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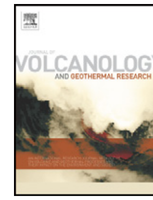

Discussion

Reply to the comment on the paper “Is the track of the Yellowstone hotspot driven by a deep mantle plume?—Review of volcanism, faulting, and uplift in light of new data”

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We thank Robert Hershler and Hsiu-Peng Liu for their comments. The history of drainages associated with the track of the Yellowstone hotspot is complex. We attempted to outline the evolving directions of drainages associated with the track of the Yellowstone hotspot at four time intervals along the 16-to-0-Ma track (Pierce and Morgan, 2009, Fig. 16). In our paper, we briefly cited two contrasting interpretations of drainage on the north side of the upper Snake River Plain in the 6- to 3-Ma interval.

The biogeography described by Hershler et al. (2008) is a valuable contribution to this history of drainage changes. The authors document the southward drainage from the present upper Missouri River Basin across the present Continental Divide into the Great Basin. Their research is based upon two species (not one, as we listed) of gastropods now found north of the Continental Divide but closely related to a Great Basin species. Using molecular clock age estimation, they dated this southward drainage across the present Continental Divide at 3 Ma.

We cited geological evidence that drainage was to the northeast about 6 Ma based on both detrital zircon ages and a diagnostic chert in Ruby Graben sediments of the upper Missouri Basin (Stroup et al., 2008a,b; Sears et al., 2009). This northeast direction was dated as somewhat older than 6 Ma based on inferred down-valley flow to the northeast of the 6-Ma Timber Hill Basalt (Fritz and Sears, 1993). Fritz and Sears (1993) attributed this to northward tilting associated with passage of the Yellowstone hotspot.

We accept that molecular phylogenetic studies show that drainage across the present Continental Divide was to the south at about 3 Ma (Hershler et al., 2008 and references therein). Hershler et al. (2008) conclude this drainage had its headwaters at least 200 km north of the present Continental Divide at about 3 Ma. In also suggesting a connection across the present Continental Divide, we might better have cited the two papers on the worm (*Rhynchelmis gustafsoni*) rather than a personal communication. We agree with the qualifications (only organismal distribution, species may require taxonomic revision) noted in the Comment by Hershler and Lui (2011-this issue).

We welcome this timely discussion between geologists and biogeographers who are pursuing very similar questions on topics of mutual interest using different techniques/approaches, methods, and vocabulary. How the results from one set of data (for example, geologic) may translate to another data set (for example, biologic) has yet to be fully resolved; the disciplines are ripe for cross-pollination which may result in more complete answers. In a dynamic landscape like that along the track of the Yellowstone hotspot, multiple reversals in drainage may have occurred. Current geologic data indicate northeastward drainage into the Ruby Graben at ~6 Ma; molecular clock data indicate the next drainage to the east (the Madison River) flowed south at ~3 Ma.

The area under discussion is north and northeast of the Heise volcanic field and may have been influenced by Heise's four large-caldera-forming events beginning 6.62 Ma and ending 4.45 Ma (Morgan and McIntosh, 2005). The volcanism, faulting, and uplift associated with the 0- to 2-Ma hotspot beneath the Yellowstone Plateau probably also occurred when the hotspot was beneath the Heise volcanic field (Pierce and Morgan, 1992). Large-scale changes in the topography of the upper Snake River Plain in late Cenozoic time also include: (1) the northern Teton Range whose rapid uplift mostly post-dates emplacement of the 4.45-Ma Kilgore Tuff from the Heise volcanic field (Pierce and Morgan, 1992; Morgan and McIntosh, 2005) and (2) uplift of the youthful Centennial Range (also cited by Hershler et al., 2008) which mostly post-dates emplacement of the 2.05-Ma Huckleberry Ridge Tuff from the Yellowstone Plateau volcanic field.

References

Fritz, W.J., Sears, J.W., 1993. Tectonics of the Yellowstone hotspot wake in southwestern Montana. Geology 21, 427–430.

Hershler, R., Liu, H.-P., 2011. Comments on the paper “Is the track of the Yellowstone hotspot driven by a deep mantle plume? — Review of volcanism, faulting, and uplift in light of new data”. Journal of Volcanology and Geothermal Research 202, 262–263 (this issue).

Hershler, R., Liu, H.-P., Gustafson, D.L., 2008. A second species of *Pyrgulopsis* (Hydrobiidae) from the Missouri River basin, with molecular evidence supporting

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faunal origin through Pliocene stream capture across the northern continental divide. Journal of Molluscan Studies 74, 403–413.
Morgan, L.A., McIntosh, W.C., 2005. 40Ar/39Ar ages of silicic volcanic rocks in the Heise Volcanic Field, Eastern Snake River Plain, Idaho: timing of volcanism and tectonism. Geological Society of America Bulletin 117 (3/4), 288–306.
Pierce, K.L., Morgan, L.A., 1992. The track of the Yellowstone hot spot: volcanism, faulting, and uplift. In: Link, P.K., Kuntz, M.A., Platt, L.B. (Eds.), Regional Geology of Eastern Idaho and Western Wyoming, 179. Geological Society of America Memoir, pp. 1–53.
Pierce, K.L., Morgan, L.A., 2009. Is the track of the Yellowstone hotspot driven by a deep mantle plume?—review of volcanism, faulting, and uplift in light of new data. In: Morgan, L.A., Cathey, H.E., Pierce, K.L. (Eds.), Track of the Yellowstone Hotspot: Journal of Volcanology and Geothermal Research, 188, pp. 1–25.
Sears, J.W., Hendrix, M.S., Thomas, R.C., Fritz, W.J., 2009. Stratigraphic record of the Yellowstone hotspot track, Neogene Sixmile Creek Formation, SW Montana. In: Morgan, L.A., Cathey, H.E., Pierce, K.L. (Eds.), Track of the Yellowstone Hotspot: Journal of Volcanology and Geothermal Research, 188, pp. 250–259.
Stroup, C.N., Link, P.K., Fanning, C.M., 2008a. Provenance of late Miocene fluvial strata of the Sixmile Creek Formation, southwest Montana: evidence from detrital zircon. Northwest Geology 37, 69–84.
Stroup, C.N., Sears, J.W., Link, P.K., 2008b. Idaho sources for detrital zircons in late Miocene Sixmile Creek Formation, SW Montana. Geological Society of America Abstracts with Programs, 40. 1, p. 78.