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Upper Paleozoic Volcanosedimentary Assemblages of the Western North American Cordillera

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ABSTRACT: Stratigraphically and structurally complex upper Paleozoic volcanogenic strata of the western North American Cordillera can be grouped into regionally extensive assemblages, on the bases of homotaxial stratigraphy, lithological association, and faunas. The assemblages are inferred to have originated in various tectonic settings. Although their relationships to one another at their time of deposition are not known, they almost certainly were not in their present configuration; they include assemblages deposited along the western margin of the continent, more or less in place, assemblages that probably formed along the continental margin but later were displaced by lateral slip, and assemblages that are far traveled. West of the sedimentary continental shelf and slope deposits in the conterminous United States and southern Canada are marginal basin deposits (Assemblage 1) and probably related volcanic arc assemblages (Assemblages 2,3). Faunas in these assemblages can be correlated with those to the east. Farther west, Assemblage 4 probably represents far-traveled ancestral Pacific Ocean crust and overlying deposits of Mississippian to Triassic age, accreted to the continental margin during early Mesozoic subduction. It contains a Permian Tethyan fauna. Assemblages 5, 6, and 7, west of Assemblage 4, are volcanic arc deposits, with faunas generally similar to Assemblages 2 and 3, that probably were emplaced by lateral slip in late Mesozoic time. Assemblage 8 is a volcanic arc deposit; paleomagnetic measurements on overlying early Mesozoic strata indicate its southern hemisphere provenance. Assemblage 9 is comparable in origin with Assemblage 4, but is mainly of early and middle Mesozoic age, although in places it contains carbonate blocks with a Tethyan fusulinid fauna.

INTRODUCTION

This paper summarizes the stratigraphy and paleontology of upper Paleozoic volcanosedimentary strata in the North American Cordillera, with the exception of those in Alaska. Formerly, these rocks were combined as eugeosynclinal deposits (King, 1969), partly because of the superficial similarity imposed by the presence of volcanic rocks and general low-grade metamorphism and deformation, and partly because little was known of the variety of tectonic settings on which volcanosedimentary rocks could be deposited. In recent years, detailed studies of the stratigraphy, the chemistry of volcanic units, and the paleontology of the strata have shown their great diversity and indicate the nature of the former late Paleozoic eugeosyncline.

Below, local formations are grouped into the regionally extensive successions shown in figure 1. The common patterns and numbers of this figure indicate successions that, for reasons of homotaxial stratigraphy, distinctive lithological and/or faunal associations, reasonably can be correlated for considerable distances. It must be emphasized that detailed stratigraphic sections are rarely available, not only because of later deformation, metamorphism, and disruption by Mesozoic plutonic rocks, but also because of the complex and rapid facies changes displayed in the few places where these volcanogenic strata are little disturbed. Such successions, whose dominant characteristics apparently derive from deposition in a particular tectonic environment, have been called *assemblages* (Roberts et al., 1958) or *terranes* (Berg et al., 1972). Some assemblages are very different from neighbouring ones and most are separated by major fault zones.

Several lines of reasoning have led to current concepts regarding the upper Paleozoic Cordilleran eugeosyncline as a collage of assemblages of different origins and provenances brought together by a variety of tectonic processes during the Mesozoic (Hamilton, 1969; Davis et al., 1978). One reason is the great contrast between Permian fusulinid faunas in the western Cordillera. Tethyan fusulinid faunas, similar to those in regions bordering the western Pacific, are juxtaposed with coeval "non-Tethyan" faunas that can be correlated with those of shelf successions in western North America (fig. 2; Danner, 1965; Bostwick and Nestell, 1967; Monger and Ross, 1971; Yancey, 1975). Although local environments may well have contributed to some differences, other evidence suggests that the contrast in faunas resulted mainly from tectonic juxtaposition of different biogeographic provinces. A second reason is that paleolatitudes determined from

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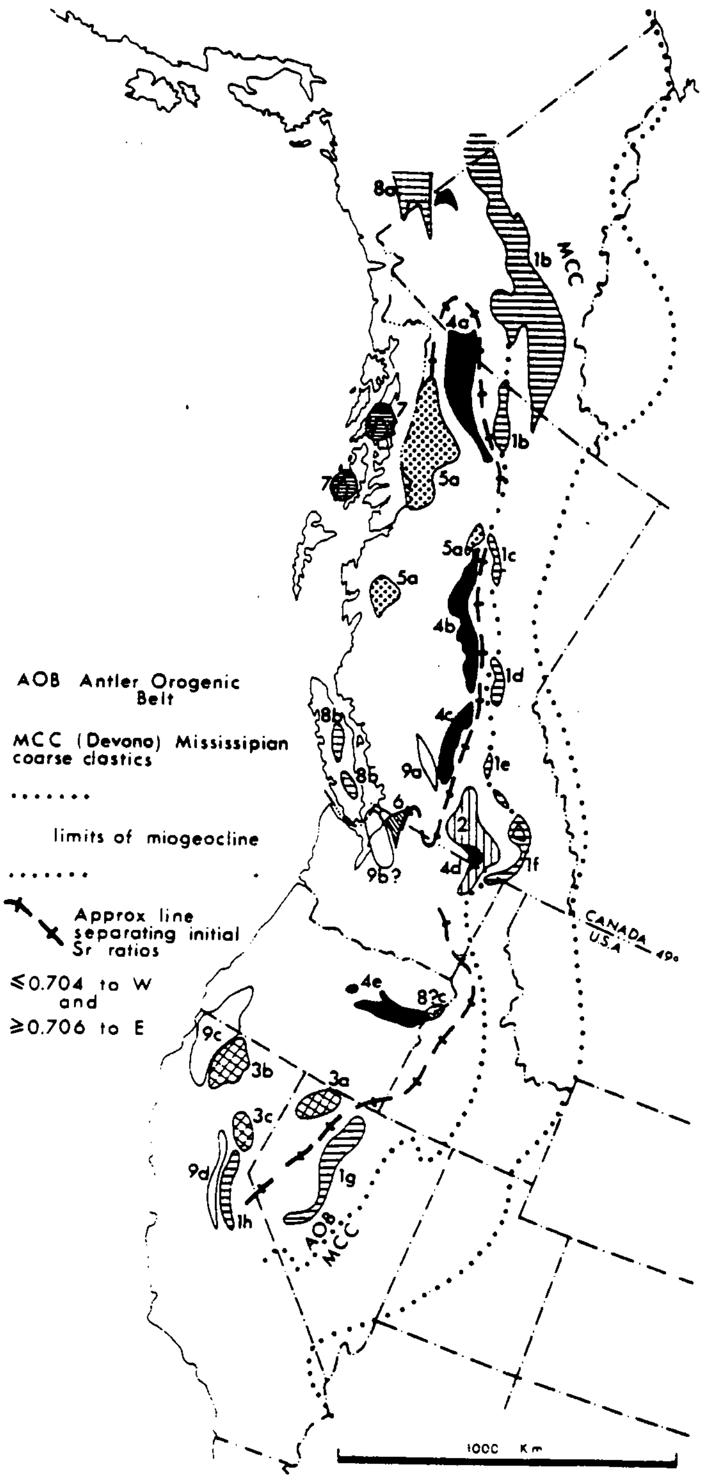

FIGURE 1. Generalized distribution of upper Paleozoic strata in North American Cordillera, exclusive of much of Alaska. Common patterns and numbers indicate groupings of isolated strata into assemblages. Probable western limits of Precambrian crust indicated by Sr ratio line.

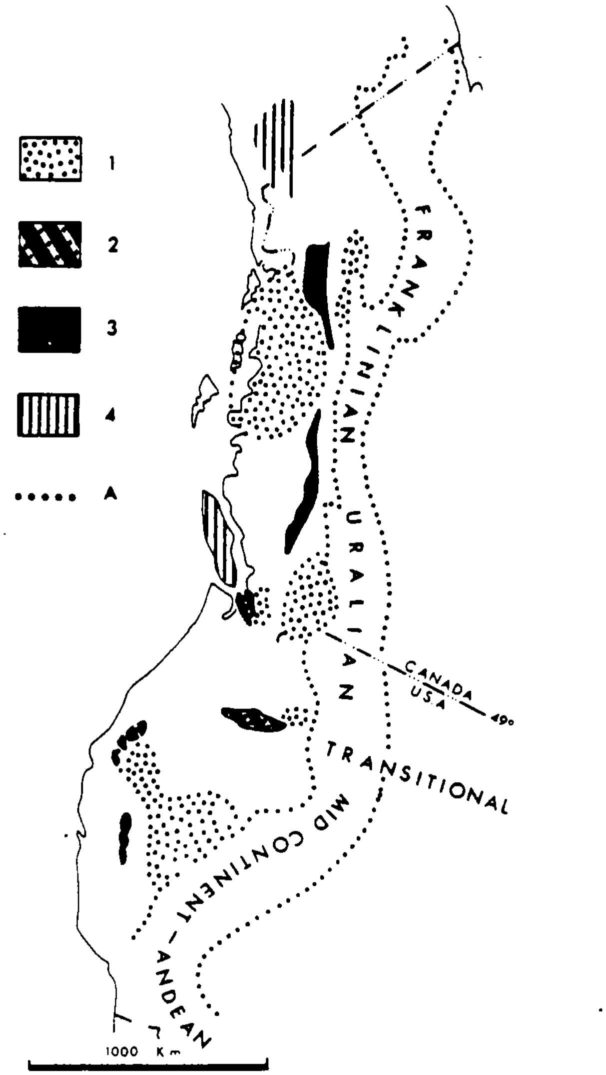

FIGURE 2. Distribution of fusulinacean faunas near Carboniferous-Permian boundary. *1*, locally abundant faunas of limited diversity, typically with Franklinian-Uralian affinities and featuring schwagerinid fusulinids and *Pseudofusulinella*. *2*, tectonically (?) mixed 1 and 3 faunas. *3*, abundant, diverse faunas with Tethyan affinities; younger Permian faunas with verbeekinid fusulinids. *4*, fusulinacean faunas relatively rare, although locally abundant; brachiopods and bryozoa common; all have Franklinian-Uralian affinities.

magnetic studies on layered Mesozoic rocks overlying some Paleozoic assemblages in the western Cordillera differ from those of coeval rocks in cratonic North America. Western Cordilleran determinations show varying amounts of northward displacement with respect to determinations from the continental margin (fig. 3; Irving, 1979). A third reason is that some Paleozoic–early Mesozoic assemblages are interpreted as being subduction complexes, on the basis of deformational style and associated blueschist metamorphism (fig. 4; Davis et al., 1978). Because subduction complexes reflect crustal convergence, and because the ancient western continental margin of North America was oriented more or less north-south in the Mesozoic (Irving, 1979, figs. 14,15), these assemblages appear to record longitudinal movements. The presence of Tethyan faunas indicates that the movements may have been considerable.

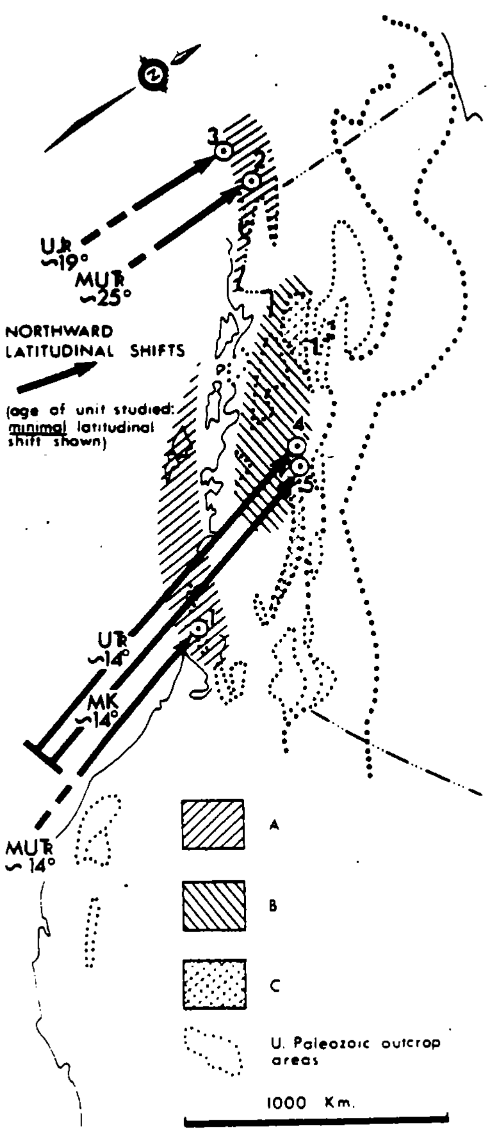

FIGURE 3. Latitudinal, northward displacements of Mesozoic rocks overlying late Paleozoic assemblages, as shown by measurements of paleomagnetic inclination with respect to bedding and layering. Shown are ages of rocks sampled and displacements with respect to determinations from coeval rocks in "stable" North America. *Minimal* amounts of displacement only are given; a more reasonable displacement for locality 1, involving far less rotation, is about 46°. *A,B*, Mesozoic assemblages sampled; *C*, deformed rocks of Assemblage 4 intruded by a sampled Lower to mid-Cretaceous layered gabbro. References: *1*, Irving and Yole, 1972; *2*, Hillhouse, 1977; *3*, Packer and Stone, 1974; *4,5*, Irving, Monger et al., 1980.

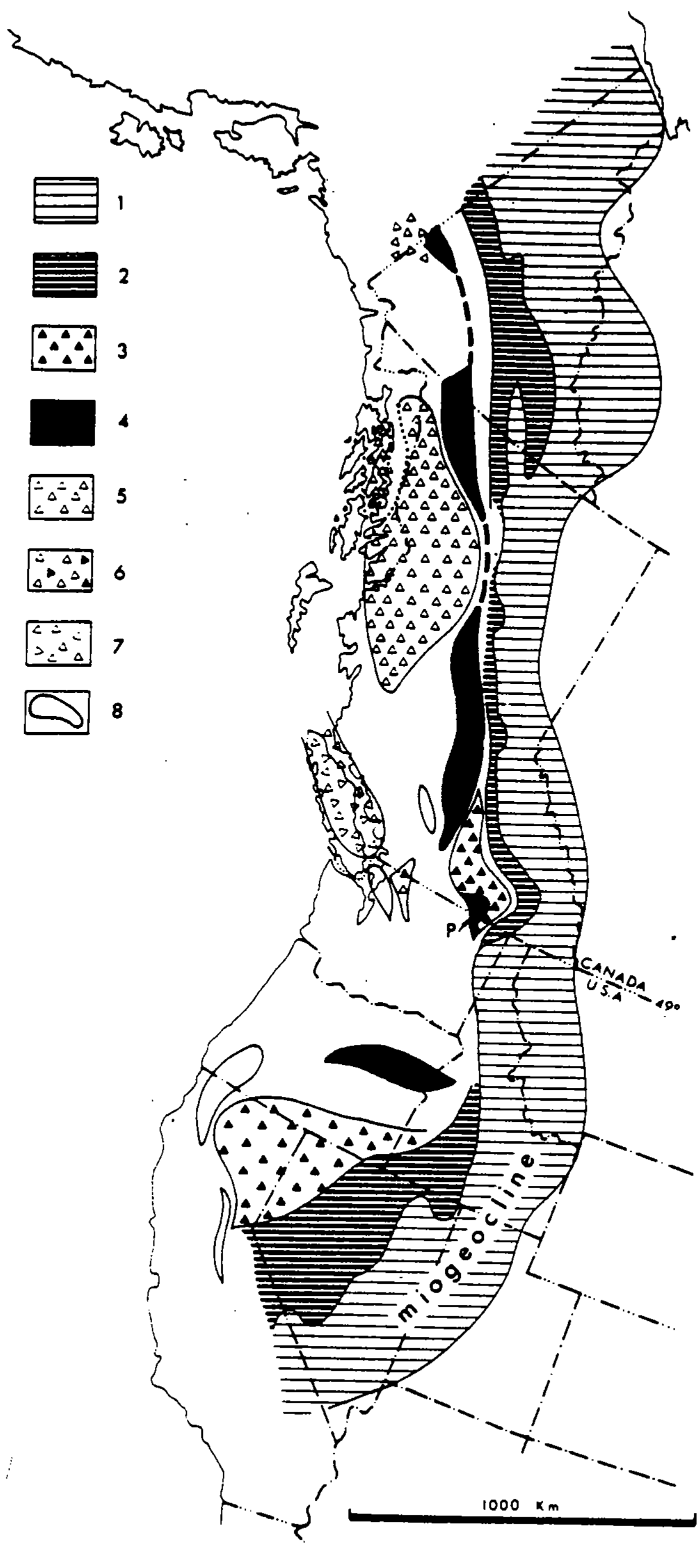

FIGURE 4. Interpreted tectonic settings during deposition of upper Paleozoic assemblages. *1*, continental shelf and slope; *2*, marginal basin; *3*, "autochthonous" volcanic arcs; *4*, oceanic crust, accreted in early Mesozoic subduction zone (*P*, may be late Paleozoic subduction zone); *5,6*, volcanic arcs probably displaced from western margin of North America; *7*, volcanic arc probably displaced from beyond margin of continent; *8*, mainly oceanic crust, largely of Mesozoic age but containing some Paleozoic fragments, accreted in middle and late Mesozoic time.

The relationships of most upper Paleozoic assemblages, shown in figure 1, to one another at the time they were deposited is unknown but almost certainly different from the present configuration. Various paleogeographic, mainly plate tectonic, schemes have been devised, but as pointed out by Dickinson (1977, p. 150–152), none is proven. Some assemblages appear to be far traveled, whereas others probably formed close to the ancient western margin of North America. The stratigraphy of these assemblages, their faunas, and their possible degrees of allochthoneity are briefly indicated below, in the numerical and alphabetical order given in figure 1. Our hope is that by emphasizing possible amounts of allochthoneity, correlatives of some of these assemblages may be recognized elsewhere around the Pacific margin by other contributors to the symposium.

LOCATION OF THE ANCIENT WESTERN MARGIN OF THE CONTINENT

The ancient western margin of the continent lay somewhere between the western limit of the miogeocline and Assemblage 4 (fig. 1). Systematic facies changes from east to west, from shallow water, platformal carbonates with many hiatuses, through thick, relatively continuous carbonates in the eastern miogeocline, to thinner shales in the western miogeocline, link these strata to the craton. However, thrust faulting in late Paleozoic, Mesozoic, and early Tertiary times has moved western miogeoclinal rocks one or two hundred kilometres to the east, and has juxtaposed volcanogenic strata, obscuring the location of the ancient margin and the relationship of these facies to one another. The location of the ancient continental margin beneath the thrusts is indicated by initial Sr^{87}/Sr^{86} ratios from magmatic rocks. The boundary between ratios ≤ 0.704 to the west, indicating derivation from oceanic crust or volcanic arcs, and ratios ≥ 0.706 to the east, indicating derivation from evolved, Precambrian continental crust, lies generally west of the margin indicated by geology (fig. 1; Kistler and Peterman, 1973; Armstrong et al., 1977; Armstrong, 1979). Local high ratios in the west, as in the Northern Cascades and southwestern Yukon, are in terranes that from geological evidence are probably displaced. Taking into account the shortening by thrust faulting, most strata discussed below probably were deposited west of the ancient continental margin.

In the northern part of the miogeoclinal fold and thrust belt, Carboniferous and Permian fusulinacean faunas have low diversity and appear in dominantly clastic sections. The minor amount of carbonate present is thin bedded and commonly silicified, and many of the sections are condensed sequences with a number of widespread unconformities. These sections show that Early and Middle Carboniferous strata are generally truncated by a broad regional unconformity and that latest Carboniferous or earliest Permian strata were deposited on the erosional surface. The fusulinaceans in the Carboniferous and Early Permian parts of the succession are similar to those of the Franklinian and Uralian regions. In the southwestern United States segment, the faunas are more diverse, in a broad carbonate shelf, and show affinities with the mid-continent–Andean faunal region (fig. 2; Ross, 1984).

Assemblage 1 is an apparently homotaxial sequence that ranges in age from Mississippian to Permian and extends discontinuously from Alaska to Nevada (fig. 1). From north to south, it includes the Anvil Range Group (loc. 1a, fig. 1), Sylvester Group (loc. 1b), Nina Creek greenstone (loc. 1c), Slide Mountain Group (loc. 1d), Fennell Formation (loc. 1e), Milford and Kaslo groups (loc. 1e), Havallah sequence (Havallah and Pumpernickel formations; loc. 1g) and, tentatively, part (?) of the Calaveras complex (loc. 1h). The rocks are commonly strongly folded and disrupted by faults, but in localities where the stratigraphy is coherent, the assemblage commonly consists of a lower sequence of thin-bedded chert, argillite, quartz-and-chert-grain sandstone, and local conglomerate, with minor limestone and rare acidic volcanics, and an upper sequence of mafic volcanics, chert, local carbonate and alpine-type ultramafic rock (fig. 5). In places, the contact between the volcanics and underlying sedimentary strata is depositional and gradational, and diabasic intrusions, feeders to the volcanics, cut the sediments in places. Elsewhere, as in much of the Yukon (Tempelman-Kluit, 1977), the assemblage is tectonically disrupted and the upper sequence is in fault contact with the lower. The presence of alpine-type ultramafics within the volcanic successions is indicative of great structural disruption. Figure 5 summarizes stratigraphy, unit names, lithologies, thicknesses and available fossil ages of this assemblage in Canada. In Nevada (loc. 1g), Silberling (1975, p. 14) has described a coherent section in the Havallah sequence (Pumpernickel and Havallah formations) that appears to be very similar to sections to the north. Possibly correlative rocks in the western Sierra Nevada (loc. 1h) have been described by Schweikert et al. (1977).

In several localities in Canada (fig. 5), Assemblage 1 lies on Devonian strata that are part of the miogeoclinal succession. So far as is known, the successions are in normal stratigraphic contact, but the sharp break between shallow-water Devonian strata and overlying deeper water argillite and chert, and the lack of basic feeders in Devonian and older strata where they are present in the lower succession of Assemblage 1, raises the possibility that the contact may be faulted. In southeastern British Columbia, a lower Paleozoic metamorphic terrane with Devonian (?) granites is basement to the assemblage, which has a basal conglomerate containing schistose and granitic clasts (Read, 1976). In Nevada, the basal contact is a Permo-Triassic thrust fault, which brings the assemblage over coeval Pennsylvanian and Permian sedimentary rocks (Silberling, 1975). These in turn lie on deformed Devonian and older strata of the Antler Orogenic Belt (fig. 1). Rocks of the Antler Orogenic Belt were thrust eastward in Devonian-Mississippian time over miogeoclinal strata to the east. Coarse, turbiditic detritus of Mississippian age, derived from the Antler Orogenic Belt, lies farther east of it in Nevada and Idaho (Poole, 1977; Nilsen, 1977). The presence of similar conglomerates in the northern Canadian Cordillera (fig. 1; Gordey, 1978) raises the possibility of similar but as yet unrecognized tectonism there.

Fusulinid faunas of Middle Carboniferous and latest Carboniferous–earliest Permian ages show affinities with those of the Franklinian-Uralian realm. Early Late Permian fusulinids from northern British Columbia compare closely with species reported from northern Sonora in Mexico (Ross, 1969; Ross and Monger, 1977). A rich late

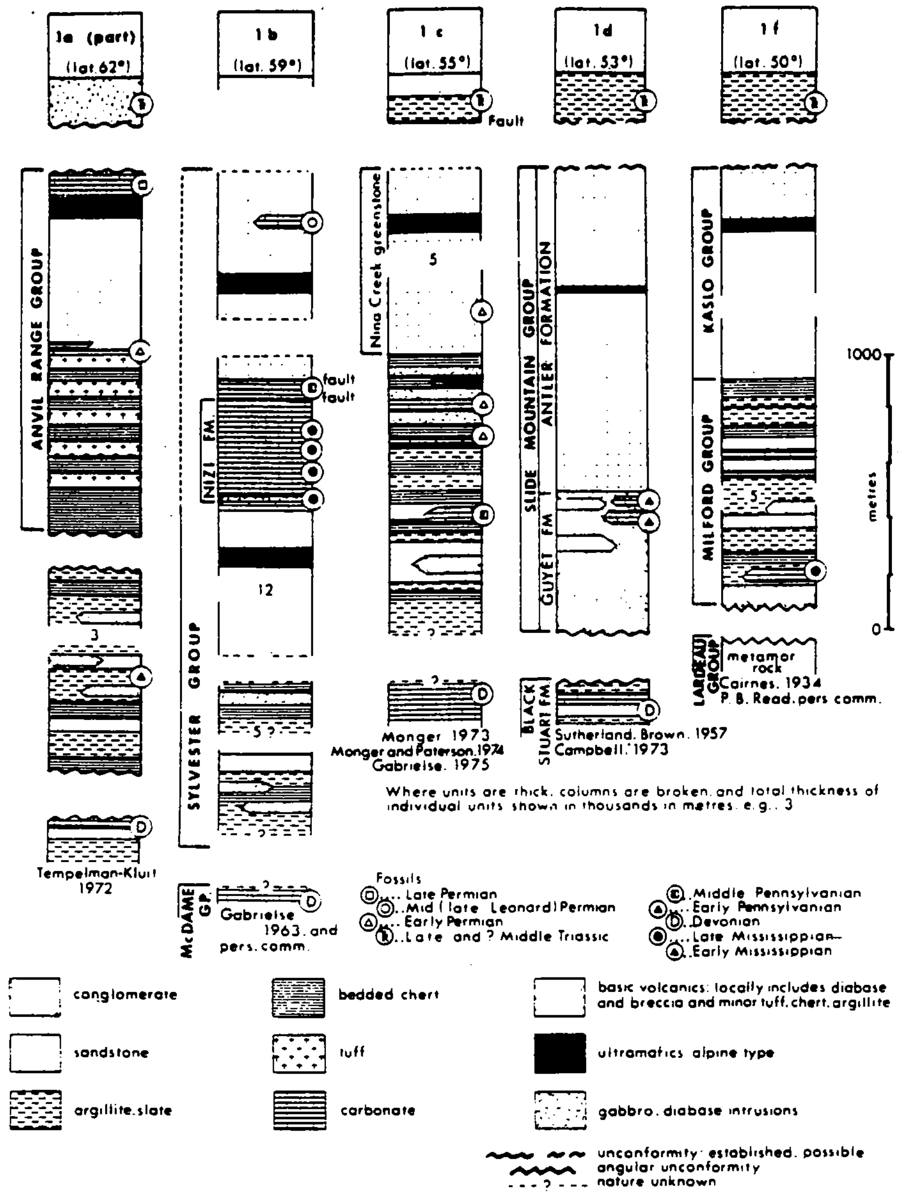

FIGURE 5. Apparent generalized stratigraphy of Assemblage 1 to illustrate gross stratigraphic similarity of rocks included in this assemblage (modified from Monger, 1977).

Viséan to early Namurian (Early Carboniferous) fauna in northern British Columbia (loc. 1b) contains a mixture of Eurasiatic and mid-continent foraminifers (Mamet and Gabrielse, 1969).

The tectonic setting in which these rocks were deposited is believed by most workers to be a marginal basin that developed between the continental margin (and Antler Orogenic Belt) to the east, and volcanic arcs to the west, represented by Assemblages 2 and 3 (Burchfiel and Davis, 1972; Monger, 1977; Stevens, 1977). Linkages to the continent are provided by the basal conglomerate in southeastern British Columbia, and by quartzite, chert, and locally metamorphic clasts in the conglomerates, which in many places are very similar in composition to Mississippian clastics to the east. Fusulinacean faunas are similar to those along the continental margin (fig. 2). The upper volcanic sequence, although tectonically disrupted in places, elsewhere is clearly in stratigraphic continuity with underlying rocks.

Assemblage 2 comprises many outcrop areas, each of limited extent and with poorly known stratigraphy, separated by extensive granitic and high-grade metamorphic rocks and Tertiary cover. It includes the Anarchist Group, "Cache Creek Group" near Vernon and Kamloops, Chapperon Group, and Mount Roberts Formation, all in British Columbia, and the Mission Argillite of northeastern Washington. Late Mississippian to Late Permian fossils occur in a heterogeneous assemblage of basaltic to andesitic flows, intermediate to acidic pyroclastics, carbonate, and argillite (Monger, 1977). Linkages to Assemblage 1 are suggested by chert pebble conglomerates in argillites in the eastern part of the assemblage, but the volcanics are very different and suggestive of a volcanic arc regime. No base has been recognized, although underlying lower Paleozoic and Proterozoic rocks may be in some of the high-grade metamorphic terranes. The upper contact is an angular unconformity above which are Middle and Upper Triassic strata (Read and Okulitch, 1977).

In most places, the Permian fauna is typically Franklinian-Uralian, but appears to have greater species diversity than the faunas of Assemblage 1. Sada and Danner (1976) described *Pseudoschwagerina*, of Early Permian age, from near Kamloops, British Columbia. This genus is atypical of other non-Tethyan faunas in the Cordillera, but is common in the Tethyan faunas of Assemblage 4.

Assemblage 3. The most complete section known of rocks in Assemblage 3 is in the eastern Klamath Mountains, where Mississippian and Permian strata are separated by an unconformity (loc. 3b, fig. 1; Albers and Robertson, 1961). In this assemblage are the Happy Creek volcanics and limestone near Quinn River crossing (loc. 3a), the Mississippian Bragdon and Baird formations and Permian McCloud Limestone, Nosoni Formation, and Dekkas Formation (loc. 3b), and rocks in the Taylorsville area, northern Sierra Nevada (loc. 3c). In the eastern Klamaths (loc. 3a), Mississippian strata lie on Middle Devonian and older sedimentary and volcanic rocks and consist of more than 2000 m of shale, conglomerate (with notable chert pebbles), pyroclastic rocks, and mafic flows. Permian strata include thick (700 m) carbonate of Early Permian age overlain by argillite and tuff, passing up into basic and acidic flows of Late Permian age. Andesitic and basaltic flows, pyroclastics, and carbonate lying to the east are probably correlative with Permian strata in the Klamaths (Silberling, 1973, p. 358). Rocks in the northern Sierra Nevada (loc. 3c, fig. 1) include abundant pyroclastics and Permian and Mississippian fossils and appear to be most similar to those in the eastern Klamaths (Burchfiel and Davis, 1972). The assemblage has been interpreted as a volcanic arc. Most likely correlatives are Assemblages 2 and 6 in northeastern Washington and southern British Columbia. Most paleogeographic reconstructions (e.g., Stevens, 1977) show this arc separated from the continental margin by the marginal basin of Assemblage 1, although, as pointed out by Dickinson (1977), this is not proven.

The latest Carboniferous and very earliest Permian fusulinaceans have several species similar to those in the Kamloops area (Assemblage 2). Higher in the lower part of the Permian, the fusulinaceans start to show some species affinities with those of the West Texas region. This change suggests some latitudinal shifting of faunal boundaries during the early part of the Permian.

Assemblage 4 is lithologically distinctive and contains faunas typical of the Tethyan realm. It ranges in age from Early Mississippian to (locally) Late Triassic and extends for much of the length of the Canadian Cordillera, occurs in eastern and central Oregon, and may form part of Assemblage 9 in California. It is probably a far-traveled terrane, for its Permian faunas, at least, are very similar to those in regions bordering the western Pacific, and its structural and metamorphic characteristics indicate that it is a subduction complex of mainly late Paleozoic rocks accreted to the western margin of North America early in the Mesozoic. Most rocks in Assemblage 4 in the Yukon belong to the Cache Creek Group in the restricted sense of Monger (1977). Rocks in south-central British Columbia, the Kabau Group, Shoemaker, Old Tom, and Independence formations (loc. 4d), may be a slightly older assemblage of similar composition (Okulitch and Peatfield, 1976). The Canyon Mountain Complex, Elkhorn Ridge Argillite, and Burnt River Schist of eastern Oregon (loc. 4e) are also included in the assemblage.

Lithologies in the assemblage are typically thin-bedded radiolarian chert and argillite, locally prominent massive carbonate, basic volcanic rock, and alpine-type ultramafics. Many lithological contacts are faults across which rock units of different ages are juxtaposed, and the assemblage, as a whole, appears to be tectonic mélange, although there are local areas with stratigraphic continuity. The deformation is associated with local blueschist metamorphism, of Triassic age in localities 4b, 4e, and 9b (fig. 1; Paterson and Harakal, 1974; Hotz, 1977).

The extensive region underlain by the assemblage in northern British Columbia (loc. 4a, fig. 1; fig. 6) contains areas of coherent stratigraphy (Monger, 1977). Basalt of Mississippian age, intimately faulted with ultramafic rocks, is overlain gradationally by thick (up to 2000 m), massive, algal, crinoidal and fusulinid, shallow-water to intertidal carbonate that ranges in age from Late Mississippian to Late Permian (facies belt A, fig. 6). Laterally (belt B, fig. 6), pods of carbonate and volcanic rock, that at least locally are olistoliths, occur in radiolarian chert and argillite, whose known age ranges from Pennsylvanian to Middle Triassic. The assemblage is interpreted as a carbonate ridge or atoll founded on an oceanic volcanic pediment. Laterally equivalent deep-water rocks consist of chert and submarine slump deposits. Elsewhere (facies belt C), volcanics capped by shallow-water carbonate of Permian age and surrounded by chert may represent local seamounts.

Similar terranes to the south in British Columbia contain Pennsylvanian and Permian carbonates and cherts as young as Late Triassic. In Oregon (loc. 4e, fig. 1), a pre-Late Triassic mélange contains elements similar to those of Assemblage 4, tectonically mixed with other units (Dickinson, 1979) that perhaps have more affinity with arc-terranes in the region (e.g., Assemblages 2 and 6). In California, a mélange terrane emplaced in the Jurassic (Assemblage 9) contains late Paleozoic lithologies similar to those in Canada, but is probably mainly of Late Triassic and Jurassic age (Irwin, 1977).

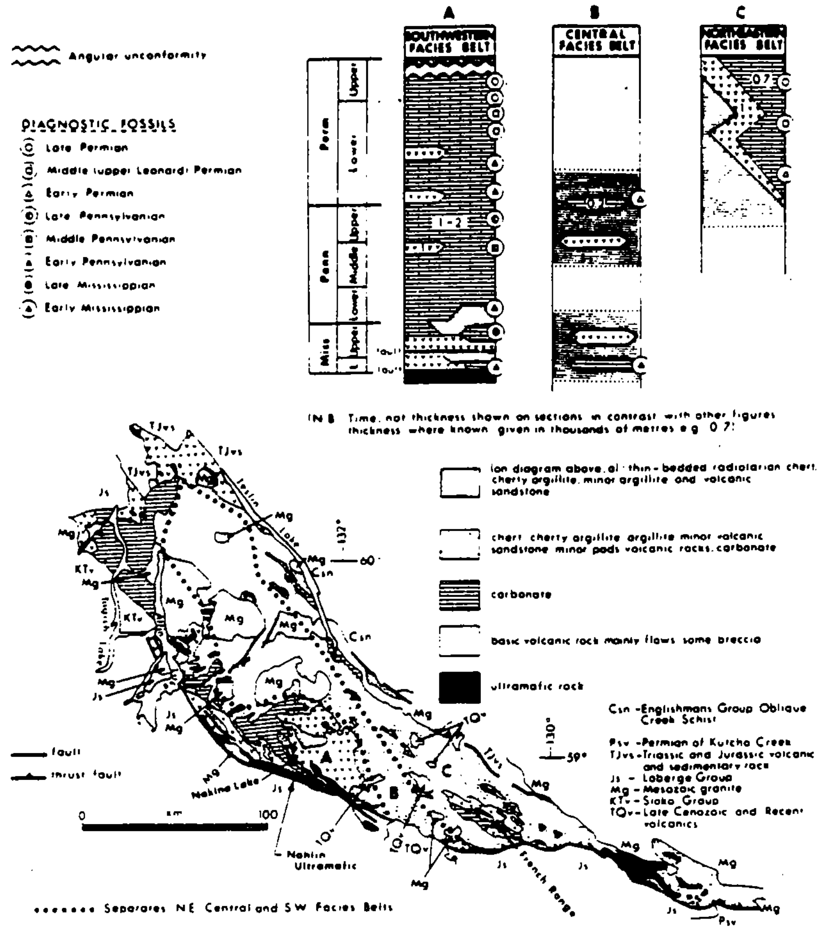

FIGURE 6. Distribution and generalized stratigraphy of rocks in Assemblage 4 from northern British Columbia (loc. 4a). Note great lateral facies changes, and great thickness and time span of carbonate in southwestern facies belt (modified from Monger, 1977).

The Tethyan fusulinid faunas are distinctive and occur with crinoidal and algal detritus and only rare examples of other phyla. They contain abundant and diverse Verbeekinidae as well as characteristic species complexes of *Schwagerina* and *Parafusulina* (Ross, *in* Monger, 1975).

Assemblage 5, centred on the Stikine region of northwestern British Columbia, is almost certainly allochthonous, by virtue of its position west of Assemblage 4 and from paleomagnetic evidence from overlying strata (fig. 3). Its Permian faunas are similar to those of arc terranes believed to have formed elsewhere along the western margin of the continent (Assemblages 2,3), and it may have been displaced from further south along the continental margin rather than being completely exotic (Monger and Ross, 1971).

Eastern exposures, known as the Asitka Group, (loc. 5a, fig. 1) comprise approximately 1000 m of basalt, rhyolite, tuff, and argillite, with local tuffaceous carbonate containing Early Permian fossils. Unnamed western rocks include, locally, more than 3000 m of Mississippian argillites and intermediate pyroclastics interbedded with 1000 m of Late Mississippian carbonate. This sequence is overlain, probably with angular unconformity, by basic volcanics and tuff grading upward into 600 m of distinctive Permian carbonate whose lower part is argillaceous and thin bedded and whose upper part is thick bedded and dolomitic. This carbonate ranges from Early to early Late Permian and, remarkably for these western assemblages, maintains its characteristics for a distance of 700 m along the regional strike.

Permian faunas include a wide range of phyla. Fusulinids are abundant but of limited diversity. As pointed out by Pitcher (1961), the fusulinid faunas show some similarities with those of the McCloud Limestone in California (loc. 36b). Mississippian foraminiferal faunas have been correlated by Mamet (1976, p. 100–102) with those in Assemblage 7 in southeastern Alaska.

Assemblage 6 includes the Chilliwack Group, which is complexly imbricated with Mesozoic strata in thrust faults on the west side of the Northern Cascades. It consists of a lower unit of argillite with thin Lower Pennsylvanian carbonate at the top, overlain disconformably by terrestrial plant-bearing sandstone and conglomerate, capped by Lower Permian carbonate and basaltic to acidic volcanics (Monger, 1977). This unit has been correlated by Sada and Danner (1976) with rocks to the east in Assemblage 2, and Davis et al. (1978, p. 17–18) suggest Assemblage 6 is equivalent to Assemblage 2, doubled up by Late Cretaceous–early Tertiary strike-slip faulting.

Fusulinid faunas from Permian strata include the three genera characteristic of "non-Tethyan" fusulinid faunas in the western Cordillera, namely *Schwagerina, Pseudofusulinella*, and *Parafusulina* (Skinner and Wilde, 1966).

Assemblage 7 is a heterogeneous sequence of chert, shale, limestone, mafic volcanics, and pyroclastics that lie on Devonian and older terranes (Brew et al., 1966; Berg, Jones et al., 1978). There are some similarities and differences between Assemblages 7 and 5. Mamet (1976, p. 100–102) correlated Late Mississippian foraminiferal faunas in the two assemblages. The post-Pennsylvanian northward latitudinal shift of 15° reported by Gromme (*in* Berg, Jones et al., 1978) is similar to that of Mesozoic rocks above Assemblage 5 (Irving, Monger et al., 1980). However, strata of Pennsylvanian age in Assemblage 7 are not known in Assemblage 5 to the east, and the characteristic Permian limestone of Assemblage 7 is not seen in Permian strata to the west. Jones, Irwin et al. (1972) speculated that this terrane was displaced by right-lateral transcurrent faulting from California, in a similar manner to Assemblage 5.

Middle Pennsylvanian and Early Permian fusulinids are reported from this assemblage (Douglas, 1974), and brachiopods and bryozoa are locally abundant.

Assemblage 8 consists of two, widely separated sequences, Skolai Group in the north and Sicker Group in the south, grouped on the basis of similar gross stratigraphy, similar faunas, and, above all, the remarkable likeness of overlying Triassic strata (Monger, 1977). Paleomagnetic studies on the latter suggest similar northward latitudinal shifts, most probably so great as to suggest these rocks originated beyond the latitudinal limits of the continent (Irving, 1979, p. 676). Ambiguity in the results, however, is permissive of the less likely, minimal latitudinal shift in figure 3. In both areas, a lower sequence of basic to acidic volcanic rocks is overlain by sandstone, siltstone, argillite, and limestone of Permian and, locally, Pennsylvanian ages (Muller and Carson, 1979; Yole, 1969; Smith and MacKevett, 1970). Triassic strata on the Oregon-Idaho boundary (loc. 3c) have been correlated by Jones, Silberling et al. (1977) with rocks overlying Assemblage 3 to the north. Similarly, underlying acid to basic volcanics, breccia, and sandstone of Early Permian age (Vallier et al., 1977) may be equivalent to Assemblage 3.

Permian faunas of this assemblage differ from those to the east in that bryozoan and brachiopod faunas predominate and have affinities with Uralian-Franklinian forms. Fusulinids, although locally abundant, are not present everywhere and show similar affinities (Petocz, 1970).

Assemblage 9. As noted above, Mesozoic rocks form the bulk of Assemblage 9. These rocks have recently been interpreted as middle and late Mesozoic subduction complexes. Formerly, most ages were from fossils in limestone blocks in a matrix of chert and argillite. These blocks contained Paleozoic and Triassic faunas, those of Permian age having either "Tethyan" or Franklinian-Uralian affinities. Recently, radiolarian studies have shown that the chert and argillite matrices are of Triassic and Jurassic ages (Irwin et al., 1978; Saleeby et al., 1978; Whetten et al., 1978). At present, it appears that most of the strata are Mesozoic, with local Paleozoic fragments perhaps largely equivalent to Assemblage 4.

CONCLUDING REMARKS

In this brief summary we can do little more than indicate the complexity and diversity of upper Paleozoic eugeosynclinal assemblages in the North American Cordillera, and point out some of the paleontological and paleomagnetic evidence that is starting to explain this diversity. It seems likely that the present configuration of upper Paleozoic assemblages was not achieved until late Mesozoic or even early Tertiary time (Davis et al., 1978; Monger and Price, 1979; Irving, Monger et al., 1980). A reasonable case can be made that some assemblages formed west of the ancient continental margin more or less where they occur today relative to the continent (Assemblages 1,2,3). Other related assemblages are perhaps displaced for relatively small distances from their present locations (Assemblages 5,6,7), and still others are far traveled (Assemblages 4,8). We wish to direct the attention of others working around the Pacific margin to these last two terranes, in the hope that stratigraphic and paleontological correlations may be established from elsewhere. Finally, it should be obvious that much more stratigraphic and paleontological information is needed on these complex terranes. Most of the work done so far, north of latitude 44° at least, is of a reconnaissance nature. Groups that give precise biostratigraphic ages, such as foraminifers and ammonoids, have received almost all the attention to date. The lack of formal paleontological descriptions of other phyla makes it extremely difficult to document faunal differences, for example those between Assemblages 5 and 8, where most of the fossils in the latter are bryozoans and brachiopods.

Finally, we wish to acknowledge the invaluable introduction to the complex terranes of the western Cordillera in the conterminous United States provided by the volumes on Paleozoic and Mesozoic paleogeography published in 1977 and 1978 by the Pacific Coast Section of the Society of Economic Paleontologists and Mineralogists.

REFERENCES

Albers, J.P., and Robertson, J.F. 1961. Geology and ore deposits of East Shasta copper-zinc district, Shasta County, California. *U.S. Geol. Survey Prof. Paper* 338.

Armstrong, R.L. 1979. Sr isotopes of the Canadian Cordillera and the extent of Precambrian rocks. *Geol. Assoc. Canada, Cordilleran Sec. Program and Abs.*: 7.

Armstrong, R.L., Taubeneck, W.H., and Hales, P.O. 1977. Rb/Sr and K-Ar geochronometry of Mesozoic granitic rocks and their Sr isotopic composition. *Geol. Soc. America Bull.* 88:397–411.

Berg, H.C., Jones, D.L., and Coney, P.J. 1978. Map showing pre-Cenozoic tectonostratigraphic terranes of southeastern Alaska and adjacent areas. *U. S. Geol. Survey Open-File Rept.* 78-1085.

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

Bostwick, D.A., and Nestell, M.K. 1967. Permian Tethyan fusulinid faunas of the northwestern United States. In *Aspects of Tethyan biogeography*, ed. C.G. Adams and D.V. Ager, 93-102. Systematics Association Pub. 7.

Brew, D.A., Loney, R.A., and Muffler, L.J.P. 1966. Tectonic history of southeastern Alaska. *Canadian Inst. Mining and Metallurgy Spec. Vol.* 8:149–170.

Burchfiel, B.C., and Davis, G.A. 1972. Structural framework and evolution of the southern part of the Cordilleran orogen, western United States. *Am. Jour. Sci.* 272:97-118.

Danner, W.R. 1965. Limestones of the western Cordilleran eugeosyncline of southwestern British Columbia, western Washington and northern Oregon. *Mining and Metall. Inst. India, D.N. Wadia Comm. Vol.*:113-125.

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 *Mesozoic paleogeography of the western United States*, ed. D.C. Howell and K.A. McDougall, 1-32. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Dickinson, W.R. 1977. Paleozoic plate tectonics and the evolution of the Cordilleran continental margin. In *Paleozoic paleogeography of the western United States*, ed. J.H. Steward et al., 137-155. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Dickinson, W.R. 1979. Mesozoic forearc basin in central Oregon. *Geology* 7:166–170.

Douglass, R.L. 1974. Fusulinids in southeastern Alaska. *Jour. Paleontology*: 854–855.

Gordey, S.P. 1978. Stratigraphy and structure of the Summit Lake area, Yukon and northwest territories. *Canada Geol. Survey Paper* 78-1a:43–48.

Hamilton, W.S. 1969. Mesozoic California and the underflow of Pacific mantle. *Geol. Soc. America Bull.* 80:2409-2430.

Hillhouse, J.W. 1977. Paleomagnetism of the Triassic Nikolai Greenstone, McCarthy Quadrange, Alaska. *Canadian Jour. Earth Sci.* 14:1187-1208.

Hotz, P.E., Lanphere, M.A., and Swanson, D.A., 1977. Triassic blueschist from northern California and north-central Oregon. *Geology* 5:659-663.

Irving, E. 1979. Paleopoles and paleolatitudes of North America and speculations about displaced terrains. *Canadian Jour. Earth Sci.* 16:669–694.

Irving, E., Monger, J.W.H., and Yole, R.W. 1980. New paleomagnetic evidence for displaced terranes in British Columbia. *Geol. Assoc. Canada Spec. Paper* 20:441-456.

Irving, E., and Yole, R.W. 1972. Paleomagnetism and the kinematic history of mafic and ultramafic rocks in fold mountain belts. *Canadian Earth Physics Pub.* 42:87-95.

Irwin, W.P. 1977. Review of Paleozoic rocks of the Klamath Mountains. In *Paleozoic paleogeography of the western United States*, ed. J.H. Stewart et al., 441–454. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Irwin, W.P., Jones, D.L., and Kaplan, T. 1978. Radiolarians from pre-Nevadan rocks of the Klamath Mountains, California and Oregon. In *Mesozoic paleogeography of the western United States*, ed. D.G. Howell and K.A. McDougall, 303-310. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

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

Jones, D.L., Silberling, N.J., and Hillhouse, J.W. 1977. Wrangellia—a displaced terrane in northwestern North America. *Canadian Jour. Earth Sci.* 14:2565–2577.

King, P.B. 1969. *Tectonic map of North America*. United States Geological Survey.

Kistler, R.W., and Peterman, Z.E. 1973. Variations in Sr, Rb, K, Na, and initial Sr^{87}/Sr^{86} in Mesozoic granitic rocks and intruded wall rocks in central California. *Geol Soc. America Bull.* 84:3489-3512.

Mamet, B.L. 1976. An atlas of microfacies in Carboniferous carbonates of the Canadian Cordillera. *Canada Geol. Survey Bull.* 255.

Mamet, B.L., and Gabrielse, H. 1969. Foraminiferal zonation and stratigraphy of the type section of the Nizi Formation (Carboniferous System, Chesteran Stage) British Columbia. *Canada Geol. Survey Paper* 69-16.

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

Monger, J.W.H. 1977. Upper Paleozoic rocks of the western Canadian Cordillera and their bearing on Cordilleran evolution. *Canadian Jour. Earth Sci.* 14:1832-1859.

Monger, J.W.H., and Price, R.A. 1979. Geodynamic evolution of the Canadian Cordillera—progress and problems: *Canadian Jour. Earth Sci.* 16:770-791.

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

Muller, J.E., and Carson, D.J.T. 1969. Geology and mineral deposits of Alberni map-area, British Columbia (92F). *Canada Geol. Survey Paper* 68-50.

Nilsen, T.H. 1977. Paleogeography of Mississippian turbidites in south-central Idaho. In *Paleozoic paleogeography of the western United States*, ed. J.H. Stewart et al., 275-299. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Okulitch, A.V., and Peatfield, G.R. 1977. Geologic history of the late Paleozoic-early Mesozoic eugeocline in southern British Columbia and eastern Washington. *Geol. Assoc. Canada Program and Abs.*

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

Petocz, R.G. 1970. Biostratigraphy and Lower Permian Fusulinidae of the Upper Delta River area, east-central Alaska Range. *Geol. Soc. America Spec. Paper* 130.

Pitcher, M.G. 1961. Fusulinids of the Cache Creek Group, Stikine River area, Cassiar District, British Columbia, Canada. *Brigham Young Univ. Geology Studies* 7 (7).

Poole, F.G., and Sandberg, C.A. 1977. Mississippian paleogeography and tectonics of the western United States. In *Paleozoic paleogeography of the western United States*, ed. J.H. Stewart et al., 67-85. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Read, P.B. 1976. Lardeau map-area (82K west half), British Columbia. *Canada Geol. Survey Paper* 76-19:95-96

Read, P.B., and Okulitch, A.V. 1977. The Triassic unconformity of south-central British Columbia. *Canadian Jour. Earth Sci.* 14:606-638.

Roberts, R.J., Hotz, P.E., Gilluly, J., et al. 1958. Paleozoic rocks of north-central Nevada. *Am. Assoc. Petrol. Geol. Bull.* 42:2813-2857.

Ross, C.A. 1969. Upper Paleozoic Fusulinacea; *Eowaeringella* and *Weedekindellina* from Yukon Territory and giant *Parafusulina* from British Columbia. *Canada Geol. Survey Bull.* 182: 129-134.

Ross, C.A. 1984. Fusulinacean biostratigraphy near the Carboniferous-Permian boundary in North America. *9ᵉ Congr. Int. Stratigr. Géol. Carbonifère Compte Rendu* 2:535-542.

Ross, C.A., and Monger, J.W.H. 1978. Carboniferous and Permian fusulinaceans from the Omineca Mountains, British Columbia. *Canada Geol. Survey Bull.* 267:43-63.

Sada, K., and Danner, W.R. 1976. *Pseudoschwagerina* from Harper Ranch area, near Kamloops, British Columbia. *Hiroshima Univ. Comm. Vol. of the founding of the Faculty of Integrated Arts and Sciences*: 213-227.

Saleeby, J.B., Goodin, S.E., Sharp, W.D., et al. 1978. Early Mesozoic paleotectonic-paleogeographic reconstruction of the southern Sierran region. In *Mesozoic paleogeography of the western United States*, ed. D.G. Howell and K.A. McDougall, 311-336. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Schweikert, R.A., Saleeby, J.A., Tobisch, O.T., et al. 1977. Paleotectonic and paleogeographic significance of the Calaveras Complex, western Sierra Nevada, California. In *Paleozoic paleogeography of the western United States*, ed. J.H. Stewart et al., 381-394. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Silberling, N.J. 1973. Geologic events during Permo-Triassic time along the Pacific margin of the United States. *Canadian Soc. Petrol. Geol. Mem.* 2:345-362.

Silberling, N.J. 1975. Age relationships of the Golconda thrust fault, Sonoma Range, north-central Nevada. *Geol. Soc. America Spec. Paper* 163.

Skinner, J.W., and Wilde, G.L. 1966. Permian fusulinids from Black Mountain area, northwestern Washington. *Kansas Univ. Paleont. Contr. Paper* 4:28-30.

Smith, J.E., and MacKevett, E.M. 1970. The Skolai Group of the McCarthy B-4, C-4 and C-5 quadrangles, Wrangell Mountains, Alaska. *U.S. Geol. Survey Bull.* 1274-Q.

Stevens, C.H. 1977. Permian depositional provinces and tectonics, western United States. In *Paleozoic paleogeography of the western United States*, ed. J.H. Stewart et al., 113-135. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Tempelman-Kluit, K.J. 1977. Stratigraphic and structural relations between the Selwyn Basin, Pelly Cassiar Platform and Yukon Crystalline Terrane in the Pelly Mountains, Yukon. *Canada Geol. Survey Paper* 77-1A:223-227.

Vallier, T.L., Brooks, H.C., and Thayer, T.P. 1977. Paleozoic rocks of eastern Oregon and western Washington. In *Paleozoic paleogeography of the western United States*, ed. J.H. Stewart et al. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Whetten, J.T., Jones, D.L., Cowan, D.S., et al. 1978. Ages of Mesozoic terranes in the San Juan Islands, Washington. In *Mesozoic paleogeography of the western United States*, ed. D.G. Howell and K.A. McDougall, 117-132. Society of Economic Paleontologists and Mineralogists, Pacific Coast Section.

Yancey, T.E. 1975. Permian marine biotic provinces in North America. *Jour. Paleontology* 40:758-766.

Yole, R.W. 1969. Upper Paleozoic stratigraphy of Vancouver Island, British Columbia. *Geol. Assoc. Canada Proc.* 20:30-40.