41
43

Geol. 538, Tect. Evol. W. N. Am., Reading and reference list 6 for 2/25/1988:

ACCRETIONARY TECTONICS IV: THE NATURE OF THE NEVADAN OROGENY IN THE SIERRA NEVADA; TECTONIC MODELS FOR THE CALIFORNIA COAST RANGES (FRANCISCAN & GREAT VALLEY SEQUENCES); JURASSIC EXTENSION IN THE SIERRA NEVADA REGION; MESOZOIC THRUST FAULTING IN THE WESTERNMOST GREAT BASIN

BOLD = Assigned reading; *Italicized* = Review paper

Nature and extent of the Nevadan orogeny (ca 155 +/- 3 Ma), Sierra Nevada

Schweickert and Cowan, 1975, Reading list 4.

✓ **Moores, E. M., and Day, H. W.**, 1984, Overthrust model for the Sierra Nevada: Geology, v. 12, p. 416-419. [essentially, a condensed version of Day, Moores, and Tuminas, 1985, reading list 4]

✓ **Schweickert, R. A., Bogen, N. L., Girty, G. H., Hanson, R. E., and Merguerian, Charles**, 1984, Timing and structural expression of the Nevadan orogeny, Sierra Nevada, California: GSA Bull., v. 95, p. 967-979; [Discussions and reply, GSA Bull., v. 96, p. 1346-1352; reading not req.]

Beard, J. S., and Day, H. W., 1987, The Smartsville intrusive complex, Sierra Nevada, California: the core of a rifted volcanic arc: GSA Bull., v. 99, p. 779-791. [Sorry, should have been on reading list 4.]

Ricci, E. I., Moores, E. M., Versosub, K. L., and McClain, J. S., 1985, Geologic and gravity evidence for thrust emplacement of the Smartville ophiolite: Tectonics, v. 4, p. 539-546.

Sharp, W. D., 1985, The Nevadan orogeny of the foothills metamorphic belt, California: a collision without a suture?: GSA Abstracts with Programs, v. 17, no. 6, p. 407.

✓ **Tobisch, O. T., Paterson, S. R., Longiaru, Samuel, and Bhattacharyya, Tapas**, 1987, Extent of the Nevadan orogeny, central Sierra Nevada, California: Geology, v. 15, p. 132-135.

✓ **Paterson, S. R., Tobisch, O. T., and Radloff, J. K.**, 1987, Post-Nevadan deformation along the Bear Mountains fault zone: implications for the Foothills terrane, central Sierra Nevada, California: Geology, v. 15, 513-16.

28 JAN 07

Helwig, J., 1974, Eugeosynclinal basement and a collage concept of orogenic belts: SEPM Spec. Pub. 19, p. 359-376.

Davis, G. A., Monger, J. W. H., and Burchfiel, B. C., 1978, Mesozoic construction of the Cordilleran "collage", central British Columbia to central California: Pac. Sect. SEPM, Mesozoic paleogeography of the western U.S., p. 1-32.

Coney, P. J., Jones, D. L., and Monger, J. W. H., 1980, Cordilleran suspect terranes: Nature, v. 288, p. 329-333.

Jones, D. L., Howell, D. G., Coney, P. J., and Monger, J. W. H., 1983, Recognition, character, and analysis of tectonostratigraphic terranes in western North America, p. 21-35 in Accretion tectonics in the circum-Pacific regions (Hashimoto, M. and Uyeda, S., Eds.): Terra Scientific Publishing Co., Tokyo.

An abbreviated overview of accretionary tectonics in western Canada

Monger, J. W. H., and Ross, C. A., 1971, Distribution of fusulinaceans in the western Canadian Cordillera: CJES (Can. Jour. Earth Sciences), 8, 259-78.

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

Monger, J. W. H., Souther, J. G., and Gabrielse, H., 1972, Evolution of the Canadian Cordillera: a plate tectonic model: AJS, v. 272, p. 577-586.

Monger, J. W. H., 1977, Upper Paleozoic rocks of the western Canadian Cordillera and their bearing on Cordilleran evolution: CJES, 14, 1832-859.

Jones, D. L., Silberling, N. J., and Hillhouse, John, 1977, Wrangellia -- a displaced terrane in northwestern North America: CJES, 14, 2565-77.

Hillhouse, J. W., 1977, Paleomagnetism of the Triassic Nikolai Greenstone, McCarthy Quadrangle, Alaska: CJES, v. 14, p. 2578-2592.

28

Monger, J. W. H., and Ross, C. A., 1980, Upper Paleozoic volcanosedimentary assemblages of the western North American Cordillera: IX Int. Carb. Congress, v. 3, p.219-228.

Hillhouse, J. W., and Gromme, C. S., 1984, Northward displacement and accretion of Wrangellia: new paleomagnetic evidence from Alaska: JGR, v. 89, p. 4461-4477. *Combine review with Panuska (below).*

Panuska, B. C., 1985, Paleomagnetic evidence for a post-Cretaceous accretion of Wrangellia: Geology, v. 13, p. 880-883.

Monger, J. W. H., and Price, R. A., 1979, Geodynamic evolution of the Canadian Cordillera -- progress and problems: CJES, v. 16, p. 770-791.

Templeman-Kluit, D. J., 1979, Transported cataclasite, ophiolite, and granodiorite in Yukon: evidence of arc-continent collision: GSC Paper 79-14, 27 p.

Van der Voo, Rob, Jones, Meridee, Gromme, C. S., Eberlein, G. D., and Churkin, Michael, Jr., 1980, Paleozoic paleomagnetism and northward drift of the Alexander terrane, southeastern Alaska: JGR, 85, 5281-296.

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

Gehrels, G. E., and Saleeby, J. B., 1987, Geologic framework, tectonic evolution and displacement history of the Alexander terrane: Tectonics, v. 6, p. 151-173.

Monger, J. W. H., and Berg, H. C., 1987, Lithotectonic map of western Canada and southeastern Alaska: USGS Misc. Field Studies Map MF-1874-B, 1:2,500,000.

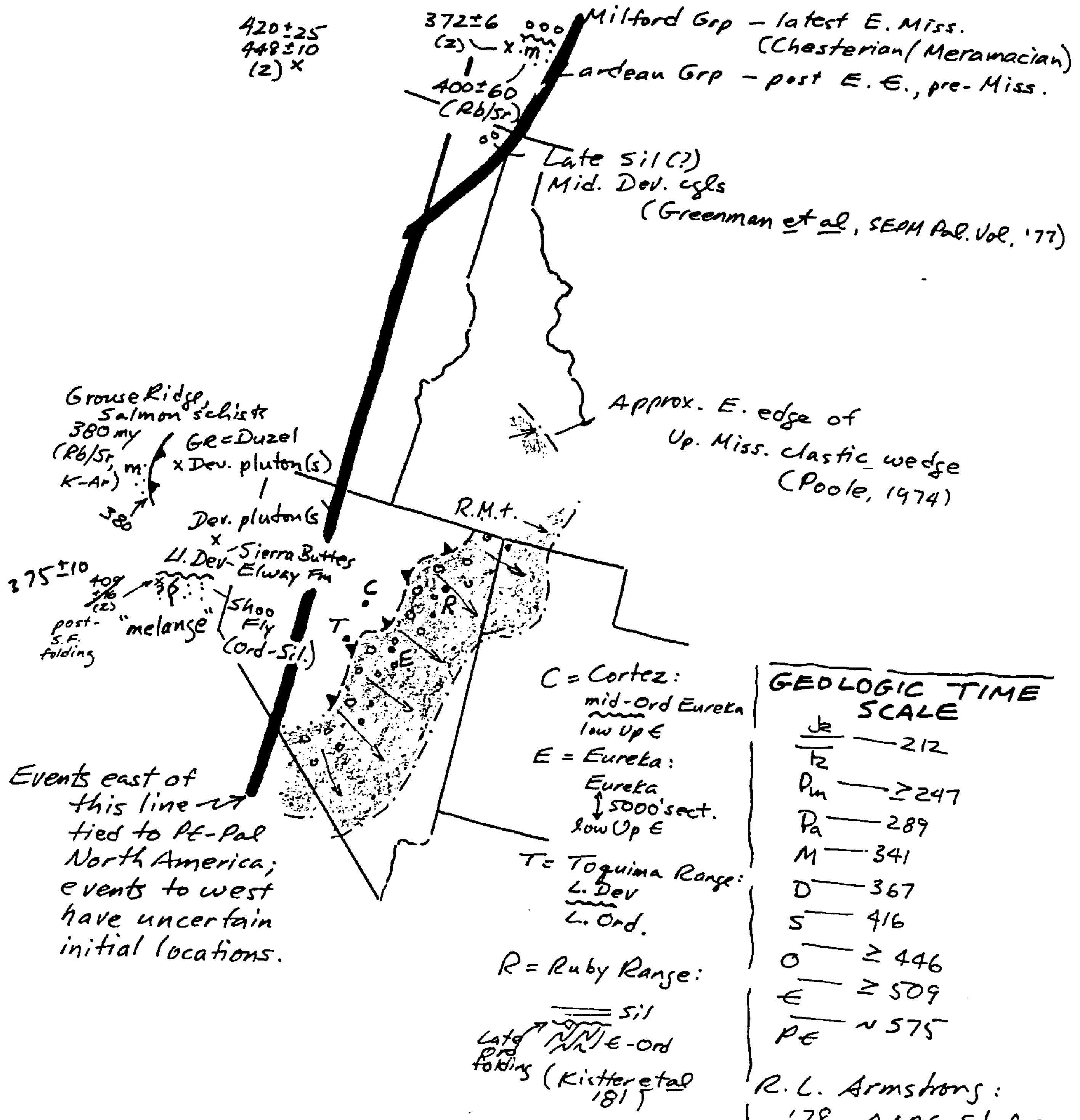
Silberling, N. J., Jones, D. L., Black, M. C., Jr., and Howell, D. G., 1987, Lithotectonic terrane map of the western conterminous United States: USGS Misc. Field Studies Map MF-1874-C, 1:2,500,000.

m = metamorphism
~~ = unconformity
▲ = thrust fault

28 JAN 84

INDICATORS OF EARLY PALEOZOIC THROUGH MID-PALEOZOIC DEFORMATION, UPLIFT, METAMORPHISM, AND PLUTONIC ACTIVITY

538 Spring, 8



GEOLOGIC TIME SCALE

Jr / Tr	212
Pm	≥ 247
Pa	289
M	341
D	367
S	416
O	≥ 446
Є	≥ 509
PЄ	~ 575

R.L. Armstrong: '78 AAPG Studies in Geology #6

Renne, P. R., and Turrin, B. D., 1987, Constraints on timing of deformation in the Benton Range, southeastern California, and implications to Nevadan orogenesis: Geology, v. 115, p. 1031-1034.

Nelson, K. D., Zhu, T. F., Gibbs, A., Harris, R., Oliver, J. E., Kaufman, S., Brown, L., and Schweickert, R. A., 1986, COCORP deep seismic reflection profiling in the northern Sierra Nevada, California: Tectonics, v. 5, p. 321-334.

Tectonics of the California Coast Ranges (an extremely condensed selection)

✓ **Ernst, W. G.**, 1970, Tectonic contact between the Franciscan melange and the Great Valley sequence -- crustal expression of a Late Mesozoic Benioff zone: JGR, v. 75, p. 886-902.

✓ **Jones, D. L., Blake, M. C., Jr., and Rangin, Claude**, 1976, The four Jurassic belts of northern California and their significance to the geology of the Southern California Borderland, p. 343-362 in Aspects of the geologic history of the California continental borderland (Howell, D. G., Ed.): Pacif. Sect. AAPG, Misc. Pub. 24, 651 p.

QE 89 C128
1975
R CHEN

✓ **Ingersoll, R. V.**, 1978, Paleogeography and paleotectonics of the late Mesozoic forearc basin of northern and central California, p. 471-482 in Mesozoic paleogeography of the western United States: Pacif. Sect., SEPM, Los Angeles, 573 p.

Ingersoll, R. V., and Dickinson, W. D., 1981, Great Valley Group (sequence), Sacramento Valley, California, p. 1-33 in Upper Mesozoic Franciscan rocks and Great Valley sequence, central Coast Ranges, California (Frizzell, V., Ed.): Annl. Mtng., Pacif. Sect. SEPM Field Trips 1 and 4.

Blake, M. C., Jr., and Jones, D. L., 1981, The Franciscan assemblage and related rocks in northern California: a reinterpretation, p. 307-28 in The geotectonic evolution of California (Ernst, W. G., Ed.): Prentice-Hall, Inc., 706p

Wentworth, C. M., Blake, M. C., Jr., Jones, D. L., Walter, A. W., and Zoback, M. D., 1984, Tectonic wedging associated with emplacement of the Franciscan assemblage, California Coast Ranges, p. 163-175 in Franciscan geology of northern California (Blake, M. C., Jr., Ed.): Pacif. Sect., SEPM, Los Angeles, 254 p.

QE 90 N8
F72 1984
R. Short

Cloos, Mark, 1985, Thermal evolution of convergent plate margins: thermal modeling and reevaluation of isotopic Ar-age for blueschists in the Franciscan complex of California: Tectonics, v. 4, p. 421-434.

Platt, J. P., 1986, Dynamics of orogenic wedges and the uplift of high-pressure metamorphic rocks: GSA Bull., v. 97, p. 1037-1053,

✓ **Jayko, A. S., Black, M. C., Jr., and Harms, Tekla**, 1987, Attenuation of the Coast Range ophiolite by extensional faulting, and nature of the Coast Range "thrust", California: Tectonics, v. 6, p. 4756- 88.

Jurassic extensional tectonics in the Sierra Nevada and western Great Basin

Busby-Spera, C. J., 1984, The lower Mesozoic continental margin and marine intra-arc sedimentation at Mineral King, California, p. 135-156 in Tectonics and sedimentation along the California margin (Crouch, J. K., and Bachman, S. B., Eds.): Pacif. Sect. SEPM, v. 38.

Tobisch, O. T., Saleeby, J. B., and Fiske, R. S., 1986, Structural history of continental volcanic arc rocks, eastern Sierra Nevada, California: a case for extensional tectonics: Tectonics, v. 5, p. 65-94.

160 - 130 Ma.
DESCRIBE SEQUENCES
IN ROOF PENDANTS
- MAJOR RETENTION IN STRATIGRAPHIC
SEQUENCE

Oldow, J. S., and Bartel, R. L., 1987, Early to Middle (?) Jurassic extensional tectonism in the western Great Basin: growth faulting and synorogenic deposition of the Dunlap Formation: Geology, v. 15, p. 740-743.

Middle or Late Jurassic to Early Cretaceous thrust faulting, w. Great Basin

Speed, R. C., 1978, Paleogeographic and plate tectonic evolution of the early Mesozoic marine province of the western Great Basin: Mesozoic paleogeography volume, Pacif. Sect. SEPM, p. 253-270.

✓ **Oldow, J. S.**, 1983, Tectonic implications of a late Mesozoic fold and thrust belt in northwestern Nevada: Geology, v. 11, p. 542-546.

Oldow, J. S., 1984, Evolution of a late Mesozoic back-arc fold and thrust belt, northwestern Great Basin, U.S.A.: Tectonophysics, v. 102, p. 245-274.

Oldow, J. S., Ave´ Lallemant, and Schmidt, W. J., 1984, Kinematics of plate convergence deduced from Mesozoic structures in the western Cordillera: Tectonics, v. 3, p. 201-227.

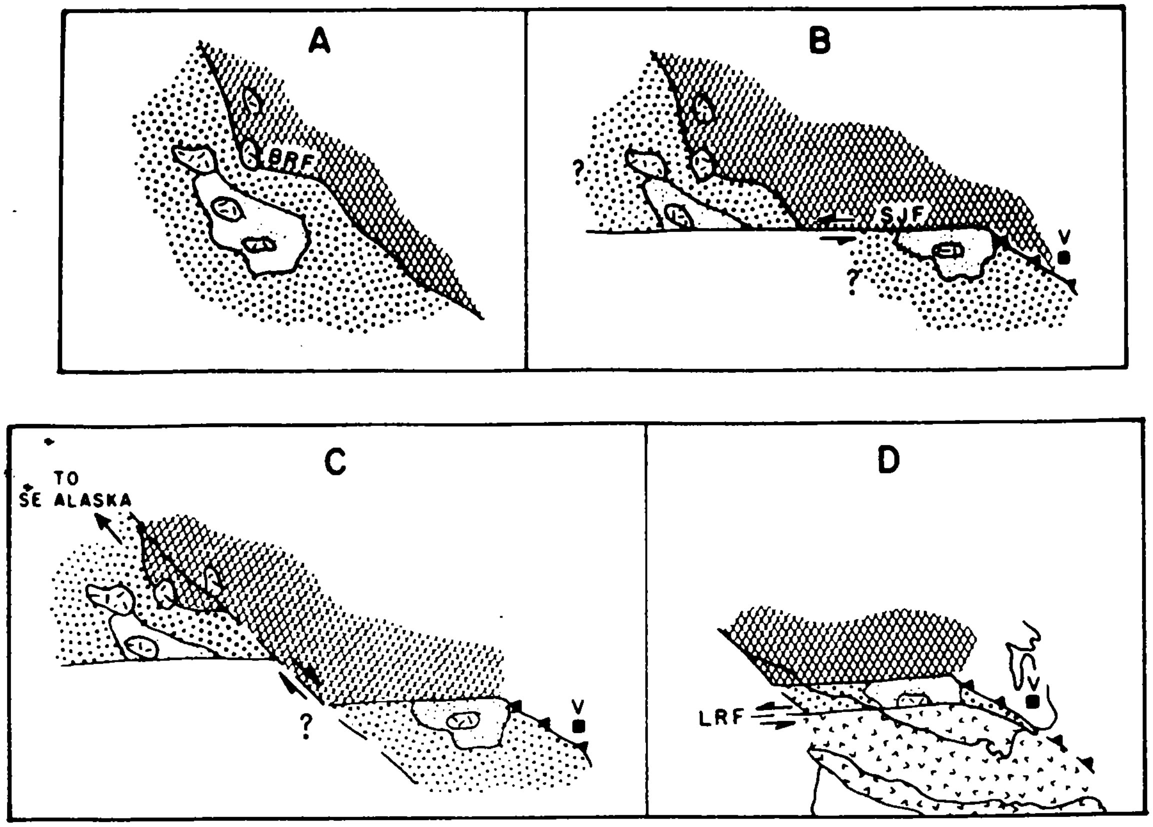


Figure 4. Diagrammatic maps showing possible early Tertiary geography and hypothesized tectonic evolution of area around what is now Juan de Fuca Strait (see Fig. 2). Most patterns are same as in Figures 2 and 3, except that short dashes represent lower Tertiary intrusive rocks. V indicates bedrock underlying Victoria, British Columbia, for reference. A: About 42 to 45 m.y. ago. Light stipple depicts synkinematically metamorphosed Jurassic-Cretaceous (?) rocks, associated with Eocene intrusive bodies, that are now exposed as Leech River complex and schistose rocks on southern Baranof Island; BRF = Border Ranges fault. B: After end of metamorphism and penetrative deformation at about 39 to 41 m.y. ago, Leech River complex and adjacent lower grade equivalents were emplaced against southern edge of Wrangellia by left-lateral slip along San Juan fault (SJF). Fault is overlain by upper Eocene–lower Oligocene Carmanah Formation. C: Truncation of margin after about 40 m.y. ago along major northwest-trending transcurrent fault carried schistose rocks on southern Baranof Island toward their final resting place in Alexander Archipelago. This allochthonous slice included what is now Chugach terrane in Figure 3 and perhaps small fragment of Wrangellia. D: Lower to middle Eocene basalts of Metchosin Volcanics and Crescent Formation were juxtaposed with Leech River complex, probably by left-lateral slip along Leech River fault (LRF) (Fairchild, 1979; Fairchild and Cowan, 1982). Emplacement postdated metamorphism of Leech River complex and predated deposition of upper Oligocene strata that unconformably overlie Leech River fault. Present-day shorelines of southern Vancouver Island and northern Olympic Peninsula are shown for reference. (FROM JOHNSON, 1984)

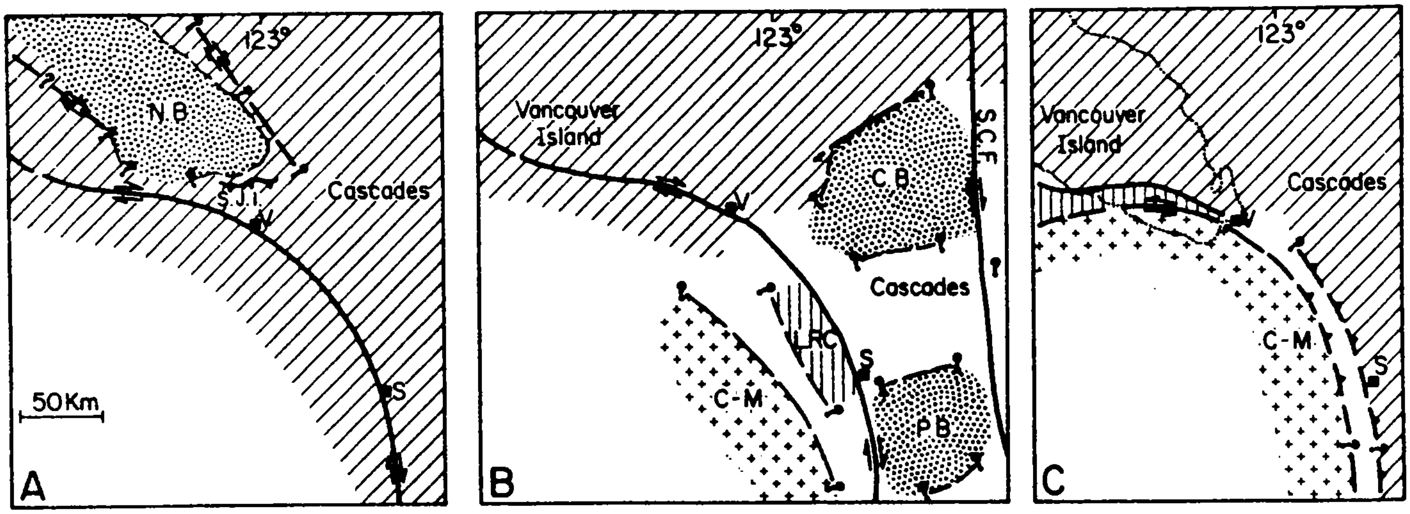


Figure 3. Schematic diagram showing postulated Late Cretaceous–early Tertiary paleogeography of western Washington and southern Vancouver Island. CB = Chuckanut Basin; C-M = Crescent-Metchosin formations; LRC = Leech River Complex; NB = Nanaimo Basin; PB = Puget Basin; S = Seattle; S.C.F. = Straight Creek fault; S.J.I. = San Juan Islands; V = Victoria. A: Late Cretaceous (Santonian-Campanian) strike-slip fault truncates pre-Tertiary basement and moves western terranes north. Splays off of main fault generate tensional setting in which Nanaimo Basin forms. Bend in fault may provide transpressive mechanism for thrusting in San Juan Islands. B: Middle Eocene. Chuckanut and Puget basins form in tensional zone between Straight Creek fault and postulated structure to west. Leech River Complex is metamorphosed in Puget Lowland and moves northwestward. Crescent-Metchosin seamount province has been accreted and is likewise moving north, outboard of the Leech River Complex. C: Latest Eocene–early Oligocene. Inferred transcurrent fault is no longer active. Margin is compressed by major left-lateral faulting on Leech River fault and thrusting in Puget Lowland (see MacLeod et al., 1977; Fairchild and Cowan, 1982; Cowan, 1982). This deformation greatly modifies original geometry of postulated fault. Dotted line shows present-day outline of Vancouver Island (FROM COWAN, 1982)

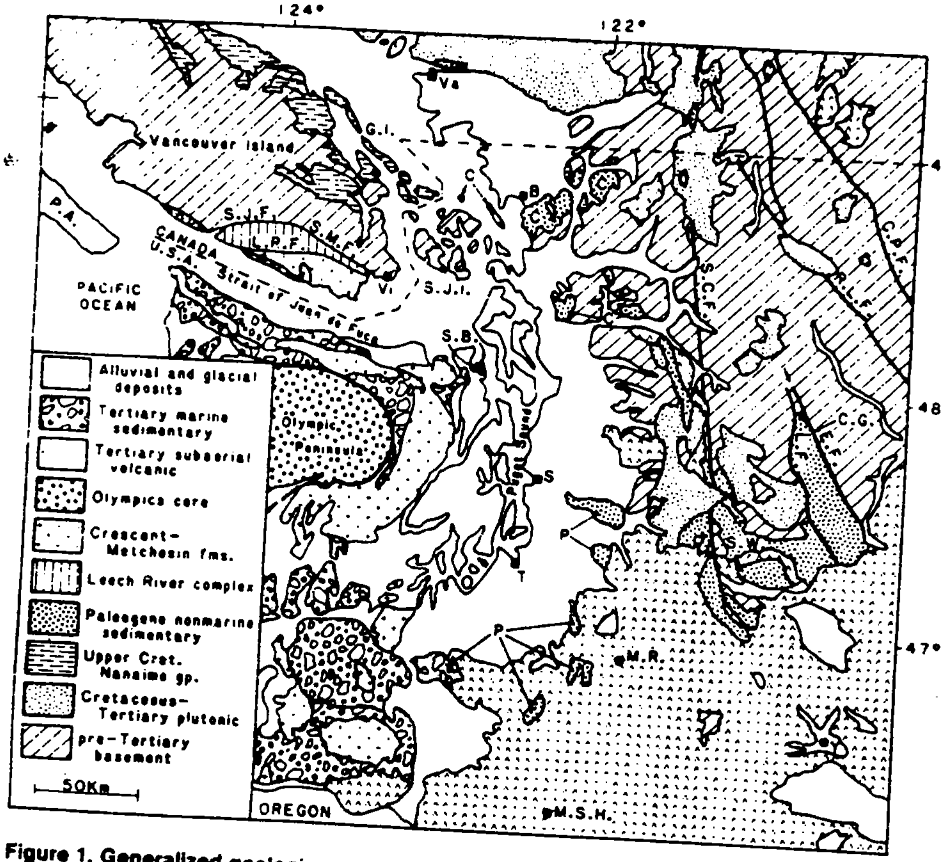


Figure 1. Generalized geologic map of northwest Washington and southwest British Columbia. B = Bellingham; C = Chuckanut Formation; C.P.F. = Chewack-Pasayten fault; C.G. = Chiwaukum graben; E.F. = Entiat fault; G.I. = Gulf Island; L.F. = Leavenworth fault; L.R.F. = Leech River fault; M.R. = Mount Rainier; M.S.H. = Mount Saint Helens; P = Puget Group; P.A. = Prometheus magnetic anomaly; R.L.F. = Ross Lake fault; S = Seattle; B = Scow Bay unit; S.C.F. = Straight Creek fault; S.J.F. = San Juan fault; S.J.I. = San Juan Islands; S.M.F. = Survey Mountain fault; S.W. = Swauk Formation; T = Tacoma; Vi = Victoria; Va = Vancouver; Y = Yakima.

(FROM JOHNSON, 1984)

Geol. 538, Tect. Evol. W. N. Am., Reading and reference list 9 for 3/17/1988:

THE CORDILLERAN FORELAND FOLD AND THRUST BELT, CANADA TO CALIFORNIA

BOLD = Assigned reading; *Italicized* = Review paper

Armstrong, F. C., and Oriel, S. S., 1965, Tectonic development of Idaho-Wyoming thrust belt: AAPG Bull., v. 49, p. 1847-1866.

Armstrong, R. L., 1968, Sevier orogenic belt in Nevada and Utah: GSA Bull., v. 79, p. 429-458. *[In my opinion, perhaps the finest single paper written on the southern half of the US segment of the foreland fold and thrust belt; introduced concept of Sevier vs. Laramide orogenies.]*

Burchfiel, B. C., and Davis, G. A., 1968, Two-sided nature of the Cordilleran orogen and its tectonic implications: Proc. 23rd Intern. Geol. Congress, Sec. 3, p. 175-184. *[The paper that only the Russians and their Warsaw Pact allies could stop!!]*

Bally, A. W., Gordy, P. L., and Stewart, G. A., 1966, Structure, seismic data, and orogenic evolution of southern Canadian Rocky Mountains: Bull. Can. Petroleum Geology, v. 14, p. 337-374. *[A classic paper! One of first papers ever to apply seismic reflection data to the interpretation of a foreland fold and thrust belt ... the death knell to the "gravity sliders".]*

Dahlstrom, C. D. A., 1970, Structural geology in the eastern margin of the Canadian Rocky Mountains: Bull. Can. Petroleum Geology, v. 18, p. 332-406. *[A classic paper in describing geometry and kinematics of low-angle thrusts; provided much inspiration to Boyer and Elliot, 1982.]*

Price, R. A., and Mountjoy, E. W., 1970, Geologic structure of the Canadian Rocky Mountains between Bow and Athabasca Rivers -- a progress report: Geol. Assoc. Canada Spec. Paper 6, p. 7-27. *[An eloquent, integrated description of the geometric and kinematic characteristics of a thrust belt, somewhat superceded by Price, 1981, see below. The concept of gravitationally-induced spreading to form thrust belts was introduced here, but the next paper (Campbell, 1973) presented valid geologic arguments against this tectonic model.]*

Campbell, R. B., 1973, Structural cross-section and tectonic model of the southeastern Canadian Cordillera: Can. J. Earth Sci., v. 10, p. 1607-1620.

Burchfiel, B. C., and Davis, G. A., 1975, Nature and controls of

KEITH

538 Reading list for 3/24, p. 2

Bird, Peter, in press, Formation of the Rocky Mountains, western United States: a continuum computer model: Science.

Rand, Pelona, and Orocopia Schists; Rand, Vincent, and Chocolate Mountain thrusts, southern California and southwestern Arizona

Ehlig, P. L., 1968, Causes of distribution of Pelona, Rand, and Orocopia Schists along the San Andreas and Garlock faults, in Conference on geologic problems of San Andreas fault system, proceedings (Dickinson, W. R., and Grantz, A., eds.): Stanford Univ. Publications, Geol. Sciences, v. 11, p. 294-306.

Haxel, Gordon, and Dillon, John, 1978, The Pelona-Orocopia Schist and Vincent-Chocolate Mountain thrust system, southern California: Pacif. Sect. SEPM, Mesozoic Paleogeography Volume, p. 453-469.

Burchfiel, B. C., and Davis, G. A., 1981, Mojave Desert and environs, in The geotectonic development of California (Ernst, W. G., ed.): Rubey Vol. I, Prentice-Hall, Inc., p. 217-252.

Jacobson, C. E., 1983, Structural geology of the Pelona Schist and Vincent thrust, San Gabriel Mountains, California: GSA Bull., v. 94, p. 753-767.

Late Cretaceous-Early Tertiary compressional deformation, SE CA & S ARIZ

Haxel, G. B., Tosdal, R. M., May, D. J., and Wright, J. E., 1984, Latest Cretaceous and early Tertiary orogenesis in south-central Arizona: thrust faulting, regional metamorphism, and granitic plutonism: GSA Bull., v. 95, p. 631-653.

Reynolds, S. J., Spencer, S. E., Richard, S. M., and Laubach, S. E., 1986, Mesozoic structures in west-central Arizona, in Frontiers in geology and ore deposits of Arizona and the Southwest (Beatty, Barbara, and Wilkinson, P. A. K., eds.): Ariz. Geol. Soc. Digest, v. 16, p. 35-51.

Bykerk-Kauffman, Ann, and Janecke, S. U., 1987, Late Cretaceous to early Tertiary ductile deformation: Catalina-Rincon metamorphic core complex, southeastern Arizona: Geology, v. 15, p. 462-465.

Drewes, Harald, 1981, Tectonics of southestern Arizona: USGS PP 1144, 96 p.

KEITH

Geol. 538, Tect. Evol. W. N. Am., Reading and Reference List II for 3/24/88

LATEST CRETACEOUS-EARLY TERTIARY COMPRESSIONAL TECTONICS: LARAMIDE ROCKY MOUNTAINS; VINCENT-OROCOPIA THRUST; SW, S ARIZONA

BOLD = Assigned reading; Italicized = Review paper

Style and origin of Laramide compressional structures, Rocky Mountains

Berg, R. R., 1962, Mountain flank thrusting in Rocky Mountain foreland, Wyoming and Colorado: Bull. AAPG, v. 46, p. 2019-2032.

Sales, J. K., 1968, Crustal mechanics of Cordilleran foreland deformation: a regional and scale-model approach: Bull. AAPG., v. 52, p. 2016-2044.

Lowell, J. D., 1974, Plate tectonics and foreland basin deformation: Geology, v. 2, p. 275-278.

Armstrong, R. L., 1974, Magmatism, orogenic timing, and orogenic diachronism in the Cordillera from Mexico to Canada: Nature, v. 247, p. 348-351.

Burchfiel, B. C., and Davis, G. A., 1975, Nature and controls of Cordilleran orogenesis, western United States: extensions of an earlier synthesis: AJS, v. 275-A, p. 363-396.

Dickinson, W. R., and Snyder, W. S., 1978, Plate tectonics of the Laramide orogeny: GSA Mem. 151, p. 355-366.

Stearns, D. W., 1978, Faulting and forced folding in the Rocky Mountains foreland: GSA Mem. 151, p. 1-37.

Davis, G. H., 1978, Monocline fold pattern of the Colorado Plateau: GSA Mem. 151, p. 215-233.

Smithson, S. B., and others, 1978, Nature of the Wind River thrust, Wyoming, from COCORP deep-reflection data and from gravity data: Geology, v. 6, p. 648-652.

Cross, T. A., 1986, Tectonic controls of foreland basin subsidence and Laramide style deformation, western United States: Spec. Publs int. Ass. Sediment., v. 8, p. 15-19,

106
copies

Geol. 538, Tect. Evol. W. N. Am., Reading and Reference List II for 3/24/88

LATEST CRETACEOUS-EARLY TERTIARY COMPRESSIONAL TECTONICS: LARAMIDE ROCKY MOUNTAINS; VINCENT-OROCOPIA THRUST; SW, S ARIZONA

BOLD = Assigned reading; Italicized = Review paper

Style and origin of Laramide compressional structures, Rocky Mountains

= Bow Berg, R. R., 1962, Mountain flank thrusting in Rocky Mountain foreland, Wyoming and Colorado: Bull. AAPG, v. 46, p. 2019-2032.

Sales, J. K., 1968, Crustal mechanics of Cordilleran foreland deformation: a regional and scale-model approach: Bull. AAPG., v. 52, p. 2016-2044.

Lowell, J. D., 1974, Plate tectonics and foreland basin deformation: Geology, v. 2, p. 275-278.

Armstrong, R. L., 1974, Magmatism, orogenic timing, and orogenic diachronism in the Cordillera from Mexico to Canada: Nature, v. 247, p. 348-351.

Burchfiel, B. C., and Davis, G. A., 1975, Nature and controls of Cordilleran orogenesis, western United States: extensions of an earlier synthesis: AJS, v. 275-A, p. 363-396.

Dickinson, W. R., and Snyder, W. S., 1978, Plate tectonics of the Laramide orogeny: GSA Mem. 151, p. 355-366.

Stearns, D. W., 1978, Faulting and forced folding in the Rocky Mountains foreland: GSA Mem. 151, p. 1-37.

Davis, G. H., 1978, Monocline fold pattern of the Colorado Plateau: GSA Mem. 151, p. 215-233.

Smithson, S. B., and others, 1978, Nature of the Wind River thrust, Wyoming, from COCORP deep-reflection data and from gravity data: Geology, v. 6, p. 648-652.

Cross, T. A., 1986, Tectonic controls of foreland basin subsidence and Laramide style deformation, western United States: Spec. Publs int. Ass. Sediment., v. 8, p. 15-19,

Bird, Peter, in press, Formation of the Rocky Mountains, western United States: a continuum computer model: Science.

Rand, Pelona, and Orocopia Schists; Rand, Vincent, and Chocolate Mountain thrusts, southern California and southwestern Arizona

Ehlig, P. L., 1968, Causes of distribution of Pelona, Rand, and Orocopia Schists along the San Andreas and Garlock faults, in Conference on geologic problems of San Andreas fault system, proceedings (Dickinson, W. R., and Grantz, A., eds.): Stanford Univ. Publications, Geol. Sciences, v. 11, p. 294-306.

Haxel, Gordon, and Dillon, John, 1978, The Pelona-Orocopia Schist and Vincent-Chocolate Mountain thrust system, southern California: Pacif. Sect. SEPM, Mesozoic Paleogeography Volume, p. 453-469.

Burchfiel, B. C., and Davis, G. A., 1981, Mojave Desert and environs, in The geotectonic development of California (Ernst, W. G., ed.): Rubey Vol. I, Prentice-Hall, Inc., p. 217-252.

Jacobson, C. E., 1983, Structural geology of the Pelona Schist and Vincent thrust, San Gabriel Mountains, California: GSA Bull., v. 94, p. 753-767.

Late Cretaceous-Early Tertiary compressional deformation, SE CA & S ARIZ

Haxel, G. B., Tosdal, R. M., May, D. J., and Wright, J. E., 1984, Latest Cretaceous and early Tertiary orogenesis in south-central Arizona: thrust faulting, regional metamorphism, and granitic plutonism: GSA Bull., v. 95, p. 631-653.

Reynolds, S. J., Spencer, S. E., Richard, S. M., and Laubach, S. E., 1986, Mesozoic structures in west-central Arizona, in Frontiers in geology and ore deposits of Arizona and the Southwest (Beatty, Barbara, and Wilkinson, P. A. K., eds.): Ariz. Geol. Soc. Digest, v. 16, p. 35-51.

Bykerk-Kauffman, Ann, and Janecke, S. U., 1987, Late Cretaceous to early Tertiary ductile deformation: Catalina-Rincon metamorphic core complex, southeastern Arizona: Geology, v. 15, p. 462-465.

Drewes, Harald, 1981, Tectonics of southestern Arizona: USGS PP 1144, 96 p.

21 JAN 88

Geol. 538, Tect. Evol. W. N. Am., Reading list 2 for 1/28/1988:

THE PALEOZOIC OROGENIES: PRE-ANTLER (N. SIERRAN NEVADA), ANTLER, ANCESTRAL ROCKIES, SONOMA

Paleozoic stratigraphy of the miogeocline, the Antler clastic wedge, and post-Antler deposits

(**Bold** = read; *review papers*)

Stewart, J. H., and Poole, F. G., 1974, Lower Paleozoic and uppermost Precambrian Cordilleran miogeocline, Great Basin, western United States: SEPM Spec. Pub. 22, p. 28-57 **(read only from p. 42, "Ord. System", on). Somewhat tedious reading, so do so quickly.**

Wrucke, C. T., Churkin, Michael, Jr., and Heroupolon, Chris, 1978, Deep-sea origin of Ordovician pillow basalt and associated sedimentary rocks, northern Nevada: GSA Bull., v. 89, p. 1272-1280.

Miller, E. L., and Larue, D. K., 1983, Ordovician quartzite in the Roberts Mountains allochthon, Nevada: deep sea fan deposits derived from cratonal North America, p. 91-102 <u>in</u> Pre-Jurassic rocks in western North American suspect terranes (Stevens, C. H., Ed.): Pac. Sect. SEPM, Los Angeles, 141 p.

✓ **Poole, G. G.**, 1974, Flysch deposits of Antler foreland basin, western United States: SEPM Spec. Pub. 22, p. 58-82. **Read rather quickly.**

Poole, G. G., and Sandberg, C. A., 1977, Mississippian paleogeography and tectonics of the western U. S.: Pac. Sect. SEPM, Paleoz. Paleogeog., 67-85.

Bissell, H. J., 1974, Tectonic control of late Paleozoic and early Mesozoic sedimentation near the hinge line of the Cordilleran miogeosynclinal belt, SEPM Spec. Pub. 22, p. 83-97.

Paleozoic stratigraphy and pre-Antler orogeny in the northern Sierra Nevada-eastern Klamath Mountains: North American affinities?

✓ **Burchfiel, B. C., and Davis, G. A.**, 1972, Structural framework and evolution of the southern part of the Cordilleran orogen, western United States: AJS, v. 272, p. 97-118. **Read p. 98-103.**

Burchfiel, B. C., and Davis, G. A., 1975, Nature and controls of

21 JAN 88

Cordilleran orogenesis, western United States: extensions of an earlier synthesis: AJS, v. 275-A, p. 363-396. **Read p. 364-373 (top).**

D'Allura, J. A., Moores, E. M., and Robinson, L., 1977, Paleozoic rocks of the northern Sierra Nevada: their structural and paleogeographic implications: Pac. Sect. SEPM, Paleozoic paleogeography vol., p.395-408.

Bond, G. C., and Devay, J. C., 1980, Pre-Upper Devonian quartzose sandstones in Shoo Fly Formation, northern California -- petrology, provenance and implications for regional tectonics: Jour. Geol. v. 88, p. 285-308.

Varga, R. J., and Moores, E. M., 1981, Age, origin, and significance of an unconformity that predates island-arc volcanism in the northern Sierra Nevada: Geology, v. 9, p. 512-518. Note: collectively review this and next two papers.

Girty, G. H., Wardlaw, M. S., Schweickert, R. A., Hanson, R. E., and Bowring, S. A., 1984, Timing of pre-Antler deformation in the Shoo Fly Complex, Sierra Nevada, California: Geology, v. 12, p. 673-676.

Saleeby, Jason, Hannah, J. L., and Varga, R. J., 1987, Isotopic age constraints on middle Paleozoic deformation in the northern Sierra Nevada, California: Geology, v. 15, p. 757-760.

Hannah, J. L., and Moores, E. M., 1986, Age relationships and depositional environments of Paleozoic strata, northern Sierra Nevada, California: GSA Bull., v. 97, p. 787-797.

Miller, M. M., and Wright, J. E., 1987, Paleogeographic implications of Permian Tethyan corals from the Klamath Mountains, California: Geology, v. 15, p. 266-269.

The Devono-Mississippian Antler orogeny and the Roberts Mtns. allochthon

Burchfiel, B. C., and Davis, G. A., 1972, 1975, same pages as above.

Silberling, N. J., 1973, Geologic events during Permian-Triassic time along the Pacific margin of the United States, p. 345-362 in The Permian and Triassic Systems and their mutual boundary: Alberta Soc. Petroleum Geol.

Dickinson, W. R., 1977, Paleozoic plate tectonics and the evolution of the Cordilleran continental margin: Pac. Sect. SEPM, Paleozoic paleogeography vol., p. 137-155.

Nilsen, T. H., and Stewart, 1980, Penrose Conference Report: The Antler orogeny - mid-Paleozoic tectonism in western North America: Geology, v. 8, p. 298-302.

Johnson, J. G., and Pendergast, Anne, 1981, Timing and mode of emplacement of the Roberts Mountains allochthon, Antler orogeny: GSA Bull., v. 92, p. 648-658.

Moore, J. C., Biju-Duval, Bernard, and 16 others, 1982, Offscraping and underthrusting of sediment at the deformation front of the Barbados Ridge: Deep Sea Drilling Project Leg 78A: GSA Bull., v. 93, p. 1065-1077.

Speed, R. C., and Larue, D. K., 1982, Barbados: architecture and implications for accretion: JGR, v. 87, p. 3633-3643.

✓ **Speed, R. C., and Sleep, N. H.,** 1982, Antler orogeny and foreland basin: a model: GSA Bull., v. 93, p. 815-828. **Critically evaluate ideas here.**

Dickinson, W. R., Harbaugh, D. W., Saller, A. H., Heller, P. L., and Snyder, W. S., 1983, Detrital modes of upper Paleozoic sandstones derived from Antler orogen in Nevada: implications for nature of Antler orogeny: AJS, v. 283, p. 481-509.

Oldow, J. S., 1984, Spatial variability in the structure of the Roberts Mountains allochthon, western Nevada: GSA Bull., v. 9a5, p. 174-185.

Schweickert, R. A., and Lahren, M. M., 1987, Continuation of Antler and Sonoma orogenic belts to the eastern Sierra Nevada, California, and Late Triassic thrusting in a compressional arc: Geology, 15, p. 270-273.

Gordey, S. P., Abbott, J. G., Tempelman-Kluit, H. Gabrielse, 1987, "Antler" clastics in the Canadian Cordillera: Geology, v. 15, p. 103-107.

Gehrels, G. E., and Smith, M. T., 1987, "Antler" allochthon in the Kootenay arc: Geology, v. 15, p. 769-770.

Permo-Triassic Sonoma orogeny and the Golconda allochthon

21 JAN 88

Stewart, J. H., MacMillan, J. R., Nichols, K. M., and Stevens, C. H., 1977, Deep-water upper Paleozoic rocks in north-central Nevada -- a study of the type area of the Havallah Formation: Pac. Sect., SEPM, Paleozoic paleogeography of the western U.S., p. 337-347.

Speed, R. C., 1979, Collided microplate in the western United States: Jour. Geol., v. 87, p. 279-292.

Miller, E. L., Kanter, L. R., Larue, D. K., Turner, R. J., Murchey, B., and Jones, D. L., 1982, Structural fabric of the Paleozoic Golconda allochthon, Antler Peak Quadrangle, Nevada: progressive deformation of an oceanic sedimentary assemblage: JGR, v. 87, p. 3795-3804.

Gabrielse, Hubert, Snyder, W. S., and Stewart, J. H., 1983, Penrose Conference Report: Sonoma orogeny and Permian to Triassic tectonism in western North America: Geology, v. 11, p. 484-486.

Miller, E. L., Holdsworth, B. K., Whiteford, W. B., and Rodgers, D., 1984, Stratigraphy and structure of the Schoonover sequence, northeastern Nevada: implications for Paleozoic plate-margin tectonics: GSA Bull., v. 95, p. 1063-1076.

Brueckner, H. K., and Snyder, W. S., 1985, Structure of the Havallah sequence, Golconda allochthon, Nevada: evidence for prolonged evolution in an accretionary prism: GSA Bull., v. 96, p. 1113-1130. **and Tomlinson, A. J., Miller, E. M., Holdsworth, B. K., and Whiteford, W. B.**, 1987, Discussion: GSA Bull., v. 98, p. 615-616; **Snyder, W. S., and Brueckner, H. K.**, Reply: p. 616-617.

Stewart, J. H., Murchey, B., Jones, D. L., and Wardlaw, B. R., 1986, Paleontologic evidence for complex tectonic interlayering of Mississippian to Permian deep-water rocks of the Golconda allochthon in Tobin Range, north-central Nevada: GSA Bull., v. 97, p. 1122-1132.

Babaie, H. A., 1987, Paleogeographic and tectonic implications of the Golconda allochthon, southern Toiyabe Range, Nevada: GSA Bull., v. 99, 231-43.

Ancestral Rocky Mountains (Pennsylvanian/Permian)

Kluth, C. F., and Coney, P. J., 1981, Plate tectonics of the Ancestral Rocky Mountains: Geology, v. 9, p. 10-15.

28 JAN 88

Geol. 538, Tect. Evol. W. N. Am., Reading list 3, for 2/4/1988:

LATE PALEOZOIC-EARLY MESOZOIC CONTINENTAL TRUNCATION IN THE SOUTHWESTERN UNITED STATES?

(**Bold** = assigned reading; *italicized* = student review)

Hamilton, Warren, and Myers, W. B., 1966, Cenozoic tectonics of the western United States: Rev. Geophysics, v. 4. p. 509-549.

Burchfiel, B. C., and Davis, G. A., 1972, The structural framework and evolution of the southern part of the Cordilleran orogen, western United States: AJS, v. 272, p. 97-118.

Burchfiel, B. C., and Davis, G. A., 1981, Triassic and Jurassic tectonic evolution of the Klamath Mountains-Sierra Nevada geologic terrane, p. 50-70 in Ernst, W. G., ed., The geotectonic development of California (Rubey Volume I): Prentice Hall, Inc., Englewood Cliffs, New Jersey. **Read only p. 50-57** (*to* L. Tr. and E. Jr. History)

Dickinson, W. R., 1981, Plate tectonic evolution of the southern Cordillera, p. 113-135 in Dickinson, W. R., and Payne, W. D., eds., Relations of tectonics to ore deposits in the southern Cordillera: Ariz. Geol. Soc. Digest Vol. XIV, Tucson. **Read only p. 113-122** (*to* L Jr and Cret)

Miller, E. L., and Sutter, J. F., 1982, Structural geology and ^{40}Ar-^{39}Ar geochronology of the Goldstone-Lane Mountain area, Mojave Desert, California: GSA Bull., v. 93, p. 1191-1207. *Emphasize structural, stratigraphic, and regional relationships*

ACCRETIONARY TECTONICS I: FOUNDING CONCEPTS; AN OVERVIEW OF THE ACCRETIONARY HISTORY OF THE CANDADIAN CORDILLERA

Founding concepts

Hamilton, Warren, 1969, Mesozoic California and the underflow of the Pacific mantle: GSA Bull., v. 80, p. 2409-2430.

- Alaska

- most terranes were accreted in Paleocene (Wrangellia, Alex.) S. Alaska superterrane,
- Alex. terrane may have been attached to E. Australia in Paleozoic (Saleeby + Gehrel^{8}

Franciscan
- Laytonville blocks (L.S.) Alvarez et al.
  - paleomag says orig. 15° S lat.
  - thought B.S. at first, but later proven true
- 4 belts
- 1.) Eastern (E.J→L.K) 25°N ← OK based on Farallon plate reconstruct.
  2.) Central (LAYTONVILLE 101-88 Ma) 14° S ←
  3.) Coastal (73 Ma) 27°N ←
  4.) Permanente (105-90 Ma) 18-25°N
  5.) Sipes (113-91 Ma) 28° S ← need to start on Farallon & hop onto the Kula plate

Klamaths
- no rotation from E.K. onward
  - may be remagnetized, but considered good
  - ≈90° rotation J → E.K
    - ind. an E-W trench
    - most is remagnetized & overprinted
    - most likely not real

Wash.-Oregon -
- Coast Ranges (Eocene) 70°-80° rotation in Eoc.
  - hinge rotation
  - right-lat. transpression causing small-block roller ball differential rotation
  - 20-30° clockwise rotation over most of Ore. & Wash. (Cascades, Col. R. [illegible] in last 12 Ma
    - due to sliver rotation

[illegible]

- prior to 200 Ma, most polar wandering paths are plotted with redbeds (hematite rich)
- little data in Ɛ C → M.J. for polar wander paths

- S. Calif - mostly terranes accreted in Eocene
- Salinia K granites - allochthonous
  - 100-120 Ma Salinia & San Obispo were a composite terrane
- Peninsular range terrane is different from N. Amer. in K
  - 15° farther S. in K; 30° rotation since 50 Ma
- Salinia
  - 3500 - 4000 km of N motion compared to N. Amer.
  - accreted in Eocene
  - 85 - 60 Ma is major motion
    - also true in Alaska, Franciscan, etc.
    - assoc. with Kula plate
      - transpressive
      - transpressive again when Pacific plate hits
- Sierra Nevada - no rotation in N; very rotated in S (oroclinal bend) post 80
  - very dispersed data due to struct. problem
  - all plutons
  - few 100 km of N movement possibly
- most data ind. terranes were accreted in Eocene (≈ 45 Ma) in Calif.
- no rotations on Calif. coast since Miocene, except in W. Transverse ranges (15-8 Ma ≈ 90°)

- some rotation in Mojave ≈ 15° rotation above PINTO in W
  ≈ 40° " below PINTO in W

4) viscous random test
  - check against present insitu rx to see if present field is affecting rx

- no real evidence for rotated ~~pole~~ roller ball motion along the edge of the continent

F - (flattening) inclination of axial dipole at time (t)
$I_{AD}(t_1) - I_{site}(t_1)$

R - (Rotation) $D_{AD} - D_{SITE}$
$\Delta\lambda = \lambda_{AD} - \lambda_{SITE}$

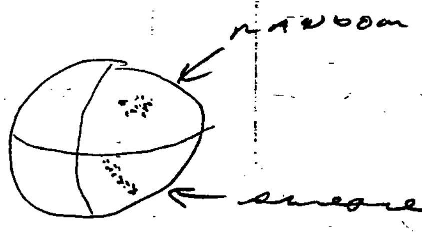
- definite change in motion of N. Amer in Jur. (J_1) late Jurassic (J_2) & in Paleocene
  - based on cusps in paleomag data

- euler poles allow you to get longitude

- Non axial dipole magnetic field of earth
  - slight descrepencies - different polar positions at different latitudes
  - these descrepancies are not constant, but change
  - 2°-4° of non dipole error in inclination

- pole positions for polar wander paths of North Amer. are really screwy & not very reliable ± 10° latitude

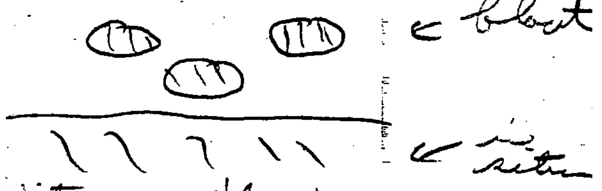
- minerals
  - magnetite / titanomagnetite - good
  - hematite + magnetic sulfides - worry
    - usually ind. a CRM
- need at least 12 sites to test
  - use stats to get an avg
    $\alpha 95 = 2\sigma$,
    $\alpha_{95} < 15°$ allright
    $> 15°$ problems
- smearing



- tests

1.) fold test
- as unfold
  remanence converges ind. pre-folding
  " diverges ind. contemporaneous with folding

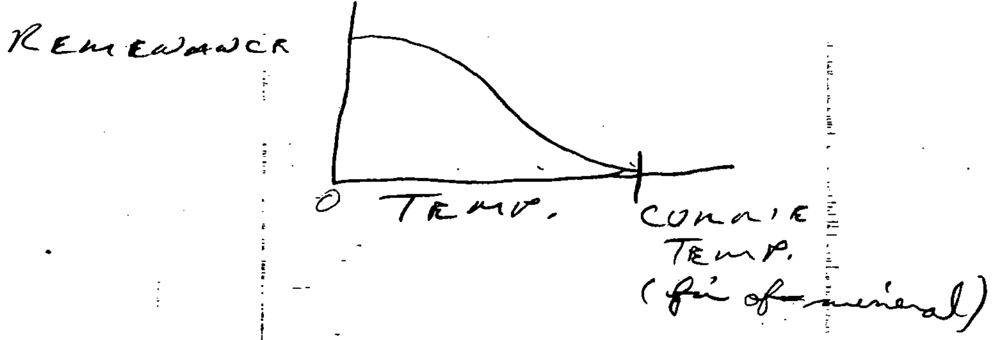
2.) conglomerate test



- test remanence in float,
  if random then in situ mat'l is good
  ±15° if not random, then rem. is post-dep

3.) reversal test
- test mixed polarity
  $2\tan\lambda = \tan I = -2\tan\lambda$

- 3 basics
1.) what carries mag. rem.
2.) when was it acquired
3.) can you effectively separate components
~~Ex~~.

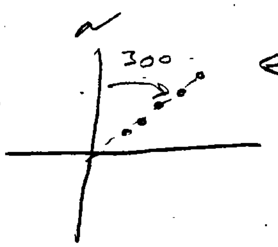


Ex. multiple intrusions
chem. alteration of sed. rx

- characteristics
low blocking temp. - worry (much overprint)
hi " " - good
highly sensitive (low coercivity) to alternating field - worry)
not " " " " - good

- characteristic remanence

1.) heat up
2.) cool down
3.) measure

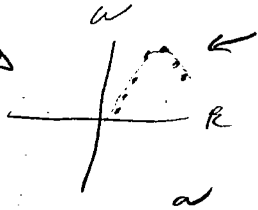


Demag. of fresh lava flow

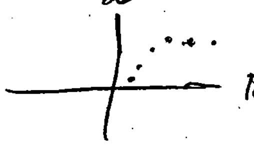
2 comps remanence

- difficult to separate components

ZUIGERVELD



demag of 2 comps. in flow can separate



2 comp. can't use

STEVE LUND (PALEOMAG)

3/10/88

- flakes - small plates
- Paleomag

- dipole - goes thru core & || to rotation axis
  - horiz comp. declination
  - vert. " inclination (I)
    - tan (I) = 2 tan λ (latitude)
      - essential eq., but isn't quite correct due to non-axial dipole components
      - usually ignored
- axial geocentric dipole field
  - if mag. dipole = earths rotation axis
  - not really true

- magnetic remanence
  1.) TRM - thermal remnant magnetization
    - due to cooling magma

best

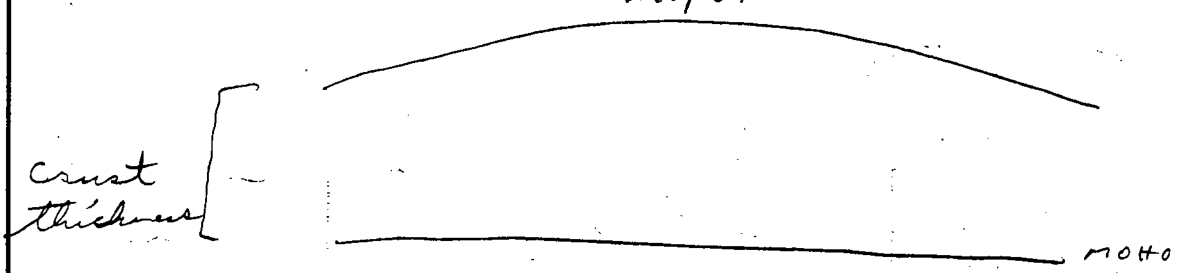
  2.) DRM - depositional remnant magnetization
    - in sediments
    - magnetized grains will statistically allign with magnetic field while being deposited
    - need quiet water

OK

  3.) PDRM - post-depositional RM
  4.) CRM - chemical rem. mag.
    - as crystals grows (hematite) it acquires a magnetic field
    - frequently post-depositional in seds.
    - always post-dep in magma

worry

B + K



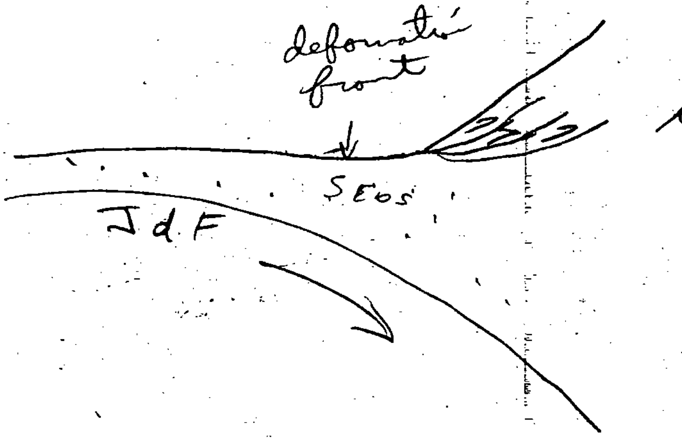
- doming coincides with core complexes

4/21/88

* Field Trip
- Day I - Clark Mtns.
Day 2 - " " + Death Valley
Day 3 - Death Valley + Titus Canyon (Grapevine
- leaving USC at 8:45 AM

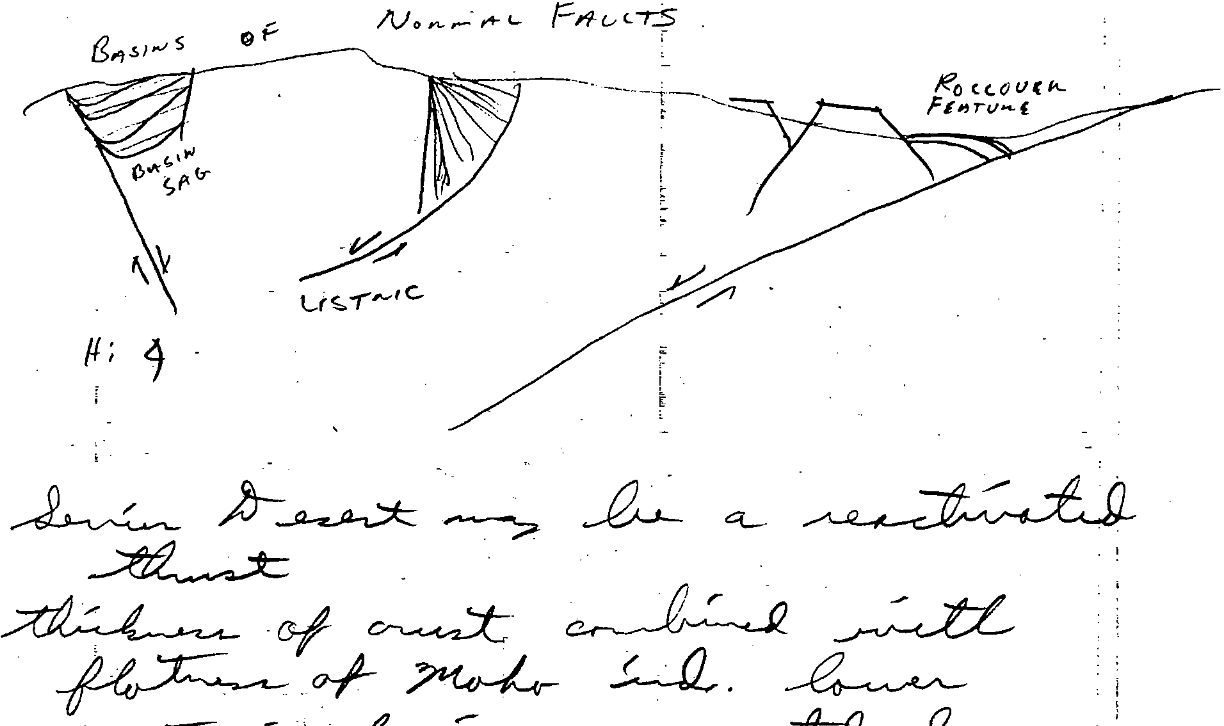
* Final 7-9 PM
- general questions
  - 2 essays
  - map questions

* Neotectonics of W. N. Amer.
- Juan de Fuca Plate
- much internal deformation in N + S
  near subd. zone (buckling, etc.)
- doesn't act as a strong coherent plate



- deformation front - deformation due
  to dewatering
  - occurs a few km in front
    of trench
- trench is covered by one of the
  deepest sed. seq. of the world

- heat flow ind. brittle/ductile transition based on qtz is ≈ 8 km & not 15 km as most ~~fault~~ Earthquakes propogate downward
  - dep. on strain rate
- get deeper earthquakes in few places
- seismic evidence sometimes shows anisotropies, which may be mylonite zones
- moho beneath B&R is not offset by faulting
  - remarkably flat
- subhorizontal reflections at base may be
  1.) mylonitic fabrics
  2.) igneous sills



- Sevier Desert may be a reactivated thrust
- thickness of crust combined with flatness of Moho ind. lower crust is being compensated by magmatic injection during extension

Basin & Range
- Province is domed in center around NEV/UT. border
  - higher than Columbia Plat.
- not a high degree of symmetry as previously ~~thought~~
- ~~thick~~ crustal layer (brittle)
- ranges bend toward Walker Lane
  - may mark real Edge of Sierra Nev. block
- Death Valley is due to oblique pull-apart
- Mojave shouldn't be part of B+R
- most dips are ≈ 60°
- hi ∠ faults may become listric at depth due to ductile regime as in Eaton (19) paper
- transition between det. faulting & high ∠ B+R. faulting is coincident with calc-alk → bimodal volc. transition

  ↗ subd.-related ↖ not subd. related
- extension in G. Basin was related to initiation of San Andreas (Atwater, 1971)
  - would expect oblique slip on B+R faults
    - found in W, but not E
    - time relationships are wrong
      B+R. faulting started long before pass of Mendocino fracture zone
      ∴ may have superposed deformation, but did not initiate extension
- earthquakes on normal faults in normal faults go to 12-15 km & don't appear to flatten with depth (sometimes do)

- core complex fm.

Eoc. BC/Wash
Olig. Ut/NV.
Mio S. Nv/SE cal/S. Az.

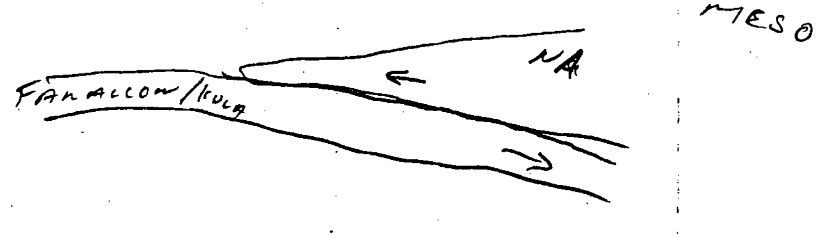
are discordant with fault

core complex theories

1.) crust is thickened in Meso. + later relaxes in mid Tert.

- may be triggered by magmatism which provides heat for ductility & spreads due to gravitational instability

2.) due to steepening of subd. slab + asthenosphere flow in the gap

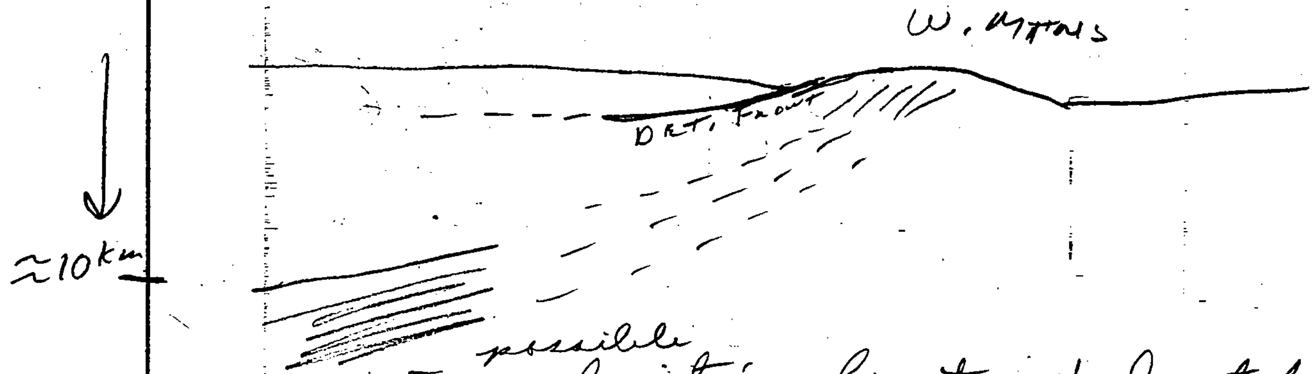


may break & asthenosphere flows in or rolls back

- no low-dipping slab in Canada for Shuswap terrane

4/14/88

- Basin & Range
  - 26 cm/1000 yrs uplift (up to 36 cm/1000 yrs,
    - tilted fault block in NE Calif B&R province (Warner Range)
- MID-TERT. uplift in Whipples (lower plate)



↖ possible mylonitic front at depth as shown on CALCRUST seismic line

- mylonites started at ≈$16^{\pm 4}$ km depths
- uplift in ≈.3→1.3 MM/YR 16 km → 0 km
  .27 mm/yr at 40 km → 16 km

mylonization @ 26 Ma @ 540°C + 7kb
mylonites stopped rising @ 16 Ma
most transport is 20-18 or 16 Ma

- get uplift of 3 mm/yr (10 x Warner Range
  + may get as high as 6 mm/yr
- slip on fault is as high as 1.4 cm/yr
- very fast uplift, much faster than B+R uplift rates
- mylonites predate det. fault + det. fault later forms in often mylonites

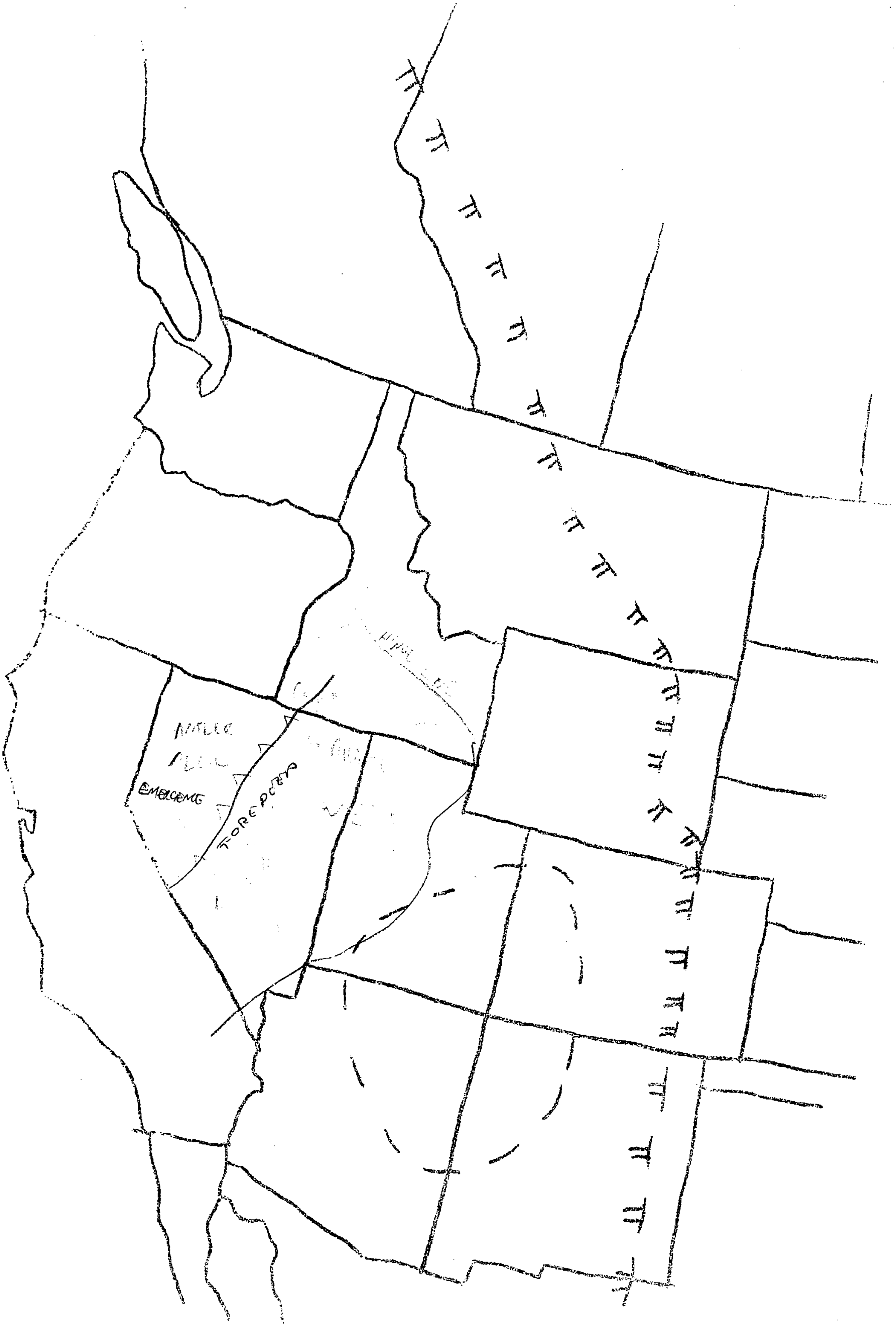

EMERGENT
FOREDEEP

PLATE TECTONICS: REFERENCES ON THE PALEOMAGNETIC EVIDENCE FOR MESOZOIC AND CENOZOIC PLATE TECTONIC MOTIONS OF CENTRAL AND NORTH AMERICAN SUSPECT TERRANES AND RELATED AREAS.

BOLD papers are required reading.
ITALICIZED papers are potential review papers.

REVIEW PAPERS***

Beck, M.E., Jr., 1976. Discordant paleomagnetic pole positions as evidence of regional shear in the western Cordillera of North America, Amer. Jour. Sci., v.276, p.694-712.

Beck, M.E., Jr., 1980. Paleomagnetic record of plate-margin tectonic processes along the western edge of North America, J. Geophys. Res., v.85, p.7115-7131.

Hillhouse, J.W., and M.O. McWilliams, 1987. Application of paleomagnetism to accretionary tectonics and structural geology, Rev. Geophys., v.25, p.951-959.

Kent, D.V., and S.R. May, 1987. Polar wander and paleomagnetic reference pole controversies, Rev. Geophys., v. 25, p.961,970.

McWilliams, M.O., 1983. Paleomagnetism and the motion of large and small plates, Rev. Geophysics and Space Phys., v.21, p.644-651.

PACIFIC/NORTH AMERICAN PLATE CONFIGURATIONS AND APWPs ***

Debiche, M.G., A. Cox, and D. Engebretson, 1987. The motion of allochthonous terranes across the north Pacific basin, Geol. Soc. Amer. Special Paper 207.

Engebretson, D., A. Cox, and R.G. Gordon, 1987. Relative motions between oceanic and continental plates in the Pacific Basin, Geol. Soc. Amer. Special Paper 206.

Engebretson, D. C., 1983. Relative motions between oceanic and continental plates in the Pacific basin, unpublished Phd. dissertation, Stanford University, Palo Alto, California.

Gordon, R.G., A. Cox, and S. O'Hara, 1984. Paleomagnetic Euler

poles and the apparent polar wander and absolute motion of North America since the Carboniferous, *Tectonics*, v. 3, p.499-537.

Irving, E., 1979. Paleopoles and paleolatitudes of North America and speculations about displaced terranes, *Canad. J. Earth Sci.*, v.16, 669-694.

Irving, E., and G. A. Irving, 1982. Apparent polar wander paths, Carboniferous through Cenozoic and the assembly of Gondwana, *Geophys. Surveys*, v. 5, p. 141-188.

Smith, A.G., and J.C. Briden, 1977. *Mesozoic and Cenozoic Paleocontinental Maps*, Cambridge University Press, London.

STABLE CRATON NORTH AMERICA (other data) ***************

Barnes, A.E., and R.F. Butler, 1980. A Paleocene paleomagnetic pole from the Gringo Gulch Volcanics, *Geophys. Res. Lett.*, v.7, p.545-548.

Burke, D.B., J.W. Hillhouse, E.H. McKee, S.T. Miller, and J.L. Morton, 1982. Cenozoic rocks in the Barstow basin area of southern California - Stratigraphic relations, radiometric ages, and paleomagnetism, *U.S. Geological Survey Bulletin 1529-E*, 14 pp.

Calderone, G., and R.F. Butler, 1984. Paleomagnetism of Miocene volcanic rocks from southwestern Arizona: tectonic implications, *Geology*, v.12, p.627-630.

Carter, J., R.R. Terres, and B.P. Luyendyk, 1983. Paleomagnetic study of the Eagle and Pinto Mountains, Eastern Transverse Ranges, California, *Trans Amer. Geophys. Union EOS*, v.64, p.686.

Golombek, M.P., and L.L. Brown, 1988. Clockwise rotation of the western Mohave desert, *Geology*, v. 16, p.126-130.

Kluth, C.F., R.F. Butler, L.E. Harding, M. Shafiqullah, and P. Damon, 1982. Paleomagnetism of late Jurassic rocks in the northern Canelo Hills, southeastern Arizona, *J. Geophys. Res.*, v.87, p.7079-7086.

Kono M., K. Kobayashi, M. Ozima, H. Kinoshita, T. Nagata, E. Larson, and D. Strangway, 1967. Paleomagnetism of Pliocene basalts from the southwestern U.S.A., *J . Geomag. Geoelect.*, v.19, p.357.

Russell, B.J., M.E. Beck, Jr., R.F. Burmester, and R.C. Speed, 1982. Cretaceous magnetizations in northwestern Nevada and tectonic implications, Geology, v.10, p.423-428.

Vugteveen, R.W., A.E. Barnes, and R.F. Butler, 1981. Paleomagnetism of the Roskruge and Gring Gultch Volcanics, southeastern Arizona, J. Geophys. Res., v.86, p.4021-4028.

MEXICO/CENTRAL AMERICA (other data) ********************

Bohnel, H., 1985. Paleomagnetische untersuchungen an Jurassischen bis Quartaren gesteinen aus zentral und sudMexiko, unpublished Phd. dissertation, Westfalischen Wilhelms-Universitat Munster.

Gose, W., 1983. Late Cretaceous - early tertiary tectonic history of southern Central America, J. Geophys. Res., v.88, p.10,585-10,592.

Gose, W.A., R.C. Belcher, and G.R. Scott, 1982. Paleomagnetic results from northeastern Mexico: evidence for large Mesozoic rotations, Geology, v.10, p.50-54.

Gose, W.A., and D.K. Swartz, 1977. Paleomagnetic results from Cretaceous sediments in Honduras: tectonic implications, Geology, v.5, p.505-508.

Mooser, F., A.E.M. Nairn, and J.F.W. Negendank, 1974. Paleomagnetic investigations of the Tertiary and Quaternary rocks, Valley of Mexico, Geol. Rund., v.63, p.451.

Nairn, A.E.M., 1976. A paleomagnetic study of certain Mesozoic formations in northern Mexico, Phys. Earth Planet. Int., v.13, p.47-56.

Urrutia-Fukugauchi, J., 1979. Preliminary apparent polar wander path for Mexico, Geophys. J. R. Astron. Soc., v.56, p.227-235.

Urrutia-Fukugauchi, J., 1981. Paleomagnetism of the Miocene Jantetelco granodiorites and Tepexco volcanic group and inferences for crustal block rotations in central Mexico, Tectonophys., v. 76, p.149-168.

Urrutia-Fukugauchi, J., 1981. Paleomagnetic evidence for tectonic rotation of northern Mexico and the continuity of the Cordilleran orogenic belt between Nevada and Chihuahua, Geology, v. 9, p.178-183.

Urrutia-Fukugauchi, J., and S. Pal, 1977. Paleomagnetic data from Tertiary igneous rocks, northeast Jalisco, Mexico, Earth Planet. Sci. Lett., v.36, p.202-206.

PENINSULAR RANGES TERRANE (paleolatitude information) ******

Beck, M.E., Jr., and P.W. Plumley, 1979. Late Cenozoic subduction and continental-margin truncation along the northern Middle America ternch: Discussion and Reply, Geol. Soc. Amer. Bull., v.90, p. 792-794.

Champion, D.E., D.G. Howell, and M.C. Marshall, 1986. Paleomagnetism of cretaceous and Eocene strata, San Miguel Island, California, borderland and the northward translation of Baja California, J. Geophys. Res., v. 91, p. 11557-11570.

Erskine, B., and M. Marshall, 1980. A paleomagnetic and rock magnetic investigation of the northern Peninsular Ranges batholith, Southern California, Trans. Amer. Geophys. Union EOS, v.61, p.948.

Fry, J. G., D. J. Bottjer, and S. P. Lund, 1985. Magnetostratigraphy of displaced upper Cretaceous strata in southern California, Geology, v. 13, p. 648-651.

Hagstrom, J.T., M. McWilliams, D.G. Howell, and S. Gromme, 1985. Mesozoic paleomagnetism and northward translation of the Baja California penninsula, Geol. Soc. Amer. Bull., v.96, p.1077-1090.

Hausback, B. P., 1984. Cenozoic and tectonic evolution of Baja California Sur, Mexico, in Geology of the Baja California Peninsula, SEPM Pacific Coast Sec., Los Angeles, California, V. A. Frizzell Jr. Ed, p. 219-236.

Kamerling, M.J., and B.P. Luyendyk, 1979. Tectonic rotations of the Santa Monica mountains region, western Transverse ranges, California, suggested by paleomagnetic vectors, Geol. Soc. Amer. Bull., v.90, p.331-337.

Kamerling, M. J., and B. P. Luyendyk, 1985. Paleomagnetism and Neogene tectonics of the North Channel Islands, California, J. Geophys. Res., v. 90, p. 12485-12502.

Lund, S.P., and D.J. Bottjer, (in review). Paleomagnetic evidence for microplate tectonic development of southern and Baja California, in Geology of Baja California, AAPG Special Memoir.

Luyendyk, B. P., M. J. Kamerling, R. R. Terres, and J. S. Hornafius, 1985. Simple shear of southern California during Neogene time suggested by paleomagnetic declinations, *J. Geophys. Res.*, v. 90, p. 12454-12466.

Marshall, M., and G.J. McNaboe, 1979. Preliminary paleomagnetic results from the Cretaceous Point Loma Formation, *in* Geological Excursions in the Southern California area, P.L. Abbott ed., San Diego State Univ., San Diego.

Morris, L. K., S. P. Lund, and D. J. Bottjer, 1986. Paleolatitude drift history of displaced terranes in southern and Baja California, *Nature*, v. 321, p. 844-847.

Patterson, D.L., 1984. Paleomagnetism of the Valle Formation and the late Cretaceous paleogeography of the Vizcaino Basin, Baja California, Mexico, *in* V.A. Frizzelli, Jr., Ed., Geology of the Baja California penninsula, Pacific Section S.E.P.M., v39, p.173-182.

Pischke, G. M., C. M. Marshall, and R. G. Gastil, 1979. Miocene paleomagnetic study of tectonic history of Baja California, Mexico, *Geol. Soc. Amer. Abstr. Progr.*, v. 11, p.122.

Strangway, D.W., B.E. McMahon, T.R. Walker, and E.E. Larson, 1971. Anomalous Pliocene paleomagnetic pole positions from Baja California, *Earth Planet. Sci. Lett.*, v.13, p.161-166.

Teissere, R.F., and m.E. Beck, Jr., 1973. Divergent Cretaceous paleomagnetic pole position for the southern California Batholith, U.S.A., *Earth Planet. Sci. Lett.*, v.18, p.296-300.

SOUTHERN CALIFORNIA NEOGENE ROTATIONS *****************

Burbank,

Carter, J., R.R. Terres, and B.P. Luyendyk, 1983. Paleomagnetic study of the Eagle and Pinto Mountains, Eastern Transverse Ranges, California, *Trans Amer. Geophys. Union EOS*, v.64, p.686.

Golombek, M.P., and L.L. Brown, 1988. Clockwise rotation of the western Mohave desert, *Geology*, v. 16, p.126-130.

Hornafius, J.S., 1985. Neogene tectonic rotation of the Santa Ynez range, western Transverse ranges, California, suggested by paleomagnetic investigation of the Monterey Formation, J. Geophys. Res., v. 90, p. 12503-12522.

Hornafius, J. S., B. P. Luyendyk, R. R. Terres, and M. J. Kamerling, 1986. Timing and extent of Neogene tectonic rotation in the western Transverse ranges, California, Geol Soc. Amer. Bull., v. 97, p. 1476-1487.

Kamerling, M., and B. Luyendyk, 1981. Paleomagnetism and tectonics of the islands of the Southern California Borderland, Trans. Amer. Geophys. Union EOS, v.62, p.855.

Kamerling, M.J., and B.P. Luyendyk, 1979. Tectonic rotations of the Santa Monica mountains region, western Transverse ranges, California, suggested by paleomagnetic vectors, Geol. Soc. Amer. Bull., v.90, p.331-337.

Kamerling, M. J., and B. P. Luyendyk, 1985. Paleomagnetism and Neogene tectonics of the North Channel Islands, California, J. Geophys. Res., v. 90, p. 12485-12502.

Luyendyk, B.P., M.J. Kamerling, and R. Terres, 1980. Geometric model for Neogene crustal rotations in southern California, Geol. Soc. Amer. Bull., v.91, p. 211-217.

Luyendyk, B. P., M. J. Kamerling, R. R. Terres, and J. S. Hornafius, 1985. Simple shear of southern California during Neogene time suggested by paleomagnetic declinations, J. Geophys. Res., v. 90, p. 12454-12466.

Luyendyk, B.P., et al., 1982. Simple shear of southern California during Neogene, paleomagnetic evidence, Trans. Amer. Geophys. Union EOS, v.63, p.914- 915.

Terres, R. R., and B. P. Luyendyk, 1985. Neogene tectonic rotation of the San Gabriel region, California, suggested by paleomagnetic vectors, J. Geophys. Res., v. 90, p. 12467-12484.

Terres, R.R., B.P. Luyendyk, and M. Marshall, 1981. Clockwise rotation of the Vasquez Formation in the Transverse Ranges province, California, Trans. Amer. Geophys. Union EOS, v.62, p.855.

SALINIA

Carter, J., R.R. Terres, and B.P. Luyendyk, 1983. Paleomagnetic study of the Eagle and Pinto Mountains, Eastern Transverse Ranges, California, *Trans Amer. Geophys. Union EOS*, v.64, p.686.

Champion, D.E., D.G. Howell, and C. S. Gromme, 1984. Paleomagnetic and geologic data indicating 2500 Km of northward displacement for the Salinian and related terranes, California, *J. Geophys. Res.*, v. 89, p. 7736-7752.

Greenhaus, M.R., and A. Cox, 1979. Paleomagnetism af the Morro Rock-Isley Hill complex as evidence for crustal block rotations in central coastal California, *J. Geophys. Res.*, v.84, p.2393.

Hornafius, J.S., 1985. Neogene tectonic rotation of the Santa Ynez range, western Transverse ranges, California, suggested by paleomagnetic investigation of the Monterey Formation, *J. Geophys. Res.*, v. 90, p. 12503-12522.

Kanter, L. R., and M. Debiche, 1985. Modelling the motion histories of the Point Arena and central Salinia terranes, *in*

McWilliams, M.O., and D.G. Howell, 1982. Exotic terranes of western California, *Nature*, v.297, p.215.

Terres, R. R., and B. P. Luyendyk, 1985. Neogene tectonic rotation of the San Gabriel region, California, suggested by paleomagnetic vectors, *J. Geophys. Res.*, v. 90, p. 12467-12484.

SIERRA NEVADA BLOCK

Frei, L. S., 1986. Additional paleomagnetic results from the Sierra Nevada: further constraints on Basin and Range extension and northward displacement in the western United States, *Geol. Soc. Amer. Bull.*, v. 97, p. 840-849.

Frei, L.S., J.R. Magill, and A.V. Cox, 1984. Paleomagnetic results from the central Sierra Nevada: constraints on reconstructions of the western United States, *Tectonics*, v. 3, p.157-177.

Gromme, C.S., And R.T. Merrill, 1965. Paleomagnetism of late Cretaceous granitic plutons in the Sierra Nevada, California, *J. Geophys. Res.*, v.70,

p.3407-3420.

Gromme, C. S., R. T. Merrill, and J. Verhoogan, 1967. Paleomagnetism of Jurassic and Cretaceous plutonic rocks in the Sierra Nevada, California, and its significance for polar wandering and continental drift, J. Geophys. Res., v. 72, p. 5661-5684.

Hannah,J.L., and K.L. Verosub, 1980. Tectonic implications of remagnetized upper Paleozoic strata of the northern Sierra Nevada, Geology, v.8, p.520-524.

Kanter, L.R., and M.O. McWilliams, 1982. Rotation of the Southernmost Sierra Nevada, California, J. Geophys. Res., v.87, p.3819-3830.

McWilliams, M., and Y. Li, 1985. Oroclinal bending of the southern Sierra Nevada batholith, Science, v.230, p. 172-175.

Mankinen, E.A., 1978. Paleomagnetic evidence for a late cretaceous deformation of the Great Valley sequence, Sacremento valley, California, U.S. Geol. Sur. J. of Res., v. 6, p.383-390.

Plescia,J.B., and G.J. Calderone, ?. Paleomagnetic constraints on the timing of rotation of the Tehachapi mountains, California,

FRANCISCAN COMPLEX ************************************

Alvarez, W., D.V. Kent, I.P. Silva, R.A. Schweickert, and R.A. Larson, 1980. Fransiscan complex limestone deposited at 17 degrees south paleolatitude, Geol. Soc. Amer. Bull., v. 91, p.476-484.

Courtillot, V., H. Feinberg, J.P. Ragaru, R. Kerguelen, M. McWilliams, and A. Cox, 1985. Fransiscan complex limestone deposited at 24 degrees North, Geology, v.13, p. 107-110.

Tarduno, J.A., and W. Alvarez, 1985. Paleolatitudes of Franciscan limestones, Geology, v.13, p.741.

Tarduno, J.A., M. McWilliams, M.G. Debiche, W.V. Sliter, and M.C. Blake Jr., 1985. Franciscan complex Calera limestones - accreted remanents of Farallon plate ocean plateaus, Nature, v. 317, p.345-347.

Tarduno, J.A., M. McWilliams, W.V. Sliter, H.E. Cook, M.C. Blake Jr.,

and I. Premoli-Silva, 1986. Southern hemisphere origin of the Cretaceous Laytonville limestone of California, Science, v.231, p.1425.

COAST RANGE OPHIOLITES **********************************

Beebe, W., and B.P. Luyendyk, 1983. Preliminary paleomagnetic results from the Llanada remanent of the Coast Range ophiolite, San Benito County, California, Trans. Amer. Geophys. Union EOS, v.64, p.686.

Frei, L.S., A. Cox, and M.C. Blake, Jr., 1983. Paleomagnetic results from the Coast Range ophiolite in northen California and southern Oregon, Trans. Amer. Geophys. Union EOS, v.64, p.685.

KLAMATH BLOCK **

Achache, J., A. Cox, and S. O'Hara, 1982. Paleomagnetism of the Devonian Kennett limestone and the rotaiton of the Eastern Klamath mountains, California, Earth Planet. Sci. Lett., v.61, p.365-380.

Blake Jr., M.C., D.C. engebretson, A.S. Jayko, and D.L. Jones, 1985. Tectonostratigraphic terranes in southwest Oregon, in CircumPacific Terrane volume, D. Howell Ed.

Bogan, N.L., 1986. Paleomagnetism of the upper Jurassic Galice formation, southwestern Oregon: evidence for differential rotation of the eastern and western Klamath mountains, Geology, v. , p.335-338.

Fagin, S.W., and W.A. Gose, 1983. Paleomagnetic data from the Redding section of the eastern Klamath belt, northern California, Geology, v. , p.505-508.

Magill, J., and A. Cox, 1981. Post-Oligocene tectonic rotation of the Oregon western Cascade Range and the Klamath mountains, Geology, v.9, p.127-131.

Mankinen, E.A., and W.P. Irwin, 1982. Paleomagnetic study of some Cretaceous and Tertiary sedimentary rocks of the Klamath mountains province, California, Geology, v.10, p.82-87.

Mankinen, E.A., W.P. Irwin, and C.S. Gromme, 1982. Tectonic rotation of the Eastern Klamath Mountains Terrane, California, Trans. Amer. Geophys. Union EOS, v.63, p.914.

Mankinen, E.A., W.P. Irwin, and C.S. Gromme, 1985. Paleomagnetic results from the Shasta Bally plutonic belt in the Klamath mountains province, northern California, Geophys. Res. Lett., v.15, p.56-59.

Schultz, K.L., and S. Levi, 1981. Paleomagnetism of the Upper Cretaceous Hornbrook Formation--implications for tectonic rotation of the Klamath Mountains province, Trans. Amer. Geophys. Union EOS, v.62, p.854.

WASHINGTON/OREGON ************************************

Bates, R.G., M.E. Beck Jr., and R.F. Burmester, 1981. Tectonic rotations in the Cascade Range of southern Washington, Geology, v. 9, p.184-189.

Beck, M.E. Jr., 1984. Has the Washington-Oregon Coast range moved northward?, Geology, v.12, p.737-740.

Beck, M.E. Jr., and C.D. Burr, 1979. Paleomagnetism and tectonic significance of the Goble Volcanic series, southwestern Washington, Geology, v.7, p.175-179.

Beck, M.E. Jr., and P. W. Plumley, 1980. Paleomagnetism of intrusive rocks in the Coast Range of Oregon: microplate rotaitons in middle Tertiary time, Geology, v. 8, p.573-577.

Blake Jr., M.C., D.C. engebretson, A.S. Jayko, and D.L. Jones, 1985. Tectonostratigraphic terranes in southwest Oregon, in CircumPacific Terrane volume, D. Howell Ed.

Magill, J., and A. Cox, 1981. Post-Oligocene tectonic rotation of the Oregon western Cascade Range and the Klamath mountains, Geology, v.9, p.127-131.

Magill, J., A. Cox, and R. Duncan, 1981. Tillamook Volcanic series: further evidence for rotations of the Oregon Coast range, J. Geophys. Res., v. 86, p.2953-2970.

Simpson, R.W., and A. Cox, 1977. Paleomagnetic evidence for tectonic rotation of the Oregon Coast Range, Geology, v. 5, p.585-589.

BRITISH COLUMBIA TERRANES ******************************

Chamberlain, V.E., and R. St.J. Lambert, 1985. Cordilleria, a newly defined Canadian microcontinent, Nature, v.314, p.707-713.

Umhoefer, P.J., 1987. Northward translation of 'Baja British Columbia' along the late Cretaceous to Paleocene margin of western North America, Tectonics, v.6, p.377-394.

ALASKAN TERRANES ************************************

Coe, R.S., B.R. Globerman, P.W. Plumley, and G.A. Thrupp, 1985. Paleomagnetic results from Alaska and their tectonic implications, in CircumPacific Terrane volume, D. Howell Ed.

Hillhouse, J. W., and C.S. Gromme, 1982. Limits to northward drift of the Paleocene Cantwell formation, central Alaska, Geology, v.10, p.552-556.

Panuska, B.C., and D.B. Stone, 1985. Latitudinal motion of the Wrangellia and Alexander terranes and the southern Alaska superterrane, in CircumPacific Terrane volume, D. Howell Ed.

Stone, D.B., B.C. Panuska, and D.R. Packer, 1982. Paleolatitudes versus time for southern Alaska, J. Geophys. Res., v.87, p.3697-3707.

Van der Voo, R., M. Jones, C.S. Gromme, G.D. Eberlin, and M. Churkin Jr., 1980. Paleozoic paleomagnetism and northward drift of the Alexander terrane, southeastern Alaska, J. Geophys. Res., v.85, p.5281-5296.

!!!!!! Summary Notes on Alaskan/British Columbian Terranes !!!!!!!!!!

Alexander:	Van der Voo et al. (1980; JGR) Garhels and Saleeby (1987; Tectonics) Panuska and Stone (1985, Terrane vol.)
B.C. (+Chulitna):	Coe et al. (1985; Terrane vol.)
Chugach:	Stone et al. (1982; JGR) Coe et al. (1985; Terrane vol.)

Kuskokwim (+ others north of Denali Fault):
Stone et al. (1982; JGR)
Hillhouse and Gromme (1982; Geology)
Coe et al. (1985; Terrane vol.)

Peninsular: Stone et al. (1982; JGR)
Panuska and Stone (1985; Terrane vol.)
Coe et al. (1985; Terrane vol.)

Prince William: Panuska and Stone (1985; Terrane vol.)
Coe et al. (1985; Terrane vol.)

Stikinia: Stone et al. (1982; JGR)

Wrangellia: Stone et al. (1982: JGR)
Panuska and Stone (1985; Terrane vol.)
Coe et al. (1985; Terrane vol.)

Geol. 538, Tect. Evol. W. N. Am., Reading and reference list 4, for 2/17/1988:

ACCRETIONARY TECTONICS III: THE JURASSIC NORTHERN SIERRA NEVADA; THE 160+/-5 Ma OPHIOLITES OF WESTERN NORTH AMERICA; THE MOHAVE-SONORAN MEGASHEAR

BOLD = Assigned reading; *Italicized* = Review paper

Josephine Ophiolite, Klamath Mountains, California-Oregon

Harper, G. D., 1980, The Josephine ophiolite -- remains of a Late Jurassic marginal basin in northwestern California: Geology, v. 8, p. 333-337.

Harper, G. D., 1984, The Josephine ophiolite, northwestern California: GSA Bull., v. 951, p. 1009-1026.

Harper, G. D., and Wright, J. E., 1984, Middle to Late Jurassic tectonic evolution of the Klamath Mountains, California-Oregon: Tectonics, v. 3, p. 759-772.

Wyld, S. J., and Wright, J. E., 1988, The Devils Elbow ophiolite remnant and overlying Galice Formation: new constraints on the Middle to Late Jurassic evolution of the Klamath Mountains, California: GSA Bull., v. 100, p. 29-44.

The Jurassic northern Sierra Nevada; Smartville ophiolite

Davis, G. A., 1969, Tectonic correlations, Klamath Mountains and western Sierra Nevada, California: GSA Bull., v. 80, p. 1095-1108. **Skim. Read abstract, look at figures, read conclusions.**

Schweickert, R. A., and Cowan, D. S., 1975, Early Mesozoic tectonic evolution of the western Sierra Nevada, California: GSA Bull., 86, 1329-36.

Burchfiel, B. C., and Davis, G. A., 1981, Triassic and Jurassic tectonic evolution of the Klamath Mountains-Sierra Nevada geologic terrane, p. 50-70 in The geotectonic development of California (Ernst, W. G., Ed.): Prentice-Hall, Inc. 706 p. **Read only Sierra Nevada sections, p. 60-62, 68-70.**

* Saleeby, Jason, 1981, Ocean floor accretion and volcanoplutonic arc evolution of Mesozoic Sierra Nevada, p. 132-181 in Geotectonic devel. of California.

✓ **Xenophontos, Costas, and Bond, G. C.**, 1978, Petrology, sedimentation and paleogeography of the Smartville terrane (Jurassic) -- bearing on the genesis of the Smartville ophiolite: Pac. Sect. SEPM, Mesozoic paleogeography of the western U. S., p. 291-302.

Menzies, Martin, Blanchard, Douglas, and Xenophontos, Costas, 1980, Genesis of the Smartville arc-ophiolite, Sierra Nevada Foothills, California: AJS, v. 280-A, p. 329-344.

✓ **Saleeby, J. B.**, 1982, Polygenetic ophiolite belt of the California Sierra Nevada; geochronological and tectonostratigraphic development: JGR, v. 87, p. 1803-1824.

Day, H. W., Moores, E. M., and Tuminas, A. C., 1985, Structure and tectonics of the northern Sierra Nevada: GSA Bull., v. 97, p. 436-450. **Not easy reading; try to get general impressions of "Nevadan" tectonics.**

Coast Range ophiolite, California Coast Ranges

Bezore, S. P., 1969, The Mount Saint Helena ultramfafic-mafic complex of the northern California Coast Ranges: GSA Abstracts with Programs, pt. 3, p. 5-6 (Cord. Sect. Mtng., Eugene, Ore.)

Bailey, E. H., Blake, M. C., and Jones, D. L., 1970, On-land Mesozoic oceanic crust in California Coast Ranges: USGS PP 700-C, p. C70-C81.

Hopson, C. A., Mattinson, J. M., and Pessagno, E. A., Jr., 1981, Coast Range ophiolite, western California, p. 418-510 in The geotectonic development of California (Ernst, W. G., Ed.): Prentice-Hall, Inc., 706 p. **Read p. 419-436, 471, p. 490 ("Volcanic Member")-510.**

Shervais, J. W., and Kimbrough, D. L., 1985, Geochemical evidence for the tectonic setting of the Coast Range ophiolite: a composite island arc-oceanic crust terrane in western California.

Pacific Northwest ophiolites

Southwick, D. L., 1974, Geology of the alpine-type ultramafic complex near Mt. Stuart, Washington: GSA Bull., v. 85, p. 391-402.

Miller, R. B., 1985, The ophiolitic Ingalls Complex, north-central Cascade Mountains, Washington: GSA Bull., v. 96, p. 27-42.

Whetten, J. T., Zartman, R. E., Blakely, R. J., and Jones, D. L., 1980, Allochthonous Jurassic ophiolite in northwest Washington: GSA Bull., v. 91, p. 359-368.

Vance, J. A., Dungan, M. A., Blanchard, D. P., and Rhodes, J. M., 1980, Tectonic setting and trace element geochemistry of Mesozoic ophiolitic rocks in western Washington: AJS., v. 280-A, p. 359-388.

Tectonic controls on formation of Jurassic ophiolites, w. North America

Anderson, T. H., and Silver, L. T., 1979, The role of the Mojave-Sonora megashear in the tectonic evolution of northern Sonora: Geology of northern Sierra field trip, Guidebook, 1979.

Anderson, T. H., and Schmidt, V. A., 1983, The evolution of Middle America and the Gulf of Mexico-Caribbean Sea region during Mesozoic time: GSA Bull., v. 94, p. 941-966. – emphasize Mojave - Sonora megashear

Davis, G. A., Monger, J. W. H., and Burchfiel, B. C., 1978, Mesozoic construction of the Cordilleran "collage", central British Columbia to central California: Pac. Sect. SEPM Mes. volume, p. 1-32.

Harper, G. D., Saleeby, J. B., and Norman, E. A. S., 1985, Geometry and tectonic setting of sea-floor spreading for the Josephine ophiolite, and implications for Jurassic accretionary events along the California margin, p. 239-257 in Tectonostratigraphic terranes of the circum-Pacific region (Howell, D. G., Ed.): Circum-Pacific Council for Energy and Mineral Resources, Houston, 581 p.

Ingersoll, R. V., and Schweickert, R. A., 1986, A plate-tectonic model for Late Jurassic ophiolite genesis, Nevadan orogeny, and forearc initiation, northern California: Tectonics, v. 5, p. 901-912.

Cordilleran orogenesis, western United States: extensions of an earlier synthesis: AJS, v. 275-A, p. 363-396 (**read p. 373-392**). *[WOW!]*

Royse, F., Jr., Warner, M. A., and Reese, D. L., 1975, Thrust belt structural geometry and related stratigraphic problems, Wyoming-Idaho-Northern Utah, p. 41-54 <u>in</u> Deep drilling frontiers of the central Rocky Mountains: Rocky Mtn. Assoc. of Geologists, 1975 Symposium. *[A US version of Bally, Gordy, and Stewart, 1966. An impressive paper, but difficult to assign as a reading because of large fold-out sections based on seismic reflection studies by Chevron.]*

Price, R. A., 1981, The Cordilleran foreland fold and thrust belt in the southern Canadian Rocky Mountains, p. 427-448 <u>in</u> Thrust and nappe tectonics: Geol. Soc. London.

Thompson, R. I., 1981, The nature and significance of large "blind" thrusts within the northern Rocky Mountains of Canada, p. 449-463 <u>in</u> Thrust and nappe tectonics: Geol. Soc. London.

Scholten, Robert, 1982, Continental subduction in the northern U.S. Rockies -- a model for back-arc thrusting in the western Cordillera: Rocky Mtn. Assoc. of Geologists, p. 123-136. *[Must reading!! The only paper ever to reference Burchfiel and Davis, 1968!!!!!]*

Dixon, J. S., 1982, Regional structural synthesis, Wyoming salient of western overthrust belt: AAPG Bull., v. 66, p. 1560-1588. *[Great cross-sections!]*

Wiltschko, D. V., and Dorr, J. A., Jr., 1983, Timing of deformation in overthrust belt and foreland of Idaho, Wyoming, and Utah: AAPG Bull., v. 67, p. 1304-1322. *[An updated sequel to Armstrong and Oriel. 1965.]*

Boyer, S. E., and Elliot, David, 1982, Thrust systems: AAPG Bull., v. 66, p. 1196-1230. *[Winner of 1987 "Best Paper Award", GSA Div. Structural Geology and Tectonics. Popularized concept of thrust duplexes.]*

Davis, Dan, Suppe, John, and Dahlen, F. A., 1983, Mechanics of fold-and-thrust belts and accretionary wedges: JGR, v. 88, p. 1153-72. *[The 1986 "Best Paper" of the Structural Geology/Tectonics Division.]*

Price, R. A., 1986, The southeastern Canadian Cordillera: thrust faulting, tectonic wedging, and delamination of the lithosphere: J. Struct. Geol., v. 8, p.239-254.

11 FEB88

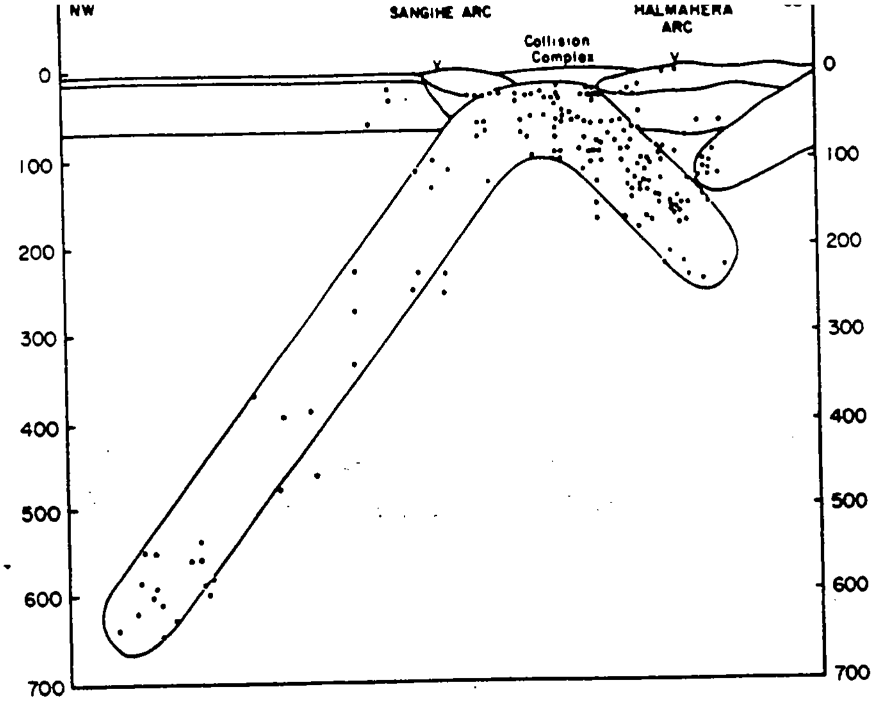


Fig. 3. Lithospheric section across the Molucca Sea collision zone based on earthquake locations by Hatherton and Dickinson [1969]. Dots are earthquake hypocenters. Location of this section is shown in Figure 2. Earthquakes were compiled over a band 300 km wide, which is why part of the Benioff zone from the subducting Philippine Sea plate can be observed on the section. V symbols on the island arcs located the volcanic lines. No vertical exaggeration.

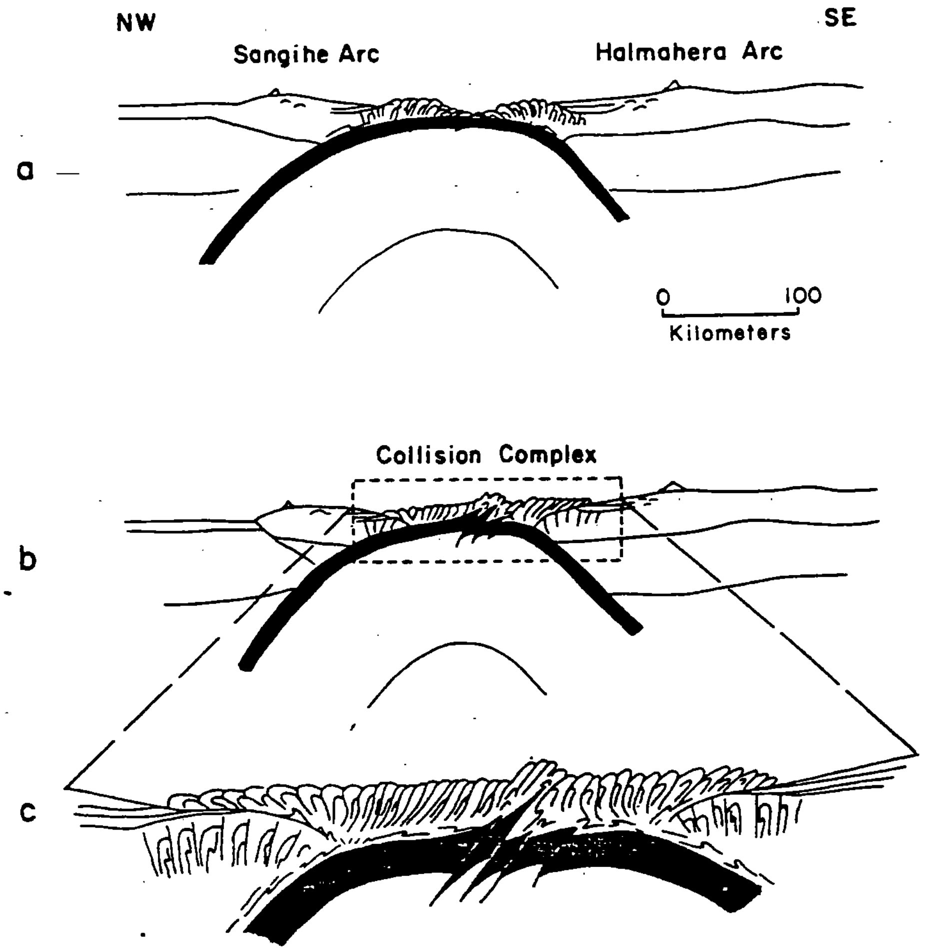


Fig. 13. Schematic interpretation of the structure of the Molucca Sea collision zone along the line of section of Figure 3 (see location in Figure 2). (a) Hypothetical structure at time of initial collision of the facing subduction complexes. (b) Hypothetical present structure of the collision zone. No scale exaggeration. Based on Figure 3. (c) Expanded view of collision complex in the dashed rectangle in Figure 13b. See discussion in text.

Silver, E. A., 1978, The Molucca Sea collision zone, Indonesia: J. G. R., v. 83, p. 1681-1691 (Figs. 2, 3, 13).

McCaffrey, Robert, 1982, Lithospheric deformation within the Molucca Sea arc-arc collision: evidence from shallow and intermediate earthquake activity: J. G. R., v. 87, p. 3663-3678 (Figs. 10, 9).

11 FEB 85

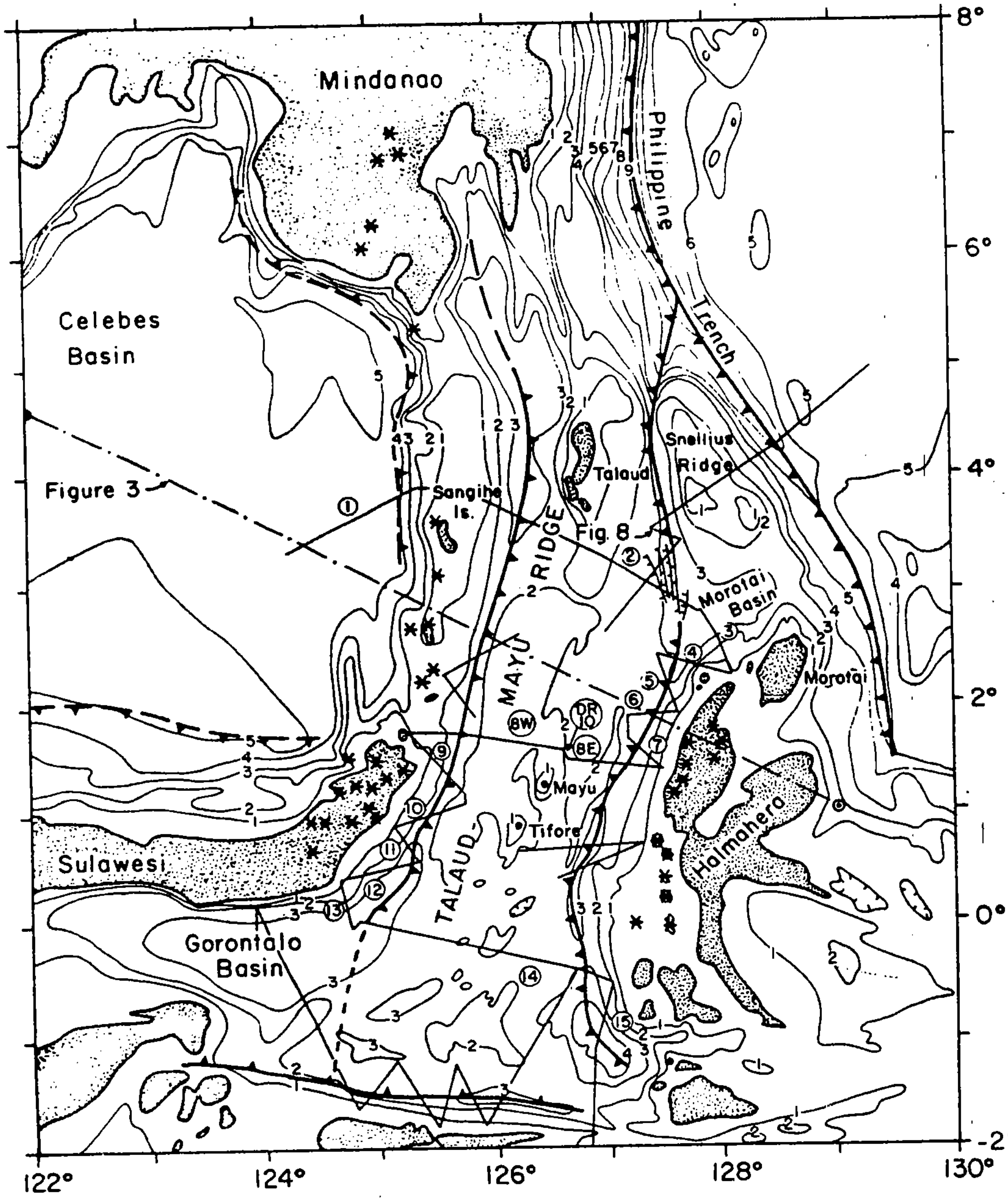


Fig. 2. Molucca Sea structure, geophysical track lines, and geographic features. Teeth are on upper plate of thrust or subduction zone as observed at the surface. Dashed thrust symbol indicates incipient subduction zone. Dashed lines extending thrust faults mean that location is poorly controlled. Circled numbers are track lines referred to in text and shown in Figures 4-10. Asterisks are Quaternary volcanos. Contour interval is 1 km. Bathymetry is based on map of Mammerickx et al [1976]. Location of Figure 3 is given by dashed-dotted line.

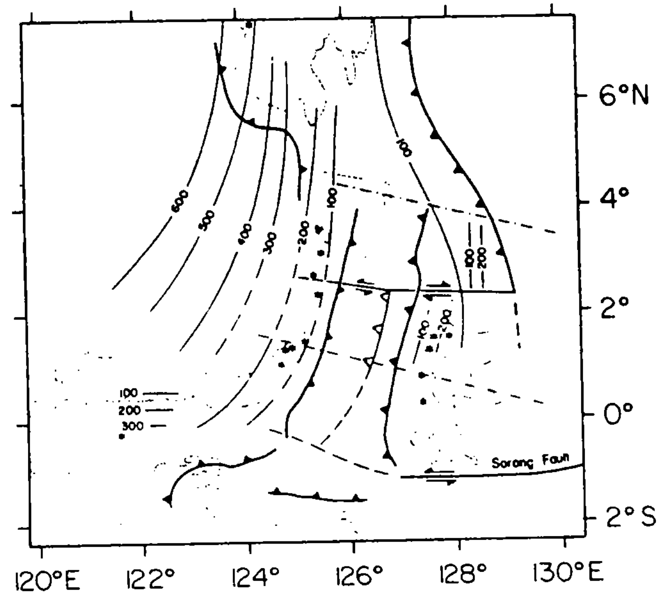


Fig. 10. Tectonic map of the Molucca Sea collision zone. Asterisks indicate active volcanoes. Surface boundaries are shown by heavy solid lines and solid teeth on the overriding plate of thrust boundaries. Lighter lines, small arrows, and open teeth refer to tectonic boundaries within the buried Molucca Sea plate. Lines are dashed where boundaries are inferred. Contours to the tops of seismic zones are labeled in kilometers and are modified from Cardwell et al. [1980]. Contours are dashed where interpolated or extrapolated because of insufficient data to resolve the seismic zone. The dash-dot lines through the central and northern Molucca Sea outline the southern and northern limits of the block diagram of Figure 2.

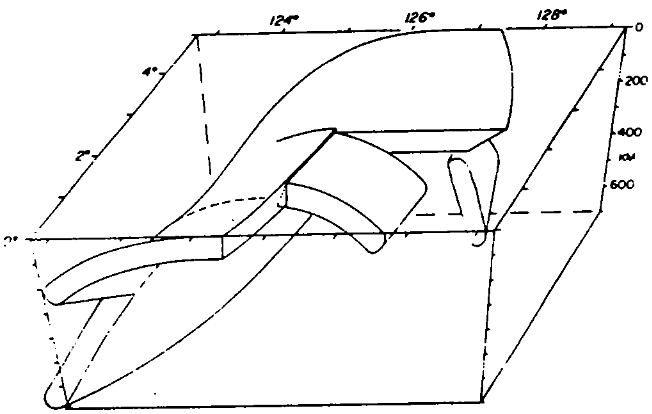


Fig. 9. Block diagram interpretation of the shape of the Molucca Sea lithosphere at the

11 FEB 88

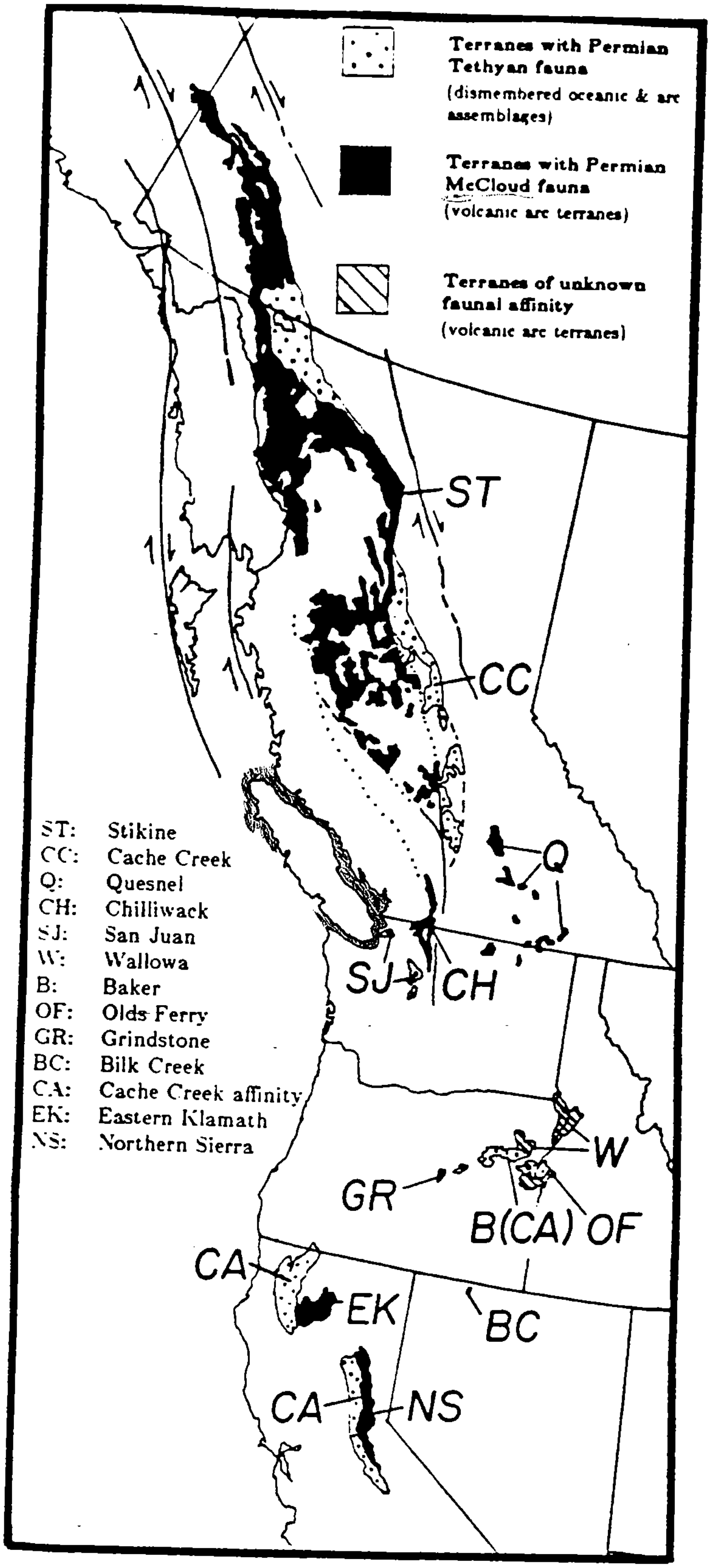


Fig. 1. Generalized distribution of western North American terranes containing contrasting Permian fauna. The Insular superterrane which underlies western British Columbia and southeastern Alaska is not shown. Terrane nomenclature and faunal distribution are modified from Monger and Berg [1984] and Silberling et al. [1984]. Additional faunal correlation is taken from Skinner and Wilde [1966], Ross and Ross [1983], and Stevens [1987 and personal communication, 1987].

GEOL 538

11 FEB 88 : A

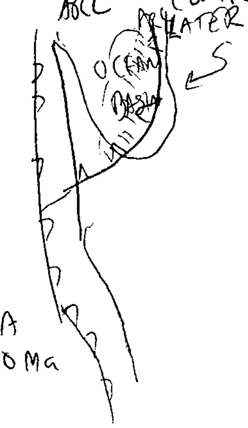
NEXT WEEK: 3 GENERAL TOPICS
Mz (esp. J) HISTORY OF SIERRA NEVADA & KLAMATHS
J EVOL. OF CONT. MARGIN

CANADA
- MZ ACCRETION HAS BEEN MUCH MORE PREVALENT IN CANADA ~~[illegible]~~ THAN IN KLAMATHS
- SOME OF TERRANES IN CAN & S. ALASKA, CAME FROM CALIFORNIA
  CONVERGENCE WAS STRONGLY NE steeply
  L. Tr TO PRESENT - DEXTRAL, FAULTS NEAR CONT EDGE
- S. PART OF CONT. IS SALAME Mid-J TO PRESENT
- N. " " " HAND
  MOST EFFICIENT HAND IS UNDERBELLY OF ALASKA

CANADA had elements ADDED TO IT
- WRANGELLIA WAS FAR TRAVELLED AND NOT N. Am., MAY HAVE BEEN S. AM.
- WAS OFFSHORE OF N.A.; MOVED 10-12 DEGREES
- STICKENIA MAY BE N.A., THAT IS,
  60 mi/deg

MONGER & ROSS: CATALOGUE OF TERRANES
6 or 7 COEVAL Pz TERRANES DIFFER IN FACIES & FAUNAL RELATIONSHIPS (eg. CACHE CREEK) - ALLOCHTHONOUS

MARGINAL BASIN BETWEEN ARC - COMPLEX
- ~~ARC~~ IN LATE Pz

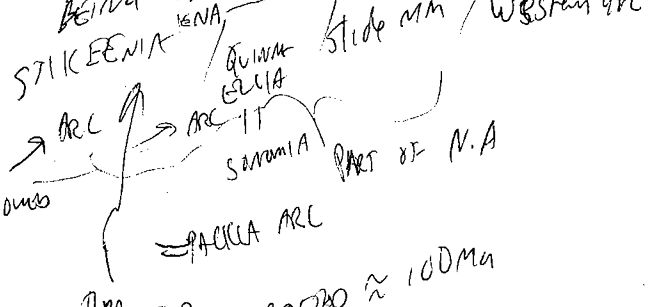


S HAVALLAH-PUMPERNICKEL BASIN

SLIDE MTN ASSEMBLEGE
MAY HAVE BEEN
IN SAME SORT OF
SETTING AS
HAVALLA - PUMP
QUINELLIA ≅ SONOMIA
165Ma 220Ma
B ~~SHARED~~ ↑
TERRANE 1 ACCRETOR

ACCRETION OF PREAMALGAMATED TERRANE
STIKINEEA
QUINELLIA
SONOMIA
} L-M EARLY J
CASHE CREEK
SAME

WERE BROUGHT TOGETHER BEFORE
BEING ADDED TO N.M.



MAY HAVE
OPERATED COEVALLY
WHILE CACHE CREEK
REGION WAS BEING NARROWED
THESE WERE COMING TO
GETHER

TERRANE 2 ACCRETED ≅ 100Ma
ADDING SIG. BREADTH

WESTERN TERRANE

Wr

ACCRETION OF 2 SUPERTERRANES
DEGREE OF ALLOCHTHONAITY
CACHE CREEK TERRANE = NON-N.A.
OK: IT'S OCEANIC

ALEXANDER TERRANE
STICKEENIA TERRANE

DIS OB ARC DIS OB ARC DIS OB CONTINENT

BRIDGE R. TERRANE

NON N.A → ALEX, CACHE CREEK, WRANGELLIA

11 FEB 88

Geol. 538, Tect. Evol. W. N. Am., Reading and reference list 4, for 2/17/1988:

ACCRETIONARY TECTONICS III: THE JURASSIC NORTHERN SIERRA NEVADA; THE 160+/-5 Ma OPHIOLITES OF WESTERN NORTH AMERICA; THE MOHAVE-SONORAN MEGASHEAR

BOLD = Assigned reading; *Italicized* = Review paper

Josephine Ophiolite, Klamath Mountains, California-Oregon

Harper, G. D., 1980, The Josephine ophiolite -- remains of a Late Jurassic marginal basin in northwestern California: Geology, v. 8, p. 333-337.

Harper, G. D., 1984, The Josephine ophiolite, northwestern California: GSA Bull., v. 951, p. 1009-1026.

Harper, G. D., and Wright, J. E., 1984, Middle to Late Jurassic tectonic evolution of the Klamath Mountains, California-Oregon: Tectonics, v. 3, p. 759-772.

Wyld, S. J., and Wright, J. E., 1988, The Devils Elbow ophiolite remnant and overlying Galice Formation: new constraints on the Middle to Late Jurassic evolution of the Klamath Mountains, California: GSA Bull., v. 100, p. 29-44.

The Jurassic northern Sierra Nevada; Smartville ophiolite

Davis, G. A., 1969, Tectonic correlations, Klamath Mountains and western Sierra Nevada, California: GSA Bull., v. 80, p. 1095-1108. **Skim. Read abstract, look at figures, read conclusions.**

Schweickert, R. A., and Cowan, D. S., 1975, Early Mesozoic tectonic evolution of the western Sierra Nevada, California: GSA Bull., 86, 1329-36.

Burchfiel, B. C., and Davis, G. A., 1981, Triassic and Jurassic tectonic evolution of the Klamath Mountains-Sierra Nevada geologic terrane, p. 50-70 in The geotectonic development of California (Ernst, W. G., Ed.): Prentice-Hall, Inc. 706 p. **Read only Sierra Nevada sections, p. 60-62, 68-70.**

Saleeby, Jason, 1981, Ocean floor accretion and volcanoplutonic arc evolution of Mesozoic Sierra Nevada, p. 132-181 in Geotectonic devel. of California.

Xenophontos, Costas, and Bond, G. C., 1978, Petrology, sedimentation and paleogeography of the Smartville terrane (Jurassic) -- bearing on the genesis of the Smartville ophiolite: Pac. Sect. SEPM, Mesozoic paleogeography of the western U. S., p. 291-302.

Menzies, Martin, Blanchard, Douglas, and Xenophontos, Costas, 1980, Genesis of the Smartville arc-ophiolite, Sierra Nevada Foothills, California: AJS, v. 280-A, p. 329-344.

Saleeby, J. B., 1982, Polygenetic ophiolite belt of the California Sierra Nevada; geochronological and tectonostratigraphic development: JGR, v. 87, p. 1803-1824.

Day, H. W., Moores, E. M., and Tuminas, A. C., 1985, Structure and tectonics of the northern Sierra Nevada: GSA Bull., v. 97, p. 436-450. **Not easy reading; try to get general impressions of "Nevadan" tectonics.**

Coast Range ophiolite, California Coast Ranges

Bezore, S. P., 1969, The Mount Saint Helena ultramfafic-mafic complex of the northern California Coast Ranges: GSA Abstracts with Programs, pt. 3, p. 5-6 (Cord. Sect. Mtng., Eugene, Ore.)

Bailey, E. H., Blake, M. C., and Jones, D. L., 1970, On-land Mesozoic oceanic crust in California Coast Ranges: USGS PP 700-C, p. C70-C81.

Hopson, C. A., Mattinson, J. M., and Pessagno, E. A., Jr., 1981, Coast Range ophiolite, western California, p. 418-510 in The geotectonic development of California (Ernst, W. G., Ed.): Prentice-Hall, Inc., 706 p. **Read p. 419-436, 471, p. 490 ("Volcanic Member")-510.**

Shervais, J. W., and Kimbrough, D. L., 1985, Geochemical evidence for the tectonic setting of the Coast Range ophiolite: a composite island arc-oceanic crust terrane in western California.

Pacific Northwest ophiolites

Southwick, D. L., 1974, Geology of the alpine-type ultramafic complex near Mt. Stuart, Washington: GSA Bull., v. 85, p. 391-402.

Miller, R. B., 1985, The ophiolitic Ingalls Complex, north-central Cascade Mountains, Washington: GSA Bull., v. 96, p. 27-42.

Whetten, J. T., Zartman, R. E., Blakely, R. J., and Jones, D. L., 1980, Allochthonous Jurassic ophiolite in northwest Washington: GSA Bull., v. 91, p. 359-368.

Vance, J. A., Dungan, M. A., Blanchard, D. P., and Rhodes, J. M., 1980, Tectonic setting and trace element geochemistry of Mesozoic ophiolitic rocks in western Washington: AJS., v. 280-A, p. 359-388.

Tectonic controls on formation of Jurassic ophiolites, w. North America

Anderson, T. H., and Silver, L. T., 1979, The role of the Mojave-Sonora megashear in the tectonic evolution of northern Sonora: Geology of northern Sierra field trip, Guidebook, 1979.

Anderson, T. H., and Schmidt, V. A., 1983, The evolution of Middle America and the Gulf of Mexico-Caribbean Sea region during Mesozoic time: GSA Bull., v. 94, p. 941-966.

EMPHASIS ON MOHAVE MEGASHEAR

Davis, G. A., Monger, J. W. H., and Burchfiel, B. C., 1978, Mesozoic construction of the Cordilleran "collage", central British Columbia to central California: Pac. Sect. SEPM Mes. volume, p. 1-32.

Harper, G. D., Saleeby, J. B., and Norman, E. A. S., 1985, Geometry and tectonic setting of sea-floor spreading for the Josephine ophiolite, and implications for Jurassic accretionary events along the California margin, p. 239-257 in Tectonostratigraphic terranes of the circum-Pacific region (Howell, D. G., Ed.): Circum-Pacific Council for Energy and Mineral Resources, Houston, 581 p.

Ingersoll, R. V., and Schweickert, R. A., 1986, A plate-tectonic model for Late Jurassic ophiolite genesis, Nevadan orogeny, and forearc initiation, northern California: Tectonics, v. 5, p. 901-912.

4 FEB 88

Geol. 538, Tect. Evol. W. N. Am., Reading and reference list 4, for 2/11/1988:

ACCRETIONARY TECTONICS II: TRIASSIC AND JURASSIC TECTONIC EVOLUTION OF THE KLAMATH MOUNTAINS, CALIFORNIA AND OREGON--- **HOW MUCH ACCRETION?**

End Member Positions A Decade Ago:

"The Triassic and Jurassic volcanic rocks of the eastern Klamaths, and the Jurassic arc-magmatic rocks of Nevada, likely are products of subduction beneath the enlarged continent, and may be paired to the subduction recorded by the Triassic blueschist and Jurassic melange that bound the eastern Klamaths on the west ...

The remainder of the Klamath Mountains, west of this Paleozoic terrain [*eastern Klamath Mountains -- GAD*], was welded to the continent in the form of variably aggregated island-arc fragments, perhaps analogous to the southern Philippine Islands* ... . Consideration of K/Si rations indicates that the Upper Jurassic trondhjemites, intruded into the western part of the Paleozoic terrain, could not have formed in response to the subduction system (or probably systems) which produced the Upper Jurassic granodiorites much farther west, so not until late Late Jurassic or Early Cretaceous time was the suturing completed. Jurassic aggregation of the Klamaths is required also by the ages of materials in the melanges. ... The island arcs were individually active during Middle and Late Jurassic time, and probably earlier; the intervening oceanic crust formed in part during the Triassic." [W. Hamilton, 1978, Pac. Sect. SEPM Mesoz. Vol., p. 46]

* "The southern Philippines represent an aggregate of the products of at least six Cenozoic island-arc systems." [ibid., p. 34]

****

"Most of the Klamath Mountains province west of the Siskiyou thrust fault ... consists of Jurassic sedimentary and igneous rocks with both arc and oceanic affinities. ... an increasing number of authors have interpreted the Jurassic rocks of the western Klamath Mountains and Sierra Nevada as exotic elements of the Cordillera, i.e. units alien to the North American plate but carried to it atop Pacific Ocean lithosphere that was subducted in Jurassic time along the western edge of the continent ... .

It is our opinion that such hypotheses are conceptually pleasing, but increasingly difficult to defend as mapping studies in the western Klamath and Sierran regions progress. [p. 21, Davis and others, see below]

... The Middle and Late Jurassic Klamath Mountains-Sierra Nevada can be interpreted as a single arc complex constructed across a previously sutured (Middle or Late Triassic to Early Jurassic) plate boundary between the North American continent and western oceanic rocks of 'Calaveras'-type. Internal Jurassic disruption and imbrication of this arc by strike-slip and thrust faulting is believed to be an intraplate response to continued plate convergence to the west, and not a direct expression of the collision and accretion to the continent of multiple arc or remnant arc complexes foreign to North America." [Davis, Monger, & Burchfiel, 1978, SEPM Mes. Vol., p. 1]

4 FEB 88

Bold = assigned reading; *italicized* = student review

Davis, G. A., 1968, Westward thrust faulting in the south-central Klamath Mountains, California: GSA Bull., v. 79, p. 911-934.

Hamilton, Warren, 1969, Mesozoic California and the underflow of the Pacific mantle: GSA Bull., v. 80, p. 2409-2430.

Davis, G. A., Monger, J. W. H., and Burchfiel, B. C., 1978, Mesozoic construction of the Cordilleran "collage", central British Columbia to central California, p. 1-32 in Mesozoic Paleogeography of the Western United States: Pac. Sect. SEPM, Los Angeles, 573 p. **Read p. 1-9 (to "BC and N. Wa."), 11 ("Klamath Mts" ...)-13 (to "Sierra Nev."), 21 ("Klamath Mts")-23 (to "Sierra Nev.").**

Hamilton, Warren, 1978, Mesozoic tectonics of the western United States, p. 33-70 in Mes. Paleogeog. ... Pac. Sect. SEPM. **Read p. 33-37 (to "Cret. Complexes ...), p. 44 ("Klam. Mts")-46 (to "Sierra Nev.").**

Miller, M. M. , 1987, Dispersed remnants of a northeast Pacific fringing arc; upper Paleozoic terranes of Permian McCloud faunal affinity, western U. S.: Tectonics, v. 6, p. 807-830.

Irwin, W. P., 1981, Tectonic accretion of the Klamath Mountains, p. 29-49 in The Geotectonic Development of California (Ernst, W. G., Ed.): Prentice-Hall, Inc., 706 p.

Davis, G. A., Ando, C. J., Cashman, P. H., and Goullaud, Lee, 1980, Geologic cross section of the central Klamath Mountains: summary: GSA Bull., Pt. 1, v. 91, p. 139-142.

Burchfiel, B. C., and Davis, G. A., 1981, Triassic and Jurassic tectonic evolution of the Klamath Mountains-Sierra Nevada geologic terrane, p. 50-70 in The Geotectonic Development of California (Ernst, W. G., Ed.), Prentice-Hall, Inc., 706 p.

Wright, J. E., 1982, Permo-Triassic accretionary subduction complex, southwestern Klamath Mountains, northern California, JGR, v. 87, p. 3805-3818.

Saleeby, J. B., Harper, G. D., Snoke, A. W., and Sharp, W. D., 1982, Time relations and structural-stratigraphic patterns in ophiolite accretion,

4 Feb 88

west-central Klamath Mountains, California: JGR, v. 87, p. 3831-3848.

Blome, C. D., and Irwin, W. P., 1983, Tectonic significance of late Paleozoic to Jurassic radiolarians from the North Fork terrane, Klamath Mountains, California, p. 77-85 <u>in</u> Pre-Jurassic rocks in western North American suspect terranes (Stevens, C. H., Ed.): Pac. Sect. SEPM, LA, 141 p.

Ando, C. J., Irwin, W. P., Jones, D. L., and Saleeby, J. B., 1983, The ophiolitic North Fork terrane in the Salmon River region, central Klamath Mountains, California: GSA Bull., v. 94, p. 236-252.

Harper, G. D., and Wright, J. E., 1984, Middle to Late Jurassic tectonic evolution of the Klamath Mountains, California-Oregon: Tectonics, v. 3, p. 759-772.

Irwin, W. P., Mankinen, E. A., and Gromme, C. S., 1984, Paleomagnetism in the Klamath Mountains, California and Oregon, p. 122-125 <u>in</u> Proc. of the Circum-Pacific Terrane Conf. (Howell, D. G., and others, Eds): Stanford Univ. Pub., Geol. Sciences, v. XVIII, 248 p.

Irwin, W. P., 1985, Age and tectonics of plutonic belts in accreted terranes of the Klamath Mountains, California and Oregon, p. 187-199 <u>in</u> Tectonostratigraphic terranes of the circum-Pacific region (Howell, D. G., Ed.): Circum-Pacific Council for Energy and Mineral Resources, Houston., 581 p.

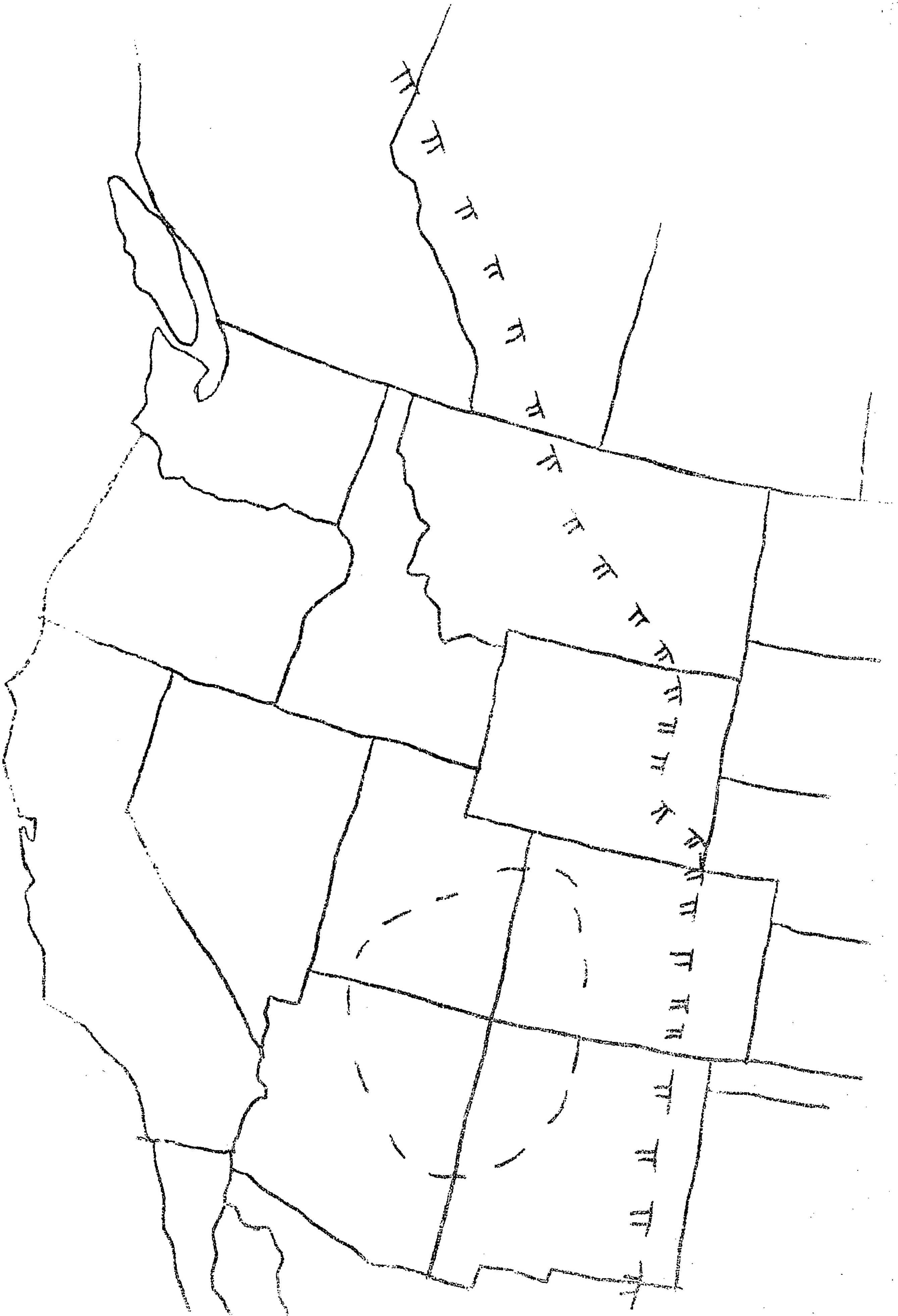
Schultz, K. L., and Levi, S., 1983, Paleomagnetism of Middle Jurassic plutons of the north-central Klamath Mountains: GSA Abst.w/ Prog., 15, p. 427.

Scott, G. R., Renne, P. R., Bazard, D. R., and Johnston, J. M., 1985, Paleomagnetism of a Permian Nosoni Fm. ignimbrite and implications to accretionary models of eastern Klamath Belt tectonics: GSA Abstracts with Programs, v. 17, no. 6, p. 407 (Cord. Sect., Vancouver, BC).

Mortimer, N., 1985, Structural and metamorphic aspects of middle Jurassic terrane juxtaposition of northeastern Klamath Mountains, California, p. 201-214 <u>in</u> Tectonostrat. terranes of circum-Pacific region.

Gray, G. G., 1986, Native terranes of the central Klamath Mountains, California: Tectonics, v. 5, p. 1043-1054.

Barnes, C. G., Rice, J. M., and Gribble, R. F., 1986, Tilted plutons in the Klamath Mountains of California and Oregon: JGR., v. 91, p. 6059-6071.



14 JAN 88

GEOL. 538: TECTONIC EVOLUTION OF WESTERN NORTH AMERICA
(G. A. DAVIS,SPRING, 88)

EMPHASIS: U.S.

COURSE OUTLINE

Meeting:	Topic(s):
1/14	Introduction: nature of course; Cordilleran overview; the geologic setting of pre-Cordillera "western" North America
1/21	Late Proterozoic Cordilleran rifting tectonics and sedimentation; Purcell-Belt "basin"; Cordilleran miogeocline
1/28	Paleozoic tectonics: Antler and Sonoma orogenies; late Paleozoic sedimentation; origin of ancestral Rocky Mtns.
2/4	Accretionary tectonics I: Basic concepts; Canadian Cordillera
2/11	Accretionary tectonics II: Triassic to mid-Jurassic events: an American case study -- the Klamath Mtns, California
2/18	Accretionary tectonics III: Mid-Jurassic events: 160 ± 5 Ma ophiolites; Mohave-Sonoran megashear
2/25	Accretionary tectonics IV: Late Jurassic & Cretaceous events with emphasis on Calif. Coast Ranges and w. Sierra Nevada; Nevadan orogeny; thrust faulting in the w. Great Basin
3/3	Post-Triassic to present interactions of Pacific plates with North America; related patterns of Cordilleran magmatism; Mesozoic and Cenozoic continental margin slivering
3/10	(tentative) Accretionary tectonics V (Steve Lund): a paleomagnetic overview
3/17	Cordilleran foreland fold-and-thrust belt: Alberta - California
3/24	Latest Cretaceous-Early Tertiary compressional tectonics: Laramide Rocky Mtns; Vincent-Orocopia thrust; S. Arizona
3/31	No seminar - Easter recess
4/7	Extensional tectonics I: metamorphic core complexes
4/14	Extensional tectonics II: Basin-and-Range structure
4/21	Cordilleran neotectonics (non-extensional): B.C. to Baja Calif.

14 JAN 88

Geol. 538, Tect. Evol. W. N. Am., Reading list 1 for 1/21/1988:

LATE PROTEROZOIC CORDILLERAN RIFTING TECTONICS AND SEDIMENTATION

Belt-Purcell Supergroup (**Bold** = assigned reading; *italicized* = to be reviewed)

Gabrielse, Hubert, 1972, Younger Precambrian of the Canadian Cordillera: AJS, v. 272, p: 521-536. ✓

Harrison, J. E., 1972, Precambrian Belt basin of northwestern United States: its geometry, sedimentation, and copper occurrences: GSA Bull., v. 83, p. 1215-1240. ✓

Harrison, J. E., Griggs, A. B., and Wells, J. D., 1974, Tectonic features of the Precambrian Belt basin and their influence on post-Belt structures: USGS Prof. Paper 866, 15 p.

Elston, D. P., and Bressler, S. L., 1980, Paleomagnetic poles and polarity zonation from the Middle Proterozoic Belt Supergroup, Montana and Idaho: JGR, v. 85, p. 339-355.

Stewart, J. H., 1976, Late Precambrian evolution of North America: plate tectonics implications: Geology, v. 4, p. 11-15.

Badham, J. P. N., 1978, Has there been an oceanic margin to western North America since Archean time?: Geology, v. 6, p. 621-625. **Also**, v. 7, 226. ✓

Sears, J. W., and Price, R. A., 1978, The Siberian connection: a case for Precambrian separation of the North American and Siberian cratons: Geology, v. 6, p. 267-270. Also, 466-9. ✓

Young, G. M., Jefferson, C. W., Delaney, G. D., and Yeo, G. M., 1979, MIddle and late Proterozoic evolution of the northern Canadian Cordillera and Shield: Geology, v. 7, p. 125-128.

Young, Grant, 1984, Proterozoic plate tectonics in Canada with emphasis on evidence for a Late Proterozoic rifting event: Precambrian Research, v. 25, p. 233-256.

McMechan, M. E., and Price, R. A., 1982, Superimposed low-grade metamorphism in the Mount Fisher area, southeastern British Columbia -- implications for the East Kootenay orogeny: Can. Jour. Earth Sci., v.

14 JAN 88

19, p. 476-489. Note: review should combine this and following paper; assess bearing of these papers on ages of Belt rifting and a subsequent late Proterozoic tectonic/metamorphic event affecting Belt strata.

Evans, K. V., and Fischer, L. B., 1986, U-Pb geochronology of two augen gneiss terranes, Idaho -- new data and tectonic implications: Can. Jour. Earth Sci., v. 23, p. 1919-1927.

Sears, J. W., Graff, P. J., and Holden, G. S., 1982, Tectonic evolution of lower Proterozoic rocks, Uinta Mountains, Utah and Colorado: GSA Bull., v. 93, p. 990-997. ✓

Wright, L. A., Troxel, B. W., Williams, E. G., Roberts, M. T., and Diehl, P. E., 1974, Precambrian sedimentary environments of the Death Valley region, eastern California, in Guidebook: Death Valley region, California and Nevada: Death Valley Publishing Co., Shoshone, Ca., p. 27-35. QE 2 G2902g 1974

Walker, J. D., Klepacki, D. W., and Burchfiel, B. C., 1986, Late Precambrian tectonism in the Kingston Range, California: Geology, v. 14, p. 15-18. **Also**, v. 15, p. 274-275. ✓

Windermere Supergroup and Cordilleran miogeocline

Kay, Marshall, 1947, Geosynclinal nomenclature and the craton: Bull. AAPG, v. 31, p. 1289-1293. TN 960 A51 ✓

Roberts, R. J., Hotz, P. E., Gilluly, James, and Ferguson, G. G., 1958, Paleozoic of north-central Nevada: Bull. AAPG, v. 42, p. 2815-2857.

Kay, Marshall, 1960, Paleozoic continental margin in central Nevada, western United States: 21st. Int. Geol. Cong., Rept., pt. 12, p. 94-102.

✓ **Stewart, J. H., 1972,** Initial deposits in the Cordilleran geosyncline: evidence of a late Precambrian (<850 m.y.) continental separation: GSA Bull., v. 83, p. 1345-1360.

Stewart, J. H., and Poole, F. G., 1974, Lower Paleozoic and uppermost Precambrian Cordilleran miogeocline, Great Basin, western United

14 JAN 88

States: S.E.P.M. Spec. Pub. 22, p. 28-57.

Burchfiel, B. C., and Davis, G. A., 1975, Nature and controls of Cordilleran orogenesis, western United States: extensions of an earlier synthesis: AJS, v. 275-A, p. 363-397.

Stewart, J. H., and Suczek, C. A., 1977, Cambrian and latest Precambrian paleogeography and tectonics of the western United States: Pac. Sect. SEPM, Paleozoic Paleogeography Vol., p. 1-17.

Rowell, A. J., Rees, M. M., and Suczek, C. A., 1979, Margin of the North American continent in Nevada during Late Cambrian time: AJS, v. 279, p. 1-18.

Armin, R. A., and Mayer, Larry, 1983, Subsidence analysis of the Cordilleran miogeocline: implications for timing of late Proterozoic rifting and amounts of extension: Geology, v. 11, p. 702-705. Also, v. 12, p. 699-700.

Bond, G. C., and Kominz, M. A., 1984, Construction of tectonic subsidence curves for the early Paleozoic miogeocline, southern Canadian Rocky Mountains: implications for subsidence mechanisms, age of breakup, and crustal thinning; GSA Bull., v. 95, p. 155-173.

Piper, J. D. A., 1983, Dynamics of the continental crust in Proterozoic times: GSA Mem. 161, p. 11-34.

Bond, G. D., Nickeson, P. A., and Kominz, M. A.., 1984, Breakup of a supercontinent between 625 Ma and 555 Ma: new evidence and implications for continental histories: EPSL, v. 70, p. 325-346.

Evenchick, C. A., Parrish, R. R., and Gabrielse, Hubert, 1984, Precambrian gneiss and late Proterozoic sedimentation in north-central British Columbia: Geology, v. 12, p. 233-237. Note: review should combine this and following paper; assess bearing of this papers on age of Windermere sedimentation and volcanism.

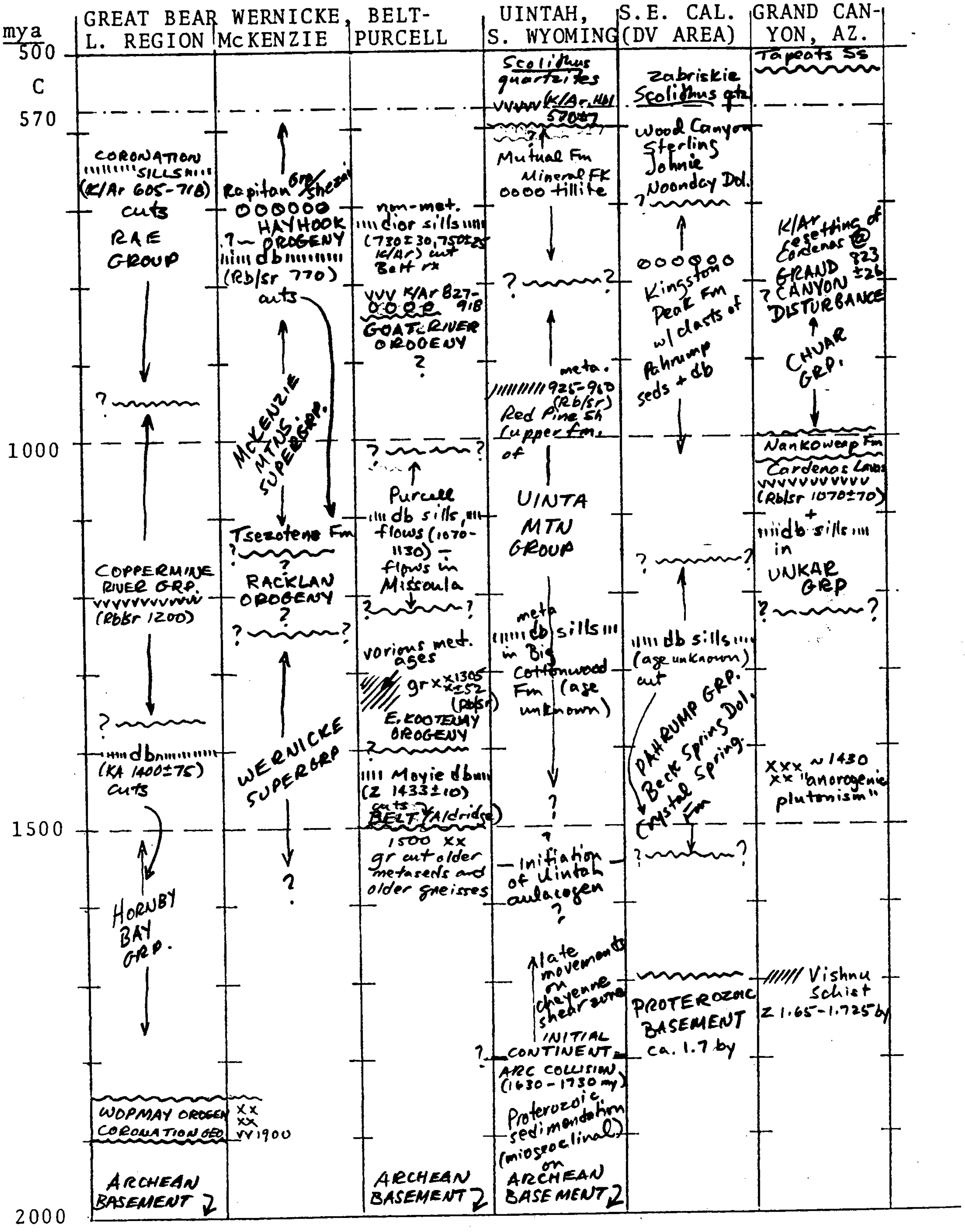
Devlin, W. J., Bond, G. C., and Brueckner, H. K., 1985, An assessment of the age and tectonic setting of volcanics near the base of the Windermere Supergroup in northeastern Washington: implications for latest Proterozoic-earliest Cambrian continental separation: CJES, v. 22, p. 829-837.

Harper, G. D., and Link, P. K., 1986, Geochemistry of Upper Proterozoic rift-related volcanics, northern Utah and southeastern Idaho: Geology, v. 14, p. 864-867.

21 JAN 84

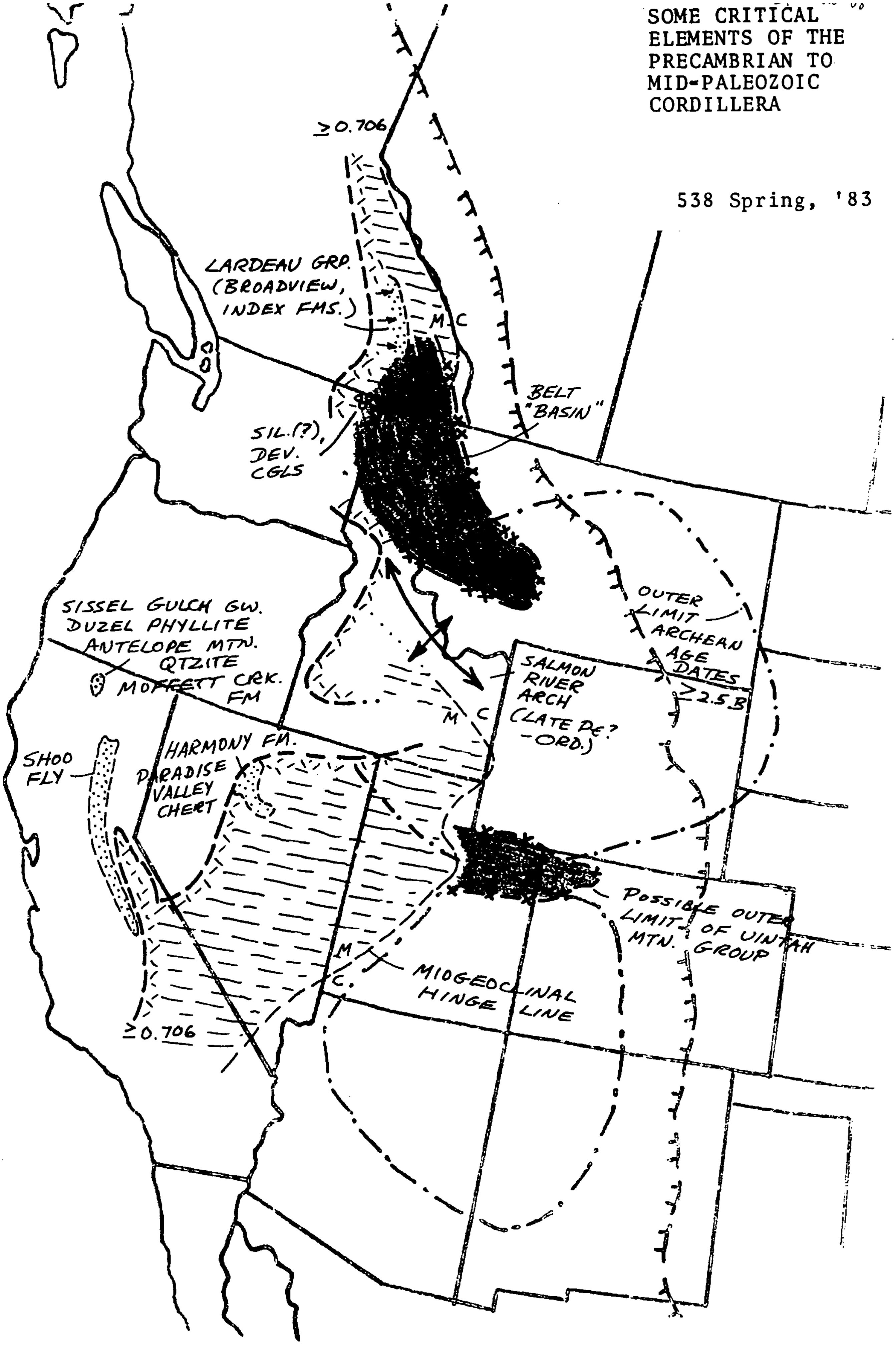
HIGHLY SIMPLIFIED STRATIGRAPHIC SECTIONS OF SELECTED AREAS IN WESTERN NORTH AMERICA EMPHASIZING AVAILABLE GEOCHRONOLOGIC DATA FOR CONTROLLING SEDIMENTATIONAL, MAGMATIC, AND TECTONIC EVENTS

(GAD, 538, 1/85)



SOME CRITICAL ELEMENTS OF THE PRECAMBRIAN TO MID-PALEOZOIC CORDILLERA

538 Spring, '83



21 JAN 88

Tectonic significance of an Early Proterozoic two-province boundary in central Arizona

KARL E. KARLSTROM *Department of Geology, Northern Arizona University, Flagstaff, Arizona 86011*
SAMUEL A. BOWRING *Department of Earth and Planetary Sciences, Washington University, St. Louis, Missouri 63130*
CLAY M. CONWAY *U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, Arizona 86001*

ABSTRACT

A compilation of U-Pb zircon dates for lower Proterozoic rocks in central Arizona shows that, although rocks tend to be older in the northwest (1800–1696 m.y.) than the southeast (1738–1630 m.y.), there is no single boundary separating distinct geochronologic provinces in Arizona. Instead, the distribution of isotopic ages reflects the presence of two major tectonic provinces separated by a regionally subhorizontal boundary or boundaries. The northwestern part of central Arizona contains the Yavapai Series (1800–1755 m.y.) and calc-alkaline batholiths (1750–1696 m.y.), both believed to represent oceanic island-arc materials. The southeastern part of central Arizona is dominated by the Alder, Red Rock, and Mazatzal Groups and related hypabyssal intrusions (1710–1692 m.y.), with voluminous rhyolitic ash-flow tuffs and quartz arenite believed to record a relatively stable continental tectonic setting.

Two working hypotheses emerge to explain the juxtaposition of representatives of these two tectonic provinces over a 100-km-wide zone in central Arizona. One interpretation (model 1) suggests that rocks of the southeast province were deposited with angular unconformity on newly accreted continental crust composed of northwest province rocks. A second interpretation (model 2) suggests that the two areas represent allochthonous terranes that evolved separately and were juxtaposed by large subhorizontal movements on thrusts and strike-slip faults. An important new constraint is that the 1699-m.y.-old strongly peraluminous Crazy Basin Quartz Monzonite was emplaced in the northwest province during ductile deformation at depths greater than 8 km at the same time that rhyolitic ash-flow tuffs and quartz arenite were being deposited in the southeast province. For model 1, this implies a rapid change of tectonic regimes about 1700 Ma, from convergence to uplift, erosion, sedimentation, and possibly extension. For model 2, the differences in crustal level, structural style, and petrologic affinity between ~1700-m.y.-old rocks in both provinces are believed to result from juxtaposition of different crustal blocks after 1700 Ma.

INTRODUCTION

Proterozoic continental crust beneath central Arizona makes up part of a 1,300-km-wide orogenic zone that extends from southern Wyoming to northern Mexico (Fig. 1). Rocks within this wide zone were accreted to North America ca. 1800–1600 Ma. Recent geochronologic and isotopic studies (Van Schmus and Bickford, 1981; DePaolo, 1981; Stacey and Hedlund, 1983; Nelson and DePaolo, 1984, 1985) have continued to support a model wherein the North American continent grew some 20% in less than 200 m.y., by addition of predominantly mantle-derived material to the continent. Studies of Proterozoic orogenic history in the Southwest are thus of importance in terms of evaluating secular changes in processes of

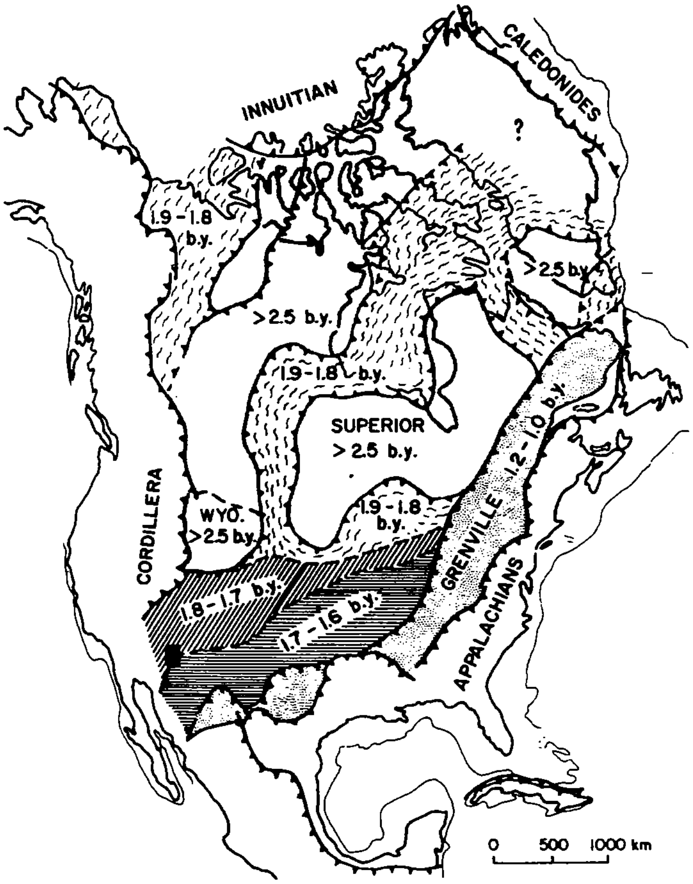


Figure 1. Distribution of major Precambrian orogenic belts and age provinces in North America, adapted from Hoffman (unpub. map). Lower Proterozoic rocks were added to southwestern North America between 1800 and 1600 Ma. This resulted in growth of the North American continent by some 20% in 200 m.y.

Geological Society of America Bulletin, v. 99, p. 529–538, 5 figs., 1 table, October 1987.

21 JAN 88

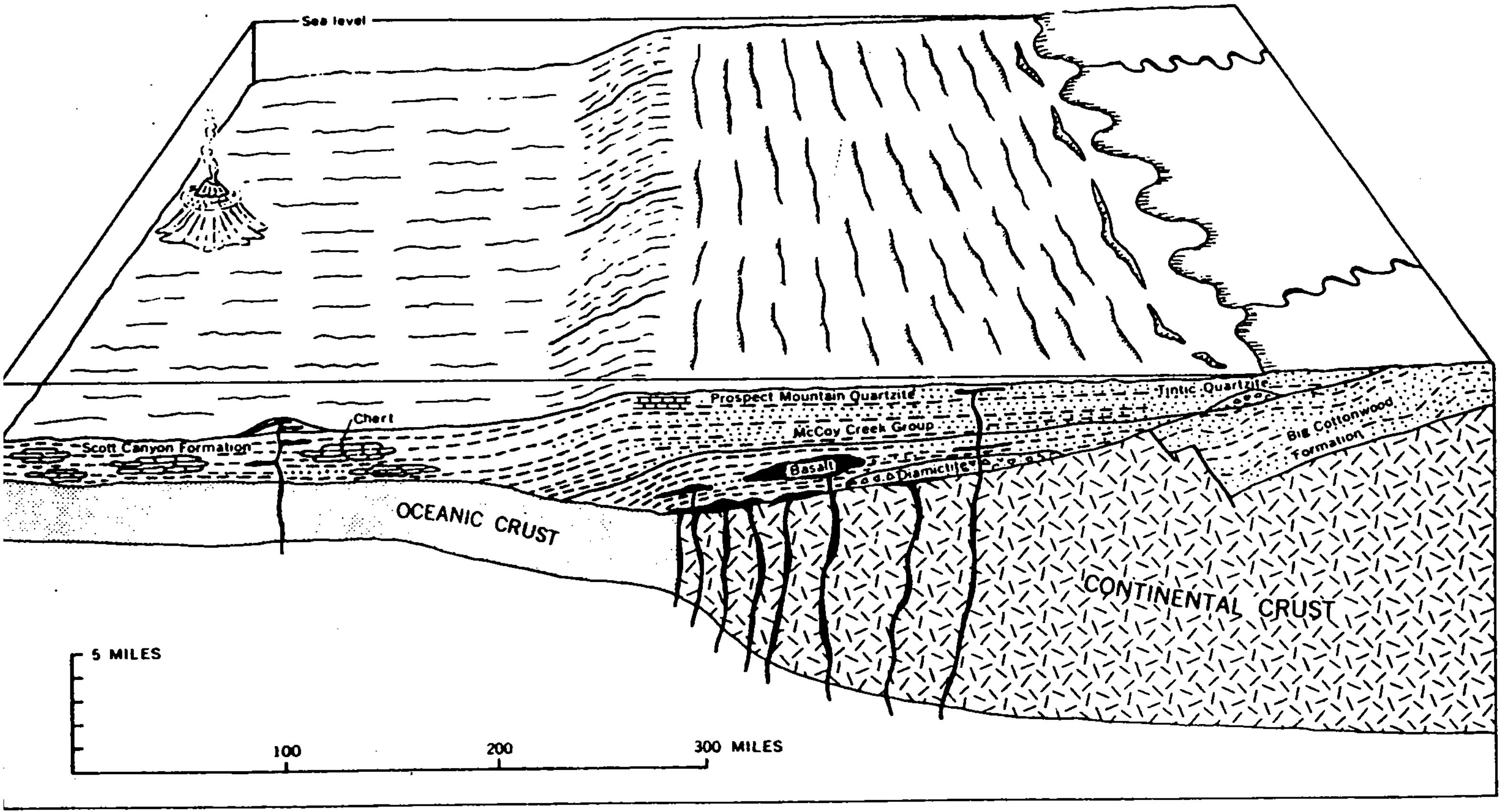


Figure 3. Diagrammatic cross section showing upper Precambrian and Lower Cambrian rocks in the northern Great Basin, Nevada and Utah.

STEWART, J., 1972, GSA BULL.

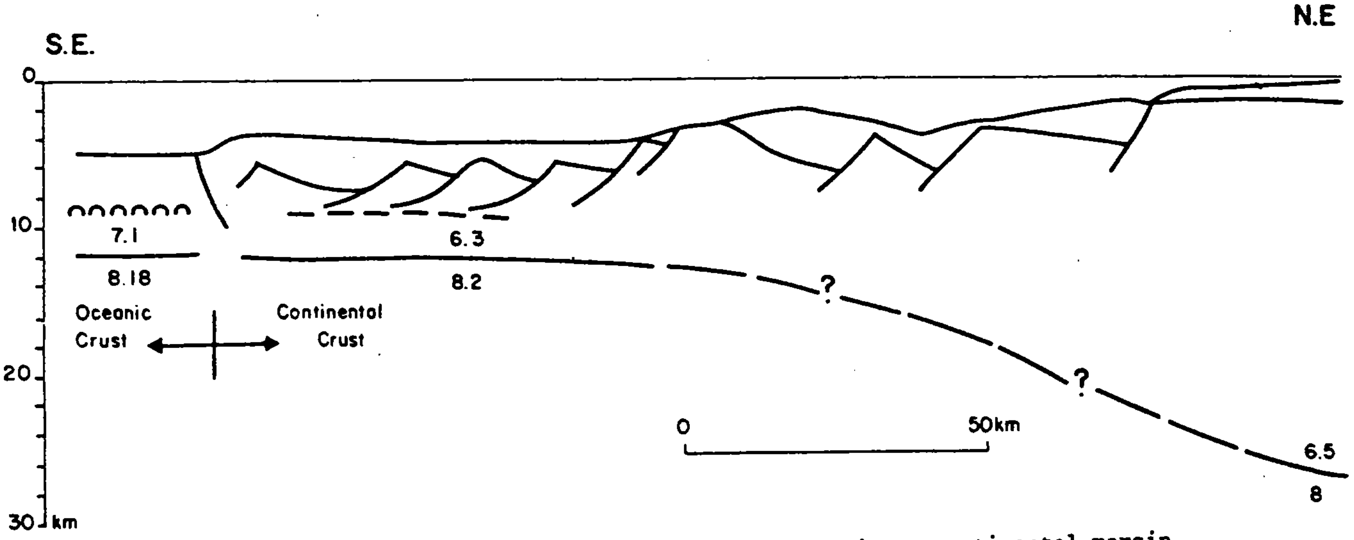


Fig. 18. Schematic crustal section through the N. Biscay continental margin.

MONTADERT AND OTHERS, 1979

1) Folger, D. W., Dillon, W. P., Grow, J. A., Klitgord, K. D., and Schlee, J. S., 1979, Evolution of the Atlantic continental margin of the United States: A.G.U. Maurice Ewing Series 3, p. 87-108.

2) Montadert, Lucien, de Charpal, Olivier, Roberts, David, Guennoc, Pol, and Sibuet, Jean-Claude, 1979, Northeast Atlantic passive continental margins: rifting and subsidence processes: ibid, p. 154-185.

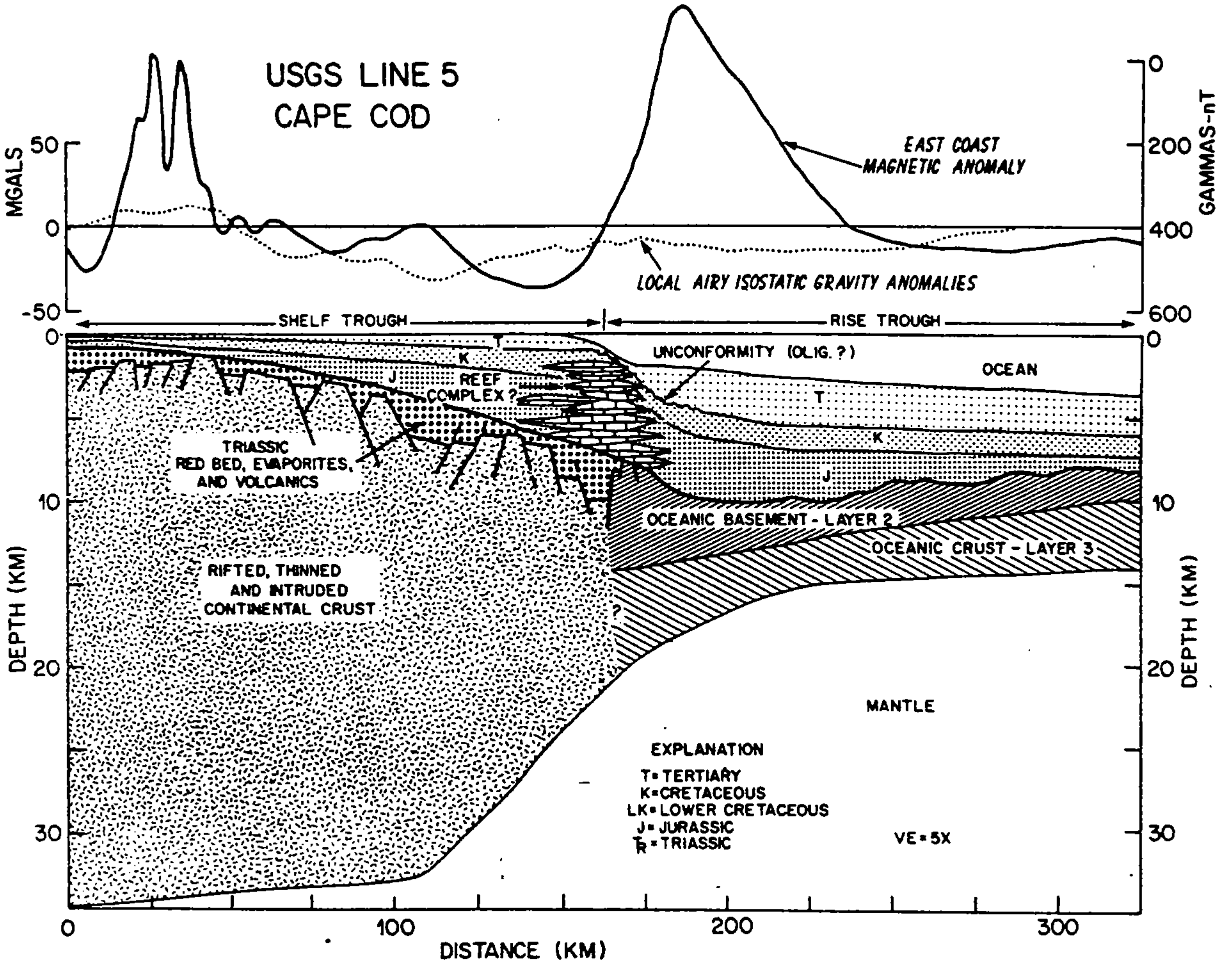


Fig. 6. Interpretative cross section along CDP Line 5 southeast of Cape Cod across the northeastern part of the Long Island platform (0 to 75 km distance) and the southwestern end of the Georges Bank basin (75 to 175 km distance). Line 5 is unique in that the top of oceanic basement can be clearly traced to a depth of 10 km at the axis of the East Coast Magnetic Anomaly (Grow and others, 1979). The Moho configuration is based on gravity modeling (Grow and others, in press).

FOLGER AND OTHERS,

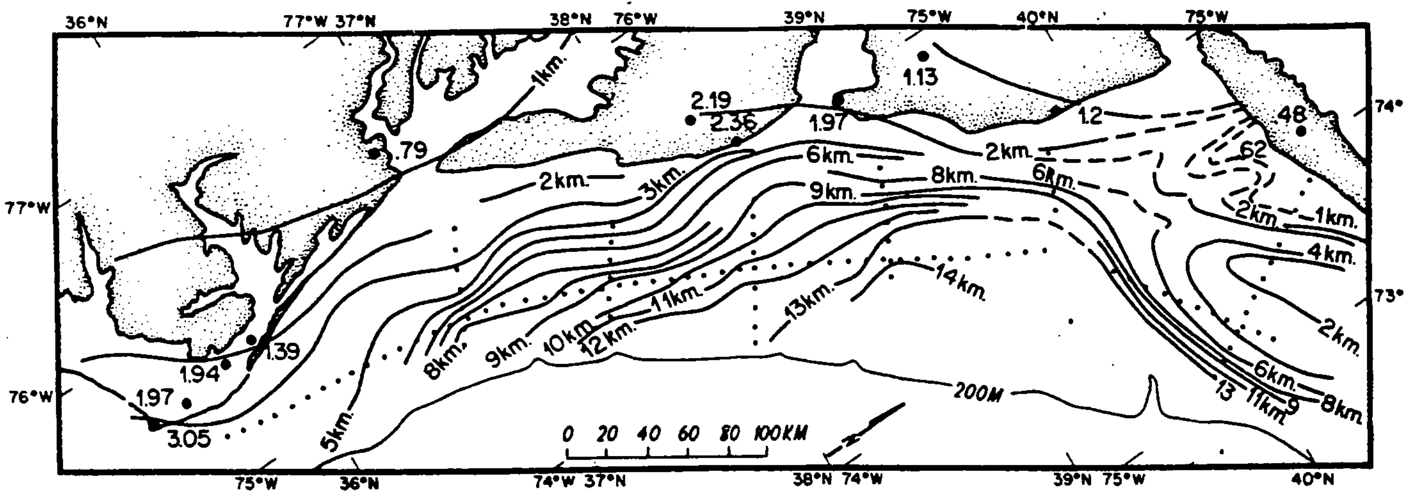
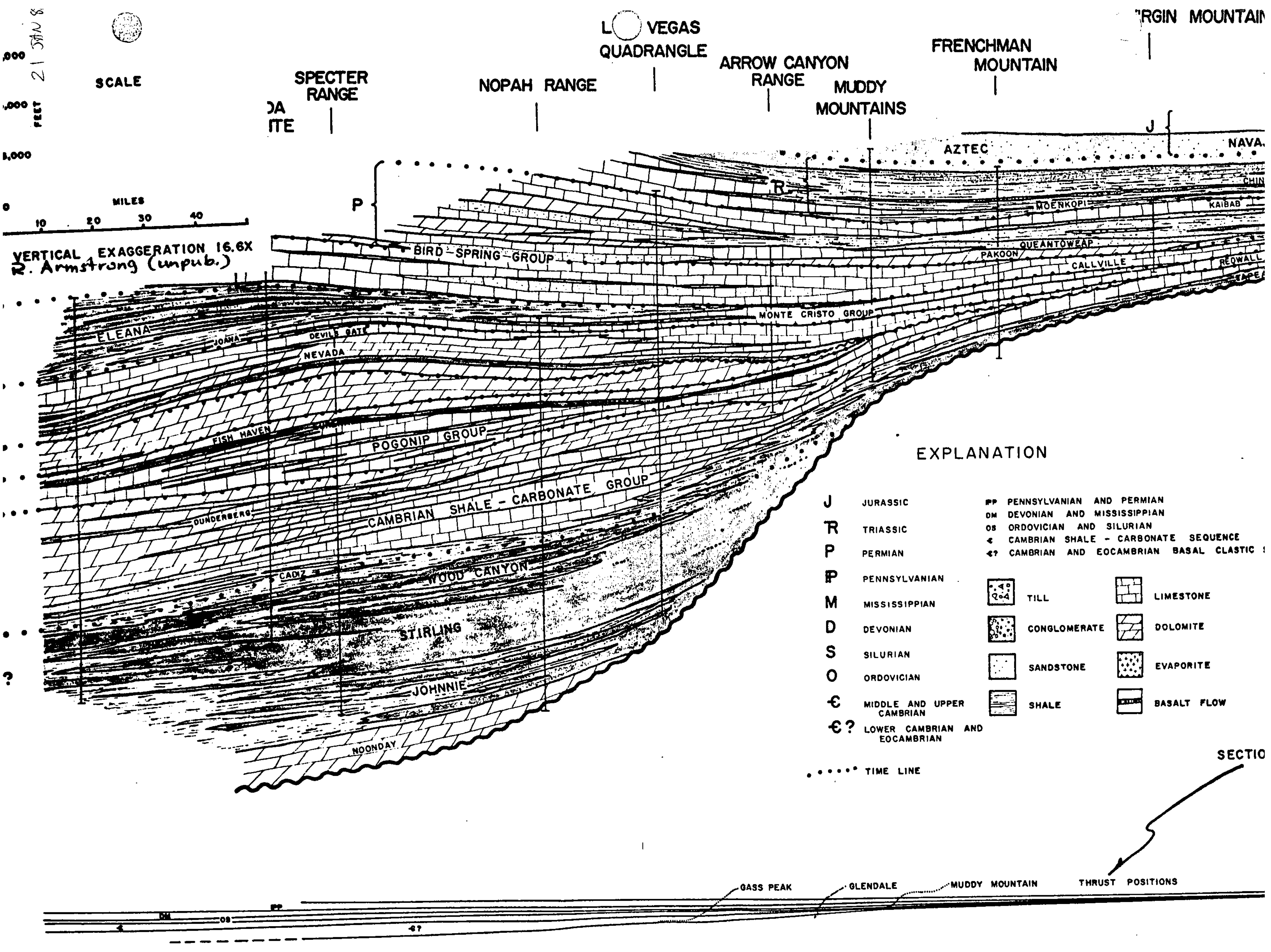
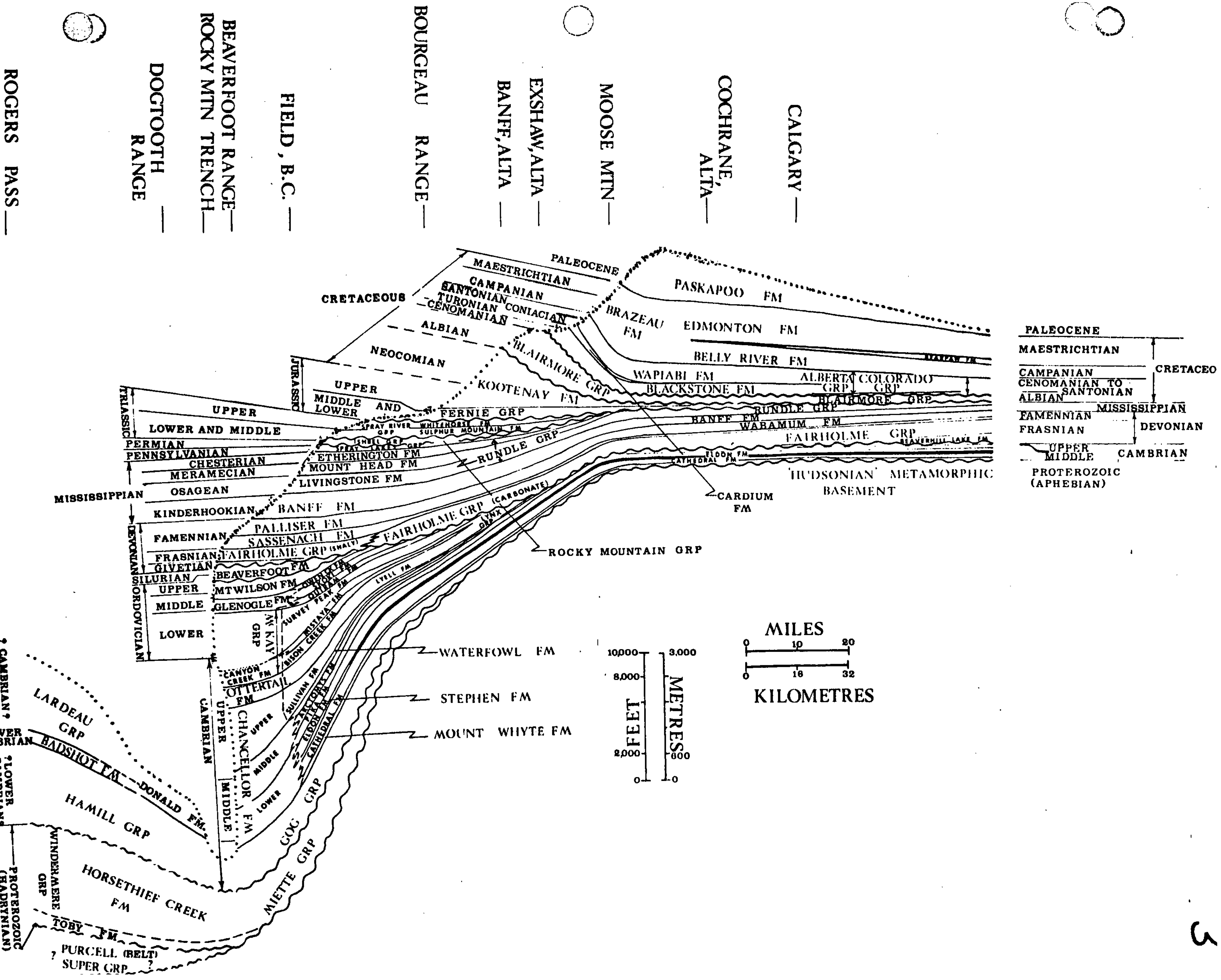


Fig. 12. Depth to basement in the Baltimore Canyon Trough area based on CDP seismic data (from Schlee and others, 1977).


21 JAN 8
,000
FEET
,000
,000
SCALE
0
MILES
10
20
30
40
VERTICAL EXAGGERATION 16.6X
R. Armstrong (unpub.)
DA
ITE
SPECTER RANGE
NOPAH RANGE
L VEGAS QUADRANGLE
ARROW CANYON RANGE
MUDDY MOUNTAINS
FRENCHMAN MOUNTAIN
RGIN MOUNTAIN
P
J
R
AZTEC
NAVA.
CHIN
KAIBAB
MOENKOPI
QUEANTOWEAP
PAKOON
CALLVILLE
REDWALL
BIRD SPRING GROUP
MONTE CRISTO GROUP
ELEANA
JOANA
DEVILS GATE
NEVADA
FISH HAVEN
POGONIP GROUP
DUNDERBERG
CAMBRIAN SHALE - CARBONATE GROUP
CADIZ
WOOD CANYON
STIRLING
JOHNNIE
NOONDAY
?
EXPLANATION
J JURASSIC
R TRIASSIC
P PERMIAN
P PENNSYLVANIAN
M MISSISSIPPIAN
D DEVONIAN
S SILURIAN
O ORDOVICIAN
€ MIDDLE AND UPPER CAMBRIAN
€? LOWER CAMBRIAN AND EOCAMBRIAN
PP PENNSYLVANIAN AND PERMIAN
DM DEVONIAN AND MISSISSIPPIAN
OS ORDOVICIAN AND SILURIAN
€ CAMBRIAN SHALE - CARBONATE SEQUENCE
€? CAMBRIAN AND EOCAMBRIAN BASAL CLASTIC
TILL
LIMESTONE
CONGLOMERATE
DOLOMITE
SANDSTONE
EVAPORITE
SHALE
BASALT FLOW
TIME LINE
SECTIO
GASS PEAK
GLENDALE
MUDDY MOUNTAIN
THRUST POSITIONS
PP
DM
OS
€
€?

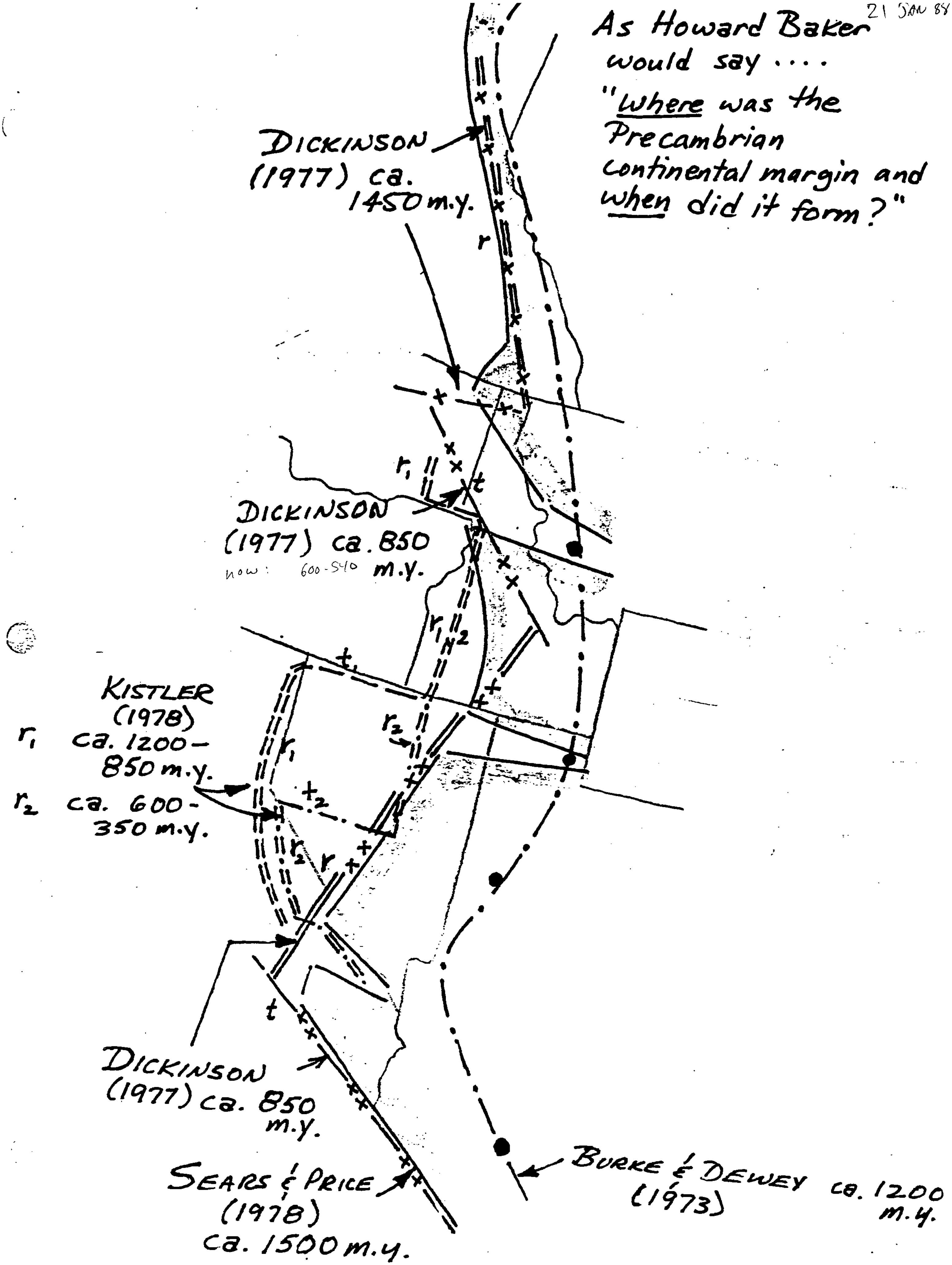
21 JAN 88


ROGERS PASS
DOGTOOTH RANGE
BEAVERFOOT RANGE
ROCKY MTN TRENCH
FIELD, B.C.
BOURGEAU RANGE
BANFF, ALTA
EXSHAW, ALTA
MOOSE MTN
COCHRANE, ALTA
CALGARY
CRETACEOUS
PALEOCENE
MAESTRICHTIAN
CAMPANIAN
SANTONIAN
TURONIAN CONIACIAN
CENOMANIAN
ALBIAN
NEOCOMIAN
JURASSIC
UPPER
MIDDLE AND LOWER
TRIASSIC
UPPER
LOWER AND MIDDLE
PERMIAN
PENNSYLVANIAN
CHESTERIAN
MERAMECIAN
MISSISSIPPIAN
OSAGEAN
KINDERHOOKIAN
DEVONIAN
FAMENNIAN
FRASNIAN
GIVETIAN
SILURIAN
ORDOVICIAN
UPPER
MIDDLE
LOWER
CAMBRIAN
UPPER
MIDDLE
PASKAPOO FM
BRAZEAU FM
EDMONTON FM
BELLY RIVER FM
BEARPAW FM
WAPIABI FM
BLACKSTONE FM
ALBERTA GRP
COLORADO GRP
BLAIRMORE GRP
KOOTENAY FM
FERNIE GRP
SPRAY RIVER GRP
WHITEHORSE FM
SULPHUR MOUNTAIN FM
ISHBEL GRP
SPRAY LAKES GRP
ETHERINGTON FM
MOUNT HEAD FM
LIVINGSTONE FM
RUNDLE GRP
BANFF FM
PALLISER FM
SASSENACH FM
FAIRHOLME GRP (SHALY)
FAIRHOLME GRP (CARBONATE)
BEAVERFOOT FM
MTWILSON FM
GLENOGLE FM
OWEN CREEK FM
SKOKI FM
OUTRAM FM
SURVEY PEAK FM
MISTAYA FM
BISON CREEK FM
LYELL FM
McKAY GRP
CANYON CREEK FM
OTTERTAIL FM
CHANCELLOR FM
UPPER
MIDDLE
LOWER
SULLIVAN FM
ARCTOMYS FM
PIKA FM
ELDON FM
CATHEDRAL FM
LYNX GRP
GOG GRP
MIETTE GRP
WATERFOWL FM
STEPHEN FM
MOUNT WHYTE FM
ROCKY MOUNTAIN GRP
CARDIUM FM
WABAMUN FM
FAIRHOLME GRP
BEAVERHILL LAKE FM
ELDON FM
CATHEDRAL FM
'HUDSONIAN' METAMORPHIC BASEMENT
? CAMBRIAN ?
LARDEAU GRP
LOWER CAMBRIAN
BADSHOT FM
DONALD FM
?LOWER CAMBRIAN?
HAMILL GRP
WINDERMERE GRP
HORSETHIEF CREEK FM
TOBY FM
PROTEROZOIC (HADRYNIAN)
? PURCELL (BELT) SUPER GRP ?
PALEOCENE
MAESTRICHTIAN
CRETACEO
CAMPANIAN
CENOMANIAN TO SANTONIAN
ALBIAN
MISSISSIPPIAN
FAMENNIAN
FRASNIAN
DEVONIAN
UPPER
MIDDLE
CAMBRIAN
PROTEROZOIC (APHEBIAN)
FEET
0
2,000
8,000
10,000
METRES
0
600
3,000
MILES
0
10
20
KILOMETRES
0
16
32

6

21 JAN 88

As Howard Baker would say....
"*Where* was the Precambrian continental margin and *when* did it form?"



GSA Bull '87

21 JAN 80

south. The differing
ization-age and Nd-
es in Arizona may be
ıs significant for each
istinctions in bounda-
ɔpes, Sr isotopes, and
in areas identified as
the Nd isotope data.

c map of the western
o test the compatibil-
rn affinity (so-called
tonic western North
talline rock terranes
Powell (1981) in the
the Joshua Tree and
The San Gabriel ter-
supracrustal and plu-
. old on the basis of
The Joshua Tree ter-
terozoic rocks (1.65
ain by mature meta-
nown age. In this
ch of these terranes
reas fault) was ana-
hist from the oldest
rrane. The resultant
itial ϵ_{Nd} (−2.89) are
e being part of the
pport for the sugges-
this terrane extends
River and south to
t it is exotic to south-

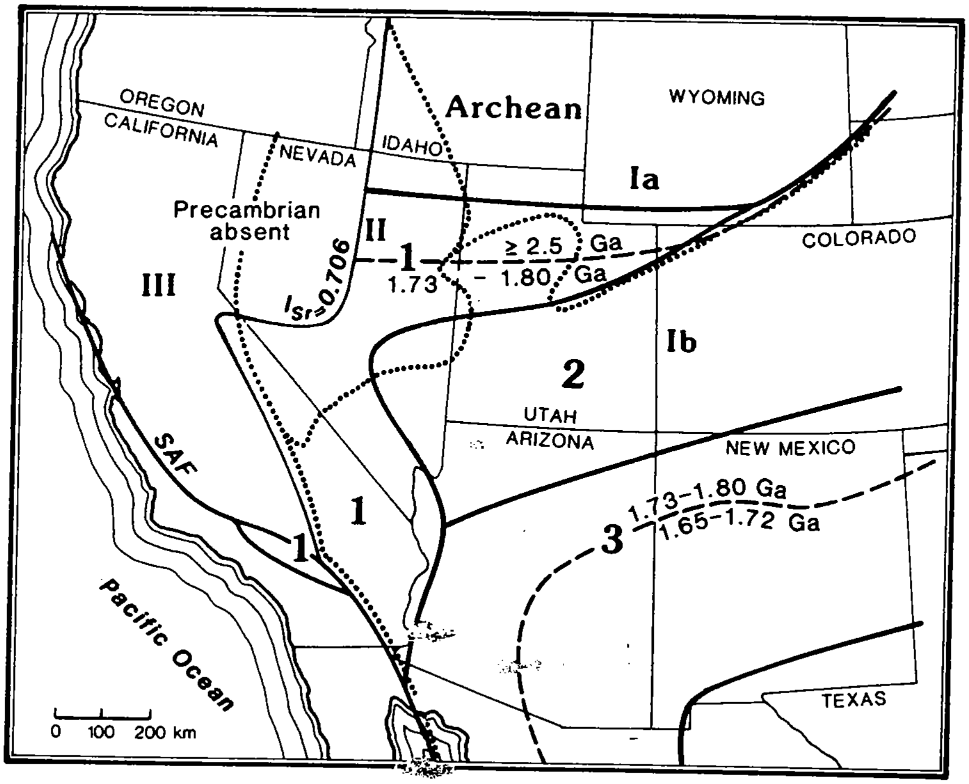


Figure 6. Comparison of crustal boundaries defined on the basis of crystallization ages (dashed lines) (Condie, 1981), Pb isotopes (dotted lines) (Zartman, 1974), and Nd isotopes (heavy solid lines). Edge of Precambrian basement is as defined on the basis of initial $^{87}Sr/^{86}Sr$ ratios in Tertiary and Mesozoic granitic rocks (Kistler and Peterman, 1978). Ages refer to crystallization ages as determined by zircon U-Pb data and whole-rock Rb-Sr data. Roman numerals are lead isotopic provinces.

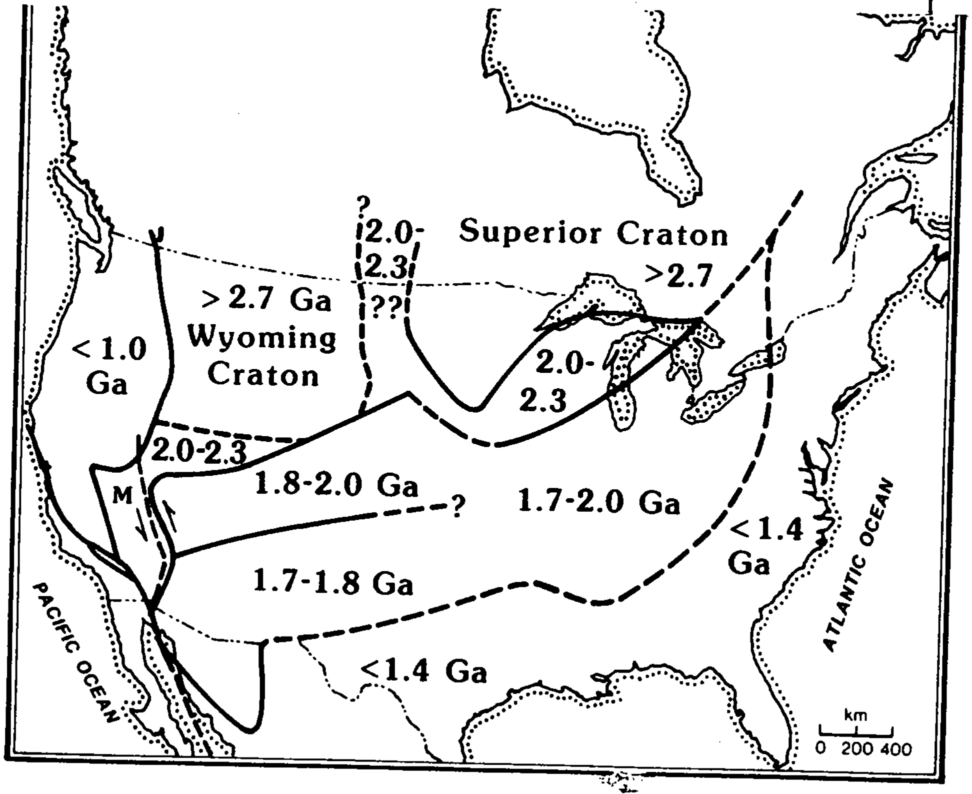
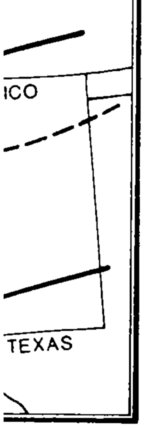


Figure 7. Map of North America, showing the distribution of Nd-model age provinces on the basis of data from this study, Nelson and DePaolo (1985), Farmer and DePaolo (1983), Patchett and Arndt (1986), and Van Schmus and others (1987). M indicates the Mojavia terrane. The adjacent dashed curve is the inferred location of a Proterozoic shear.



**llization ages
Nd isotopes
tial $^{87}Sr/^{86}Sr$
Ages refer to
data. Roman**

ed a region in
having prov-
the Nd data
. 1.4-Ga crys-
water (1984)

STATES

This method should be parti
case in which the contine
been separated since the Pr
had very different subseque

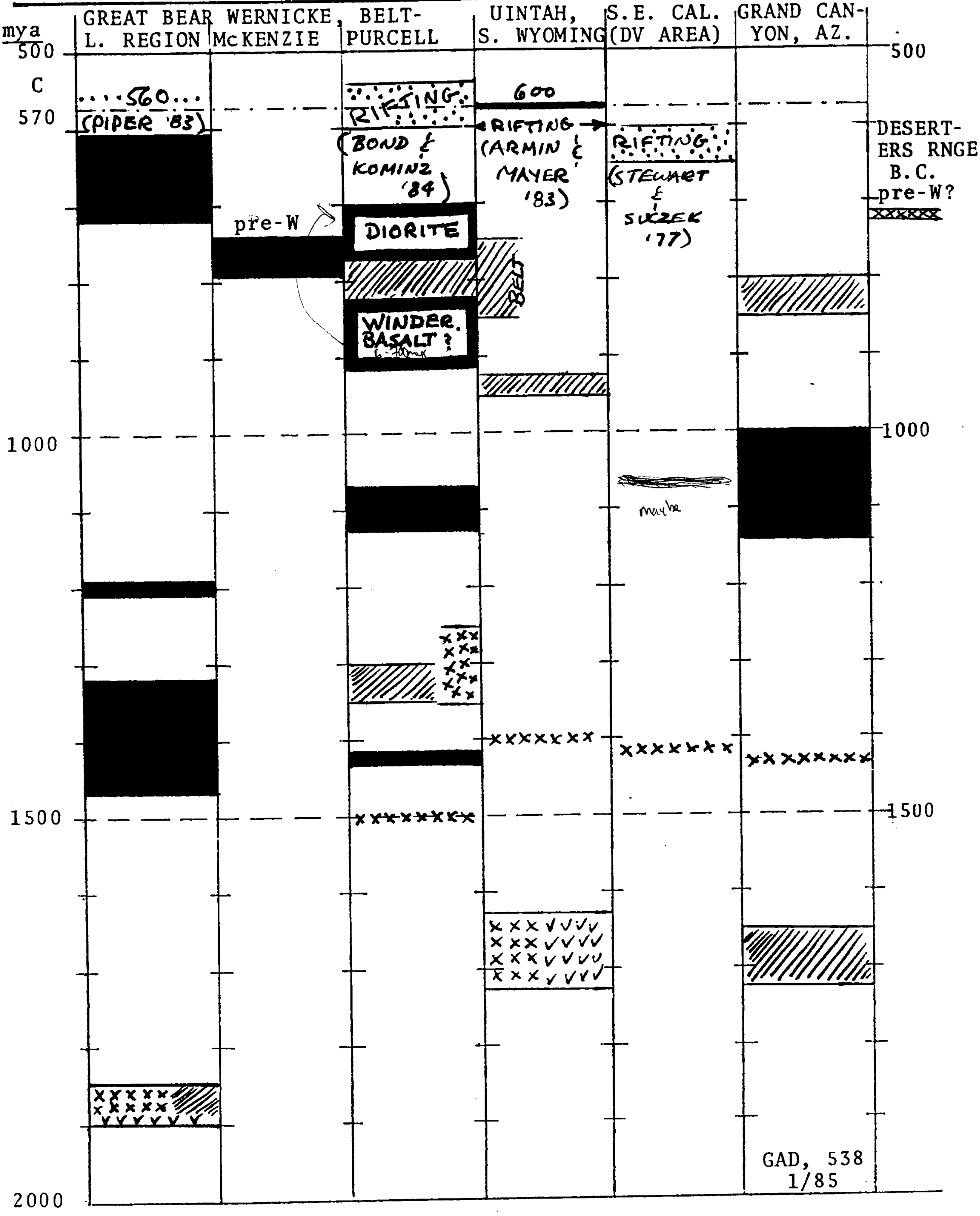
ORIGIN OF 2.0–2.3 Ga MODEL AGES

For all of the lower Proter
via and related terranes, the p
tion ages are between 1.65 a
model ages are 2.0–2.3 Ga
exist to account for this age
rocks originally crystallized b
b.y. ago and were subsequent
fied that little evidence of the
zation age remains, or (2) the
a mixture of Archean crustal
~ −11] and mantle derivativ
and therefore have interm
values and corresponding old

If the first case is true, we
to be some remaining eviden
Ga orogenic episode. Althou
zircon studies have provided
crystallization ages in the rang
zircon data from rocks within
an event between 2.0 and 2
others (1961) interpreted U-P
a gneiss in the Panamint Mou
as reflecting a *minimum* age
recently, J. Wooden (1985, p
has determined an upper inte
for a metavolcanic sample fro
Mountains, California. Hedge
determined a zircon age of 2.
core sample from Antelope I
Utah, but Nd isotopes meas
samples give Archean model
rather than model ages in th

21 JAN 85

AGE RANGES BASED ON ISOTOPIC DATING OF IGNEOUS AND METAMORPHIC ROCKS IN WESTERN NORTH AMERICA. BLACK PATTERN = MAFIC DIKES, SILLS, AND/OR FLOWS; X's = GRANITIC ROCKS; V's = VOLCANIC ROCKS (ARC AFFINITIES); CROSSRULED PATTERN = METAMORPHISM OR REHEATING



21 JAN 84

Kistler, R.W., Ghent, E. D., and O'Neil, J. R., '81, Petrogenesis of two-mica granites, Ruby Mtns., Nevada: JGR, v. 86, p. 10591-10606.

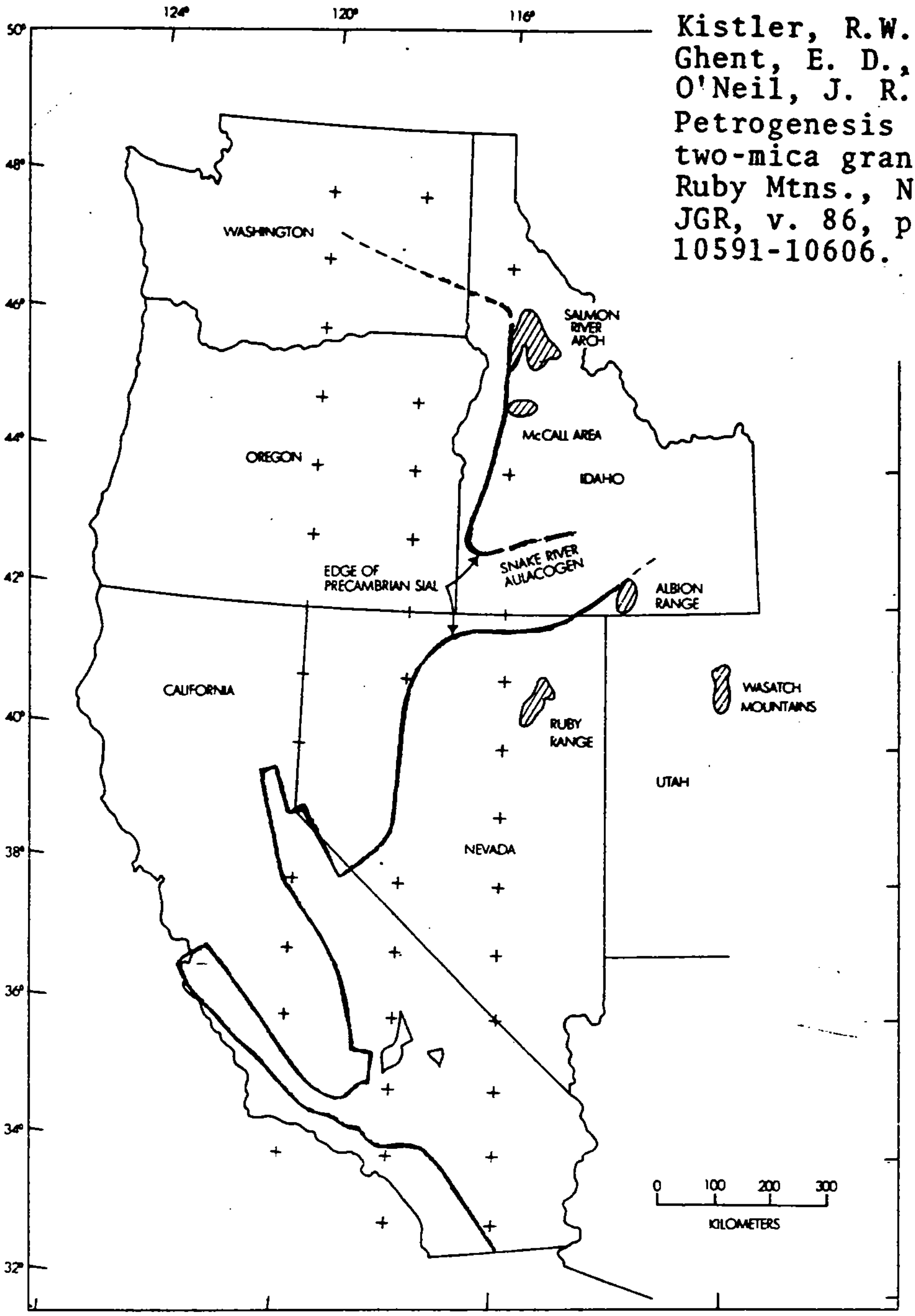


Fig. 4. Outline map of the western United States showing edge of Precambrian sialic crust as indicated by initial strontium isotopic composition of Mesozoic and Cenozoic plutons (modified from *Kistler and Peterman* [1978]). Areas that have yielded approximtely 550 m.y. metamorphic ages of rocks and minerals are hachured.

biotite and muscovite. Garnet and beryl are occasional accessory minerals.

In thin section, albite (30 to 35%), microcline (40 to 45%), and quartz (20 to 25%) are seen as generally 0.1 to 3 mm anhedral interlocking grains. Muscovite (1%) and/or biotite (2 to 4%) occur as anhedral crystals or as ragged crystals interstitial to the feldspar and quartz. Apatite inclusions in the feldspars are the most abundant and ubiquitous accessory mineral. Euhedral garnet, beryl, and zircon are minor accessory minerals. Opaque oxides are absent from the rock.

The chemical composition of two specimens of the two-mica granite in the Dawley Canyon area are given in Table 1, and their locations are shown on Figure 1. Normative albite, orthoclase, and quartz of these specimens normalized to 100% are plotted on a ternary diagram in Figure 5.

Electron microprobe analyses of muscovite, garnet, and both plagioclase and alkali feldspar from a specimen of the Cretaceous granite (RM-38-66) are given in Tables 3, 5, and 6, respectively. Biotite from this specimen was too altered to give a reliable analysis. The muscovite composition is the same as that in the Jurassic granite. The garnet is spessartine and almandine-rich with very low grossular and pyrope contents (Figure 6). The MnO zoning, however, is not as pronounced as the zoning in garnet RM-31-66 in the Jurassic granite. The plagioclase is albite, and X ray study indicates that the alkali feldspar is microcline and orthoclase.

Geol. 538, Tect. Evol. W. N. Am., Reading and reference list 7 for 3/3/1988:

POST-TRIASSIC TO PRESENT INTERACTIONS OF PACIFIC PLATES WITH NORTH AMERICA; MESOZOIC AND CENOZOIC CONTINENTAL MARGIN SLIVERING

BOLD = Assigned reading; *Italicized* = Review paper

Pacific-North American plate interactions: post-Triassic to Present

Cross, T. A., and Pilger, R. H., Jr., 1978, Constraints on absolute motion and plate interaction inferred from Cenozoic igneous activity in the western United States: AJS, v. 278, p. 865-902.

✓ **Beck, M. E., Jr.**, 1984, Introduction to the special issue on correlations between plate motions and Cordilleran tectonics: Tectonics, v. 3, p. 103-6.

✓ **Jurdy, D. M.**, 1984, The subduction of the Farallon plate beneath North America as derived from relative plate motions: Tectonics, v. 3, p. 107-13.

✓ **Engebretson, D. C., Cox, A., and Thompson, G. A.**, 1984, Correlation of plate motions with continental tectonics: Laramide to Basin-Range: Tectonics, v. 3, p. 115-119.

✓ **Henderson, L. J., Gordon, R. G., and Engebretson, D. C.**, 1984, Mesozoic aseismic ridges on the Farallon plate and southward migration of shallow subduction during the Laramide orogeny: Tectonics, v. 3, p. 121-132.

✓ **Page, B. M., and Engebretson, D. C.**, 1984, Correlation between the geologic record and computed plate motions for central California: Tectonics, v. 3, p. 133-155.

Engebretson, D. C., Gordon, Rk. G., and Cox, A., 1985, Relative motions between oceanic and continental plates in the Pacific basin: GSA Spec. Paper 206, 59 p.

Mesozoic and Cenozoic tectonic slivering of the continental margin

✓ **Jarrard, R. D.**, 1986, Terrane motion by strike-slip faulting of forearc slivers: Geology, v. 14, p. 780-783.

Cowan, D. S., 1982, Geological evidence for post-40 m.y.B.P. large-scale northwestward displacement of part of southeastern Alaska: Geology, v. 10, p. 309-313. *Review Cowan, Johnson, Davis & Plafker collectively.*

Johnson, S. Y., 1984, Evidence for a margin-truncating transcurrent fault (pre-late Eocene) in western Washington: Geology, v. 12, p. 538-541.

Davis, A. S., and Plafker, George, 1986, Eocene basalts from the Yakutat terrane: evidence for the origin of an accreting terrane in southern Alaska: Geology, v. 14, p. 963-966.

✓ **Wells, R. E., Engebretson, D. C., Snavely, P. D., Jr., and Coe, R. S.**, 1984, Cenozoic plate motions and the volcano-tectonic evolution of western Oregon and Washington: Tectonics, v. 3, p. 275-294.

Beck, M. E., Jr., 1984, Has the Washington-Oregon Coast Range moved northward?: Geology, v. 12, p. 737-740.

Heller, P. L., Tabor, R. W., and Suczek, C. A., 1987, Paleogeographic evolution of the United States Pacific Northwest during Paleogene time: Can. Jour. Earth Sciences, v. 24, p. 1652-1667. QE 1 C158

✓ **Davis, G. A., Monger, J. W. H., and Burchfiel, B. C.**, 1978, Mesozoic construction of Cordilleran "collage"... : Mes. Vol., SEPM, **p. 25-28 only.**

✓ *Gabrielse, H.*, 1985, Major dextral transcurrent displacements along the Northern Rocky Mountain Trench and related lineaments in north-central British Columbia: Geol. Soc. America Bull., v. 96, p. 1-14.

Brown, E. H., 1987, Structural geology and accretionary history of the Northwest Cascades system, Washington and British Columbia: GSA Bull., v. 99, p. 201-14.

Brown, E. H., and Blake, M. C., Jr., 1987, Correlation of Early Cretaceous blueschists in Washington, Oregon, and northern California: Tectonics, v. 6, p. 795-806.

✓ **Beck, M. E., Jr.**, 1986, Model for late Mesozoic-early Tertiary tectonics of coastal California and western Mexico and speculations on the origin of the San Andeas fault: Tectonics, v. 5, p. 49-64.

Umhoefer, P. J., 1987, Northward translation of "Baja British Columbia" along the late Cretaceous to Paleocene margin of western North America: Tectonics, v. 6, p. 377-394.

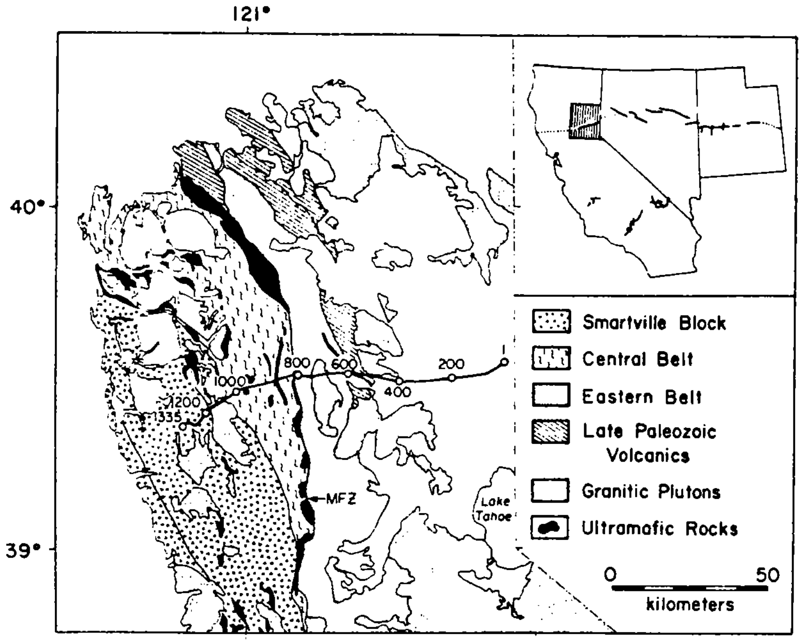


Fig. 1. Generalized geologic map of the northern Sierra showing location of COCORP profile and its relation to major geologic terranes in the region. MFZ - Melones fault zone. Inset map shows location of COCORP profiles in the western U.S.

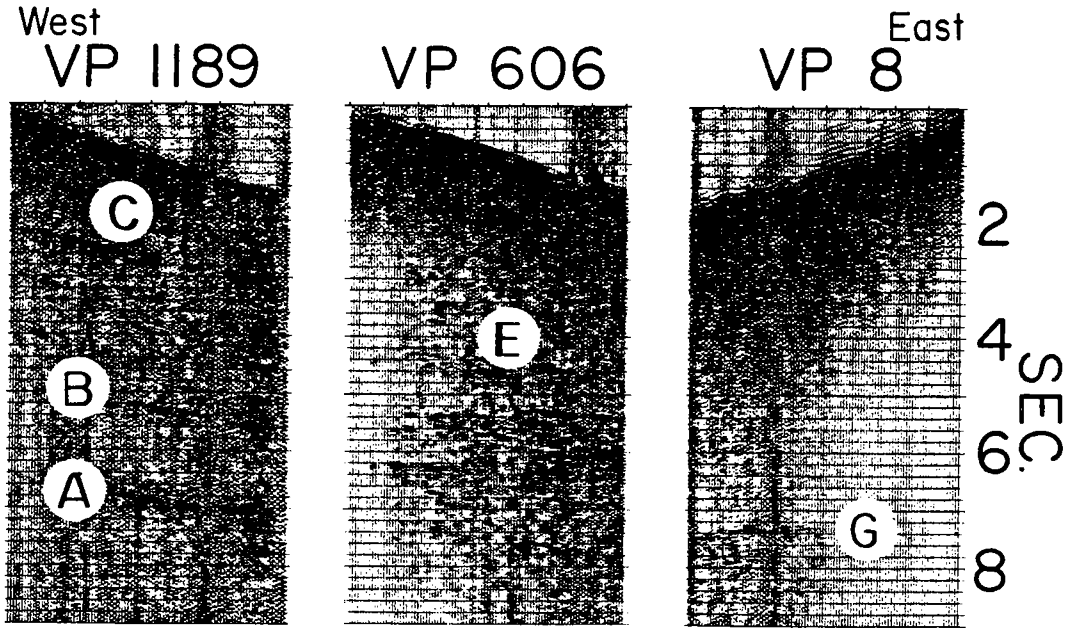


Fig. 4. Individual VP files, section scaled, no automatic gain control. Letters correspond to features shown in Figure 2 and discussed in the text.

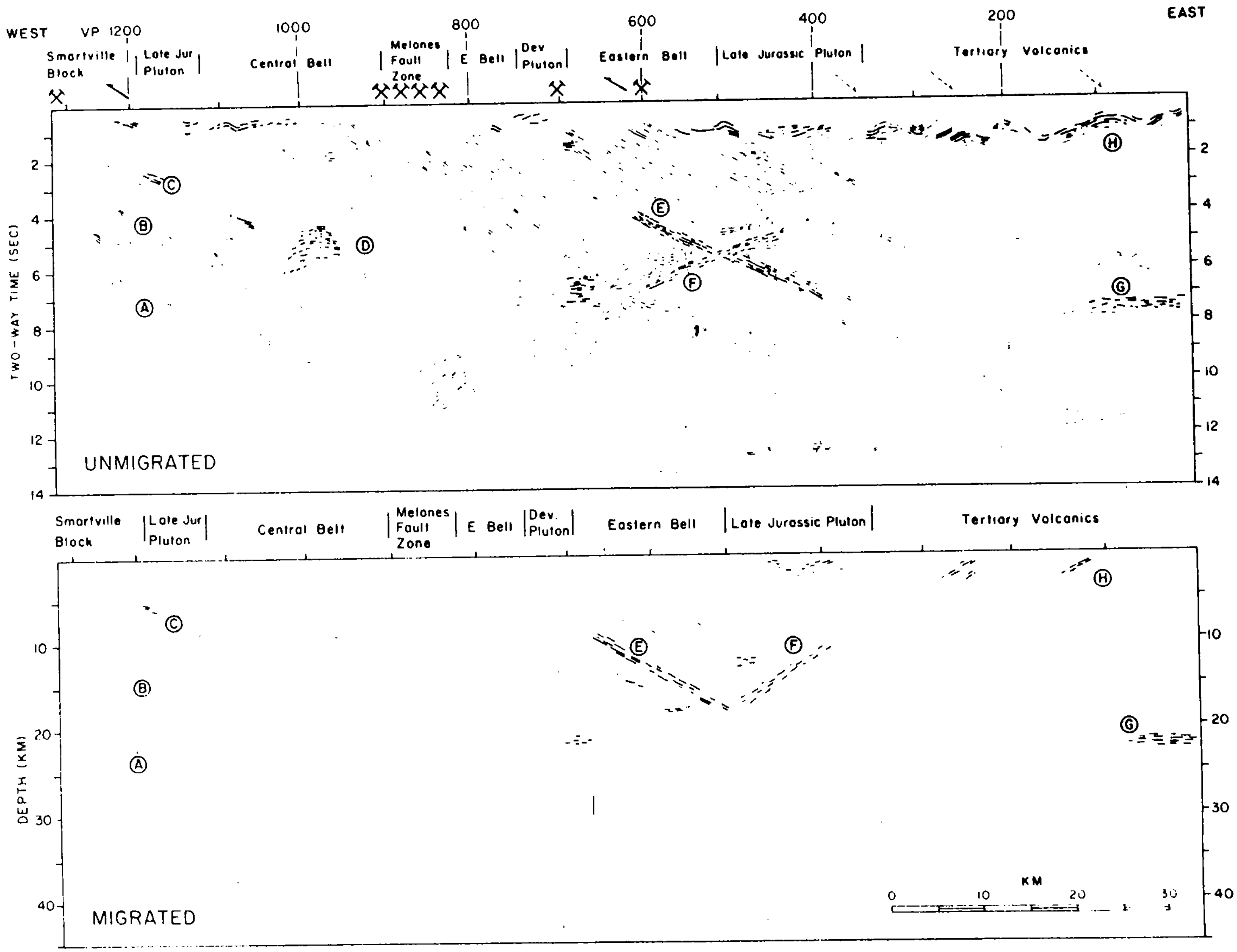
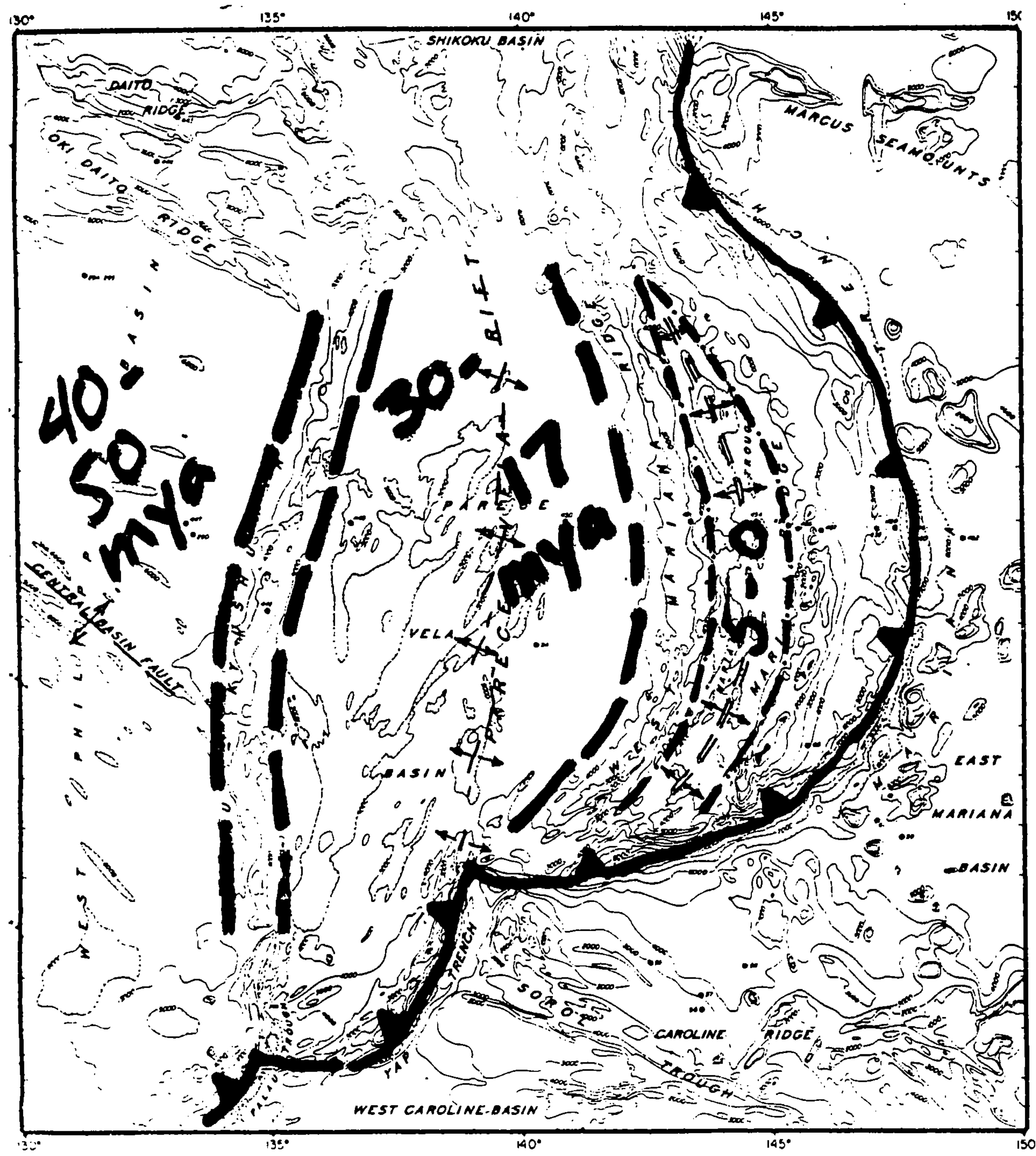


Fig. 2. (top) Line drawing of the upper 14 s of the COCORP Sierra profile (unmigrated). The figure is approximately 1:1 assuming an average crustal velocity of 6 km/s. The line weights illustrate schematically the relative prominence of reflections as seen on the seismic section. (Bottom) Line drawing of COCORP Sierra profile after migration and depth conversion. Figure is 1:1 (see text for discussion).



ıg. 1. Bathymetric map of the eastern Philippine Sea, simplified from map of Mammerickx et al. [54]. Major morphological atures and DCDP sites have been labelled. The position of the Parece Vela Rift has been plotted from topographic profiles ong ship tracks. Bathymetric contours are in meters.

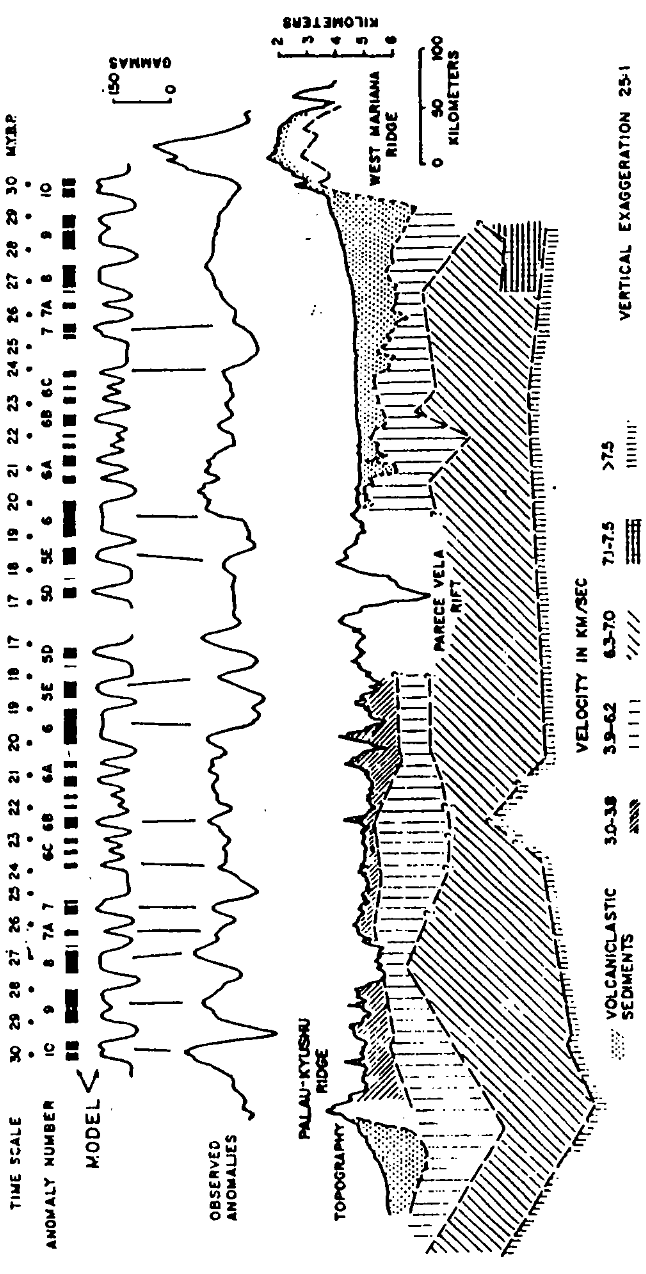
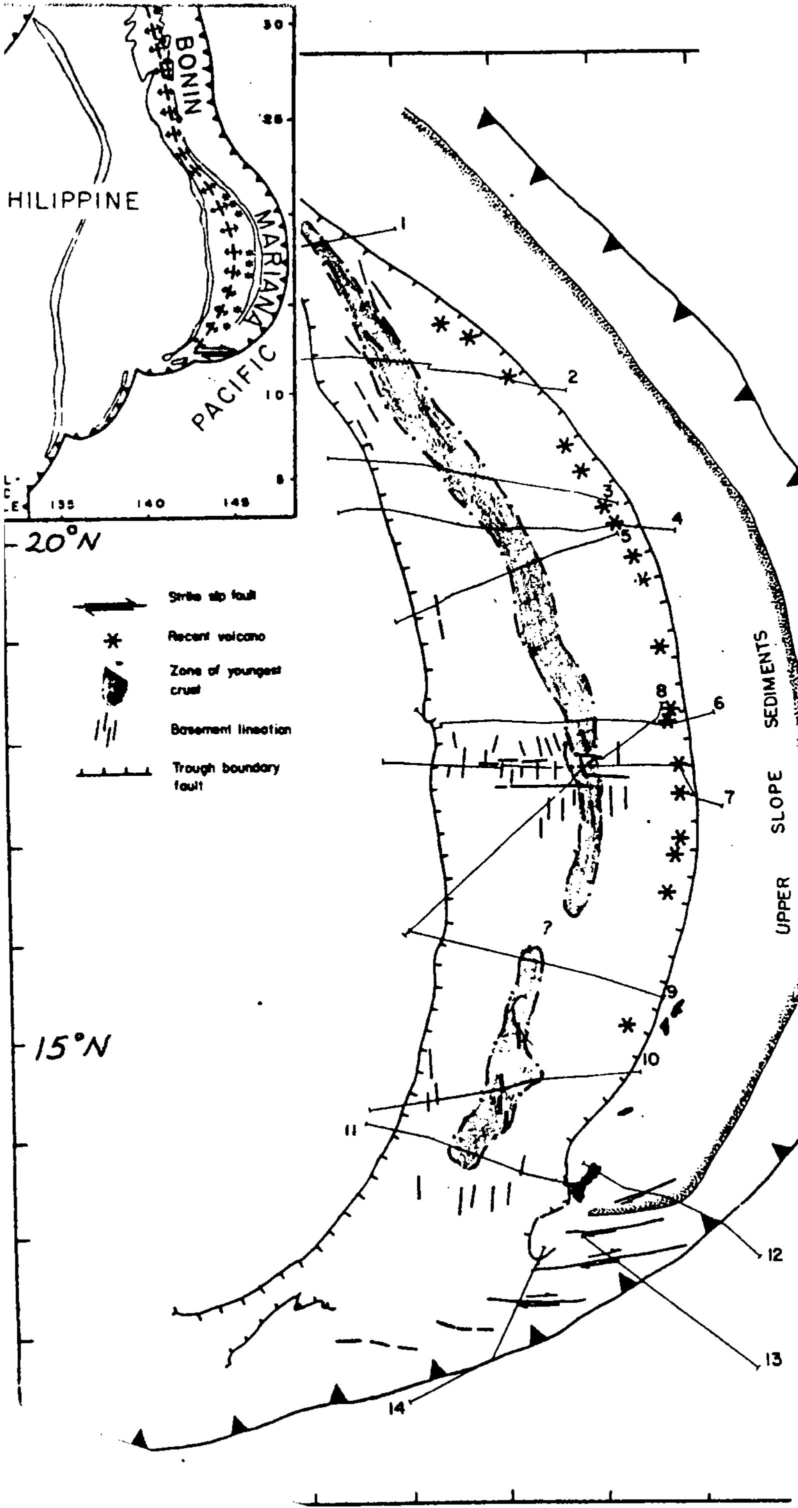


Fig. 10. Magnetic anomaly profile, topography and crustal structure at 18°N. Note lack of correlation between topography and observed anomalies. Also shown are a proposed magnetic block model and computed anomalies. Model parameters are: magnetization contrast = 0.015 emu/cm^3, magnetic layer thickness = 500 m, depth to magnetic layer = 5 km, $I_0 = 20°$, $D_0 = 0°$, I_R = 24.8°, D_R = 0, half-spreading rate = 2.9 cm/year, except for period 24–25 m.y. B.P. where half-spreading rate = 2.0 cm/year. The rate change was used to improve the model fit and may or may not be physically meaningful. Crustal section based on data presented in Fig. 6a and 6b and Table 1, and on L–DGO MCS profiles.

Mrozowski, C. L., and Hayes, D. E., 1979, The evolution of the Parece Vela Basin, eastern Philippine Sea:
E. P. S. L., v. 46, p. 49-67.

11 FEB 88

Karig, D. E., Anderson, R. N., and Bibee, L. D., 1978, Characteristics of back arc spreading in the Mariana trough: J. G. R., v. 83, 1213-26.



-- of the Mariana Trough and location

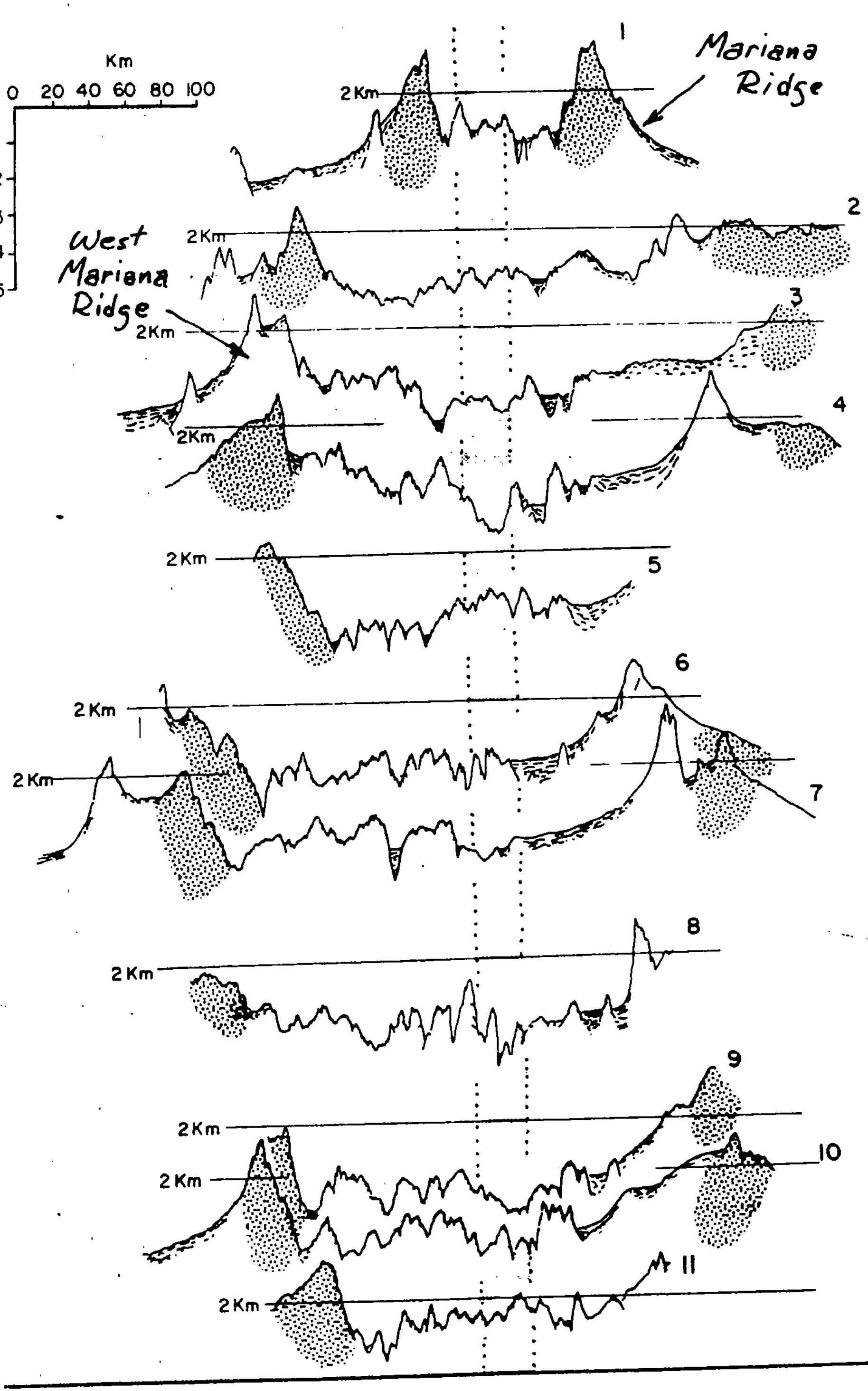
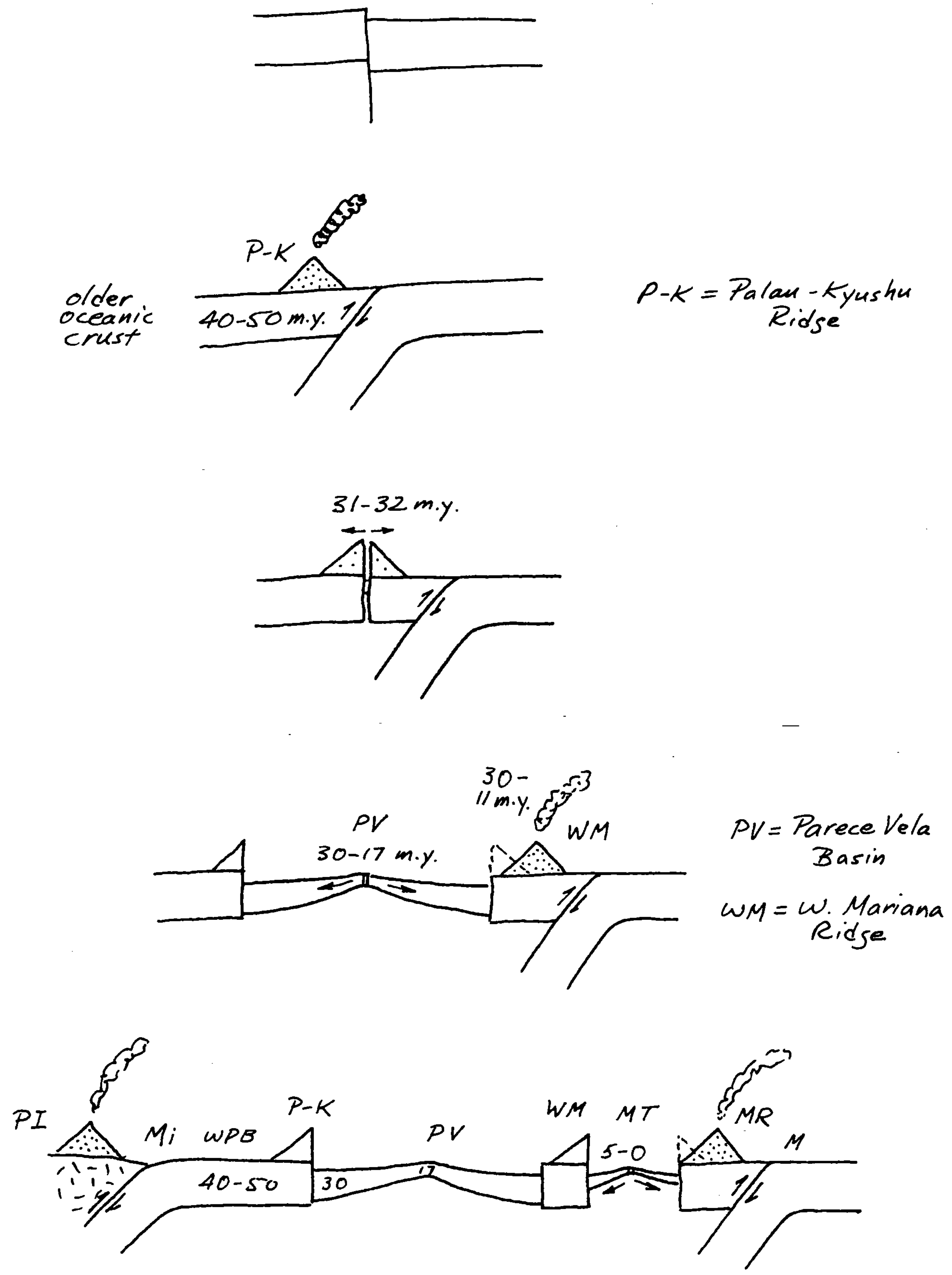


Fig. 4. Profiles across the Mariana Trough from north (top) to south. Locations are in Figure 3. The original profiles have been reoriented into an east-west plane, and all replotted at the same scale. Profile spacing approximates location in the basin. ... ght to be underlain by frontal arc basement.

11 FEB 80



P-K = Palau-Kyushu Ridge

PV = Parece Vela Basin

WM = W. Mariana Ridge

PI = Philippine Islands
Mi = Mindanao Trench
WPB = W. Philippine Basin
MT = Mariana Trough
MR = Mariana Ridge
M = Mariana Trench

SCHEMATIC REPRESENTATION OF EVENTS LEADING TO THE PRESENT CONFIGURATION (LOWER FIGURE) OF THE PHILIPPINE SEA AREA (AFTER KARIG & OTHERS, 1978; MROZOWSKI AND HAYES, 1979)

GAD, 538, 2/83

ns and forms the
Muskwa Antic-
.973); southeast-
›ut if the antic-
:es form a narrow
ninent peaks that
he Rocky Moun-
On the W is the
omprising more
per Proterozoic
c clastic facies
& Norford 1979;
ntinuity and scale
is developed, and
erse.
Canadian Rockies
›vinces (North &
which is charac-
›hic, stratigraphic
irated by major
ne southern Roc-
s, Front Ranges,
Ranges, but as
northward to the
56°N) the lateral
of each become
iguish, and only
n: the Foothills
E and the undi-
ural subprovince
ust may separate
'oothills subpro-
with the Rocky
s a topographi-
valley with no
il break between
ed contrast with
irge thrusts such
. with displace-
ed in tens of
s of Proterozoic
s against topog-
in composed of

ls, the northern
ountainous fold
litude box and
trata mainly of
), although large
Permian strata
n (Fig. 3). Some
nally associated
omplexes. Simi-
untains subpro-
h the Front and
hanges in struc-
ross the strike,
tructural grain.

KENT

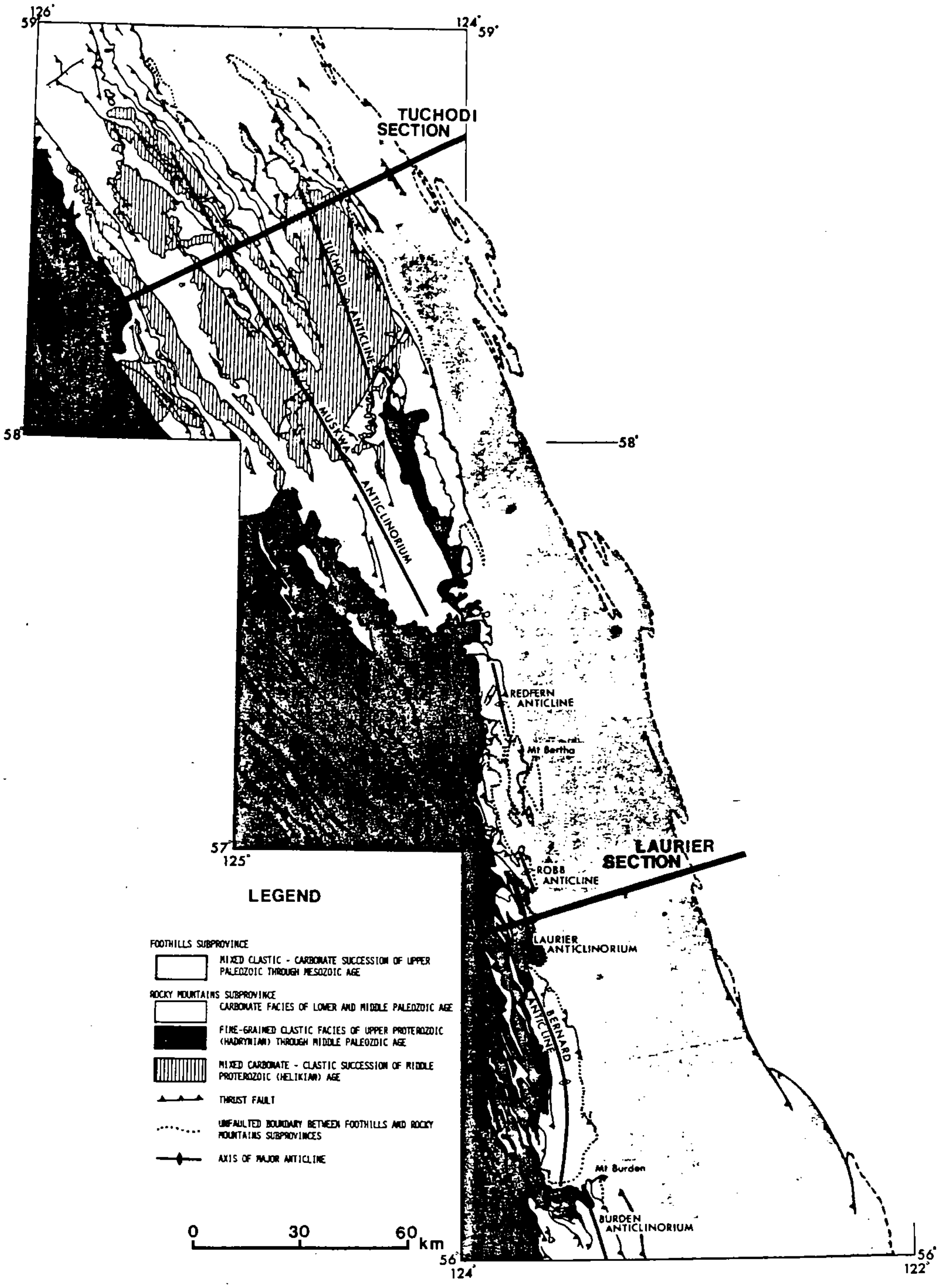
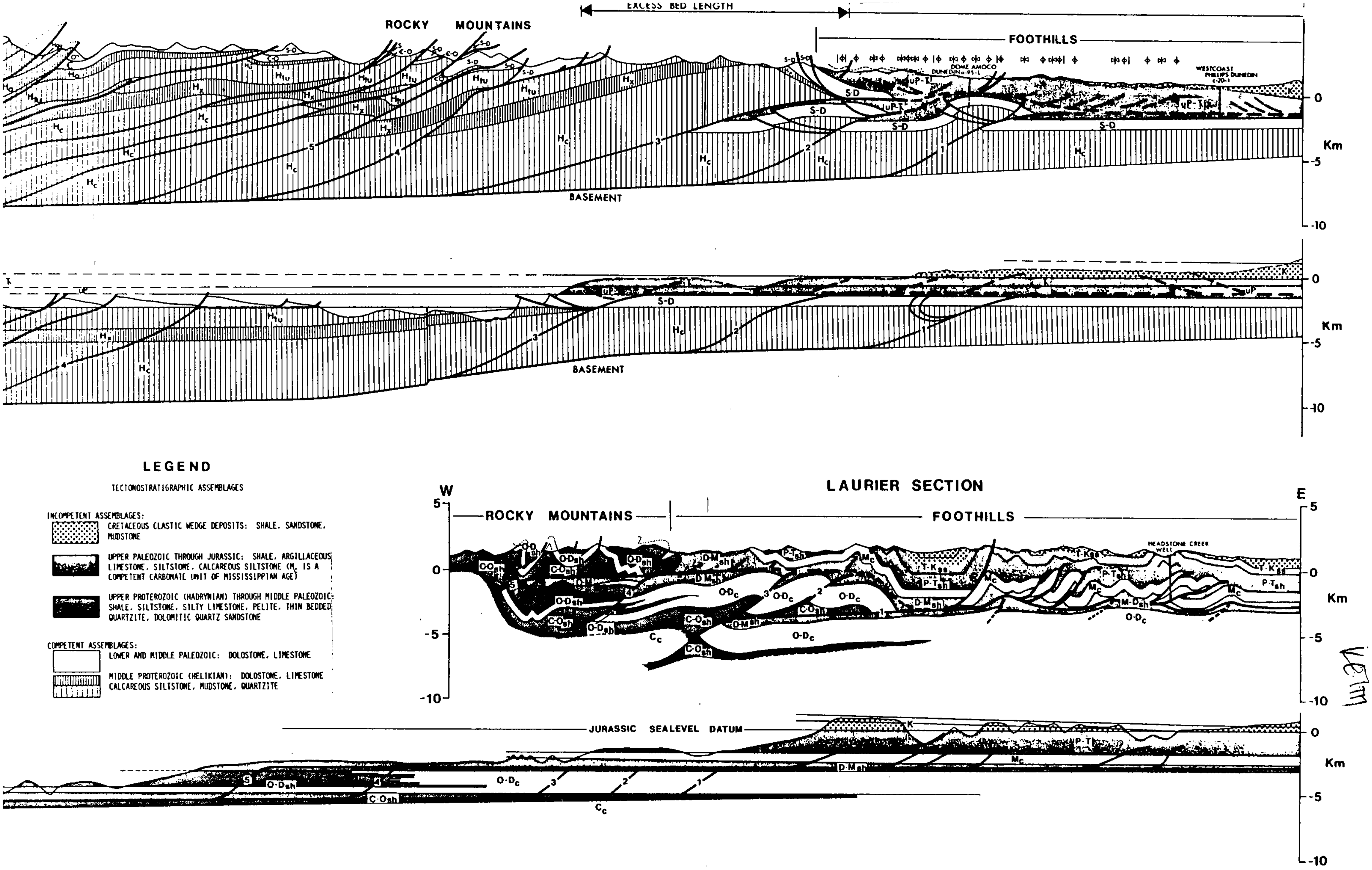


FIG. 2. Generalized tectonic-stratigraphic assemblage map showing the distribution of major thrust faults, the location of major mountain front anticlines, the Muskwa Anticlinorium, and the location of the Laurier and Tuchodi structure cross-sections.



KETM

:hodi and Laurier structure cross-sections (see Fig. 2 for locations). Symbols on the Tuchodi the following stratigraphic units: H_c—Helikian Chischa Fm; H_x—Helikian Tetsa, George and ns.; H_{tu}—Helikian Tuchodi Fm.; H_a—Helikian Aidia Fm.; H_{ga}—Helikian Gataga Fm.; C–O—:ian Kechika Group; S–D—Silurian and Devonian Nonda, Muncho McConnell, Wokkpash, :din Formations; uP-T—Upper Palaeozoic and Triassic Besa River, Kindle, Fantasque, Toad-and Luddington Formations; K-lower Cretaceous Fort St. John Group and Upper Cretaceous Kotaneelee Formations (see Taylor 1973 for stratigraphic descriptions). Symbols on the Laurier section refer to the following stratigraphic units: C_c—Cambrian carbonate unit; C–O_{sh}—Cambro-Ordovician Kechika Group; O–D_{sh}—Ordovician through Devonian unnamed clastic facies; O–D_{sh}—Ordovician through Devonian carbonate facies; O–D_c—Ordovician through Devonian carbonate facies; D–M_{sh}—Devonian and Mississippian Besa River Formation; M_c—Mississippian Prophet Formation; P–T_{sh}—Permian through Triassic Stoddart Group and Toad-Grayling Formation; T–K_{ss}—Triassic through lower Cretaceous Liard, Charlie Lake, Baldonnel, Pardonet Formations and Minnes, Bullhead and Fort St. John Groups (see Thompson 1979, 1976; Irish 1970 for stratigraphic descriptions).

ıns and forms the
Muskwa Antic-
1973); southeast-
ɔut if the antic-
tes form a narrow
ninent peaks that
he Rocky Moun-
On the W is the
comprising more
ɔper Proterozoic
ic clastic facies
& Norford 1979;
ntinuity and scale
ss developed, and
'erse.
Canadian Rockies
ɔvinces (North &
which is charac-
ɔhic, stratigraphic
ırated by major
he southern Roc-
s, Front Ranges,
Ranges, but as
northward to the
56°N) the lateral
of each become
ıguish, and only
in: the Foothills
E and the undi-
ural subprovince
ust may separate
Foothills subpro-
with the Rocky
s a topographi-
valley with no
al break between
ed contrast with
ırge thrusts such
. with displace-
ed in tens of
s of Proterozoic
s against topog-
in composed of

lls, the northern
ountainous fold
litude box and
trata mainly of
), although large
Permian strata
ı (Fig. 3). Some
mally associated
ɔmplexes. Simi-
ıntains subpro-
h the Front and
hanges in struc-
ross the strike,
tructural grain.

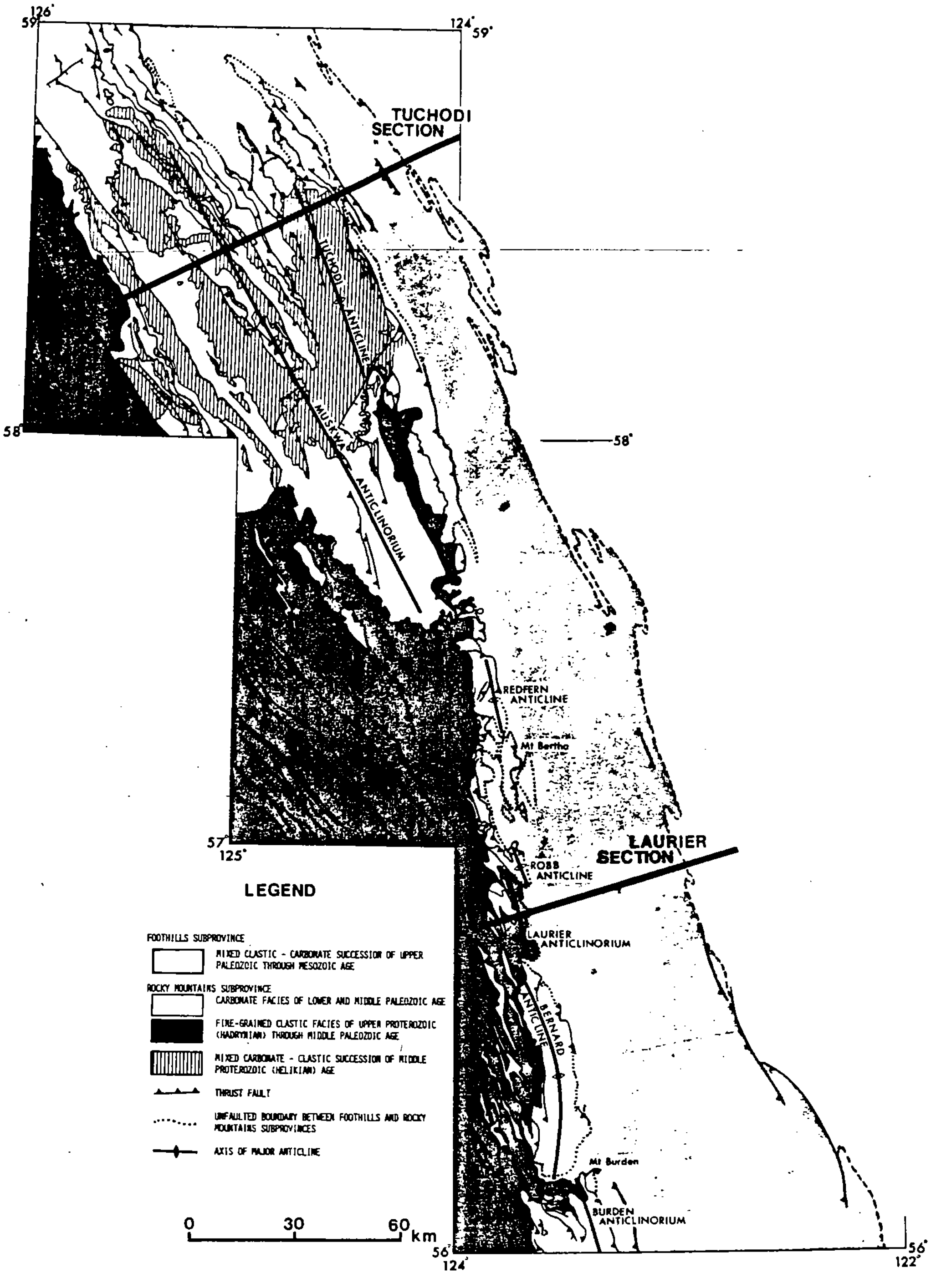
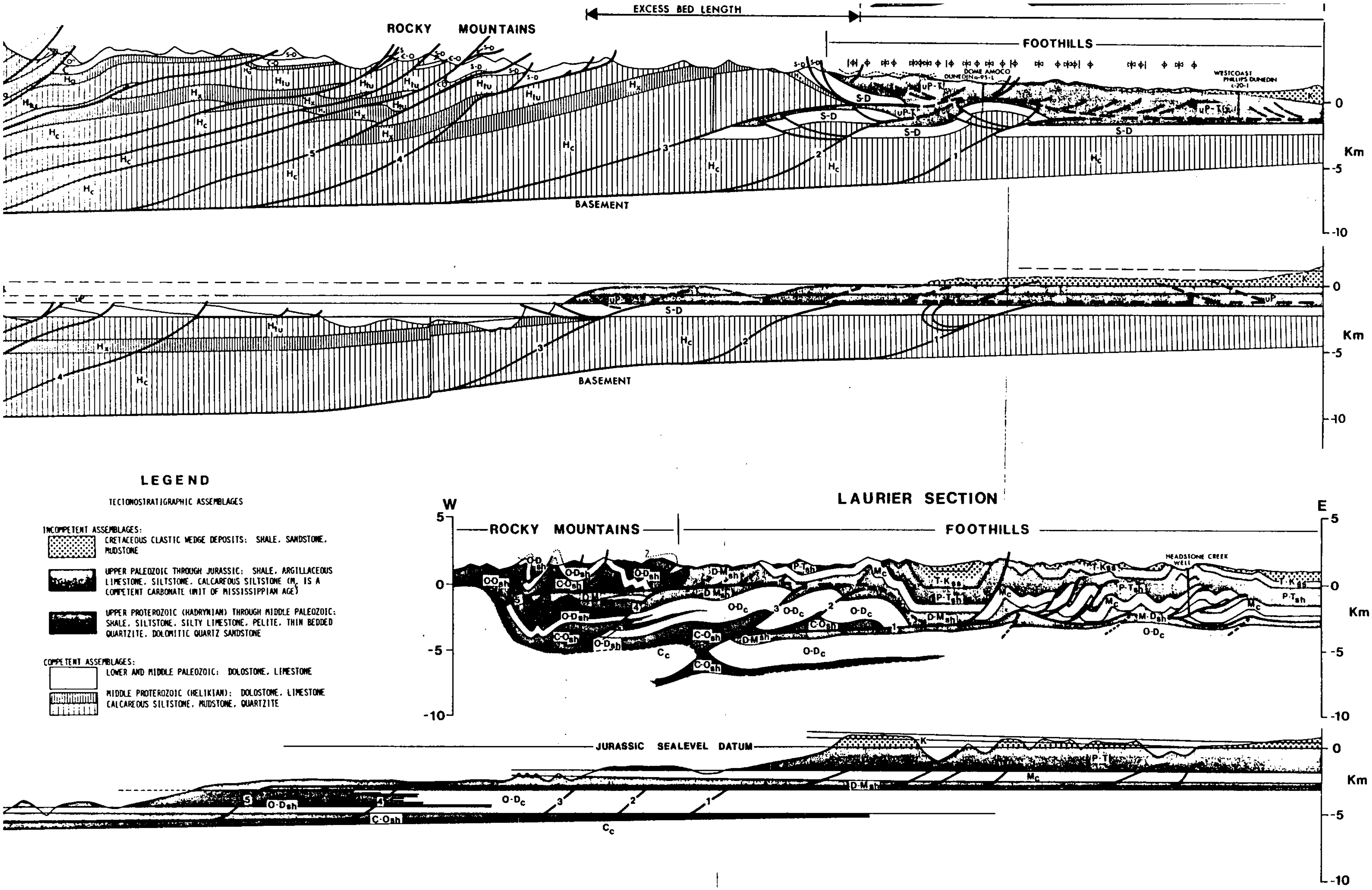


FIG. 2. Generalized tectonic-stratigraphic assemblage map showing the distribution of major thrust faults, the location of major mountain front anticlines, the Muskwa Anticlinorium, and the location of the Laurier and Tuchodi structure cross-sections.



hodi and Laurier structure cross-sections (see Fig. 2 for locations). Symbols on the Tuchodi he following stratigraphic units: H_c—Helikian Chischa Fm; H_x—Helikian Tetsa, George and s.; H_{tu}—Helikian Tuchodi Fm.; H_a—Helikian Aidia Fm.; H_{ga}—Helikian Gataga Fm.; C–O—ian Kechika Group; S–D—Silurian and Devonian Nonda, Muncho McConnell, Wokkpash, din Formations; uP–T—Upper Palaeozoic and Triassic Besa River, Kindle, Fantasque, Toad-nd Luddington Formations; K–lower Cretaceous Fort St. John Group and Upper Cretaceous otanecle Formations (see Taylor 1973 for stratigraphic descriptions). Symbols on the Laurier section refer to the following stratigraphic units: C_c—Cambrian carbonate unit; C–O_{sh}—Cambro-Ordovician Kechika Group; O–D_{sh}—Ordovician through Devonian unnamed clastic facies; O–D_{sh}—Ordovician through Devonian carbonate facies; O–D_c—Ordovician through Devonian carbonate facies; D–M_{sh}—Devonian and Mississippian Besa River Formation; M_c—Mississippian Prophet Formation; P–T_{sh}—Permian through Triassic Stoddart Group and Toad-Grayling Formation; T–K_{ss}—Triassic through lower Cretaceous Liard, Charlie Lake, Baldonnel, Pardonet Formations and Minnes, Bullhead and Fort St. John Groups (see Thompson 1979, 1976; Irish 1970 for stratigraphic descriptions).

Quaternary flake tectonics of the California Transverse Ranges

Robert S. Yeats
Department of Geology, Oregon State University
Corvallis, Oregon 97331

Geology v. 9, pp. 16-20, 1981

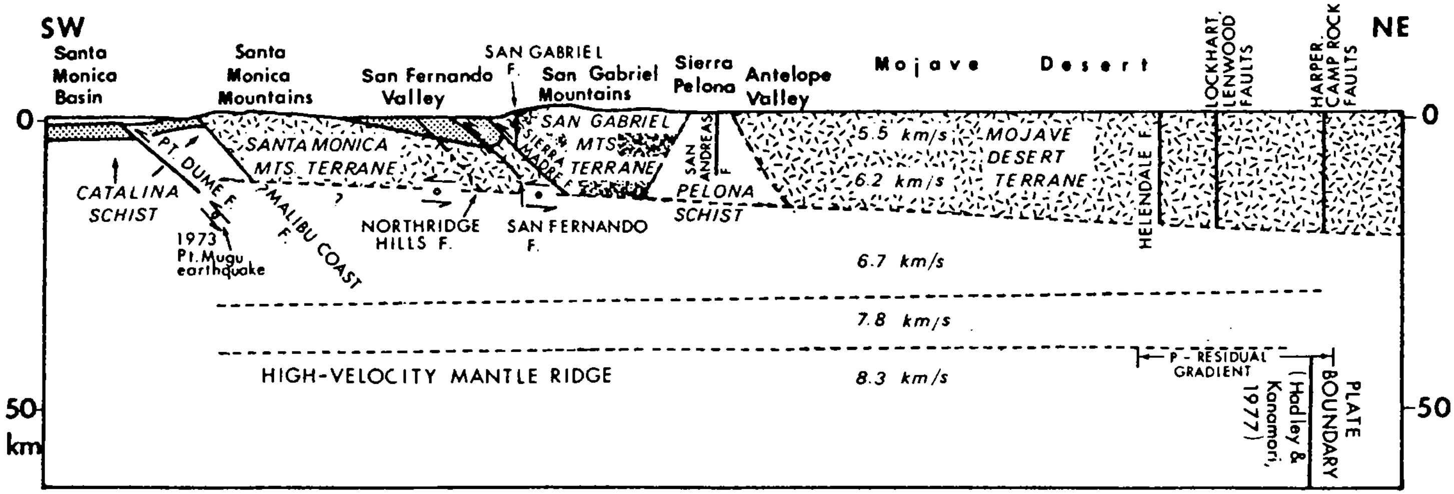
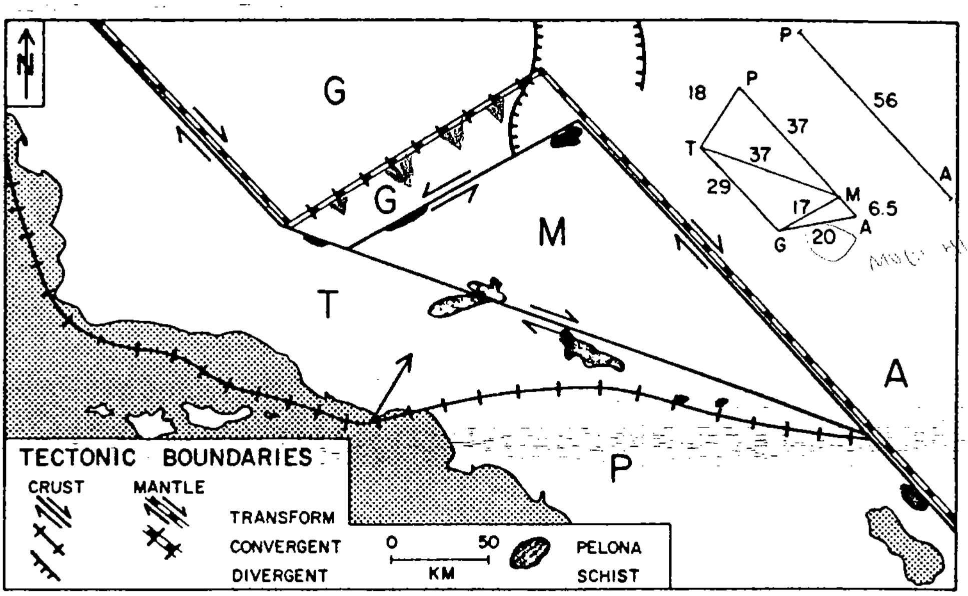


Figure 3. Crustal cross section between Santa Monica Basin and central Mojave Desert. Velocities and location of *P*-residual gradient from Hadley and Kanamori (1977); flat-thrust focal mechanisms below San Fernando Valley and San Gabriel Mountains are diagrammatic representations of data presented by Hadley and Kanamori (1978). Detachment may occur on zone of partial melting, as suggested by Hadley and Kanamori (1977, 1978) or on ductile Pelona and Catalina Schist, as suggested in this paper. No vertical exaggeration.



[illegible]

Figure 4. Flake-tectonics model of Transverse Ranges, with possible velocity diagram for flakes and plates. Pelona Schist distribution from Haxel and Dillon (1978). Simplification of flake geometry from actual fault pattern (see Fig. 1) places Pelona Schist on southwest rather than northeast side of plate boundary in southeast corner of map. Numbers indicate displacements in millimetres per year, based on velocity diagram. Pacific-American plate motion of 56 mm/yr from Minster and Jordan (1978). Letters designate plates and flakes: A, America; G, Great Valley-Sierra; M, Mojave, P, Pacific; T, Transverse Ranges.

Fig. 2. Seismicity (black dots) and focal mechanisms of the Gorda region. Size of dots corresponds to magnitudes of earthquakes. Magnitudes range from 4 to 7. Focal mechanisms are from *Bolt et al.* [1968], *Seeber et al.* [1970], and *Chandra* [1974].

CLOCKRISE ROT OF
JdF PLATE / GORDA PLATE

9-C Rigid Plate Models

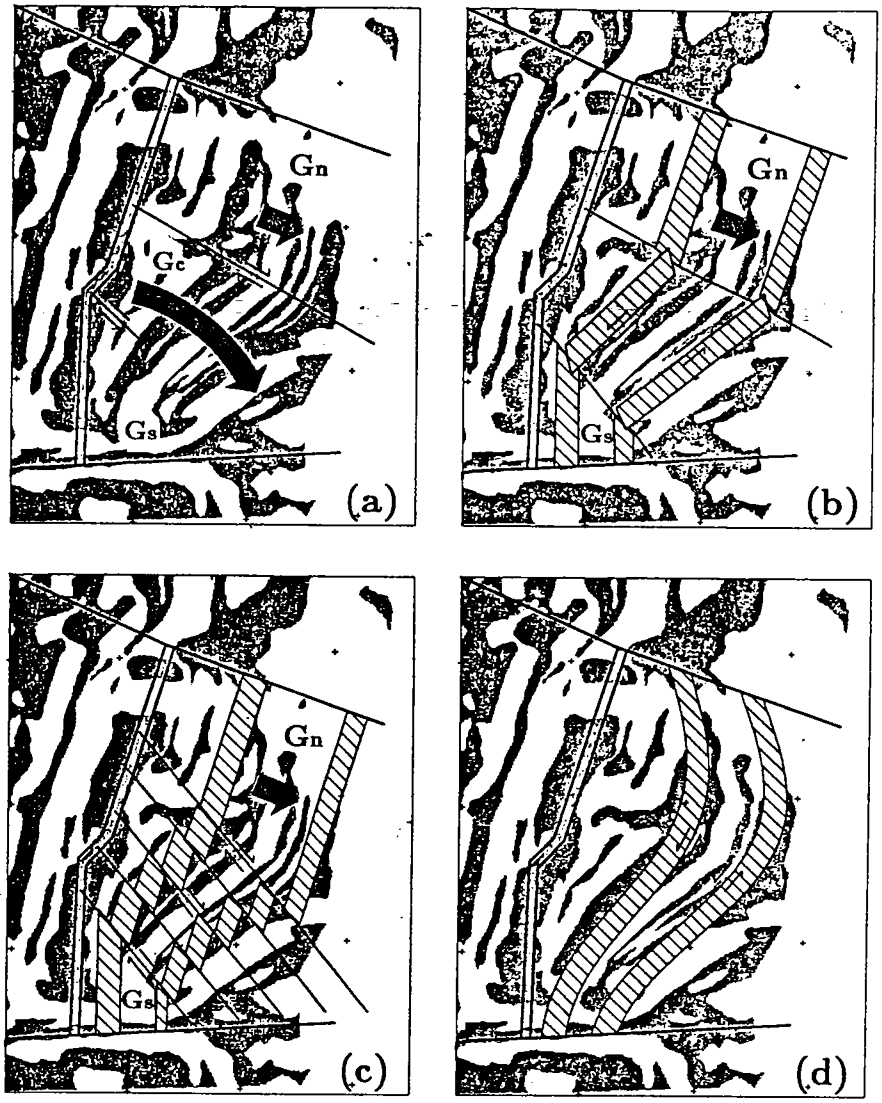


Fig. 3. Proposed deformation models for the Gorda Plate. (*a*) Central rotation model of ***Riddihough*** [1980]. (*b*) Left-lateral shear model [*Knapp*, 1982]. (*c*) Right-lateral shear model [*Bolt et al.*, 1968]. (*d*) Flexural-slip buckle model [*Silver*, 1971; *Carlson and Stoddard*, 1981].

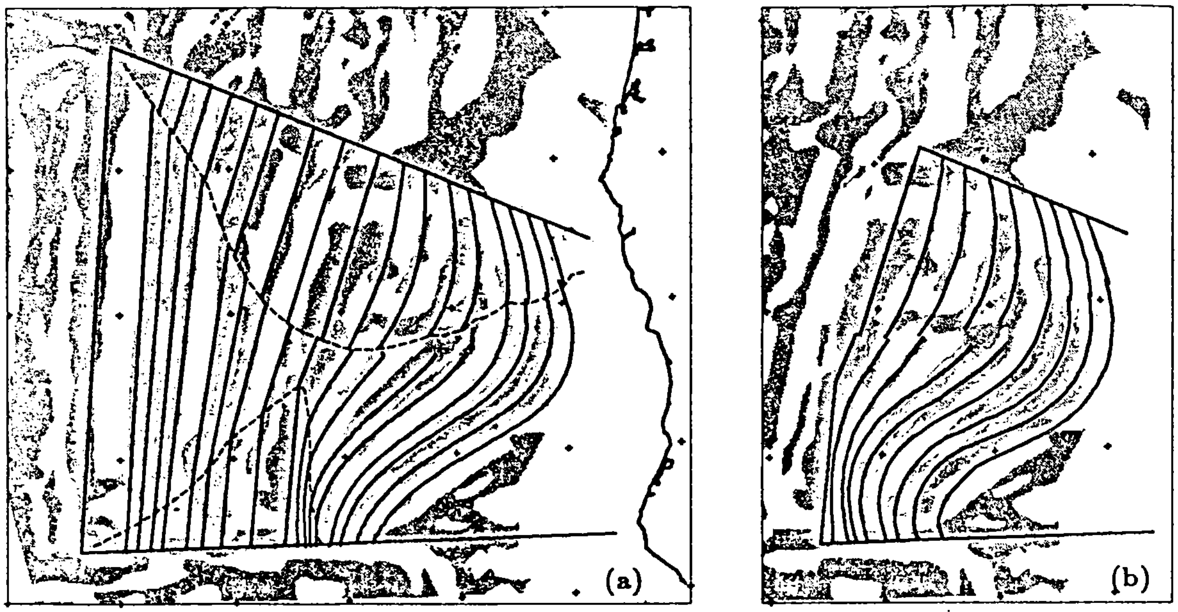


Fig. 7. Comparison of model predictions with observed lineations. (*a*) Convergence at Mendocino transform fault is allowed. Dashed lines indicate propagator wakes. (*b*) No convergence allowed (shortening case). Note that for the southern portion of anomaly 3 (easternmost four lines) there is too much curvature.

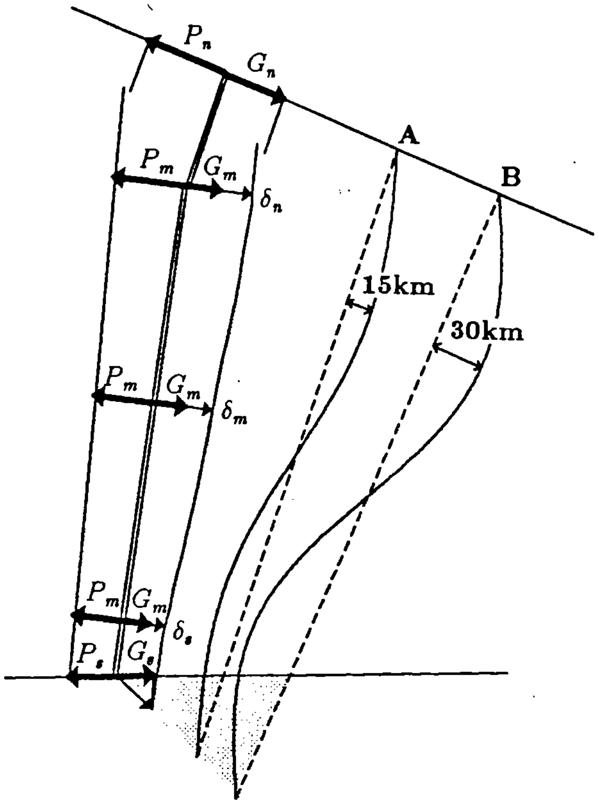


Fig. 6. Schematic diagram of Gorda evolution model. Bold vectors G_n, G_m, and G_s represent velocity of the Gorda block with respect to the northern, middle, and southern segments of the Gorda Rise, respectively. Bold vectors P_n, P_m, and P_s are the velocity vectors for the Pacific plate. Note that velocities decrease southward along the middle segment. Shaded region is "obducted" material. Light vectors δ_n, δ_m, and δ_s are corrections to Gorda-side spreading along the middle segment (see text): $\delta_n = G_n - G_m$, $\delta_s = G_s - G_m$, $\delta_m = (\delta_n + \delta_s)/2$.