Significance of Jurassic radiolarians from the Cache Creek terrane, British Columbia

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ABSTRACT

The discovery of new radiolarian localities in the western belt of the Cache Creek terrane in southern British Columbia possibly changes its upper age limit from Late Triassic to Early or Middle Jurassic. It favors a Middle Jurassic, rather than a Late Triassic, age of amalgamation for the Cache Creek terrane and Quesnellia (parts of superterrane I) in southern British Columbia. The new Jurassic ages also mean that the western Cache Creek terrane could be equivalent in age to the Bridge River–Hozameen terrane in British Columbia and to terranes containing the Tethyan fusulinid *Yabeina* in northwest Washington and the Klamath Mountains of California.

INTRODUCTION

The Cache Creek terrane extends for more than 1000 km along the length of the Canadian Cordillera from lat 50°30′ to 60°30′ (Fig. 1; Monger et al., 1982). It is frequently cited in discussions of North American Cordillera geology as a classic example of an exotic Carboniferous to Late Triassic accreted oceanic terrane (e.g., Davis et al., 1978; Monger et al., 1982); thus, any new data bearing on this status is of major importance. The subject of this paper is the discovery of new fossil localities in a small part of the type area of the Cache Creek Group in southern British Columbia (Figs. 1 and 2). For descriptions of Cache Creek rocks in British Columbia and Yukon and discussions of the terms "Cache Creek Group," "terrane," and "complex," see Monger (1977), Monger et al. (1982), Monger and McMillan (1984), and references therein. We use the term "Cache Creek terrane" throughout this paper.

Samples were collected during field work in southern British Columbia by Cordey and Mortimer in 1985 and Mortimer in 1986. Radiolarians were extracted and identified by Cordey and DeWever. A simplified geologic map of this area, along with sample localities, is shown in Figure 2.

GENERAL GEOLOGY

The Cache Creek terrane in southern British Columbia is divided into three belts (Fig. 1; Duffell and McTaggart, 1952; Monger and McMillan, 1984). The eastern belt is subdivided into units of greenstone and melange; the melange contains blocks of limestone, marble, greenstone, tuff, and ribbon radiolarian chert, all in a variably sheared matrix of argillite (Shannon, 1981). Fusulinids, conodonts, and radiolarians from the eastern belt range in age from Middle Pennsylvanian to Late Triassic, the blocks yielding older ages than the matrix (Monger and McMillan, 1984; Orchard, 1984; Danner, 1985; Cordey, 1986, and references therein). The eastern belt is in fault contact with the central belt of the Cache Creek terrane to the west and in fault contact with the Late Triassic Nicola Group of the tectonostratigraphic terrane Quesnellia to the east (Monger and McMillan, 1984). Conglomerate, sandstone, and shale of the Sinemurian to Callovian Ashcroft Formation unconformably overlie the Nicola Group and occur as slices faulted into the eastern belt (Travers, 1982; Monger and McMillan, 1984).

The central belt of the Cache Creek terrane consists of massive limestone and marble of the Marble Canyon Formation and subordinate chert, argillite, and volcanic rocks. Conodonts and radiolarians from the central belt range in age from middle Permian to Late Triassic (Orchard, 1984; Cordey, 1986). Fusulinids from the Marble Canyon Formation are Late Permian in age and include species of *Yabeina*,

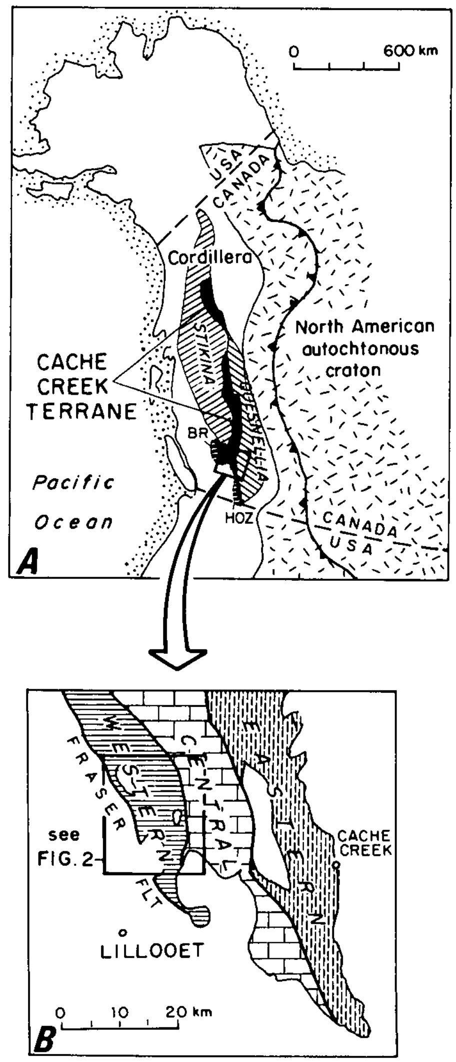

Figure 1. A: Location map of Cache Creek terrane in western Canada (after Monger et al., 1982). BR = Bridge River Group; HOZ = Hozameen Group. B: Subdivision of terrane into three belts in southern British Columbia (after Duffell and McTaggart, 1952); inset shows area of Figure 2.

which belong to a Tethyan, rather than North American, faunal province and are frequently cited as evidence that the Marble Canyon Formation is far-traveled (e.g., Monger and Ross, 1971; Monger et al., 1982; Danner, 1985).

The western belt consists mainly of chert, argillite, and siliceous argillite, along with subordinate tuff, limestone, and marble. We also include the informally named, dominantly volcaniclastic Pavilion beds (Trettin, 1980) as part of the western belt. The western belt is the least well dated of the three belts: only five fossil localities have been reported, and all in limestones; three localities close to the contact with the Marble Canyon Formation have yielded middle to Late Permian fusulinids (Trettin, 1980) and Early and Late Triassic conodonts (Orchard, 1981), and two localities in the Pavilian beds have yielded Middle to Late Triassic (possibly Norian) corals (Trettin, 1980) and Middle to Late Triassic conodonts (Rafek, 1980).

Recent fieldwork (Mortimer, 1987) supports earlier interpretations that the contact between the central and western belts of the Cache Creek terrane is probably depositional and tightly folded (Trettin, 1980) rather than faulted (interpretations of Travers, 1982; Monger and McMillan, 1984). The central and western belts of the Cache Creek terrane should thus be considered a single tectonostratigraphic unit, distinct from the eastern belt.

RADIOLARIAN LOCALITIES AND ASSOCIATIONS

We describe herein five new radiolarian localities from the western belt of the Cache Creek terrane. Previously reported radiolarian dates (Cordey, 1986) were from ribbon cherts in the central and eastern belts. The fact that no argillaceous facies had previously been dated in the Cache Creek terrane made these lithologies a focus of our sampling.

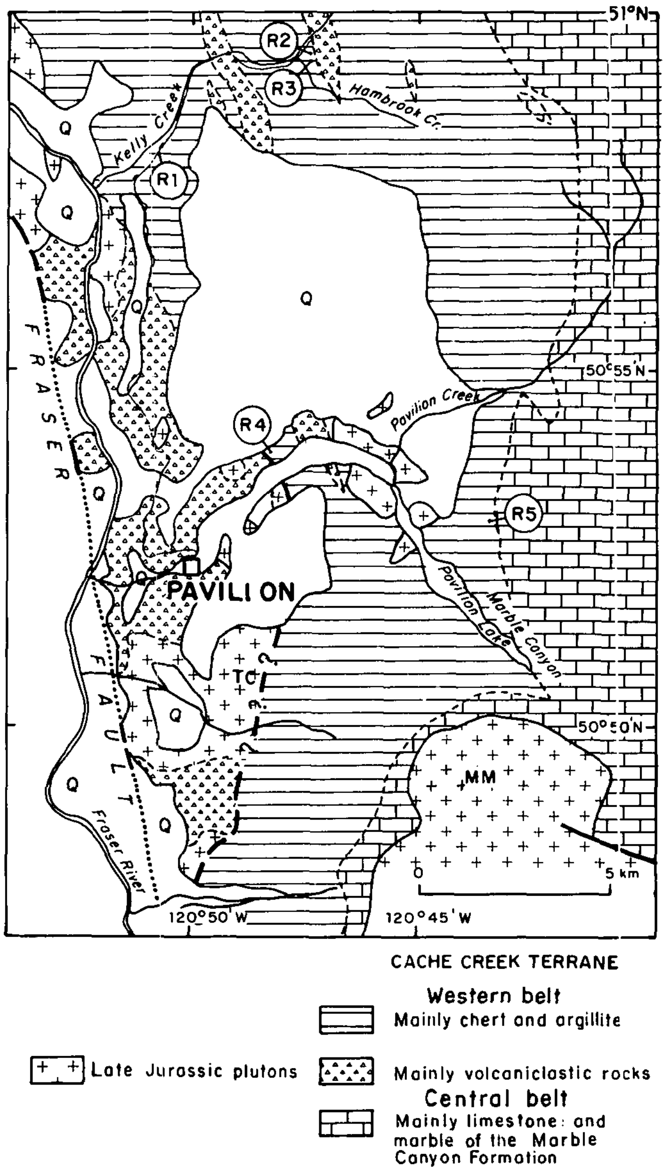

Figure 2. Simplified geologic map of part of central and western belts of Cache Creek terrane (after Trettin, 1961; Monger and McMillan, 1984; Mortimer, 1987). Q = Quaternary, Tertiary, and Cretaceous cover; MM = Mount Martley pluton; TC = Tiffin Creek stock. Volcaniclastic rocks north and south of Pavilion are known informally as Pavilion beds (Trettin, 1980). R1, R2, R3, R4, R5 are radiolarian sample localities. Geology west of Fraser fault not shown.

At locality R1 (Fig. 2), gray chert is exposed in cuts along the British Columbia Railroad above Kelly Creek. Intercalated argillite composes less than 5% of the section. Several Middle to Late Triassic forms of *Triassocampe* sp. were obtained from chert (sample FC85-P07).

Localities R2 and R3 (Fig. 2) are in roadcuts along the Pavilion–Kelly Lake Road in the Hambrook Creek drainage. Interbedded angular volcaniclastic sandstone and siliceous argillite dominate the section. In places, these lithologies are rhythmically interbedded and show primary slump structures. Argillite is present in minor amounts, but chert is absent. At R2, a tuffaceous siliceous argillite (sample FC85-P11) yielded an identifiable fauna. Special processing was needed for the extraction; alternating high- and low-concentration acid baths were used, a modification of usual radiolarian extraction techniques (see DeWever and Cordey, 1986, and references therein). The radiolarian association at locality R2 is composed of the following genera: *Hsuum* sp., *Pantanellium* sp., *Paronaella* sp., *Praeconocaryomma* sp., *Triactoma* sp., and *Zartus* sp. Precise determination of species is difficult because of the generally bad preservation of the fauna. The presence of several specimens of *Zartus* sp. (6–9, Fig. 3), which range in age from Pliensbachian to Bajocian (Pessagno and Blome, 1980), establishes the age of the locality R2. The *Zartus* specimens occurring in our sample FC85-P11 have more affinities with Bajocian forms than Pliensbachian ones known from literature, but their bad state of preservation prevents a precise correlation. At locality R3, radiolarians were extracted from a black siliceous argillite (sample FC85-P12) and reveal a probable Early Jurassic age. They are *Emiluvia* sp., *Hsuum* sp., *Napora* sp., and *Paronaella* sp.

At locality R4 (Fig. 2), sample NM86-6B was collected from an exposure of gray, lenticular chert with features similar to that at locality R1. At locality R5 (Fig. 2), chert sample NM86-10C was collected. At R5, black chert is interbedded with argillite in a section consisting dominantly of intercalated argillite, marble, and metavolcanic rocks. This section is immediately west of the contact with the Marble Canyon Formation. Localities R4 and R5 yielded similar radiolarian associations: *Triassocampe* sp. (15 and 16, Fig. 3), *Pseudostylosphaera* sp. cf. *P. nazarovi* (Kozur & Mostler), and *Eptingium*(?) sp. cf. *E. manfredi* (Dumitricà). These radiolarians occur in Middle and Late Triassic strata.

To summarize, we report three new Middle to Late Triassic radiolarian localities from the western belt of the Cache Creek terrane. These are in general agreement with previous fossil ages obtained from the western belt. In addition, we report two Jurassic localities, the radiolarian faunas being of Early or Middle Jurassic (Pliensbachian-Bajocian) age at R2 and probable Early Jurassic age at R3 (Fig. 2). These are the first recorded Jurassic fossils from the Cache Creek terrane.

DISCUSSION

The nearest Early–Middle Jurassic rocks to localities R2 and R3 are fault-bounded slices of Ashcroft Formation, exposed 20 km to the east within the eastern belt of the Cache Creek terrane (Monger and McMillan, 1984). An obvious point to address is whether the interbedded siliceous argillite and volcaniclastic sandstones at localities R2 and R3 represent similar infaulted or folded slices of Ashcroft Formation. We consider such a correlation unlikely for the following reasons: (1) Ashcroft sedimentary facies become more distal to the west (Travers, 1982), implying an absence of ties with a westerly volcanic source. (2) The Ashcroft Formation contains rich pelecypod and ammonite macrofaunas (Monger and McMillan, 1984) which are absent from the similar sedimentary facies in the Cache Creek terrane. (3) Rhythmically interbedded siliceous argillite and volcaniclastic sandstone, indistinguishable from that at localities R2 and R3, is common in the western belt of the Cache Creek terrane, and especially in Trettin's (1980) "Pavilion beds" (Fig. 2; Mortimer, 1987), indicating compatible intra–Cache Creek sedimentary facies. (4) There is no evidence within the western belt for major block faulting, other than the fault shown in Figure 2, or for any unconformities in pre–middle Cretaceous rocks (Mortimer, 1987). We consider it significant that the Jurassic radiolarians were extracted from siliceous argillites interbedded with volcaniclastic sandstones and siltstones, whereas Permian and Triassic radiolarians from the Cache Creek terrane came from ribbon cherts (Cordey, 1986). A similar lithostratigraphic record has been noted in another well-investigated *Yabeina*-bearing terrane in the North American Cordillera, the North Fork terrane of the Klamath Mountains in northern California. The North Fork terrane has yielded Late Permian and Late Triassic radiolarians from volcaniclastic-free ribbon cherts and Early or Middle Jurassic radiolarians from siliceous tuff (Irwin et al., 1977) and siliceous argillite interbedded with tuffaceous sandstone (Murchey and Jones, in Mortimer, 1984). The San Juan terrane of northwestern Washington (Silberling et al., 1984) also contains *Yabeina* (Danner, 1977) and Jurassic radiolarians (Whetten et al., 1978) and is another example of a Tethyan oceanic terrane with which the Cache Creek terrane may well be age-equivalent.

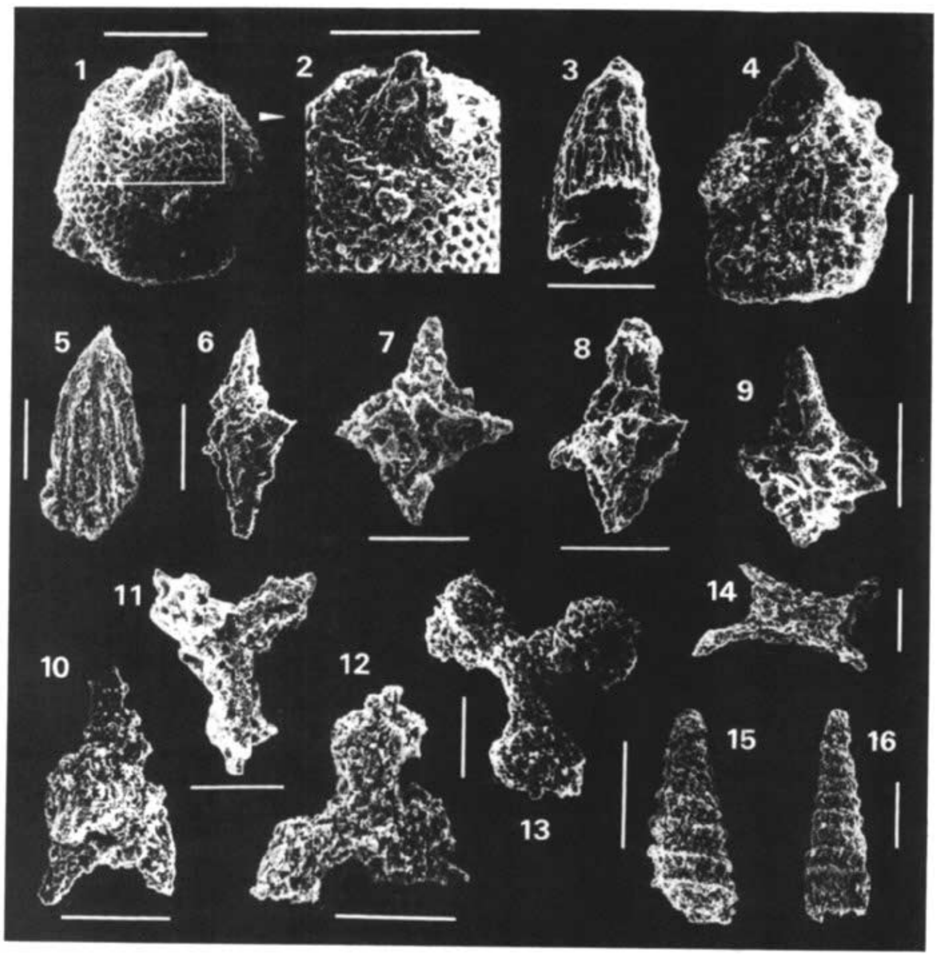

Figure 3. Scanning electron micrographs of Triassic and Jurassic radiolarians from western belt of Cache Creek terrane. Scale bars = 100 μm. 1: *Triactoma* sp. (sample FC85-P11, locality R2). 2: Detail of 1. 3: *Hsuum* sp. 1 (FC85-P11, R2). 4: *Hsuum* sp. 2 (FC85-P11, R2). 5: *Hsuum* sp. 3 (FC85-P12, R3); 6–9: *Zartus* sp. (FC85-P11, R2). 10: *Napora* sp. (FC85-P12, R3). 11: *Paronaella* sp. 1 (FC85-P11, R2). 12: *Paronaella* sp. 2 (FC85-P12, R3). 13: *Paronaella* sp. 3 (FC85-P12, R3). 14: *Emiluvia* sp. (FC85-P12, R3). 15: *Triassocampe* sp. (NM86-6B, R4). 16: *Triassocampe* sp. 2 (NM86-6B, R4).

REGIONAL IMPLICATIONS

Middle Jurassic Deformation

Previously, the youngest fossils obtained from the Cache Creek terrane in southern British Columbia were Late Triassic (early Norian) conodonts from the central belt (Orchard, 1984) and various Late Triassic fossils from the western belt (Rafek, 1980; Trettin, 1980; Orchard, 1981). Our new data show that deposition in some parts of the Cache Creek terrane possibly continued at least until Pliensbachian to Bajocian time. This, in turn, could provide a new lower limit on the time of deformation and metamorphism of the western and central belts of the Cache Creek terrane. A new upper limit for Cache Creek deformation has recently been provided by a 152 ±5 Ma K-Ar hornblende age (latest Jurassic) from the Tiffin Creek stock (Fig. 2), which crosscuts deformed western belt rocks (Mortimer, 1987).

These data support a Middle Jurassic age of regional deformation in southern British Columbia (Travers, 1982), contrary to hypotheses involving Late Triassic juxtaposition of Quesnellia and the Cache Creek terrane (Monger, 1981; Monger et al., 1982) and the interpretation that the Cache Creek terrane represents a Late Triassic subduction complex, genetically associated with the Nicola arc (Monger et al., 1982). We add that because the eastern melange belt of the Cache Creek terrane is a tectonostratigraphic unit distinct from the western and central belts (Monger and McMillan, 1984; Mortimer, 1987), the Jurassic depositional ages do not apply to the eastern belt, and deformation within it may extend as far back as the Late Triassic.

Until Jurassic fossils are found in the Cache Creek terrane of northern British Columbia and the Yukon, we cannot state that deposition continued beyond the Late Triassic in the part of the ocean basin represented by the northern Cache Creek terrane (Fig. 1). Thus, superterrane I of Monger et al. (1982) may have been assembled by Late Triassic time in northern British Columbia and not until the Middle Jurassic in the south. However, Mortimer (1986) noted early Mesozoic stratigraphic differences between arc rocks of Quesnellia and Stikinia that are best explained by the existence of a Cache Creek ocean between them that also did not close in the north until the Middle Jurassic.

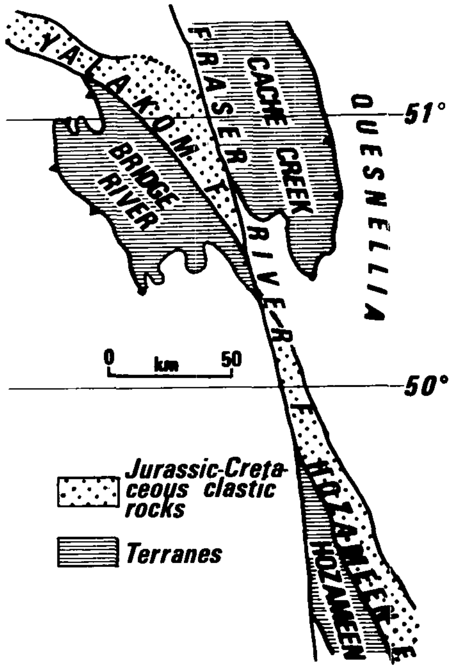

Figure 4. Map showing spatial relation between Cache Creek and Bridge River–Hozameen terranes (after Monger, 1985). They are separated by Jurassic-Cretaceous clastic sedimentary rocks and major strike-slip faults, Yalakom fault–Hozameen fault (probable major strike-slip movement), and Fraser River fault (80–100 km dextral strike slip).

Correlation with Other Terranes in Canada

Volcaniclastic strata in the western belt of the Cache Creek terrane have so far been dated as Late Triassic and Early or Middle Jurassic (Rafek, 1980; Trettin, 1980; and this study). Volcanism and/or volcaniclastic deposition of these ages is absent in Quesnellia but common in Stikinia (Stuhini and Hazelton Groups) and the Cadwallader terrane of southern British Columbia (Cadwallader and Tyaughton Groups). Any correlation must, however, await more (and more precise) dating of the volcanogenic Cache Creek rocks.

South and west of the Cache Creek terrane in southern British Columbia, the Bridge River and Hozameen Groups (here considered a single tectonostratigraphic unit; Figs. 1 and 4) have yielded fossils ranging in age from Permian to Middle Jurassic (Potter, 1983; R. A. Haugerud, in Monger and McMillan, 1984; Cordey, 1986). The generally accepted and conservative regional noncorrelation of the Cache Creek and Bridge River–Hozameen terranes has been based on the absence of Permian limestones in the latter and the absence of Jurassic strata in the former. The discovery of Jurassic radiolarians in the western Cache Creek terrane means that it could be age-equivalent to the Bridge River terrane, and rocks of both terranes could be interpreted as relics of ocean basins that closed in the Middle Jurassic.

REFERENCES CITED

Cordey, F., 1986, Radiolarian ages from the Cache Creek and Bridge River complexes and from chert pebbles in Cretaceous conglomerates, southwestern British Columbia: Geological Survey of Canada Paper 86-1A, p. 595–602.

Danner, W.R., 1977, Paleozoic rocks of northwest Washington and adjacent parts of British Columbia, *in* Stewart, J.H., Stevens, C.H., and Fritsche, A.E., eds., Paleozoic paleogeography of the western United States: Society of Economic Paleontologists and Mineralogists, Pacific Section, Pacific Coast Paleogeography Symposium 1, p. 481–502.

——1985, Tethyan exotic terrane, southwestern British Columbia: Geological Society of America Cordilleran Section Meeting, Guidebook, 17 p.

Davis, G.A., Monger, J.W.H., and Burchfiel, B.C., 1978, Mesozoic construction of the Cordilleran "collage," central British Columbia to central California, *in* Howell, D.G., and McDougall, K.A., eds., Mesozoic paleogeography of the western United States: Society of Economic Paleontologists and Mineralogists, Pacific Section, Pacific Coast Paleogeography Symposium 2, p. 1–32.

DeWever, P., and Cordey, F., 1986, Datations par les radiolaires de la Formation des Radiolarites s.s. de la Série du Pinde-Olonos (Grèce): Bajocien(?)-Tithonique: Marine Micropaleontology, v. 11, p. 113–127.

Duffell, S., and McTaggart, K.C., 1952, Ashcroft map area, British Columbia: Geological Survey of Canada Memoir 262, 122 p.

Irwin, W.P., Jones, D.L., and Pessagno, E.A., 1977, Significance of Mesozoic radiolarians from the pre-Nevadian rocks of the southern Klamath Mountains, California: Geology, v. 5, p. 557–562.

Monger, J.W.H., 1977, Upper Paleozoic rocks of the western Canadian Cordillera and their bearing on Cordilleran evolution: Canadian Journal of Earth Sciences, v. 14, p. 1832–1859.

——1981, Geology of parts of western Ashcroft map area, southwestern British Columbia, *in* Current research, Part A: Geological Survey of Canada Paper 81-1A, p. 185–189.

——1985, Structural evolution of the southwestern Intermontane belt, Ashcroft and Hope map areas, British Columbia: Geological Survey of Canada Paper 85-1A, p. 349–358.

Monger, J.W.H., and McMillan, W.J., 1984, Bedrock geology of Ashcroft (92 I) map area: Geological Survey of Canada Open-File Report 980.

Monger, J.W.H., and Ross, C.A., 1971, Distribution of fusulinaceans in the Canadian Cordillera: Canadian Journal of Earth Sciences, v. 8, p. 259–278.

Monger, J.W.H., Price, R.A., and Tempelman-Kluit, D.J., 1982, Tectonic accretion and the origin of the two major metamorphic and plutonic welts in the Canadian Cordillera: Geology, v. 10, p. 70–75.

Mortimer, N., 1984, Petrology and structure of Permian to Jurassic near Yreka, Klamath Mountains, California [Ph.D. thesis]: Stanford, California, Stanford University, 84 p.

——1986, Late Triassic, arc-related, potassic igneous rocks in the North American Cordillera: Geology, v. 14, p. 1035–1038.

——1987, Lithologic map of Pavilion (92I/13) map area, British Columbia: British Columbia Ministry of Energy, Mines and Petroleum Resources Open-File 1987-18, scale 1:50,000.

Orchard, M.J., 1981, Triassic conodonts from the Cache Creek Group, Marble Canyon, southern British Columbia, *in* Current research, Part A: Geological Survey of Canada Paper 81-1A, p. 357–359.

——1984, Pennsylvanian, Permian and Triassic conodonts from the Cache Creek Group, southern British Columbia: Geological Survey of Canada Paper 84-1B, p. 197–206.

Pessagno, E.A., Jr., and Blome, C.D., 1980, Upper Triassic and Jurassic Pantanelliinae from California, Oregon and British Columbia: Micropaleontology, v. 26, p. 225–273.

Potter, C.J., 1983, Geology of the Bridge River Complex, southern Shulaps Range, British Columbia: A record of convergent tectonics [Ph.D. thesis]: Seattle, University of Washington, 192 p.

Rafek, M.B., 1980, Triassic conodonts from the Pavilion beds, Big Bar Creek, central British Columbia: Geological Survey of Canada Paper 80-1C, p. 129–133.

Shannon, K.R., 1981, The Cache Creek Group and contiguous rocks, near Cache Creek, British Columbia, *in* Current research, Part A: Geological Survey of Canada Paper 81-1A, p. 217–221.

Silberling, N.J., Jones, D.L., Blake, M.C., Jr., and Howell, D.G., 1984, Lithotectonic terrane maps of the North American Cordillera; part C, Lithotectonic terrane map of the western conterminous United States: U.S. Geological Survey Open-File Report 84-523, 76 p.

Travers, W.B., 1982, Possible large-scale overthrusting near Ashcroft, British Columbia: Implications for petroleum prospecting: Bulletin of Canadian Petroleum Geology, v. 30, p. 1–8.

Trettin, H.P., 1961, Geology of the Fraser River Valley between Lillooet and Big Bar Creek: British Columbia Department of Mines and Petroleum Resources Bulletin 44, 105 p.

——1980, Permian rocks of the Cache Creek Group in the Marble Range, Clinton area, British Columbia: Geological Survey of Canada Paper 79-17, 13 p.

Whetten, J.T., Jones, D.L., Cowan, D.S., and Zartman, R.E., 1978, Ages of Mesozoic terranes in the San Juan Islands, Washington, *in* Howell, D.J., and McDougall, K.A., eds., Mesozoic paleogeography of the western United States: Society of Economic Paleontologists and Mineralogists, Pacific Section, Pacific Coast Paleogeography Symposium 2, p. 117–132.

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