Forum Comment

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Wyoming on the run—Toward final Paleoproterozoic assembly of Laurentia

Jeffrey Hrncir[1], Karl Karlstrom[1], and Peter Dahl[2]
[1]*Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131, USA*
[2]*Geology Department, Kent State University, Kent, Ohio 44240, USA*

Kilian et al. (2016) present new paleomagnetic data that they interpret in terms of dramatic plate tectonic mobility for the Wyoming craton between 2100 and 1715 Ma. This proposed cratonic excursion is developed into a new hypothesis for assembly of the United States part of Nuna's Laurentian core. The single paleomagnetic pole provided by the Sourdough dike swarm is a welcome contribution and shows that Wyoming (WU) and Superior (SU) both occupied moderate paleolatitudes at 1900 Ma, but provides no constraints on the distance across an intervening ocean basin or the history of later cratonic assembly. We prefer an alternative model (closer to position B in Kilian et al.'s figure 3) of a more proximal position of WY relative to SU at 1.9 Ga. Similar to Roscoe and Card (1993), we argue that position B is more compatible with geologic data that require only clockwise rotation of the WY craton following separation from SU's southern margin at ca. 2.2 Ga, rather than an additional "run" of 7,000 km.

The Black Hills (BH) are presently situated between WY and SU and provide an important geologic laboratory to study interactions between these cratons from 2.2 to 1.7 Ga. Based on geologic data from BH exposures (see review of Dahl, 2010), most workers prefer a model that places WY closer to SU throughout this timeframe, as supported by new detrital zircon data (e.g., Hrncir and Karlstrom, 2016). We disagree with the interpretation of the BH as an exotic block. Instead, it may reliably record WY's interactions with other cratons in the following respects. A third of the WY craton's area was added at ca. 2.65 Ga as a collage of juvenile 2.74–2.67 Ga arcs and older crustal blocks, closely followed by 2.63–-2.55 Ga magmatism (Frost et al., 2006); the BH also expose Archean supracrustal rocks intruded by 2.66–2.56 Ga granitoids with similar isotopic signatures (Dahl, 2010; Hrncir and Karlstrom, 2016). Correlative 2.5–2.1 Ga passive margin sequences extend from the Sierra Madres to the BH; these contain detrital zircons with good age matches to the WY craton and record continued input of Archean detritus into BH basins as young as 1.87 Ga with Pb and Nd isotopic signatures similar to older WY crust (Frei et al., 2008). These points (and crustal models cited by Dahl [2010]) argue for a maintained connection of the BH block to WY throughout all or most of the Proterozoic. Whereas geophysical data of Worthington et al. (2016) show a major albeit undated crustal boundary between the BH and the core of WY, we argue that this feature is more likely of Neoarchean, not Paleoproterozoic, age.

Structural timing suggests that the reported "conspicuously young ages ca. 1715 Ma" in southeast WY do not record the time of suturing of WY and SU, but rather a young overprint. BH peak deformation resulting from esat-west convergence of these cratons is well constrained to 1750 Ma and this was only the latest in a series of regional tectonic events. The strong 1750 Ma deformation in the BH obscures older events (Dahl, 2010) such as folding and unconformity development between deposition of the Flag Rock Group at 1.88 Ga and Green Mountain arc accretion at 1.78 Ga (Hrncir and Karlstrom, 2016). A modest proportion of BH monazite ages fall between 1810 and 1860 Ma (e.g., Dahl, 2010), especially in regions outside the 1715 Ma contact metamorphic aureole of the Harney Peak granite. Structural analyses in the same region show early folding due to northeast-southwest contraction that predates the 1780 Ma folding due to northwest-southeast contraction during Green Mountain arc accretion (Bell, 2013). The earlier deformation events are likely related to amalgamation of WY with outboard arc terranes and suturing of WY and SU synchronous with the Trans Hudson and Penokean Orogens. Corresponding evidence of this history in the southwestern SU craton is lacking because it remains buried beneath cover. We interpret the 1715 Ma age peak seen in the BH and Hartville Uplift as a thermal/ tectonic overprint imposed by intrusion of the post-orogenic Harney Peak and Haystack granites as seen in the BH where the 1715 Harney Peak granite drove important metamorphism but no major penetrative deformation. Such localized deformation related to thermal softening during post-suturing events is common throughout the Yavapai Province and is analogous to Mazatzal reactivation of the older Cheyenne Belt in southern WY (Duebendorfer et al., 2015). Furthermore, basement exposures in the Bighorn Mountains near the preferred suture of Kilian et al. (2016) contain no evidence for significant Proterozoic deformation as would be expected if it marks the suturing of two cratons.

Overall, BH geologic data, plus use of pole position B of Kilian et al. (2016), suggest a more parsimonious interpretation that WY was in relative proximity to SU, and the BH occupied an intervening position from 2100 to 1715 Ma. New and existing evidence reveals a significant pre-1800 Ma accretionary history for the BH comparable to Penokean and Trans Hudson events, followed by terminal WY-SU convergence at ca. 1750 Ma. Future attention should be directed to locating additional Wyoming dikes amenable to paleomagnetic studies that intruded in the critical 1.9–1.8 Ga timeframe to further investigate this question. Ongoing work in the BH has identified several new episodes of mafic magmatism between 1.88 and 1.77 Ga that may have analogues in nearby (less deformed) uplifts.

REFERENCES CITED

Bell, C.C., 2013, Structural controls on gold mineralization at the Homestake mine and their implications for the geology of the Black Hills [Ph.D. thesis]: Townsville, Australia, James Cook University, 232 p.

Dahl, P.S., 2010, Precambrian geochronology of the Black Hills, South Dakota: Past results and future directions, in Terry, M.P., et al., eds., Geologic field trips in the Black Hills region, South Dakota: South Dakota School of Mines and Technology Bulletin 21, p. 187–201.

Duebendorfer, E.M., Williams, M.L., and Chamberlain, K.R., 2015, Case for a temporally and spatially expanded Mazatzal orogeny: Lithosphere, v. 7, p. 603–610.

Frei, R., Dahl, P.S., Duke, E.F., Frei, K.M., Hansen, T.R., Frandsson, M.M., and Jensen, L.S., 2008, Trace element and isotopic characterization of Neoarchean and Paleoproterozoic iron formations in the Black Hills (South Dakota, USA): Assessment of chemical change during 2.9–1.9 Ga deposition bracketing the 2.4–2.2 Ga first rise of atmospheric oxygen: Precambrian Research, v. 162, p. 441–474, doi:10.1016/j.precamres.2007.10.005.

Frost, C.D., Fruchey, B.L., Chamberlain, K.R., and Frost, B.R., 2006, Archean crustal growth by lateral accretion of juvenile supracrustal belts in the south-central Wyoming Province: Canadian Journal of Earth Sciences, v. 43, p. 1533–1555, doi:10.1139/e06-092.

Hrncir, J.A., and Karlstrom, K.E., 2016, Tectonic evolution of the Black Hills, South Dakota from new U-Pb and Hf analyses of igneous and detrital zircon: Geological Society of America Abstracts with Programs, v. 48, no. 7, p. 259.

Kilian, T.M., Chamberlain, K.R., Evans, D.A.D., Bleeker, W., and Cousens, B.K., 2016, 2016, Wyoming on the Run—Toward final Paleoproterozoic assembly of Laurentia: Geology, v. 44, p. 863–866, doi:10.1130/G38042.1.

Roscoe, S.M., and Card, K.D., 1993, The reappearance of the Huronian in Wyoming: rifting and drifting of ancient continents: Canadian Journal of Earth Sciences, v. 30, p. 2475–2480, doi:10.1139/e93-214.

Worthington, L.A., Miller, K.C., Erslev, E.A., Anderson, M.L., Chamberlain, K.R., Sheehan, A.F., Yeck, W.L., Harder, S.H., and Siddoway, C.S., 2016, Crustal structure of the Bighorn Mountains region: Precambrian influence on Laramide shortening and uplift in north-central Wyoming: Tectonics, v. 35, p. 208–236, doi:10.1002/2015TC003840.