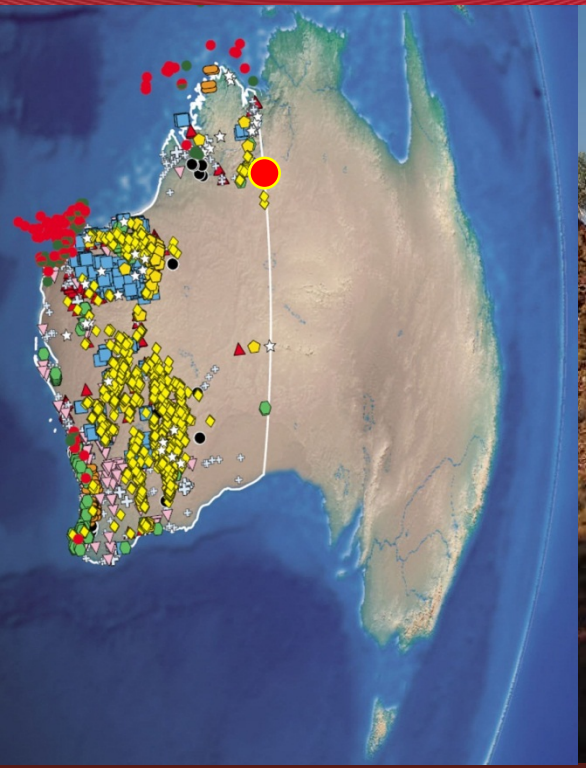
Government of **Western Australia**
Department of **Mines and Petroleum**



ALTERATION AND AGE OF THE BROWNS RANGE RARE-EARTH ELEMENT DEPOSITS

Morin-Ka, S, Beardsmore, TJ, Hancock, EA, Rasmussen, B, Dunkley, D, Muhling, J, Zi, J, Wilson, R and Chapman, J

GSWA Open Day

26 February 2016

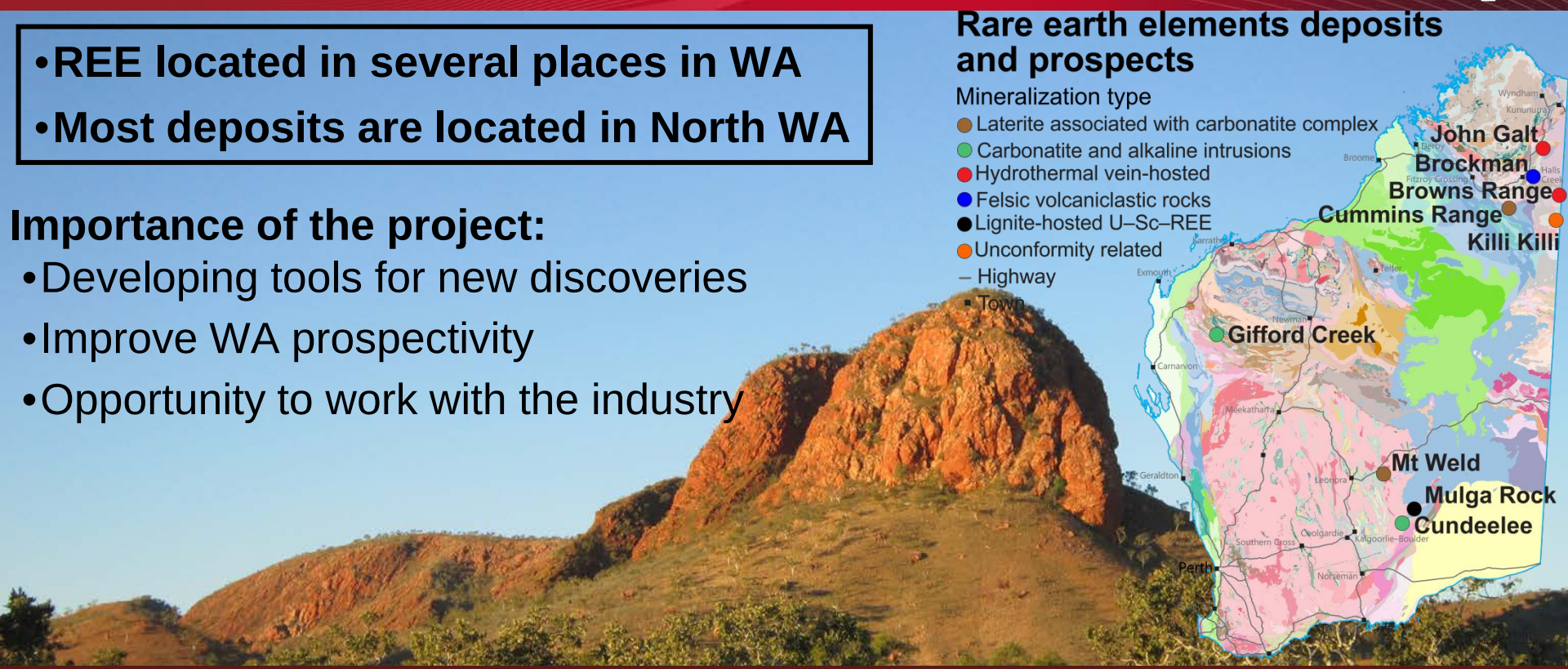
Geological Survey of Western Australia

Rare Earth Elements in WA

- **REE located in several places in WA**
- **Most deposits are located in North WA**

Importance of the project:

- Developing tools for new discoveries
- Improve WA prospectivity
- Opportunity to work with the industry



Rare Earth Opportunities

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	39
La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Y
138.91	140.12	140.91	144.24	(145)	150.36	151.96	157.25	158.93	162.50	164.93	167.26	168.93	173.04	174.97	88.906

LREE

HREE

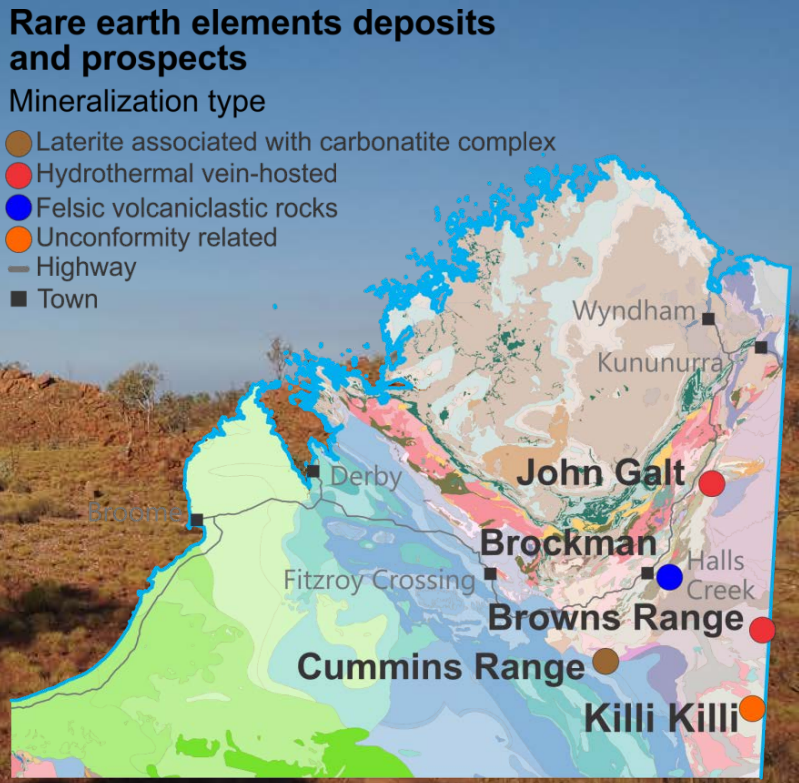
- Not all REE are equal (abundance, value)
- Light-REE are relatively common and lower value
- Heavy-REE are rarer, higher value

- REE are widely used in high tech / “green tech”
- China is the only HREE producer

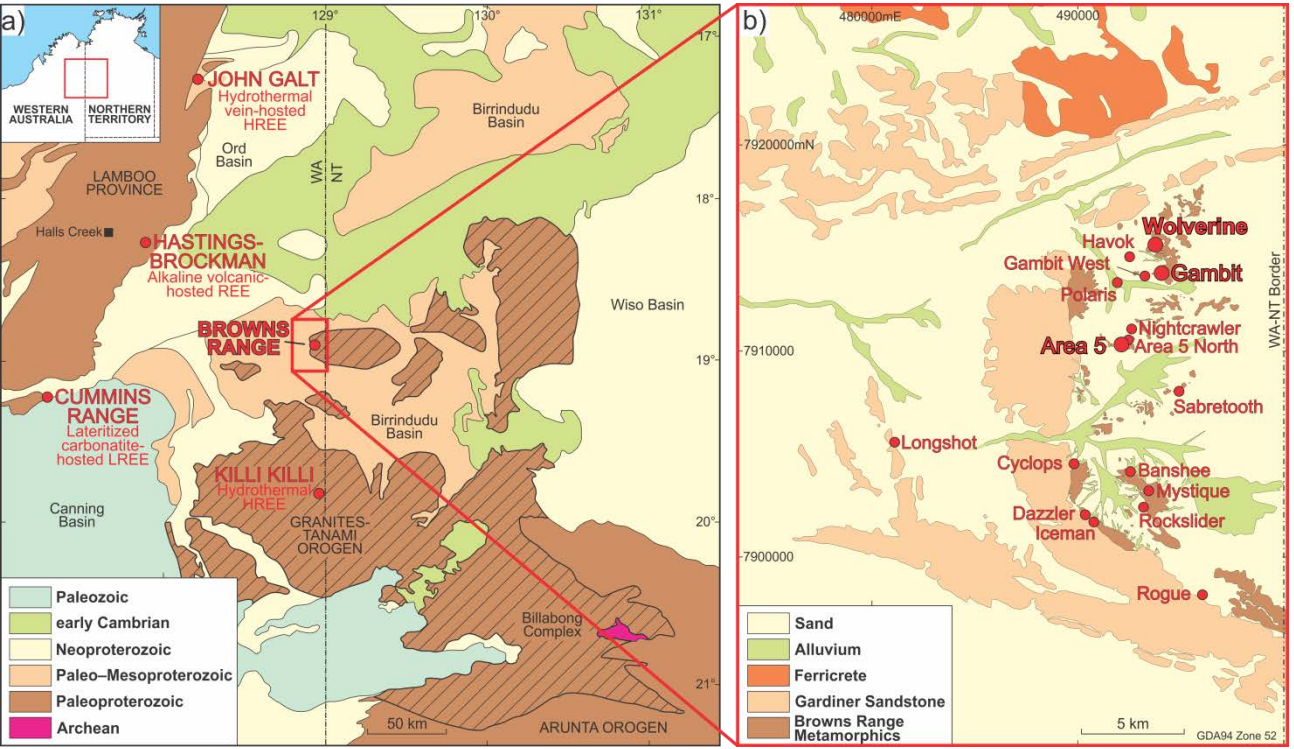
An emerging REE Province

- Northern WA is an emerging REE province
- Several HREE deposits: (*John Galt, Browns Range, Brockman, Killi Killi*)
- Also LREE potential *(Cummins Range)*

- Northern Minerals interested in detectable alteration footprint
- GSWA offered research collaboration to:
  - *Improve understanding of REE origin*
  - *Enhance REE prospectivity in North WA*



Location and …



- North Australian Craton, Tanami Orogen
- West end of dome on WA-NT border
- Several HREE deposits
- Principal resource is **Wolverine**…
- …Gambit, Area 5 and many other prospects

a) Map of Tanami-East Kimberley REE deposits; b) Map of the Browns Range deposits

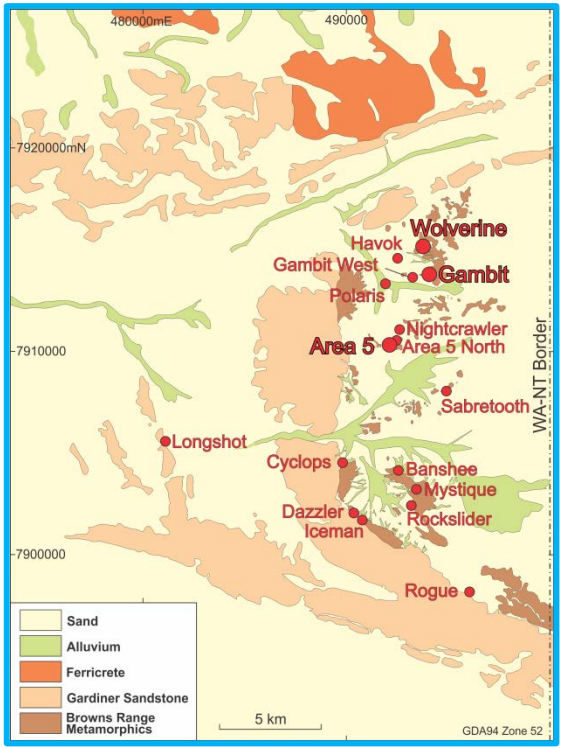
…and setting

TANAMI COMPLEX

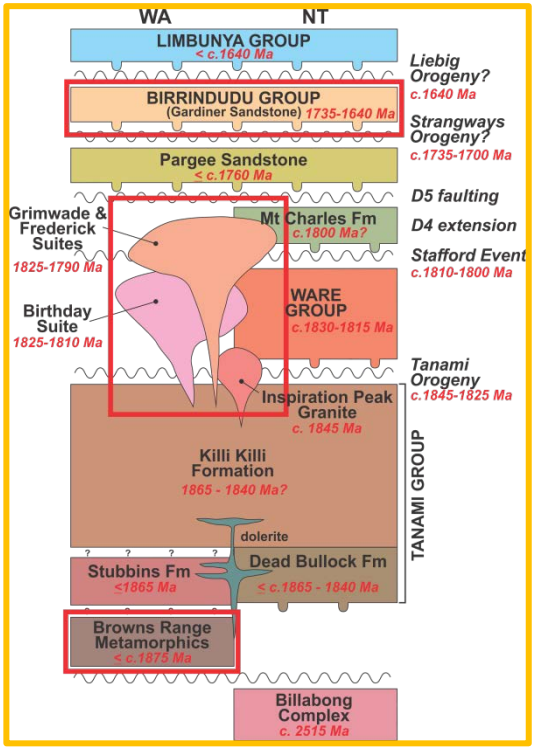
- Palaeo-Mesoproterozoic
- Clastic sediments, volcanic rocks, syn-tectonic granitoids

- Browns Range Metamorphics (“meta-arkose”)
- Overlain by siliciclastic Gardiner Sandstone

- Stratigraphy and REE ages poorly constrained
- Related to the granites?



Map of the Browns Range deposits



Stratigraphic column of Tanami region

Research program

- **Confirm nature and distribution of hydrothermal alteration**
- **Determine age of mineralization**

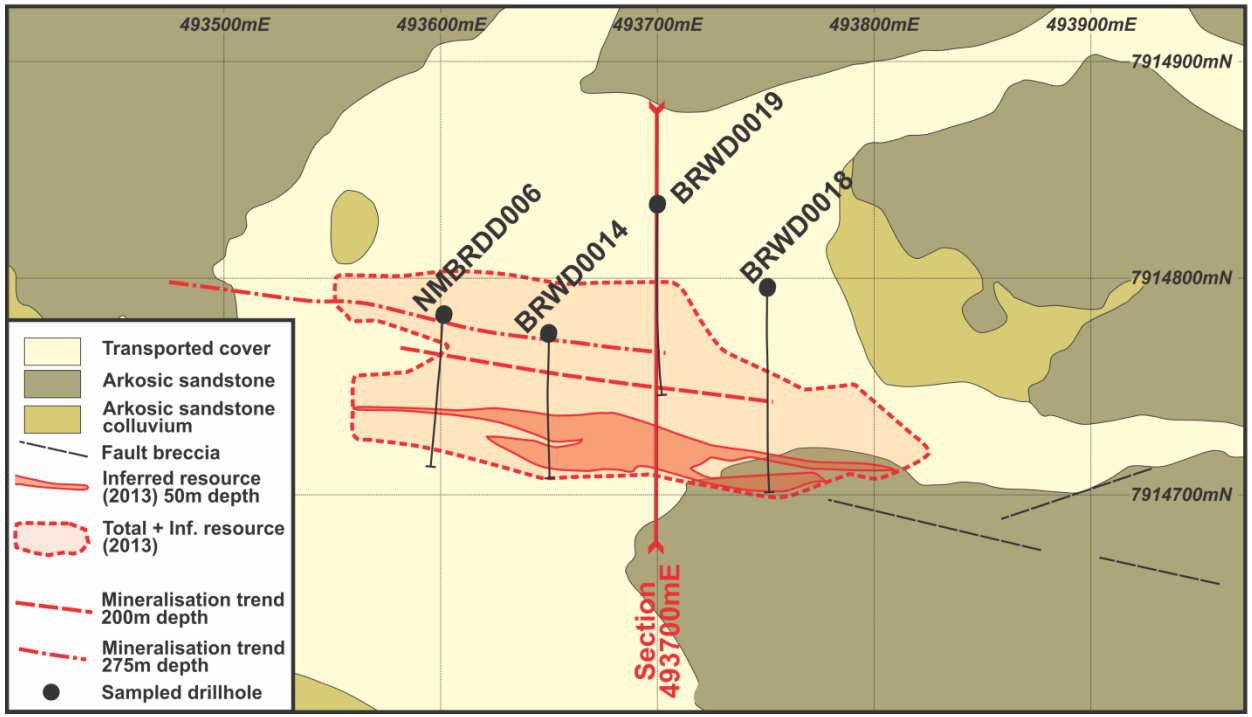
Sampling and data collected:

- Petrography [40 samples] → identify rock type, alteration
- Phosphate geochronology [19 samples] (SHRIMP, U-Pb)
- Hyperspectral scans of core [6 drill cores]
- Company drill assay geochemical data

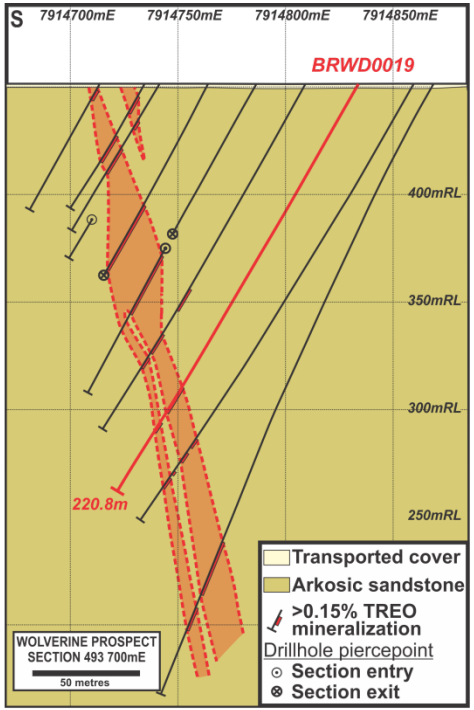
Prospect	# of drill-cores
Wolverine	4
Gambit	1
Area 5	1

Wolverine

Quartz breccia & vein array



Map view of the Wolverine deposit



Cross-Section

(modified after Northern Minerals 2013 ASX releases)

Petrography

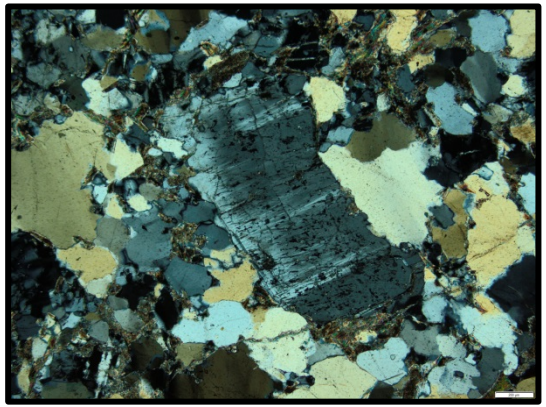
Host rock: feldspathic lith-arenite to lithic arkose

Outcrop

Drill core

&

Thin-section



Feldspar surrounded by quartz
TL-XPL 50x

Massive to crudely graded, thick bedded, Local pebbly conglomerates units

Petrography

Mineralization: Quartz breccia & xenotime

Outcrop

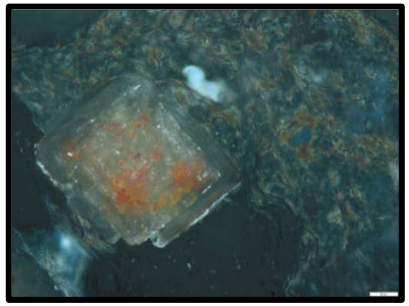
Drill core

BRWD0019

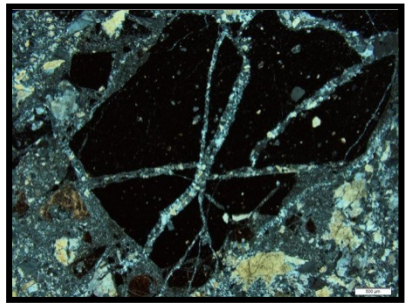
&

BRGD001

Thin-section



Xenotime crystal
TL-XPL X500



Brecciated xenotime
TL-XPL X25

Open-fill and disseminated Xenotime with hematite dusting

Petrography

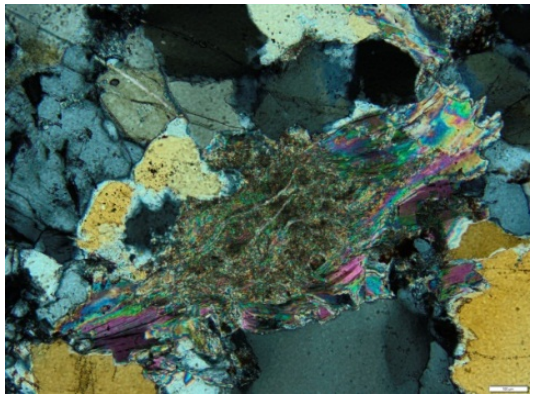
Alteration: Clays, Quartz ± Mica

Outcrop

Drill core

&

Thin-section



Lithic fragment being sericitized
TL-XPL 100x

Feldspars adjacent to mineralized zone are replaced by sericite and clays

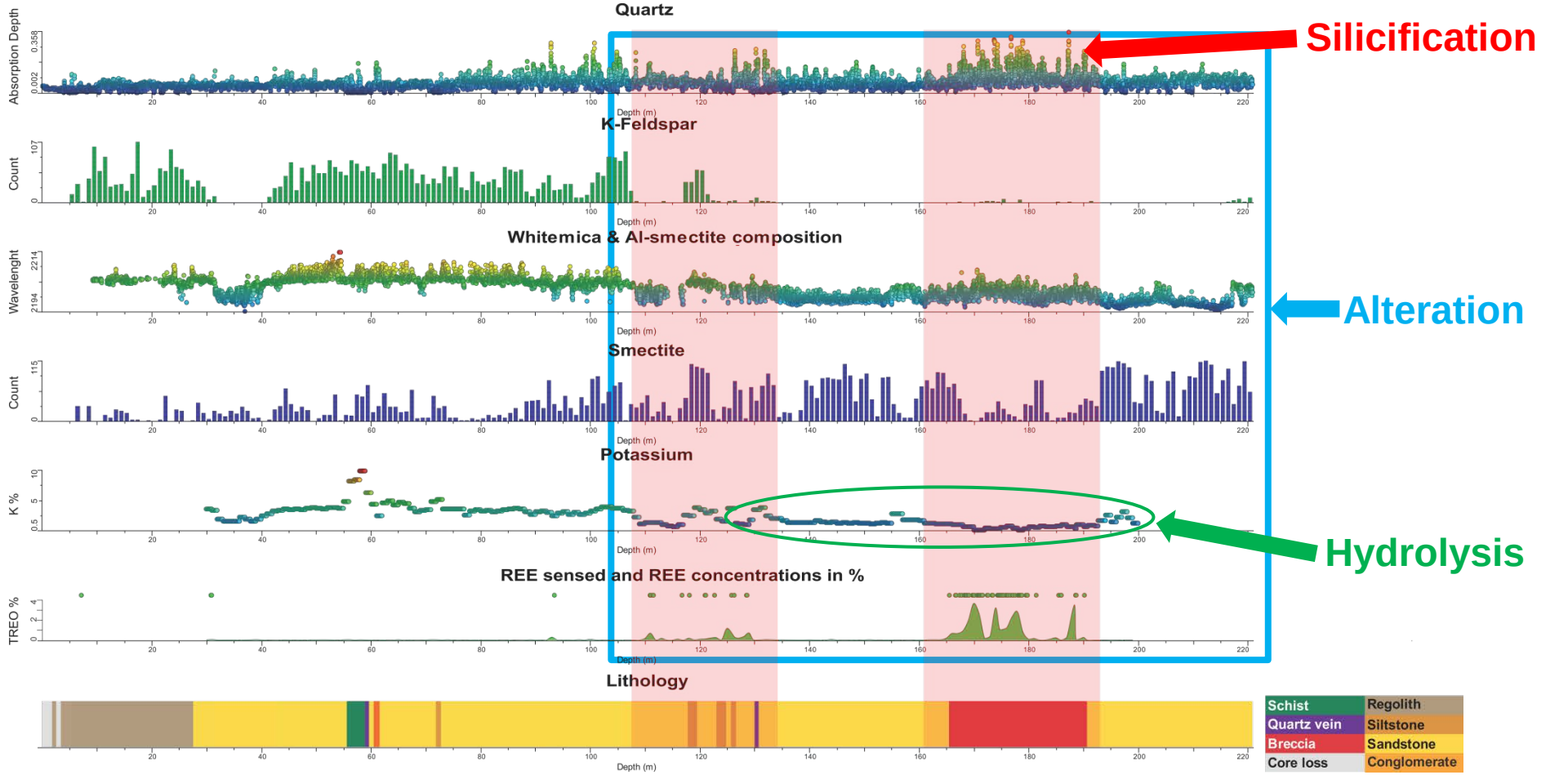
HyLogger

- Most **minerals** & **alteration cannot** be distinguished by **naked eye**
- Define distribution of **REE** and associated **alteration**
- More **objective** mineral ID and chemistry
- Define significant **trends** and **variations**

HyLogger Setup

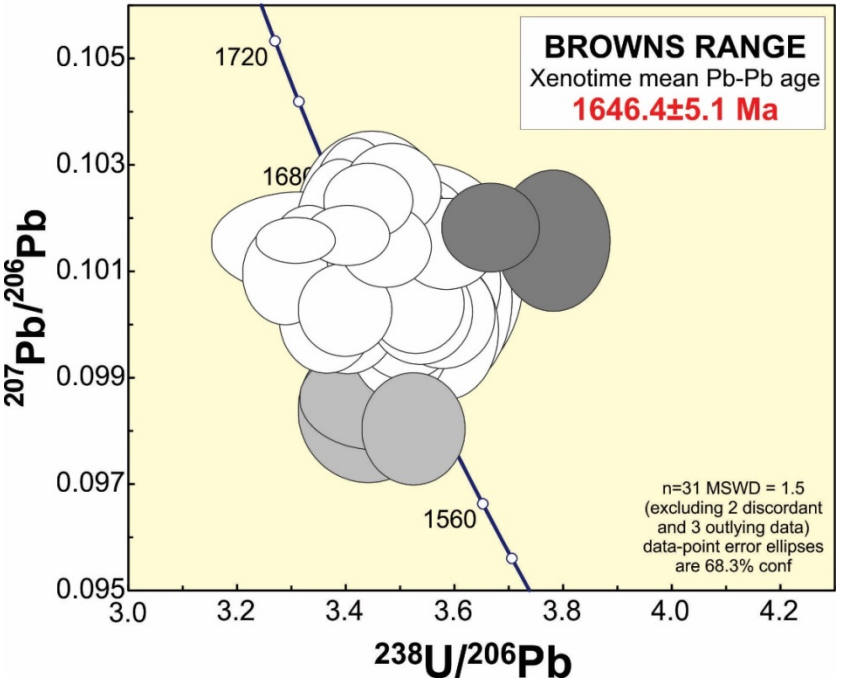
HyLogger downhole plots

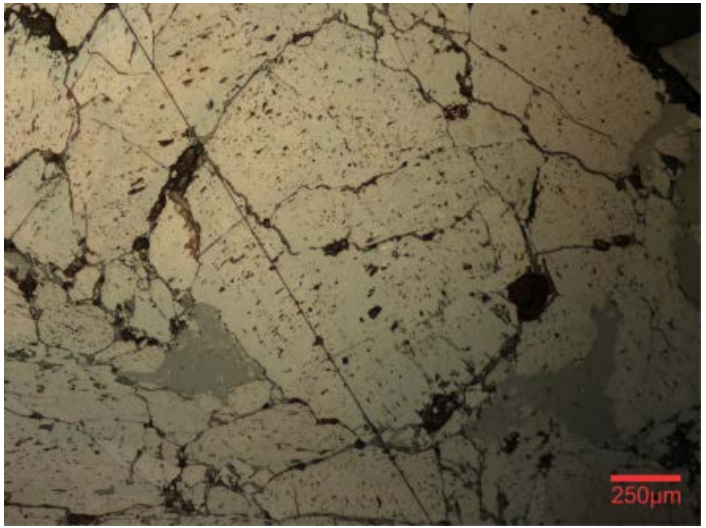
Wolverine BRWD0019



Age of REE mineralization

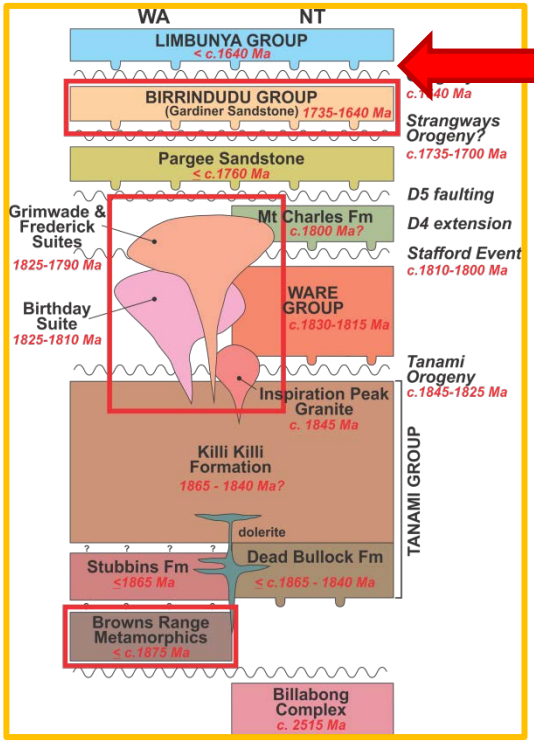
Xenotime [YPO_4] SHRIMP U-Pb age well-constrained **1646 ± 5 Ma**





Xenotime crystals

Local implications



Stratigraphic column of Tanami region

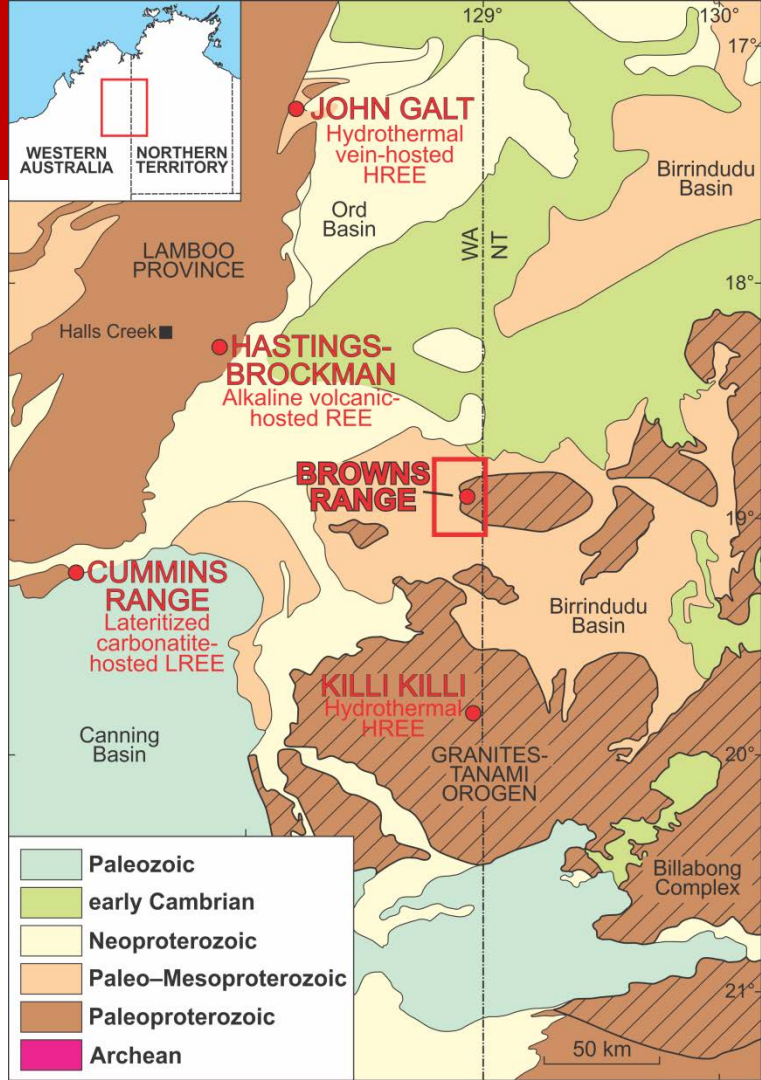
1646 ± 5 Ma

- Mineralization **younger** than cover rocks
- Granites **much older** than mineralization
- **Silica-Clay ± Mica alteration** possibly provides a large footprint
- "**Alteration exhaust plume**" could be **detectable** using spectral techniques

Regional implications

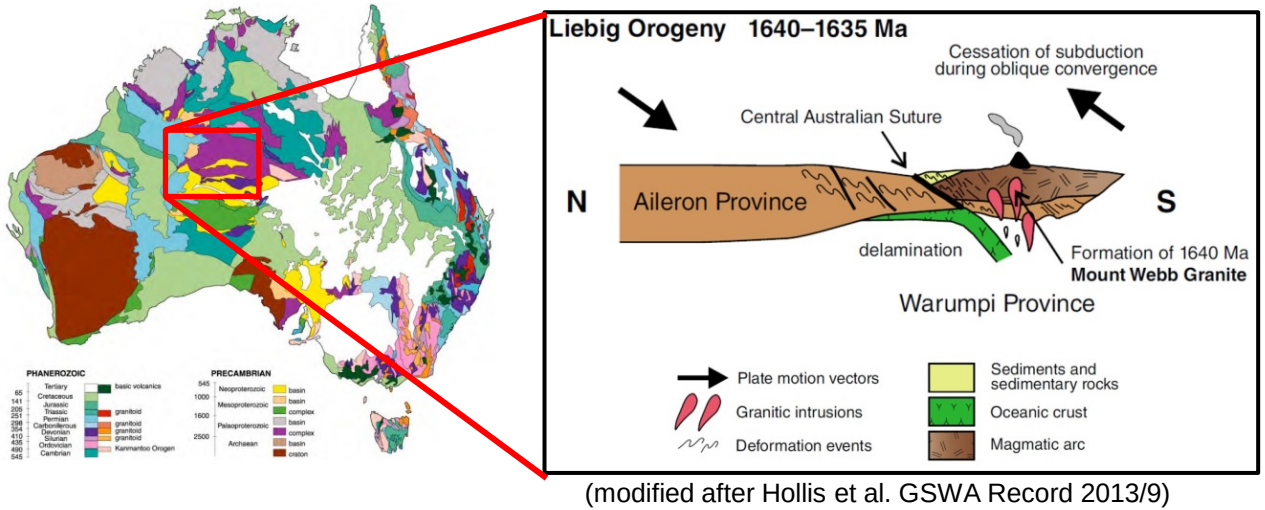
- Several **similar deposits** in region:
- **Similar** xenotime U-Pb **ages**
- Broadly **similar age** to **NT** unconformity-related **U**
- Suggests **widespread event** (?)
- **Increased** (H)REE **prospectivity** for Northern Australian Craton

Deposit	Type	Xenotime (U-Pb Age)	Citation
Browns Range	Hydrothermal	1646 ± 5Ma	GSWA, in prep.
John Galt	“Epithermal”	1619 ± 9Ma	GSWA, in prep.
Killi Killi	“Diagenetic”	1632 ± 3Ma	Vallini et al. (2007) Min Dep v42 p51-64



Where does the fluid comes from?

No known local driver for REE mineralization



(modified after Hollis et al. GSWA Record 2013/9)

? Related to accretion of Warumpi Terrane to southern Arunta during Liebig Orogeny ?

Conclusions

- **REE** in hydrothermal breccias and vein arrays
- **Silica-Clay ± Mica** alteration
- Large alteration footprint

- Mineralization younger than cover rocks
- HyLogger detects **REE** and **alteration**
- Potentially detectable through cover rocks

- Widespread **REE** (±U?) “event”
- North Australia Craton prospective for (**H**)**REE**