Reply

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INTRODUCTION

The paper by Stevens and Stone (2002) was an attempt to correlate tectonic events represented by structures and rocks in the Inyo Mountains with those of the eastern Sierra Nevada. Of necessity, this correlation was partly speculative and relied upon a number of interrelated interpretations. In his discussion, Wise questions many of our interpretations without considering how they are interrelated, and in most cases he offers no alternative solutions for the structural problems present in the region. Nonetheless, we welcome this discussion as an opportunity to present our evidence in a more condensed fashion.

Wise organizes his discussion into five topics, to which we will respond in order.

INCOMPLETE TO INCORRECT REPRESENTATION OF THE STRUCTURES AT THE MOUNT MORRISON PENDANT

Wise raises several objections to our interpretation of the deformational history of the Mount Morrison pendant (MMP), which bears strongly on our regional interpretations. For example, Wise recognizes only one set of northwest-striking folds, whereas we recognize two sets of different age. As stated in our paper, we base our interpretation on a combination of factors. First, the small folds measured by Wise (1996) in the MMP have a more westerly trend than the very large-scale folds in the same area (Stevens and Greene, 2000; Greene and Stevens, 2002), suggesting two episodes of deformation. This interpretation is consistent with that of Russell and Nokleberg (1977), who recognized three northwest-trending fold sets in the MMP, the oldest two of which apparently correspond to the two sets recognized by us. In addition, the existence of two sets of northwest-trending folds in the MMP is consistent with the presence of two fold sets of similar orientation and geometry in the Tinemaha Reservoir area 65 km to the south, which we interpret to have been adjacent to the MMP at the time of folding. There, one fold set predates and the other postdates deposition of the Early and Middle(?) Triassic Union Wash Formation, clearly indicating two separate periods of deformation.

Wise also discounts the presence of northeast-trending folds in the MMP, which we interpret to refold some of the northwest-trending folds. He apparently has misinterpreted where the northeast-trending fold discussed by Stevens and Greene (2000) and mapped by Greene and Stevens (2002) is located in the Sevehah Cliffs ~0.5 km north-northeast of Laurel Mountain. This fold is visible from Convict Lake and is cored by the Aspen Meadow Formation (see Greene and Stevens, 2002). Wise also makes a major point that the northeast-trending folds at Sevehah Cliff and inferred on McGee Mountain do not extend across the Laurel-Convict fault into upper Paleozoic rocks, implying that this relation is inconsistent with our structural interpretation. On the contrary, Stevens and Greene (2000) clearly recognized this relationship and interpreted it as evidence that considerable strike-slip displacement took place on the Laurel-Convict fault after folding about the northeast-trending axes had ended.

Finally, and perhaps most importantly, Wise does not accept our correlation of the Hilton Creek Marble of Rinehart and Ross (1964) with the Pennsylvanian to Lower Permian Mount Baldwin Marble. This correlation is highly significant because, if true, it limits the age of the oldest major deformation in the MMP to post–Early Permian. We correlate these units based on several lines of evidence. First, the two units are very similar lithologically, contrary to the assertion of Wise (1996) that the Hilton Creek Marble differs in lacking chert nodules and in being darker gray and finer grained. Rinehart and Ross (1964) reported that the Hilton Creek Marble contains scattered chert nodules in one area and described the marble as being light gray to dark bluish-gray. They described the Mount Baldwin Marble similarly as having locally abundant chert nodules, and composed of medium gray, dark gray, and bluish-gray, fine-grained marble, with an abundance of crinoid ossicles. Willahan (1991), in a detailed study of the rocks in the MMP, also described the Mount Baldwin Marble as light to dark bluish-gray with scattered black chert nodules near the base and some near the top. The only significant difference between the two units appears to be the lack of crinoid debris in the Hilton Creek Marble, and this is likely due to its intense alteration.

The Hilton Creek Marble also strongly resembles rocks assigned to the Mount Baldwin Marble by Bateman (1965) and Stevens and Greene (1999) in the Pine Creek pendant ~17 km south of the MMP. Like the Hilton Creek Marble, these rocks are highly altered and contain no remnants of crinoids. Underlying clastic rocks in the Pine Creek pendant include conglomerate that contains clasts of dark gray argillite probably derived from the Upper Devonian Squares Tunnel Formation and clasts of a distinctive sandstone that occurs only in the Middle to Late Devonian Sevehah Group. These clasts support assignment of the enclosing strata to the Mississippian Bright Dot Formation (Stevens and Greene, 1999) and assignment of the marble to the

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only upper Paleozoic carbonate unit known in the region, the Mount Baldwin Marble.

Furthermore, mapping by Bateman (1965, 1992) shows that the steeply dipping Mount Baldwin Marble in the Pine Creek pendant trends directly toward the steeply dipping outcrops of the Hilton Creek Marble in the MMP. These outcrops are almost connected by an arcuate string of small pendants along the east margin of the Round Valley Granodiorite. Tikoff et al. (1999) have shown that forceful emplacement of the Mono Creek pluton created a bulge that locally deflected the contact between the metamorphic wall rocks (including the Mount Baldwin Marble) and the Wheeler Crest Granodiorite by ~7 km. Removal of this deflection aligns the Hilton Creek Marble in the MMP, the string of small pendants, and the Mount Baldwin Marble in the Pine Creek pendant, strongly suggesting that all three are closely related stratigraphically.

In summary, lithologic similarity, stratigraphic position, and regional structural relations all provide strong evidence for our correlation of the Hilton Creek Marble with the Mount Baldwin Marble.

INVALID CORRELATION OF TWO STRUCTURAL DOMAINS

In this section, Wise questions our structural correlation between the MMP and the Tinemaha Reservoir area. In his first few comments he asserts that our data on fold orientation and style at Strange Hill in the Tinemaha Reservoir area are insufficient to prove such a correlation. We agree that these data, taken alone, are only suggestive of a correlation with structures in the MMP, as we clearly indicated in our paper (Stevens and Stone, 2002, p. 1219). Our structural correlation, however, is based not only on this one limited data set but also on other independent evidence that the Tinemaha Reservoir area and the MMP were once adjacent to each other. In this context, our structural data become much more convincing.

Wise further states that the Mule Spring syncline near Tinemaha Reservoir, which is now largely upright but which we interpret as having originated as a recumbent syncline in the footwall of the Strange Hill thrust, has no analogs in the MMP. As we stated in our paper (Stevens and Stone, 2002, p. 1219), however, based on the previous work by Stevens and Greene (2000), we believe that similar upright synclines, also originating as footwall synclines, are indeed present in the MMP. In all respects the large synclines in both areas are very similar, and we interpret all of them to have been originally recumbent and later rotated approximately to the vertical. In the MMP, detailed mapping by Stevens and Greene (2000) and more recently Greene and Stevens (2002) shows that some of the synclines have thinned western limbs, consistent with their inferred origin as overturned footwall synclines (Stevens and Greene, 2000). At Tinemaha Reservoir, an unconformably overlying sequence of Triassic rocks provides a direct basis for inferring the pre-Triassic orientation of the Mule Spring syncline. The absence of Triassic rocks in the MMP precludes an accurate determination of the original orientation of these structures, but the structural relationships are entirely consistent with the interpretation that they originally dipped moderately to gently westward, similar to the Mule Spring syncline.

Finally, Wise states that the MMP is in the footwall of the Roberts Mountains allochthon, implying that the oldest deformation in the pendant was due to the Antler orogeny and not to our Late Permian to earliest Triassic Morrison orogeny. This interpretation, however, overlooks critical regional stratigraphic and structural relationships, particularly with regard to the Saddlebag Lake and Log Cabin Mine pendants ~50 km northwest of the MMP. In the Saddlebag Lake pendant, only ~30 m of Permian conglomerate, unconformably overlying deformed lower Paleozoic Antler belt rocks, comprises the entire late Paleozoic section (Schweickert and Lahren, 1987). By contrast, late Paleozoic rocks in the Log Cabin Mine pendant only ~5 km to the east include the Mount Baldwin Marble and a small amount of the Mississippian Bright Dot Formation. This section is inferred to have been at least 2500 m thick and composed primarily of fine-grained siliciclastic rock, similar to that in the MMP (Stevens and Greene, 1999), although only a partial section now remains because of structural complications. This difference in thickness and lithology strongly suggests that the rocks in the Saddlebag Lake pendant are allochthonous relative to the Mount Baldwin Marble in the Log Cabin Mine pendant, and that they were much farther west than today until well after the Antler orogeny. If this interpretation is valid, there is no reason to think that any deformation in the MMP must have been related to the Antler orogeny.

LACK OF UNIQUE PIERCING POINT ON THE PROPOSED TINEMAHA FAULT

Wise takes issue with evidence we presented for existence of the cryptic Tinemaha fault, on which we interpret dextral displacement of ~65 km. Our interpretation was based on three lines of evidence: (1) apparent displacement of the Sri = 0.706 isopleth of ~65 km; (2) possible displacement of the main channel of the Morrison submarine fan from the Tinemaha Reservoir area to McGee Mountain in the MMP (a distance of ~65 km); and (3) the presence of similar unique structures in the MMP and the Tinemaha Reservoir area (again ~65 km apart). None of these lines of evidence by itself proves the existence of the Tinemaha fault, although Kistler (1993) suggested that the Sri data alone were sufficient to postulate considerable dextral displacement in this area. More recently Kylander-Clark et al. (2003) reported that Late Cretaceous dikes apparently are offset 65 km dextrally across southern Owens Valley and Glazner et al. (2003) suggested that a minimum of 65 km of dextral displacement of Late Jurassic dikes has occurred across southern and central Owens Valley. These displacements are closely similar to the proposed displacement on the Tinemaha fault, suggesting that these dikes may have been displaced on a southern extension of the Tinemaha fault.

INCONSISTENT REPRESENTATION OF TRIASSIC FAULTING FAVORING UNDOCUMENTED RIGHT-LATERAL SLIP OVER POSSIBLY SIMULTANEOUS KNOWN LEFT-LATERAL FAULTING

Wise argues that our interpretation of Middle to Late Triassic dextral displacement on the Tinemaha fault is incompatible with the known history of Triassic sinistral displacement in the region, which he relates to plate motions. We also have had concern about the age of the Tinemaha fault, but favored the interpretation that dextral displacement on this fault is older than left-lateral displacement on the Middle to Late Triassic Laurel-Convict fault (Greene et al., 1997). On page 1220 of our paper (Stevens and Stone, 2002), we acknowledged that the Tinemaha fault "could be younger (than Middle to Late Triassic) because we cannot conclusively demonstrate that it is intruded by the (Late Triassic) Wheeler Crest Granodiorite," which appears to cross the inferred fault trace. The recent work by Glazner et al. (2003) and Kylander-Clark et al. (2003) indeed suggests that displacement in Owens Valley, including that on the Tinemaha fault, may be much younger than we previously interpreted.

INCOMPLETE REPRESENTATION OF CENOZOIC FAULTING ALONG THE BASE OF THE INYO MOUNTAINS

In the final section of his discussion, Wise criticizes us for not considering the possibility of a buried normal fault between Big Hill and Strange Hill in the Tinemaha Reservoir area that may have reoriented the older structures, which would weaken our structural correlation between this area and the MMP. In response, we can say only that there is no indication of a significant fault in this position. Equivalent strata with opposing facing directions are exposed on opposite sides of the covered interval, suggesting that the only major structure present is the Mule Spring syncline. We therefore see no reason to suspect a fault-related reorientation of older structures such as that suggested by Wise.

SUMMARY

In summary, there are certainly gaps in knowledge that leave some of our interpretations open to debate, and Wise has made a useful contribution in highlighting some of these. We do not think, however, that his comments seriously weaken or disprove any of our significant interpretations. Therefore, we believe that our paper provides the best available synthesis of the stratigraphic and structural relations in this important area, and we stand by all of the statements made with the possible exception of the age of the Tinemaha fault. Nevertheless, we strongly encourage additional work in the region to test and, if necessary, modify our interpretations.

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