Forum Reply

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The birth of a forearc: The basal Great Valley Group, California, USA

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We welcome comments from Rogov and Zakharov (2019) and appreciate the opportunity to further clarify our interpretation that the base of the Great Valley Group (GVG), California, USA, is diachronous and largely younger than previously mapped. The original age determinations for the oldest strata in the GVG are based on the zonal succession of *Buchia* bivalves *(B. piochii* and *B. Aff. B. okensis*), which indicate a Tithonian depositional age for the basal GVG (Jones et al., 1969; Imlay and Jones, 1970). As Rogov and Zakharov note, species *B. okensis* was subsequently transferred to the Berriasian (Zakharov, 1981; Bralower, 1990). More recently, the presence of Cretaceous detrital zircons and robust Cretaceous maximum depositional ages (MDAs; YC2σ(3+) method [weighted mean age of the youngest cluster of dates ($n \geq 3$) in a sample that overlapped at 2σ uncertainty) within strata mapped as Jurassic call into question the presence and/or extent of Jurassic strata in the GVG (Surpless et al., 2006; Orme and Surpless, 2019).

In particular, Rogov and Zakharov take issue with our assertion that *Buchia*, absent other age-diagnostic fossils, "may not be a reliable age constraint" (Orme and Surpless, 2019). Eighteen of twenty detrital zircon samples from mapped "Jurassic strata" contain Cretaceous zircons, with nine samples yielding robust Cretaceous MDAs, and two overlapping the Jurassic/Cretaceous boundary. Of 11 samples collected from outcrops with *Buchia* bivalves, nine contain Cretaceous zircons and four yield Cretaceous MDAs. In the Grindstone Creek area, four samples from the *Buchia* localities of Jones et al. (1969) contain Cretaceous zircon, and one yields a Cretaceous MDA (Sample JR07, 142.88 ± 0.82 Ma). All zircon samples come from non-calcareous, fine-to-medium–grained, deep-marine, turbiditic sandstone deposits, not autochthonous cold seeps identified by Campbell et al. (1993) and referenced by Rogov and Zakharov. Thus, the Great Valley *Buchia* of Tithonian age appear in strata that robust detrital zircon ages indicate are Cretaceous. Our detrital zircon results support the interpretation that the age of the basal "Jurassic" GVG must be revised to include both Cretaceous and Jurassic strata, and that the basal age of the GVG varies along strike.

We agree with Rogov and Zakharov that the uncertainty associated with the absolute age of the Tithonian-Berriasian boundary is problematic. We use the most recent, widely accepted version of the Geologic Time Scale (GTS2012; Ogg et al., 2012), which is also accepted by the Geological Society of America (Walker et al., 2018). Potential revision of the Tithonian-Berriasian boundary by Lena et al. (2019) to 140.7–140.9 Ma would restore all but one of our Cretaceous samples to Jurassic deposition, with an additional three samples within error of this date. Thus, extending the younger limit of the Tithonian Age to ca. 141 Ma still requires revision of the extent and thickness of the Jurassic and Lower Cretaceous strata within the Great Valley forearc basin, but may largely resolve the question of Great Valley *Buchia* as indicators of Tithonian deposition.

Regardless of the Jurassic/Cretaceous boundary age used, our large-*n* detrital zircon results indicate that (1) deposition of much of the basal strata in the Great Valley forearc basin began at least 5 million years later than previous mapping suggests, and (2) initial sedimentation in the Great Valley forearc basin was diachronous. As described in Orme and Surpless (2019), this compressed time frame for basal deposition and evidence of diachronous initiation of sedimentation is critical to understanding the development of the Great Valley forearc basin. Moreover, accurate numerical dates for the timing of basin development enable improved estimates of sedimentation rates in the basin, and comparison with dated magmatic and tectonic events, such as the timing of magmatic flare-up events in the Sierran arc and the development of an accretionary margin, thus placing Great Valley forearc basin development within the context of the evolution of the California convergent margin.

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