



New insights into the character of the Medicine Hat Block (southern Alberta, northern Montana) from zircon LA-ICPMS U/Pb and Hf isotopic analysis

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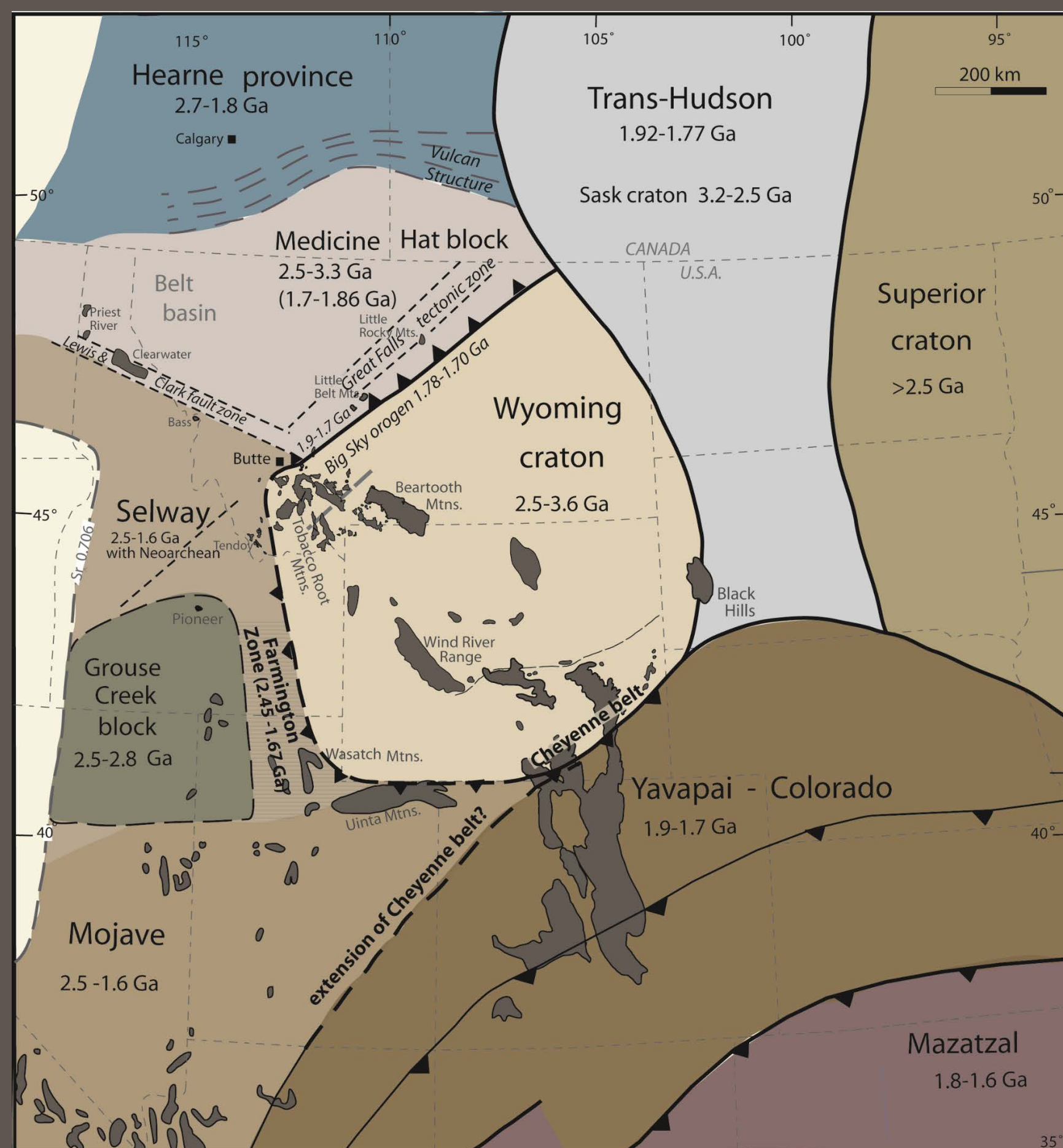
Abstract:

The Medicine Hat Block (MHB) of southern Alberta and northern Montana is a largely concealed province of Archean and Paleoproterozoic rock buried by younger supracrustal successions. The MHB was involved in a complex collision between the Archean Hearne and Wyoming provinces during the formation of the Great Falls Tectonic Zone (GFTZ), Trans Hudson Orogen (THO) and Vulcan Zone during the amalgamation of Laurentia. However, its role in this collision is poorly defined by limited high precision geochronology and geochemistry. Xenoliths recovered by the Geological Survey of Canada from Eocene minette dikes and boreholes in the MHB north of the Wyoming craton include a population of gneisses, granulites, monozites, tonalities, amphibolites, and diorites sampling the otherwise concealed MHB crust. Previous research on these samples yielded U/Pb ages from abraded, acid-washed bulk-zircon dissolution methods with ages ranging from ~1.70 Ga to 3.26 Ga. Sm/Nd model ages for the samples range from ~1.80 Ga to 3.48 Ga. This has been interpreted to represent a mixture between evolved Archean crustal sources (i.e. MHB-Wyoming crust) and Proterozoic magmas (i.e. GFTZ-THO).

New LA-ICPMS U/Pb age and Hf isotopic data from zircon separates from these sources improves understanding of the age and origins of the MHB crust. 20 μ U/Pb spot data on zircon generated more precise ages for the MHB. Core samples yielded basement crystallization ages of ~2.63 Ga, ~2.74 Ga, ~3.28 Ga, and ~2.82 Ga. These ages generally agree with those previously found for the MHB, but can be considered more accurate due to the analysis technique. Xenoliths from the Sweetgrass Hills area yielded further ages for both the MHB crust and the mafic underplating cited by Gorman et al. (2002). A biotite-hornblende tonalite yielded an age of ~2.83 Ga which agrees with previous work done in the area. Two further granulite samples yielded ages via weighted average and discordia line of ~1.78 and ~1.82 Ga. Hf data yielded an array of ϵ Hf values ranging from 8.3 to -8.7 for the Archean samples and -6.8 to -21.2 for the Paleoproterozoic samples. Depleted mantle model ages range from ~1.980 to 3.780 Ga.

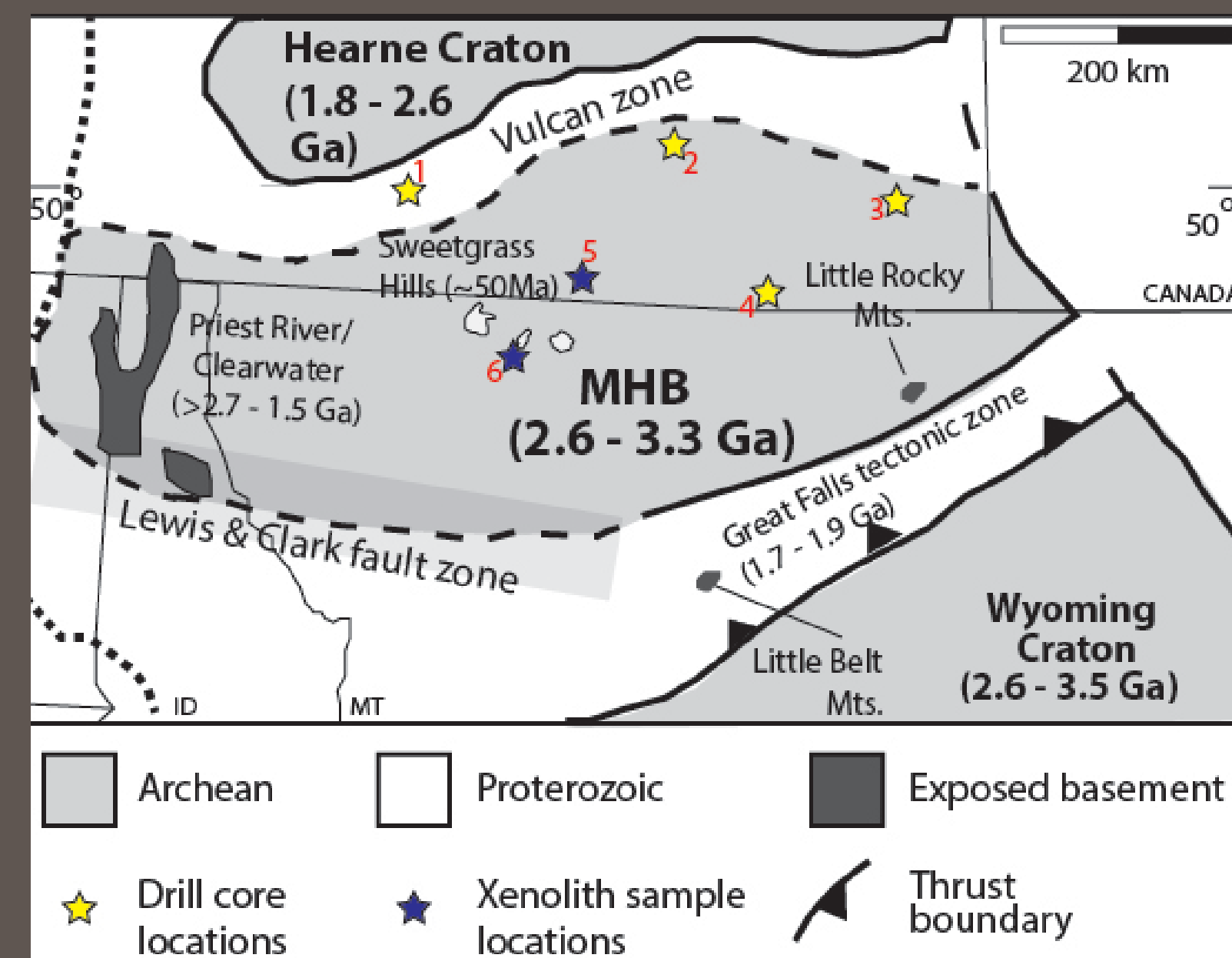
Due to the overlapping ages of the events recorded, models for reconciling the high angle junction between the GFTZ and THO require improved age and geochemical constraint provided by MHB samples. The data also provide insight into later geologic events potentially influenced by MHB crust reworked in the GFTZ, such as development of the Cenozoic Montana Alkali Province or the structural formation of the Proterozoic Belt-Purcell Basin.

Precambrian Basement Provinces:



Generalized map of Precambrian basement provinces of southwestern Laurentia (after Foster et al., 2006).

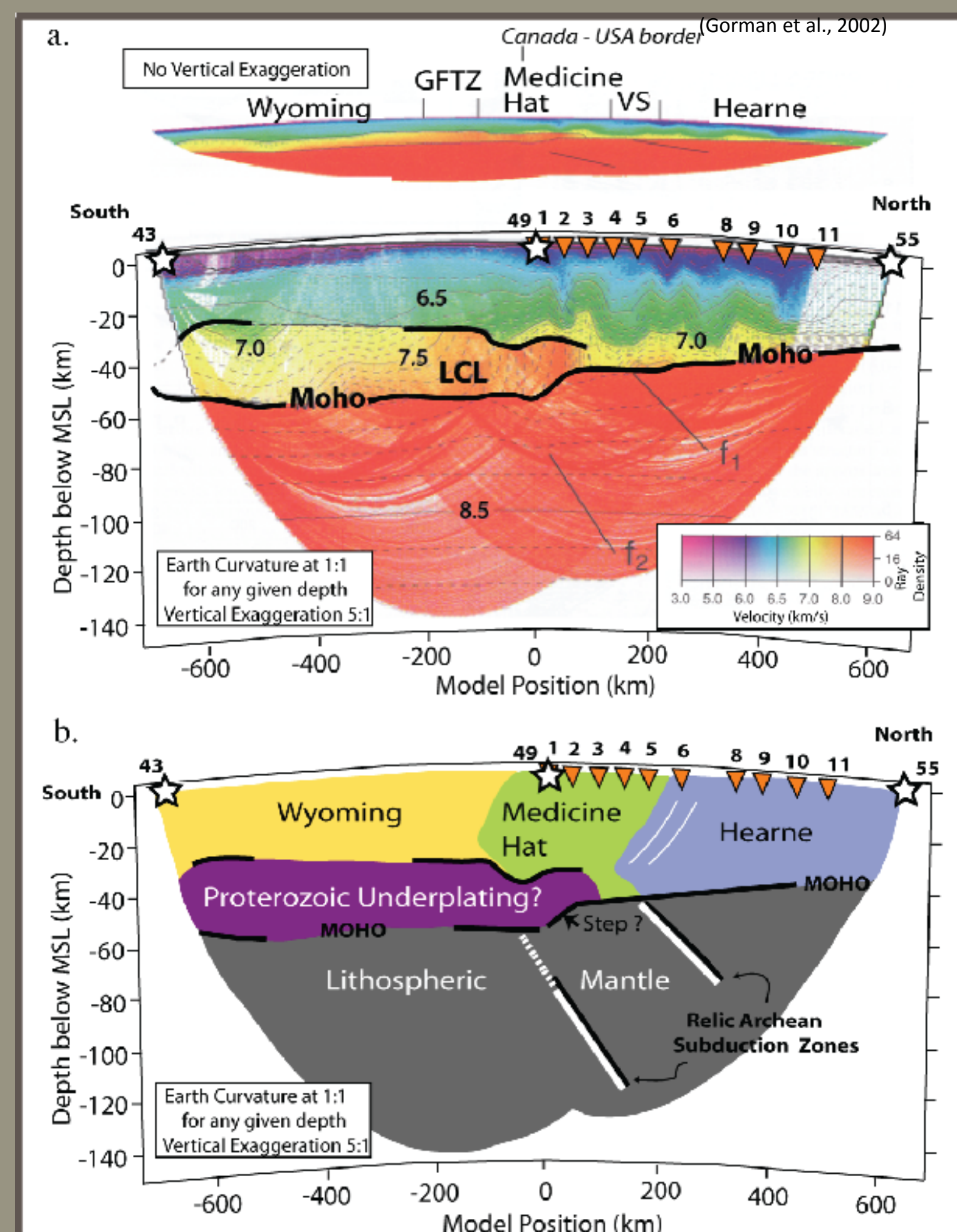
Sample Locations: Drill Cores & Xenoliths



Location, name, lithology and previous age data (figure modified from Foster et al., 2006 and Villeneuve et. al, 1993).

- 1) Calstan Parkland, garnet metabasite, 2627 \pm 4 Ma
- 2) Imperial Calstan Lake Newell, pegmatitic granitic gneiss, 2715 \pm 41 Ma
- 3) PCP Medicine Hat, granodiorite gneiss, 2.7 – 2.8 Ga
- 4) Home Pacific Knappen, quartz diorite, 3278 \pm 22 Ma
- 5) & 6) Coulee 29 & Sill 39, tonalites, mafic and felsic granulites, 2840 \pm 9 Ma, 2.65 Ga, 2.6 - >3.0 Ga

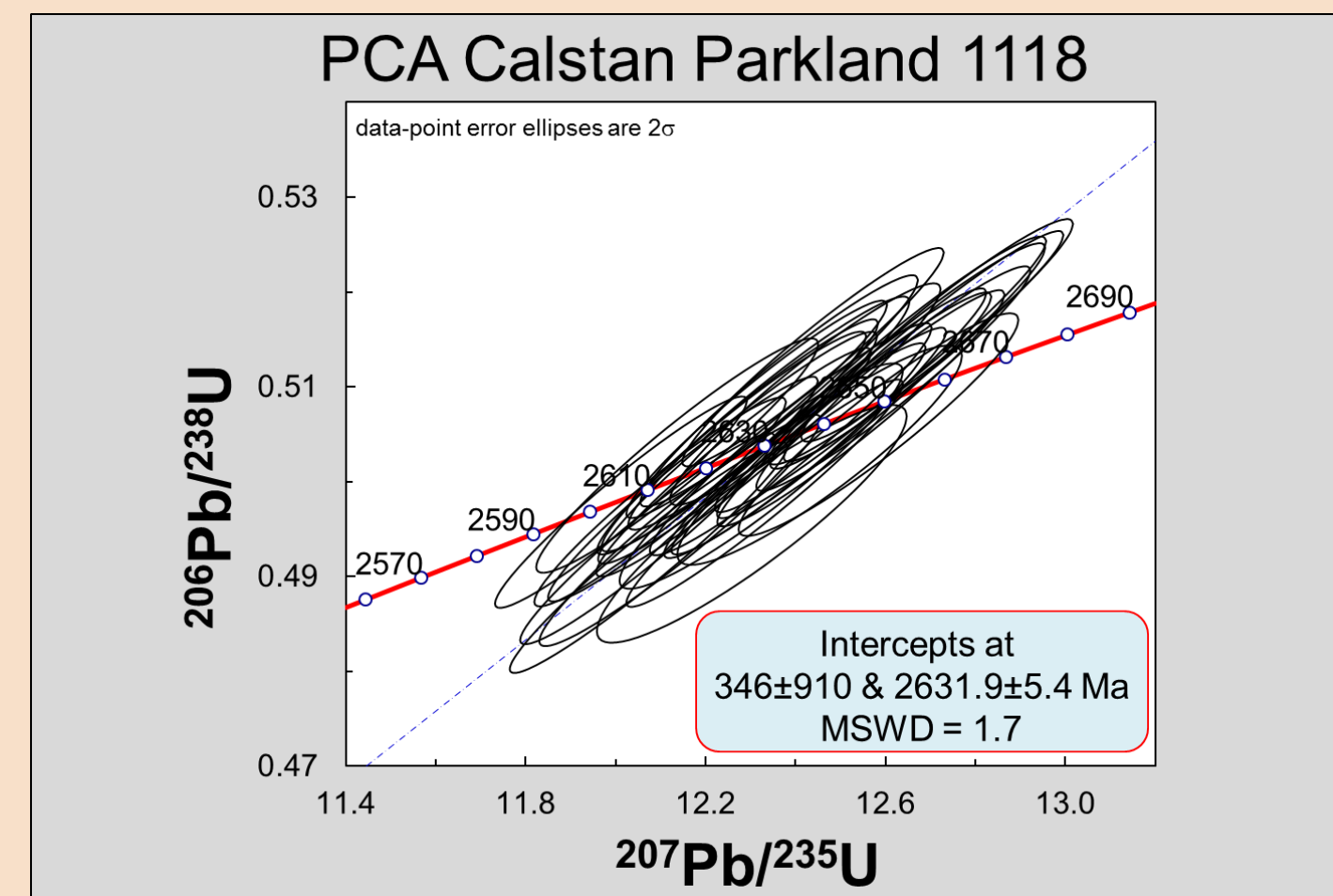
Mafic Underplating:



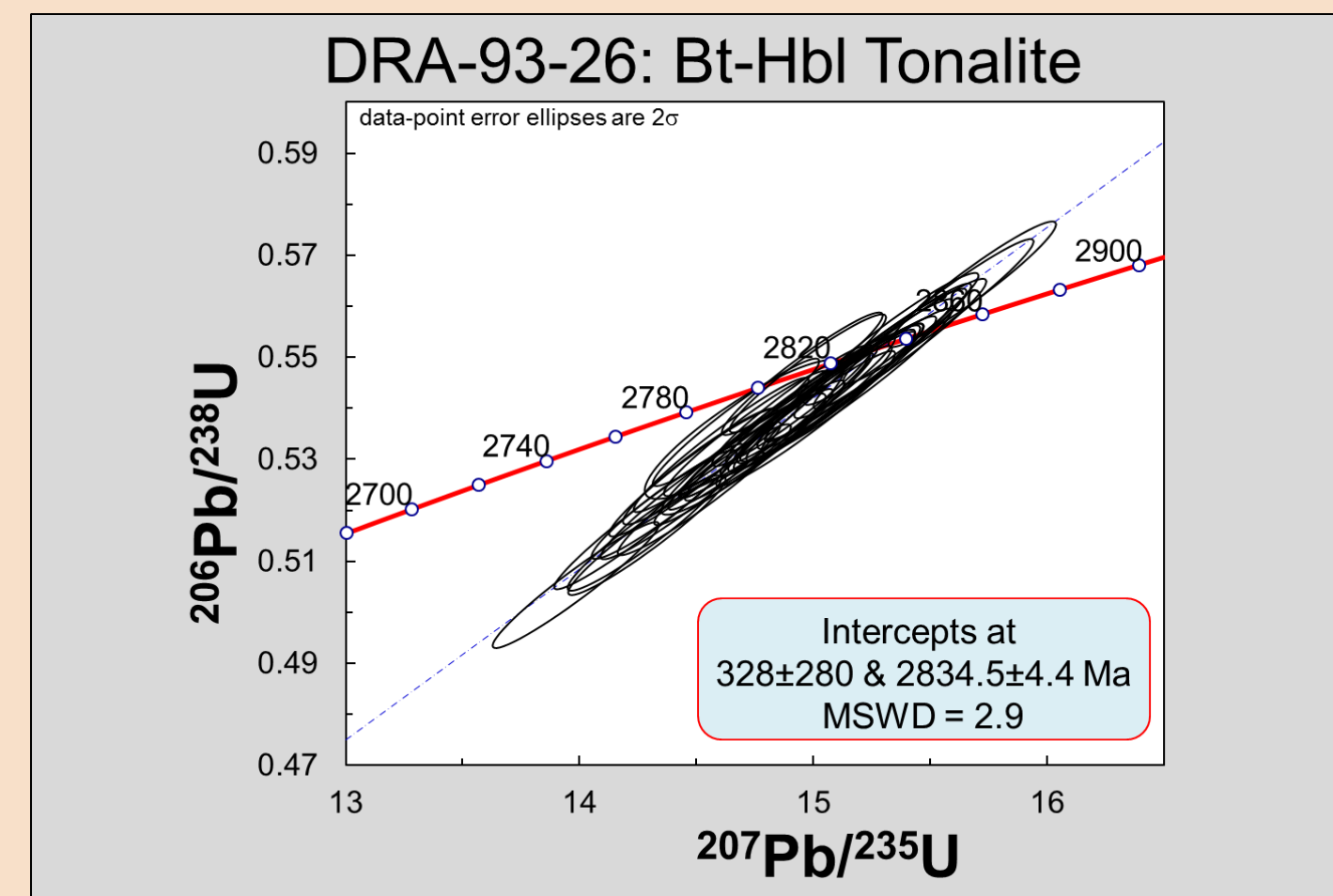
The crustal structure is currently defined by the Deep Probe-SAREX active source data (Gorman et al., 2002). These results show a high P-wave velocity layer in the lower crust of the MHB, GFTZ and northern Wyoming Province.

Isotopic data from crustal xenoliths (Gorman et al., 2002; Davis et al., 1995) suggests that the lower crust is Paleoproterozoic in age, even in areas with documented Archean upper crust (i.e. xenoliths collected from the MHB).

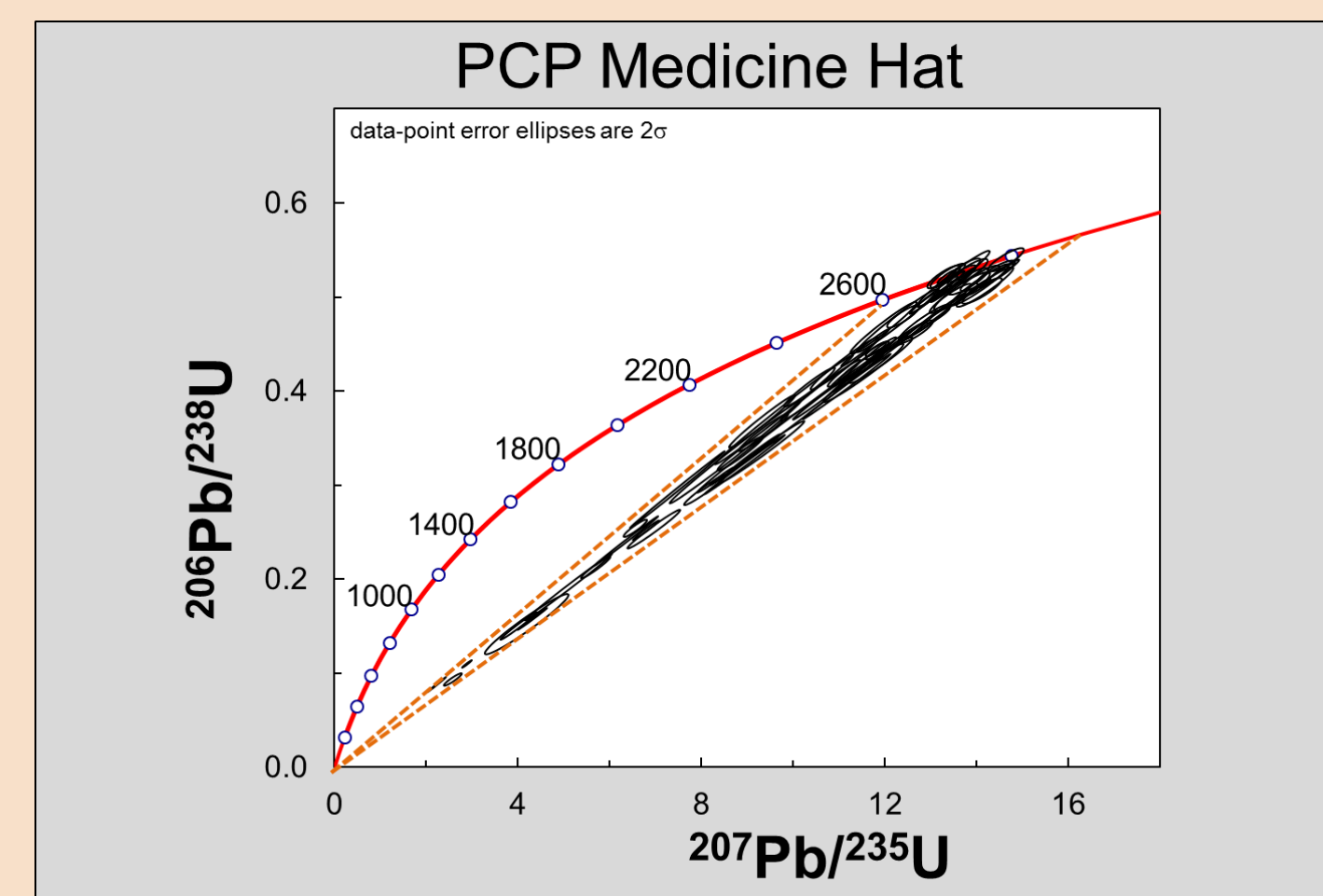
U-Pb Zircon Isotopic Data:



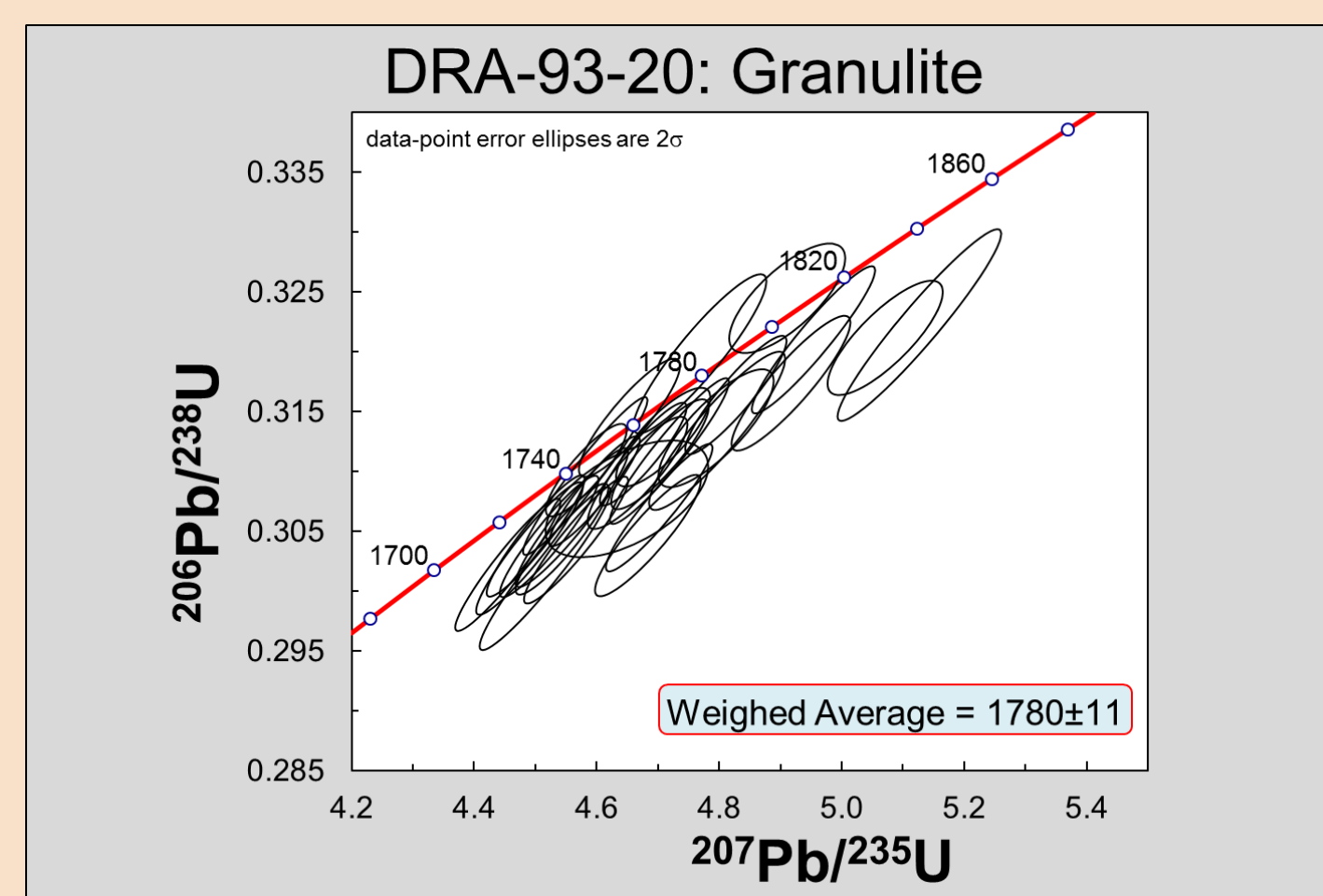
PCA Calstan Parkland 1118: Data plotting along a discordia line yields an upper intercept age of 2632 Ma.



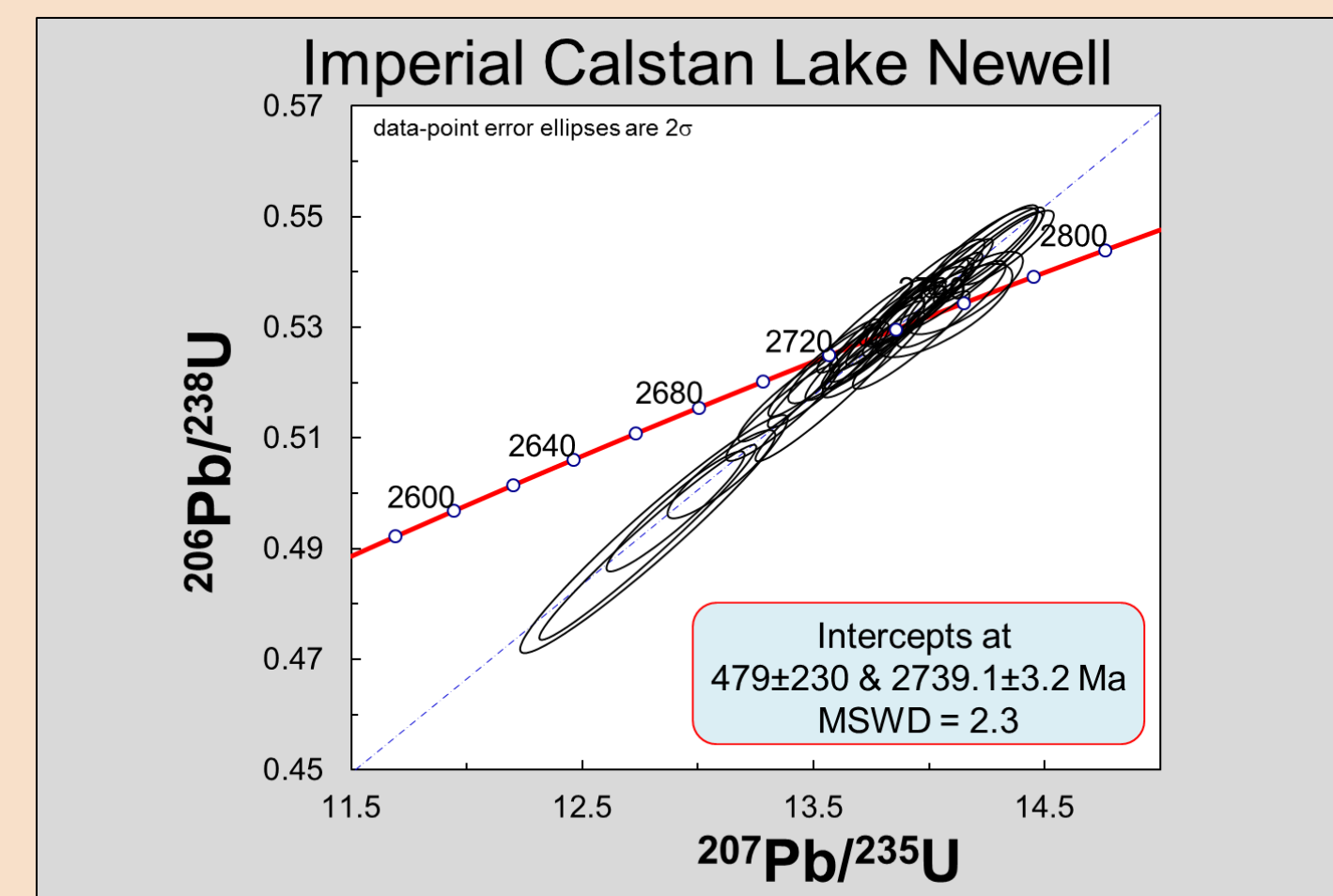
DRA-96-26: Data plotting along a discordia line yields an upper intercept age of 2834 Ma. Xenolith found at the Sill 39 site (6 in sample location figure).



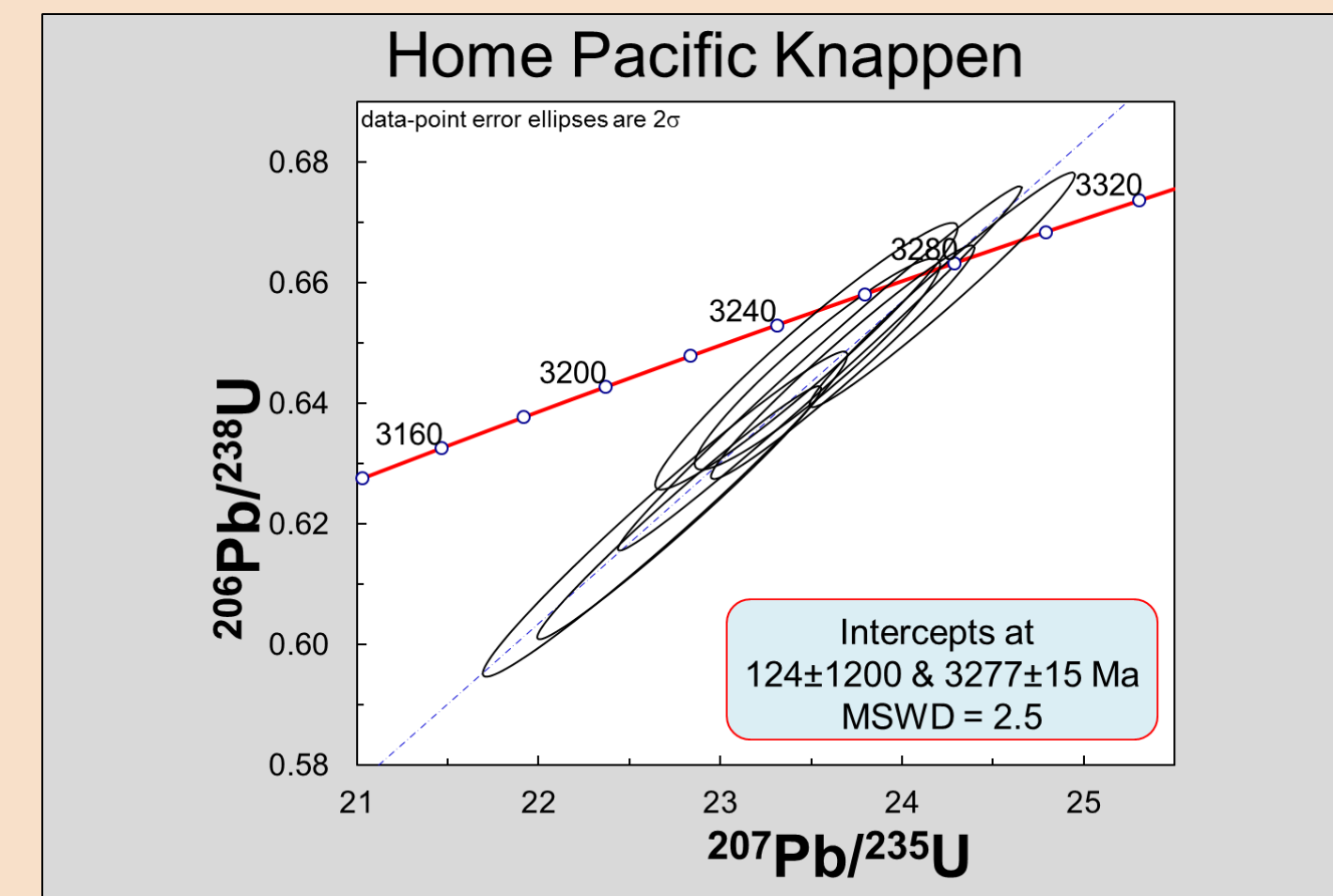
PCP Medicine Hat: Part 1. Discordant dataset from all analyses. These data suggest a "triangle of Pb-loss" with the oldest cluster of near concordant grains ranging from 2696 Ma to 2843 Ma.



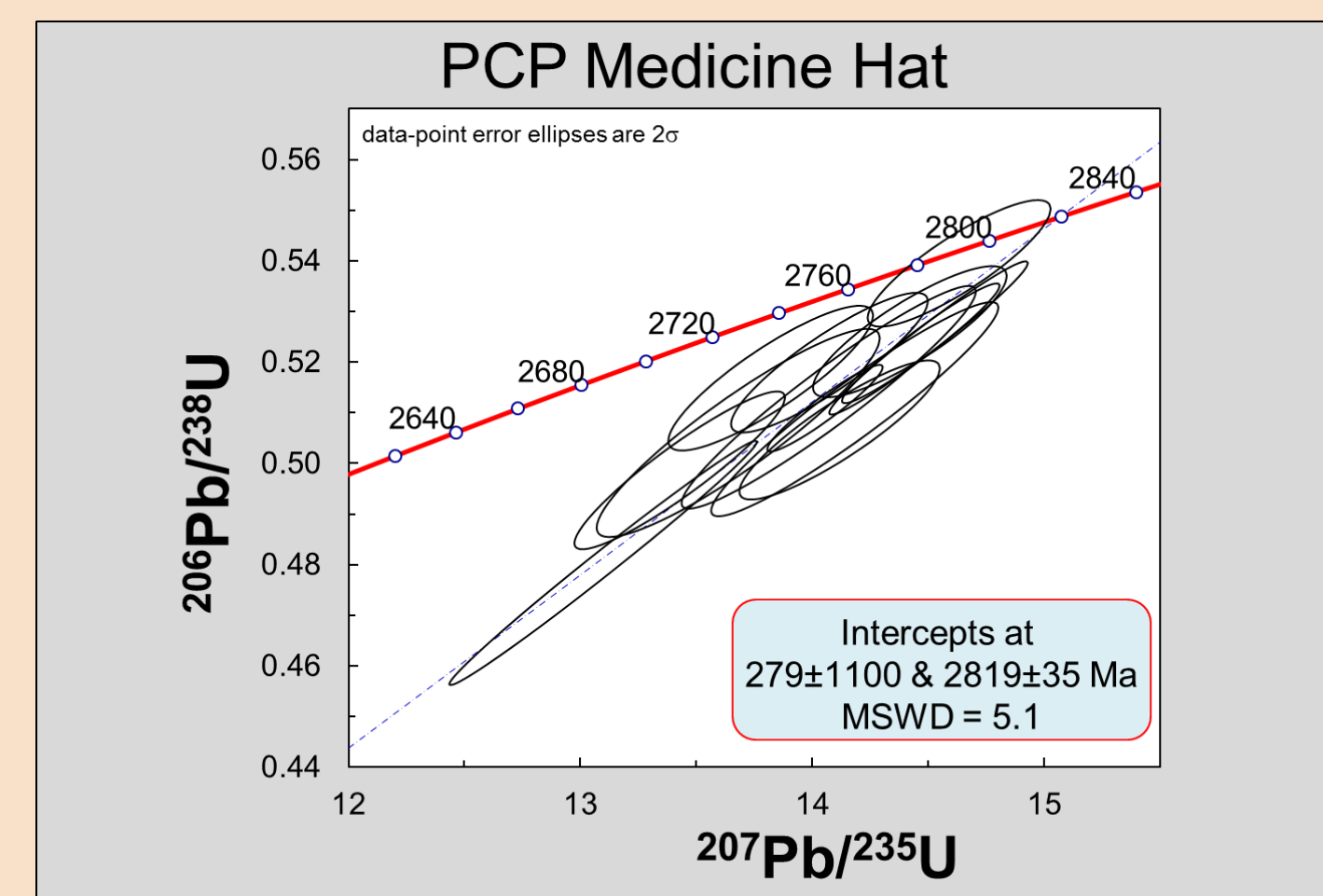
DRA-93-20: Data shows a wide spread of ages, attributed to Pb-loss during high temperature metamorphism. A weighted average age of 1780 Ma suggests the approximate age of metamorphism, which likely disturbed and recrystallized older zircon.



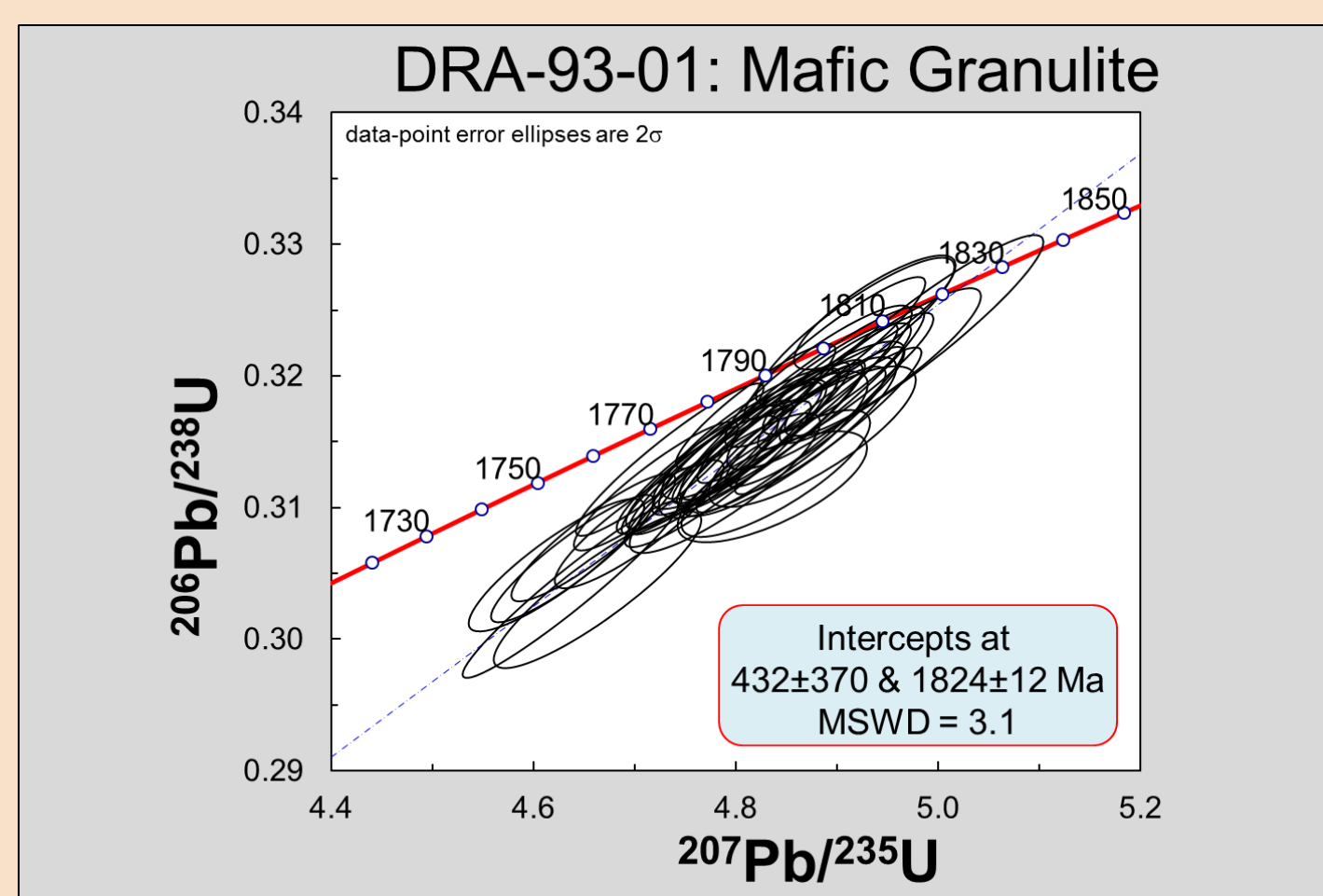
Imperial Calstan Lake Newell: Data plotting along a discordia line yields an upper intercept age of 2739 Ma.



Home Pacific Knappen: Data plotted along a discordia line yields an upper intercept age of 3277 Ma.

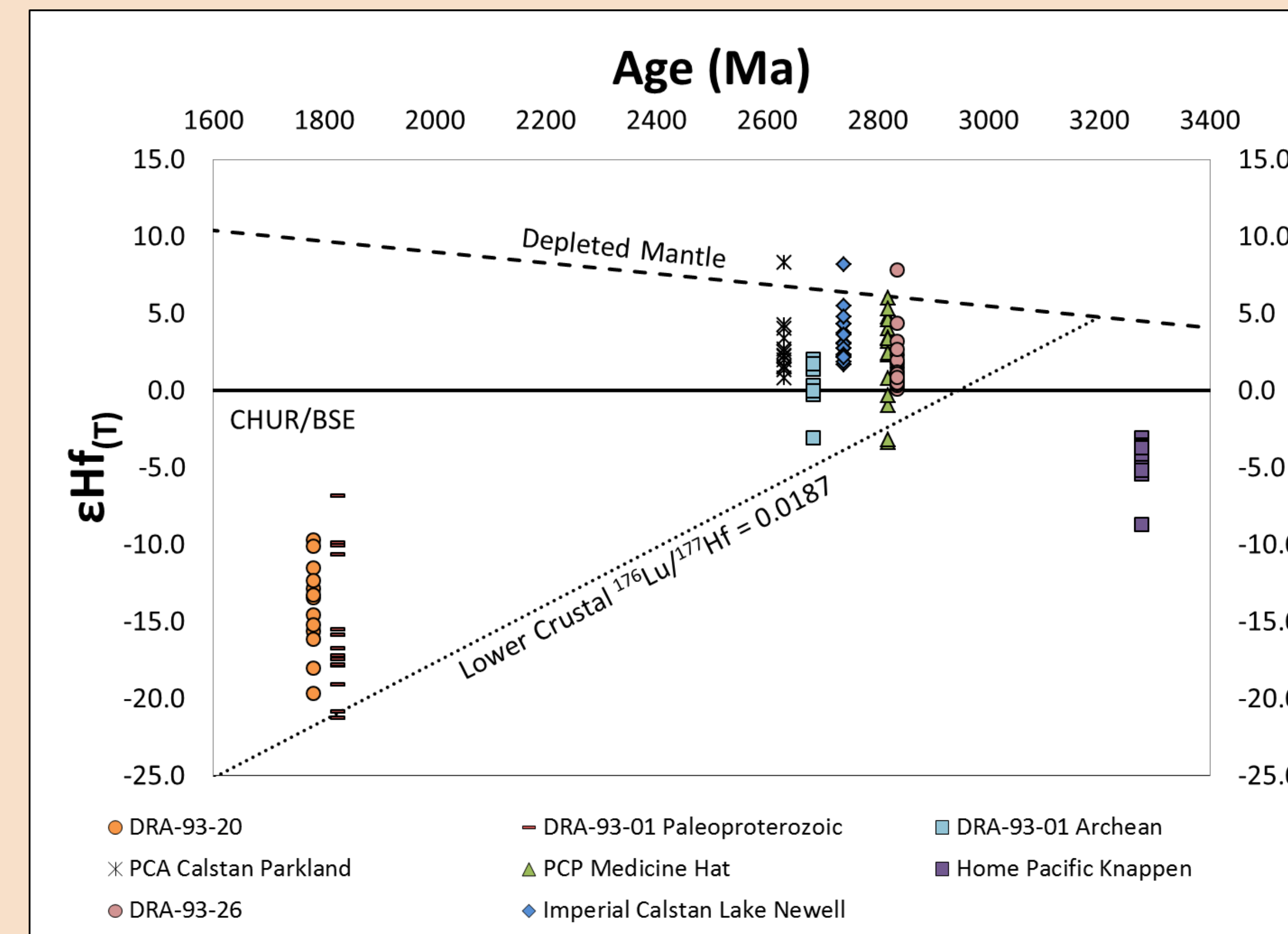


PCP Medicine Hat: Part 2. Close-up of the oldest group near concordant grains, showing an interpreted discordia line yielding a poorly constrained upper intercept age of 2819 Ma.



DRA-93-01: Data shows a discordia line, yielding an upper intercept age of 1824 Ma. Additionally, several older grains scatter back towards a c. 2600 Ma intercept as well, suggesting extensive resetting of zircon ages by granulite facies metamorphism.

Hf Zircon Isotopic Data:



Archean samples show a mixture of Hf values ranging from Depleted Mantle to slightly evolved. These values indicate that subduction likely played a large part in the formation of the samples. Paleoproterozoic samples yielded Hf values much more indicative of evolved (crustal) sources, indicating a mixture of older (Archean?) crust with possible younger, more primitive (DM) sources. Sweetgrass Hills samples DRA-93-01 and DRA-93-20, characterized by younger zircon ages, preserve evidence of reworked Archean material and suggest that older U-Pb ages were reset by granulite facies metamorphism and zircon recrystallization.

Conclusions:

- New U-Pb ages generally agree with previous age determinations for the region (Villeneuve et al., 1993; Davis et al., 1995); however, we resolve complexities hinted at by previous analyses.
- Ages from this study tend to be slightly older than the previous studies, possibly due to Pb loss or the incorporation of later metamorphic zircon growth in the earlier analyses.
- New Hf data show clear evidence of re-worked crust with a mixture of primitive DM and more evolved crustal material.
- Xenoliths from the Sweetgrass Hills (DRA-93-01 & DRA-93-20) are characterized by younger zircon ages, which preserve evidence of reworked Archean material and suggest that older U-Pb ages were reset by granulite facies metamorphism and zircon recrystallization

Acknowledgements:

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References:

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