Miogeocline extends into CA on NNE-SSW trend but then vanishes—but very similar rocks show up in Caborca, Mexico. Which geometry is right?
J.H. Stewart

commonly considered to have been deposited in deep water west of the miogeoclinal belt and to have fringed the western margin of ancestral North America. Transport along thrust faults emplaced these strata over miogeoclinal strata of ancestral North America. The history of emplacement is complex. In Nevada, the first emplacement took place during the Late Devonian to Early Mississippian Antler orogeny, when Ordovician to Devonian strata were transported along the Roberts Mountains thrust over miogeoclinal strata. Renewed offshelf deep-water deposition took place in Nevada in the Pennsylvanian and Permian, and these rocks were in turn emplaced over miogeoclinal strata during the Late Permian to Early Triassic Sonoma orogeny. The history of emplacement in Mexico is different. Here Ordovician to Permian deep-water siliceous strata are in a continuous sedimentary succession that was emplaced over, or transpressional against, miogeoclinal strata in the Permian or Early Triassic. As described previously, no evidence of the Antler orogeny has been described in Mexico, and the relation of a continuous succession of siliceous strata unbroken by a thrust comparable to the Roberts Mountains thrust is indicative of the difference in tectonic history between Nevada and Mexico.

Ordovician to Devonian deep-water siliceous rocks of the Roberts Mountains allochthon and comparable age strata in the Sonora allochthons (Fig. 13) consist of relatively deep-water marine strata originally deposited along the Laurentian continental margin outboard of the Cordilleran miogeocline (Madrid et al., 1992b). The rocks consist of complexly deformed radiolarian chert, graptolitic shale, quartzite, feldspathic sandstone, siltstone, minor mafic lava flows, bedded tuff, limestone, and bedded barite (Poole et al. 1991, 1995b; Madrid et al., 1992b; Jeep et al., 1997; Madrid et al., 1999).

The Neoproterozoic and Paleozoic Cordilleran miogeocline (Stewart, 1998; Madrid et al., 1995a) is a large, complex belt of miogeoclines and continental cover strata that extends from the western United States and northwestern Mexico to the Pacific Ocean (Fig. 12). The miogeocline is characterized by a trend of high-grade metamorphism and deformation, and it is bounded by the Neoproterozoic and Paleozoic continental cover strata. The miogeocline is divided into the Ouachita orogenic belt and the Cordilleran miogeocline (Stewart, 1998; Madrid et al., 1995a).

The trend of the Cordilleran miogeocline is shown in Figure 12. The miogeocline is characterized by a trend of high-grade metamorphism and deformation, and it is bounded by the Neoproterozoic and Paleozoic continental cover strata. The miogeocline is divided into the Ouachita orogenic belt and the Cordilleran miogeocline (Stewart, 1998; Madrid et al., 1995a).

Symbols: BCN, Baja California Norte; BCS, Baja California Sur; EL, El Capitán; GM, Gila Mountains; SB, San Bernardino Mountains; WMD, western Mojave Desert.

Stewart, GSA SP 393, 2005
Right plot suggests that miogeoclinal trend in Caborca also cut off.
al. (1995a), and Stewart and Poole (2002). In the western United States, thicknesses in meters. The southward track of the belt through Nevada is well defined from Figures 9 and 10 of Poole and Sandberg (1991).

The Mississippian stratigraphy and structure of miogeoclinal and foreland-basin strata in Sonora is significant. Only matrix-rich sandstone, siltstone, and mudstone of the Antler trough strata, and no shale-basin strata are present east of this is limestone along the eastern part of the miogeocline. The Mississippian shelf at Rancho Placeritos in Sonora (Fig. 9) (Poole et al., 1991) has been interpreted as a part of the Antler orogeny led to a marked change in the sedimentary and structural setting of the western United States (Poole, 1974; Carr et al., 1992, 1997). However, Poole (1974) and Carr et al. (1992, 1997) interpret metaconglomerate and metaargillite as related to the Antler orogeny died out southward in eastern California and was emplaced eastward above Devonian and older Paleozoic allochthon (Fig. 9).

In the El Paso Mountains, no definition of the Mississippian strata is known, no outcrops of Ordovician or Silurian strata are known, and no shale-basin strata are present east of this is limestone along the eastern part of the miogeocline. The Mississippian fine-grained sandstone, siltstone, and mudstone strata contain deformational fabrics similar to each other (Carr et al., 1992). The zone of Devonian truncation. In the San Bernardino Mountains, Poole (1974) similarly has interpreted clastic strata and siltstone as relating to the Antler orogeny and was emplaced eastward above Devonian and older Paleozoic allochthon.

Systematic left-lateral offset of strata and facies and recognition of structures related to the belt are less well constrained and was emplaced eastward above Devonian and older Paleozoic allochthon (Fig. 9) is composed of ocean-basin siliceous strata and was emplaced eastward above Devonian and older Paleozoic allochthon.
The Pennsylvanian–Early Permian Bird Spring Carbonate Shelf (Longwell, 1928) have not gained general acceptance. Shelf carbonate strata equivalent to parts of the Bird Spring Formation are represented by the Callville Limestone (Longwell, 1928) and Pakoon Limestone (McNair, 1951) in southeasternmost Nevada, northwestern Arizona, and southwestern Utah, and by the Tippipah Limestone (Johnson and Hibbard, 1957) in southwestern Nevada.

In southeastern California, early geologic mapping and stratigraphic studies (e.g., Hazzard, 1937, 1954; Hewett, 1956) showed that the Bird Spring Formation occurs in several widely separated ranges in the Mojave Desert region. The formation is now recognized as far south as the San Bernardino Mountains (Brown, 1991) and as far north as the Death Valley area (Panamint Range and Cottonwood Mountains) (Stone and Stevens, 1984) (Fig. 1).

The seven outcrop areas represented in this study provide a regional transect across the Bird Spring Shelf in California. From southeast to northwest, these areas are (1) the Ship Mountains, (2) the Providence Mountains, (3) Old Dad Mountain, (4) Cowhole Mountain, (5) Striped Butte and (6) nearby Warm Spring Canyon in the southern Panamint Range, and (7) Panamint Butte in the southern Cottonwood Mountains (Fig. 1). Outcrop areas not considered for this study include Marble Canyon in the central Cottonwood Mountains (Stone, 1984) and the Nopah Range (Hazzard, 1937; Burchfiel et al., 1982), where fusulinids are rare and the Bird Spring Formation does not extend into the Permian; the Clark Mountain Range (Clary, 1967) and the San Bernardino Mountains (Brown, 1991), where only Pennsylvanian fusulinids
Today things are hacked up, but in the pieces between can divine the SSW trend possibly turning to SE in Mojave. Note the Permian–Tr plutons—will come back to those.
Keeler basin (late Penn) inferred to be extensional from truncation event, then shortening in early Permian starved Keeler/Lone Pine basin. Darwin basin interpreted as a foredeep to Conglomerate Mesa uplift. Get very tight age controls indicating LCT moved 3 mm/yr over 10 m.y. Associates extension with left-lateral fault, LCT with Penn. deformation (Pinon orogeny?) in Nevada.
Inferred positions prior to eastward displacement in the upper plate of the Last Chance thrust (LCT) during Sakmarian time. (A) Atokan. (B) Bursumian. (C) Late Sakmarian. (D) Middle Artinskian. Localities shown: CH—Cowhole Mountain; CM—Conglomerate Mesa; DC—Darwin Canyon; MC—Marble Canyon; OD—Old Dad Mountain; PB—Panamint Butte; PBL—Permian Bluff; PR—Providence Mountains; SB—Striped Butte; SH—Ship Slope Uplift; SRH—Santa Rosa Hills; UM—Ubehebe Mine; WSC—Warm Spring Canyon. Palinspastic restorations are based on regional relationships. We view all the faults to have undergone some amount of shortening, with Late Permian being preferred on the basis of small faults in the Mount Morrison pendant. Deformation, with Late Permian being preferred on the basis of small faults in the Mount Morrison pendant. Deformation, with Late Permian being preferred on the basis of small faults in the Mount Morrison pendant. Deformation, with Late Permian being preferred on the basis of small faults in the Mount Morrison pendant. Deformation, with Late Permian being preferred on the basis of small faults in the Mount Morrison pendant.

Summary and conclusions

Deformation represented by the Sierra Nevada–Death Valley thrust system is considered to have been related to compressional tectonics along a southeast-trending segment of the Late Paleozoic truncated margin. These thrusts, as well as all subsequent contractional deformations in the region, are here coeval with the Sonoma orogeny recognized in northern California (Stevens and Greene, 1999) and the Mule Spring orogeny of central Nevada. Barrovian metamorphism along this southeast-trending continental margin and late Paleozoic truncated-margin segments. The voluminous Sierran arc magmatism is considered to have been related to compressional deformation apparently reflects the initiation of plate convergence and subduction that later led to formation of the cross-section.

Acknowledgments

B. Miller helped greatly, especially in the construction of the cross-section. We thank Robert L. Sieh for his encouragement and implementation in the opportunity of the Late Paleozoic truncated margin. Barrovian metamorphism along this southeast-trending continental margin and late Paleozoic truncated-margin segments. The voluminous Sierran arc magmatism is considered to have been related to compressional deformation apparently reflects the initiation of plate convergence and subduction that later led to formation of the cross-section.

References


Stevens and Stone, Earth Sci Rev., 2005
Deformation belt in B is Penn deformation in Nevada. There is also deformation like that in A that was left off.
But are younger units truncated and offset? Can we look at latest Paleozoic to unravel?
Is Caborca offset late Paleozoic?
El Paso Mtns (close to proposed truncation) has lower Mississippian conglomerate

El Paso Mtns also have a pretty thick sequence of Ordovician–Cambrian deep water clastic seds and quite a bit of Devonian (including, apparently, a Devonian ash fall tuff—El Paso Mtn Geol Map)
Recall the elements of the Permian here. If we restore for Cz and likely K faults, we get picture on right. Note in particular the distribution of Permian-Triassic plutons and how they cross the Devonian facies belts in NW.
New reconstruction of the Paleozoic continental margin of southwestern North America

Figure 4. Paleogeographic reconstruction, step 2. Restoration of Cretaceous sinistral displacement of the Peninsular Ranges on the Nacimiento fault. See discussion in text. Abbreviations and symbols as in Figure 2.

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Figure 2. Index map showing Devonian facies belts, selected Paleozoic sedimentary boundaries on the continental shelf, areas interpreted to be underlain by oceanic crust, and major faults that have displaced facies belts and sedimentary boundaries. Note that in several areas rocks of the outer rise and ocean basin now are underlain by continental crust because of thrusting of those facies over the continental margin. In addition, outer-rise rocks not now exposed in the Saddlebag Lake area are inferred to underlie the ocean basin facies in that area. CB—Canal Ballenas area; CM—Coyote Mountains; CV—Cerro El Volcán; CWf—Clemens Well fault; DV-FCfz—Death Valley–Furnace Creek fault zone; EB—El Bisani; Ef—Excelsior fault; Gf—Garlock fault; H—Hermosillo; IBB2—Intrabatholithic break 2; LVVfz—Las Vegas Valley fault zone; MVf—Mojave Valley fault; RP—Rancho Placeritos; SFf—San Francisquito fault; SGf—San Gabriel fault; SLP—Sierra Las Pinta; SVf—Stewart Valley fault; Tf—Tinemaha fault.

The paleogeographic reconstruction presented here is similar in some respects to that of Stevens et al. (1992), who also interpreted the continental margin to have been truncated by late Paleozoic sinistral faulting that caused large southward displacement of both the Caborca block and rocks of the El Paso Mountains. This previous reconstruction, however, placed the truncational fault east of the present position of the El Paso Mountains rather than along the Foothills Suture to the west and did not require the El Paso terrane to have been thrust eastward to its present position in the Late Triassic. This previous reconstruction cannot be completely ruled out; in fact, it would result in a more linear belt of Permian and Triassic plutons than in the present reconstruction after restoration of the inferred Late Triassic thrust faulting (compare Figs. 4 and 5). On the other hand, the previous reconstruction does not account for the presence of Precambrian continental crust west of the El Paso Mountains, as interpreted in this paper, or for the probable role of the Foothills Suture in a late Paleozoic continental truncation event (Saleeby, 1992). Thus, the previous reconstruction would require substantial modification to remain a viable alternative to the one presented here.

Figure 7. Paleogeographic reconstruction, step 4B. Restoration of sinistral displacement on a proposed Pennsylvanian continental truncation fault predating the Mojave-Sonora megashear. See discussion in text. Abbreviations and symbols as in Figure 2.

Recovering the SW end of the miogeoclone...
Rather surprising apparent growth of the arc to the SE from El Pasos.
Note summary of ages of Permian into early Triassic on left. Oldest continental rocks receiving detritus from this arc is Chinle. Interestingly, these might not be quite as old as start of arc...
Little correlation exists between percentages of different-age zircons and Chinle Formation sample sites. Chinle exposures are shown in black; arrows indicate paleo

Figure 3. Pie plots demonstrating major detrital-zircon age similarities and differences between the Chinle Formation and Early Mesozoic arc.

Figure 4. Th/U versus age plot for detrital grains.

Many grains younger than ca. 230 Ma have less-certain sources. The in

 Subset of Permian–Triassic zircons. Suggests presence of arc even back to 280 Ma.
Lag in timing reflects, authors argue, presence of marine arc until c. 230 Ma.
Permian subduction initiation in the El Paso Mountains, California

RESEARCH

in a recrystallized mud matrix. Iron-stained grayish-orange, laminated to thin bedded argillite to sandy siltstone beds form a continuously exposed section near the top of the member. In thin section, one sample contains very angular to well-rounded, fine-to-very fine-grained chert lithic fragments (~20%), quartz grains (~7%), angular to subangular opaque grains (~7%), and trace sponge spicules, set in a cherty-silty clay matrix (~60%) with patchy calcite cement. The opaque minerals define lamination.

Member B (Phb) is more calcareous than member A (Pha) and consists of thinly to thickly bedded, medium- to dark-gray argillite and medium-gray to yellowish-brown calcareous argillite interbedded with dark-yellowish-orange calc-siltstone. Covered intervals between outcrops are more extensive than in member A (Pha). In thin section, all samples from member B (Phb) consist of clay or silt with local sponge spicules, and opaque, (organic?) material.

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Facies changes in El Paso Mtns not global—what is this telling us about SW margin c. 280 Ma? Worth noting that this same deepening was inferred by Snow long ago as a fore deep in front of the Last Chance Thrust System.
Interpreted as early phase of subduction initiation. We'll come back to the arc much later, but this would seem to help clinch truncation by Permian.
Standing back, how does all this fit in?
Standing back, how does all this fit in? And does this make sense with the Ancestral Rockies? [Wonder how this might look on a proper palinspastic base]
Note that we have both the deep water facies and the shallow shelf rocks in close quarters, like the situation in eastern NV.