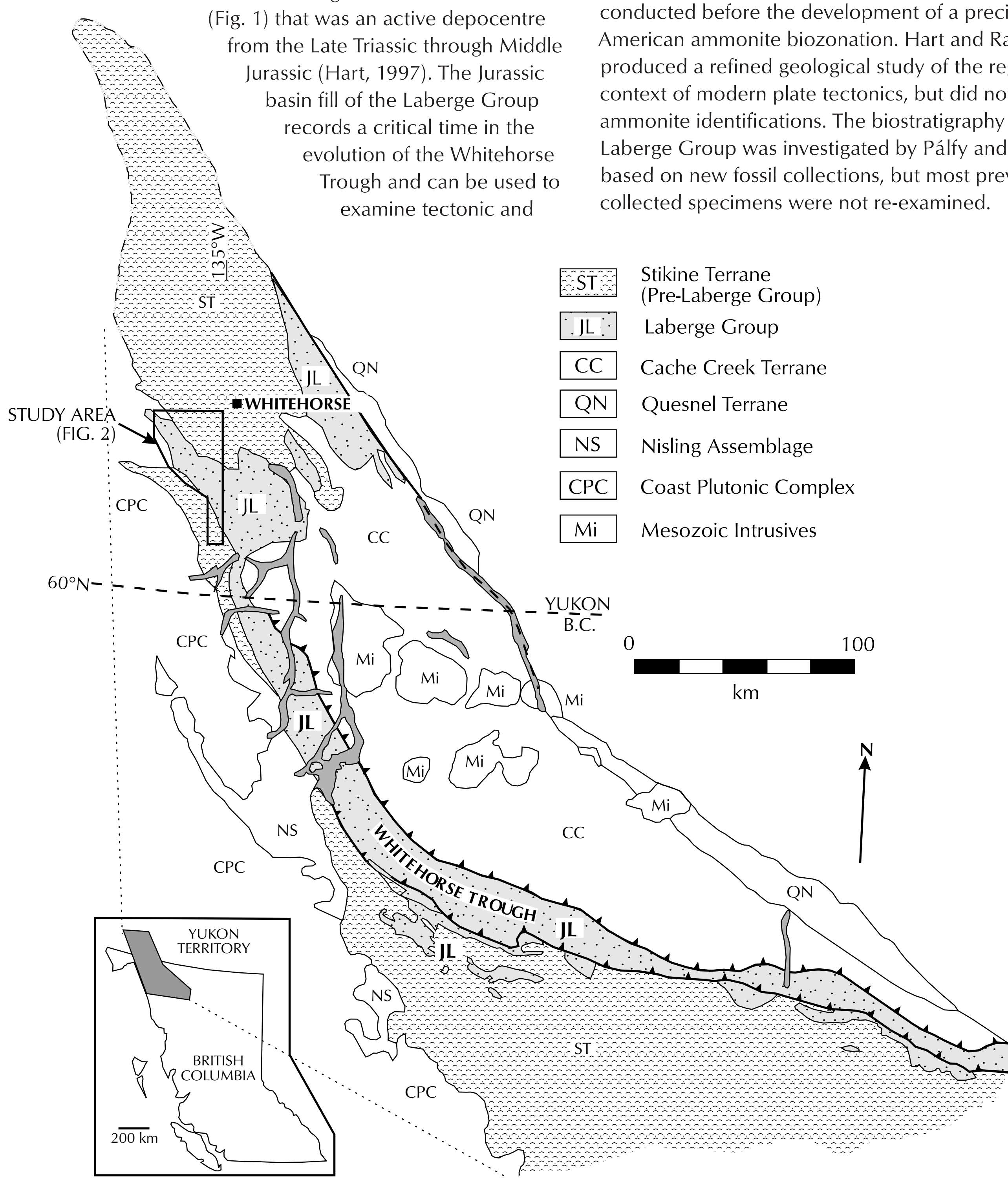


***Figure 1.*** *Regional map of the northern Stikine Terrane, showing the location of the study area in respect to the preserved extent of the Whitehorse Trough (modified after Johannson et al., 1997).*

The major contribution of this study is a re-examination of all fossil collections from the Fish Lake syncline (Fig. 2). Complete fossil locality information and systematic paleontology is provided in Clapham (2000). Ammonite identifications permit precise biochronological dating of Fish Lake syncline strata. Most specimens were collected from isolated localities that were placed in approximate stratigraphic position based on regional geologic maps. Fossils from Goat Mountain were collected from five levels over 100 m of stratigraphic thickness by Pálfy and Hart (1995), and these collections were compiled to produce an approximate stratigraphic sequence.

Most fossil collections were made by W.E. Cockfield in 1946 and H.W. Tipper in 1985, with several localities visited by other researchers. Fossil localities are shown in Figure 2. All fossil material is currently housed at the Geological Survey of Canada (Vancouver and Calgary). Most stratigraphic information in this study is based on a review of primary literature, predominantly the work published by Hart and Radloff (1990) and Wheeler (1961). Additional information was gathered on a brief trip to the Fish Lake syncline by Smith and Tipper in 1985.

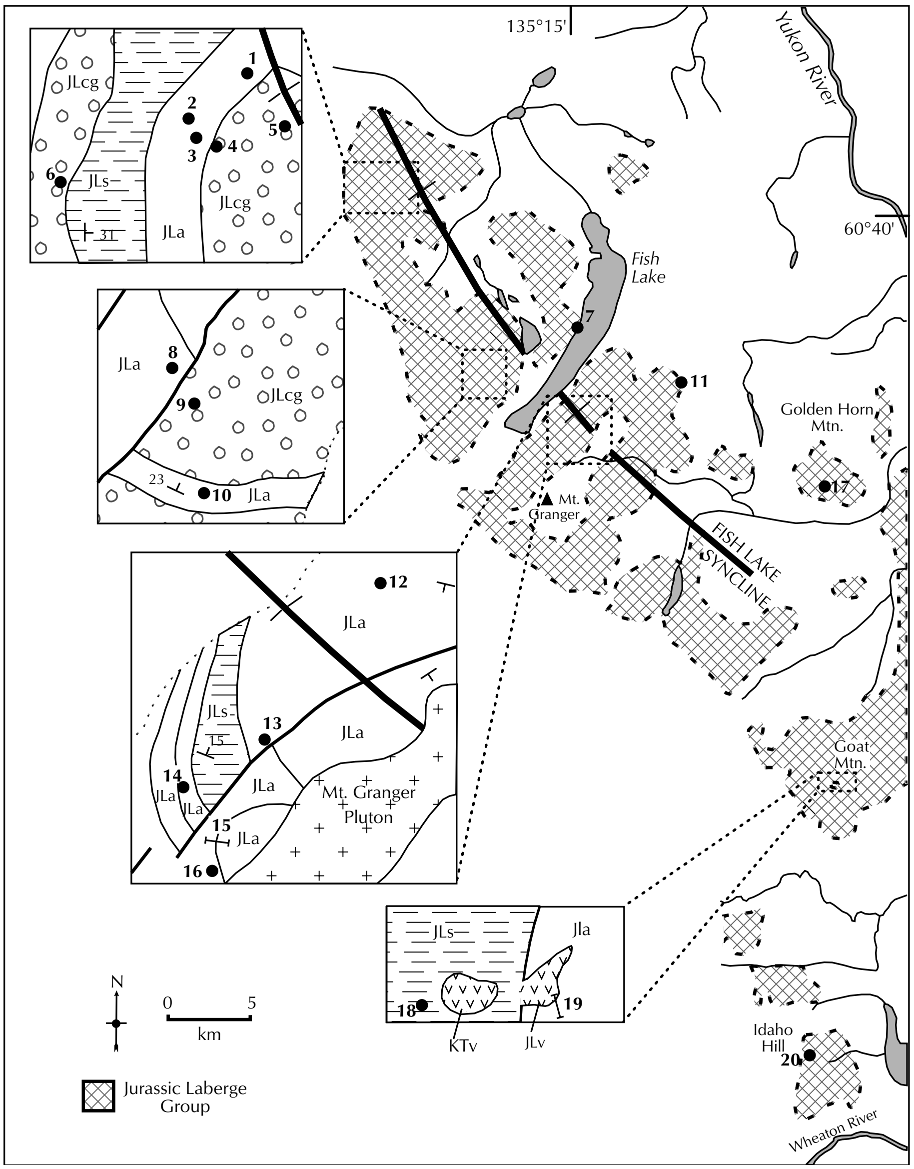


*Figure 2. Location map showing distribution of the Laberge Group within the study area and fossil localities mentioned in the text (base map after Wheeler, 1961; inset maps after Hart and Radloff, 1990). Strata in the inset maps are as follows: Laberge Group conglomerate (JLcg), sandstone (JLs), argillite (JLa), volcanic rocks (JLv) and Hutshi volcanics (KTv).*

Stratigraphic and sedimentological information from regional studies was integrated with the precise ammonite biochronology from this work to investigate the depositional and tectonic history of the Whitehorse Trough. The sedimentology and faunal composition of Fish Lake syncline strata can reveal information about environmental changes within the Whitehorse Trough. In addition, ammonite biochronology can be used to date major influxes of distinctive coarse detritus that can be used to constrain terrane interactions. These interpretations will be discussed after presenting the sedimentological background, based on literature review, and the current biostratigraphic framework developed for the Laberge Group.

## WHITEHORSE TROUGH SEDIMENTOLOGY

The Whitehorse Trough formed on the eastern margin of the Stikine Terrane (or Stikinia), one of many tectonostratigraphic terranes accreted to the western margin of North America during the Mesozoic (Monger et al., 1991). It is a 500-km-long marine basin that was an active depocentre from the Late Triassic to

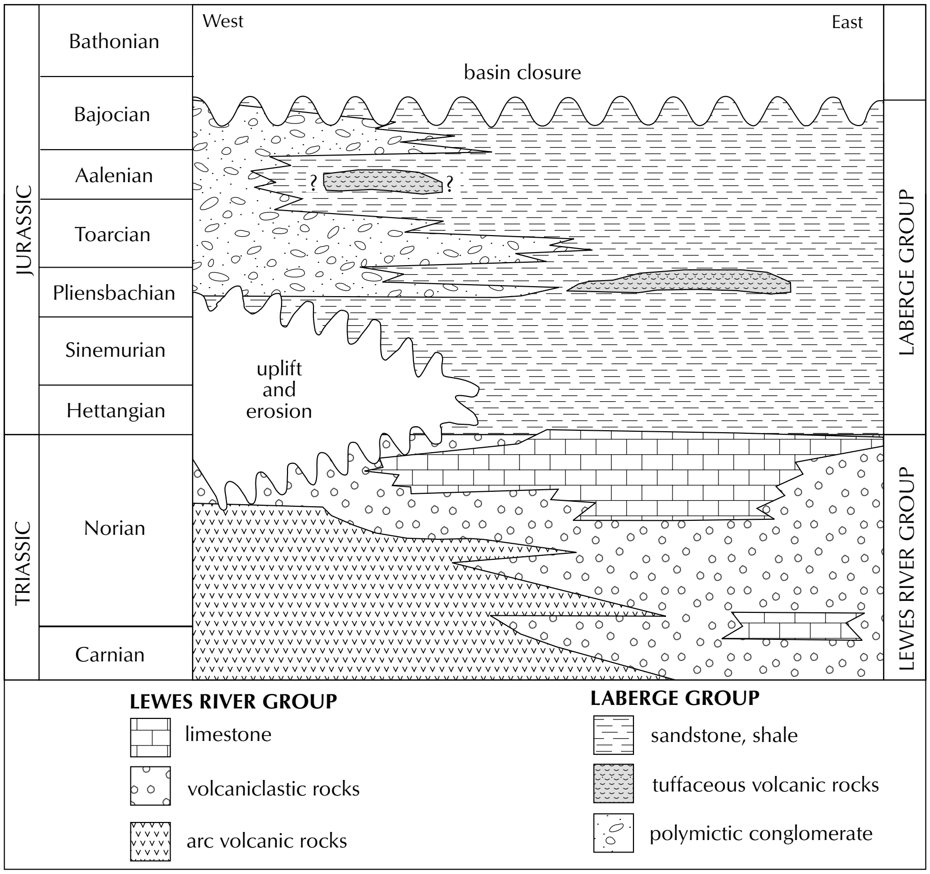


***Figure 3.*** *Generalized stratigraphy of the Whitehorse Trough in the Whitehorse map area (modified after Hart and Radloff, 1990).*

the Middle Jurassic (Hart and Radloff, 1990). Strata of the Laberge Group were deposited in a forearc environment adjacent to the east-facing Lewes River arc (Hart, 1997). In western areas, Laberge Group strata are dominantly coarse-grained and overlie Lewes River arc rocks (Fig. 3). In eastern areas, closer to the basin axis, the basement is not known although an oceanic basement, possibly of Cache Creek Terrane rocks, has been postulated (Hart, 1997).

Jurassic sedimentary rocks of the Whitehorse Trough comprise the Laberge Group (Wheeler, 1961; Hart and Radloff, 1990). Wheeler (1961) estimated a minimum thickness of 2400 m for the group. He did not create formal stratigraphic divisions for the Laberge Group because rapid facies variations, caused by tectonically active source areas, made the recognition of time-stratigraphic formations difficult. In the Carmacks map area (southern Yukon), Tempelman-Kluit (1984) divided Laberge Group strata into four informal formations: the Richthofen, Conglomerate, Nordenskiold, and Tanglefoot, using fossil constraints. Souther (1971) identified two formations in the Tulsequah area (northern British Columbia), namely the Takwahoni Formation consisting of coarse-grained, proximal conglomerates and sandstones, and the Inklin Formation consisting of more distal, finer-grained deposits.

The Triassic and older arc portion of Stikinia has been proposed as the source for Laberge Group sedimentary rocks, based in part on westerly paleocurrent indicators and similarities between volcanic clasts and subjacent Lewes River Group volcanic rocks (Hart et al., 1995). In addition, plutonic clasts with primitive Rb-Sr ratios, Triassic U-Pb radiometric dates, and a lack of inherited zircons suggest that a number of small Late Triassic plutons, which intrude the Lewes River arc, are the likely source for granitic detritus (Hart et al., 1995). Metamorphic clasts in conglomerate near Fish Lake were thought to support a potential Early Jurassic linkage with the Nisling Assemblage (Hart and Pelletier, 1989), which was supported by similar observations in older strata by Jackson et al. (1991); however, a source from Palaeozoic metasedimentary rocks of Stikinia (the Takhini Assemblage of Hart (1997)) is also possible (Hart et al., 1995). Increasing erosional dissection of the arc is suggested by increased granitic clast abundances in younger conglomerates, whereas oldest conglomerates contain only volcanic clasts (Hart and Radloff, 1990).

In the Fish Lake syncline, the Laberge Group is primarily composed of thick, polymictic conglomerate units with thinner greywacke and argillite layers (Wheeler, 1961; Hart and Radloff, 1990). Conglomerates grade laterally into fine greywacke and argillite that dominate more distal deposits of the eastern study area (Wheeler, 1961; Hart and Radloff, 1990). Thin tuff beds and volcanic flows are also present locally (Hart and Radloff, 1990). Detailed descriptions of Laberge Group lithologies in the study area are provided in Wheeler (1961), and Hart and Radloff (1990).

# BIOCHRONOLOGY

Ammonites are one of the most important index fossils for biochronological dating because of their rapid evolution and pelagic habit, which led to a near-worldwide distribution of many species. However, ammonite occurrences are facies-controlled to a minor extent and endemism can be marked, especially in the Early Jurassic Pliensbachian Stage when many European taxa are absent or rare in North America (Smith and Tipper, 1986), making correlation difficult. Biochronozones, regarded as standard zones by Callomon (1984) such that the temporal range of a given fossil or assemblage is constant at all localities, are intended to create a standard reference for temporal correlation within a given region (Smith et al., 1988). Collection of the zonal index species is not required to indicate the presence of the zone; instead, it can be recognized by a specific assemblage of temporally restricted species (Smith et al., 1988).

Biogeographic differences, and the commonly large number of endemic species, have made the standard northwest European zonal scheme of Dean et al. (1961) difficult to apply in western North America. As a result, North American standard zonations for the Pliensbachian (Smith et al., 1988) and the Toarcian (Jakobs et al., 1994; Jakobs, 1997) have been erected. A standard zonation for the Aalenian of North America has not yet been synthesized; in this paper, the regional zonation for Western Canada erected by Poulton and Tipper (1991) is used. Several regional zonations for the Bajocian have been proposed (Hall and Westermann, 1980; Taylor, 1988), but again, no standard North American zonation exists; the Bajocian zonation developed in eastern Oregon for the conterminous United States, proposed by Taylor (1988), is adopted in this paper.

# BIOSTRATIGRAPHY

## PLIENSBACHIAN STAGE

Pliensbachian sedimentary rocks are recorded by fossil collections made northwest of Fish Lake (Localities 1-7; Fig. 2) and near Idaho Hill (Locality 20; Fig. 2). Three ammonite zones are recorded: Whiteavesi Zone (Lower Pliensbachian), Kunae Zone (Upper Pliensbachian), and Carlottense Zone (Upper Pliensbachian). Compiled fossil ranges are illustrated in Figure 4.

### WHITEAVESI ZONE

The oldest Laberge Group rocks preserved are Whiteavesi Zone (Lower Pliensbachian), indicated by a single specimen of *Acanthopleuroceras* cf. *thomsoni*, collected at Locality 7 (Fig. 2). Associated fauna from the same locality include an external mould of a *Pentacrinus* sp. ossicle and moulds of the bivalves *Plagiostoma* sp., *Oxytoma* sp., *Agerchlamys* sp., *Chlamys (Chlamys)* cf. *textoria*, and *Modiolus*? sp., commonly preserved as dense aggregations of fragmented specimens covering bedding surfaces. The presence of relatively large and abundant bivalves, including *Modiolus*, and rarity of ammonites, is consistent with invertebrate depth zone B of Taylor (1982), suggesting relatively shallow water deposition (less than 50-100 m).

### FREBOLDI ZONE

Ammonites from the Lower Pliensbachian Freboldi Zone have not been collected from the study area. Sedimentary rocks of this age are well preserved in the southern Whitehorse Trough, spanning a stratigraphic interval of over 110 m near Atlin (Johannson, 1994). In addition, ammonites collected from localities north of Whitehorse may indicate the presence of Freboldi Zone-aged strata (Hart, 1997).

### KUNAE ZONE

Near Fish Lake, the oldest widespread Laberge Group rocks are Kunae Zone (Late Pliensbachian) in age and unconformably overlie the Triassic Lewes River Group (Wheeler, 1961; Hart and Radloff, 1990) and locally Whiteavesi Zone strata. Kunae Zone strata are present in two main outcrop areas within the Fish Lake syncline: north of Fish Lake and in the south of the study area near Idaho Hill.

The ammonite fauna collected from north of Fish Lake (Localities 2, 3, 6; Fig. 2) is low diversity, composed entirely of hildoceratid ammonites. Specimens include *Leptaleoceras accuratum*, *Fuciniceras cf. intumescens*, *Fuciniceras*? sp., and *Protogrammoceras (Protogrammoceras)* sp. Four aptychi were also collected from Kunae Zone strata north of Fish Lake. Amaltheids, typical of the early Kunae Zone, were not collected from Fish Lake, suggesting that only late Kunae Zone strata are present.

Kunae Zone strata are also present near Idaho Hill (Locality 20; Fig. 2), represented by 8 fossil collections and almost

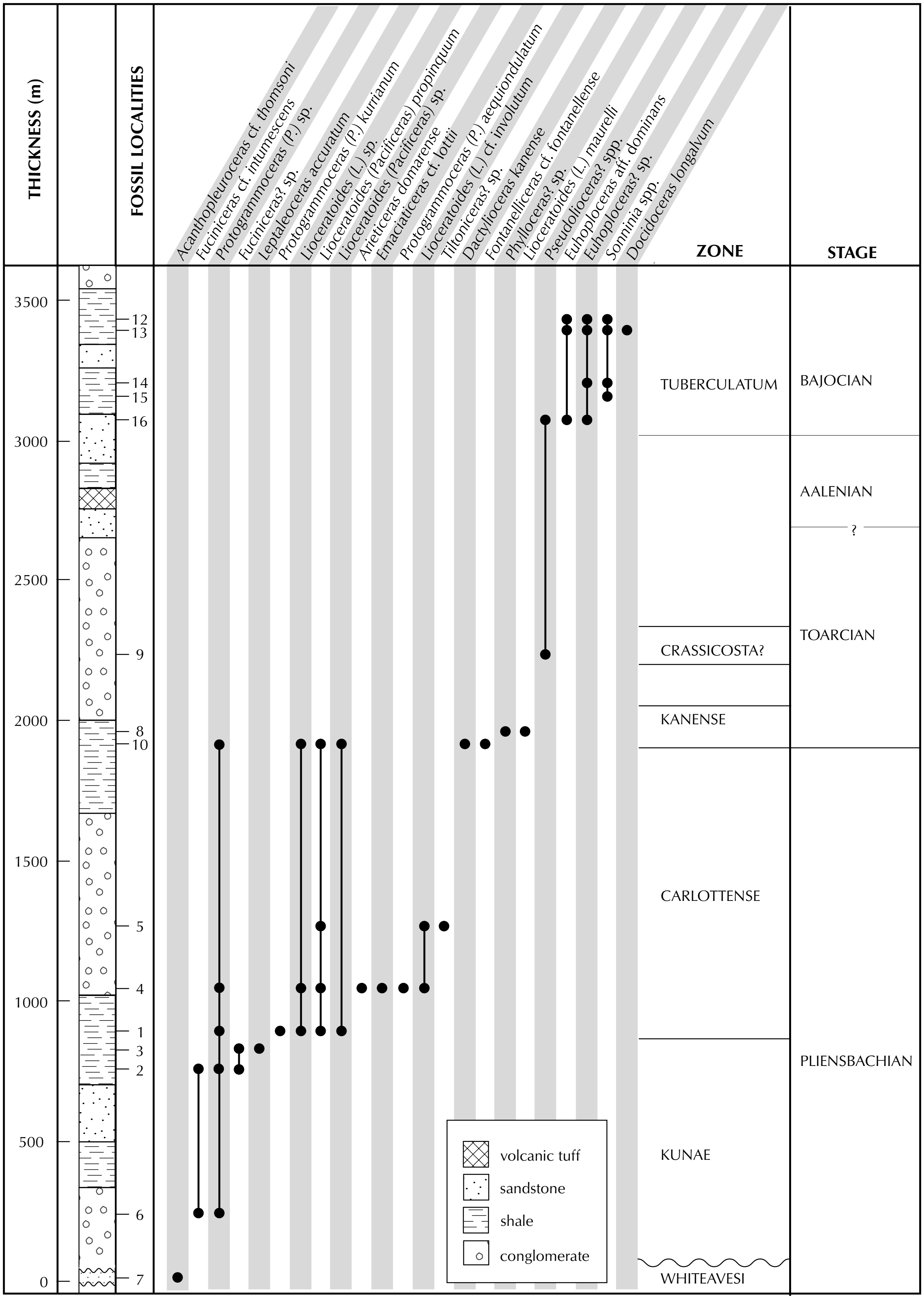


***Figure 4.*** *Composite stratigraphic column and fossil range chart for the Laberge Group in the Fish Lake section of the study area.*

100 ammonite specimens. This fauna is characterized by a higher diversity and a slight dominance of amaltheids (54 specimens) over hildoceratids (43 specimens). Amaltheids are almost entirely *Amaltheus stokesi*; only a single specimen of *A. margaritatus* is present. *Amaltheus margaritatus* is rarely found in the Cordillera and has only been collected from elsewhere in the Whitehorse Trough (Cry Lake (104I) and Tulsequah (104K and L) map areas). Hildoceratids from Idaho Hill are predominantly *Leptaleoceras accuratum* and *Arieticeras algovianum* but also include four specimens of *Fuciniceras* cf. *targionii* and single specimens of *Arieticeras domarense*, *Fuciniceras* cf. *intumescens*, and *Fontanelliceras* cf. *fontanellense*. In addition, a single dactylioceratid, *Reynesoceras italicum*, is present. Two specimens of *Chlamys*? sp. and several indeterminate internal moulds of other bivalves were also collected from Idaho Hill.

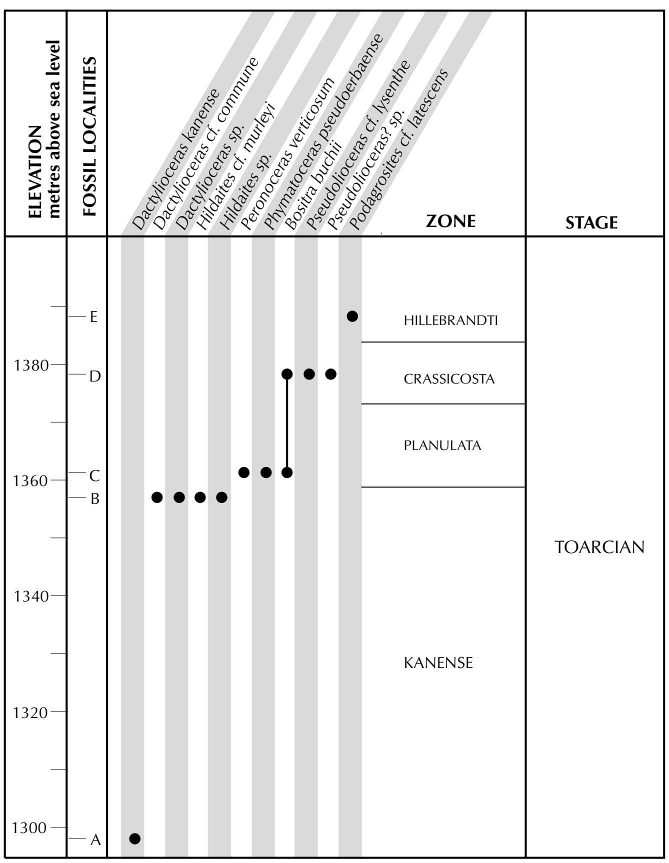


**Figure 5.** *Fossil ranges from a measured section of Laberge Group argillites, Goat Mountain (Locality 19, Fig. 2). Letters refer to collections from different elevations within the locality.*

## CARLOTTENSE ZONE

The Carlottense Zone in the Whitehorse Trough is indicated by an ammonite fauna, which shows high diversity within the Family Hildoceratidae but lacks representatives of other families (e.g., the East Pacific genus *Fanninoceras*). Specimens characteristic of the Carlottense Zone were collected from Localities 1, 4 and 5 (Fig. 2), and include *Lioceratoides (Lioceratoides)* cf. *involutum*, *Lioceratoides (Pacificeras) propinquum*, and *Tiltoniceras*? sp. Other ammonites present include *Arieticeras domarense*, *Protogrammoceras (Protogrammoceras) kurrianum*, and *P. (P.) aequiondulatum*. In addition, three specimens assigned to *Emaciaticeras* cf. *lottii* have been collected north of Fish Lake (Locality 4, Fig. 2). This genus has previously been described only from northern and central Italy, Sicily, and southern Spain (Braga, 1983).

## TOARCIAN STAGE

Toarcian rocks are found throughout the study area: northwest of Fish Lake (Localities 8-10; Fig. 2), southwest of Fish Lake (Localities 11, 17; Fig. 2), and a series of collections at Goat Mountain (Locality 19; Fig. 2), detailed in Figure 5. Most fossil collections are Lower or lower Middle Toarcian (Kanense or Planulata Zone). The upper Middle and Upper Toarcian (Crassicosta and Hillebrandti Zones) are only recorded from the upper collections at Locality 19 (Fig. 5).

## KANENSE ZONE

The base of the Toarcian stage in the study area is marked by the appearance of *Dactylioceras kanense* occurring with holdovers from the Upper Pliensbachian, such as *Fontanelliceras* cf. *fontanellense*, *Lioceratoides (Pacificeras) propinquum*, and *Protogrammoceras (Protogrammoceras)* sp., all of which extend into the lowermost Toarcian. Basal Kanense Zone strata are present at locality 10 west of Fish Lake (Fig. 2) and at 1298 m elevation on Goat Mountain (Locality 19; Fig. 2). Three fragments of *Phylloceras*? sp. are present, associated with *Lioceratoides (Lioceratoides)* cf. *maurelli* in lower Kanense Zone strata west of Fish Lake (Locality 8; Fig. 2). Upper parts of the Kanense Zone are indicated in the Goat Mountain section by specimens of *Dactylioceras* cf. *commune* and *Hildaites* cf. *murleyi* at 1356 m elevation (Fig. 5).

### PLANULATA ZONE

Presence of the Planulata Zone at Goat Mountain (Locality 19; Fig. 2) is shown by specimens of *Peronoceras verticosum* and *Phymatoceras pseudoerbaense* at 1362 m elevation (Fig. 5). *Peronoceras verticosum* indicates a Planulata Zone age for argillite east of Fish Lake (Locality 11; Fig. 2) and *Peronoceras* sp., present at Golden Horn Mountain (Locality 17; Fig. 2), suggests a Middle Toarcian (likely Planulata Zone) age for that locality. Shell pavements of the bivalve *Bositra buchii* are widespread in the Goat Mountain section younger than mid-Planulata Zone and occur elsewhere in the study area in Middle and Upper Toarcian strata, as well as from Whitehorse Trough strata in the Carmacks, Tulsequah, Telegraph Creek, and Cry Lake areas (Aberhan, 1998). Elsewhere, *Bositra* also forms shell pavements in rocks as old as Middle Toarcian (Damborenea, 1987; Etter, 1996; Hallam, 1995).

### CRASSICOSTA ZONE

The presence of this zone is indicated in the Goat Mountain section (Locality 19; Fig. 2) by specimens of *Pseudolioceras* cf. *lysenthe* and *Pseudolioceras*? sp. collected from 1378 m elevation (Fig. 5). In addition, *Pseudolioceras* cf. *lysenthe* and *Peronoceras* cf. *crassicostatum* are present in talus collections from the same locality. A single specimen of *Pseudolioceras*? sp. from Locality 9, west of Fish Lake (Fig. 2), may suggest a Crassicosta Zone age for that site.

### HILLEBRANDTI ZONE

A single specimen of *Podagrosites* cf. *latescens* from 1388 m of the Goat Mountain section (Locality 19; Fig. 2) is the only Hillebrandti Zone ammonite collected from the study area.

### YAKOUNENSIS ZONE

Presence of the Yakounensis Zone is indicated by a specimen resembling either *Dumortiera* sp. or *Troitsaia* sp. associated with the trigoniid bivalve *Myophorella* sp., reported from the southeastern Fish Lake syncline by Poulton and Tipper (1991) but not re-examined in this study. Abundant *Bositra buchii* shell pavements are also present at the locality (Aberhan, 1998). The ammonite specimens indicate either a Late Toarcian or Early Aalenian age; however, *Bositra* is found in Toarcian deposits elsewhere in the study area and likely confirms a Yakounensis Zone age for this site.

## AALENIAN

Diagnostic Aalenian fossils have not been collected from the study area. A sandy limestone unit on Goat Mountain (Locality 18; Fig. 2) contains a single specimen of *Ceratomya*? sp. and three samples of densely packed bivalve coquina containing the trigoniid *Myophorella lupheri*. The lithology and fossil content are suggestive of shallow water deposition but the stratigraphic position is poorly constrained. *Ceratomya*? sp. ranges from at least the Aalenian through Bajocian, and *Myophorella lupheri* ranges from the Lower or Middle Aalenian to the Middle Bajocian, reaching greatest abundance during the Aalenian (Poulton, 1980). The anomalous lithology of the site compared with Bajocian strata elsewhere in the study area, combined with the maximum abundance of *M. lupheri* in the Aalenian, suggests that the locality may represent Aalenian deposits.

## BAJOCIAN

Only the lowermost zone of the Lower Bajocian, the *Euhoploceras tuberculatum* zone of Taylor (1988), is present in the study area, restricted to outcrops south of Fish Lake (Localities 12-16; Fig. 2). This zone is characterized by the first appearance of sonniniid ammonites. No representatives of the Family Stephanoceratidae are present, suggesting that only the lowest faunal zone of the Lower Bajocian is represented.

### EUHOPLOCERAS TUBERCULATUM ZONE

The ammonite fauna is dominated by sonniniids, although one specimen of *Pseudolioceras*? sp. and three of *Docidoceras longalvum*, previously identified as *Stephanoceras* in Wheeler (1961), are also present at localities 16 and 13 (Fig. 2), respectively. Sonniniid classification is problematic, but at least two species of *Sonninia* and two of *Euhoploceras* are present. Only one, *Euhoploceras* aff. *dominans*, is referrable to a previously described taxon. Numerous aptychi, presumably derived from sonniniid ammonites, are preserved at several localities and four specimens of the bivalve *Camptonectes (Costicamptonectes*?) sp. are also found in the uppermost site (Locality 12; Fig. 2).

## DEPOSITIONAL AND TECTONIC HISTORY

The generalized stratigraphic section (Fig. 4) is constructed from regional geological maps (e.g., Hart and Radloff, 1990), using precise ammonite biostratigraphy to place localities in their stratigraphic context. Because no sections were measured during this research, thicknesses are based on published regional geology maps and are only approximate. In addition, deposition in submarine fans from an active source area results in extremely rapid lateral facies variations (Dickie and Hein, 1995), further complicating the construction of a generalized stratigraphic section for the Fish Lake syncline. Nevertheless, it is still possible to recognize major events in the Pliensbachian to Bajocian depositional history of the basin.

### PLIENSBACHIAN

Early Pliensbachian (Whiteavesi Zone) rocks are only found in a single area near Fish Lake. Freboldi Zone (Late Pliensbachian) strata are apparently absent and the oldest widespread deposition is Late Pliensbachian Kunae Zone in age. The Pliensbachian strata near Fish Lake are dominated by thick conglomerate wedges with finer-grained, fossiliferous interbeds, suggesting that the Freboldi Zone should be thick and would likely yield ammonite fossils if it is present. This implies that Freboldi Zone sediments near the basin margins were not deposited, or were eroded during sea-level fall. Deposition of Whiteavesi Zone sediments likely occurred during a small-scale transgression, possibly related to early source area uplift and basin subsidence. These strata were deposited in shallow water, in contrast to the dominantly deep-water facies found in much of the younger basin fill. The strata were partly removed during a later relative sea level drop, but small pockets of Whiteavesi Zone sediments were preserved locally in paleotopographic depressions.

The lowest conglomerate horizon is Early Pliensbachian age in the Carmacks map area (Tempelman-Kluit, 1984) and northern Whitehorse (105D) map area (Hart, 1997). However, the base of the conglomeratic Takwahoni Formation in the Tulsequah area is Late Pliensbachian (Kunae Zone) in age (Souther, 1971). This indicates that rapid uplift and erosion of the Lewes River arc likely began by the Early Pliensbachian in the north and progressed southward during the Late Pliensbachian in Tulsequah. The presence of isolated Whiteavesi Zone strata near Fish Lake may indicate an intermediate stage since the shallow marine sandstones are preserved only in isolated localities, representing initial stages of uplift prior to the major influx of arc-derived material in the Late Pliensbachian (Kunae Zone).

During the late Kunae and Carlottense zones, two major conglomerate wedges, approaching 600 m in thickness, were deposited in the Fish Lake area. They are separated by 800 m of argillite and greywacke. Each wedge contains thinner intercalated beds of finer material. Conglomerates, however, are subordinate or absent in central and eastern areas of the Whitehorse Trough during the Late Pliensbachian (Wheeler, 1961; Hart and Radloff, 1990). For example, Late Pliensbachian (early Kunae Zone) strata near Idaho Hill are dominated by a thick section of fine- to medium-grained greywacke (Hart and Radloff, 1990).

Based on a detailed facies analysis of Laberge Group strata, Dickie and Hein (1995) suggested that conglomerate wedges were deposited in a submarine fan in a base-of-slope setting. Conglomerate fan deposition was triggered by rapid uplift of the Stikinian arc source area (Pálfy and Hart, 1995). Thicker greywacke and argillite units may represent finer turbidite deposits at the margin of fan lobes, possibly generated as a result of lobe switching or migration (Dickie and Hein, 1995). Alternatively, finer-grained sediments may have been deposited during times of relative quiescence, with coarse-grained sedimentation linked to pulses of uplift and denudation (Ineson, 1989).

Whitehorse Trough sedimentation was diachronous: the age of deposition ranges from as old as Sinemurian or possibly Hettangian near the basin axis (Lees, 1934; Frebold and Poulton, 1977) to no older than Late Pliensbachian near the western margin (Souther, 1971). Marginward younging of basal strata is also observed in the Fish Lake syncline. Lowermost strata near Idaho Hill are at least as old as early Kunae Zone, whereas basal strata near Fish Lake, closer to the basin margin, are late Kunae Zone in age.

### TOARCIAN

Toarcian deposits are also typified by rapid facies changes: the transition from conglomerate submarine fan deposits near Fish Lake to argillitic facies near Golden Horn Mountain occurs over only 15 km. Although biostratigraphic control near Fish Lake is minimal, the conglomerate pulse appears to be confined to the Lower and possibly Middle Toarcian near the western basin margin. A single specimen of *Pseudolioceras*? sp. from Locality 9 (Fig. 2) may indicate a Crassicosta Zone youngest age. An excellent Lower to basal Upper Toarcian section near Goat Mountain (Locality 19; Fig. 2) records dominantly argillite deposition in more distal areas. Upper Toarcian deposits, if present, are likely recessive-weathering black shales throughout the entire area (C. Hart, pers. comm., 2000), suggesting a rapid cessation of coarse sediment supply.

Presence of shell pavements consisting of closely packed, articulated *Bositra buchii* specimens in Planulata to Yakounensis Zone strata suggests that the Whitehorse Trough became anoxic during those times. The life mode of *Bositra* has been controversial, although a benthic habit is now preferred based on regular (i.e., non-random) specimen distribution and taphonomic evidence indicative of in situ preservation (Etter, 1996). Distribution of *Bositra* shell pavements along a paleo-oxygenation gradient supports the hypothesis that it was highly tolerant to low oxygen levels and used opportunistic dispersal strategies to rapidly colonize severely dysoxic environments (Etter, 1996). *Bositra* shell pavements are present in Middle Toarcian rocks from the Cry Lake (Aberhan, 1998), Tulsequah, and the Carmacks areas. The spatially widespread, but temporally limited distribution of *Bositra* suggests that anoxia affected the entire basin, at least sporadically, throughout the Middle and Late Toarcian. *Bositra* shell pavements occur after the youngest conglomeratic pulse, suggesting that anoxia and decreased sediment supply may be linked, possibly to a rapid transgression.

### AALENIAN

Aalenian deposits are thought to be widespread, but thin, throughout the Whitehorse Trough (Poulton and Tipper, 1991). In the Fish Lake syncline, the Aalenian is likely represented by a thick argillite unit, which underlies the first distinctive Bajocian fossils. Volcanic rocks may also be more abundant in the Aalenian, although there are minimal stratigraphic and radiometric controls. Rhyolitic tuff, possibly of Aalenian age, is present near the Bonneville Lakes (Hart and Radloff, 1990). In addition, a 15-m-thick andesitic flow or sill overlies the Lower to basal Upper Toarcian section on Goat Mountain (Pálfy and Hart, 1995).

### BAJOCIAN

Early Bajocian strata in the study area are composed of organic-rich argillite to fine-grained greywacke interbedded with cm-scale resedimented tuffaceous turbidite deposits. This unit was informally referred to as 'pyjama beds' in equivalent strata in the Spatsizi (Thomson, 1985) and Iskut (Nadaraju, 1993) areas. The abundance of fine-grained sediment indicates that deposition occurred in a distal setting, possibly beneath a vigorous upwelling zone as suggested by the organic-rich sediments (Calvert et al., 1992; Ganeshram et al., 1999; Pedersen et al., 1992). Probable volcanic spherulites within the argillite layers and abundant tuffaceous turbidites suggest that sediments were deposited near a long-lived volcanic arc, and that volcanism occurred throughout the Early Bajocian.

Upper beds in the Fish Lake syncline are composed of chert-pebble conglomerate (Wheeler, 1961), likely correlative with the Tantalus formation of Tempelman-Kluit (1984). An oldest age of early *Euhoploceras tuberculatum* zone is indicated by a rich sonniniid ammonite fauna in the immediately underlying strata. Early Bajocian strata from the northern Whitehorse (Hart, 1997) and Tulsequah (Souther, 1971) map areas also contain chert-pebble conglomerates. The widespread influx of chert in Early Bajocian times is consistent with the obduction of the Cache Creek Terrane, the most plausible source for large volumes of chert (Hart, 1997). Thus, the final stages of basin-fill record obduction of the Cache Creek Terrane in the Early Bajocian.

## CONCLUSIONS

Fossil identifications and ammonite biochronology indicate that Laberge Group strata in the study area form a conformable sequence from Upper Pliensbachian (Kunae Zone) to Lower Bajocian *(Euhoploceras tuberculatum* zone). Investigation of Fish Lake syncline stratigraphy reveals information about the tectonic and environmental history of the Whitehorse Trough. Dating of the lowest coarse detritus in the Fish Lake syncline indicates that tectonic uplift of the source area was diachronous across the Whitehorse Trough. Early Pliensbachian uplift in the north progressed southward, occurring primarily in the Late Pliensbachian, but with a minor pulse in the Early Pliensbachian. Influx of coarse detritus is restricted to the Late Pliensbachian in southern areas.

It is also possible to correlate environmental events between the Fish Lake syncline and other areas of the Whitehorse Trough. For example, basin-wide anoxia during the Middle and Late Toarcian is suggested by the widespread occurrence of *Bositra buchii* shell pavements.

Biochronological dating of major influxes of lithologically distinctive coarse detritus in the Fish Lake syncline places constraints on terrane interactions. Chert-pebble conglomerate deposited in the Early Bajocian yields a minimum age constraint on the obduction of the Cache Creek Terrane.

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