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New geological and paleontological data from the Harper Ranch Group, Kamloops, British Columbia[1]

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Abstract: The Harper Ranch Group comprises an Upper Paleozoic succession characterized by limestone and volcaniclastic, and siliciclastic rocks that underlie the Quesnel Terrane in the Canadian Cordillera. The relatively unmetamorphosed portion of the Harper Ranch Group outcrops immediately north and northeast of the city of Kamloops, British Columbia and is overlain by Triassic Nicola group to the north and west, and Jurassic (?) Rossland Group to the east. Recent field studies have produced new data which make it possible to divide the group into recognizable units on the basis of paleontology and apparent bounding surfaces. Additions to the body of paleontological data include: Early Mississippian (Tournaisian) conodonts, furnishing a maximum age of the Mississippian volcaniclastic unit; Late Mississippian (Serpukhovian) goniatites providing the potential for intercalibrated conodont-goniatite biostratigraphy; and Early Jurassic (Sinemurian) ammonites dating the base of the volcanic and volcaniclastic succession unconformably overlying the Harper Ranch Group to the east.

Résumé : Le Groupe de Harper Ranch renferme une succession du Paléozoïque supérieur se composant de roches silicoclastiques, de roches volcanoclastiques et de calcaires qui s'étend au terrane de Quesnel dans la Cordillère canadienne. La partie relativement peu métamorphisée du Groupe de Harper Ranch affleure immédiatement au nord et au nord-est de la ville de Kamloops (Colombie-Britannique); elle est recouverte au nord et à l'ouest par le Groupe de Nicola du Trias et, à l'est, par le Groupe de Rossland du Jurassique(?). Des études récentes sur le terrain ont fourni de nouvelles données permettant de diviser le groupe en unités distinguables d'après le contenu paléontologique et la présence de surfaces limites apparentes. À l'ensemble existant de données paléontologiques, se sont ajoutés les éléments suivants : des conodontes du Mississippien précoce (Tournaisien) qui fournissent un âge maximal pour l'unité volcanoclastique du Mississippien; des goniatites du Mississippien tardif (Serpukhovien) qui offrent la possibilité d'établir un étalonnage comparatif des échelles biostratigraphiques des goniatites et des conodontes; et des ammonites du Jurassique précoce (Sinémurien) qui permettent de dater la base de la succession volcanique et volcanoclastique qui, à l'est, repose en discordance sur le Groupe de Harper Ranch.

[1] Contribution to the Ancient Pacific Margin NATMAP Project

INTRODUCTION

Limestone units of the Harper Ranch Group near Kamloops, British Columbia have long been the focus of paleontological investigation, however, detailed stratigraphic and biostratigraphic studies are limited in the area. Recent discoveries of volcanic-associated massive sulphide deposits have generated new exploration programs in the region (Thompson et al., 2000). With renewed interest in the nature and evolution of the western North American continental margin, the stratigraphic and faunal affinities of the terranes of the Canadian Cordillera are of increasing importance. Exploration efforts will benefit from an enhanced understanding of the tectonostratigraphic history of the Harper Ranch Group and of the Quesnel Terrane in general.

A new investigation of the Harper Ranch Group has been undertaken as part of the Ancient Pacific Margin NATMAP Project (Fig. 1). This study, which will constitute the thesis component of a Masters of Science degree, includes five main objectives: 1) the development and formalization of an internal stratigraphy for the Harper Ranch Group based on faunal and stratigraphic successions; 2) the production of a geological map of the study area; 3) the documentation of the stratigraphic position and extent of the regional unconformities; 4) the production of a detailed conodont biostratigraphy for the limestone units; and 5) the improvement of regional correlations between the Harper Ranch Group and rocks elsewhere in western North America. The following provides a brief summary of the previous work done in the area and highlights initial findings of fieldwork and laboratory work completed in 2000–2001.

PREVIOUS WORK

This stratigraphic sequence was first studied by G.M. Dawson in 1879 who included the Harper Ranch Group within the Cache Creek Group, which lies approximately 100 km to the west of Kamloops (Danner and Orchard, 2000). Until the mid-1980s work in the area concentrated on the occurrence of fusulinaceans (Thompson and Verville, 1950; Skinner and Wilde, 1966; Sada and Danner, 1974, 1976) and some notable macrofauna such as ammonoids (Miller and Warren, 1933), rugose and tabulate corals (Nelson, 1982; Nelson and Nelson, 1985), and brachiopods (Nelson and Nelson, 1985). The presence of Upper Devonian (Upper Famennian), Upper Mississippian (Upper Visean to Serpukhovian) (Orchard, 1984, 1987, 1991), and Lower to Middle Permian strata (Orchard and Forster, 1988) were revealed by conodonts collected by M.J. Orchard (GSC). Upper Carboniferous strata are conspicuously absent. Apart from reconnaissance mapping during a regional study of the Ashcroft map area (NTS 92-I) (Monger and McMillan, 1984), attempts at placing the Harper Ranch Group into a regional geological context have been limited, leaving much unknown about the internal and external relationships of this important part of Quesnellia.

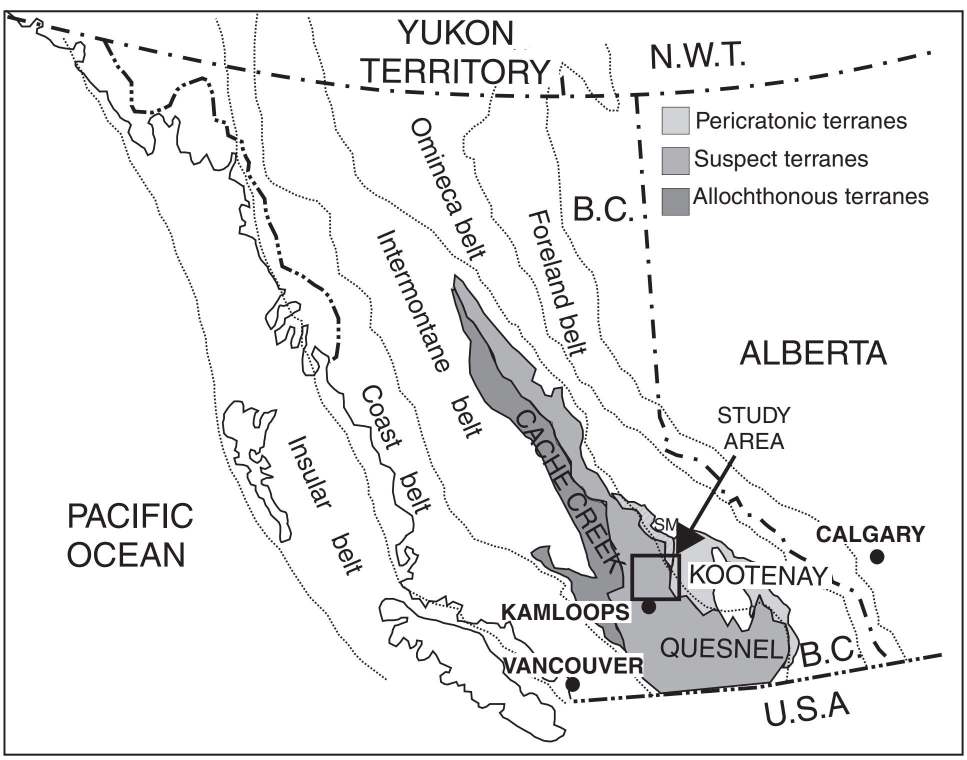

__Figure 1.__ Location of the study area; Quesnel and adjacent terranes. SM = Slide Mountain Terrane.

STRATIGRAPHY

Famennian sandstone, bioclastic sandstone, and chert-pebble conglomerate (unit DF)

Unit DF (Fig. 2, 3, 4) occurs in a single, 30 m long exposure outcropping along the Mount Harper access road approximately halfway between the community of Paul Lake and Harper Mountain ski resort. Several outcrops in the surrounding woods to the north and the northwest appear to be of similar lithology, and although not biostratigraphically constrained, are included in this unit.

Unit DF is mostly buff- to orange-brown-weathering siltstone and fine- to medium-grained sandstone with rare beds of sandy bioclastic limestone containing brachiopods, gastropods, echinoderms, ostracodes, plant debris, and what has been interpreted as a late Famennian, shallow-water, high-energy conodont fauna (Orchard, 1987). Rare bioclastic beds occur at the base, whereas sandstone beds thicken and coarsen upward; a sandy, chert-pebble conglomerate marks the apparent top of the section. Beds are steep dipping with strong east-west orientation. Unit DF represents the oldest strata in the Harper Ranch Group. Stratigraphic relationships with overlying units have yet to be observed.

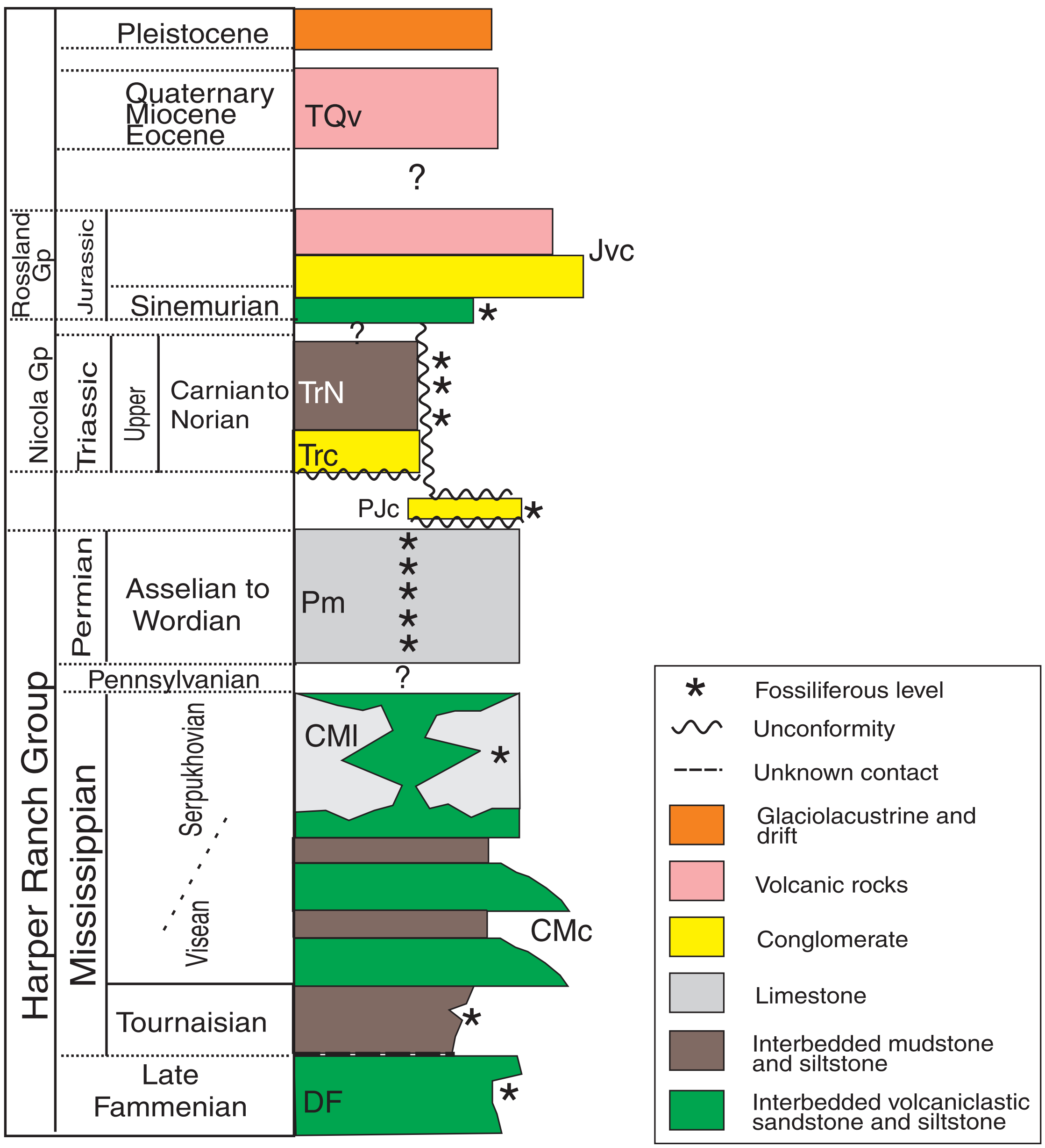

***Figure 2.** Idealized stratigraphy of the Harper Ranch Group, and overlying strata in the Kamloops area. Map units appear in bold.*

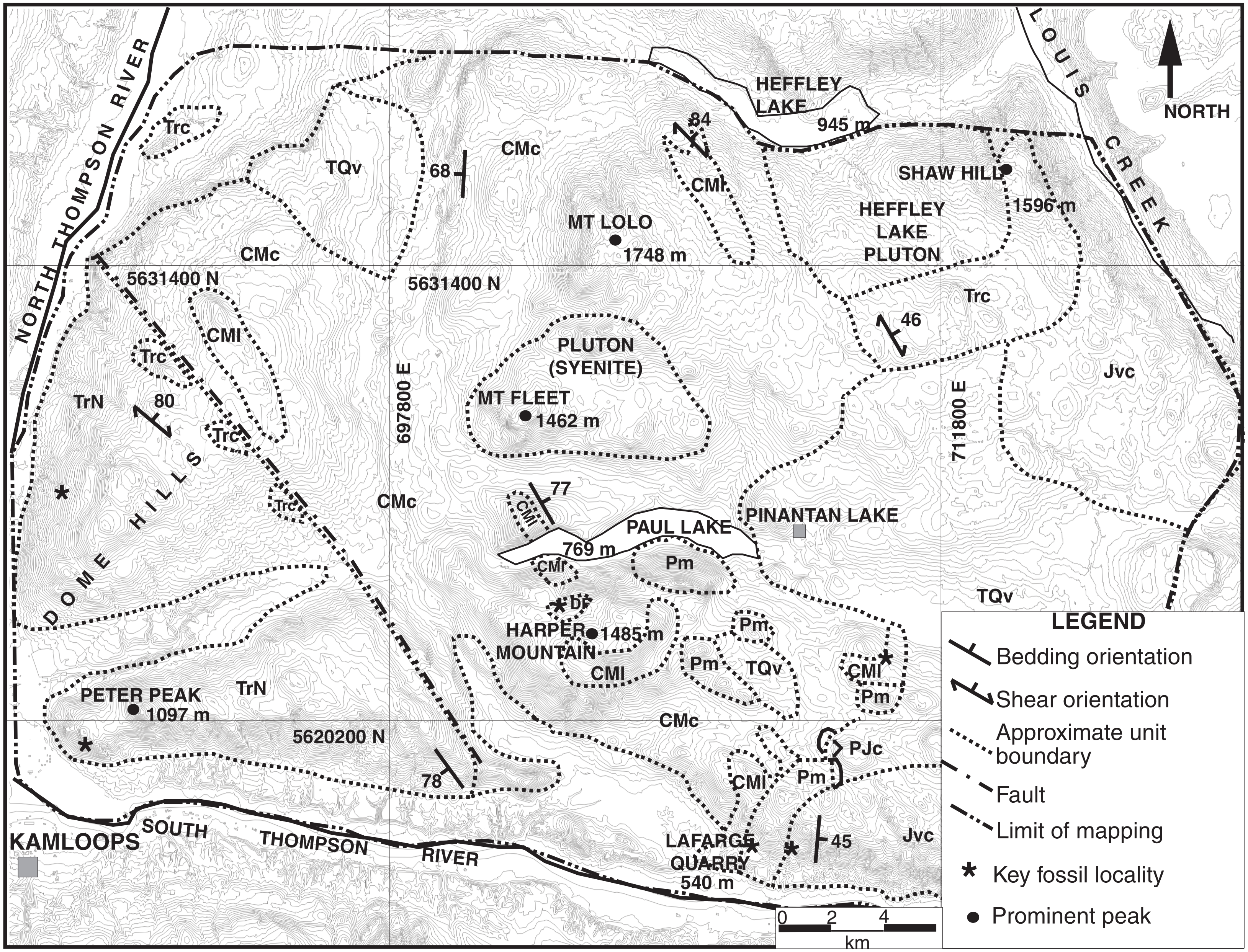

Figure 3. *Preliminary geological map of the Harper Ranch, Nicola, and possibly Rossland groups in the Kamloops area. Contour interval is 20 m. Fault trace from Smith (1979) and Monger and McMillan (1984).*

Figure 4. Chert-pebble conglomerate occurring at the top of unit DF. Rock hammer head is 17 cm long.

Mississippian volcaniclastics and mudstone (unit CMc)

Mississippian clastic rocks occupy regions of lower elevation throughout the study area, and are generally exposed in small, low-relief outcrops on hillsides. To the south, exposures are mantled with unconsolidated Pleistocene valley fill consisting of proglacial silt, sand, and conglomerate. To the west, unit CMc is in fault contact with the Triassic Nicola Group (Smith, 1979). Relationships in the east are not well documented but it is assumed that Jurassic volcanic rocks and Eocene basalt unconformably overlie unit CMc. The northern extent of this unit has not been delineated.

Unit CMc comprises interbedded mudstone, siltstone, and fine- to very coarse-grained volcaniclastic sandstone. Mudstone beds, commonly planar laminated, range from millimetres to centimetres thick and have poorly developed nonpenetrative cleavage formed at steep angles to bedding. Siltstone interbeds display fining-upward gradations and generally have scoured basal contacts with the underlying mudstone. Bioturbation is rare to absent, represented by very rare *Helminthopsis* in the siltstone and rare vertically compressed burrows in the mudstone. Fossils recovered from unit CMc consist of very rare stick-like plant fossils and rare echinoderm and brachiopod molds in the mudstone beds.

The volcaniclastic sandstone is composed of mainly grey to purple-grey lithic fragments and grey, white, and black chert. Volcaniclastic sandstone ranges from fine to very coarse grain size. Beds are generally massive ranging from 10 cm to more than 2 m in thickness with coarser grained beds tending to be the thickest. Basal contacts of the beds are sharp to scoured where visible and contain common elongate rip-up clasts (5 cm to >30 cm in diameter) of the underlying mudstone. Upper contacts are commonly gradational into the overlying mudstone or, rarely, limestone.

Mississippian limestone (unit CMl)

Mississippian limestone outcrops discontinuously throughout the study area, forming lenses tens of metres thick within the volcaniclastic sandstone of unit CMc and buildups hundreds of metres thick overlying the volcaniclastic sandstone.

Unit CMl is composed of medium grey- to light grey-brown-weathering, massive to centimetre-scale bedded grainstone, packstone, wackestone, and minor mudstone. Abundant allochems include brachiopods, crinoids, bryozoans, rugose and tabulate corals, gastropods, and ammonoids. Common, large, partially articulated crinoid columnals with diameters as large as 3 cm are believed to be a diagnostic feature of this unit (W.R. Danner, pers. comm., 1999). Metre thick, bioclastic packstone beds, consisting mostly of productid brachiopods are commonly seen in outcrops that display internal stratigraphy. Chert, argillaceous limestone, and ooid packstone beds also occur in more complete sections. Interbeds of 10–30 cm thick, medium-grained, volcaniclastic sand are present in the smaller (tens of metres thick) outcrops. A Late Visean–Early Serpukhovian conodont fauna is frequently recovered from samples of this unit.

Permian limestone (unit Pm)

Permian limestone generally outcrops as massive units, unconformably overlying units CMc and CMl. In the southeast portion of the study area, unit Pm outcrops in a series of east-trending terraces, from the lowermost of which the Canada Lafarge Cement Company is extracting its raw materials.

Unit Pm comprises massive-bedded, grey-brown- to light grey-weathering limestone interbedded with less common continuous or lensoidal, dark grey, chert beds. Crinoidal packstone and wackestone containing brachiopods, fusulinaceans, tabulate corals, bryozoans, and gastropods are typical of the limestone. Packstone and wackestone units are generally massive to weakly bedded, whereas rare argillaceous limestone intervals are well bedded and display tight to open folding; compositional layering and folding is most apparent on the large, fresh surfaces exposed in the quarry. Conodonts recovered from this unit constrain its age to Asselian to Roadian and (?)Wordian (Orchard and Forster, 1988; M.J. Orchard, pers. comm., 2001).

Upper Permian to Lower Jurassic chert-pebble conglomerate (unit PJc)

Chert-pebble conglomerate, unconformably overlying Permian limestone, is exposed in three localities: near Robbins Lake, approximately 1100 m to the southeast at Unconformity hill, and in the gully east of the Lafarge quarry.

Unit PJc is composed of pebble- to cobble-sized, well rounded to subangular, light grey to dark grey chert, and well rounded crinoidal wackestone clasts, supported in a limestone matrix. Beds with well rounded chert are clast supported and contain abundant limestone clasts; pebbles and clasts show no apparent grading. Beds with subrounded chert clasts are matrix supported and limestone clasts are rare to absent. Fusulinid (L. Rui, unpub. report, 2001) and conodont data provide Lower–Middle Permian dates for what are presumed to be clasts; the possibility of achieving independent age constraint for the matrix is low due to the difficulty of separating it from the clasts.

The attitude of this unit is similar to the overlying Jurassic, but lithological dissimilarities and an erosional relationship suggest that a hiatus is recorded between the two units.

(?)Basal Nicola Group conglomerate (unit Trc)

Volcaniclastic conglomerate containing boulders and cobbles of limestone (Fig. 5) outcrop in the area of Shaw Hill and the Dome Hills, in the northeastern and northwestern portions of the study area. Where the base of unit Trc is visible, it is found to be overlying limestone, the assumed source of the limestone clasts.

Volcanic clasts of basalt, andesite, augite porphyry, and possibly rhyolite are supported in a matrix of medium- to very coarse-grained volcaniclastic sand. Limestone clast component decreases upward, and limestone is absent in the upper portions of the unit. Where basal contacts are observed, volcaniclastic sand is seen to fill fissures in the underlying limestone, which appears to be a karst surface. In several localities, a penetrative northwest-trending shear is observed.

Triassic Nicola Group (unit TrN)

Rocks of the Nicola Group are abundant on the south side of the South Thompson River, and to the west and northwest of the present study area. In the southwest portion of the study area, Smith (1979) recognized Nicola Group correlatives in fault contact with Harper Ranch Group volcaniclastic rocks equivalent to unit CMc.

The Nicola Group, as recognized in the Kamloops area, consists of abundant mudstone, siltstone, volcaniclastic sandstone, pillow basalt, andesite, augite porphyry, interstitial and lensoidal limestone, and near its base, conglomerate (unit Trc). Lithologically this unit is very similar to unit CMc and presently is distinguished by map trends or more reliably the presence of Triassic conodonts in the limestone. Smith (1979) provides a more detailed account of Nicola Group lithology in the area.

Roadcuts along the western flanks of the Dome Hills, near the town of Rayleigh, expose large sections of folded and reverse faulted mudstone and siltstone. Folding, for the most part, is typically obscured due to patchy exposure in the study area, but where discernable, folds are isoclinal (Fig. 6) suggesting this structural style may be pervasive.

Lower Jurassic shale, conglomerate, and volcanic rocks (unit Jvc)

Map unit Jvc was first recognized in a gully approximately 400 m east of the Canada Lafarge quarry. The contact with unit PJc follows this gully up to its termination at Unconformity hill and then veers east. The eastern limit of unit Jvc has not been determined.

Red-brown-weathering, concretion-bearing shale, interpreted as the base of unit Jvc, unconformably overlies unit PJc. Calcareous concretions range from 5 cm to 20 cm in diameter and contain ammonites, bivalves, gastropods, and plant fragments.

The shale beds are overlain by a coarse-cobble conglomerate, containing well rounded to angular cobbles and pebbles of crossbedded sandstone and volcanic rocks supported in a medium-grained, yellow-brown-weathering, lithic-rich sandstone. Conglomerate beds variably cut down into, and incorporate clasts of unit PJc (Fig. 7). The overall thickness of the conglomerate is unknown, however, volcanic rocks consisting of porphyritic flows and flow breccias are exposed approximately 500 m to the east.

Figure 5. *(?)Basal Nicola Group (unit Trc), volcaniclastic conglomerate, cobbles of limestone common at the base of the unit. Rock hammer (33 cm) for scale.*

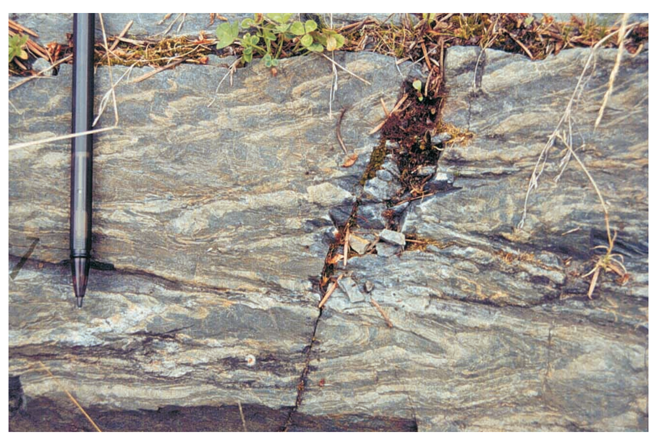

Figure 6. *Isoclinally folded mudstone and siltstone, unit TrN. Pencil (13 cm) for scale.*

***Figure 7.** Volcaniclastic conglomerate of unit Jvc, with large clast (centre left) underlying chert-pebble conglomerate (unit PJc). Rock hammer pick approximately 10 cm.*

Tertiary and Quaternary extrusive volcanic rocks (unit TQv)

Eocene, (?)Miocene, and Quaternary extrusive volcanic rocks overlie units CMl, CMc, Pm, and Jvc in the east and northeast portion of the map area. Unit TQv typically forms the lower slopes of east-facing hills, and outcrops commonly have low relief.

Several phases of plateau and valley-fill basalt are evident but are left undifferentiated. Unit TQv basalts are generally brown- to buff-weathering, deep red-brown to brown on fresh surfaces, with common agate filled amygdales. Flow laminae or breccia were not observed. A portion of these deposits represents part of the Eocene Kamloops Group. North of Pinantan Lake, presumed Quaternary pillow basalt overlies lacustrine sediments containing unlithified organic material.

PALEONTOLOGY

Conodonts

Conodonts (Fig. 8) ranging from Upper Devonian to Upper Triassic have been reported from the Harper Ranch and Nicola groups in the Kamloops area, specifically faunas representing the Late Famennian, Late Visean–Early Serpukhovian, and Asselian to Roadian, (?)Wordian from the Harper Ranch Group, and Carnian to Norian in the Nicola Group (Orchard, 1987; Orchard and Forster, 1988; Danner and Orchard, 2000). Conodont recovery, for the most part, was restricted to limestone samples although some is known from chert (Orchard, 1986).

A new Lower Tournaisian conodont fauna (GSC loc. C-305537) has been recovered from calcareous nodules collected from an outcrop of interbedded pyritic mudstone and siltstone during recent fieldwork. Conodonts recovered from the Tournaisian section include: *Siphonodella duplicata* Branson & Mehl, *Siphonodella* sp. A, *Bispathodus stabilis*

***Figure 8.** Conodonts recovered from Lower Tournaisian strata; Polygnathus vogesi and Siphonodella duplicata. Scale bar = 200 μm.*

(Branson & Mehl), *Polygnathus communis carina* Hass, *P. inornatus* Branson, *P. vogesi* Ziegler, *P.* spp. indet., *Pseudopolygnathus fusiformis* Branson & Mehl, and *Pseudopolygnathus* sp. A. These faunal elements suggest an outer-shelf succession characterized by the dominance (approximately 90%) of *Polygnathus* species, indicative of the Polygnathid Biofacies (Mawson and Talent, 1997).

Using the *Siphonodella* zonation of Sandberg et al. (1978), this fauna can be correlated with the *duplicata* Zone. The lower age limit is Early *duplicata* Zone based on the presence of *Siphonodella duplicata*; however, forms resembling both *Siphonodella duplicata* morphotype 1 and morphotype 2 are present suggesting a lower limit above the base of the *duplicata* Zone. The absence of more advanced forms of *Siphonodella* such as *S. obsoleta* or *S. quadruplicata* which have lower limits in the Upper *duplicata* Zone supports the Lower *duplicata* Zone age, but does not conclusively preclude a higher level. An upper age limit is tentatively defined at the top of the Upper *duplicata* Zone by the presence of *Polygnathus vogesi*; this species is commonly confused with the higher ranging *P. communis carina* Hass, and the possibility that *P. vogesi* may range beyond the *duplicata* Zone cannot be excluded. This is the first published record of *Polygnathus vogesi* from North America, although C.A. Sandberg (pers. comm., 2001) recently informed the author of several unreported occurrences of *P. vogesi* from (the next zone above the *duplicata*) the Lower *crenulata* Zone in Nevada and Idaho.

Goniatites

Several well preserved specimens of *Goniatites crenistria*, a cosmopolitan species from the Late Visean (W. Nassichuk, pers. comm., 2001), have been recovered from spicule-rich wackestone east of Paul Lake (GSC loc. C-305564). This is the first reported occurrence of a Carboniferous goniatitid from the Harper Ranch Group. The unit from which they were recovered was previously dated by conodonts and constrained to the Late Visean–Early Serpukhovian. Fusulinids and conodonts have also been recovered from the same sample. Conodonts recovered include: *Vogelgnathus campbelli* (Rexroad), *Gnathodus homopunctatus* Bischoff, *G. girtyi* Hass, *Lochriea commutata* (Branson & Mehl), *Cavusgnathus naviculus* (Hinde), *Hindeodus* sp., *Idioprioniodus* sp., and *Kladognathus* sp; the fusulinid *Eostafella* sp. was observed in thin section (L. Rui, unpub. report 2001). The co-occurrence of goniatites, conodonts, and fusulinids promise to allow for intercalibration of their respective successions, this would also be a first for the Harper Ranch Group.

Figure 9. *Lower Jurassic (Sinemurian) ammonite Arnioceras sp. recovered from concretion in unit Jvc. Scale bar (at top) in centimetres.*

Ammonites

The ammonite *Arnioceras* sp. (R.L. Hall, pers. comm., 2000; Fig. 9) has been recovered from a concretionary shale bed (unit Jvc) unconformably overlying Permian limestone, constraining the age of these strata as Sinemurian (GSC loc. C-305568). This is the first occurrence of ammonites in the Kamloops area. Along with the ammonites, the bivalve *Entolium* sp. (T. Poulton, pers. comm., 2000), wood, plant debris, and gastropods were recovered. Species of *Arnioceras* have also been recovered from the Rossland Group, southeast of the Harper Ranch Group and from "Map Unit 15" of Campbell and Tipper (1971), northwest of the study area in the Bonaparte Lake map area. Associated strata in the Bonaparte Lake area, such as boulder conglomerate and lithic sandstone are similar to the Jurassic strata of the Harper ranch area. The Jurassic strata of the Bonaparte Lake area show further similarities with the Harper ranch area as they too unconformably overlie Permian limestone. Lower Jurassic strata in the Harper ranch area and the Bonaparte Lake area should be considered correlative, and relationships between the underlying Permian limestone in both areas should be the focus of future study. Campbell and Tipper (1971) trace similar Jurassic strata north through the Quesnel Lake map area, and further northwest into the Prince George map area and correlate them with the Takla Group.

SUMMARY AND DISCUSSION

The shallow-water biofacies of unit DF of the Harper Ranch Group, representing outer shoreface deposition, is juxtaposed with the nearby Tournaisian outer-shelf succession. The change in depositional environment, although representing a time span of at least two conodont zones (most of the *praesulcata* zone and the entire *sulcata* zone), records a rise in relative sea level broadly coincident with a major global transgression.

Evidence such as volcaniclastic interbeds and transitional facies with limestone units of known upper Mississippian age, along with a single Tournaisian outcrop, suggest the clastic succession was deposited between the Tournaisian and the Serpukhovian.

The mudstone of unit CMc has been interpreted as hemipelagic sediments that accumulated in a relatively deep-water setting (Smith, 1979). Volcaniclastic rocks, which range from medium to very coarse grained, entered the deep basin via sediment gravity slides; this is supported by the occurrence of large mudstone rip-up clasts within the lower portions of volcaniclastic conglomerate units.

Pennsylvanian strata have yet to be conclusively reported from the area, leading to the interpretation that a long depositional hiatus ensued after the Mississippian; this is most likely due to uplift given the tectonic setting and the angular relationship of the Mississippian limestone with the overlying Permian strata. No evidence of subaerial exposure during this interval, however, such as karsting of the Mississippian limestone units, has been definitively recorded.

The Permian is represented by a thick succession of Asselian to Wordian carbonate rocks. The depositional environment has been interpreted as a subsiding carbonate bank recording progressive deepening, supported by the succession of conodont faunas from a typically shallow-water, *Adetognathus*- to *Sweetognathus*-dominated fauna, to a typically deeper water *Neogondolella*-dominated fauna (Orchard and Forster, 1988).

Conglomerate, found overlying Permian limestone and containing large clasts of Permian limestone is interpreted as the base of the Nicola Group in the area. Increase in accommodation space due to basin subsidence, and/or increase in volcaniclastic sediment supply acted to rapidly bury Permian limestone. The angular relationship between the limestone and the conglomerate suggests an episode of tectonism occurred between the Late Middle Permian and the Late Triassic. Volcanic and volcaniclastic rocks to the east, lying unconformably on Permian limestone of the Harper Ranch Group, are dated as Sinemurian and therefore can be correlated with the Lower Jurassic Rossland Group.

Continued processing of conodont samples collected during the 2001 field season will add to the micropaleontological database for the Harper Ranch Group and provide additional constraints on the age of the strata in the area.

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