LATE MESOZOIC TERRANE ACCRETION IN THE NORTHWESTERN U.S. CORDILLERA: IMPLICATIONS FOR COEVAL 'NON-COLLISIONAL' CONTRACTIONAL OROGENESIS

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SUMMARY

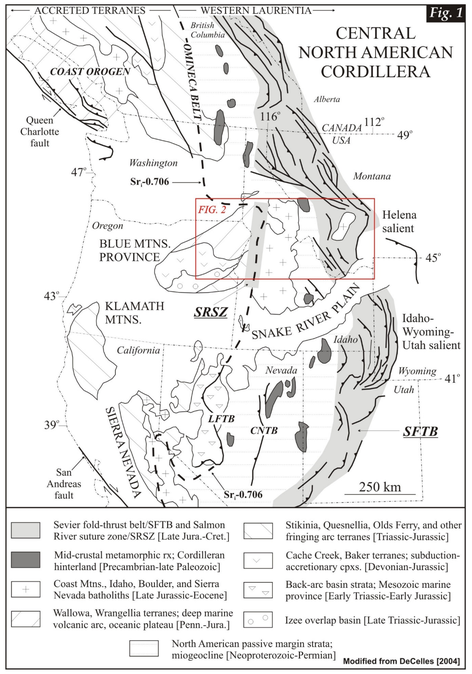
Integrated structural, geochronological, and metamorphic data provide a basis for synthesizing long-lived ~east-west shortening across the Cordilleran orogen [Fig. 1]. In the Riggins region of west-central Idaho, the north- to northeast-striking 25+ km-wide Salmon River suture zone [SRSZ: Lund and Snee, 1988; Gray, 2013; Fig. 2] records Late Jurassic to Early Cretaceous [ca. 145 to 92 Ma] contractional deformation [Table 1]. Although aspects of structural style, degree of strain, and kinematics of deformation differ, temporally overlapping structures [ca. 150 to 90 Ma] occupy the Sevier fold-thrust belt [SFTB] of southeast Idaho, western-most Wyoming, northeastern Nevada, and north-central Utah. With minor exception, east- to southeast-dipping synmetamorphic fabrics [photo montage below] and associated dip-slip fault systems [Pollock Mountain, Rapid River, Heavens Gate; Fig. 3] of the SRSZ are attributed to high-angle collision of the Blue Mountains province [Silberling et al., 1984] with western Laurentia [Fig. 1]. In contrast, ~age-equivalent contractional structures of the SFTB are historically explained by 'non-collisional' ocean-continent plate convergence [e.g., Armstrong, 1968; Burchfiel, 1980; see convergence vectors of Engebretson et al., 1985- Fig. 2 inset]. Given the coeval nature of contraction in the SRSZ and SFTB, initial accretion of the Blue Mountains block coincided with, and possibly initiated, early thrusting in the SFTB [~44º-46ºN latitude?]. Continued ~east-west contraction across the arc—continent boundary [Cordilleran hinterland] and retroarc region east of the Idaho batholith resulted in >300 km of cumulative shortening [DeCelles, 2004; Giorgis et al., 2005]. In this context, Jura-Cretaceous terrane accretion in the hinterland drove easterly-vergent deformation in upper-crustal sedimentary and volcanic rocks of the SFTB. Accordingly, west- to northwest-vergent structures in the SRSZ [i.e., major faults of Riggins region] and associated mid-crustal metamorphic rocks [tectonite fabrics in photos] evolved together with eastward-propagating supracrustal structures of the Sevier orogen. An alternative to non-collisional contractional orogenesis, this tectonic model implies a collision-related origin [initial stage of terrane accretion] and subsequent evolution for part of the SFTB.

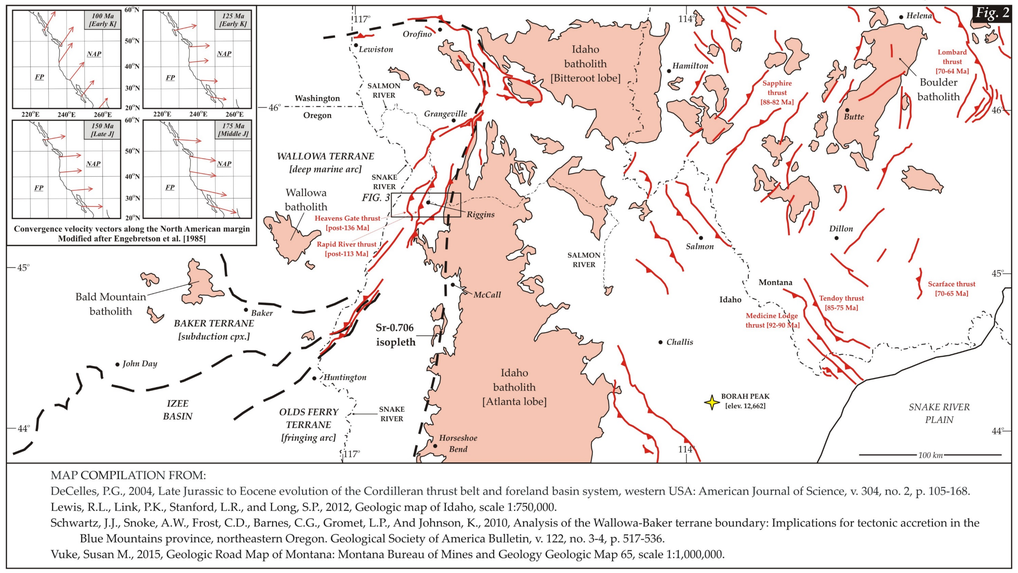
Table 1 LATE JURASSIC TO EARLY CRETACEOUS DEFORMATION, NORTHWESTERN U.S. CORDILLERA

Contractional belt	Age of deformation	Geochronological system	Comments	References
SRSZ: western Idaho	ca. 144 to 124 Ma	Sm-Nd garnet	Pollock Mountain amphibolite; intruded by ca. 118 Ma Hazard Creek complex	Getty et al., 1993; McKay, 2011
	syn- to post-136 Ma	U-Pb zircon	Heavens Gate stock; intrudes Middle/Late Triassic Wild Sheep Creek Fm.*	Gray, 2013; T.L. Vallier, 2012, personal communication*
Includes metamorphic tectonites between the	post-130 Ma	U-Pb zircon	Fish Hatchery stock; intrudes Wild Sheep Creek Fm.*; brittle + ductile fabric	Gray and Isakson, 2016; Sarewitz, 1982*
Heavens Gate fault [Seven Devils Mtns.] and	ca. 120 to 90 Ma	U-Pb zircon	deformed granitoids north of Riggins	McClelland and Oldow, 2007
Crevice pluton area [Salmon River canyon].	pre-118, 109 Ma	Ar-Ar hornblende	Squaw Creek schist; cooling age on lineated amphibole [L1: Gray et al., 2012]	Snee et al., 1995
	syn-118 Ma	U-Pb zircon	Hazard Creek complex; syntectonic emplacement, intrudes PM amphibolite	Manduca et al., 1993
	syn- to post-114 Ma	U-Pb zircon	Hazard Creek complex; Little Salmon River corridor, south of Riggins	Unruh et al., 2008
	syn- to post-111 Ma	Lu-Hf garnet	Berg Creek amphibolite; flattened/rolled [tops-west] garnet porphyroblasts	Wilford, 2012
	post-111 Ma	garnet isograd	Riggins Group; faults of Rapid River thrust system crosscut garnet isograd*	Wilford, 2012; Hamilton, 1969*
	syn-105 Ma	U-Pb zircon	Little Goose Creek complex; north of McCall; centered on Sr-0.706 isopleth	Giorgis et al., 2008
	post-105 Ma	U-Pb zircon	Crevice pluton; Salmon River canyon, east of Riggins; W to E strain gradient	Gray et al., 2012
	syn- to post-92 Ma	U-Pb zircon	Looking Glass pluton; Salmon River canyon; syntectonic emplacement*	Gray et al., 2012; Blake et al., 2009*
	syn-90 Ma	U-Pb zircon	Payette River tonalite; McCall area; syntectonic emplacement	Manduca et al., 1993
	pre-90 Ma	U-Pb zircon	undeformed granitoid; northeast of Riggins	Snee et al., 1995
SFTB: eastern Idaho, Wyoming, Nevada, Utah	ca. 153 to 144 Ma	K-Ar biotite, hornblende	northwest Utah [Newfoundland Mtns.], northeast Nevada [central Ruby Mtns.]*	Allmendinger and Jordan, 1984; Miller and Gans, 1989; Hudec, 1992*
	ca. 146 Ma	apatite fission track	central Utah [Canyon Range thrust]	Stockli et al., 2001
Includes metamorphic tectonites of Cordilleran	ca. 145 to 140 Ma	Ar-Ar muscovite; K-Ar illite	northeast Utah [Williard thrust]; eastern Idaho, northern Utah	Burtner and Nigrini, 1994
hinterland [DeCelles, 2004] and supracrustal	pre-128 Ma	Ar-Ar hornblende	northeast Nevada [Ruby Mtns., East Humboldt Range]; metamorphic core cpx.	Dallmeyer et al., 1986
sedimentary and volcanic rocks of foreland.	ca. 120 Ma	stratigraphic	central and southwestern Utah [e.g., Pavant thrust]	DeCelles et al., 1995; Mitra, 1997
	ca. 115 to 110 Ma	stratigraphic	southeast Idaho, west-central Utah [Meade thrust]	DeCelles et al., 1993; Mitra, 1997
	ca. 100 Ma	stratigraphic	southwest Montana [Lewis and Clark line/fault system]	Wallace et al., 1990
	ca. 95 Ma	stratigraphic	north-central Utah [Wasatch Range]	Yonkee, 1992
	ca. 92 to 90	stratigraphic	southeast Idaho, southwest Montana [Medicine Lodge thrust]	Schmitt et al., 1995
	ca. 90 to 84 Ma	fission track, stratigraphic	north-central Utah, southwestern Wyoming [Crawford thrust]	Burtner and Nigrini, 1994; DeCelles, 1994
	ca. 88 to 75 Ma	stratigraphic	southwest Montana [Tendoy and Sapphire thrusts]	Schmitt et al., 1995
	ca. 74 to 59 Ma	K-Ar, stratigraphic	southwest Montana [Lewis, Eldorado, Hoadley thrusts]	Sears, 2001

STRUCTURAL FABRICS OF SRSZ

Polished slabs shown below are derived from arc-continent [A-C] boundary transect of Gray [2013]; see Figure 3 for corresponding field locations. Slabs #3-22 are cut perpendicular to synmetamorphic foliation, and oriented such that observer looks northerly along foliation strike. Samples #3, 4, 5: hanging wall, Heavens Gate fault; Sample #6: hanging wall, Morrison Ridge fault; Samples #7-15: hanging wall, Rapid River thrust; Sample #16: hanging wall, Pollock Mountain thrust; Samples #17, 18, 19, 21: intrusive rocks along A-C boundary. Previous workers attribute fabrics in #13-21 to the western Idaho shear zone [Blake et al., 2009; Kauffman et al., 2014].





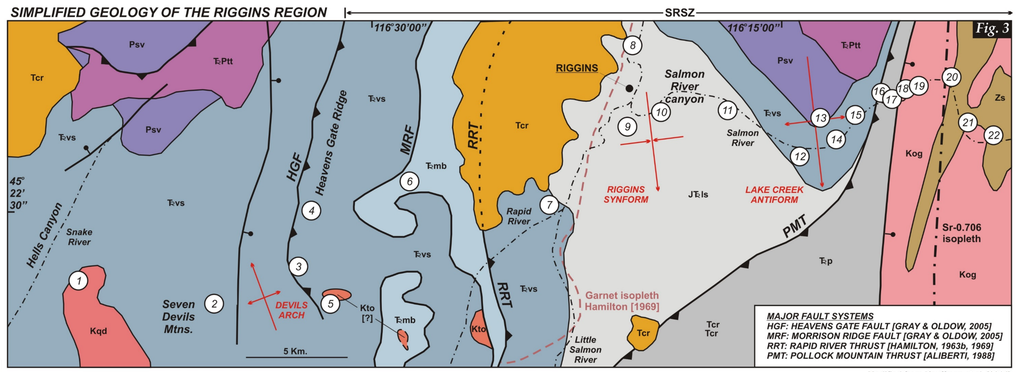
MAP COMPILATION FROM:

DeCelles, P.G., 2004, Late Jurassic to Eocene evolution of the Cordilleran thrust belt and foreland basin system, western USA: American Journal of Science, v. 304, no. 2, p. 105-168.

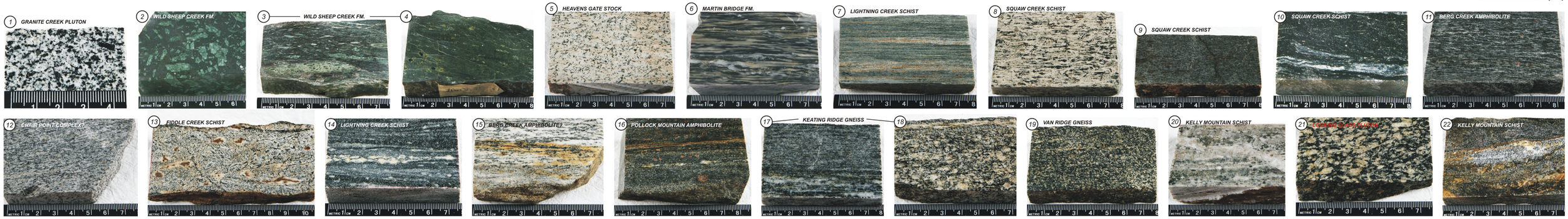
Lewis, R.L., Link, P.K., Stanford, L.R., and Long, S.P., 2012, Geologic map of Idaho, scale 1:750,000.

Schwartz, J.J., Snoke, A.W., Frost, C.D., Barnes, C.G., Gromet, L.P., And Johnson, K., 2010, Analysis of the Wallowa-Baker terrane boundary: Implications for tectonic accretion in the Blue Mountains province, northeastern Oregon. Geological Society of America Bulletin, v. 122, no. 3-4, p. 517-536.

Vuke, Susan M., 2015, Geologic Road Map of Montana: Montana Bureau of Mines and Geology Geologic Map 65, scale 1:1,000,000.



Modified from Kauffman et al. [2014]



REFERENCES

Allmendinger, R.W., and Jordan, T.E., 1984, Mesozoic structure of the Newfoundland Mountains, Utah: Horizontal shortening and subsequent extension in hinterland of the Sevier belt: GSA-B, v. 95, no. 11, p. 1280-1292.

Blake, D.E., Gray, K.D., Giorgis, S., and Tikoff, B., 2009, A tectonic transect through the Salmon River suture zone along the Salmon River Canyon in the Riggins region of west-central Idaho: Geologic Field Trips through the Dynamic Landscape of the Pacific Northwest: Geological Society of America Field Guide 15, p. 345-372.

Burtner, R.L., and Nigrini, A., 1994, Thermochronology of the Idaho-Wyoming thrust belt during the Sevier orogeny: A new, calibrated, multi-process thermal model: AAPG Bulletin, v. 78, no. 10, p. 1586-1612.

Dallmeyer, R.D., Snoke, A., and McKee, E.H., 1986, Mesozoic-Cenozoic tectonothermal evolution of Ruby Mountains, East Humboldt Range, Nevada: A Cordilleran metamorphic core complex: Tectonics, v. 5, no. 6, p. 931-954.

DeCelles, P.G., 2004, Late Jurassic to Eocene evolution of the Cordilleran thrust belt and foreland basin system, western USA: American Journal of Science, v. 304, no. 2, p. 105-168.

DeCelles, P.G., 1994, Late Cretaceous-Paleocene synorogenic sedimentation and kinematic history of Sevier thrust belt, northeast Utah and southwest Wyoming: GSA-B, v. 106, no. 1, p. 32-56.

DeCelles, P.G., Pile, H.T., and Coogan, J.C., 1993, Kinematic history of the Meade thrust based on provenance of the Bechler conglomerate at Red Mountain, Idaho, Sevier thrust belt: Tectonics, v. 12, no. 6, p. 436-450.

DeCelles, P.G., Lawton, T.F., and Mitra, G., 1995, Thrust timing, growth of structural culminations, and synorogenic sedimentation in the type Sevier orogenic belt, western United States: Geology, v. 23, no. 8, p. 699-702.

Engebretson, D.C., Cox, A., and Gordon, R.G., 1985, Relative motions between oceanic and continental plates in the Pacific basin: Geological Society of America Special Paper 206, 59 p.

Getty, S.R., Selverstone, J., Wernicke, B.P., Jacobsen, S.B., Aliberti, E.A., and Lux, D.R., 1993, Sm-Nd dating of multiple garnet growth events in an arc-continent collision zone, northwest US Cordillera: Contributions to Mineralogy and Petrology, v. 115, p. 45-57.

Giorgis, S., McClelland, W., Fayon, A., Singer, B.S., and Tikoff, B., 2008, Timing of deformation and exhumation in the western Idaho shear zone, McCall, Idaho: Geological Society of America Bulletin [GSA-B], v. 70, p. 1119-1133.

Gray, K.D., 2013, Structure of the arc-continent transition in the Riggins region of west-central Idaho: Strip maps and structural sections: Idaho Geological Survey, Technical Report 13-1, scale 1:24,000, 2 plates.

Gray, K.D., and Oldow, J.S., 2005, Contrasting structural histories of the Salmon River belt and the Wallowa terrane: implications for terrane accretion in northeastern Oregon and west-central Idaho: GSA-B, v. 117, p. 687-706.

Gray, K.D., and Isakson, V.H., 2016, Age, setting, and tectonic significance of the Fish Hatchery stock: lower Rapid River canyon, west-central Idaho: Geological Society of America *Abstracts with Programs*, v. 48, no. 6.

Gray, K.D., Watkinson, A.J., Gaschnig, R.M., and Isakson, V.H., 2012, Age and structure of the Crevice pluton: over-lapping orogens in west-central Idaho? Canadian Journal of Earth Sciences, v. 49, no. 6, p. 709-731.

Hamilton, W. 1969, Reconnaissance geologic map of the Riggins quadrangle, west-central Idaho: USGS Miscellaneous Geologic Investigations Map I579, scale 1:250,000.

Hudec, M.R., 1992, Mesozoic structural and metamorphic history of the central Ruby Mountains metamorphic core complex, Nevada: GSA-B, v. 104, no. 9, p. 1086-1100.

Kauffman, J. D., Schmidt, K. L., Lewis, R. S., Stewart, D.E., Othberg, K. L., and Garwood, D. L. 2014, Geologic map of the Idaho part of the Grangeville 30x60 minute quadrangle, and adjoining areas of Washington and Oregon: Idaho Geological Survey, Geologic Map 50, scale 1:100,000.

Manduca, C.A., Kuntz, M.A., and Silver, L.T., 1993, Emplacement and deformation history of the western margin of the Idaho batholith near McCall, Idaho: Influence of a major terrane boundary: GSA-B, v. 105, p. 749-765.

McClelland, W.C., and Oldow, J.S., 2007, Late Cretaceous truncation of western Idaho shear zone in the central North American Cordillera: Geology, v. 35, p. 723-726.

McKay, M.P., 2011, Pressure-temperature-time paths, prograde garnet growth, and protolith of tectonites from a polydeformational, polymetamorphic terrane: Salmon River suture zone, west-central Idaho [M.S. thesis]: Tuscaloosa, University of Alabama, 135 p.

Miller, E.L., and Gans, P.B., 1989, Cretaceous crustal structure and metamorphism in the hinterland of the Sevier thrust belt, western US Cordillera: Geology, v. 17, no. 1, p. 59-62.

Mitra, G., 1997, Evolution of salients in fold-and-thrust belt: effects of sedimentary basin geometry, strain distribution and critical taper: *In* Evolution of Geological Structures, Micro-to Macro-scales, p. 59-90, Springer Netherlands.

Schmitt, J.G., Haley, J.C., Lageson, D.R., Horton, B.K., and Azevedo, P.A., 1995, Sedimentology and tectonics of the Bannack-McKnight Canyon-Red Butte area, southwest Montana: new perspectives on the Beaverhead Group and Sevier orogenic belt: Northwest Geology, v. 24, p. 245-313.

Sears, J.W., 2001, Emplacement and denudation history of Lewis-Eldorado-Hoadley thrust slab in northern Montana Cordillera, USA: Implications for steady-state orogenic processes: American J. of Sci., v. 301, no. 4-5, p. 359-373.

Silberling, N.J., Jones, D.L., Blake, M.C., Jr., and Howell, D.G., 1984, Lithotectonic terrane map of the western conter-minous US, Pt. C.: Lithotectonic terrane maps of N. American Cordillera: USGS Open-File Report 84-523, 43 p.

Snee, L.W., Lund, K., Sutter, J.F., Balcer, D.E., and Evans, K.V., 1995, An 40Ar/39Ar chronicle of tectonic development of the Salmon River suture zone, western Idaho: USGS Professional Paper 1438, p. 271-304.

Stockli, D.F., Linn, J.K., Walker, J.D., and Dumitru, T.A., 2001, Miocene unroofing of Canyon Range during extension along the Sevier Desert Detachment, west central Utah: Tectonics, v. 20, no. 3, p. 289-307.

Unruh, D. M., Lund, K., Kuntz, M.A., and Snee, L.W., 2008, Uranium-lead zircon ages and Sr, Nd, and Pb isotope geochemistry of selected plutonic rocks from western Idaho: USGS Open-File Report 2008-1142, p. 137.

Wallace, C.A., Lidke, D.J., and Schmidt, R.G., 1990, Faults of central part of Lewis-Clark line and fragmentation of the Late Cretaceous foreland basin in west-central Montana: GSA-B, v. 102, no. 8, p. 1021-1037.

Wells, M.L., Dallmeyer, R.D., and Allmendinger, R.W., 1990, Late Cretaceous extension in hinterland of the Sevier thrust belt, northwestern Utah and southern Idaho: Geology, v. 18, no. 10, p. 929-933.

Wilford, D., 2012, Lu-Hf geochronology of the Salmon River suture zone, west-central Idaho [M.S. thesis]: Pullman, Washington State University, 97 p.

Yonkee, W.A., 1992, Basement-cover relations, Sevier orogenic belt, northern Utah: GSA-B, v. 104, no. 3, p. 280-302.

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