Accretion Tectonics in the Circum-Pacific Regions, edited by M. Hashimoto and S. Uyeda, 21–35.

DAVID BLOOM

Recognition, Character, and Analysis of Tectonostratigraphic Terranes in Western North America

D. L. JONES,* D. G. HOWELL,*
P. J. CONEY,** and J. W. H. MONGER***

**U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, California 94025, U.S.A.*
***University of Arizona, Tucson, Arizona, U.S.A.*
****Geological Survey of Canada, Vancouver, Canada*

Continental growth involves accretion of allochthonous terranes driven by plate tectonic processes. The Pacific region is rimmed by a tectonic collage composed of accreted terranes. Individual tectonostratigraphic terranes are fault-bounded geologic entities of regional extent, each characterized by a geologic history which is distinct from that of neighboring terranes. Terranes comprise one of four types: (1) stratigraphic terranes composed of coherent stratigraphic sequences which reflect geologic environments of continental fragments, ocean basins and/or volcanic arcs; (2) disrupted terranes characterized by blocks of heterogeneous lithology and age set in a matrix of sheared graywacke or serpentinite, (3) metamorphic terranes represented by areas with a regional penetrative metamorphic fabric that obscures and is more distinctive than original petrogenetic aspects; and (4) composite terranes represented by two or more terranes that amalgamated prior to accretion onto a continental margin. Terranes vary enormously in size from some that require mapping at 1:25,000 to others that are easily depicted at 1:20,000,000. Post-accretionary tectonic processes cause terrane dispersion further complicating the geometry of terrane distribution.

1. Introduction

Most of the Cordillera of western North America is a tectonic collage composed of accreted crustal fragments or terranes. The relations of the terranes to one another during the time of formation of their component rocks is unknown or uncertain, (CONEY *et al.*, 1980). These lithospheric fragments can be discriminated through a process known as terrane analysis. In this brief report, we explain the methodology of terrane analysis, including how terranes are identified and how their boundaries are established. A critical feature of terrane analysis is that geologic and geophysical data must be clearly separated from plate tectonic interpretations concerning the genetic relations among terranes. Because of the large amount of differential movement that various terranes have undergone, it is no longer safe or reasonable to assume that nearby terranes are genetically related—such relations now must be vigorously proven before meaningful paleogeographical and paleotectonic reconstructions should be attempted.

2. Terrane Definition

Terranes are fault-bounded geologic entities of regional extent, each characterized by a geologic history that is different from the histories of contiguous terranes. Ideally, such histories are determined from the stratigraphic succession preserved in a terrane, but in some cases such histories are largely or completely destroyed by tectonic or sedimentological disruptions or by metamorphic overprinting. In the latter cases the disruptive or metamorphic event itself may characterize the terrane. In addition, some terranes are composite entities produced by amalgamation of two or more terranes into a single terrane. In cases where juxtaposed terranes possess coeval strata, one must demonstrate different and unrelated geologic histories as well as the absences of intermediate lithofacies that might link the two terranes. The basic question that must be asked while analyzing stratigraphic sequences of possibly distinct terranes is whether or not the inferred geologic histories are compatible with the present spatial relations. This decision is not always easy to make, and is heavily dependent on the quality and quantity of geologic controls that are available to the analyzer. The degree of differences noted between terranes is thus variable, and classifications will differ according to the judgement, experience, and competency of the analyzer. New data always require reexamination of existing terrane classifications, and it is expected that new combinations or subdivisions will result from additional paleontologic, geologic, and geophysical research. In this regard, terrane nomenclature is similar to stratigraphic nomenclature, and is subject to continuous revision as data accumulate and concepts evolve. Terranes are conveniently categorized into four general types (1) stratified, (2) disrupted, (3) metamorphic, and (4) composite; examples of each are discussed below.

2.1 Stratigraphic terranes

These terranes are characterized by coherent stratigraphic sequences in which depositional relations between successive lithologic units can be demonstrated. Basement rocks may or may not be preserved. Rock sequences within stratified terranes may be subdivided into three broad categories (some terranes have passed through successive tectonic phases encompassing two or three of these categories):

a. Fragments of continents: These terranes are characterized by the presence of a Precambrian basement with an overlying sequence of shallow-water sedimentary rocks of Paleozoic and Mesozoic ages. Included are sedimentary rocks of continental derivation that are detached from their basement substratum. Examples include the Nixon Fork terrane of Alaska and the Tujunga terrane of southern California.

b. Fragments of oceanic basins: These terranes are characterized by sequences of mafic and ultramafic rocks characteristic of oceanic crust with overlying deep-sea sedimentary deposits, e.g. the Del Puerto terrane of California and the Chulitna terrane of Alaska. Both have ophiolitic basements and deep-sea sediments, yet younger strata in both indicate continental margin depositional environments. These progradational sequences reflect translational mobility characteristic of many terranes. Also included are deep-sea deposits that are detached from their basement substratum, e.g. the Pingston terrane of Alaska.

c. Fragments of volcanic arcs: These terranes are composed dominantly of volcanic rocks, or the plutonic roots of arcs, and sedimentary debris derived from volcanos that are similar in composition to rocks of presently active volcanic arcs such as the Aleutians. Examples include the Stikine terrane of British Columbia, the Peninsular terrane of Alaska, and the Salinia terrane of California.

2.2 Disrupted terranes

These terranes are characterized by blocks of heterogeneous lithology and age, usually set in a matrix of sheared shale, flysch, or serpentinite. Most of these terranes contain fragments of ophiolitic rocks, blocks of shallow water limestone, deep-water chert, and packages of graywacke with lenses of conglomerate; in addition, many disrupted terranes contain blue schists both as exotic blocks or as a regional metamorphic overprint. Some disrupted terranes have been interpreted as subduction complexes. Examples include parts of the Chugach terrane of Alaska, the Franciscan terrane of California, and parts of the Cache Creek terrane of British Columbia.

2.3 Composite terranes

These terranes are composed of two or more distinct terranes that became amalgamated and subsequently shared or common geologic history prior to their accretion to North America (see discussion below). Examples of amalgamated terranes include: arc-arc amalgams (Alexander-Wrangellia); arc-continental-oceanic-disrupted amalgam (Salinia-Tujunga-Stanley Mountain-San Simeon terrane amalgam that equals the Santa Lucia-Orocopia allochthon of southern California; see Fig. 4). The Tujunga terrane by itself is a composite with basement rocks comprising at least three distinct Precambrian terranes and the Alexander terrane is a composite composed of the pre-Triassic Craig, Admiralty and Annette terranes (see Fig. 3).

2.4 Metamorphic terranes

These terranes are characterized by a regional, terrane-wide penetrative metamorphic fabric and development of metamorphic minerals to such a degree that original stratigraphic features and relations are obscured. In addition to metamorphic differences, protolithic contrasts with adjoining terranes also must be demonstrable. Examples include the Yukon-Tanana terrane of Alaska and the Baldy terrane of California composed of the Pelona, Orocopia and Rand Schists.

3. Size of Terranes

The terranes of the western Cordillera vary enormously in size. Some are of subcontinental dimensions whereas others cover only a few hundred square kilometers or less. A few terranes are not now continuous bodies, but consist of separate, disjunct patches that can be unequivocally correlated. The best example of a terrane that is disjunct is Wrangellia, which presently is distributed as isolated bodies from the state of Oregon, through British Columbia to southern Alaska, a latitudinal spread of nearly 24 degrees. Paleomagnetic data however, indicate that the original latitudinal spread was likely less than 4 degrees. The Santa Lucia-Orocopia composite terrane is currently

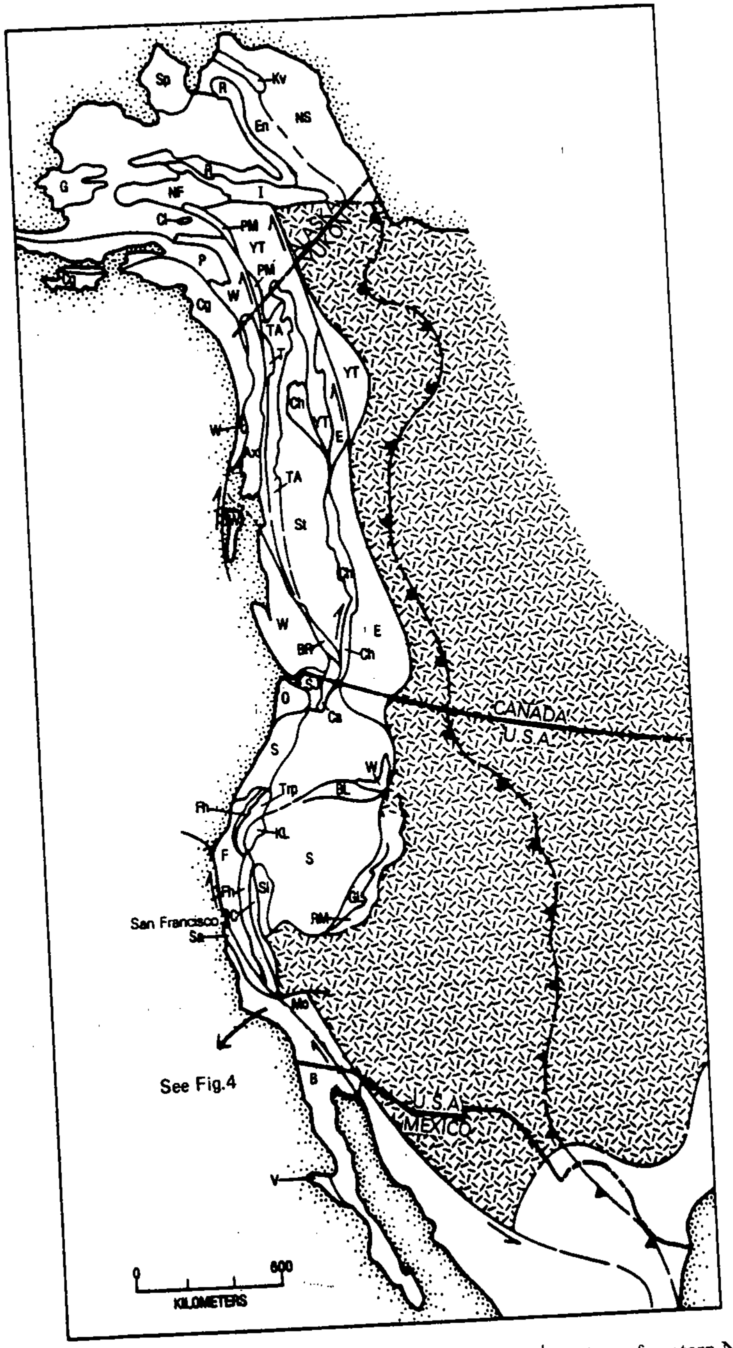


Fig. 1. Generalized distribution of selected terranes throughout the Cordillera of western North America. Dashed pattern is cratonic basement of authochthonous North America; barbed line represents the eastern limit of Cordilleran Mesozoic-Cenozoic deformation, and arrows show sense of major strike-slip movements. Terranes are described below, from CONEY *et al.* (1980).

Alaska

Sp. Seward Peninsula—structurally complex assemblage of Precambrian metamorphic and sedimentary rocks, and Palaeozoic carbonate rocks.

Ns. North Slope—Precambrian. Palaeozoic, and Mesozoic clastic and carbonate sequence—part of North America, but may have moved from original position.

Kv. Kagvik—Thin sequence of radiolarian chert, argillite, shale, and minor volcanics, Mississippian to Triassic in age.

En. Endicott—metamorphosed Lower to Upper Palaeozoic clastic and carbonate rocks intruded by Palaeozoic granitic rocks.

R. Ruby—composite terrane comprising at least three separate units, including Precambrian metamorphic rocks, mid to Upper Palaeozoic volcanic and sedimentary rocks, and thick piles of Lower Mesozoic basalt and chert.

I. Innoko—structurally deformed sequence of Upper Palaeozoic to early Mesozoic chert, argillite, graywacke, and basic to intermediate volcanics.

NF. Nixon Fork—Precambrian metamorphic rocks overlain by Palaeozoic and Mesozoic carbonate, clastic, and cherty rocks.

G. Goodness (composite)—includes three terranes: (1) a complex assemblage of deformed Upper Palaeozoic volcanics, chert, and graywacke with blocks of older limestone, (2) Precambrian gneisses and schist: and (3) Mesozoic arc-derived volcanic flows, tuff, and graywacke, with interbedded chert.

Cl. Chulitna (composite)—includes three terranes: (1) Devonian ophiolite overlain by Palaeozoic chert, volcanic conglomerate, limestone, and flysch, and Mesozoic limestone, redbeds, flysch, and chert: (2) Mesozoic chert, argillite, crystal tuff, and conglomeratic sandstone: (3) Upper Palaeozoic tuff and chert, volcanic graywacke, with blocks of Lower Palaeozoic limestone.

PM. Pingston & McKinley (composite)—includes three terranes: (1) Upper Palaeozoic phyllite and Triassic thin-bedded limestone and sooty black shale; (2) Upper Palaeozoic chert, Triassic pillow basalt, and Upper Mesozoic flysch and conglomerate; (3) Lower Palaeozoic limestone: tuff and flysch of unknown ages.

YT. Yukon-Tanana (composite)—includes regionally metamorphosed schist and gneiss of Precambrian(?) age. Devonian limestone, Upper Palaeozoic silicic metavolcanic rocks, Permian ophiolite, and foliated granitic rocks of unknown age.

W. Wrangellia—Upper Palaeozoic arc complex composed of flows, breccias, and volcaniclastic rocks overlain by limestone, clastics, and chert, and Mesozoic pillowed and subaerial basalt flows succeeded by limestone, cherty limestone, and clastic rocks.

P. Peninsular—rare Palaeozoic limestone, Triassic basalt, argillite, and limestone. Lower Jurassic volcanic and volcaniclastic rocks, younger clastics.

Cg. Chugach (composite)—includes (1) deformed Upper Mesozoic flysch and melange units, and (2) deformed Lower Cenozoic flysch and volcanic rocks.

Ax. Alexander—complex terrane of Precambrian (?) and Palaeozoic volcanic rocks, clastics, and limestone, and Mesozoic volcanics, limestone, and clastic rocks.

T. Taku—structurally complex assemblage of Upper Palaeozoic volcaniclastics, limestone, flysch (?) and Lower Mesozoic basalt, limestone, and flysch.

TA. Tracy Arm—structurally complex assemblage of marble, pelitic gneisses, and schist of unknown ages.

Canada

Ch. Cache Creek terrane—Mississippian t Middle (Upper?) Triassic, highly disrupte radiolarian chert, argillite, basalt, alpine-typ ultramafics, large shallow-water carbonates and local blueschist metamorphism.

BR. Bridge River terrane—Middle Triassic t Lower Middle Jurassic, highly disrupte radiolarian chert, argillite, basalt, alpine-typ ultramafics and minor carbonate.

St. Stikine terrane—Mississippian and Permia volcaniclastics, basic to acidic volcanics an carbonates, locally deformed and intruded i middle to late Triassic time, overlain by Uppe Triassic to Middle Jurassic volcanogeni strata.

E. Eastern assemblage (composite)—include possible late Precambrian-early Palaeozo metamorphic terranes, of possible continent affinity, together with Mississippian t Triassic basalt, ultramafics and chert an volcaniclastics and carbonates, overla unconformably by Middle Triassic to Low Jurassic volcanogenic strata.

Fig. 1 (continued).

Washington and Oregon

SJ. San Juan (composite)—includes highly deformed Mesozoic chert, argillite, graywacke, and volcanic rocks, partly in melanges, with blocks of lower Palaeozoic plutonic rocks. Palaeozoic chert, carbonates, and volcanic rocks. Permian limestone blocks contain Tethyan fusulinids.

Ca. Northern Cascades (composite)—includes crystalline and pelitic genesses, and thrust sheets composed of (1) Upper Palaeozoic andesitic volcanics and associated sedimentary rocks: (2) greenschist and blueschist; and (3) Jurassic ophiolite.

O. Olympic—Lower Cenozoic volcanic rocks and associated deep and shallow water sedimentary rocks. Basement unknown, but presumed to be oceanic.

S. Lower Cenozoic volcanic and sedimentary rocks lying west of the Cascade Range. Palaeomagnetic data imply post-Eocene clockwise rotation of 70°.

BL. Blue Mountains (composite)—includes melange with blocks of Palaeozoic ophiolite, limestone, and chert, and Mesozoic chert and sandstone, structurally overlain by Triassic and Jurassic volcanic sandstone, conglomerate, and argillite.

California

Fh. Foothills—Upper Jurassic andesitic volcanic and volcaniclastic rocks associated with phyllite, slate, and graywacke, and Upper Jurassic ophiolite.

Trp. Triassic and Palaeozoic of Klamath Mountains (composite)—includes a structurally complex assemblage of Lower Mesozoic ophiolite, chert, basalt, Jurassic andesitic rocks, and associated sedimentary rocks.

KL. Eastern Klamath Mountains—Middle to Upper Palaeozoic clastic, volcanic, and carbonate rocks, overlain by Triassic and Jurassic volcanics and minor limestone.

Si. Northern Sierra—Lower Palaeozoic clastic sedimentary rocks. Upper Palaeozoic and Lower Mesozoic volcanic and associated sedimentary rocks.

C. Calaveras (composite)—including a western belt of melange with ophiolite and Mesozoic chert, and an eastern belt of quartzose clastic rocks, argillite, and minor Permian limestone.

F. Franciscan (composite)—includes Upper Mesozoic Great Valley sequence with ophiolite at base, and structurally underlying disrupted and partially metamorphosed rocks of the Franciscan Complex.

Sa. Salinia—includes metamorphosed pelitic rocks, marble, and graywacke of unknown ages, intruded by Cretaceous granite plutons.

Mo. Mojave (composite)—juxtaposed and disrupted Palaeozoic sedimentary sequences. Lower Mesozoic sedimentary and volcanic rocks intruded by Mesozoic plutons.

Mexico

B. Baja—includes scattered localities of Upper Palaeozoic limestone and Lower Mesozoic clastic rocks, overlain by a thick pile of Upper Mesozoic volcanic and volcaniclastic rocks, capped by latest Cretaceous quartzofeldspathic sandstone.

V. Vizcaíno (composite)—includes Triassic basalt, chert, and limestone, Upper Jurassic arc-derived volcanic and volcaniclastic rocks, Upper Jurassic and Cretaceous clastic rocks, ophiolite, and structurally underlying Upper Mesozoic blue schist and distupted rocks similar to the Franciscan Complex.

Nevada

S. Sonomia (composite)—includes Upper Palaeozoic volcanics in the south, and Lower Mesozoic volcanics in the north. Si and Kl. terranes originally included in Sonomia.

Gl., Golconda—structurally deformed assemblage of chert, argillite, minor limestone, and volcanics of Mississippian to Permian age.

RM. Roberts Mountains—structurally complex assemblage of chert, argillite, sandstone, basalt, and minor limestone of Cambrian to latest Devonian or early Mississippian ages.

being disrupted into northwest-oriented slivers owing to Neogene displacement along the San Andreas fault system.

3.1 Terrane boundaries

By definition, all terranes must be separated from adjoining terranes by major faults, fault zones, or complex sutures. In practice one may be confronted with two nearby areas with different stratal units yet the boundary conditions are not known. In such cases the most conservative tack is to assume a fault until other linking relations can be demonstrated.

Confusion may arise in discriminating between fault bounded terranes and successive tectonic elements within a particular terrane. For example, in our definition, the development of a volcanic arc assemblage on top of an earlier-formed sedimentary or igneous package does not constitute formation of a new terrane. This definition is crucial to terrane analysis and failure to discriminate between terranes and contrasting lithogenetic elements within terranes is a potential source of confusion.

3.2 Amalgamation to form composite terranes

Two similar but unrelated events in the history of terranes should be distinguished. An early event referred to as *amalgamation*, is the joining together of separate terranes to form a composite terrane prior to the addition of the amalgamated terrane to a cratonal margin. The later event, termed *accretion*, is the collision and welding of a terrane (either composite or individual) to the craton. These events may be widely separated in time, or closely follow one other. Timing of amalgamation and accretion can be established by three main criteria (Fig. 2): 1) overlap assemblages that depositionally overlie two distinctive, juxtaposed stratigraphic sequences (e.g. the Bowser Basin deposits of British Columbia that link the Stikine and Cache Creek terranes and the Gravina-Nutzotin belt of southeastern Alaska that links Wrangellia to the Alexander composite terrane); 2) sudden appearance of detritus in one terrane derived from its dissimilar neighbor (e.g. in California granite boulders in paralic facies of the Stanley Mountain terrane indicate an Upper Cretaceous suturing to the Salinia terrane); 3) welding together of unlike sequences by granitic intrusions (e.g. 60 m.y. old plutons stitch all the terranes between the Denali and Border Ranges faults of southern Alaska).

By means of a flow chart we can schematically depict successive amalgamation stages of a variety of terranes. Figure 3 demonstrates the suturing sequence for some of the terranes in Alaska and Fig. 4 depicts suturing events in Southern California. In both instances episodes of accretion and amalgamation are inferred from the geologic relations of overlap sequences, plutonic intrusions or debris from a distinctive provenance.

4. Accretion of Terranes

The major tectonic event experienced by most terranes in the Cordillera is their accretion to North America. In many cases, this collisional event has produced intense folding, thrust faulting, penetrative deformation, and recrystallization under green-

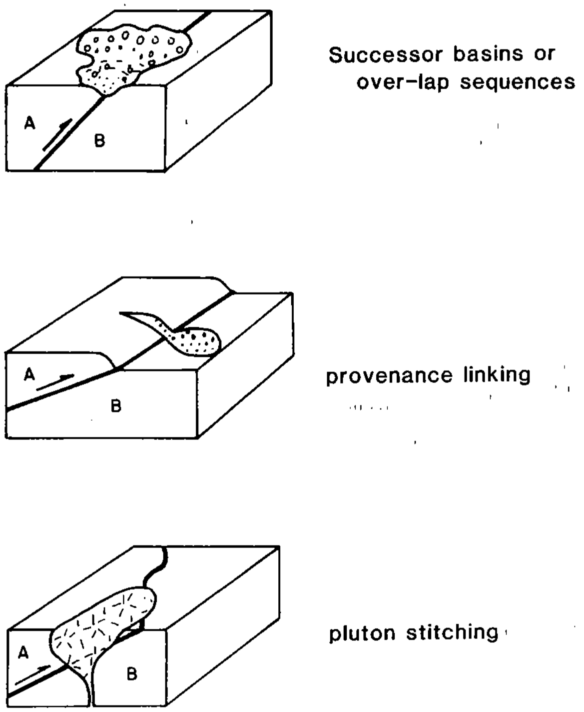


Fig. 2. Three geologic relations that help establish the timing of terrane amalgamation and accretion.

schist, blueschist, amphibolite facies conditions. These resulting tectonite fabrics in some instances are regional in scale while in other cases only thin or narrow zones are highly tectonized. Igneous activity directly related to accretion seems to be rare but low temperature alteration is widespread, and local instances of high temperature alteration, including anatexis, have been documented (HUDSON *et al.*, 1979).

Structural styles in accreted terranes vary widely; isoclinal folding is common, but vergence of folds is not consistent even within a single terrane. Thrust faults are ubiquitous, although most fault surfaces have themselves been folded. Identification of the initial accretionary structures that have not been altered by later movements is extremely rare.

The mechanisms of terrane accretion and amalgamation remain obscure; nonetheless, these phenomena are not to be confused with the concept of subduction accretion which relate to off-scraping of soft unconsolidated pelagic or trench deposits during subduction. Many terranes of the Cordillera are composed of sedimentary units which indicate past involvement in subduction accretion, yet their present tectonic position reflects emplacement mainly as coherent, strongly lithified masses, above either the continental margin or on earlier accreted terranes. This implies that the terranes are obducted flakes that are mere remnants of once much larger plates that have now mostly been subducted.

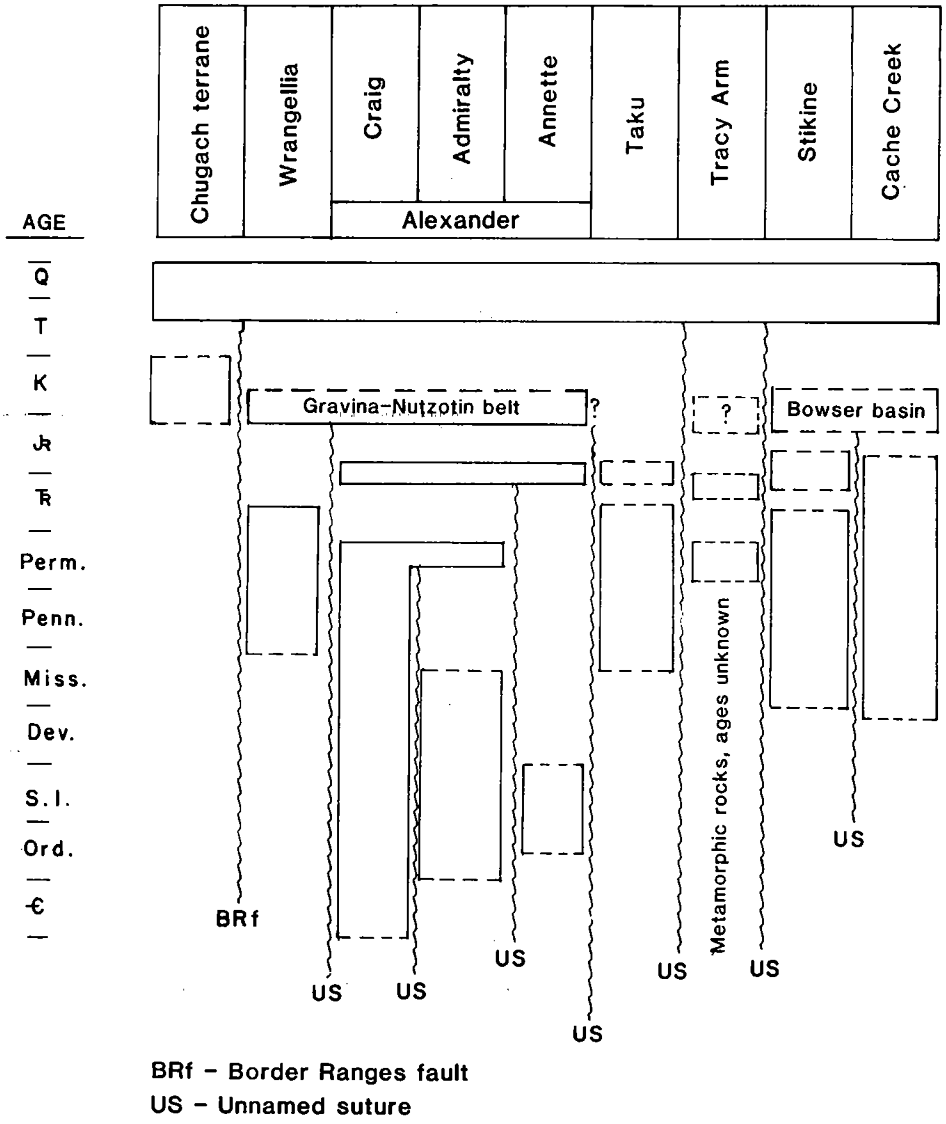
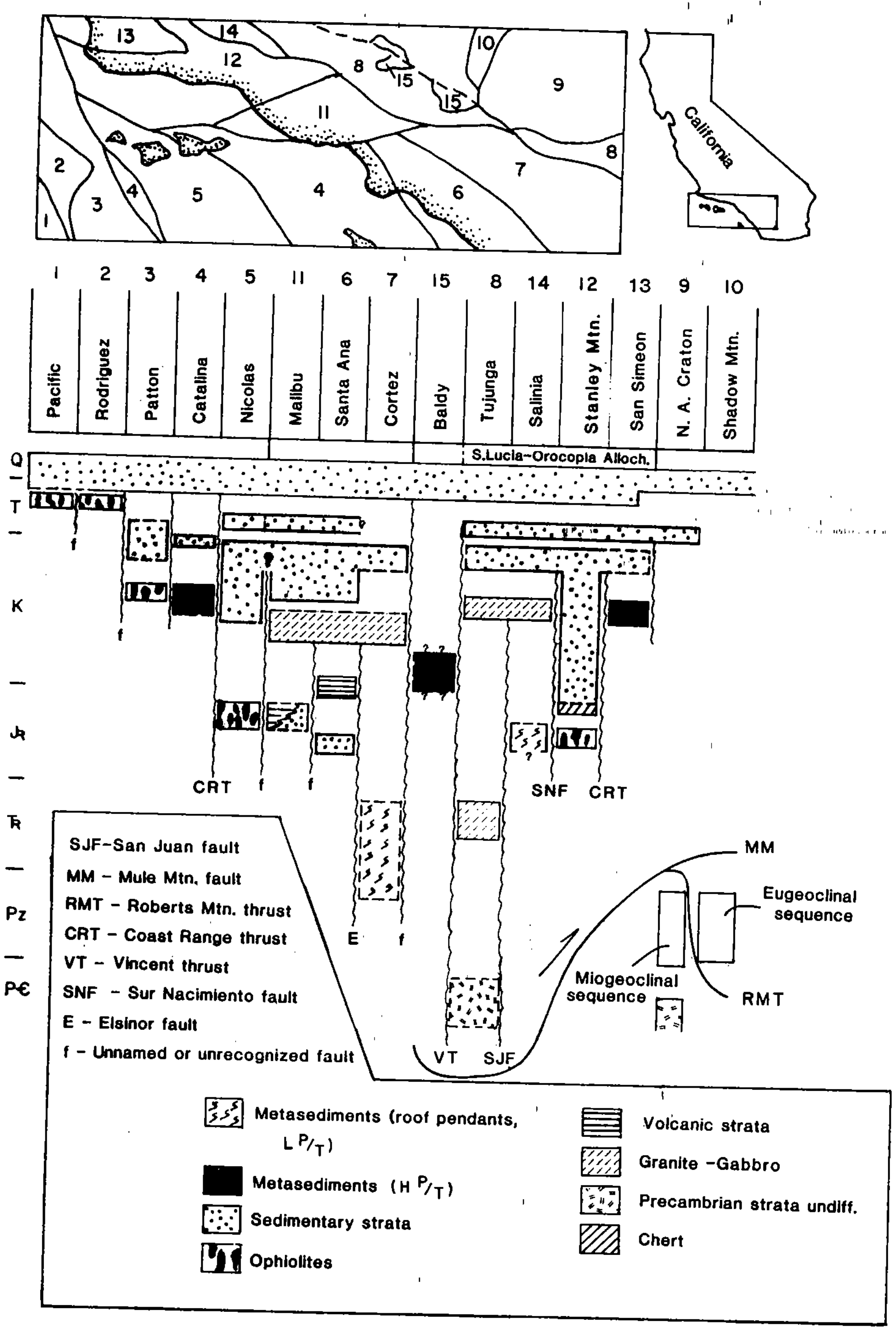


Fig. 3. Generalized cross sections of presently contiguous terranes in southern Alaska showing inferred ages of amalgamation and accretion.

We suspect the major differences between the accretionary wedge-model and the accretionary terrane setting are due to differences in crustal thickness of material being subducted. Sediment subduction involves oceanic crust with a thin cover of pelagic deposits being subducted without the formation of a growing accretionary wedge; the formation of the latter may be dependent on the presence of thick clastic trench deposits above a zone of over-pressured pore water (SCHOLL *et al.*, 1980). Thick crustal sections, such as seamounts, oceanic plateaus and ridges, and continental fragments,



g. 4. Generalized cross sections of presently contiguous terranes in southern California showing inferred s of amalgamation and accretion.

appear to be more difficult to subduct, and are instead, accreted as intact blocks (BEN-AVRAHAM *et al.*, 1981). Complete kinematic and dynamic explanations of terrane accretion processes, however, remain to be elucidated.

4.1 *Post accretionary dispersion*

The main period of accretionary activity ended by early Tertiary time in the Cordillera. These accretionary episodes have been followed by a long and still poorly known history of complex strike slip faulting, folding, and thrust faulting resulting in the breakup of some terranes. This crustal rearranging still is locally active and represents continuing interactions between oceanic plates of the Pacific and the continental plate of North America. The results of this neotectonic activity is to disperse the terranes and to further complicate the structures formed during accretion. Large scale right slip faults, such as the San Andreas, Fairweather, Denali, Fraser River, and Tintina, all have minimum displacements of a few hundred kilometers, and some may have much more. The cumulative relative movement on all of these, plus innumerable subsidiary faults, must amount to several thousand kilometers. Such a kinematic history agrees well with the plate tectonic motions between the Pacific and North American plates. Some of these structures originated during the late Cretaceous to early Cenozoic Laramide Orogeny, which profoundly affected much of western North America, including the Precambrian cratonal basement. The Laramide orogeny has been interpreted as a final "tightening" of a poorly consolidated crust composed of earlier accreted allochthonous terranes.

4.2 *Measuring terrane displacements*

The fact that fault-bounded terranes in the Cordillera have different stratigraphic sequences implies that they have moved relative to each other and to the craton. The amount of movement may not be large, but must be sufficient to juxtapose dissimilar rocks and to completely disrupt original facies trends.

Much effort is now being expended in order to establish the kinematic history of the various terranes. The principal methods of determining relative movements are: (1) offset of linear geologic elements, e.g. shorelines, dike swarms, fold axes etc.; (2) matching offset but similar stratigraphic sequences or distinctive rock types; (3) matching offset biogeographical provinces; (4) matching climatically controlled lithologic features (e.g., red beds, sabhkas, etc.) with their world-wide regional extent; (5) determination of paleolatitude through paleomagnetic investigations.

The method (1) permits precise analyses of slip but offsets greater than 500 km are rarely determined whereas method (5) gives quantitative measurements for displacements that have a very large latitudinal component. Offset in a longitudinal sense is not possible with paleomagnetic data unless detailed polar-wandering paths are available. The other methods are mainly qualitative for large displacements, although direct matching of offset stratigraphic sequences can be quite precise for displacement ranges of a few tens to a few hundreds of kilometers. Paleomagnetic measurements are now available from several terranes of the Western Cordillera and these data clearly substantiate minimum large scale northward displacements in some instances on the order of thousands of kilometers. Coupled with these right-slip translations are clockwise rotations commonly of 60° or more.

Thorough terrane analysis involves all of the above parameters to assess relative differential movements of terranes. If two or more methods of estimating original paleolatitude are in essential agreement, much more confidence can be placed on palinspastic and paleogeographic reconstructions. A good example of concordance of geophysical and geologic data is afforded by Wrangellia, where paleomagnetic measurements from Triassic basaltic rocks show equatorial paleolatitudes (HILLHOUSE, 1977) and Triassic carbonates overlying the basalt are Sabhka deposits characteristic of shallow tropical supratidal conditions (ARMSTRONG and MACKEVETT, 1977). These rocks are now at latitudes as high as 62° N, and are completely out of place with respect to cratonal Triassic sequences.

5. Paleogeographic Reconstructions

The aims of terrane analysis are to (1) identify, characterize, and portray on terrane maps all major allochthonous terranes; (2) to relate their faunal and floral characteristics through time to major paleobiogeographic provinces; (3) to establish paleolatitudes through time; (4) and finally, in the case of the Cordillera and Pacific region, to attempt paleogeographic reconstructions of the paleo-Pacific region, to attempt paleogeographic reconstructions of the paleo-Pacific Ocean (Panthalassa) and surrounding cratonal regions. Deep-sea drilling has established that no part of the present Pacific Ocean floor is older than Middle Jurassic—thus, pre-Jurassic history of the Pacific basin can only be gleaned from scraps and fragments plastered around the Pacific Margin in the form of accreted, allochthonous terranes.

REFERENCES

References cited and recommended reading germane to terrane analysis of western Cordillera of North America.

ALBERS, J. P., A Lithologic-tectonic framework for the metallogenic provinces of California, *Econ. Geol.*, **76**, 765–790, 1981.

ALVAREZ, Walter, D. V. KENT, I. PREMOLI-SILVA, R. A. SCHWEICKERT, and R. A. LARSON, Franciscan complex limestone deposited at 17° south paleolatitude, *Geol. Soc. Am. Bull.*, **91**, (pt. 1, no. 8), 476–484, 1980.

ARMSTRONG, A. K. and MACKEVETT, E. M., Jr., The Triassic Chitistone Limestone, Wrangell Mountains, Alaska, stressing detailed descriptions of Sabkha facies and other rocks in the Chitistone and their relations to Kennecott-type copper deposits, U. S. Geol. Survey Open File Report, 77-217, 72p., 1977.

BAILEY, E. H., M. C. BLAKE, and D. L. JONES, Onland Mesozoic oceanic crust in California Coast Ranges, *U.S. Geol. Survey Prof. Paper*, 700-C, C70–C81, 1970.

BECK, M. E., JR., Discordant paleomagnetic pole positions as evidence of regional shear in the western Cordillera of North America, Am. *J. Sci.*, **276**, 694–712, 1976.

BECK, M. E., JR., The paleomagnetic record of Plate-margin tectonic processes along the western edge of North America, *J. Geophys. Res.*, in press, 1982.

BEN-AVRAHAM, Z., A. NUR, D. JONES, and A. COX. Continental accretion and orogeny: From ocean plateaus to allochthonous terranes, *Science*, **213**, 47–54, 1981.

BERG, H. C., D. L. JONES, and P. J. CONEY, Map showing pre-Cenozoic tectonostratigraphic terranes of southeastern Alaska and adjacent areas, *U.S. Geol. Survey Open-file Report*, 78-1085, Scale 1:1,000,000, 1978.

BERG, H. C., D. L. JONES, and D. H. RICHTER, Gravina-Nutzotin belt-Tectonic significance of an upper Mesozoic sedimentary and volcanic sequence in southern and southeastern Alaska, *U.S. Geol. Survey Prof. Paper*, 800-D, D1–D24, 1972.

BLAKE, M. C. and D. L. JONES, Origin of Franciscan melanges in northern California, in *Modern and Ancient Geosynclinal Sedimentation: Soc. Econ. Paleontologists and Mineralogists Spec. Pub.*, **19**, edited by R. H. DOTT, Jr. and R. H. SHAVER, 345–357, 1974.

BLAKE, M. C. Jr. and D. L. JONES, The Franciscan assemblage and related rocks in northern California: a reinterpretation, in *The Geotectonic Development of California*, edited by W. G. Ernst, pp. 307–328, 1981.

BLAKE, M. C. Jr., D. L. JONES, and C. H. LANDIS, Active continental margins: Contrasts between California and New Zealand, in *The Geology of Continental Margins*, edited by C. A. Burk and C. L. Drake, pp. 853–872, Springer-Verlag, 1974.

CHAMPION, D. E., D. G. HOWELL, and C. S. GROMMÉ, Paleomagnetic and geologic data indicating 2,500 km of northward displacement for the Salinian, Sur Obispo, Tujunga and Baldy (?) terranes, California, *J. Geophys. Res.*, in press, 1982.

CHURKIN, Michael Jr., Claire CARTER, and J. H. TREXLER, Jr., Collision-deformed Paleozoic continental margin of Alaska-Foundation for microplate accretion, *Geol. Soc. Am.*, pt. 1, **91**, 648–654, 1980.

CHURKIN, Michael JR. and G. D. EBERLEIN, Ancient borderland terranes of the North American Cordillera: Correlation and microplate tectonics, *Geol. Soc. Am. Bull.*, **88**, 769–786, 1977.

CHURKIN, Michael Jr., W. J. NOKLEBERG, and Carl HUIE, Collision-deformed Paleozoic continental margin, western Brooks Range, Alaska, *Geology*, **7**, 379–383, 1979.

CONEY, P. J., D. L. JONES, and J. W. H. MONGER, Cordilleran suspect terranes, *Nature*, **288**, 329–333, 1980.

DAVIS, G. A., J. W. H. MONGER, and B. C. BURCHFIEL, Mesozoic construction of the Cordilleran "collage," central British Columbia to Central California, in *Mesozoic Paleogeography of the Western United States*, edited by D. G. Howell and K. A. McDougall, Pacific Coast Paleogeography Symposium 2, Pacific Coast Section, Soc. Econ. Paleont. and Mineral., pp. 1–32, Los Angeles, California 1978.

HAMILTON, Warren, Mesozoic tectonics of western United States, in *Mesozoic Paleogeography of the Western United States*, edited by D. G. Howell and K. A. McDougall, Pacific Coast Paleogeography Symposium 2, Pacific Coast Section, Soc. Econ. Paleont. and Mineral., pp. 33–70, Los Angeles, California, 1978.

HILLHOUSE, John, Paleomagnetism of the Triassic Nikolai greenstone, south-central Alaska, *Can. J. Earth Sci.*, **14**, 2578–2592, 1977.

HILLHOUSE, J. W. and C. S. GROMMÉ, Paleomagnetism of the Triassic Hound Island Volcanics, Alexander Terrane, southeastern Alaska, *J. Geophys. Res.*, **85**, No. B5, 2594–2602, 1980.

HUDSON, T., George PLAFKER, and Z. E. PETERMAN, Paleogene anatexis along Gulf of Alaska Margin, *Geology*, **7**, 12, 573–577, 1979.

IRVING, E., J. W. H. MONGER, and R. W. YOLE, New paleomagnetic evidence for displaced terranes in British Columbia, in *The Continental Crust and Its Mineral Deposits*, edited by D. W. Strongway, *Geol. Assoc. Canada Spec. Paper*, **20**, 441–456, 1980.

IRVING, E. and R. W. YOLE, Paleomagnetism and the kinematic history of mafic and ultramafic rocks in fold mountain belts, *Ottawa, Earth Physics Branch Pubs.*, **42**, 87–95, 1972.

IRWIN, W. P., Terranes of the western Paleozoic and Triassic belt in the southern Klamath Mountains, California, *U.S. Geol. Survey Prof. Paper*, 800-C, C103–C111, 1972.

IRWIN, W. P., Ophiolitic terranes of California, Oregon, and Nevada, in *North America ophiolites*, edited by R. G. Coleman and W. P. Irwin, *Oregon Dept. Geol. and Min. Ind. Bull.*, **95**, 75–92, 1978.

IRWIN, W. P. and D. L. JONES, Distribution, age, and tectonic significance of ophiolites of western North America, *IGCP Ophiolite Project*, edited by N. Bogdonov, Wiley, London, in press, 1982.

JONES, D. L., M. C. BLAKE, Jr., E. H. BAILEY, and R. J. MCLAUGHLIN, Distribution and character of upper Mesozoic subduction complexes along the west coast of North America, *Tectonophysics*, **47**, 207–222, 1978.

JONES, D. L., M. C. BLAKE, Jr., Claude RANGIN, The four Jurassic belts of northern California and their significance to the geology of the southern California borderland, *Am. Assoc. Petrol. Geologists, Pacific Sect., Misc. Pub.*, **24**, 343–362, 1976.

Jones, D. L. and N. J. Silberling, Mesozoic stratigraphy-the key to tectonic analysis of southern and central Alaska: Frontiers in AAAS, Pac, Div. Sym., in *Frontiers of Western Exploration*, edited by P. Rodola, (Also available as *U.S. Geol. Survey Open-file Report*, 79–1200), 1979.

Jones, D. L., N. J. Silberling, H. C. Berg, and George Plafker, Tectonostratigraphic terrane map of Alaska, *U.S. Geol. Survey Open-file Report*, 81–792, Scale 1:2,500,000, 1981.

Jones, D. L., N. J. Silberling, Bela Csejtey, Jr., W. H. Nelson, and C. D. Blome, Age and structural significance of ophiolite and adjoining rocks in the Upper Chulitna district, south-central Alaska, *U.S. Geol. Suvey Prof. Paper*, 1121–A, 21, 1980.

Jones, D. L., N. J. Silberling, Wyatt Gilbert, and Peter Coney, Character, distribution, and tectonic significance of accretionary terranes in the central Alaska Range, *J. Geophy. Res*, in press, 1982.

Jones, D. L., N. J. Silberling, and J. Hillhouse, Wrangellia—A displaced terrane in north-western North America, *Can. J. Earth Sci.* **14**, 2565–2577, 1977.

Jones, D. L., N. J. Silberling, and J. W. Hillhouse, Microplate tectonics of Alaska—Significance for the Mesozoic history of the Pacific Coast of North America, in *Mesozoic Paleogeography of the Western United States*, edited by D. G. Howell and K. A. McDougall, Pacific Coast Paleogeography Symposium 2, Pacific Coast Section, Soc. Econ. Paleont. and Mineral., pp. 71–74, Los Angeles, California, 1978.

Monger, J. W. H., Correlation of Eugeosynclinal Tectono-stratigraphic belts in the North American Cordillera, *Geo. Sci. Can.*, **2**, 4–10, 1975a.

Monger, J. W. H., Upper Paleozoic rocks of the Atlin terrane, northwestern British Columbia and south-central Yukon, *Geol. Survey Can., paper* 74–47, p. 63, 21 figs, 1975b.

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

Monger, J. W. H. and E. Irving, Northward displacement of north-central British Columbia, *Nature*, **285**, 289–294, 1980.

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

Monger, J. W. H., R. A. Price, and D. J. Tempelman-Kluit, Tectonic accretion and the origin of the two major metamorphic and plutonic welts in the Canadian Cordillera, *Geology*, in press, 1982.

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

Packer, D. R. and D. B. Stone, An Alaska Jurassic paleomagnetic pole and the Alaskan Orocline, *Nature Phys. Sci.*, **237**, 25–26, 1972.

Packer, D. R. and D. B. Stone, Paleomagnetism of Jurassic rocks from southern Alaska and the tectonic implications, *Can. J. Earth Sci.*, **11**, 976–997, 1974.

Plafker, George, D. L. Jones, and E. A. Pessagno, Jr., A Cretaceous accretionary flysch and melange terrane along the Gulf of Alaska Margin, *U.S. Geol. Circ.*, 751-B, B41–B43, 1977.

Richter, D. H. and D. L. Jones, Structure and stratigraphy of eastern Alaska Range, Alaska, *Arctic Geology, AAPG, Mem.*, **19**, 408–420, 1973.

Scholl, D. W., T. Vallier, R. E. von Huene, and D. G. Howell, Concepts about tectonic processes that affect large sediment bodies at under-thrust ocean margins, *Geology*, **8**, 564–568, 1980.

Stone, D. B., Tectonic history of the Continental Margin of southwestern Alaska: Late Triassic to earliest Tertiary, in *The Relationship of Plate Tectonics to Alaskan Geology and Resources*, edited by H. Sisson, pp. K1–K29, Alaska Geol. Soc., 1979.

Stone, D. B. and D. R. Packer, Tectonic implications of Alaska Peninsula paleomagnetic data, *Tectonophysics*, **37**, 183–201, 1977.

Stone, D. B. and D. R. Packer, Paleomagnetic data from the Alaska Peninsula, *Geol. Soc. Am. Bull.*, **90**, 545–560, 1979.

Tempelman-Kluit, D. J., The Yukon crystalline terrane: enigma in the Canadian Cordillera, *Geol. Soc. Am. Bull.*, **87**, 1343–1357, 1976.

Tempelman-Kluit, D. J., Transported cataclasite, ophiolite, and granodiorite in Yukon: evidence of arc-continent collision, *Geol. Survey Can. Paper*, 79–14, 27p., 1979a.

Tempelman-Kluit, D. J., Five occurrences of transported synorogenic clastic rocks in Yukon Territory,

Geol. Surv. Can. Paper, 79-1A, 1–12, 1979b.

Tipper, H. W., Offset of an Upper Pliensbachian geographic zonation in the North American Cordillera by Transcurrent faulting, *Can. J. Earth Sci*, in press, 1982.

van der Voo, R., M. Jones, C. S. Gromme, G. D. Eberlein, and M. Churkin, Jr., Paleozoic paleomagnetism and the northward drift of the Alexander Terrane, southeastern Alaska, *J. Geophys. Res.*, **85**, No. B10, 5281–5296, 1980.

Vedder, J. G., D. G. Howell, and Hugh McLean, Stratigraphy, sedimentation, and tectonic accretion of exotic terranes, southern Coast Ranges, California, *Am. Assoc. Petrol. Geol. Memoir Ser. Hedb.* in press, 1982.

Whetten, J. T., D. L. Jones, D. S. Cowan, and R. E. Zartman, Ages of Mesozoic terranes in the San Juan Islands, Washington, in *Mesozoic Paleogeography of the Western United States*, edited by D. G. Howell and K. A. McDougall, Pacific Coast Paleogeography Symposium 2, Pacific Section, Soc. Econ. Paleont. and Mineral., pp. 117–132, Los Angeles, California, 1978.

Yancey, T. E., Permian marine biotic provinces in North America, *J. Paleon*, **40**, 758–766, 1975.

Yole, R. W. and E. Irving, Displacement of Vancouver Island: paleomagnetic evidence from the Karmutsen Formation, *Can. J. Earth Sci.*, **17**, 1210–1228, 1980.