Correlation of Permian and Triassic deformations in the western Great Basin and eastern Sierra Nevada: Evidence from the northern Inyo Mountains near Tinemaha Reservoir, east-central California: Discussion

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Stevens and Stone (2002) proposed a complex structural history along the eastern Sierra Nevada and west flank of the Inyo-White Mountains involving two phases of latest Permian to early Triassic deformation, and two events of Triassic strike-slip faulting of opposite sense of slip. Several major problems with their outline of events include: (1) incomplete to incorrect representation of the structures at the Mount Morrison pendant, (2) invalid correlation of two structural domains, (3) lack of a unique piercing point on the proposed Tinemaha fault, (4) inconsistent representation of Triassic faulting favoring undocumented right-lateral slip over possibly simultaneous known left-lateral faulting (Greene et al., 1997a), and (5) incomplete representation of Cenozoic faulting along the base of the Inyo Mountains. Many of these points deserve clarification and the ideas set forth by Stevens and Stone (2002) may accordingly require revision.

1. Deformation at both the Mount Morrison pendant (MMP) and Strange Hill (SH) is highly complex and to date not fully understood. Stevens and Stone (2002) used the locally termed Morrison orogeny (a.k.a. Sonoma orogeny), originally proposed by Stevens and Greene (1999), to explain their interpreted first phase of deformation in the MMP, and then inferred superimposed earliest Triassic deformation to refold the first generation structures. Locations cited as containing the superimposed deformation give a misleading picture of the MMP where most of the rocks uniformly contain a single strong northwest-striking hinge surface cleavage and lack small-scale fold superposition (Wise, 1996). At Sevehah Cliffs, the cited works by Stevens (1998) and Stevens and Greene (1999, 2000) indicate the presence of a large-scale syncline that was refolded by an inferred fault restraining bend along the Laurel-Convict fault, producing northeast-trending second folds. Note that folds hosted in upper Paleozoic strata to the west of the fault have linear hinge lines, and the fault sharply cuts all older structures. Less common very steeply plunging northeast-trending minor folds all lie within the northwest-striking plane of foliation and cleavage, and should not be interpreted as a second set of folds because northeast-striking hinge surfaces are absent. Very few minor folds lie with a northeast-trend, and not a single northeast-trending fold occurs in the upper Paleozoic rocks of the pendant. I have assigned the same units at Sevehah Cliffs to different formations that do not require a fold (Wise, 1996). The second location at McGee Mountain used by Stevens and Stone (2002) does not demonstrate superimposed deformation. Stevens and Stone (2002) omit a critical description of the upper Paleozoic rocks of the MMP, rocks that only contain one generation of upright subhorizontal folds, a pattern completely different from that of SH. Finally, their summary of the undated Hilton Creek Marble along the Nevahbe ridge in the eastern part of the MMP as belonging to the Pennsylvanian Mount Baldwin Marble to support the Morrison orogeny (Stevens and Greene, 1999, 2000) is tenuous at best and most likely incorrect. Petrologic descriptions of the two units provided by Rinehart and Ross (1964) and Wise (1996) clearly detail the differences.

2. The limited orientation data at SH (n = 18), while coincident with that of lower Paleozoic strata in the MMP, do not prove coeval formation, nor can much confidence be placed that the SH structures have not undergone Cenozoic rotation (discussed below with item 5). The SH data are from Triassic and Mississippian strata, whereas the MMP data used in Stevens and Stone's (2002) comparison come from pre-Mississippian strata. Stevens and Stone (2002) stated that the fold style is similar between the two areas, but did not describe the fold form, such as that defined by dip isogons, nor give interlimb angles from the Tinemaha Reservoir area, and therefore their inference is unsupported. Their Figure 3 suggests more shallowly plunging folds than data given in the stereonet of their Figure 7. The structures shown in their Figure 5 and diagrammed in the cross section of their Figure 6 imply that the pre-Triassic rocks formed a very large recumbent fold they call the Mule Spring syncline. In contrast, not a single recumbent fold has been described from the MMP.

The structural scenario of Stevens and Stone (2002) calls for only early Mesozoic deformation, whereas both Russell and Nokleberg (1977) and Wise (1996) considered the earlier Antler orogeny to have deformed rocks of the MMP. Note that the pendant lies south in the footwall area of both the Roberts Mountains and Golconda allochthons (Schweickert and Lahren, 1987; Greene et al., 1997b). Absolute age constraints on the deformation in the eastern half of the pendant are younger than Upper Devonian and older than 225 Ma (Greene et al., 1997a). At present, cited ar-

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guments presented by Stevens and Greene (1999, 2000) are insufficient to exclude older deformation. At SH, the first deformation is after the Pennsylvanian and older than the Lower to Middle(?) Triassic Union Wash Formation, which is clearly younger than the Antler orogeny.

3. Stevens and Stone (2002) inferred the buried right-lateral Tinemaha fault to be active in the middle to late Triassic, but do not provide valid offset markers. Sense of slip is based on inferred offset of a Devonian submarine fan distributary channel, offset of two structural domains, and an apparent step in the initial $^{87}Sr/^{86}Sr = 0.706$ line near Long Valley Caldera. The Mount Morrison Sandstone at MMP is similar to very thin channels preserved in the Inyo Mountains, however, I emphasize that it does not provide a unique piercing point. Submarine fans may form by a series of parallel distributary channels down gradient of the continental slope. Therefore, the Mount Morrison Sandstone may not necessarily have been fed from the channel in the Inyo Mountains. Even if the two locations were related, a distance of 65 km of present separation is not out of bounds for submarine channel transport. Another inferred marker of offset along the Tinemaha fault uses the inference that the rocks of SH once formed or were nearby those of MMP as based on comparison of the structural style of the two domains. As discussed above, the structural similarities between the two regions are not convincing, and even if they were identical, they would not define a true piercing point. The third criteria of offset used an apparent right-lateral jog of the initial $^{87}Sr/^{86}Sr = 0.706$ line at Long Valley Caldera (Kistler, 1993). Sample locations around Long Valley Caldera are few and the strontium data can be contoured without interpreting sharp breaks or offsets. The shape of the 0.706 line may reflect older variations in the basement and need not have been modified by a fault.

4. Early to middle Triassic left-lateral faulting along the eastern Sierra Nevada is known from the Laurel-Convict and McGee Creek faults in the MMP (Wise, 1995; Greene et al., 1997a), and is inferred from a major regional continental truncation event which translated rocks of the Roberts Mountains allochthon southward to the El Paso Mountains (Burchfiel and Davis, 1981; Walker, 1988; Stone and Stevens, 1988; Martin and Walker, 1995). Age constraints for the inferred right-lateral Tinemaha fault nearly require coeval slip with that of the Laurel-Convict fault. Plate margin strike-slip faults are commonly driven by oblique subduction, and this is unlikely to generate closely spaced parallel strike-slip faults with opposite sense of slip. From exposed faults and regional considerations, left-lateral and reverse faults are characteristic for the Triassic eastern Sierra Nevada.

5. Cenozoic normal faults perhaps reoriented rocks of SH, making the comparison of folds to other areas equivocal. Despite Stevens and Stone's (2002) discussion of the range front normal faults of the western Inyo Mountains, their map in Figure 2 leaves open the possibility of normal faults buried in the alluvium. If a normal fault lies between SH and Big Hill, then significant hanging-wall block rotation may have reoriented the older structures. Stevens and Stone (2002) do not discuss this area marked with the hinge line of the Mule Spring syncline as potentially concealing a normal fault. Their interpretation of the Big Hill fault as being low-angle and westward-dipping makes additional upper-plate normal faults likely and warrants further examination.

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