

COMMENTS AND REPLIES

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Reply

REPLY to Comment: “Late Oligocene–early Miocene Grand Canyon: A Canadian connection?”

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Eric Clausen argues that my paper, “Late Oligocene–early Miocene Grand Canyon: A Canadian connection?” (*GSA Today*, Nov. 2013), does not assess alternative hypotheses for the origin of the upper Missouri River, especially his own proposal that the river was formed, not by a north-flowing pre-ice age stream, but rather by massive south-flowing meltwater outbursts from an Antarctic-sized North American ice sheet. Clausen contends that the meltwater then reversed its flow to fill a hypothetical hole left by the melting glacier. Clausen bases his proposal on interpretation of topographic maps of the region, as discussed in detail on his website (geomorphologyresearch.com).

The sedimentological evidence that I cited for a north-flowing paleo-river system derives from fluvial deposits with excellent paleo-flow indicators, including channels, cobble imbrication, grain-size distribution, and the provenances of clasts and detrital zircons. The fluvial deposits are well dated to Oligocene and Miocene age from rich vertebrate fossil collections, augmented by radiometric dates from intercalated volcanic ash and flows. Furthermore, the Oligocene and Miocene deposits of the paleo-valley are dissected by well-documented Pleistocene landforms. These *pre-ice age* fluvial deposits clearly cannot have formed as a result of glacial meltwater outbursts.

Moreover, emerging evidence from apatite fission track and (U-Th)/He dating indicates that Grand Canyon had been carved to some depth by late Oligocene–early Miocene time, precluding Pleistocene meltwater initiation of that landform.

I conclude that Clausen’s hypothesis of south-flowing meltwater outbursts to form the upper Missouri River valley and Grand Canyon is falsified by this and other evidence cited in my paper.

REFERENCES CITED

- Clausen, E., 2014, COMMENT: “Late Oligocene–early Miocene Grand Canyon: A Canadian Connection?”: *GSA Today*, v. 24, no. 4/5, p. e32, doi: 10.1130/GSATG202C.1.
- Sears, J.W., 2013, Late Oligocene–early Miocene Grand Canyon: A Canadian connection: *GSA Today*, v. 23, p. 4–10, doi: 10.1130/GSATG178A.1.

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