COMMENTS AND REPLIES

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Reply

REPLY to "COMMENT on 'Preexisting fractures and the formation of an iconic American landscape: Tuolumne Meadows, Yosemite National Park, USA,' by Jeffrey P. Schaffer"

Richard A. Becker *and* ***Basil Tikoff,*** *Dept. of Geoscience, University of Wisconsin, 1215 W. Dayton Street, Madison, Wisconsin 53706, USA;* ***Paul R. Riley,*** *ExxonMobil Production Co., 800 Bell St., Houston, Texas 77002, USA; and* ***Neal R. Iverson,*** *Dept. of Geological and Atmospheric Sciences, Iowa State University, Ames, Iowa 50011, USA*

Schaffer (2015) misrepresents our central argument. Our central argument is that the Tuolumne Meadows landscape—as it exists today—is the result of the glaciation of rock hosting varying tabular fracture cluster (TFC) concentrations. We argue that TFC concentration, "clumpiness," and orientation relative to ice flow are fundamental controls on the landforms etched in this iconic landscape.

It is appropriate to compare Tuolumne Meadows with the Mono Recesses. Tuolumne Meadows has TFCs, is underlain by Cathedral Peak Granodiorite, and was glaciated. Determining what role TFCs have played in the evolution of this landscape requires comparing Tuolumne Meadows with a glaciated landscape that has a similar lithology but with few to no TFCs. The Mono Recesses fit this description. They were glaciated (Birman, 1964) and are underlain by the Mono Creek Granite, which so closely resembles the Cathedral Peak Granodiorite that it was initially mapped as the Cathedral Peak (Huber and Rinehart, 1965). Both plutons are megacrystic and straddle the boundary between granite and granodiorite. There are few to no TFCs in the Mono Recesses, while there are several hundred to a few thousand in the Tuolumne Meadows area (Riley and Tikoff, 2010). The comparison is nearly ideal.

Schaffer (2015) suggests comparing Tuolumne Meadows with Vermillion Valley, but this comparison is less appropriate. Vermillion Valley is underlain by Lake Edison Granodiorite, a fine- to medium-grained equigranular pluton that resembles the Half Dome Granodiorite and not the megacrystic Cathedral Peak (Bateman, 1992). While we acknowledge that this textural difference is unlikely to greatly alter how erosion sculpts the pluton, this is a needless compromise when the megacrystic Mono Creek Granite is available for comparison. Furthermore, Tuolumne Meadows remains anomalously broad and open even when compared with Vermillion Valley.

Schaffer (2015) argues that Tuolumne Meadows should have been compared with unglaciated meadows in the southern Sierra Nevada, but—provided these meadows are also underlain by TFCs—this would have tested a different question, that of how glaciation has affected the Sierra Nevada's geomorphic history. Our aim, in contrast, was to address how TFCs have modified the morphology of Tuolumne Meadows; because Tuolumne Meadows was glaciated, we needed to compare it with a lithologically similar, glaciated landscape lacking in TFCs (i.e., the Mono Recesses).

Schaffer (2015) also criticizes us for "presuming" the presence of TFCs beneath Tuolumne Meadows, but it is unreasonable to think that TFCs are *not* present. In Becker et al. (2014), we presented three lines of evidence that argue strongly for the presence of TFCs: (1) high TFC concentrations are on strike in the adjacent hillsides; (2) the few bedrock outcrops visible above the Meadows-filling sediments have high TFC concentrations; and (3) a gravity survey (Titus et al., 2005) inferred the Johnson Granite Porphyry's near-surface presence, and TFCs are genetically associated with this pluton (Riley and Tikoff, 2010). Here, we add a fourth piece of evidence: GPR transects show buried bedrock furrows on strike with TFCs exposed in the adjacent hillsides (Chris Lowry, 2015, personal commun., data in preparation for *Water Resources Research*).

Schaffer's (2015) main criticism, however, is of our assessment of glacial erosion's efficacy. Yet, ultimately, we think that our positions are not that divergent. While Schaffer (1997, p. 26) argues that "glaciers are virtually powerless to erode resistant bedrock," he acknowledges that glaciers are capable of "major erosion in nonresistant bedrock, such as incoherent sedimentary and volcanic rocks" and in "pervasively fractured, readily quarried bedrock" (1997, p. 256 and 259, respectively). We think that the phrase "virtually powerless" is too strong, but what defines "major erosion" and "resistant" versus "nonresistant" bedrock? TFCs epitomize pervasive fracturing. If "major" glacial erosion is possible anywhere, it is possible in rock hosting high TFC concentrations. It is this spatial variability in fracture concentration—as exemplified by the presence or absence of TFCs—and in glacial erosion to which the iconic landscape of Tuolumne Meadows owes its origins.

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*Becker e-mail address: rabecker2@wisc.edu