

Tectonic Elements and Evolution of Northwest Washington

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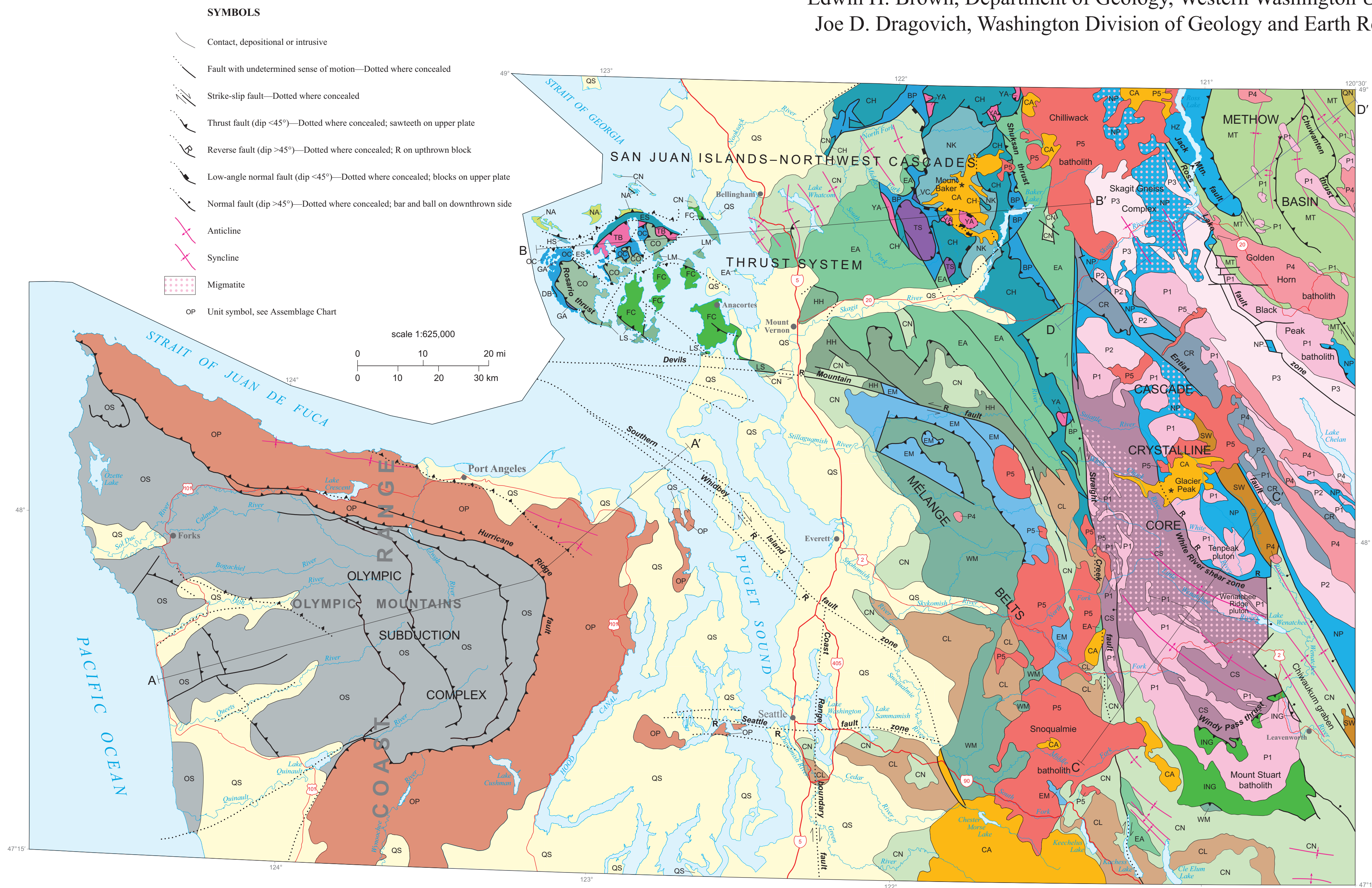


FIGURE 1

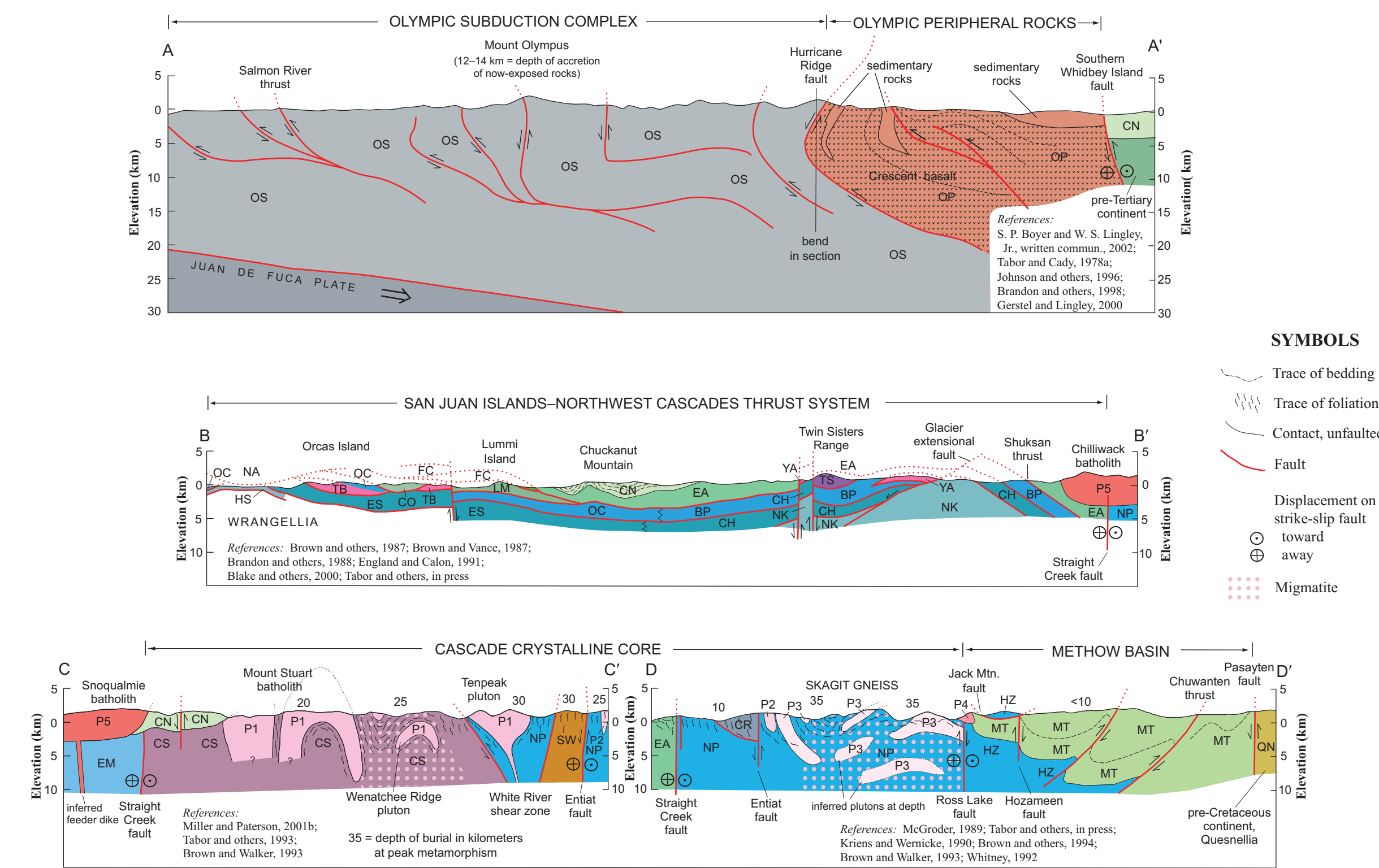


FIGURE 2

INTERPRETIVE TECTONIC HISTORY

The tectonic evolution of northwest Washington from early Mesozoic time to the present is interpreted here to be in a general sense a consequence of oblique plate convergence. Observed structures define a broad zone of transpression across the entire map area. Convergence is evidenced by products of subduction in the form of blueschists and arc-related igneous rocks and by orogen-normal displacements on folds and faults. Margin-parallel motions are inferred from displacements on faults and folds, orogen-parallel stretching lineations, patterns of sedimentation in fault-controlled basins, and best-fit restorations of regional geology. This general model is well supported and widely accepted for the Cenozoic Era, but the inference of major margin-parallel displacements in the Mesozoic Era is less easily documented and remains controversial (see references below). The 'Baja B.C.' hypothesis that a large block of the northwest Cordillera originated at Mexican latitudes (Beck, 1976; Irving and others, 1985; Umbhoefer, 1987) is not depicted here because structures that could be related to this displacement have not been documented in the map area and would therefore lie east of northwest Washington. Whether or not the Mesozoic geology of northwest Washington developed outboard of Mexico remains uncertain. However the hypothesis favored here that terranes of the San Juan Islands-Northwest Cascades thrust system originated in California and moved north (see below) is not consistent with placement of the thrust system south of California as in the Baja B.C. model.

PRESENT DAY

Oblique subduction of the Juan de Fuca plate beneath North America continues to carry trench sediments under the rapidly uplifting Olympic Mountains and is moving the Olympic Mountains and Coast Range north as a 'forearc sliver'. This forearc sliver, underlain by Olympic core and peripheral rocks, is in contact with pre-Tertiary basement terranes to the east and north along the Southern Whidbey Island fault and related structures. Active north to northeast shortening in the forearc is being concentrated on several reverse and strike-slip faults in the Puget Lowland, including the Seattle (SF), Southern Whidbey Island (SWI), Devils Mountain (DMF), and other faults. Present-day activity in the Cascade arc is observable in the stratovolcanoes, Mount Baker, Glacier Peak, Mount Rainier, and others to the north and south. (Johnson and others, 1994, 1996, 2001; Brandon and others, 1998).

EARLY EOCENE (55-50 MA)

Mobile terranes of the Cretaceous were by this time assembled, establishing a continental margin outboard of the Cascade core and Vancouver Island. Along the continental margin, dextral oblique convergence of the Kula plate created forearc, strike-slip related rift zones out of which erupted Crescent basalts, accumulating in thickness up to 15 km. The ancestral Southern Whidbey Island fault (SWI) was born as the locus of displacement between the forearc and continent. Olympic core sediments accumulated off the continental margin and were transported under the Crescent basalts as part of the subduction process. Inland, fluvial sediments of the Chuckanut and Swauk formations formed in fault-controlled basins subsiding to accommodate six or more kilometers of sediment thickness. The Ross Lake (RLF), Entiat (EF), and Straight Creek (SCF) faults, showing primarily dextral strike-slip and normal dip-slip, were active in this period. Transpression is inferred for the eastern part of the map area. The Challis was active across the area of the present-day Cascades and to the east. (Vance, 1982; Johnson, 1985; Babcock and others, 1992; Johnson and others, 1996; Miller and Brandon, 1998; Bowring, 1990; Miller and others, 2002).

MID-LATE CRETACEOUS (100-65 MA)

At this time, prior to approximately 170 kilometers of dextral displacement on the Straight Creek fault (SCF), the Washington Cascade core was contiguous with related rocks in southern British Columbia (Misch, 1977). Wrangellia had moved south into place outboard of the Cascade core and formed a corner area in the continental margin (Monger and others, 1994). Dextral oblique convergence of the Farallon plate created large-scale, orogen-parallel displacements in the forearc bringing terranes of the San Juan Islands and Northwest Cascades northward from perhaps as far south as California, to be thrust against the south end of Wrangellia and the Cascade core (Brown, 1987; Mackawa and Brown, 1991). Transpressional deformation occurred across the entire orogen as manifest by contractile folds, and reverse faults (Miller and Peterson, 1992), strike-parallel lineations, strike-slip faults and oblique-slip faults (Brown and Talbot, 1989; Brown and others, 2000). The Ross Lake fault likely became active during this time interval (Trexler and Bourgeois, 1985; Miller and Bowring, 1990). Voluminous subduction-related plutons were emplaced in the Cascade core, closely associated with and possibly causing Barrovian metamorphism (Brown and Walker, 1993). (For alternative models, emphasizing contraction over wrench tectonics, see Brandon and others, 1988; McGroder, 1991; Cowan and Brandon, 1994; Whitney and others, 1999).

LATE JURASSIC TO MID-CRETACEOUS (160-100 MA)

Early in this period Wrangellia was well north of Washington. The Methow basin was situated along the continental margin, with open ocean to the west. Chitaukum Schist protolith formed as an accretionary complex outboard of the Methow basin. In the Early Cretaceous, oblique sinistral convergence of the Farallon plate displaced Wrangellia and the adjacent Jurassic arc, including the Nooksack Formation (NK), southward, to a position outboard of the southern British Columbia coast (Monger and others, 1994; Monger and Journeay, 1994). In the late Early Cretaceous orogen-normal contraction telescoped the continental margin, forming a thrust-assembled complex of terranes in the Cascade core and a foredeep in the Methow basin (Haugerud and others, 2002). Meanwhile, far to the south, terranes of the San Juan Islands-Northwest Cascades thrust system have formed by various tectonic processes along the continental margin, to be later translated north as 'forearc slivers' (Brown, 1987; Brown and Blake, 1987; Ganer, 1988; Brandon and others, 1988).

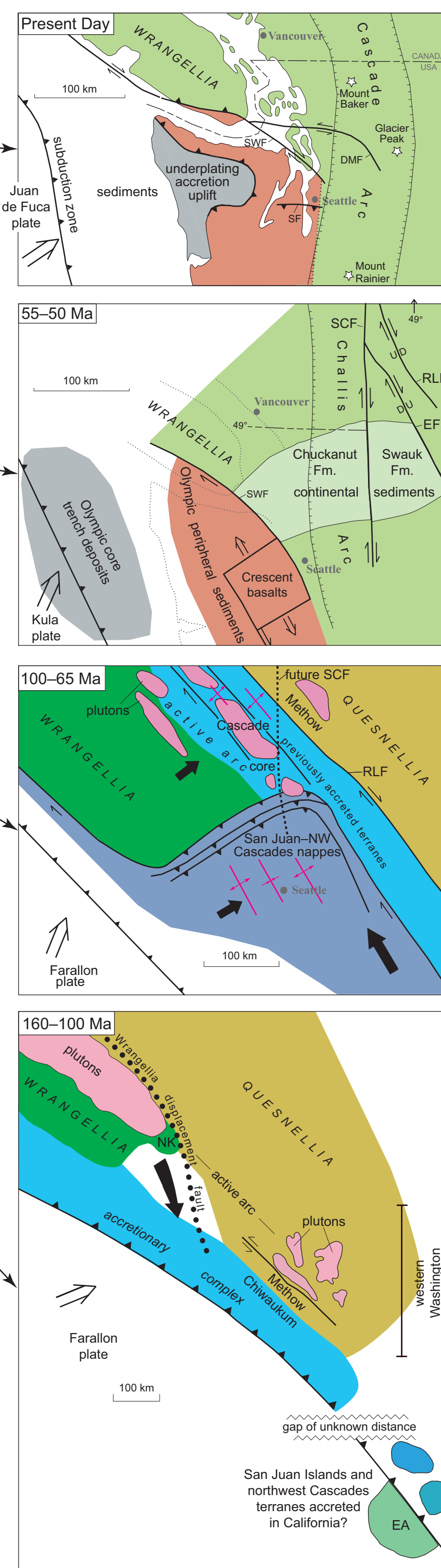


FIGURE 4

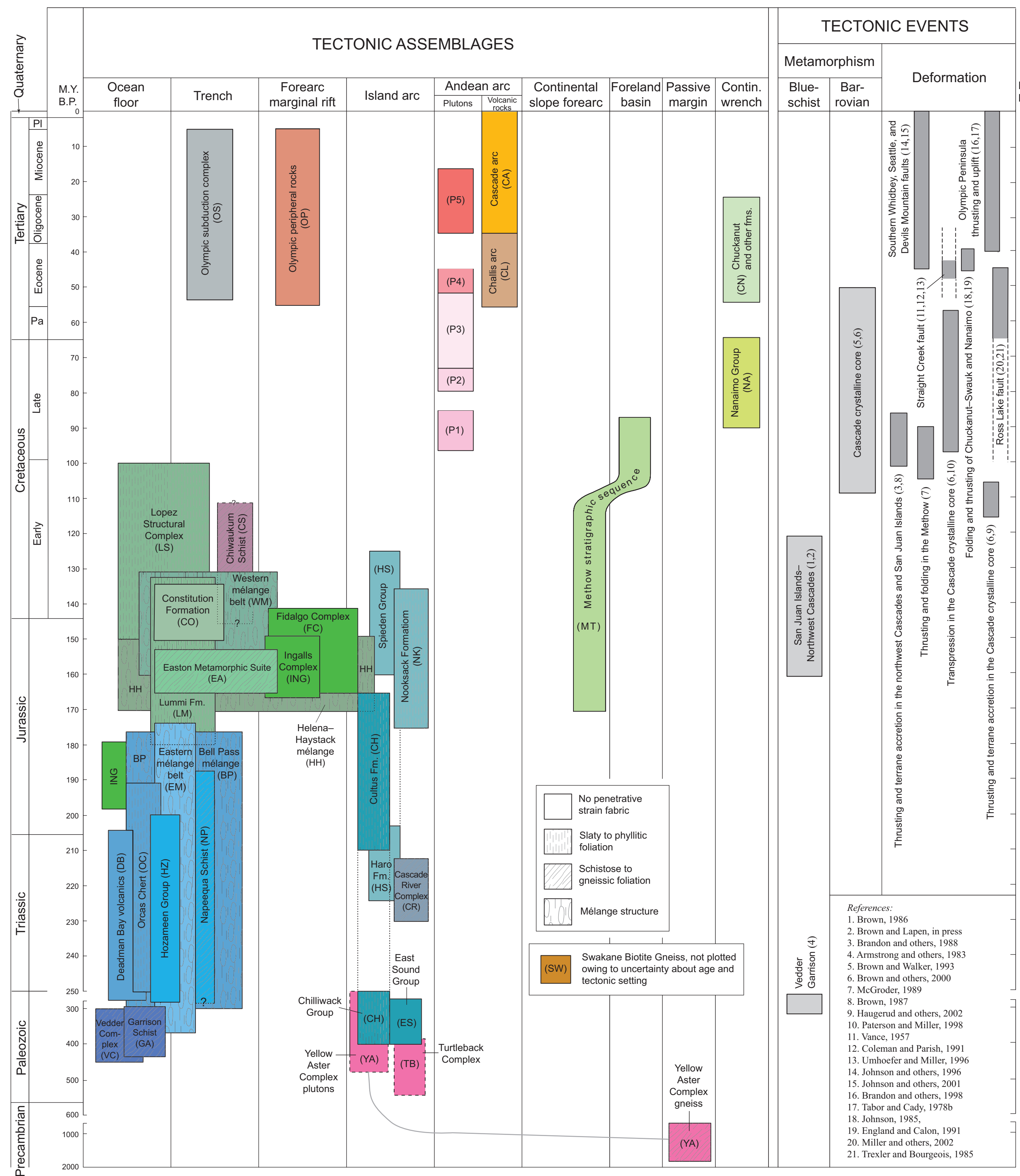


FIGURE 3