Phanerozoic palinspastic reconstructions of Great Basin geotectonics (Nevada-Utah, USA)

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ABSTRACT

Palinspastic reconstructions of Phanerozoic geotectonic elements in the Great Basin (Nevada-Utah, USA) to restore the effects of Basin and Range extension, Sevier thrust telescoping, and evolution of the Cordilleran magmatic arc and forearc region to the west provide the following insights: (1) the position of the Neogene Walker Lane incipient transform system was controlled by thermal weakening of the lithosphere beneath the extinct southern segment of the ancestral Cascades arc; (2) Eocene to Miocene magmatism swept across the Great Basin from northeast to southwest, in a direction normal to the continental margin, rather than from north to south parallel to the continental margin; (3) the elevated Paleogene Nevada-plano and Sevier thrust belt between the Sierra Nevada and the Sevier foreland basin was comparable in width to the modern Altiplano and Subandean thrust belt between the Andean volcanic chain and the Brazilian foreland; (4) the late Mesozoic Sierra Nevada and Idaho batholiths formed in the roots of the Cordilleran magmatic arc as segments of a linear batholith belt that lacked curvature; (5) early to middle Mesozoic backarc basins, thrusts, and plutons were coordinated geodynamically with arc accretion and closure of a suture belt in the Sierra foothills, Klamath Mountains, and Blue Mountains of the Cordilleran arc terrane to the west; and (6) Devonian–Mississippian Roberts Mountains and Permian–Triassic Golconda thrusts and allochthons, emplaced successively from the west upon the flank of the Cambrian–Devonian miogeoclinal belt, were formed as linear features subparallel to the Wasatch hinge line marking the western edge of undeformed craton.

INTRODUCTION

The configurations of geotectonic elements that lie between the Sierra Nevada and the Colorado Plateau within the Great Basin of the intermountain west (United States) are commonly depicted in the context of modern geography (e.g., Dickinson, 2006). Yet we know that crustal extension within the Basin and Range province (Stewart, 1998; Stewart et al., 1998; Sonder and Jones, 1999; Dickinson, 2002) distorted all pre-Neogene geologic features of the Great Basin, and that crustal contraction across the late Mesozoic Sevier thrust belt of the eastern Great Basin shifted the positions of all more westerly pre-Tertiary geologic features eastward relative to the craton (e.g., Levy and Christie-Blick, 1989). This paper presents a series of palaeotectonic-paleogeographic maps that incorporate palinspastic reconstructions to restore the regional geometric effects of late Cenozoic crustal extension and late Mesozoic thrusting. The maps provide fresh insights into the geotectonic history of the Great Basin.

Palinspastic restorations that amount to <75 km of net fault slip (~12.5% of the width of the Great Basin) are ignored as insignificant for the scale of this study. Distributed extension and contraction were recovered within the Great Basin by shifting points and lines proportionately to honor the net percentage of extension or contraction. The region treated is bounded on the south by the Garlock fault marking the northern edge of the Mojave block of southern California and on the north by backarc Cenozoic volcanic fields of the Pacific Northwest (Fig. 1). To show the regional context of Great Basin geotectonic elements, palinspastic reconstructions are extended westward to restore the paleotectonic relations of more coastal rock assemblages, and eastward to depict paleogeographic relations with interior sedimentary assemblages of the craton. The segment of the Basin and Range province north of the Snake River Plain (Fig. 1) in eastern Idaho and western Montana is not included in the analysis.

Because palinspastic reconstructions are additive through time, palaeotectonic maps were prepared in reverse order, going backward in time from the present configuration of the Great Basin and its surroundings (Fig. 1). Because tectonic motions are sequential and incremental, no finite series of palinspastic maps can depict in detail all phases of the geotectonic evolution of any region. The time frames for the palinspastic maps of this paper were selected to highlight the dominant stages in the evolution of the Great Basin, and are keyed to a summary diagram of Great Basin geologic history (Fig. 2) adapted from Dickinson (2006). As the purpose of this paper is to address palinspastic issues, no detailed review of Great Basin geologic history is attempted.

NEOGENE RELATIONS

The modern Basin and Range province extends across the Great Basin from the western escarpment of the High Plateaus of Utah on the east to the faulted east face of the Sierra Nevada on the west (Fig. 1). Extensional block faulting within the Great Basin (16–0 Ma) has occupied the same time span as the migration of volcanic centers marked by successive silicic calderas along the Snake River Plain to the north. The Northern Nevada rift of the central Great Basin was coeval with the principal eruptions of Middle Miocene Columbia River and Steens Basalts in the Pacific Northwest (Dickinson, 1997). Younger lavas mantle the Modoc, Oregon, and Owyhee plateaus between Nevada and the Columbia River Plateau.

The Walker Lane (Fig. 1) is a zone of distributive dextral shear in the western Great Basin that has displaced the Sierra Nevada and more coastal parts of California northward with respect to the centroid of the Great Basin during the past ~12.5 m.y. (Faulds and Henry, 2008). No attempt is made here to reverse the intricate
pattern of Walker Lane slip, which declines from 60 to 65 km on the southeast to nil on the northwest, and is achieved by an array of subparallel and en echelon fault traces linked variously by multiple pull-apart basins, inverted (transextensional) flower structures, superextensional core complexes, and transrotational domains (Oldow and Cashman, 2009; Jayko and Bursik, 2012). As an integral component of the San Andreas transform system, the Walker Lane separates a sliver plate, including much of California, from the continental interior (Faulds et al., 2005), and since its inception has absorbed 10%–20% of net Pacific–North American plate motion (Dickinson and Wernicke, 1997; Kreemer et al., 2009; DeMets et al., 2010).

Walker Lane displacements link to the south through the Eastern California shear zone (Dokka and Travis, 1990; Dokka 1992) to the San Andreas fault system in the Salton Trough (Fig. 3), but the regional kinematic role of the Middle to Late Miocene Las Vegas Valley shear zone (Faulds and Henry, 2013) remains uncertain where it splay to the southeast from near the junction of the Walker Lane and the Eastern California shear zone (Fig. 3). Net displacement across the Walker Lane declines northward and dies out near the latitude of the Mendocino triple junction at the northern end of the San Andreas fault and Lassen Peak at the southern terminus of the active Cascades arc (Fig. 3). There is no impetus for transform slip north of that latitude, where subduction is still under way at the continental margin. Although oblique subduction of the Farallon plate at the Cascades subduction zone (Fig. 3) may impart some lateral shear to the continental block, no structural feature similar to the Walker Lane is present in the Cascades forearc, arc, or backarc.

Displacements along the Walker Lane began ca. 12.5 Ma when the Mendocino fracture zone and triple junction were located off southern California, far south of their present locations (Dickinson, 2002). As the Mendocino fracture zone and triple junction continue to migrate northward along the coast to lengthen the San Andreas fault system, the Walker Lane is expected to propagate northward to intersect the Cascades subduction zone (Fig. 3), and thereby complete separation of a coastal sliver plate from the continental block (Faulds and Henry, 2008). In the western Great Basin, the close spatial relationship between the Walker Lane and the extinct southern segment of the ancestral Cascades arc (Fig. 1), which extended along the Sierra Nevada and the adjacent fringe of the modern Great Basin (Busby et al., 2008; Cousens et al., 2008; Busby, 2012), suggests that thermal weakening of the lithosphere by arc magmatism controlled the position of the Walker Lane slip belt subparallel to but far east of the San Andreas fault (Busby et al., 2008, 2013; McQuarrie and Oskin, 2010). In that respect, the Walker Lane is analogous to the Semangko or Sumatran fault, a dextral strike-slip fault that trends longitudinally along the Sunda magmatic arc of Sumatra (Dickinson, 2002). As the Mendocino fracture zone and triple junction were located off southern California shear zone (Fig. 3). Net displacement across the Walker Lane declines northward and dies out near the latitude of the Mendocino triple junction at the northern end of the San Andreas fault system, the Walker Lane is expected to propagate northward to intersect the Cascades subduction zone (Fig. 3), and thereby complete separation of a coastal sliver plate from the continental block (Faulds and Henry, 2008).
termination of pre–Walker Lane arc volcanism and the northward lengthening of the Walker Lane slip zone were both related to northward migration of the Mendocino triple junction along the continental margin to the west as plate configurations along the continent-ocean boundary evolved over time (McQuarrie and Oskin, 2010).

**PALEOGENE RELATIONS**

Estimates of Neogene crustal extension within the Great Basin vary (Atwater and Stock, 1998; Snow and Wernicke, 2000; Colgan et al., 2004, 2006, 2011; McQuarrie and Wernicke, 2005; Lerch et al., 2008; Van Buer et al., 2009; McQuarrie and Oskin, 2010; Egger and Miller, 2011), but a satisfactory restoration of its Early Miocene dimensions (Fig. 4) can be achieved by adopting the following compromise figures for east-west Basin and Range extension.
during post–17.5 Ma block faulting: (1) 25% in northernmost Nevada and adjacent Utah, declining northward to nil at the northern end of the straight north-south segment of the Oregon–Idaho state line, (2) 50% in central Nevada and Utah at the latitude of the angle in the California–Nevada state line at Lake Tahoe, and (3) 100% in southern Nevada west of the Arizona-Utah state line and the Grand Canyon. The assumptions of 25% extension in northern Nevada and 50% in central Nevada match the percentages of extension depicted by McQuarrie and Wernicke (2005), as repeated by McQuarrie and Oskin (2010), but the assumption of only 100% extension in southern Nevada is distinctly less than the ~150% extension depicted by those authors, and much less than the 225% (Wernicke et al., 1988) or even more (Snow and Wernicke, 2000; Niemi et al., 2001) inferred previously. The present comparatively narrow width (~350 km) of the southern transect across the Great Basin means, however, that its western margin restored for Paleogene time using the assumption of 100% Neogene extension (Fig. 4) would shift eastward by only 35 km for Neogene extension of 150% and 65 km for Neogene extension of 225%. Those discrepancies lie within the 75 km tolerance adopted here for palinspastic reconstructions, and assumed percentages of extension across the Great Basin increasing smoothly southward from 25% to 100% allow for palinspastic reconstructions of pre-Tertiary geotectonic features without positing abrupt shifts in their positions.

In detail, the direction of extension has varied areally and though time within the Great Basin from ~N80E to ~N70W (Snow and Wernicke, 2000; McQuarrie and Wernicke, 2005; Kreemer et al., 2009; McQuarrie and Oskin, 2010), averaging perhaps N75W (Dickinson and Wernicke, 1997; Kreemer et al., 2009). Adjustment of the net extension vector from east-west to N75W would not shift the northwest corner of Nevada nor the Sierra Nevada block southward by more than 50 ± 10 km, which is within the tolerance of 75 km taken here to be acceptable for restored positions of geotectonic elements. The palinspastic reconstruction inherently reverses 65 km of net sinistral slip on the Garlock fault (Burbank and Whistler, 1987). Counterclockwise backrotation of the southernmost or Tehachapi tail of the Sierra Nevada block by 45° is additionally incorporated into the reconstruction (Fig. 4) to recover transrotational Neogene deformation (Dickinson, 1996, p. 21–22).

Reconstructed Paleogene paleogeography (Fig. 4) reveals that the sweep of Cenozoic magmatism across the Great Basin was from northeast to southwest (McQuarrie and Oskin, 2010), nearly normal to the continental margin, rather than from north to south subparallel to the continental margin, as has been inferred from plotting sites of migratory Cenozoic volcanism on modern geography unadjusted for Basin and Range extension (Armstrong et al., 1969; Cross and Pilger, 1978; Dickinson and Snyder, 1978; Lipman, 1980; Stewart, 1980; Humphreys, 1995; Dickinson, 2002). Extension of the 40 Ma volcanic front to the northwest into central Oregon outside the Basin and Range province is controlled by the Clarno volcanic assemblage (50–30 Ma) erupted well to the east of the Cascades chain (Walker, 1977; Walker and Robinson, 1990). The observed pattern of

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**Figure 4. Early Eocene to Early Miocene (50–20 Ma) tectonomagmatic relations across the site of the younger Great Basin prior to Neogene Basin and Range extension. The elevated tract (curving double-headed arrow) included the Sierran slope, Nevadaplano, and Sevier thrust belt. Barbed blue lines denote principal paleodrainages including terrestrial paleovalleys of the Nevadaplano (Henry, 2008; Henry et al., 2012) linked locally to submarine canyons (Ma—Markley; Me—Meganos; P—Princeton) leading into the Delta depocenter (Dickinson et al., 1979) of the Great Valley forearc basin. Red lines are successive volcanic fronts adapted from Dickinson (2002, 2006). See Figure 1 for the states shown (boundaries distorted) and Figure 2 for the time span depicted.**
successive volcanic fronts is compatible with the interpretation that the impetus for renewed magmatism in the Great Basin was post-Laramide rollback of the subducted Farallon slab of lithosphere to a steeper angle of descent into the mantle beneath the Great Basin (Coney and Reynolds, 1977; McQuarrie and Oskin, 2010). The onset (“ignimbrite flareup”) of post-Laramide Great Basin magmatism prior to Neogene block faulting (Best and Christiansen, 1991), or to any earlier superextension associated with the structural denudation of local core complexes along detachment faults (e.g., Gans et al., 1989; Faulds et al., 2001), implies that the migratory volcanism reflected a regional geodynamic influence of slab rollback rather than crustal extension, which was post-eruptive. The onset of Neogene Basin and Range extension was not accompanied by any clear magmatic signal, suggesting that subsequent magmatism was not related to slab steepening or foundering beneath the continental block (McQuarrie and Oskin, 2010).

The high-standing Nevadaplano plateau between the Paleogene Sierra Nevada slope and the Sevier thrust belt (DeCelles, 2004; Henry et al., 2012) was comparable in its dimensions to the present-day Andean Altiplano, a modern geodynamic analogue. The distance across the elevated tract of the Nevadaplano and the Sevier thrust belt between the batholithic roots of the Sierran arc and the flank of the southern Cordilleran foreland basin was 400–500 km (Fig. 4), whereas the combined width of the modern Altiplano and Subandean thrust belt between the locus of Andean arc volcanism and the western edge of the Subandean basins is 350–400 km (de Almeida, 1978). The comparative distance between the inland margin of the Great Valley forearc basin and the interior Sevier thrust front in Paleogene North America is 450–600 km (mean of 525 km), whereas the distance between the Pacific shoreline and the Subandean thrust front in Neogene South America is ~525 km today. The apparently excessive width of the central U.S. Cordillera as compared to the central Andean Cordillera is a function of post-Nevadaplano crustal extension within the Great Basin. The surface of the Nevadaplano was evidently smoothed topographically by the spread of ignimbrite sheets from multiple source calderas (Best et al., 2009), much as broad reaches of the modern Altiplano are mantled by ignimbrites. The intricontinental drainage divide of the Nevadaplano was located in the central Great Basin of eastern Nevada (Henry, 2008) from which paleodrainages flowed both eastward toward the modern Colorado Plateau and westward into the Great Valley forearc basin (Fig. 4).

**LATE MESOZOIC RELATIONS**

When restoration of Great Basin extension is extended back into Cretaceous time (Fig. 5), the Late Cretaceous Sierra Nevada and Idaho batholiths are seen to form a nearly linear trend without notable curvature, as argued by Hamilton and Myers (1966). For Late Cretaceous paleotectonic relations west of the batholith belt, Paleogene deformation in the Pacific Northwest is recovered by reversal of dextral slip (110 km each) on the Fraser River–Straight Creek and Yalakom–Ross Lake fault systems, and by anticlockwise backrotations of the Blue Mountains.

**Figure 5.** Early Cretaceous to Paleogene (130–50 Ma) tectonomagmatic relations spanning the intermountain region (Great Basin and environs) depicted on paleogeography after Sevier thrusting and late Mesozoic forearc displacements, but before Basin and Range extension. Batholith belt shown for ≥75 Ma. Asterisks denote isolated Laramide (≤75 Ma) plutons (Stewart, 1980; Barton, 1990; du Bray, 2009; Hintze and Kowallis, 2009) emplaced during the inland sweep of magmatism associated with shallow slab descent beneath the Cordillera. Isolated exposures of Lower Cretaceous (Fig. 2) and Upper Cretaceous to Eocene strata in Nevada (Vandervoort and Schmitt, 1990; Martin et al., 2010; Druschke et al., 2011) are not plotted for reasons of scale. See Figure 1 for the states shown (boundaries distorted) and Figure 2 for the time span depicted.
province and the Oregon-Washington coast ranges by 60° and 35°, respectively (Dickinson, 2009). Backrotation has the effect of swinging the Blue Mountains closer to the Great Basin, and of translating the Klamath Mountains eastward with respect to the Great Basin (Dickinson, 2002). The Franciscan subduction complex along the continental margin was accreted mainly from Early Cretaceous to Paleogene time (Dumitru et al., 2010; Snow et al., 2010).

Latest Cretaceous (75–65 Ma) granitic plutons emplaced across nearly the full width of the Great Basin east of the main batholith belt (Fig. 5) are the record of migratory Laramide magmatism (Fig. 2) induced by shallowing of Farallon slab descent beneath the Cordillera (Coney and Reynolds, 1977) as Sierra Nevada plutonism waned after ca. 80 Ma. The peraluminous character of many or most Laramide plutons within the Great Basin (Barton, 1990) reflects extensive crustal involvement in magma genesis, and the isotopic signature of the plutons implies largely crustal melts (Wright and Wooden, 1991). The lateral span of backarc uplands extending across the Nevadaplano and the Sevier thrust belt was 300–400 km (Fig. 5), again comparable to the net width of the Altiplano and Subandean thrust belt in the modern Andes.

MIDDLE MESOZOIC RELATIONS

For middle Mesozoic paleogeography (Fig. 6), intra-Cretaceous dextral slip along the longitudinal Snow Lake fault within the batholith belt is reversed, to draw the Blue Mountains and the Klamath Mountains farther south, and distributive thrusting within the Sevier belt is reversed, to shift geotectonic elements within the Great Basin farther away from the continental interior. West of the Cordilleran magmatic arc on the Laurentian margin, accreted intra-oceanic arcs in the Klamath Mountains and Sierra Nevada (Dilek et al., 1990; Edelman, 1991; Moores, 1998; Dickinson, 2008), and within the Blue Mountains (Avé Lallemant, 1995; Dorsey and LaMaskin, 2007; LaMaskin et al., 2011; Schwartz et al., 2011), are separated from the edge of the Laurentian continental block by a suture belt of subduction mélanges that closed by crustal collision (Cloos, 1993) in Middle to Late Jurassic time (Fig. 2). A recent analysis of mantle tomography beneath North America is supportive of models for Cordilleran evolution that incorporate episodes of intra-oceanic arc accretion by slip on west-dipping subduction zones beneath the island arcs as well as slip on the east-dipping subduction zone that slanted beneath the Cordilleran magmatic arc built on the western flank of Laurentia (Sigloch and Mihalynuk, 2013).

Displacement along the Snow Lake fault is assumed here to have been 210 km (Dickinson, 2006, 2008), in harmony with estimates of ~200 km by several others (Kistler, 1993; Lewis and Girty, 2001; Memeti et al., 2010), but less than half the 400–500 km initially suggested for offset (Lahren and Schweickert, 1989; Schweickert and Lahren, 1990). Reversal of 210 km of Snow Lake offset places the Klamath Mountains west of the south-central Great Basin (Fig. 6), and places the southern Sierra Nevada appropriately in line with the trend of the Neoproterozoic–Paleozoic Cordilleran miogeocline crossing the southern Great Basin (see discussion below), whereas offset of 400–500 km would place the Klamath Mountains and the northern Sierra Nevada in an unlikely position athwart the trend of the miogeocline. Following Wyld and Wright (2001), the Snow Lake fault is assumed here to root northward into the vertical Salmon
River suture zone along the western flank of the Idaho batholith (Fig. 5) where deformation and metamorphism has been timed to the interval 118–88 Ma (Lund and Snee, 1988; Manduca et al., 1993; Snee et al., 1995). The main phase of deformation was 105–90 Ma (Giorgis et al., 2008) and therefore coordinates with inferred mid-Cretaceous slip on the Snow Lake fault.

To reconstruct pre-Cretaceous paleotectonic patterns in the Great Basin, major structural contraction across the Sevier thrust belt must be restored in addition to Tertiary extension (Levy and Christie-Blick, 1989). An estimate of 50% contraction across the Sevier belt (original width = twice observed width) is adopted here for both the Idaho-Wyoming and Utah segments of the thrust system (Skipp, 1988; DeCelles, 2004; DeCelles et al., 1995; Lawton et al., 1995), and is the same as the net 50% shortening inferred by Coney and Harms (1984). Thrust displacements are here modeled as declining rapidly to nil between southernmost Nevada and the southern termination of the thrust belt in the Mojave Desert (Dickinson, 2004, 2009) not far from the eastern end of the Garlock fault (Fig. 1). The resulting westward displacement of ground west of the thrust belt for palinspastic restoration is ~100 km, closely comparable to the net displacement of ~115 km calculated by summing observed offsets of individual thrust plates measured in their present configurations following Basin and Range extension that affected parts of the thrust system (Levy and Christie-Blick, 1989).

The timing of initial thrusting along the Sevier belt is controversial (Dickinson and Gehrels, 2010), either late Early Cretaceous in Aptian or Albian time at 125–100 Ma (Heller et al. 1986; Yingling and Heller, 1992), as applies to the frontal thrust stack and assumed here (Fig. 2), or by Late Jurassic time along ancestral thrusts in the hinterland west of the thrust front (DeCelles and Currie, 1996).

The evolution of the Cordilleran backarc region during middle Mesozoic time was controlled by the development of three geotectonic features (Fig. 6): (1) the Luning-Fencemaker retroarc thrust belt (Oldow, 1984; Wyld, 2002), which had counterparts (not shown) extending southward into California along the eastern flank of the Cordilleran arc assemblage (Dunne and Walker, 2004); (2) diffuse backarc magmatism that spread nearly 250 km behind the much narrower Cordilleran magmatic arc and incorporated significant mantle components (Wright and Wooden, 1991); and (3) the Utah-Idaho backarc trough that rapidly accumulated 1500–2000 m of Middle Jurassic strata (Hintze and Kowallis, 2009) deposited over the interval 170–160 Ma. The Utah-Idaho trough has been viewed (1) as a retroarc foredeep depressed flexurally by Luning-Fencemaker thrust loading (Bjerrum and Dorsey, 1995), although its distance (>200 km) from the thrust front calls that interpretation into question, and (2) as a backbulge basin (DeCelles and Currie, 1996), although its thickness (>1500 m) seems excessive for a backbulge setting. The Utah-Idaho trough is interpreted instead here as an extensional backarc basin (Dickinson, 2006), with flanks controlled at least partly by normal faults (Moulton, 1976). Sediment loading in the trough downflexed the Colorado Plateau, across which coeval strata of the San Rafael Group thin systematically eastward (Dickinson and Gehrels, 2010).

Sequential middle Mesozoic development of the backarc Luning-Fencemaker thrust system, widespread backarc magmatism, and the Utah-Idaho trough is interpreted speculatively to reflect backarc geodynamics related to arc collision and accretion to the west in the forearc region of the Cordilleran magmatic arc (Fig. 7). Arc contraction to induce backarc thrusting can

Figure 7. Speculative geodynamic scenario (sequential events A–D) for middle Mesozoic arc accretion, transient backarc thrusting, widespread backarc plutonism, and backarc extensional tectonism at the latitude of the Great Basin and Klamath Mountains (as restored palinspastically). Mezcalera plate after Dickinson and Lawton (2001) and Sigloch and Mihalynuk (2013).
be ascribed to the arrival of an east-facing intra-oceanic arc system (Fig. 7A) at the continental margin to produce arc-arc collision (Fig. 7B) that promoted compressive stress across the orogenic system. Subsequent removal of the trapped lithosphere of the oceanic Mezcalera plate (Dickinson and Lawton, 2001; Sigloch and Mihalynuk, 2013), which intervened between the colliding arc systems, by foundering into the mantle is inferred to have caused upwelling of asthenosphere (Fig. 7C) that produced backarc magmatism and induced crustal extension beneath the Utah-Idaho trough. After arc accretion, subduction of the oceanic Farallon plate along the seaward flank of the accreted arc system (Fig. 7D) initiated the subduction regime that led to incremental accretion of the Franciscan subduction complex at the expanded continental margin. Without taking into account tectonic events in the Cordilleran forearc to the west, the middle Mesozoic tectonic evolution of the Great Basin in the backarc region seems inexplicable.

**EARLY MESOZOIC RELATIONS**

Initiation of the Cordilleran magmatic arc early in Triassic time (Schweickert and Lahren, 1993; Barth and Woden, 2006; Dickinson et al., 2010) placed the Great Basin and Colorado Plateau in a backarc position for the first time (Fig. 8). The depocenter of the Auld Lang Syne basin in the western Great Basin was formed by backarc extensional faulting (Wyld, 2000), and accumulated thick marine strata during Late Triassic and Early Jurassic time before Middle Jurassic Luning-Fencemaker thrusting (Fig. 6) carried basal turbidites eastward over flanking shelf facies (Fig. 2). Marine facies of the basin encroached westward with both volcanic and volcaniclastic strata along the rear flank of the Cordilleran magmatic arc (Stewart, 1997; Profett and Dilles, 2008).

Late Triassic and Early Jurassic fluvial and eolian depositional systems of the Colorado Plateau extended westward across the eastern half of the Great Basin (Stewart, 1980), and encroached to within 100–200 km of the rear flank of the magmatic arc (Fig. 8). Late Triassic Chinle paleorivers had their principal headwaters in the Ouachita foreland of central Texas ~1500 km to the southeast and delivered sediment to the eastern flank of the Auld Lang Syne basin (Dickinson and Gehrels, 2010; Dickinson et al., 2010). The vast Nugget-Navajo-Aztec desert erg of Early Jurassic age acquired much of its sand from the Appalachian region via transcontinental paleorivers that positioned the sand north of the Colorado Plateau and the Wyoming craton in a place where sedimented land surfaces of floodplains or deltas could be deflated to blow sand southward by prevailing paleowinds into the erg complex (Dickinson and Gehrels, 2010). Quartzose sand from near the southern fringe of the erg complex was delivered longitudinally by fluvial and marine processes to extensional basins along the trend of the Cordilleran magmatic arc and into the Auld Land Syne backarc basin (Busby-Spera et al., 1990; Wyld and Wright, 1993; Busby, 2012). Because of post-Jurassic erosional removal of connecting sedimentary linkages, the close juxtaposition of early Mesozoic Great Basin and Colorado Plateau depositional systems cannot be appreciated without palinspastic restoration to move erosional remnants closer together in paleographic space (Fig. 8).

**LATE PALEOZOIC RELATIONS**

Late Paleozoic (Carboniferous–Permian) and Early Triassic paleogeography (Fig. 9) for the Great Basin is more interpretive than later paleogeography for lack of detailed information about patterns of depocenters and uplifts in the Sonoma foreland between the Colorado Plateau and the Golconda allochthon (Trexler et al., 2004), emplaced upon the Antler overlap sequence (Fig. 2). Crustal shortening along the continental margin associated with emplacement of the Golconda allochthon extended southward beyond the modern Garlock fault (Snow, 1992) at the southern limit of the Great Basin (Fig. 1). The foreland region east of the Golconda thrust is treated here as bounded on the north by the Oquirrh–Wood River basin (Geslin, 1998), the

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**Figure 8.** Middle Triassic to Early Jurassic (245–175 Ma) tectonomagmatic relations across the intermountain region. Asterisk denotes Currie outlier (Stewart, 1980, his figures 33 and 35) of Mesozoic Colorado Plateau stratigraphic units. Extent of erg after Dickinson and Gehrels (2010). Chinle paleorivers after Dickinson et al. (2010). See Figure 1 for the states shown (boundaries distorted) and Figure 2 for the time span depicted.
The Roberts Mountains allochthon (Fig. 2), which was emplaced across the western flank of the Cordilleran miogeocline during the Devonian–Mississippian Antler orogeny (Miller et al., 1992), formed a linear belt parallel to the Wasatch hinge line (Fig. 10), which marked the eastern limit of miogeocinal sedimentation (Hintze and Kowallis, 2009). Curvature of the allochthon on the south where both it and the younger Golconda allochthon now trend westward into the flank of the Sierra Nevada batholith (Schweickert and Lahren, 1987) is an artifact of later Great Basin deformation. A flexural foreland basin formed during the Antler orogeny with its depressed keel adjacent to the thrust load of the Roberts Mountains allochthon (Fig. 10), but the downflexed distal flank of the Antler foreland basin extended much farther to the east (Dickinson, 2006).

Accreted Devonian arc assemblages west of the Roberts Mountains allochthon (Fig. 10) are exposed now in the northern Sierra Nevada and eastern Klamath Mountains. There has long been uncertainty as to whether they represent (1) a far-traveled, east-facing exotic arc system accreted to the Laurentian margin during the Antler orogeny (Dickinson, 2000), together with the Roberts Mountains allochthon as an associated subduction complex, or (2) a west-facing fringing arc erected not far offshore (Miller et al., 1992), with the Roberts Mountains allochthon being the collapsed fill of a backarc basin. The option of an exotic accreted arc is favored by the U-Pb ages of detrital zircons in Klamath terranes, closely associated with the arc assemblage, which reflect affinity with Baltica in the Arctic region (Grove et al., 2008). That conclusion is compatible with the regionally anomalous U-Pb ages of detrital zircons from the Roberts Mountains allochthon and the closely related Shoo Fly Complex of the Sierra Nevada (Dickinson and Gehrels, 2000).

**PRINCIPAL INSIGHTS**

Systematic palinspastic reconstruction of paleotectonic and paleogeographic patterns for the Great Basin and adjacent regions through Phanerozoic time yields insights that are not apparent from the areal distribution of rock assemblages with respect to their present geography. In general, pre-Neogene geotectonic belts formed initially as more linear features with less curvature than their present configurations.

*Figure 9. Mississippian to Early Triassic (325–245 Ma) tectonomagmatic relations across the intermountain region. Selected late Paleozoic depocenters: Oquirrh–Wood River basin (Geslin, 1998; Hintze and Kowallis, 2009); Keeler–Darwin–El Paso (K-D-EP) basin cluster (Stevens et al., 1997, 2005; Stevens and Stone, 2007). See Figure 1 for the states shown (boundaries distorted) and Figure 2 for the time span depicted.*
The time span depicted.

The overthrust Roberts Mountains allochthon. The trans-Idaho discontinuity is adapted to the intermountain region. Asterisks denote windows of miogeoclinal strata exposed beneath.

Figure 10. Early Cambrian to Mississippian (520–325 Ma) tectonomagmatic relations across the intermountain region. Asterisks denote windows of miogeoclinal strata exposed beneath the overthrust Roberts Mountains allochthon. The trans-Idaho discontinuity is adapted after Yates (1968). See Figure 1 for the states shown (boundaries distorted) and Figure 2 for the time span depicted.

imply. The elevated Cretaceous–Paleogene Nevadaplano was comparable in its dimensions to the Andean Altiplano, which occupies an analogous geotectonic position in modern South America. Mesozoic backarc evolution of the Great Basin can be understood as coordinated with coeval tectonic events in the Cordilleran arc and forearc to the west. Mesozoic depositional systems of the Colorado Plateau to the east were more closely linked to coeval sedimentary systems of the Great Basin than is commonly appreciated. Distorted and disrupted Paleozoic allochthons that have been partly removed by erosion formed as originally linear and continuous belts parallel to the trend of the older Cordilleran miogeoclone. The Walker Lane belt of transform shear overprints the trend of the southern segment of the ancestral Cascades arc much as the central Sumatran fault overprints the Sunda arc in Indonesia, with both structures serving to separate a coastal sliver plate from the interior of a continental block.

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