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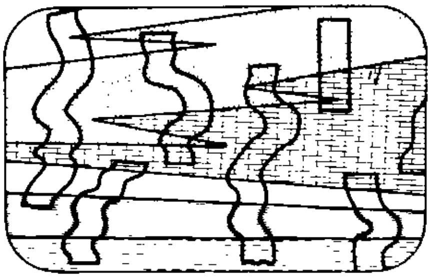

Correlation of Eugeosynclinal Tectono-Stratigraphic Belts in the North American Cordillera

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Introduction

This brief outline suggests how some of the eugeosynclinal, sedimentary and volcanic rock assemblages in the western part of the North American Cordillera can be correlated and some of the major problems, and implications of these correlations. Specifically, it is concerned with relating assemblages in the Alaska–Canada segment (King, 1966) to those better known, but less widely exposed assemblages farther south in the California–Colorado segment. No direct correlation is possible, for much of the critical area between latitudes 48° and 42° is covered by terrestrial Tertiary volcanics.

The Tectonic Map of North America (King, 1969) shows eugeosynclinal successions divided into broad units of Cambrian to Devonian, Mississippian to Permian, Triassic to Jurassic, Jurassic to Cretaceous and Early Tertiary, each separated by an orogenic (or deformational) episode from underlying or adjacent packages (*Fig. 1*). Some of these units, such as the late Paleozoic and superimposed early Mesozoic ones, are widely exposed, particularly in the Alaska–Canada segment of the Cordillera and can be further subdivided into assemblages.

Correlation of individual rock units can rarely be made over more than a few tens of miles in the western Cordillera, in marked contrast to the eastern miogeoclinal belt where many rock units can be traced for hundreds of miles. Rock units in the west tend to be discontinuous, not only because of the common later deformation, metamorphism, and disruption by intrusions and younger cover, but also because of typical rapid facies changes. The units best suited for regional correlations are "sequences" (Silberling and Roberts, 1962, p. 6), or "assemblages" (Bailey *et al.*, 1964, p. 11; Souther and Armstrong, 1966, p. 171). An assemblage may contain several formations or even groups, encompass a wide variety of lithologies and be separated from other assemblages by major unconformities. It represents an unique overall environment of deposition that reflects a particular tectonic situation, approximates in meaning to the tectotope of Sloss *et al.* (1949, p. 96), and probably characterizes the actual tectonic setting far more precisely than the blanket term "eugeosynclinal".

Assemblages can be linked up to form tectono-stratigraphic belts, some of which appear to run much of the length of the North American Cordillera.

Lower Paleozoic and Older (?) Assemblages

Exposures of Cambrian through Devonian stratified assemblages containing volcanic rocks fall into two groups. The first is located along the eastern margin of the eugeosyncline in Nevada, southeastern British Columbia and Yukon Territory. The second group outcrops in the south-western Yukon, southeastern Alaska, northwestern Washington, Oregon and northern California. Lithologically these groups are completely dissimilar and no direct correlation can be made between them.

The eastern exposures form part of the "graptolitic shale and chert" belt of Churkin (1974). In Nevada, outcrops consist of Cambrian and Ordovician sequences of mainly chert, shale, mafic volcanic rocks and minor quartzite and limestone, and Silurian and Devonian sequences of shale, chert and siliceous volcanic horizons (Roberts *et al.*, 1958). In the Lardeau district of southeastern British Columbia, pillow lavas are inter-bedded with phyllites, argillites and local quartzites (Fyles, 1964), but these rocks are in a structurally complex terrane and their stratigraphic position is not certain. In northern British Columbia and the Yukon, Cambrian and Ordovician mafic lavas are intercalated not only with chert and argillite, but also with carbonates (Gabrielse, 1967). These assemblages are reasonably inferred to be the westward equivalents of the eastward, predominantly carbonate miogeoclinal assemblage. In fact, some of the volcanics in the Yukon occur in carbonates close to, but east of, the transition to the shale and chert facies.

The western exposures are characterized by a variety of volcanic rocks, contain a wide spectrum of sedimentary rocks and include lower Paleozoic ultramafic and granitic rocks. In southeastern Alaska, the oldest fossiliferous rocks are Lower Ordovician greywackes, but there is a possibility that some metamorphic rocks in the region are older. Silurian and Devonian strata form a complex assemblage of volcanic rock, mainly basalt, andesite and related pyroclastics, carbonate and fine-grained clastic rock (Brew *et al.*, 1966). Granitic intrusions of Ordovician and Silurian age, and Lower Devonian granite-bearing conglomerate and red beds are evidence for some kind of orogenic event. In northwestern Washington, an Ordovician diorite-amphibolite complex is overlain apparently unconformably by Middle Devonian carbonate, volcanics and pelite (Danner, 1967; Mattinson, 1972). Devonian carbonate, grit, chert and argillite are exposed in central Oregon, but their relationships to older rocks are not known (Kleweno and Jeffords, 1961). Ordovician, Silurian and Devonian strata comprising volcanic rocks ranging from basalt to quartz keratophyre, conglomerate, phyllite and carbonate, outcrop in the eastern Klamath Mountains in south-eastern Oregon and northern California (Irwin, 1966), and were possibly laid down on an Ordovician mafic and ultramafic complex.

The relationships of rocks in the western lower Paleozoic outcrops to those in the east (and the North American craton) are not known. Ordovician and Silurian granitic rocks, and Siluro-Devonian granite-pebble bearing conglomerate and red beds indicating uplift in southeastern Alaska are not seen to the east, either as a disturbance or as floods of detritus

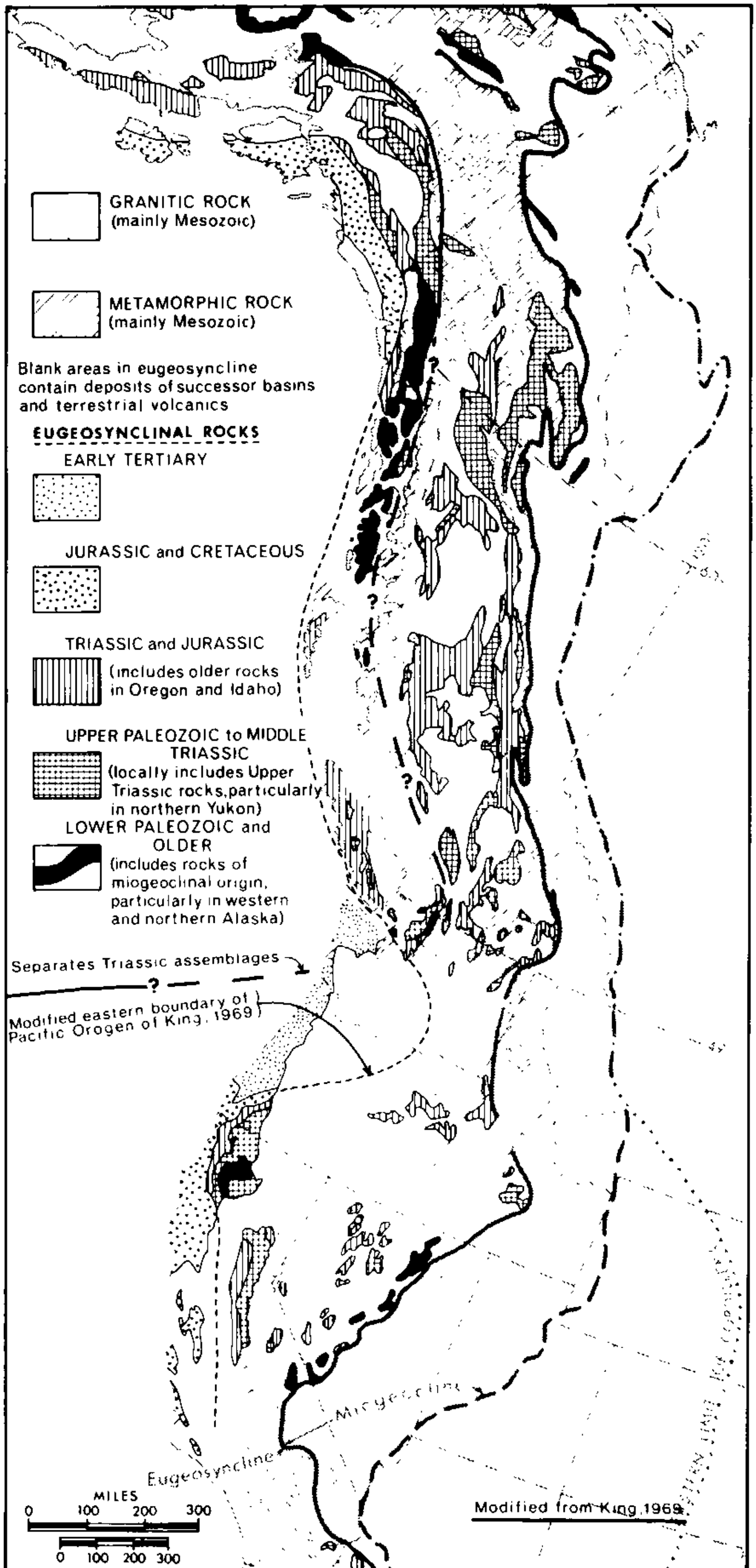

Figure 1
Eugeosynclinal terranes in the North American Cordillera, showing their relationship to the belts of mainly Mesozoic high-grade metamorphism and granitic intrusion.

from the west. Metamorphism in the central part of the Klamath Mountains apparently took place in Early Devonian (380 m.y.) time (Lanphere *et al.*, 1968). R. K. Wanless recently obtained Early Devonian (366 to 396 m.y.) zircon ages from granitoid gneiss on the west side of the Shuswap Complex in south-central British Columbia, collected by A. V. Okulitch (pers. comm.). Similarity of these ages could mean a related event, and it is possible that older terranes in the Klamath Mountains can be linked with metamorphosed 'eastern group' rocks in British Columbia.

Evidence of a mid-Paleozoic event is recorded in the eastern belt along the length of the North American Cordillera. Devono-Mississippian deformation accompanied by clastic detritus derived from a westerly source is well documented in Nevada, where it is known as the Antler Orogeny (Roberts *et al.*, 1958). In the Canadian Cordillera, the evidence is not so well displayed as it is to the south, but is of similar nature. For the first time in the history of the Canadian Cordillera, a source area of clastic rocks may have been eroded to the west, as coeval rocks to the east are shales and carbonates. Structural and stratigraphic evidence in southeastern British Columbia indicate a pre-Late Mississippian event, correlated by Wheeler (1970) with the Antler Orogeny. In central British Columbia, latitude 56°, post-Middle Devonian, pre-Permian conglomerates contain metamorphic detritus (Monger and Paterson, 1974). In northern British Columbia and southeastern Yukon, similar coarse clastic rocks overlie Middle Devonian and underlie Late Mississippian carbonates (Gabrielse, 1967).

Upper Paleozoic to Middle Triassic Assemblages

Rocks in these assemblages range in age from Early Mississippian to Middle Triassic. They are widely exposed, particularly in the Canadian segment of the Cordillera, where they are the oldest known strata of both the Intermontane Belt and the Coast Plutonic Complex. In Canada these rocks form mainly linear belts, some of which appear to continue southwards into the United States (*Fig. 2*).

Easternmost is the fairly well-defined belt **a**. In Canada, it consists of a lower sedimentary sequence, lying on Devonian and older miogeoclinal rocks, and an upper sequence of basalt with alpine-type ultramafics, locally overlain by Upper Triassic rocks. The lower sequence is pelite, minor chert and carbonate, and locally prominent sandstone and conglomerate possibly derived from a western source (see above). The interbedded carbonates range in age from Mississippian to earliest Permian. Possible correlatives to the south are the Antler and Havallah sequences (Silberling and Roberts, 1962), although these differ from the Canadian sections in containing far more sedimentary rocks, particularly conglomerate, and relatively less mafic volcanics.

Belt **b** is characterized by volcanics that range in composition from basalt to rhyolite, abundant pyroclastics and volcanic sandstones, carbonate and pelite. Acid volcanics predominate locally as in central British Columbia (locality 2b), and northwestern Nevada (locality 7b). A link between the Canadian segment of the Cordillera and Oregon, across a poorly exposed area, is provided by the great similarity in overall stratigraphy between rocks on the western side of the Cascade Mountains (Monger, 1970), and those in central Oregon (Merriam and Berthiaume, 1943).

Belt **c** is the most continuous and perhaps the most significant. It has four distinguishing features that separate it from coeval rocks. First, the lithological association comprises mainly bedded, 'ribbon' chert, pelite, carbonate, basic volcanic rocks and associated gabbro and 'alpine-type' ultramafic rock. The last three lithologies constitute probable ophiolitic assemblages that in places are Early Mississippian, elsewhere pre-Permian and pre-Middle Triassic in age. In the Yukon, volcanic rock and ultramafics predominate, and elsewhere, as near the type-area of Cache Creek Group, chert, pelite and carbonate are more abundant. Coarse clastic rocks, pyroclastics and andesitic or acidic volcanic rocks are of relatively minor importance. Similar assemblages are found in northeastern Washington (Danner, 1966), Oregon (e.g., Brown and Thayer, 1966), parts of the western Paleozoic and Triassic belt of the Klamath Mountains (Irwin, 1972), and their correlatives west of the Melones fault zone in the western Sierra Nevada (Davis, 1969). Second, the stratigraphic style of this belt is one in which rock units are typically pods or discontinuous lenses on all scales. In part, this is doubtless due to the intense deformation these rocks have undergone in many places, but partly, this reflects the original form of the rock units. Third, this belt is outlined by a distinctive Permian fusulinid fauna that has Tethyan or Asiatic affinities (Monger and Ross, 1971; Jones *et al.*, 1972). It is completely different from coeval faunas to the east, and, in Canada, to the west, which are more typical of Permian faunas found elsewhere on the North American craton. Fourth, this belt in many places has a structural style characterized by extreme disruption and mixing of rock units. Blueschist metamorphism, mainly of Permo-Triassic age, is associated in several places with this deformation. Major faults commonly isolate rocks of this belt from all but much younger, late Cretaceous or Tertiary, strata.

Upper Paleozoic assemblages west of belt **c** are known only in Canada and Alaska. They contain volcanic rock that is predominantly basalt or basaltic andesite, but locally as acidic as rhyolite, abundant pyroclastics, sandstone, carbonate and pelite (Brew *et al.*, 1966; Smith and MacKevett, 1970; Souther, 1972a). There appear to be at least two upper Paleozoic assemblages, each with its own stratigraphy. One, of Mississippian and Permian age is centred on the Stikine area, northwestern British Columbia; and the other, of Permian and (?) Pennsylvanian age is in the Alaska–Saint Elias Ranges. Their relationship to one another and to upper Paleozoic sections in southeastern Alaska that

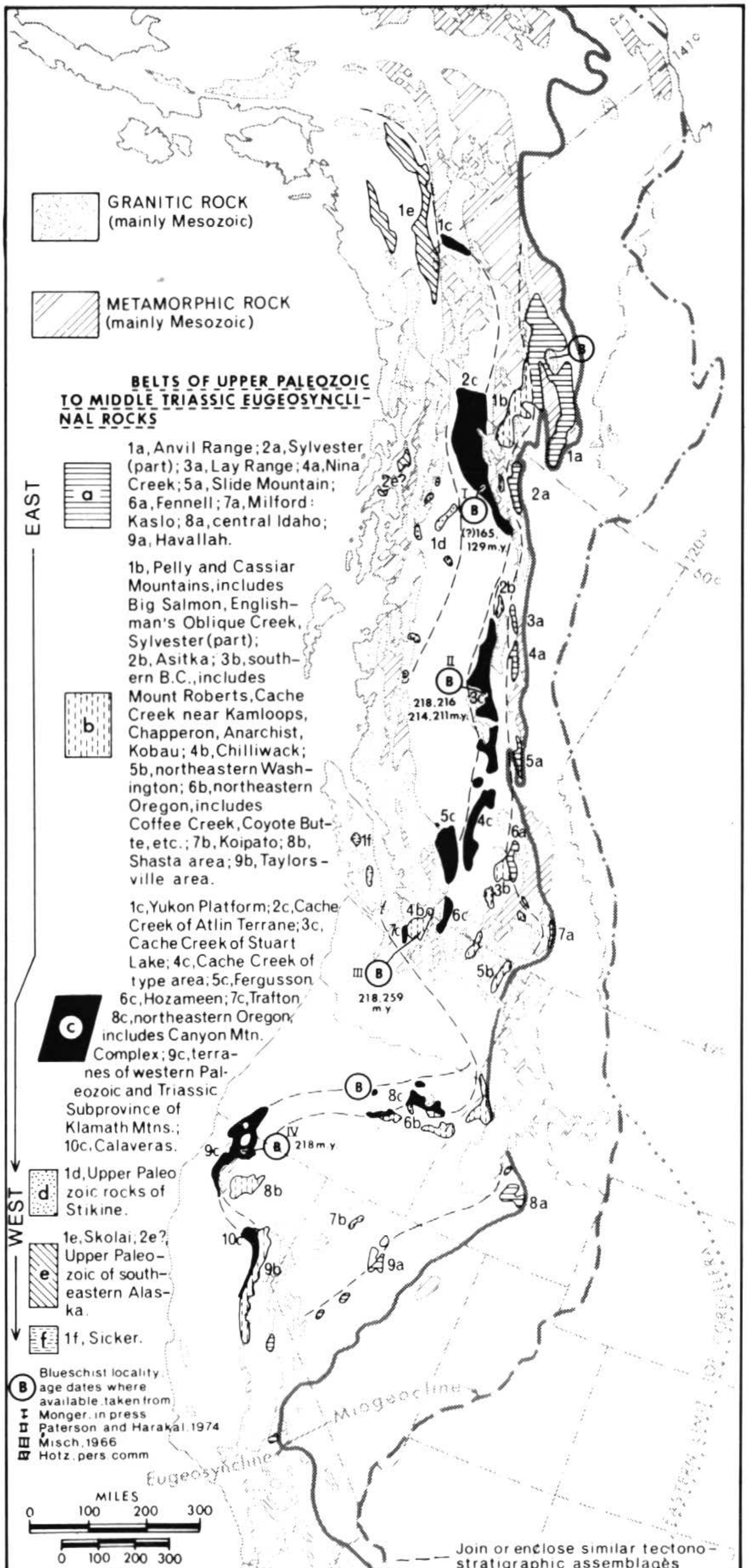

Figure 2
Upper Paleozoic to Middle Triassic eugeosynclinal rocks.

overlie older rocks, is not known. Finally, some sections on Vancouver Island show gross similarities to those in the Alaska Range.

Triassic and Jurassic Assemblages
Triassic and Jurassic volcanic and sedimentary deposits are the most extensive of all the 'eugeosynclinal' assemblages in the North American Cordillera. They are in part coeval with, and in part overlain by, the lower deposits of the successor basins (Eisbacher, 1974), and are also time-equivalent to the lowest parts of the Jurassic–Cretaceous eugeosynclinal package that lies oceanward of these rocks in the United States. Two broad assemblages are discernible in the Alaska–Canada segment of the Cordillera in the Triassic, but this distinction largely disappears by the Jurassic (Fig. 1). To the south it is not possible to make even these separations.

The westward of the two Triassic assemblages is found on Vancouver and Queen Charlotte Islands, in the Saint Elias Range of the southwestern Yukon, and the Alaska Range. It consists of thick Middle to Upper Triassic tholeiitic basalt flows, local pelites and Upper Triassic carbonate that lies stratigraphically on older rocks. Ultramafic and gabbroic rocks, probably comagmatic with the basalt, are associated with the volcanics in the north and are clearly intrusive into the underlying strata, in contrast with the tectonically emplaced Paleozoic ultramafic rocks. On Vancouver and Queen Charlotte Islands, and the western Alaska Range and Alaska Peninsula, these rocks are overlain by intermediate to acidic volcanics and sedimentary rocks of Lower or Middle Jurassic age, although in the Saint Elias and eastern Alaska Range, sedimentary rocks are dominant and volcanics rare or absent (Burk, 1965; Muller, 1971; Richter and Jones, 1973).

The eastern assemblage Triassic is very different. It consists of complexly interlayered and interfingering Upper Triassic basalt and basaltic andesite flows, typically augite porphyry, abundant pyroclastics derived from these rocks, and pelitic rocks that in places are the predominant rock type. They are overlain by Lower and Middle Jurassic flows and pyroclastics of mainly intermediate to acidic composition, with intercalated locally predominant sedimentary rocks (Souther, 1972b). This sequence is not very different lithologically from that of similar age in the western belt. The Triassic and Jurassic assemblages south of latitude 49° are comparable to the eastern Triassic and Jurassic assemblages in the Alaska–Canada segment (Dickinson, 1962).

The boundary between the two Triassic belts appears to transgress the Coast Plutonic Complex of British Columbia. In the south, basalts can be traced eastwards from Vancouver Island into the granitic Coast Plutonic Complex. In northwestern British Columbia, Triassic augite porphyry can be traced westward into the Coast Mountains. To the north, the boundary appears to be along the Shakwak-Denali Fault system. An interesting speculation is whether this boundary can be run across the Coast Plutonic Complex to link up with the prominent Yalakom–Fraser Fault system in southwestern British Columbia.

Jurassic – Cretaceous and Early Tertiary Eugeosynclinal Assemblages

These assemblages are barely represented in Canada. Southern outcrops comprise the Franciscan assemblage (Bailey *et al.*, 1964), its stratigraphic equivalents and younger rocks to the north (Rau, 1973), that are reasonably inferred to comprise oceanic crust and materials deposited on it. These rocks, their accompanying blueschist metamorphism and their relationships with rocks to the east, have been of considerable theoretical importance, leading workers to the concept of underflow of oceanic crust below continents and to models of 'Cordilleran-type' orogens (e.g., Hamilton, 1969).

In the Alaska–Canada segment, possible equivalents occur on the southwestern extremity of the Cascade Mountains (Hopson and Mattison, 1973), on the west coast of Vancouver Island (Muller, 1973), and form the extensive "younger Chugach Terrane" in southern Alaska (Berg *et al.*, 1972). All of these units taken together form the westernmost element of the Cordillera, the Pacific fold belt of King (1969).

Conclusions

This cursory summary has indicated how the eugeosynclinal terranes of King (1969) in the western Cordillera of North America can be subdivided into assemblages and how these assemblages probably can be correlated along the length of the Cordillera.

Of particular importance is the distribution of belt **c**, for it emphasizes one major difference between the Alaska–Canada, and the California–Colorado segments of the Cordillera. Belt **c** probably represents upper Paleozoic oceanic crust and overlying deposits. In the California–Colorado segment, belt **c** is bounded on the west only by later, Mesozoic, rocks of probable similar origin, whereas in Canada, belt **c** lies well within the western margin of the Cordillera and coeval and older rocks lie to the west. The much later, mid- to late Mesozoic belts of granitic and high-grade metamorphic rock mirror this distribution, for in Canada there are two belts, the Omineca Crystalline Belt to the east of belt **c**, and the Coast Plutonic Complex to the west, whereas in the California–Colorado segment, there is only one belt to the east, comprising the Sierra Nevada and Idaho Batholith. Any model of the evolution of the Cordillera must take these differences into account (see Jones *et al.*, 1972; Monger *et al.*, 1972).

The effective boundary between the Alaska–Canada and California–Colorado segments is along the Trans-Idaho Discontinuity of Yates (1968). The origin of this feature is not known, partly because the pre-Tertiary geology immediately north and south is poorly exposed and understood, and the need for further studies is great.

This summary partly results from a seminar held in November, 1973, on the correlation of older geological elements in the western Cordillera, that was attended by H. C. Berg, D. A. Brew, B. C. Burchfield, R. B. Campbell, M. Churkin, G. A. Davis, W. R. Dickinson, H. Gabrielse, D. L. Jones, P. B. King, M. A. Lanphere, J. W. H. Monger, E. M. Moores, D. H. Richter, N. J. Silberling, D. J. Tempelman-Kluit, H. W. Tipper and J. A. Vance. The correlations made here may or may not reflect the views of participants other than the writer, although he obtained considerable benefits from discussions of parts of the Cordillera with which he is not personally familiar. At this meeting, it became apparent that the Alaska–Canada segment of the western Cordillera, with its relatively continuous geology and central position, appears to hold many of the keys to understanding the pre-Jurassic development of the western margin of North America.

References

Bailey, E. H., W. P. Irwin and D. L. Jones, 1964, Franciscan and related rocks and their significance in the geology of western California: California Div. Mines and Geol., Bull. 183, 177 p.

Berg, H. C., D. L. Jones and D. H. Richter, 1972, Gravina-Nutzotin belt – tectonic significance of an upper Mesozoic sedimentary and volcanic sequence in southern and south-eastern Alaska: U.S. Geol. Survey Prof. Paper 800-D, p. D1 - D24.

Brew, D. A., R. A. Loney and L. J. P. Muffler, 1966, Tectonic history of southeastern Alaska: Can. Inst. Mining Met., Spec. Vol. 8, p. 149-170.

Brown, C. E. and T. P. Thayer, 1966, Geologic map of the Canyon City Quadrangle, northeastern Oregon: U.S. Geol. Survey Map 1-447.

Burk, C. A., 1965, Geology of the Alaska Peninsula, Island Arc and Continental Margins: Geol. Soc. Am., Mem. 99 (Pt. 1), 250 p.

Churkin, M., 1974, Paleozoic marginal ocean – basin – volcanic arc systems in the Cordilleran Foldbelt: Soc. Econ. Paleont. Mineral., Spec. Publ. 19, p. 174-192.

Danner, W. R., 1966, Limestone resources of western Washington: Washington Div. Min. Geol., Bull. 52.

Danner, W. R., 1967, Devonian of Washington, Oregon and Western British Columbia: *in* Alberta Soc. Petrol. Geol. International Symposium on the Devonian System, p. 827-842.

Davis, G. A. 1969, Tectonic correlations, Klamath Mountains and western Sierra Nevada, California: Geol. Soc. Am. Bull., v. 80, p. 1095-1108.

Dickinson, W. R., 1962, Petrogenetic significance of geosynclinal andesitic volcanism along the Pacific margin of North America: Geol. Soc. Am. Bull., v. 73, p. 1241-1256.

Eisbacher, G. H., 1974, Evolution of successor basins in the Canadian Cordillera: Soc. Econ. Paleont. Mineral. Spec. Publ. 19, p. 274-291.

Fyles, J. T., 1964, Geology of the Duncan Lake area, Lardeau district, British Columbia: British Columbia Dept. Mines and Petrol. Res., Bull. 49, 87 p.

Gabrielse, H., 1967, Tectonic evolution of the Northern Canadian Cordillera: Can. Jour. Earth Sci., v. 4, p. 271-298.

Hamilton, W., 1969, Mesozoic California and the underflow of Pacific Mantle: Geol. Soc. Am. Bull., v. 80, p. 2409-2430.

Hopson, C. A. and J. M. Mattinson, 1973, Ordovician and Late Jurassic ophiolitic assemblages in the Pacific Northwest: Geol. Soc. Am., Abstracts with Programs, v. 5, no. 1, p. 57.

Irwin, W. P., 1966, Geology of the Klamath Mountains Province: California Div. Mines and Geol., Bull. 190, p. 19-38.

Irwin, W. P., 1972, Terranes of the Western Paleozoic and Triassic Belt in the southern Klamath Mountains, California: U.S. Geol. Survey Prof. Paper 800-C, p. C103-111.

Jones, D. L., W. P. Irwin and A. T. Ovenshine, 1972, Southeastern Alaska – a displaced continental fragment?: U.S. Geol. Survey Prof. Paper 800-B, p. B211-B217.

Kleweno, W. P. and R. M. Jeffords, 1961, Devonian rocks in the Suplee area of central Oregon: Geol. Soc. Am., Spec. Paper 68, p. 34-35.

King, P. B., 1966, The North American Cordillera: Can. Inst. Mining Met., Spec. Vol. 8, p. 1-25.

King, P. B., 1969, The Tectonic Map of North America: U.S. Geol. Survey.

Lanphere, M. A., W. P. Irwin and P. E. Hotz, 1968, Isotopic age of the Nevadan Orogeny and older plutonic and metamorphic events in the Klamath Mountains, California: Geol. Soc. Am. Bull., v. 79, p. 1027-1052.

Mattinson, J. M., 1972, Age of Zircons from the Northern Cascade Mountains, Washington: Geol. Soc. Am. Bull., v. 83, p. 3769-3784.

Merriam, C. W. and S. A. Berthiaume, 1943, Late Paleozoic Formations of central Oregon: Geol. Soc. Am. Bull., v. 54, p. 145-172.

Misch, P., 1966, Tectonic evolution of the northern Cascades of Washington State: Can. Inst. Mining Met. Spec. Vol. 8, p. 101-145.

Monger, J. W. H., 1970, Hope map-area, west half, British Columbia: Geol. Survey Can. Paper 69-41, 75 p.

Monger, J. W. H., 1975, Upper Paleozoic rocks of the Atlin Terrane, northwestern British Columbia and south-central Yukon: Geol. Survey Can. Paper 74-47, *in press*.

Monger, J. W. H. and C. A. Ross, 1971, Distribution of fusulinaceans in the western Canadian Cordillera: Can. Jour. Earth Sci., v. 8, p. 259-278.

Monger, J. W. H., J. G. Souther and H. Gabrielse, 1972, Evolution of the Canadian Cordillera: Am. Jour. Sci., v. 272, p. 577-602.

Monger, J. W. H. and I. A. Paterson, 1974, Upper Paleozoic and lower Mesozoic rocks of the Omineca Mountains: Geol. Survey Can. Paper 74-1, Pt. A, p. 19-20.

Muller, J. E., 1971, Chemistry and petrology of some Mesozoic volcanic rocks of Vancouver Island, British Columbia: Geol. Survey Can. Paper 71-1, Part B, p. 5-10.

Muller, J. E., 1973, Lower Cretaceous flysch sequence of the west coast of Vancouver Island: Geol. Soc. Am., Abstracts with Programs, v. 5, no. 1, p. 84.

Paterson, I. A. and J. E. Harakal, 1974, Potassium-argon dating of blueschists from Pinchi Lake, central British Columbia: Can. Jour. Earth Sci., v. 11, p. 1007-1011.

Rau, W. W., 1973, Geology of the Washington Coast: Washington Dept. Nat. Res. Bull. 66, 58 p.

Richter, D. H. and D. L. Jones, 1973, Structure and stratigraphy of eastern Alaska Range, Alaska: Am. Assoc. Petrol. Geol. Mem. 19, p. 408-420.

Roberts, R. J., P. E. Hotz, J. J. Gilluly and H. G. Ferguson, 1958, Paleozoic rocks of north-central Nevada: Am. Assoc. Petrol. Geol. Bull., v. 42, p. 2813-2857.

Silberling, N. J. and R. J. Roberts, 1962, Pre-Tertiary stratigraphy and structure of northwestern Nevada: Geol. Soc. Am. Spec. Paper 72, 53 p.

Sloss, L. L., W. C. Krumbein and E. C. Dapples, 1949, Integrated facies analysis: Geol. Soc. Am. Mem. 39, p. 91-123.

Smith, J. G. and E. M. MacKevett, 1970, The Skolai Group in the McCarthy B-4, C-4, and C-5 Quadrangles, Wrangell Mountains, Alaska: U.S. Geol. Survey Bull. 1274-Q, 26 p.

Souther, J. G., 1972a, Telegraph Creek map-area, British Columbia: Geol. Survey Can. Paper 71-44, 38 p.

Souther, J. G., 1972b, Mesozoic and Tertiary volcanism of the western Canadian Cordillera: Can. Earth Physics Branch Publs., v. 42, p. 55-58.

Souther, J. G. and J. E. Armstrong, 1966, North-central belt of the Cordillera of British Columbia: Can. Inst. Mining Met., Spec. Vol. 8, p. 171-184.

Wheeler, J. O., 1970, Summary and discussion of Symposium on Structure of the southern Canadian Cordillera: Geol. Assoc. Can., Spec. Paper 6, p. 155-166.

Yates, R. G., 1968, The Trans-Idaho Discontinuity: Int. Geol. Congress, Rept. of 23rd Session, Czechoslovakia, Sect. 1, Upper Mantle, p. 117-123.

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