Government of **Western Australia**
Department of **Mines and Petroleum**

Geochronology & isotope geology of the Albany-Fraser Orogen and Tropicana Zone

CL Kirkland, CV Spaggiari, RH Smithies, MTD Wingate, C Clark, S Tessalina, R Creaser

John de Laeter Centre
Isotope Research for the Earth and Environment

GEMOC

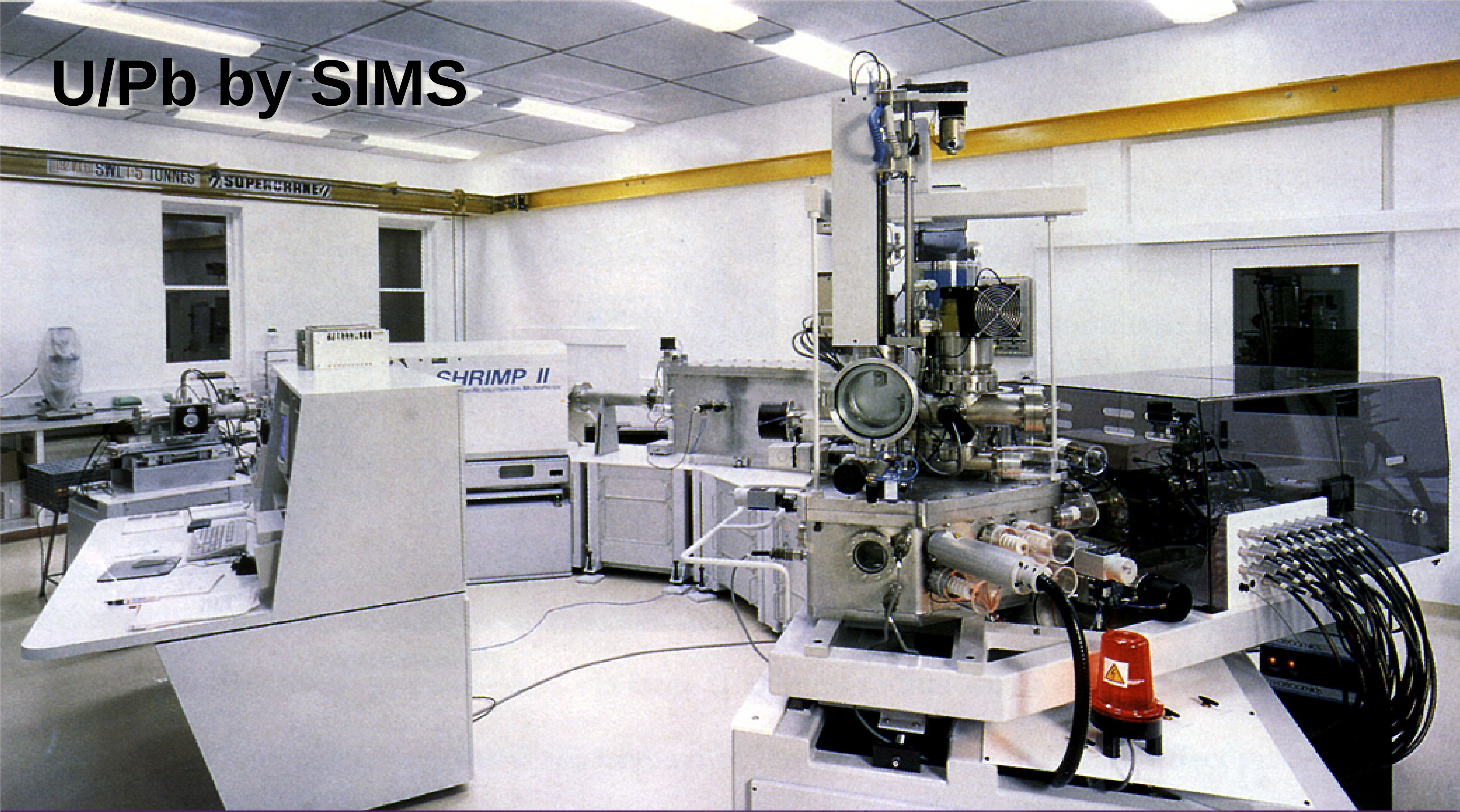
CCFS

The University of Western Australia

ROYALTIES FOR REGIONS
EXPLORATION INCENTIVE SCHEME

April 2014

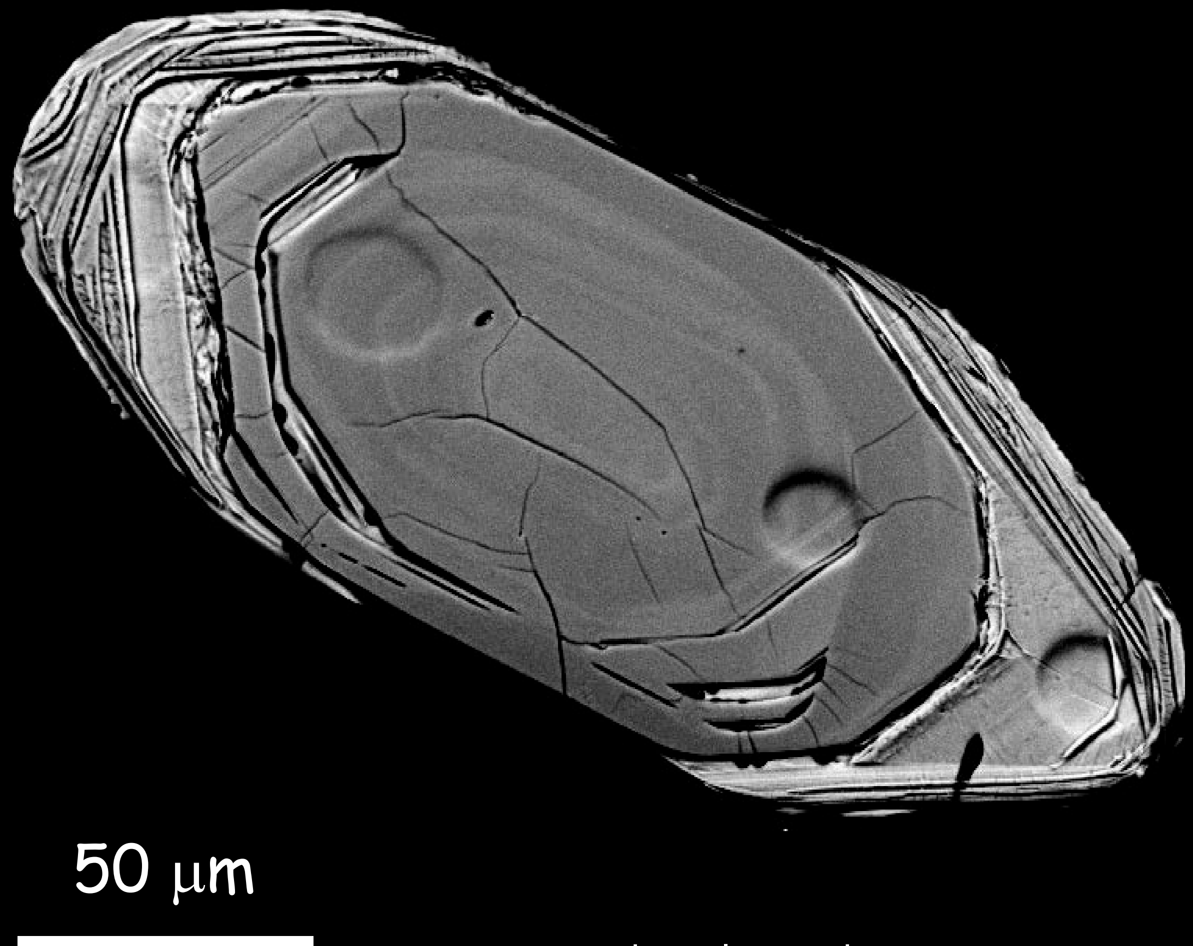
U/Pb by SIMS



John de Laeter Centre
Isotope Research for the Earth and Environment

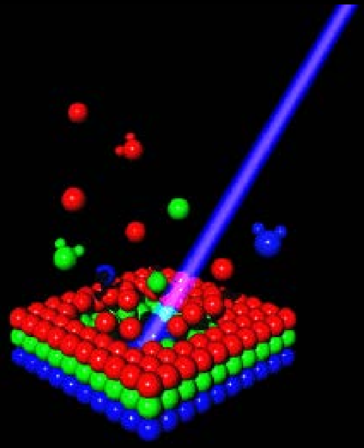
Sensitive High Resolution Ion MicroProbe (SHRIMP)

Why SHRIMP?

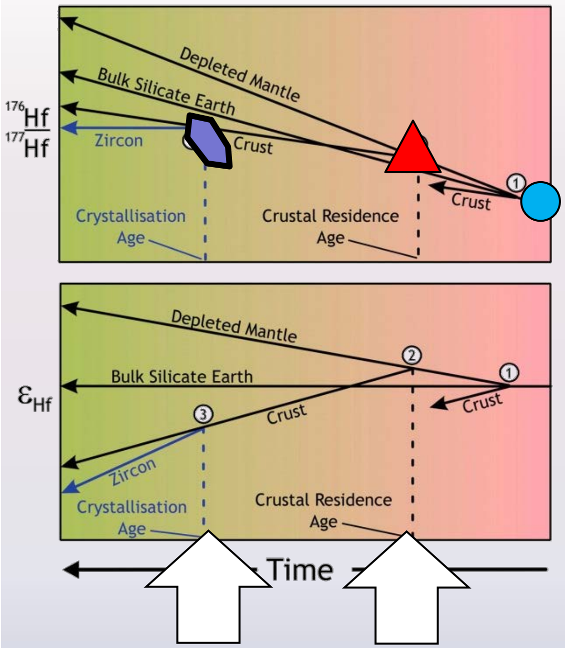


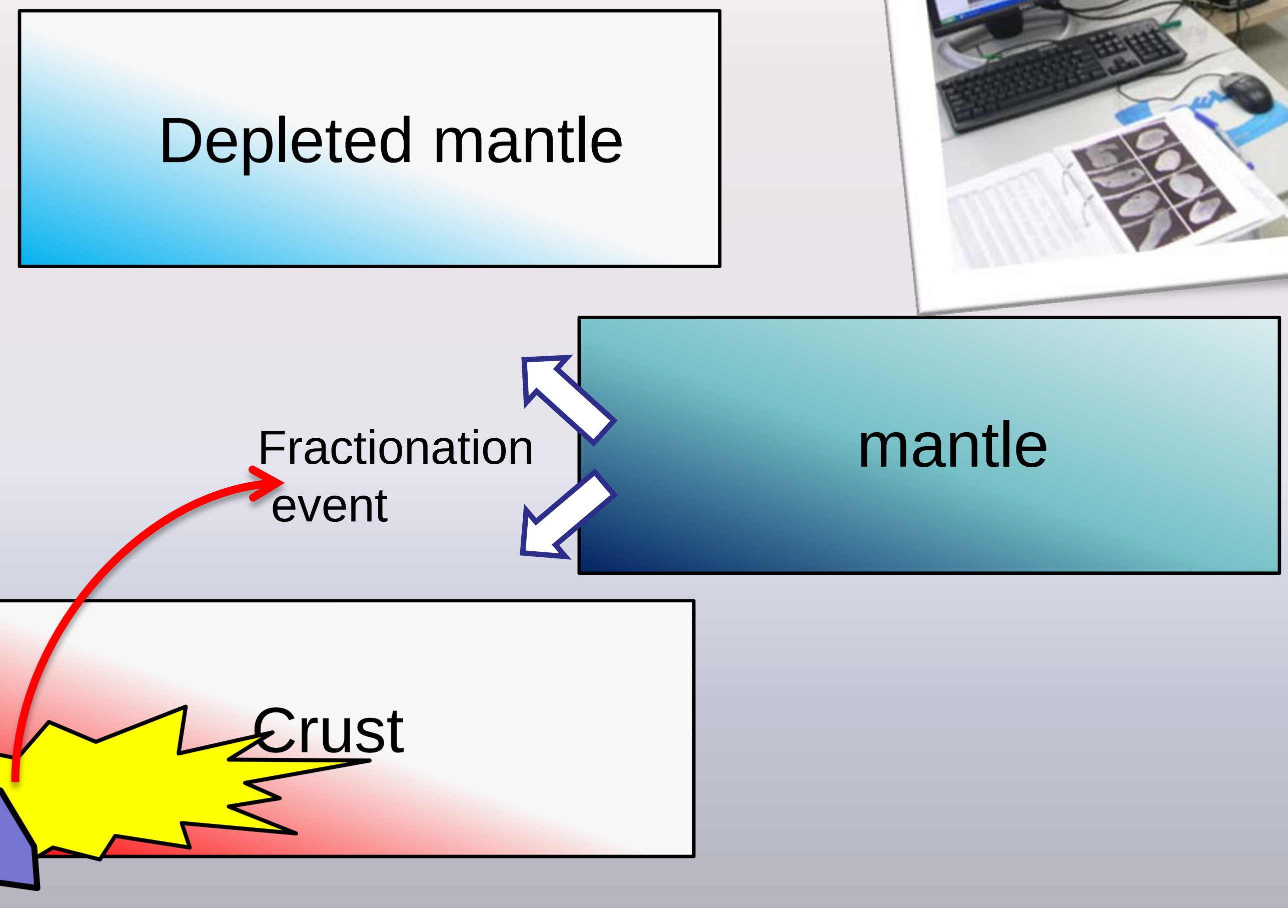
secondary electron image

in situ microsampling of geological materials

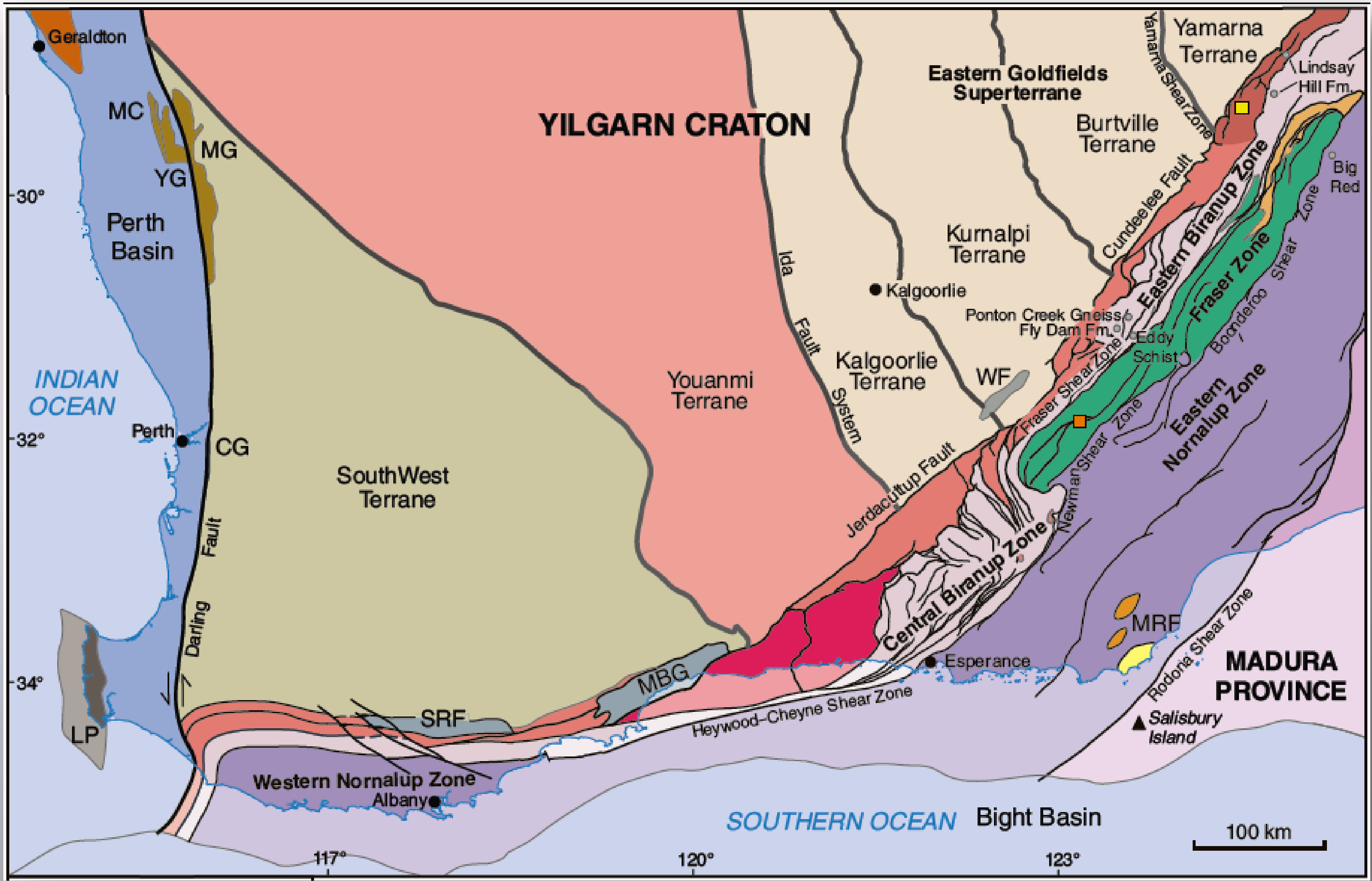


Lu-Hf in zircon

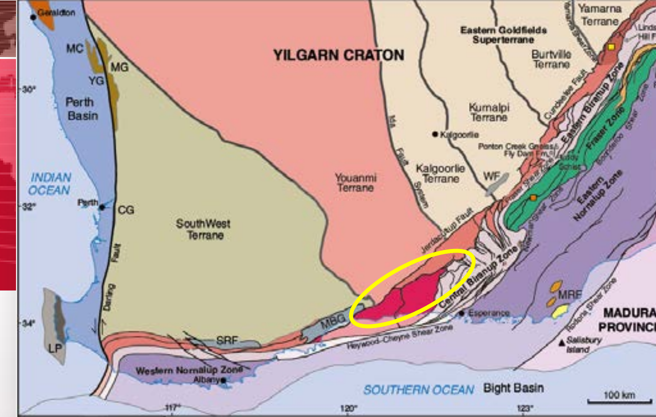


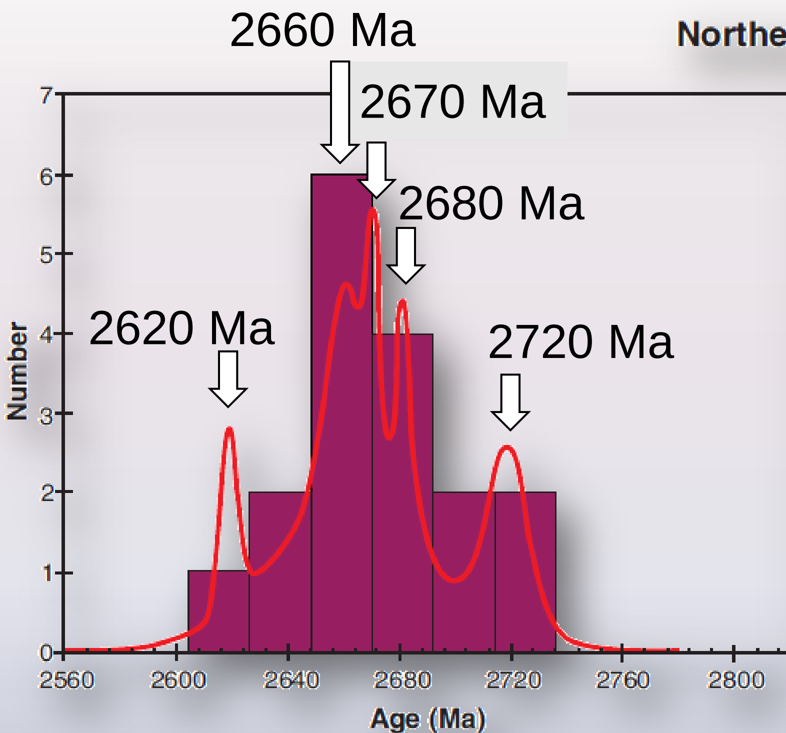


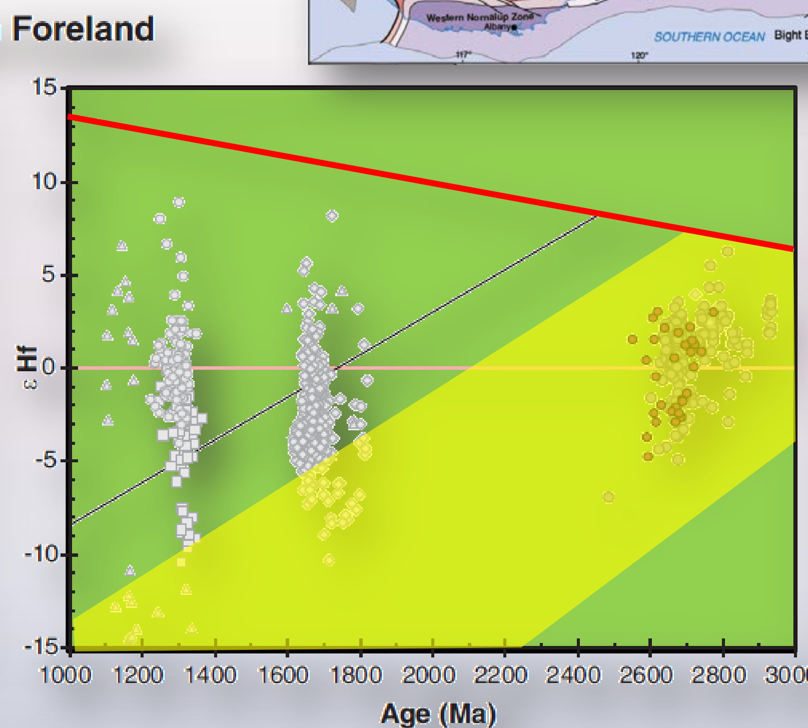
Albany-Fraser Orogen: tectonic units



Northern Foreland





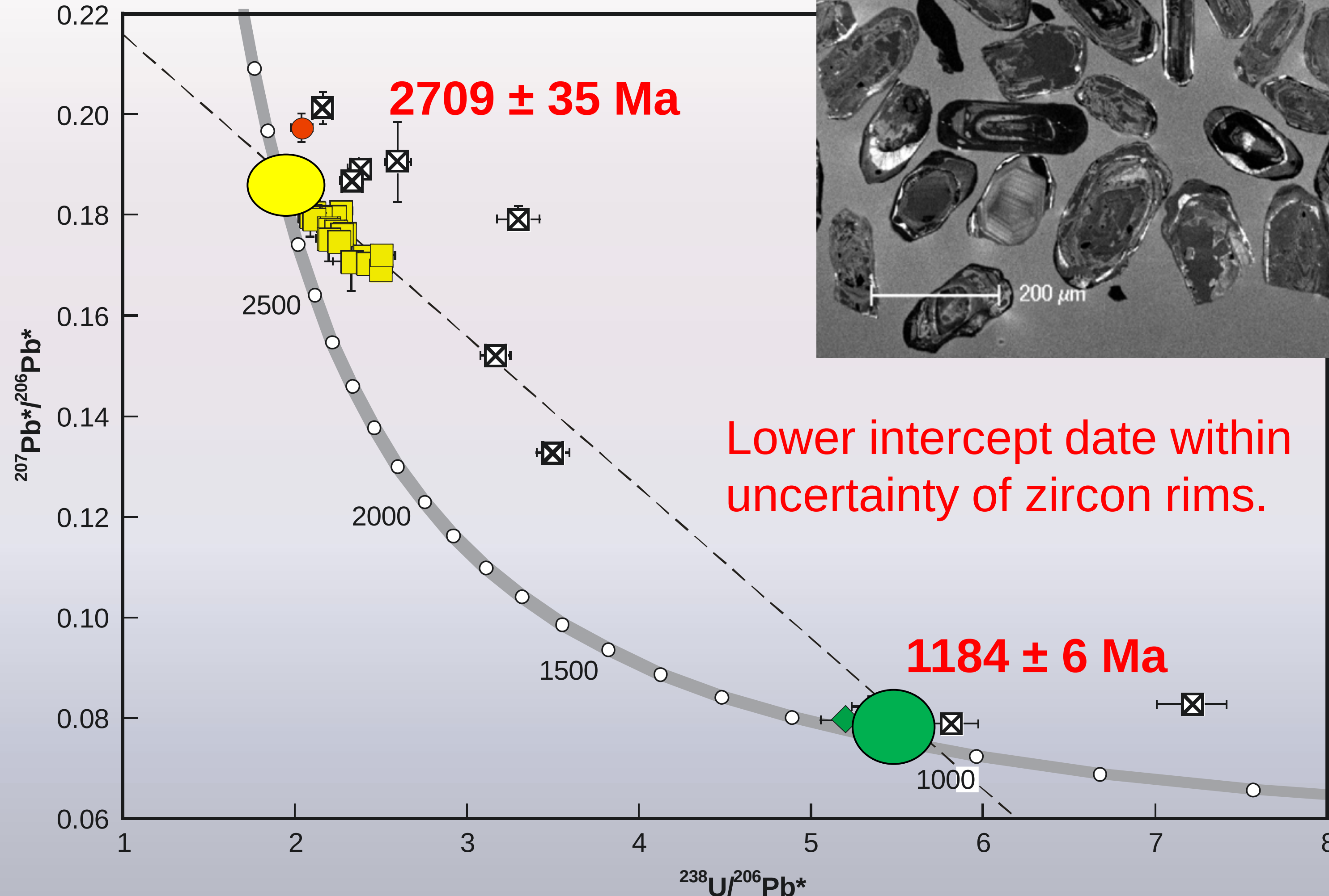


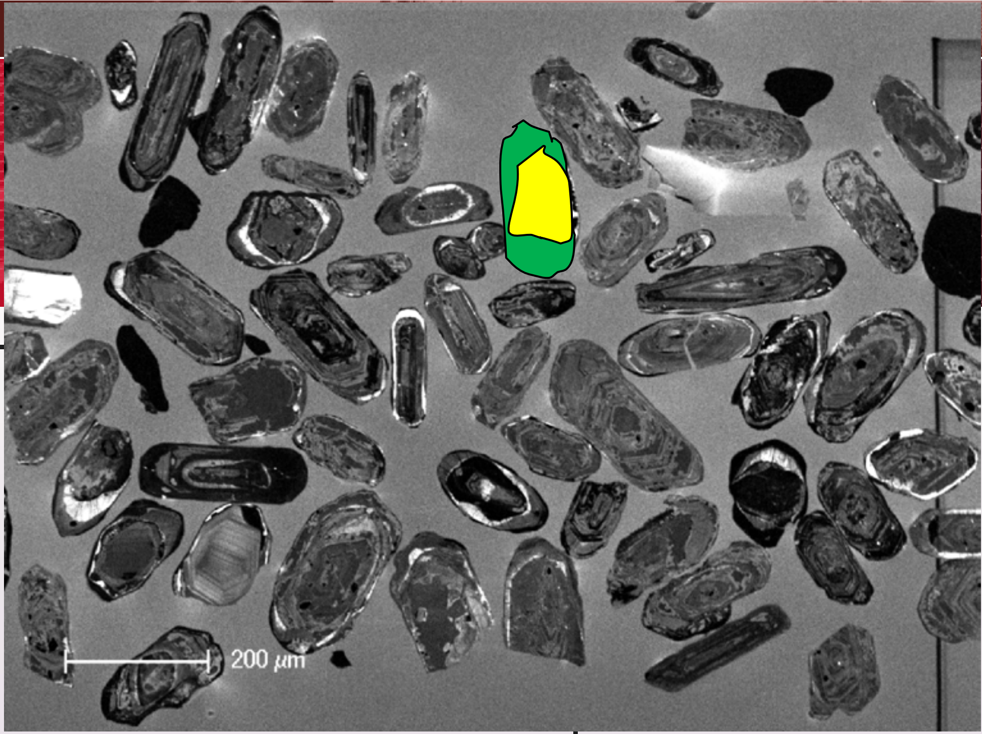
Crystallization ages of magmatic protoliths are 2722–2619 Ma

Hf-isotopic signatures are similar to those of Yilgarn Craton rocks

Represents a reworked component of the Yilgarn Craton margin

Northern Foreland Munglinup Gneiss





Lower intercept date within uncertainty of zircon rims.

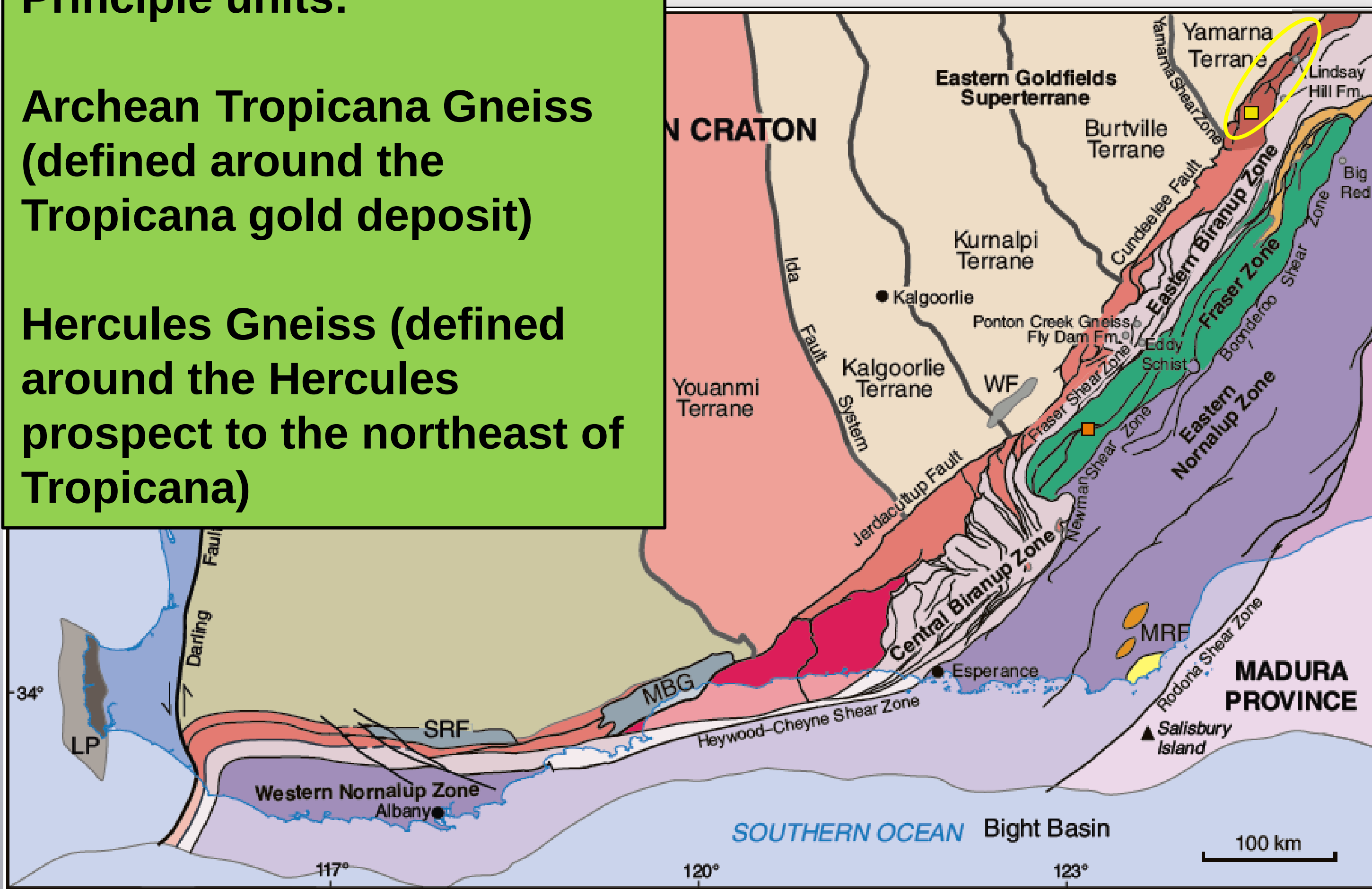
Archean granite reworked during Stage II AFO

Tropicana Zone

Principle units:

Archean Tropicana Gneiss (defined around the Tropicana gold deposit)

Hercules Gneiss (defined around the Hercules prospect to the northeast of Tropicana)

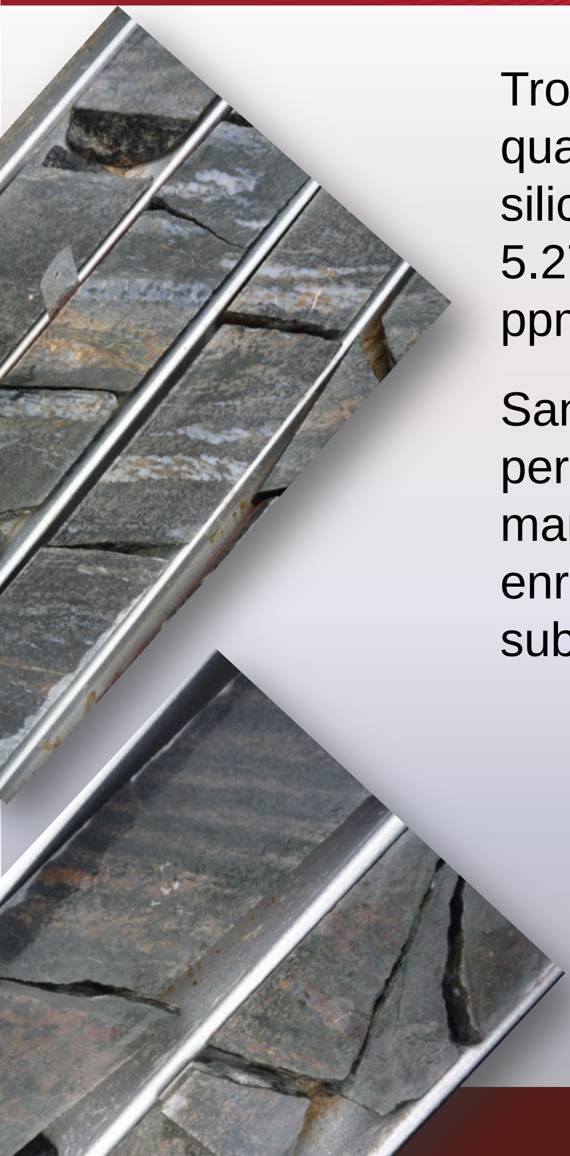


Tropicana Zone relatively unknown except from drillcore and seismic imaging

Hercules Gneiss Archean granites with dioritic compositions

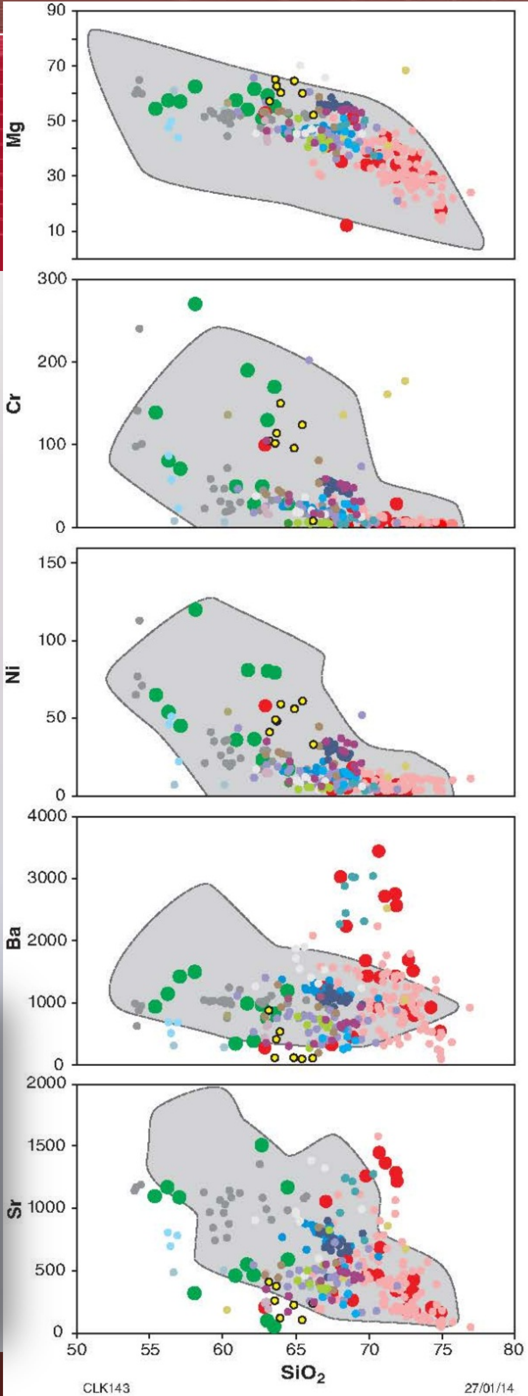
intruded by late Paleoproterozoic granites

Tropicana Zone: Hercules Gneisses

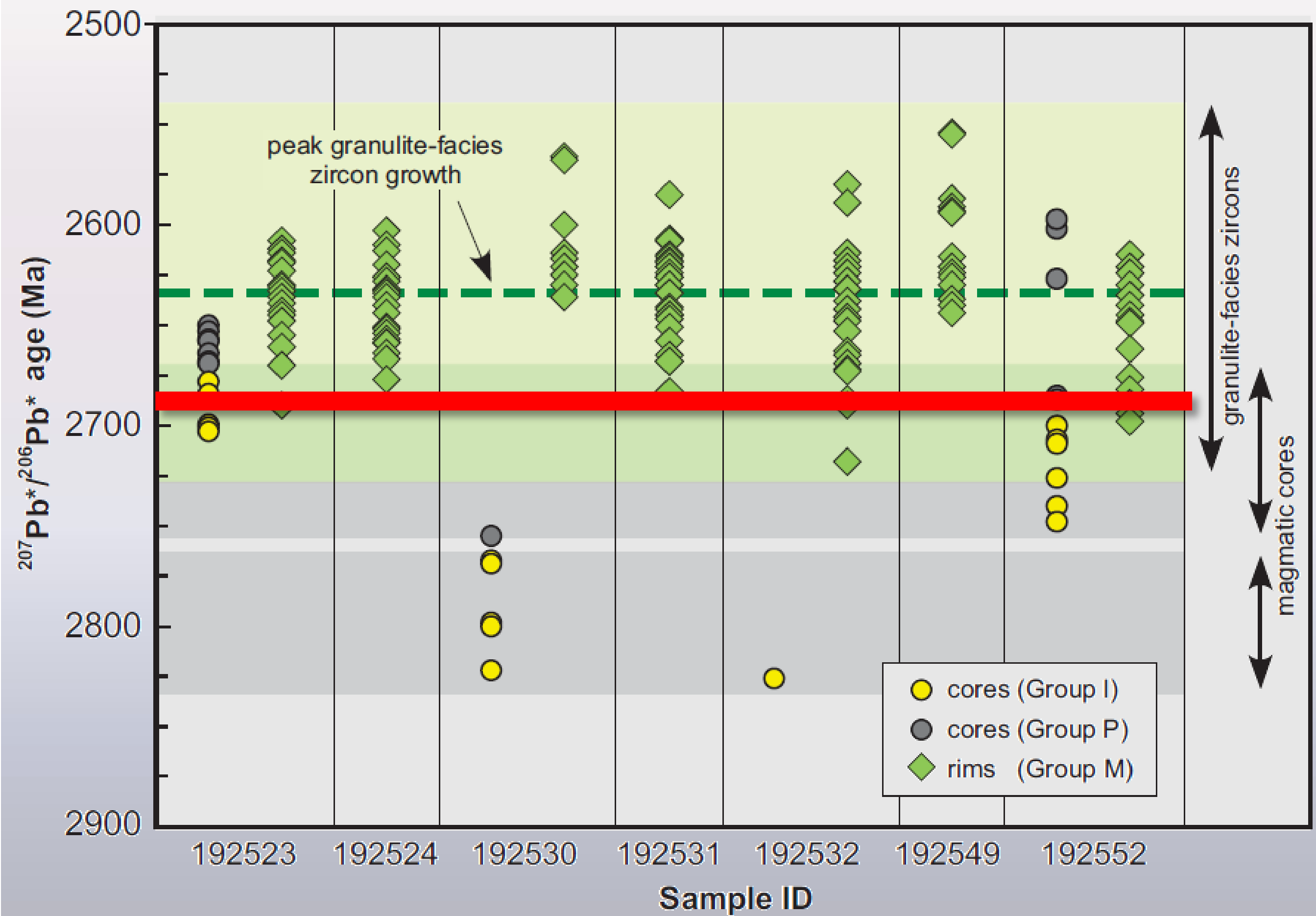


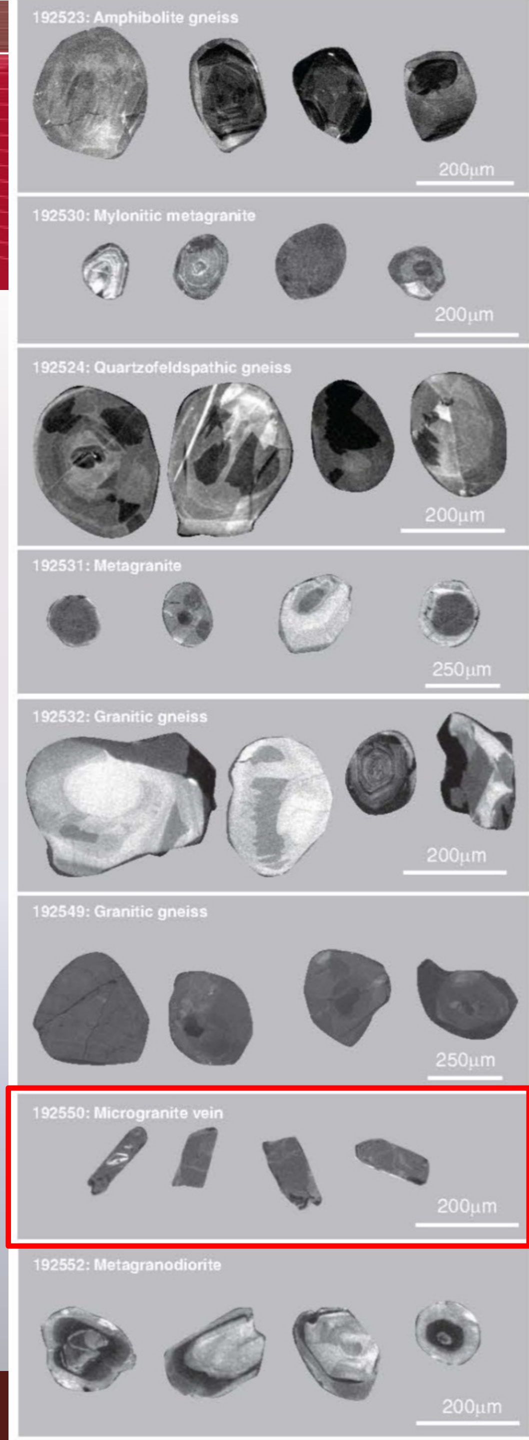
Tropicana Zone granites dioritic to quartz-monzodioritic compositions, low silica values, unusually high MgO (to 5.27 wt%), Cr (to 270 ppm) and Ni (120 ppm).

Sanukitoids: equilibration with mantle peridotite, direct derivation from a mantle source region previously enriched through interaction with subducted slab derived partial melts

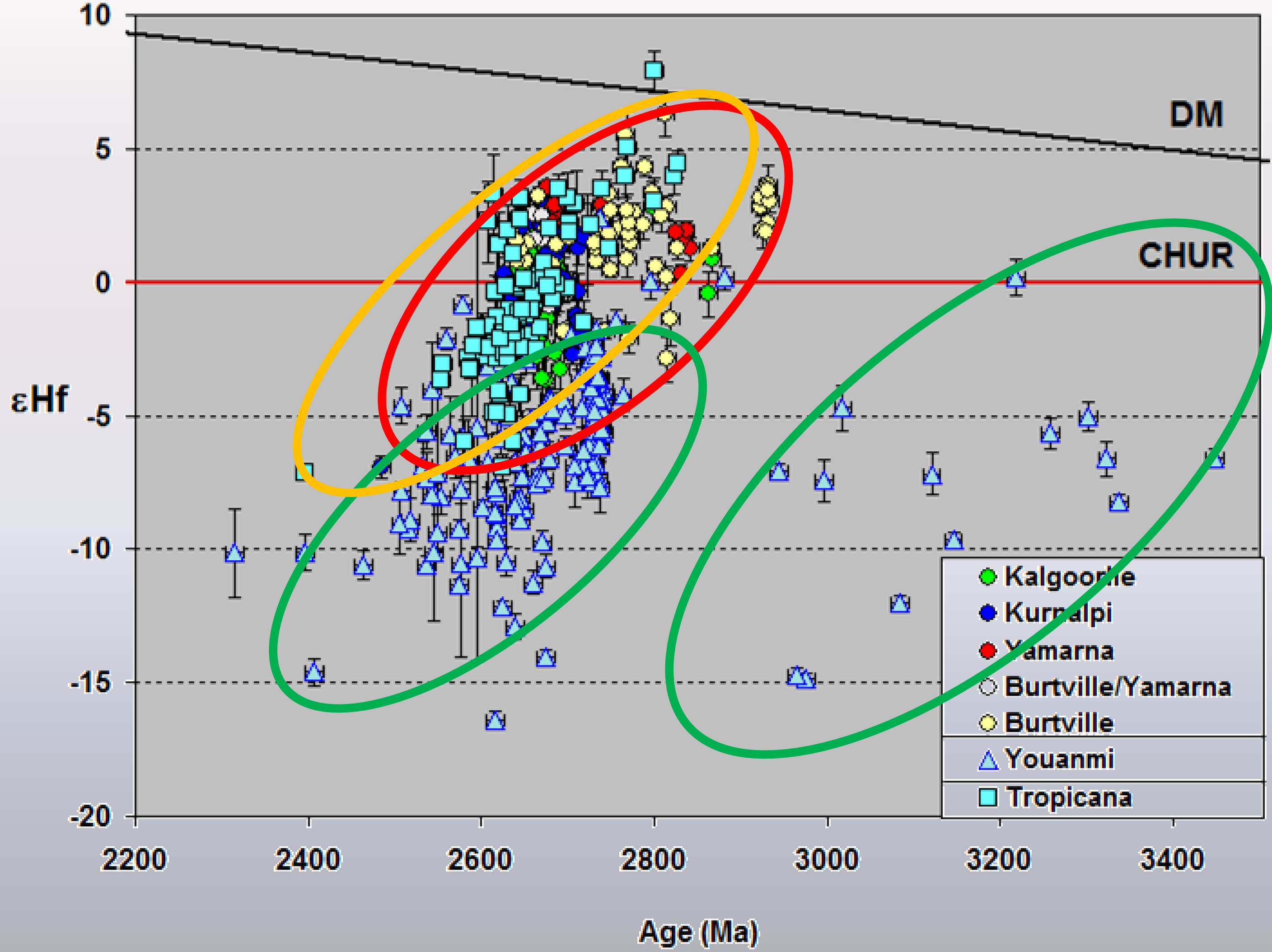


Tropicana Zone: U-Pb zircon Geochronology





Tropicana Zone: Hf signature



Tropicana Zone: Hercules Gneisses

Crystallization of sanukitoid protoliths 2692 ± 16 Ma

Prolonged granulite-facies metamorphic zircon growth at 2718–2554 Ma

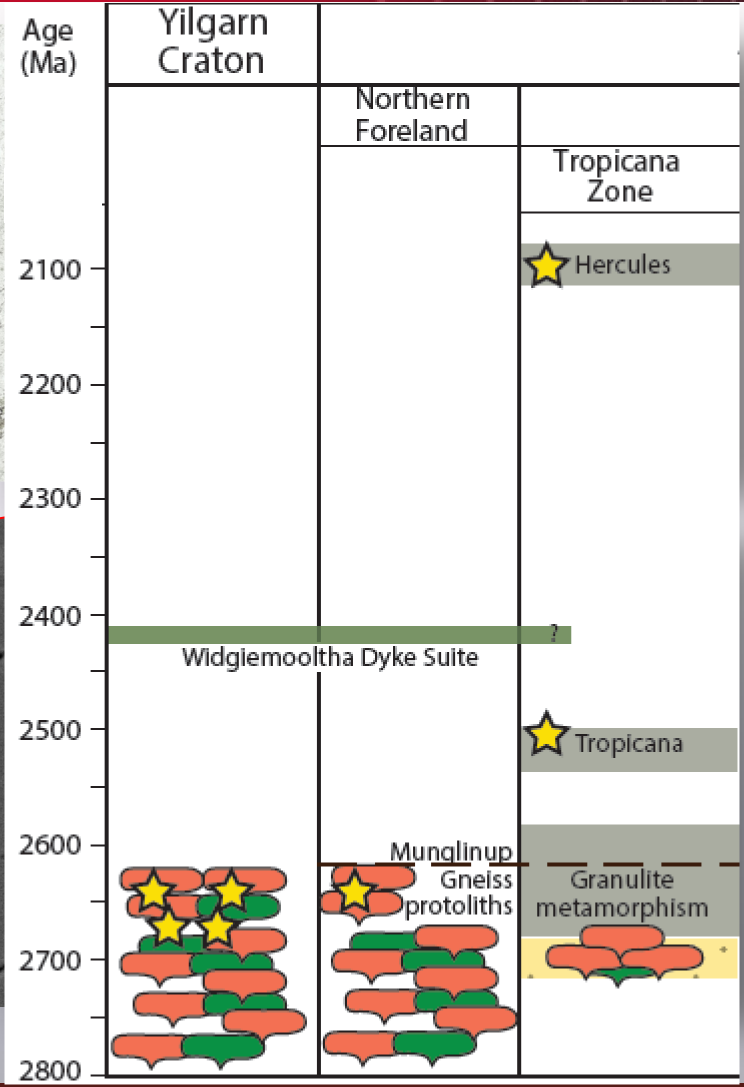
Deeper crustal level of the Yilgarn Craton

Tropicana Zone was attached to the craton at or before c. 1780 Ma

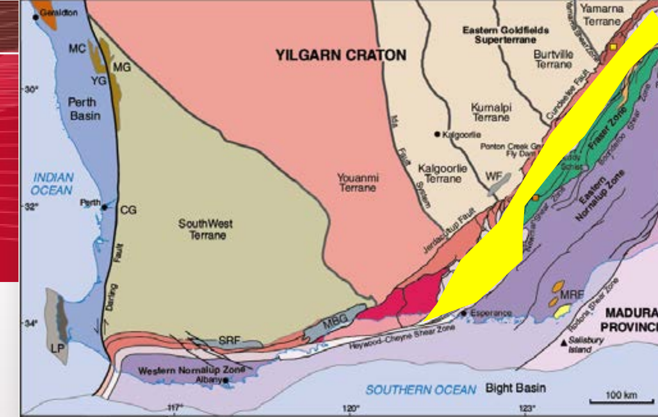
Re-Os dating of pyrite suggests an age of c. 2.1 Ga for associated gold mineralization

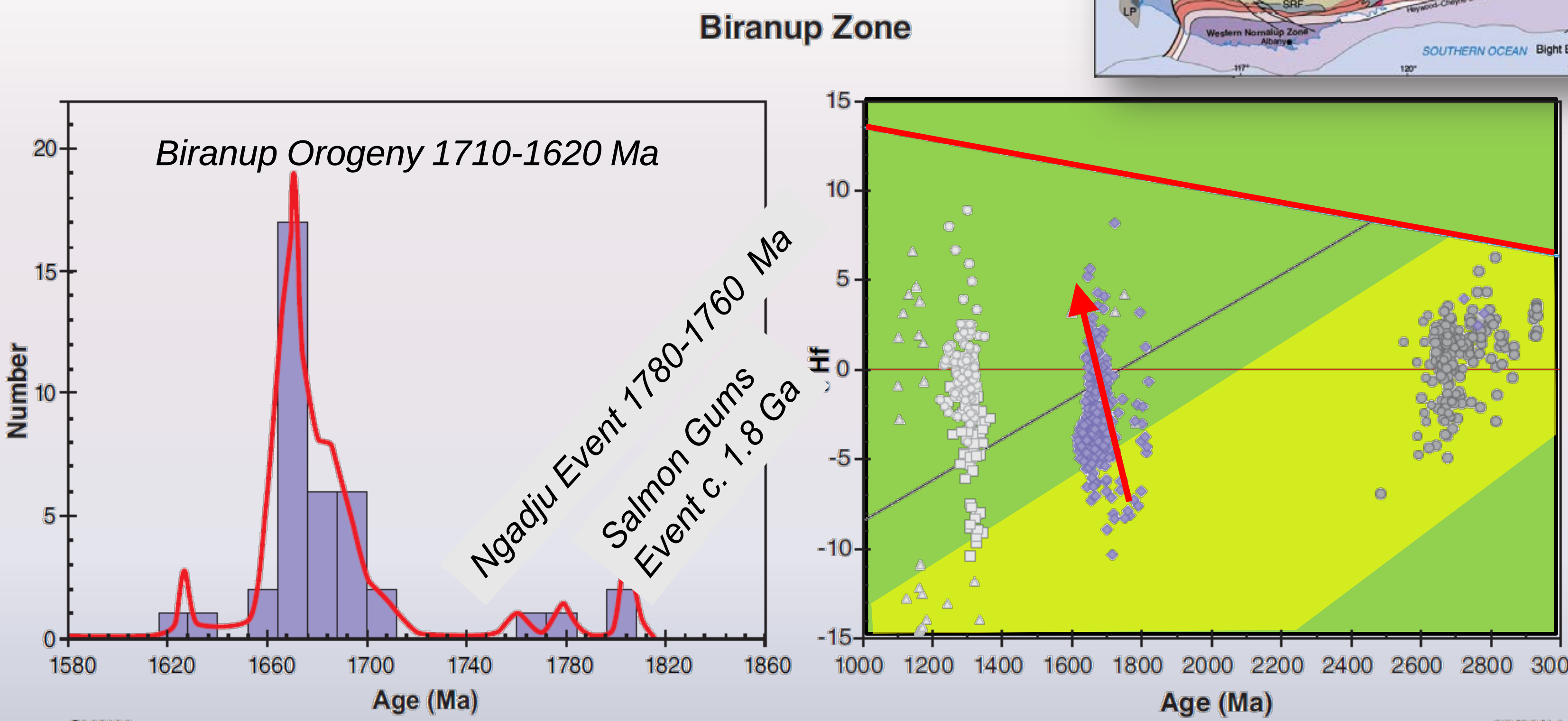
Sanukitoid magmas likely source of gold in the Tropicana Zone

Gold formation was not coeval with high-grade metamorphism



Biranup Zone



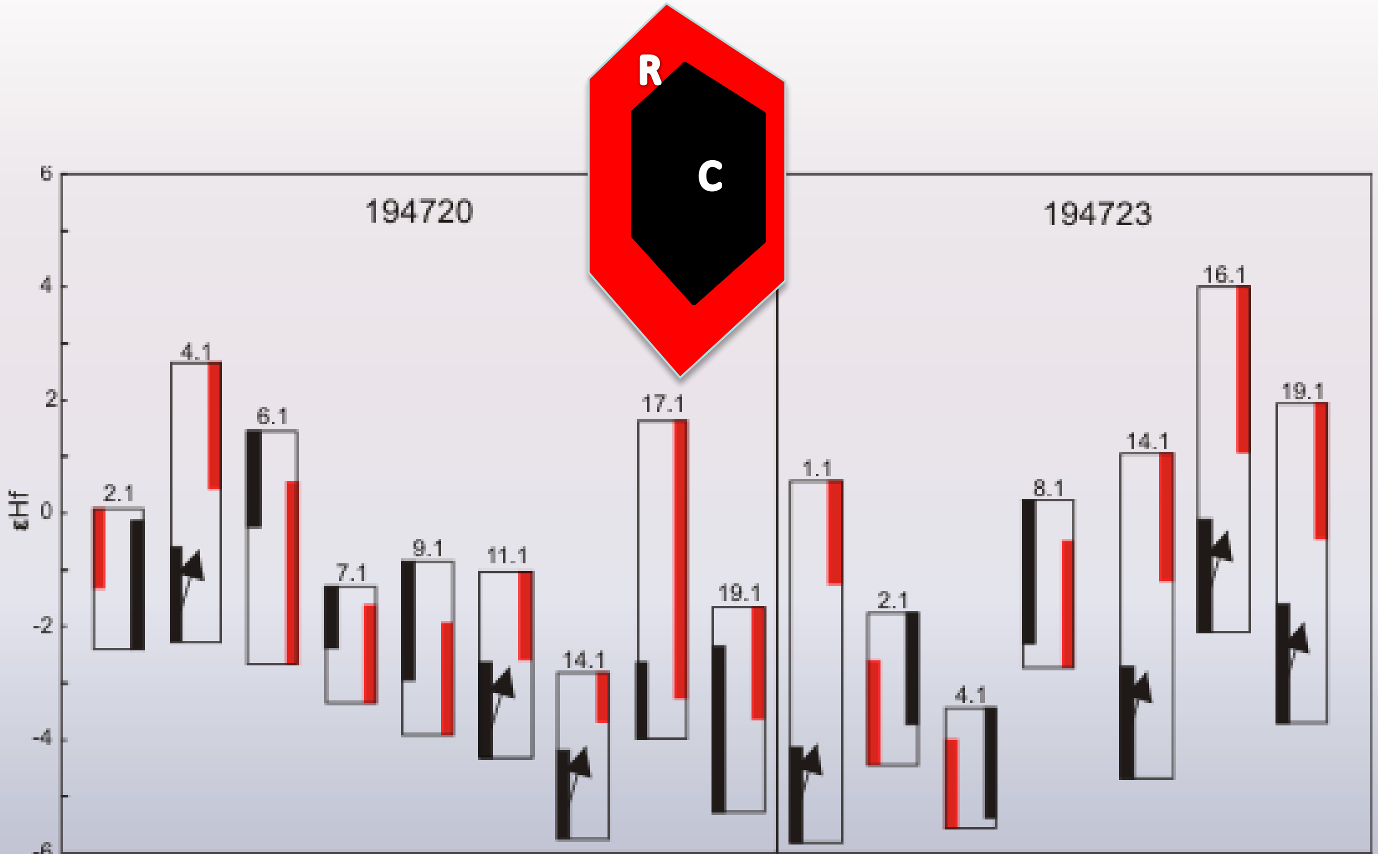


Crystallization ages of magmatic protoliths are 1806–1627 Ma

Hf-isotopic signatures are consistent with juvenile input into an Archean Yilgarn craton source numerous distinct magmatic events, including the Biranup Orogeny and prolific Stage II mineral growth

Represents a (para)autochthonous unit

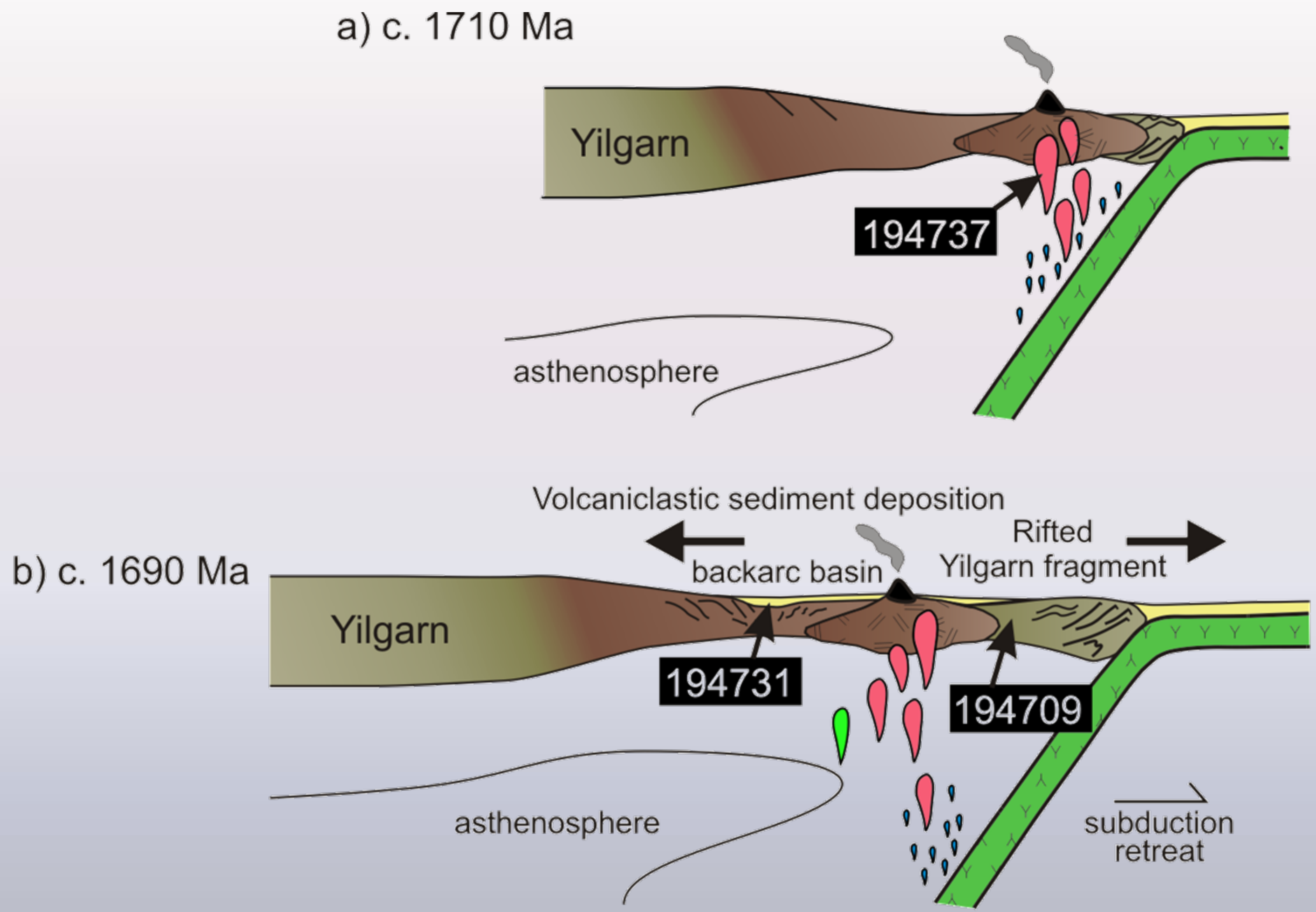
Biranup Zone

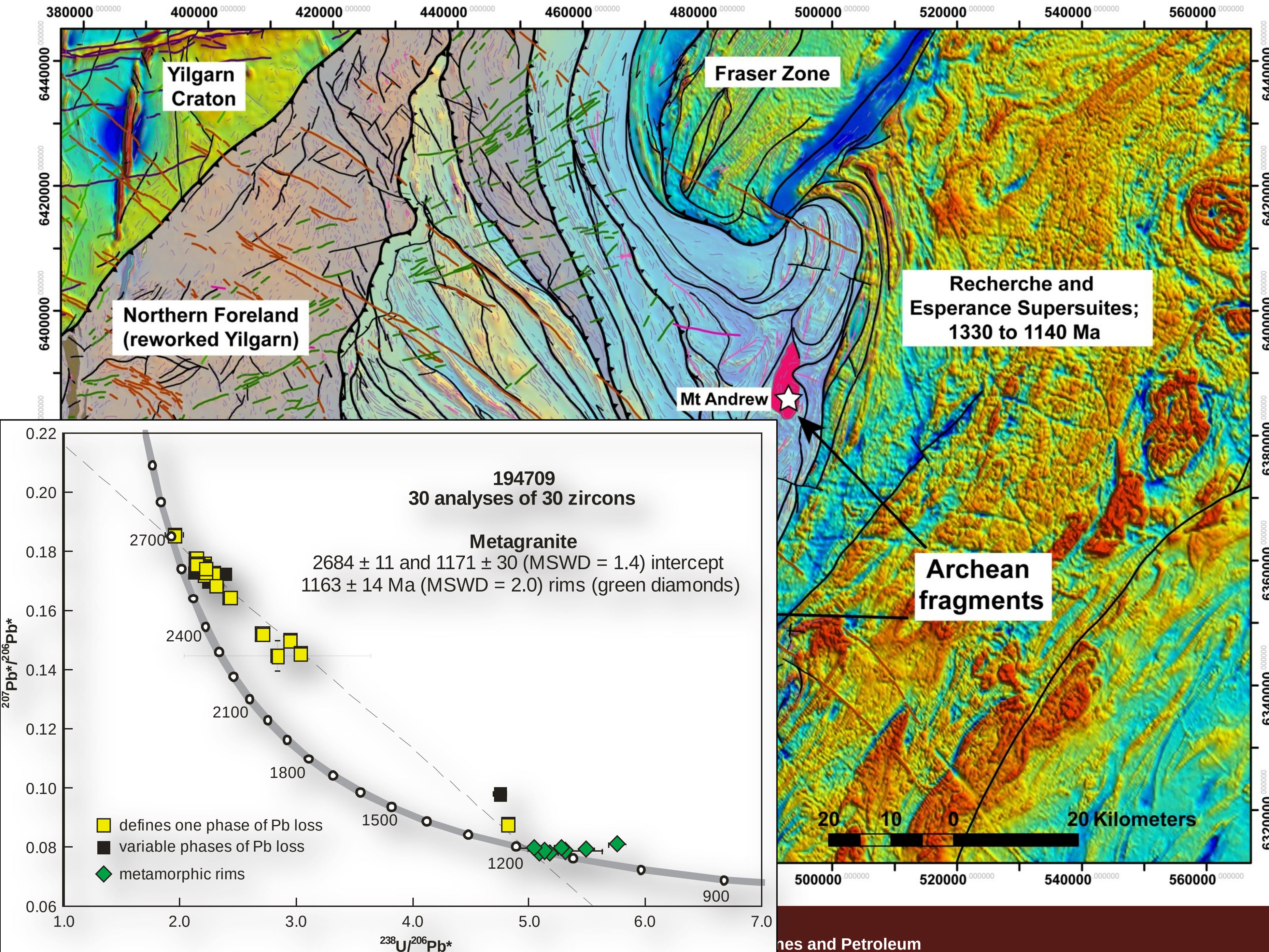


Zircon rims when outside of analytical uncertainty, always indicate higher εHf values.

Implies the incorporation of material with higher Lu/Hf ratio through time.

Biranup Zone: tectonic model





380000
400000
420000
440000
460000
480000
500000
520000
540000
560000
6440000
6420000
6400000
6380000
6360000
6340000
6320000
Yilgarn Craton
Fraser Zone
Northern Foreland (reworked Yilgarn)
Recherche and Esperance Supersuites; 1330 to 1140 Ma
Mt Andrew
Archean fragments
20 10 0 20 Kilometers
194709
30 analyses of 30 zircons
Metagranite
2684 ± 11 and 1171 ± 30 (MSWD = 1.4) intercept
1163 ± 14 Ma (MSWD = 2.0) rims (green diamonds)
defines one phase of Pb loss
variable phases of Pb loss
metamorphic rims
2700
2400
2100
1800
1500
1200
900
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
1.0
2.0
3.0
4.0
5.0
6.0
7.0
$^{207}Pb^{*}/^{206}Pb^{*}$
$^{238}U/^{206}Pb^{*}$

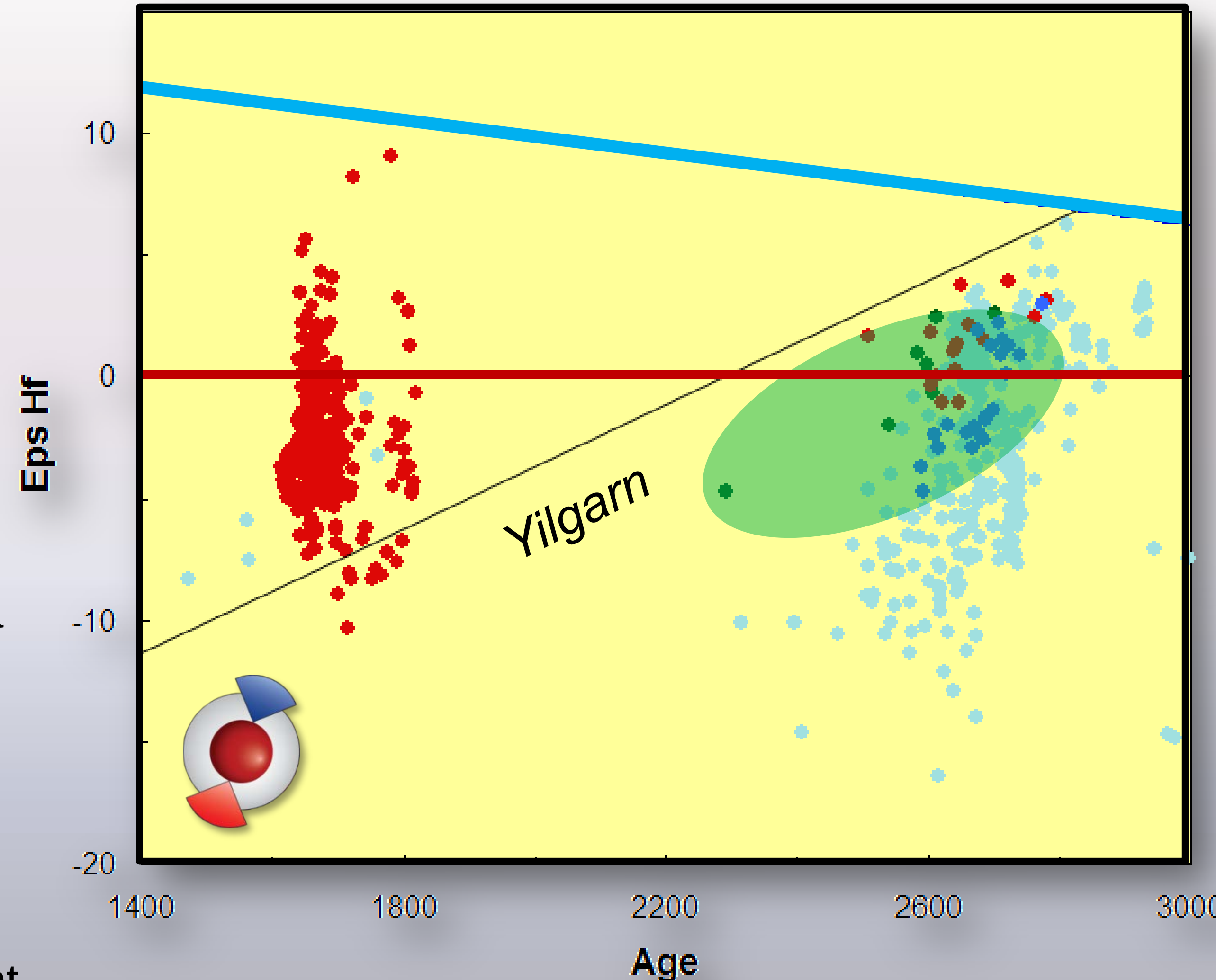
Biranup Zone: Archean remnants

- Yilgarn Craton
- Biranup Zone
- Northern foreland
- Yilgarn Craton fragment

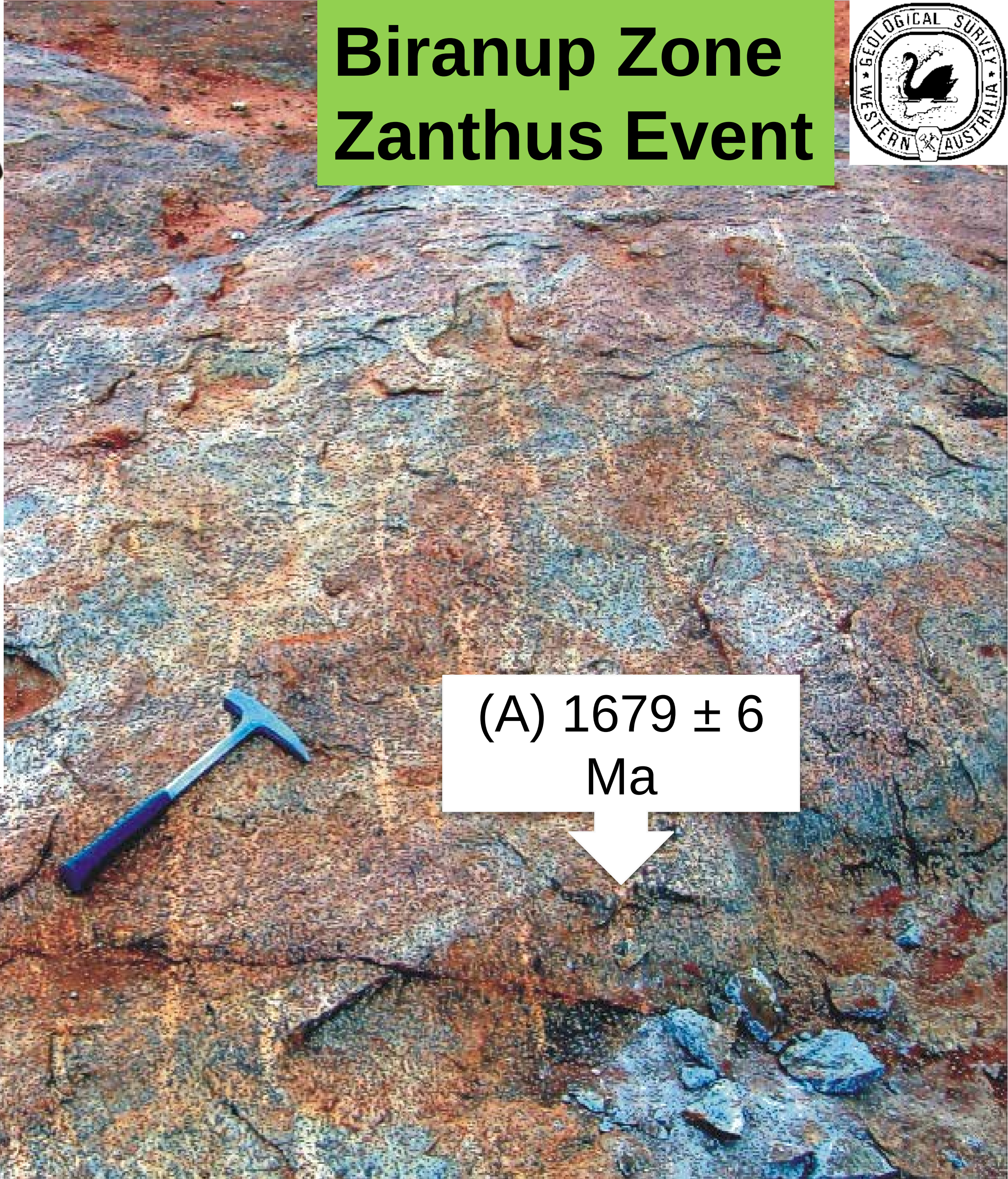
Northern Foreland = reworked Archean Yilgarn Craton

The Biranup Zone = reworked Archean Yilgarn component. Through time a greater juvenile mantle-derived component consistent with increasing lithospheric attenuation

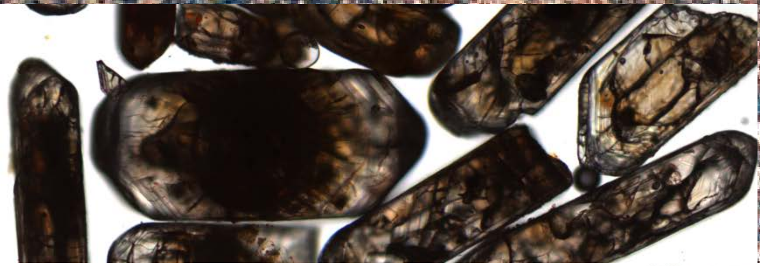
Results indicate autochthonous development

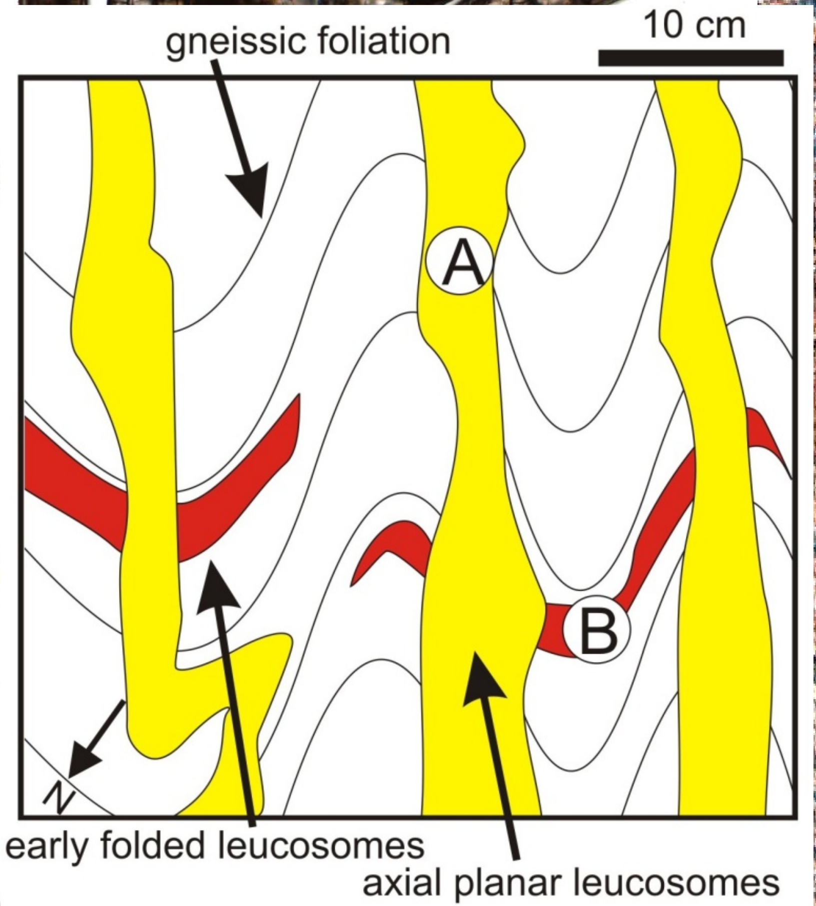


Biranup Zone
Zanthus Event

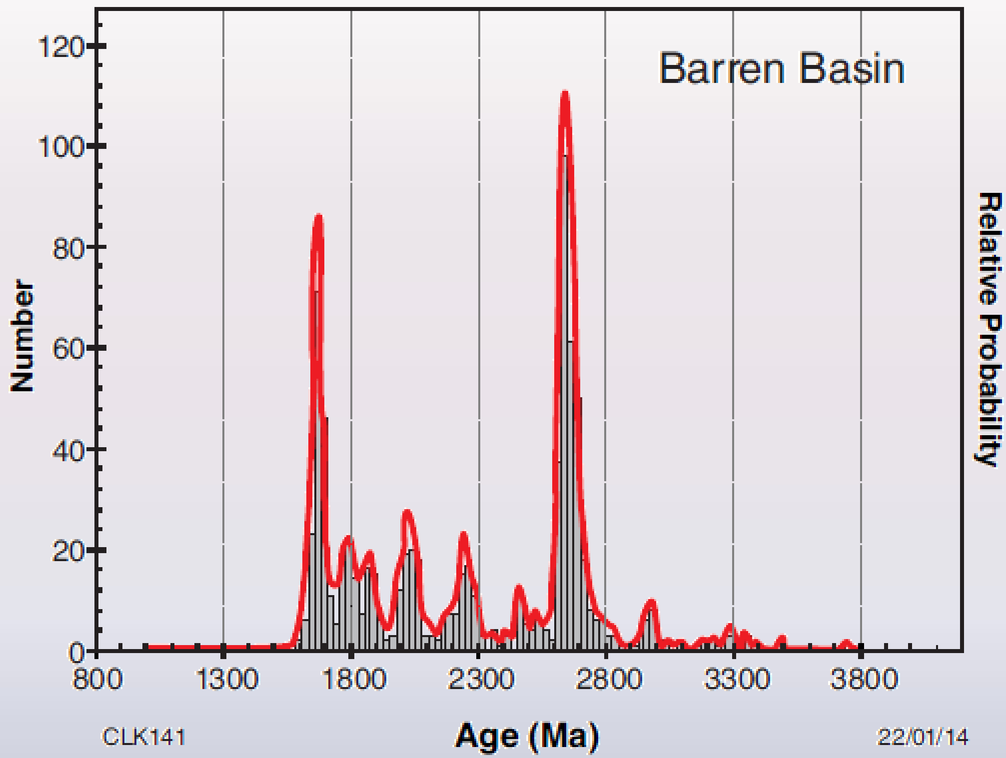


Both results agree to within uncertainty and imply deformation at 1678 ± 4 Ma.



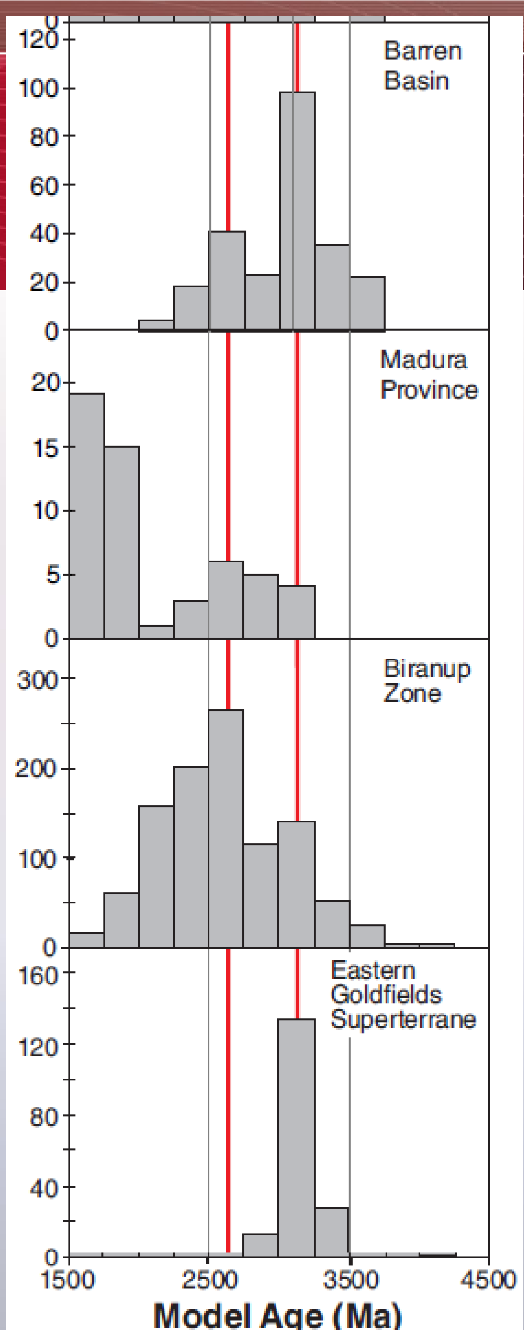


Barren Basin

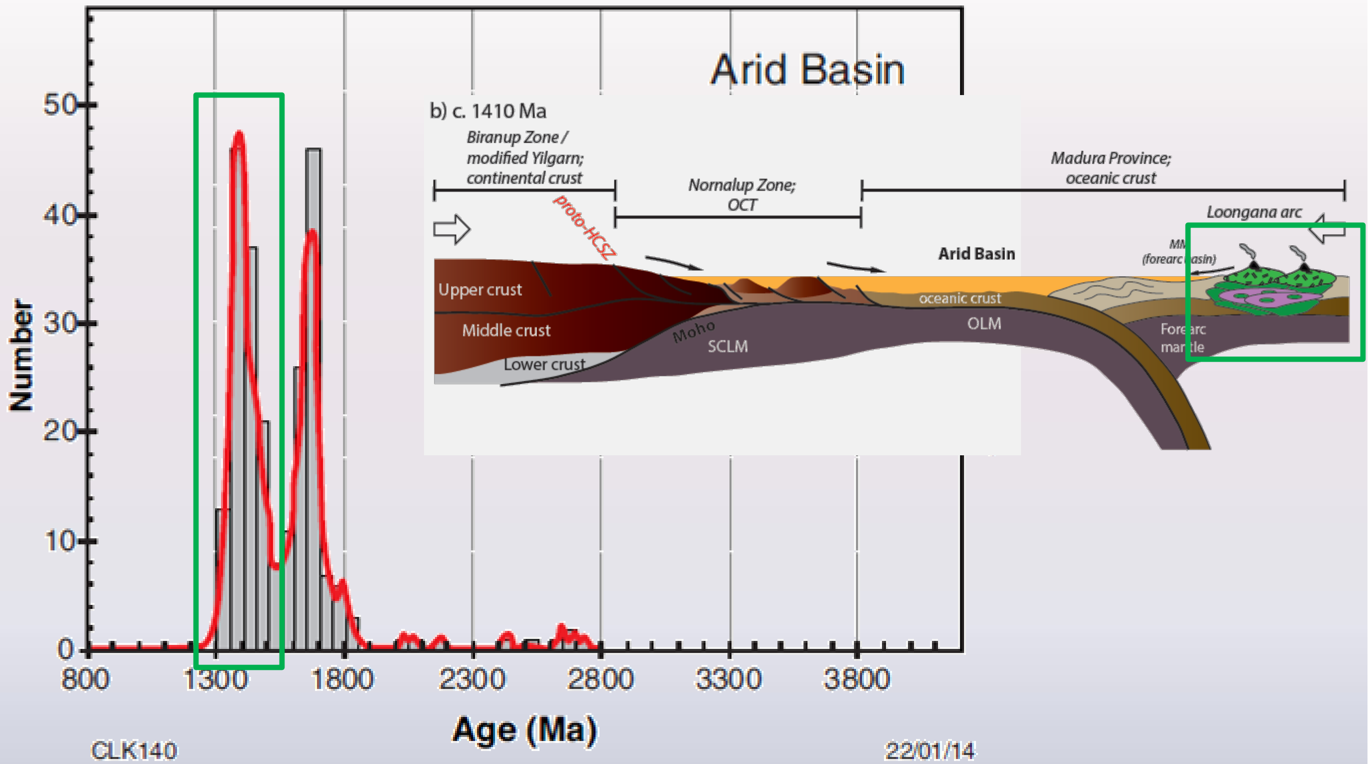


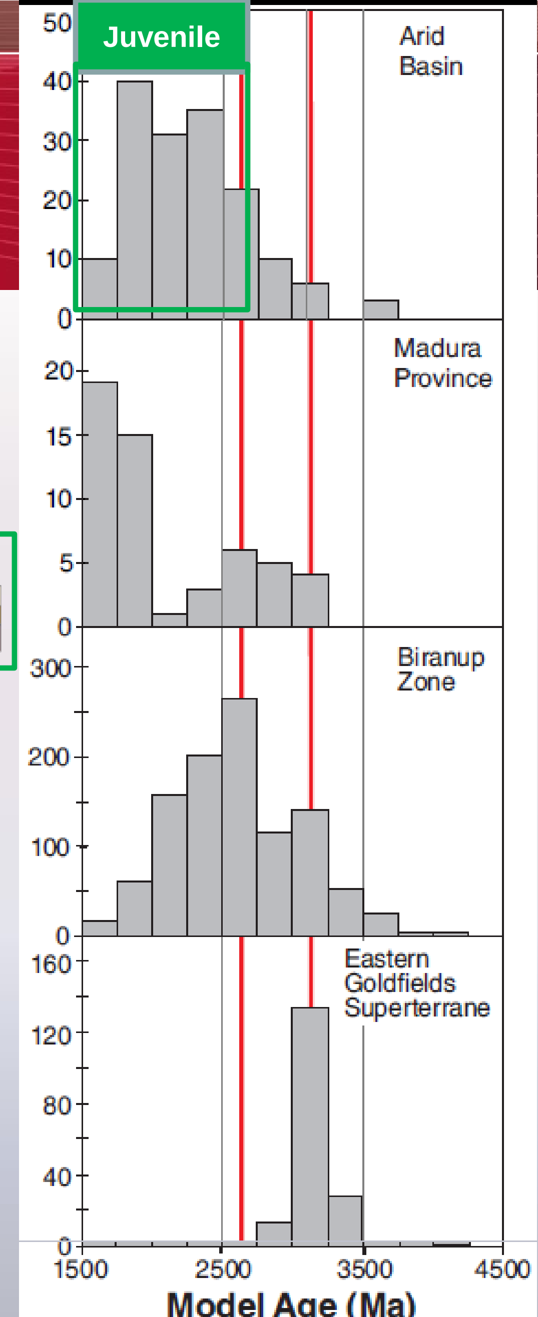
Deposition occurred before c. 1800 Ma, before c. 1700 Ma, and between 1710 and 1600 Ma

Age and Hf-isotopic signatures indicate sediments were derived from the Yilgarn Craton and Biranup Zone



Arid Basin

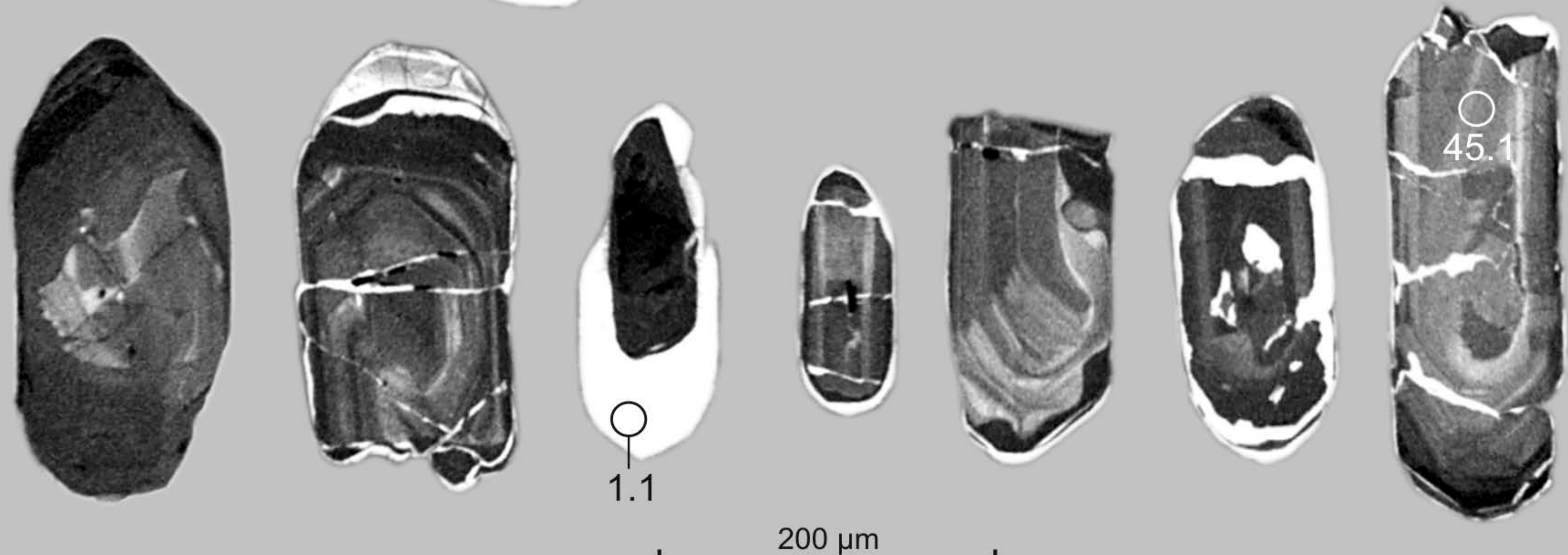


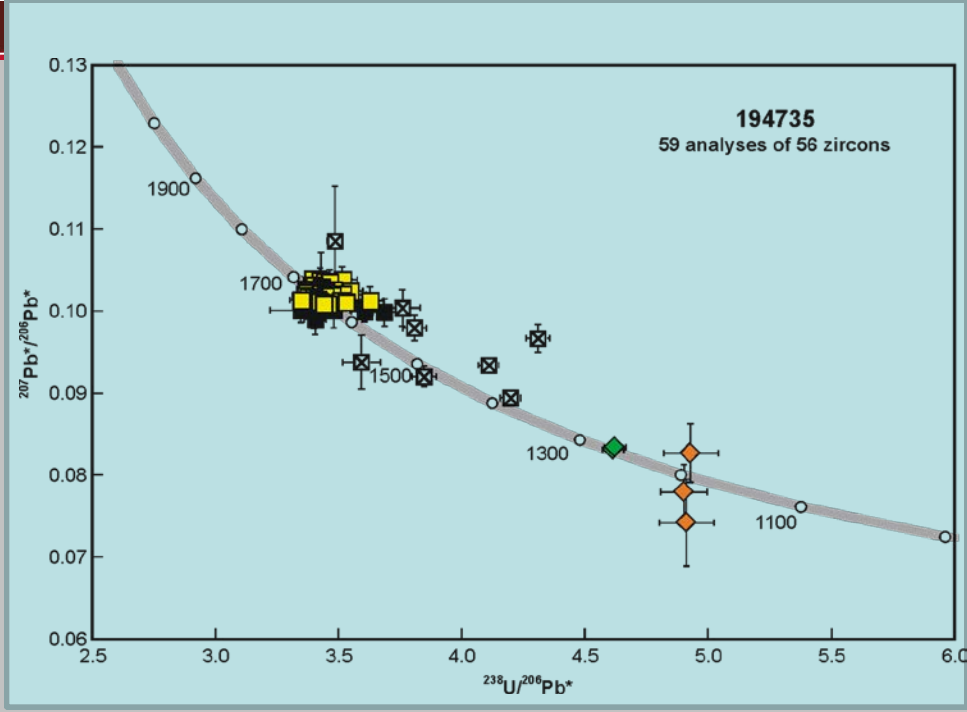


Deposition occurred after the Biranup Orogeny and (just) prior to Stage I events

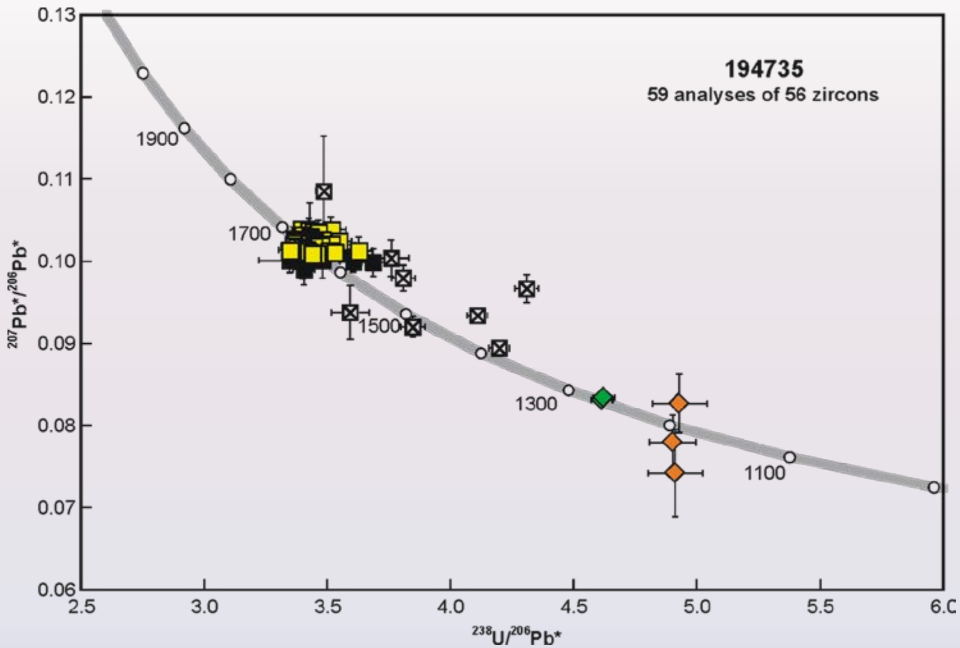
Detrital zircons were derived from the Biranup Zone, Yilgarn Craton, Loongana Arc, and possibly unknown sources

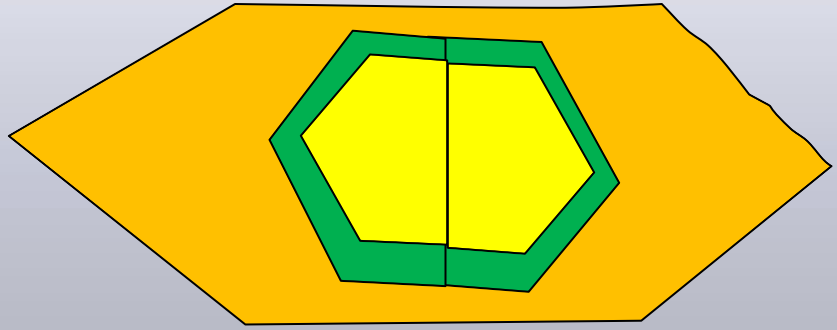
Gwynne Creek Gneiss
Arid Basin





Arid Basin: timing of uplift





Detrital source
1657 ± 5 Ma magmatic zircon cores

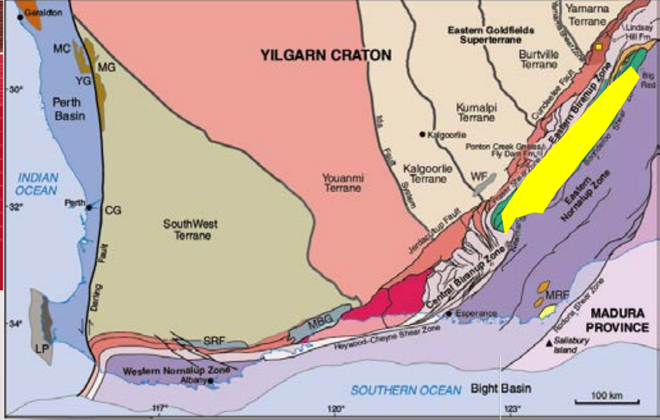
? Migmitization
1270 ± 11 Ma, high U, homogeneous zircon overgrowths

Brittle deformation
1270-1197 Ma

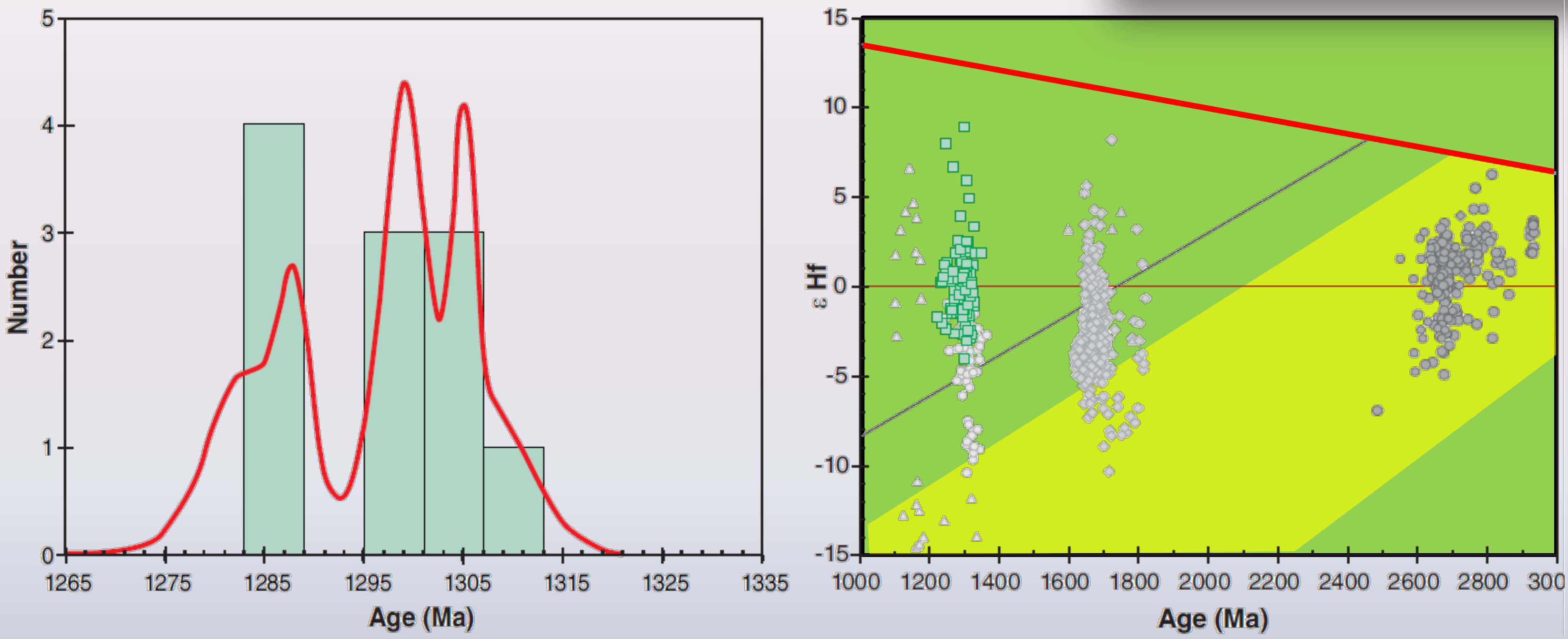
? Hydrothermal growth
1197 ± 6 Ma homogeneous low U rims

Timing of uplift identical to that in the Fraser Range Metamorphics, which were uplifted to less than ~4 kBar sometime between 1288–1260 Ma

Fraser Zone



Fraser Zone



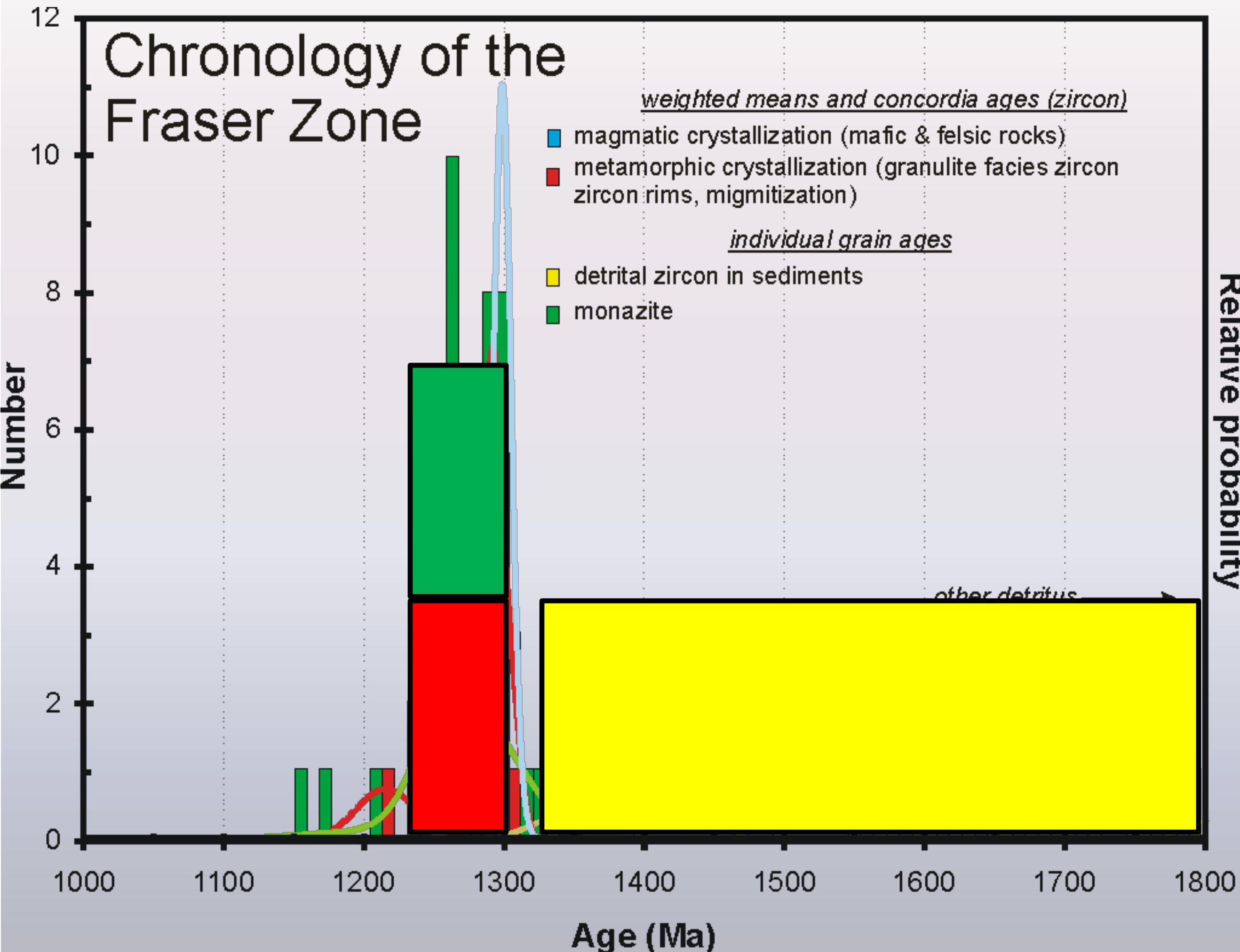
crystallization ages of magmatic protoliths are 1310–1283 Ma

Hf-isotopic signatures are consistent with juvenile input into a Biranup Zone source consistent with the age of rare inherited zircons in the Fraser Zone

high-grade metamorphism was driven by magmatism

represents an uplifted (para)autochthonous lower-crustal hot zone

Fraser Zone: chronology



Max depositional age of sediments = c. 1335 Ma

Mafic magmatism = c. 1300 Ma

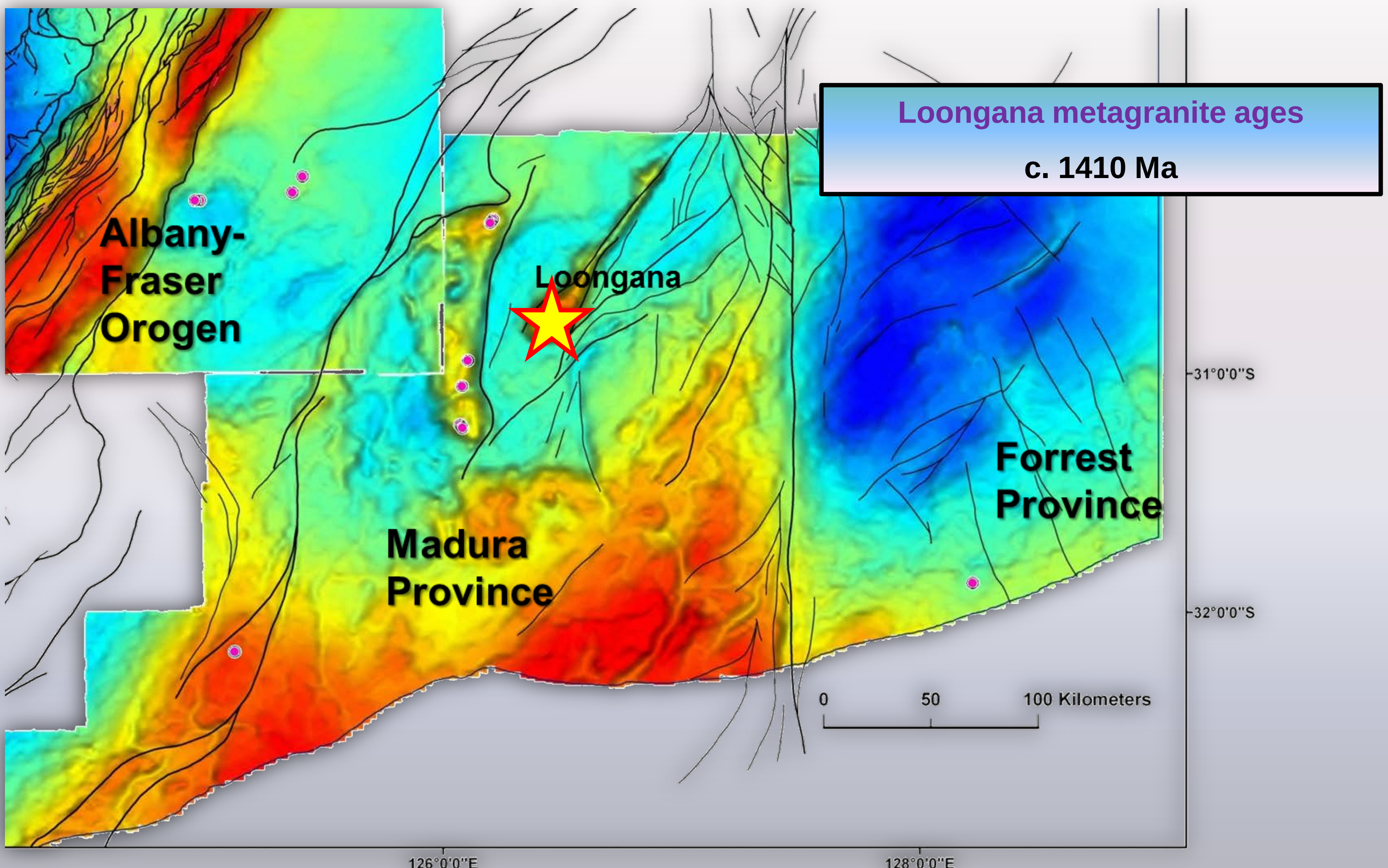
Felsic magmatism = c. 1290 Ma

Metamorphic zircon growth = c. 1290 - 1280 Ma

Metamorphic monazite growth = c. 1270 Ma

Mafic magmatism as heat source for peak metamorphic conditions at >900 °C and <8 kbar

Madura Province

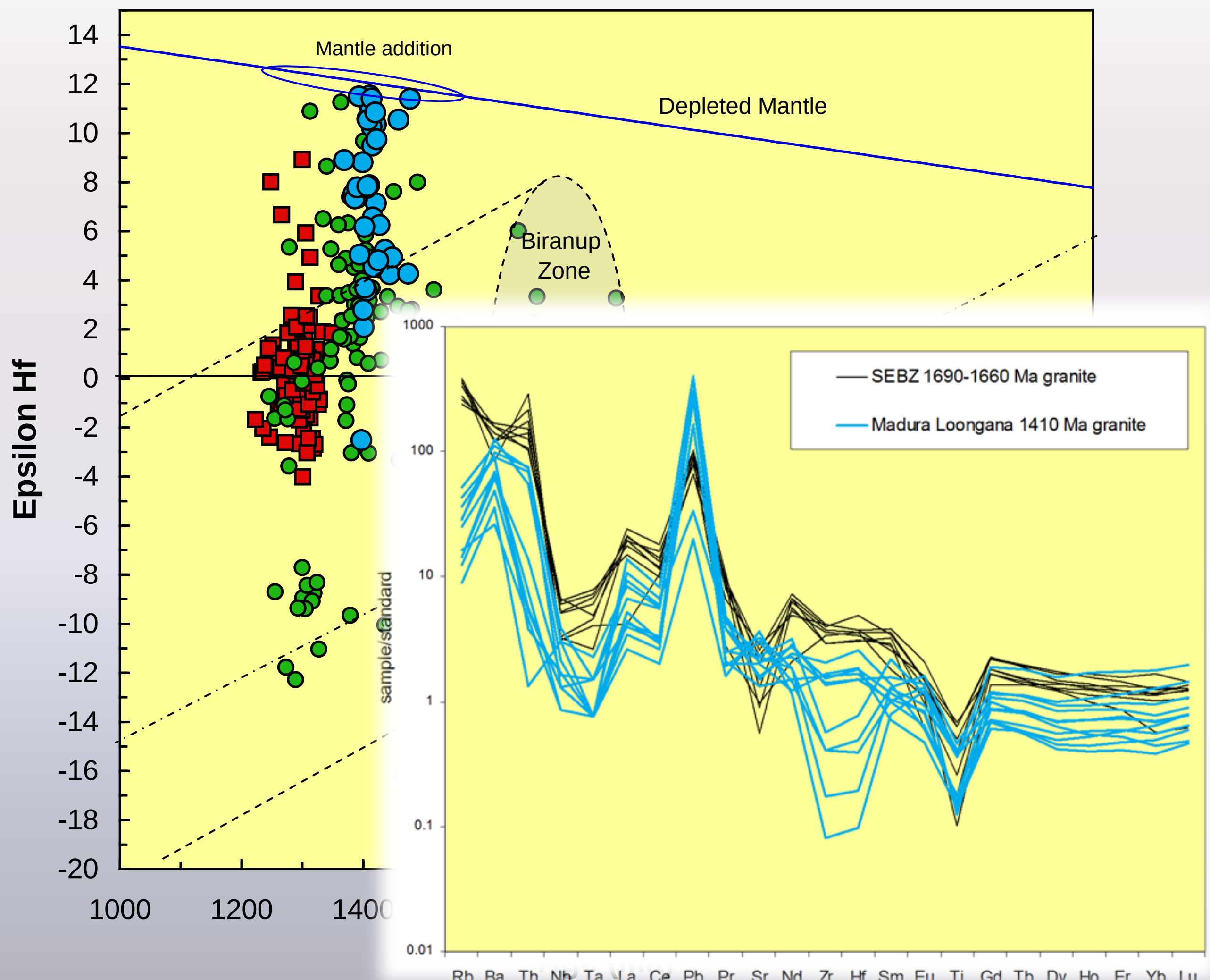


Madura Province: oceanic crust

Loongana (Madura Province)

Fraser Zone magmatic rocks

Fraser Zone sediments



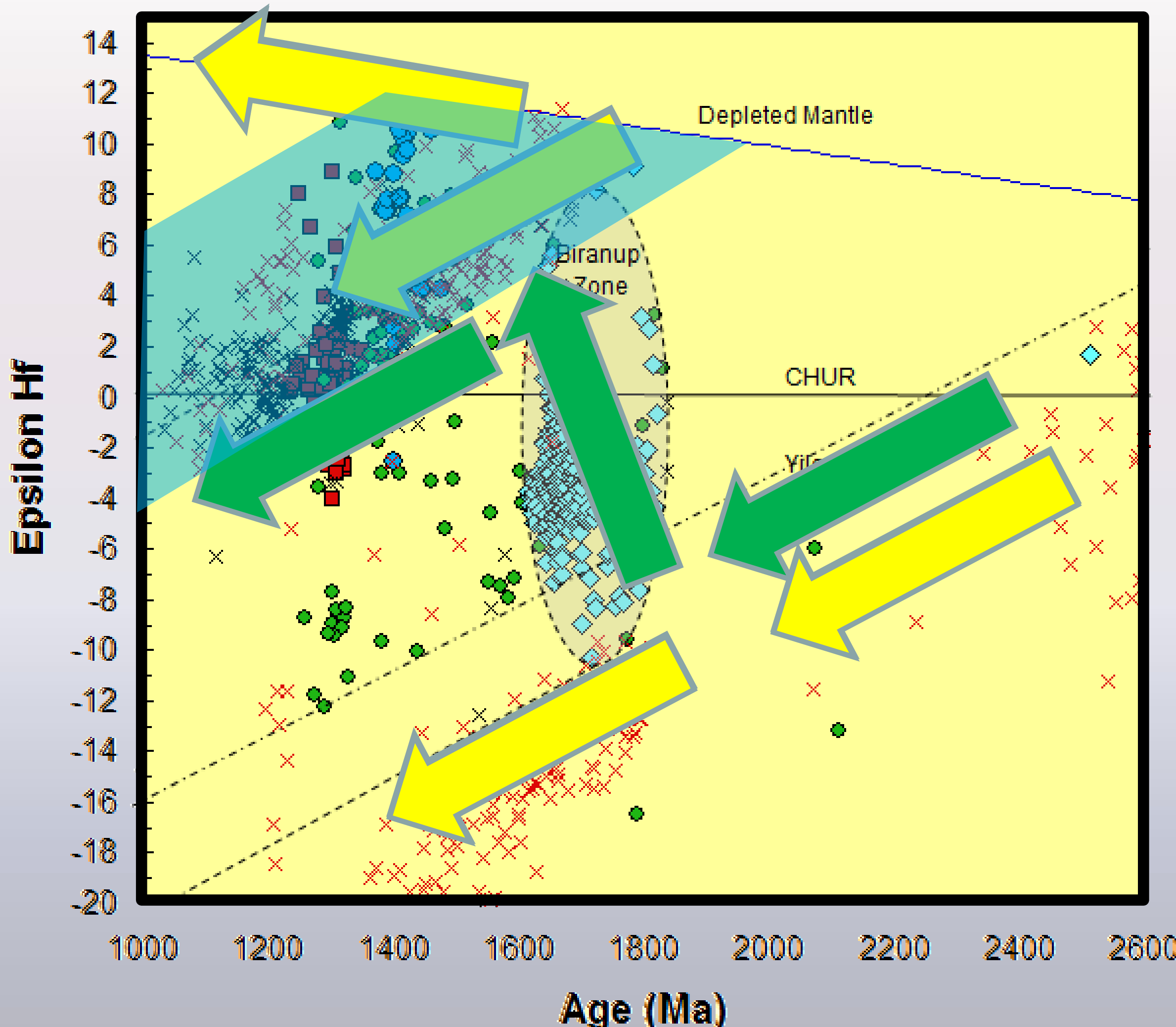
Loongana = initial-Hf isotope ratios consistent with juvenile source

Provenance for much of Fraser Zone sediments

Arc subduction chemistry

Oceanic crust

WAC marginal units

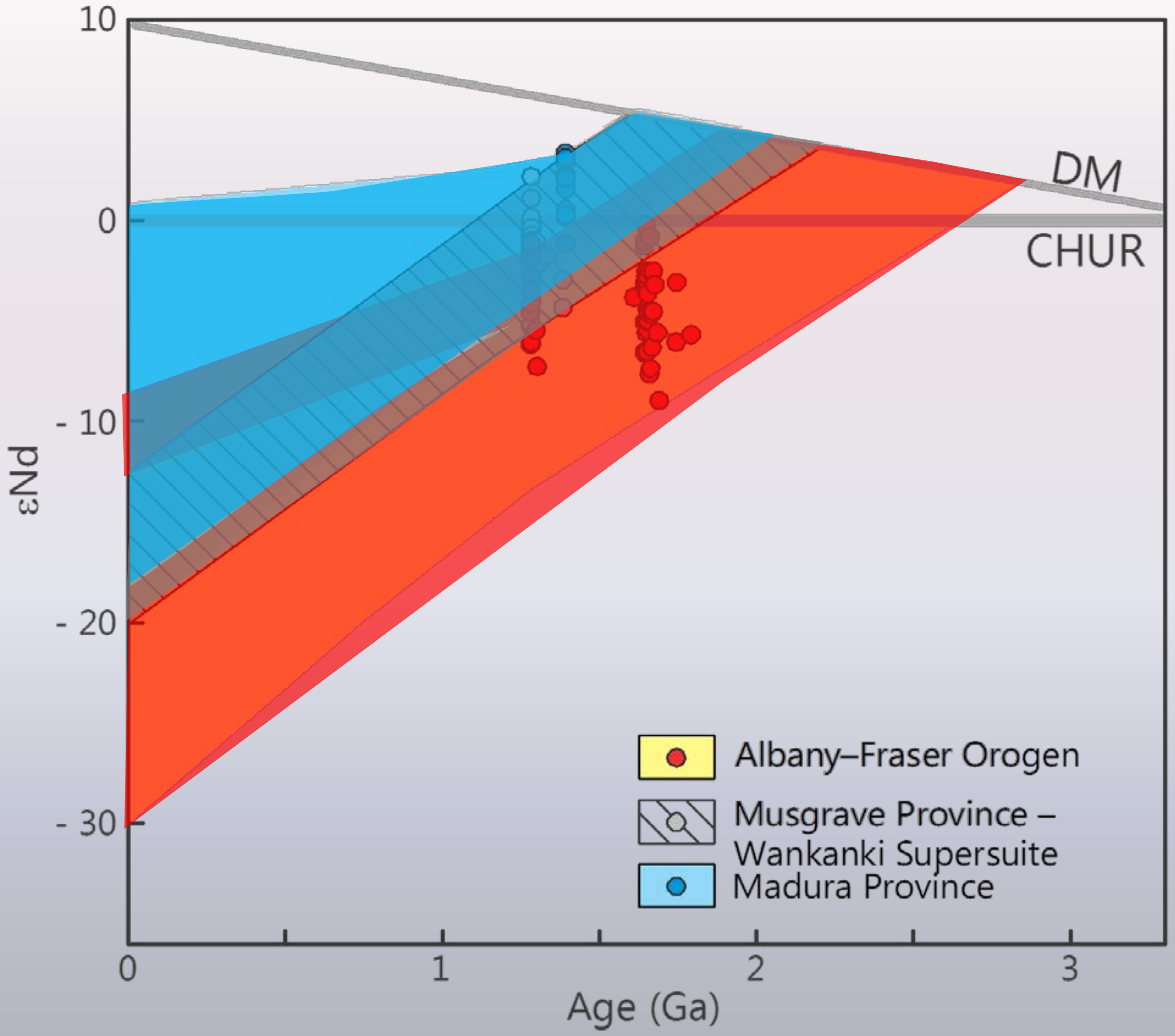


WAC marginal units

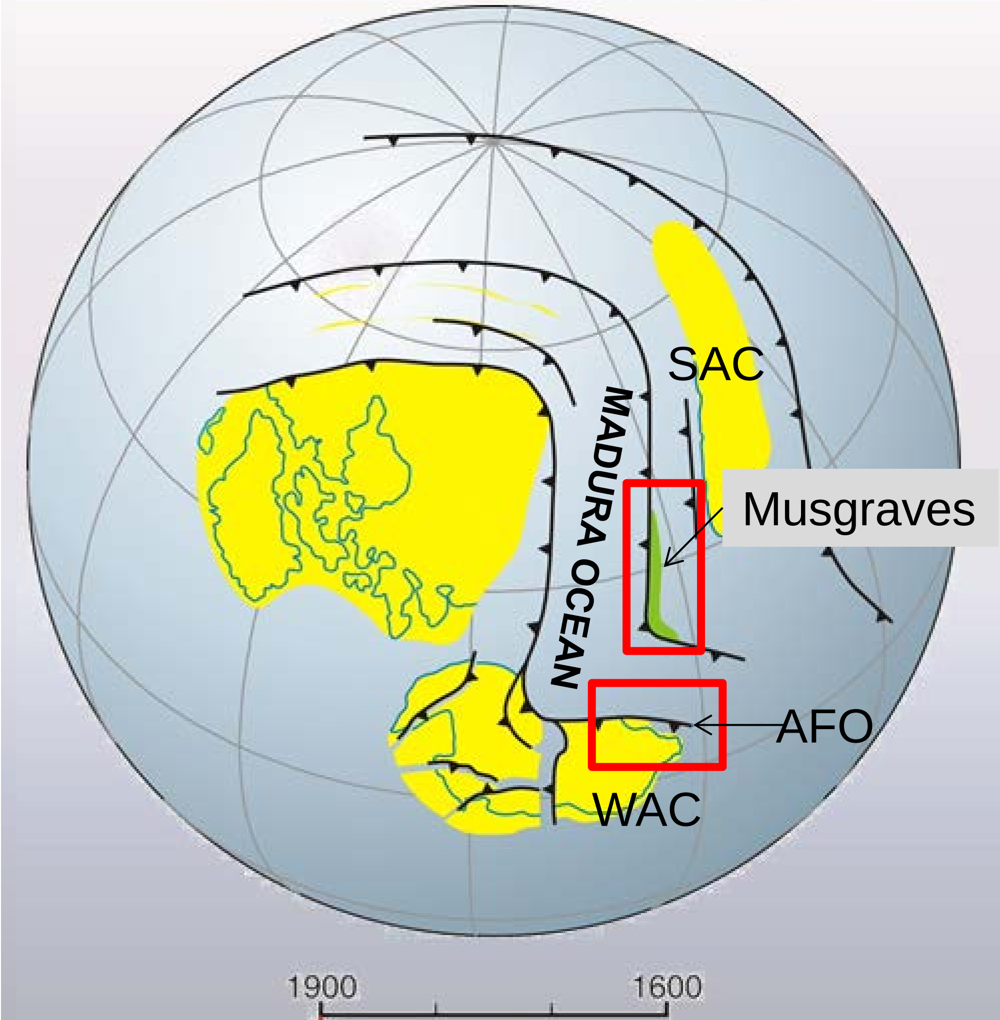
Whole rock Nd isotopic data important; comes from igneous intrusions sampling /interacting with basement

Musgraves overlaps the evolution array of Madura Province (lies at evolved end due to the HFSE enriched nature of Musgrave Province)

AFO more evolved and post crystallization has a dramatically different composition to Musgraves and Madura Province

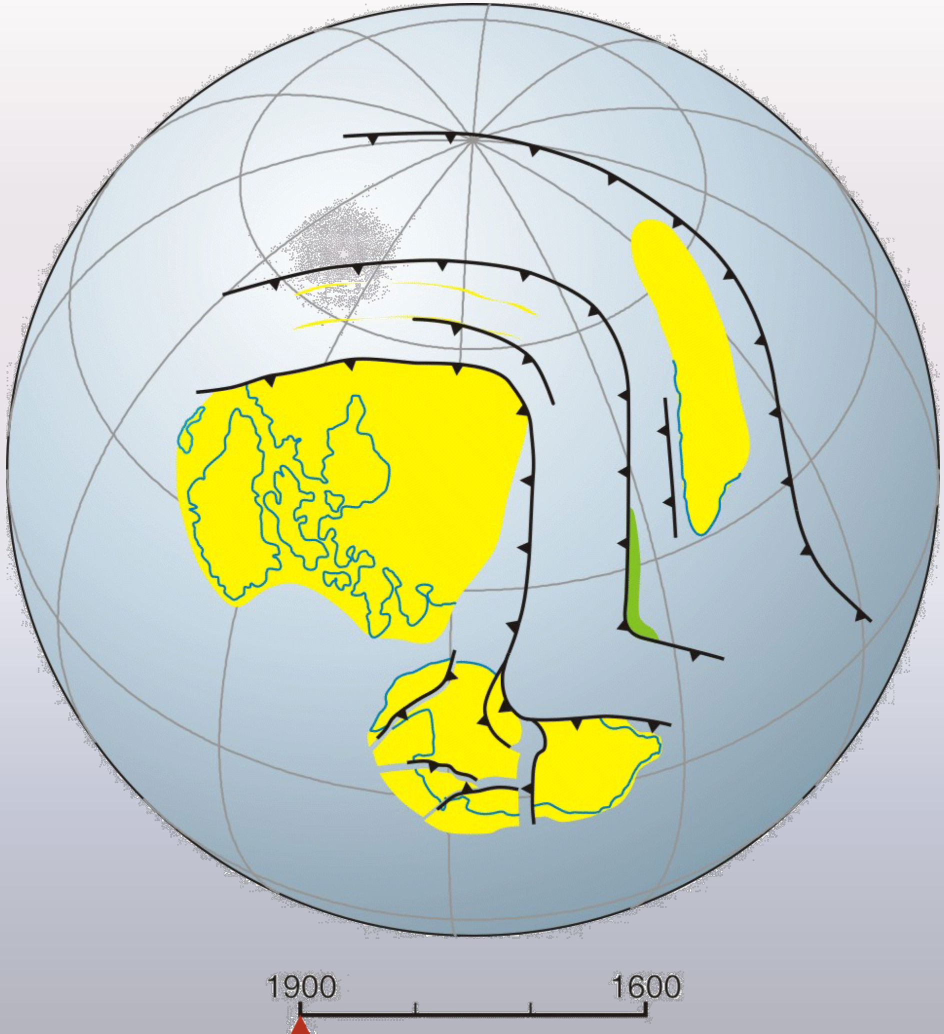


Tectonic reconstruction



- The Madura oceanic block is likely the basement which carried the Musgrave Province
- Under plating of the Madura oceanic block under the WAC formed the deep basement in the Rudall and Capricorn after c. 1450 Ma
- The Proterozoic AFO reflects the attenuated margin of the Archean Yilgarn Craton
- Archean blocks with sanukitoid magmas in this margin are fertile for gold mineralization

Tectonic reconstruction



- The Madura oceanic block is likely the basement which carried the Musgrave Province
- Under plating of the Madura oceanic block under the WAC formed the deep basement in the Rudall and Capricorn after c. 1450 Ma
- The Proterozoic AFO reflects the attenuated margin of the Archean Yilgarn Craton
- Archean blocks with sanukitoid magmas in this margin are fertile for gold mineralization