The Cratonic Crossroads:
New Age Control from the Williston Basin Basement Provides Insight into the Assembly of Laurentia
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Abstract:
The Great Falls Tectonic Zone (GFTZ) is an area of high angle structures striking NE to SW through Montana, separating the Wyoming craton from the Montana-Alkali Province. It is part of a series of collisional belts, including the north-south trending Trans-Hudson Orogen (THO) to the east, formed during the ~1.7–2.9 Ga amalgamation of Laurentia. Evaluating models for these collisions depends on high quality geology, however, sampling is hampered by the extensive Mesoproterozoic and younger cover rocks. One critical area is the basement in the Williston Basin (WB), near the presumed juncture of the GFTZ and THO. Deep test wells (DTW) penetrating the WB basement and surrounding areas provides valuable samples for high quality U-Pb on zircon and Ar-Ar on mineral separates and zircon U-Pb geochronology. The current data set is limited to poorly constrained Rb-Sr whole-rock model ages and K-Ar determinations on K-feldspar and biotite, yielding ages from ~0.65–2.9 Ga. Previous U-Pb geochronology is restricted to 7 discordant analyses, yielding upper intercept ages ranging from 1.7–2.9 Ga.

New elemental and isotopic data has vastly improved the controls on the protolith ages, thermal history, and petrogenesis of the basement at this critical juncture. Preliminary basement geochronology from cores Madison-1 and Madison-3 yielded ages of ~2.9 and ~3.0 Ga. These ages intercept ages ranging from 1.7–2.9 Ga.

Conclusions:
- DTW Madison 1 and 3 U-Pb data on zircons showing coherent age spectra similar to published Wyoming craton ages. The location of Madison 3 was previously thought to be GFTZ crusture.

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The Problem, The Plan, and The Hope
The Problem: We do not have a very well constrained view of the protolith ages, cooling histories, or petrogenesis for these samples.
The Plan: We will conduct comprehensive elemental and isotopic analyses of samples from a subset of 16 of the wells described in Sims et al. (1991). This subset contains cores from wells in North Dakota, South Dakota, Wyoming, and Montana that are suitable for preparation of both homogeneous powders for whole-rock elemental and isotopic studies as well as mineral separation for U-Pb and Ar-Ar analyses.
The Hope: These samples provide access to the margins of both the Superior and Wyoming cratons as well as the THO basement underlying the WB. Overall, the DTW samples offer the opportunity to place much better constraints on the nature of the basement to the WB and its relationship to the Paleoproterozoic crust of the GFTZ and THO.

Ar-Ar Thermochronology Data:

Examples of Ar-Ar plateau reductions for biotite, hornblende and K-feldspar, and a summary table of preliminary Ar-Ar data. Biotite ages range from ~952 Ma to 2415 Ma, K-feldspar ages range from ~1000 Ma to 2140 Ma, a single hornblende sample yielded an age of ~2550 Ma revealing numerous thermal events effecting the area surrounding the structural Williston Basin, Great Falls Tectonic Zone, and Trans-Hudson Orogeny.

Basement U-Pb Zircon Data:

DTW Madison 1 and 3 U-Pb data on zircons showing coherent age spectra similar to published Wyoming craton ages. The location of Madison 3 was previously thought to be GFTZ crusture.

DTW Madison 2 and 3 U-Pb data on zircons showing coherent age spectra similar to published Wyoming craton ages. The location of Madison 3 was previously thought to be GFTZ crusture.

DTW MADISON 3 U-Pb data on zircons showing coherent age spectra similar to published Wyoming craton ages. The location of Madison 3 was previously thought to be GFTZ crusture.