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Isotopes and geochronology: Mapping domains, fertility and mineral systems at orogen, region, and district scales

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[1]Geoscience Australia, [2]Curtin University.

GA eCat ID: 146400

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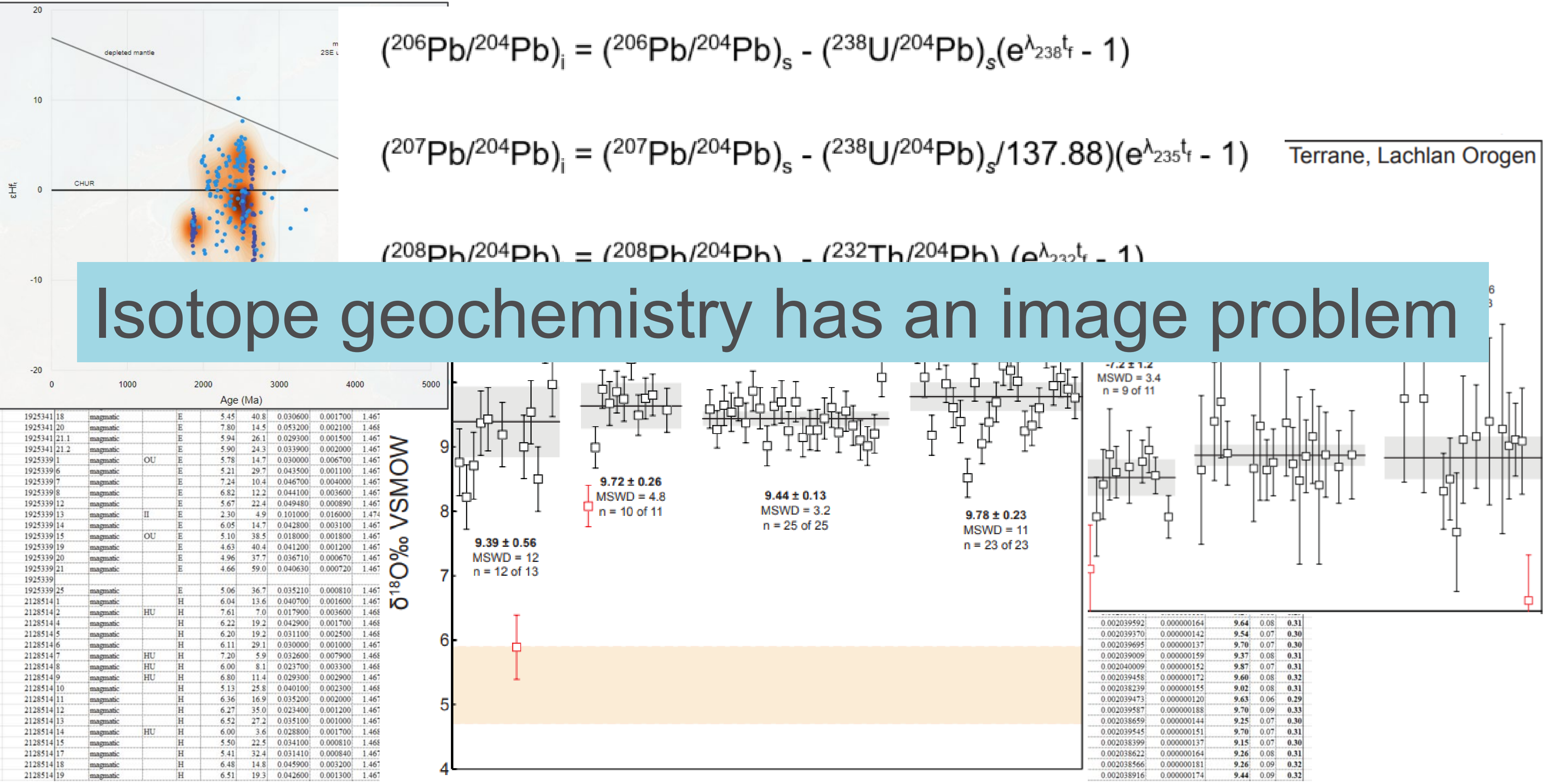

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Radiogenic Isotope Geochemistry 101

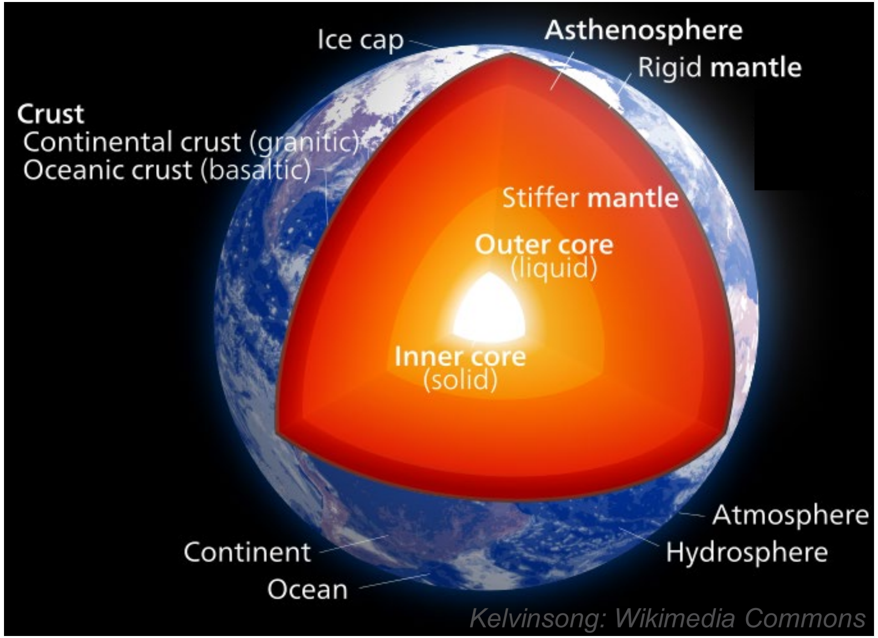
Applies isotopes to understanding development of chemical reservoirs and their interactions *through time*

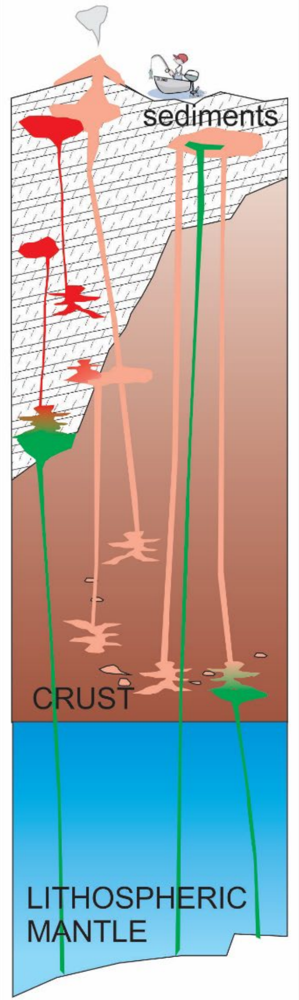
Examples:

⇒ Formation of the crust

⇒ Addition of new material from mantle to crust

⇒ Origin of fluids that generate ore deposits





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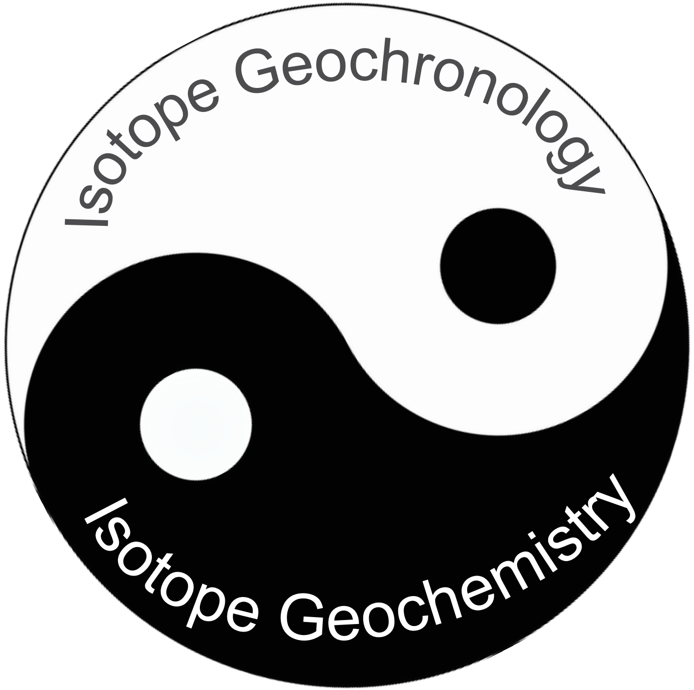
(Radiogenic) Geochronology & Isotope Geochemistry: two sides of the same coin

- Often measure the same isotopes, on the same equipment
- Geochronology – radiogenic isotopes give the age
- Isotope geochemistry – time-calibrated geochemical (isotopic) data
- eg. U-Pb geochronology and Pb-Pb isotope geochemistry use the same isotopes – but applied in different ways



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So what?

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Exploration challenges

- Deposits are hard to find, particularly as we explore under cover
- Geophysics = backbone of exploration (but snapshot of modern-day)
- We need a diversity of tools and approaches

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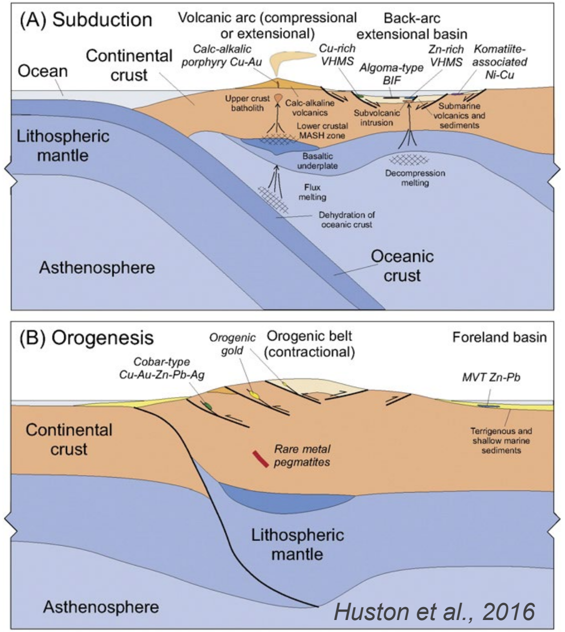
Radiogenic Isotopes Applied to Mineral Prospectivity

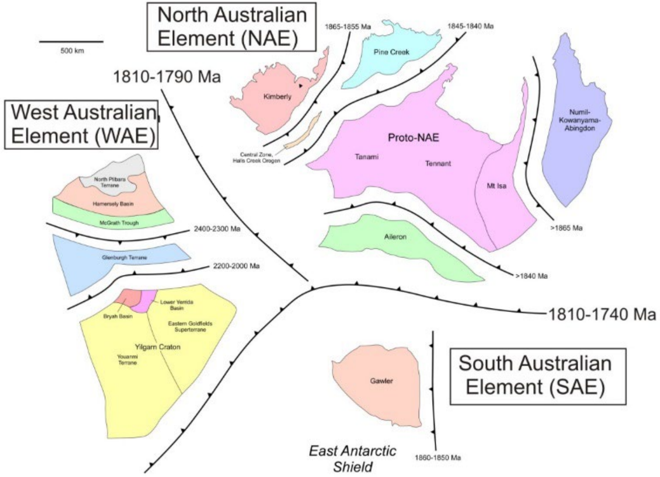
<u>Empirical</u> ← - - - - - - - - - - - - - - - - → <u>Conceptual</u>

- determine age of known deposits
- look for more in similar aged rocks

- understand favourable tectonic "ingredients"
- reconstruct past tectonic history
- predict favourable time and place for undiscovered deposits



Huston et al., 2016



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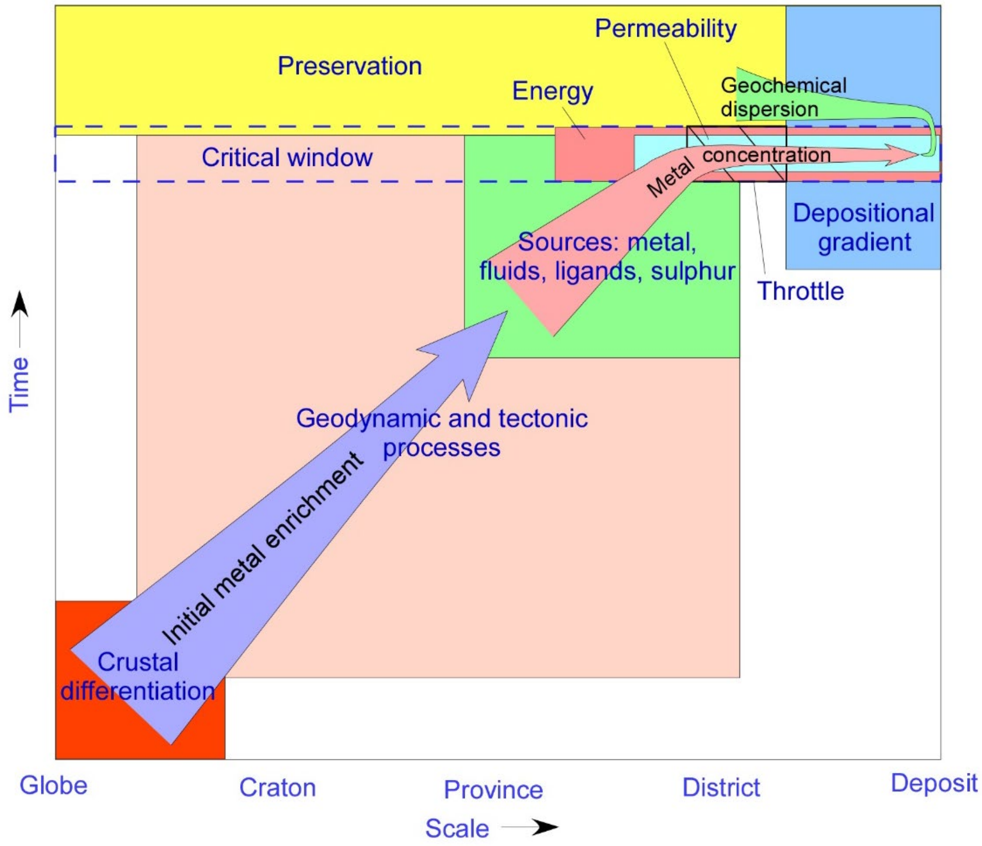
Why should you care?

- Mineral deposits are formed by processes operating over various spatial scales and timeframes
- Isotopes can help at most of these scales



Hagemann et al 2016
doi: 10.1016/j.oregeorev.2015.12.012

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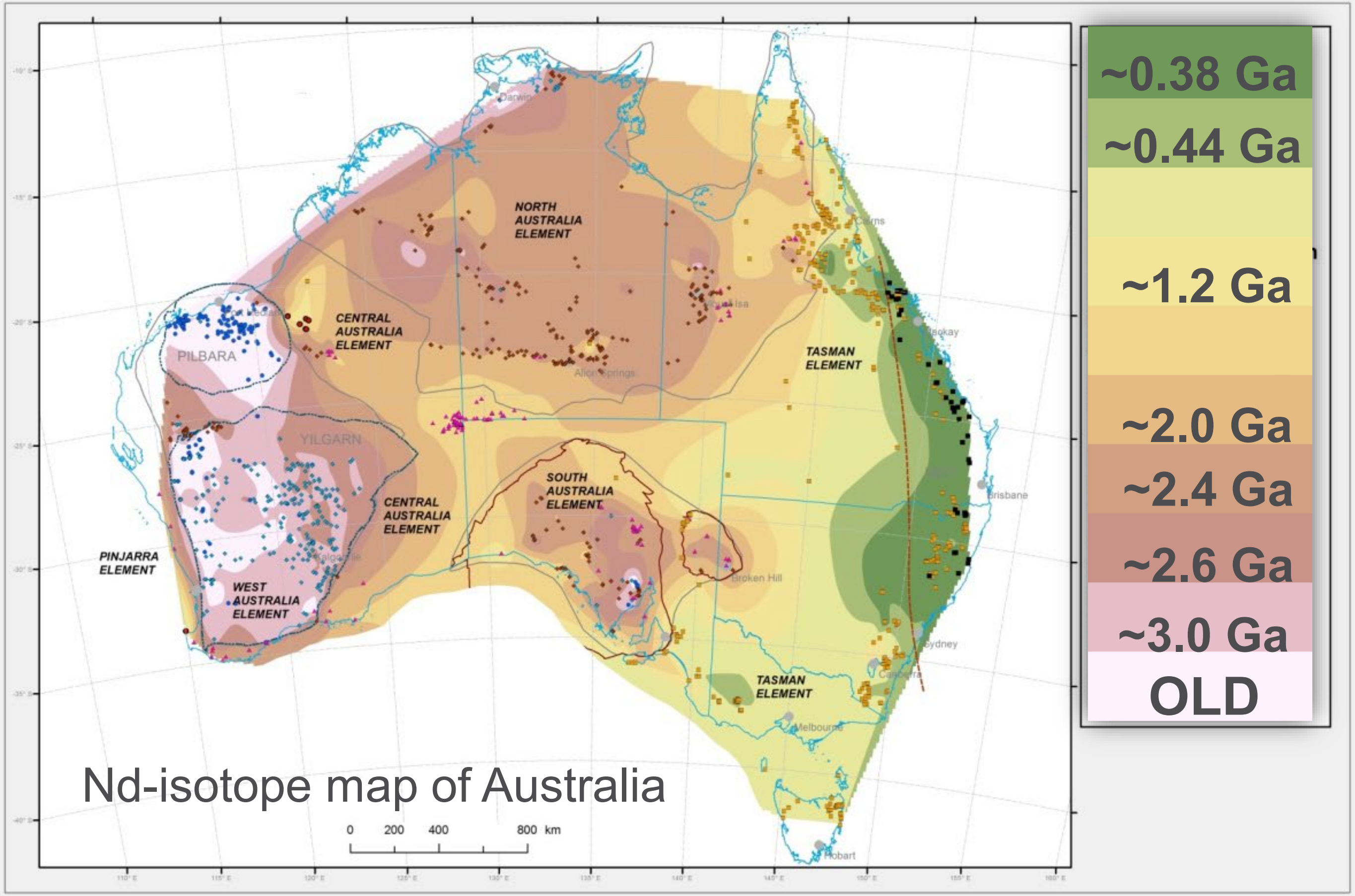
Craton-scale: Nd-isotopes



Champion 2013. doi: 10.11636/Record.2013.044

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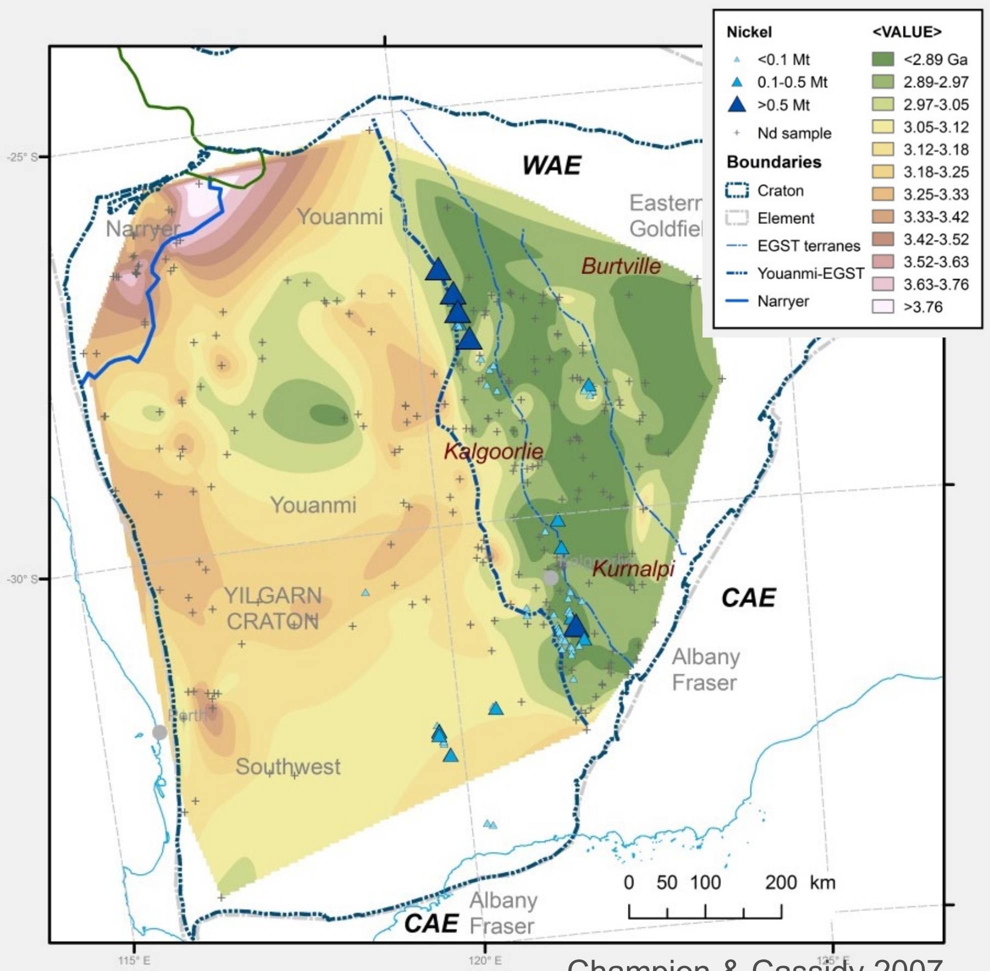
Nickel mineralisation

- Ni deposits in Kalgoorlie Terrane, Yilgarn Craton in Western Australia
- hosted in rocks from the mantle (komatiites) (Barnes & Fiorentini, 2010)
- Map: age of lower crust from Sm-Nd isotope analyses on granites: old in the west, younger in the east
- Ni deposits align with isotopic boundary
- Understand why deposits develop
- Predict location of undiscovered deposits



Champion & Cassidy 2007

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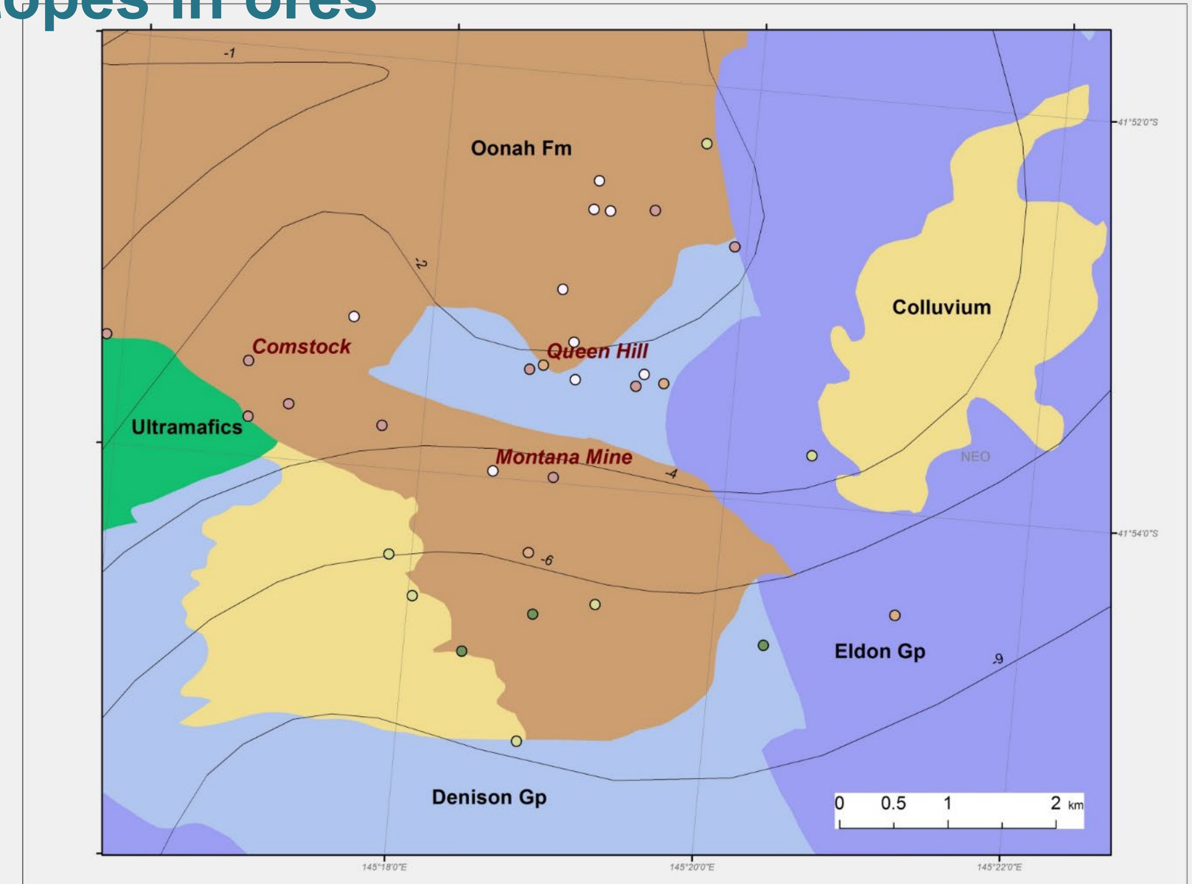
Deposit-scale: Pb-isotopes in ores

Zeehan field, Tasmania: geology

- Historical silver mining
- Current tin exploration

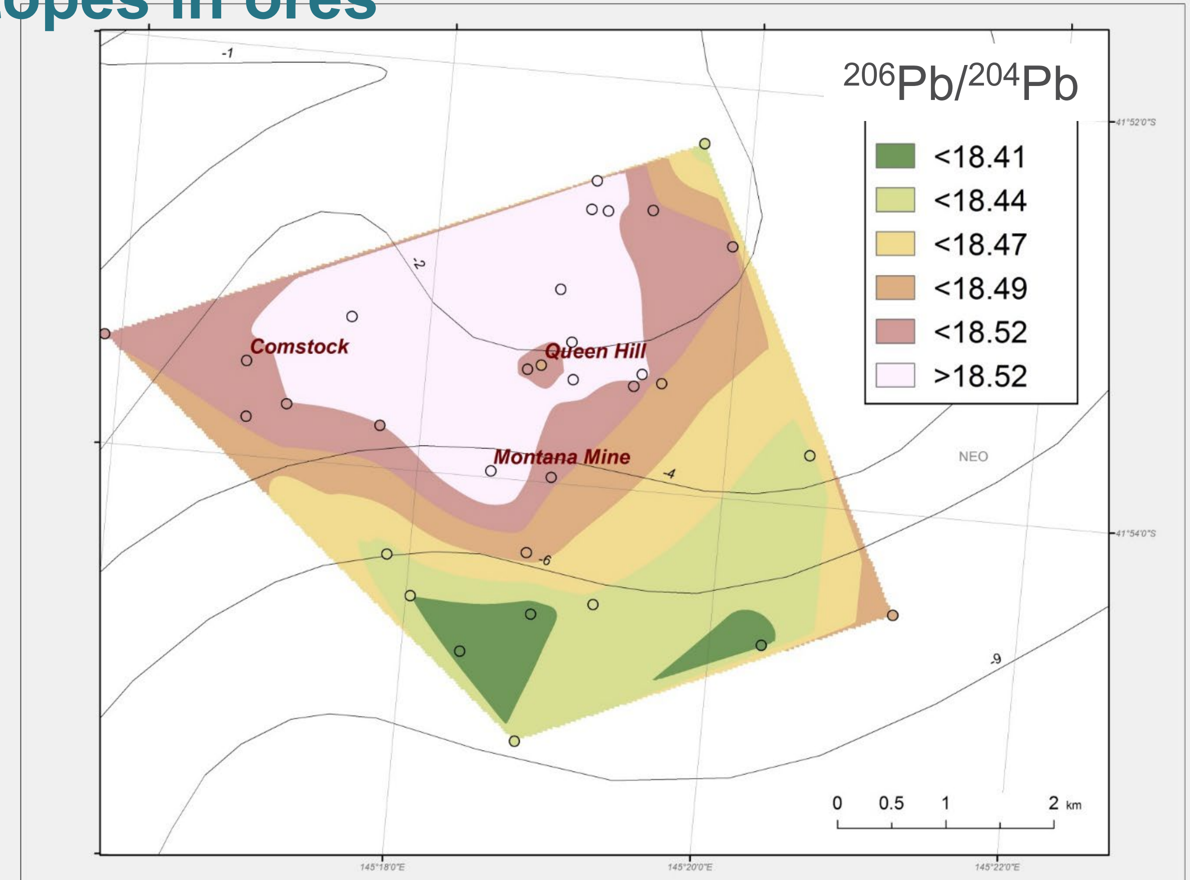


Huston et al 2017. DOI: 10.11636/Record.2017.009

Deposit-scale: Pb-isotopes in ores

Zeehan field, Tasmania: Pb-isotopes

- Spatial variations in Pb-isotopes correlate with location of buried Heemskirk Granite



Huston et al 2017. DOI: 10.11636/Record.2017.009

Problems with isotopes in exploration & mining

- Data is hard to access
- High bar for non-experts
- Needs baseline datasets for context
- Not enough discovery examples (relative to potential)

What's the plan?

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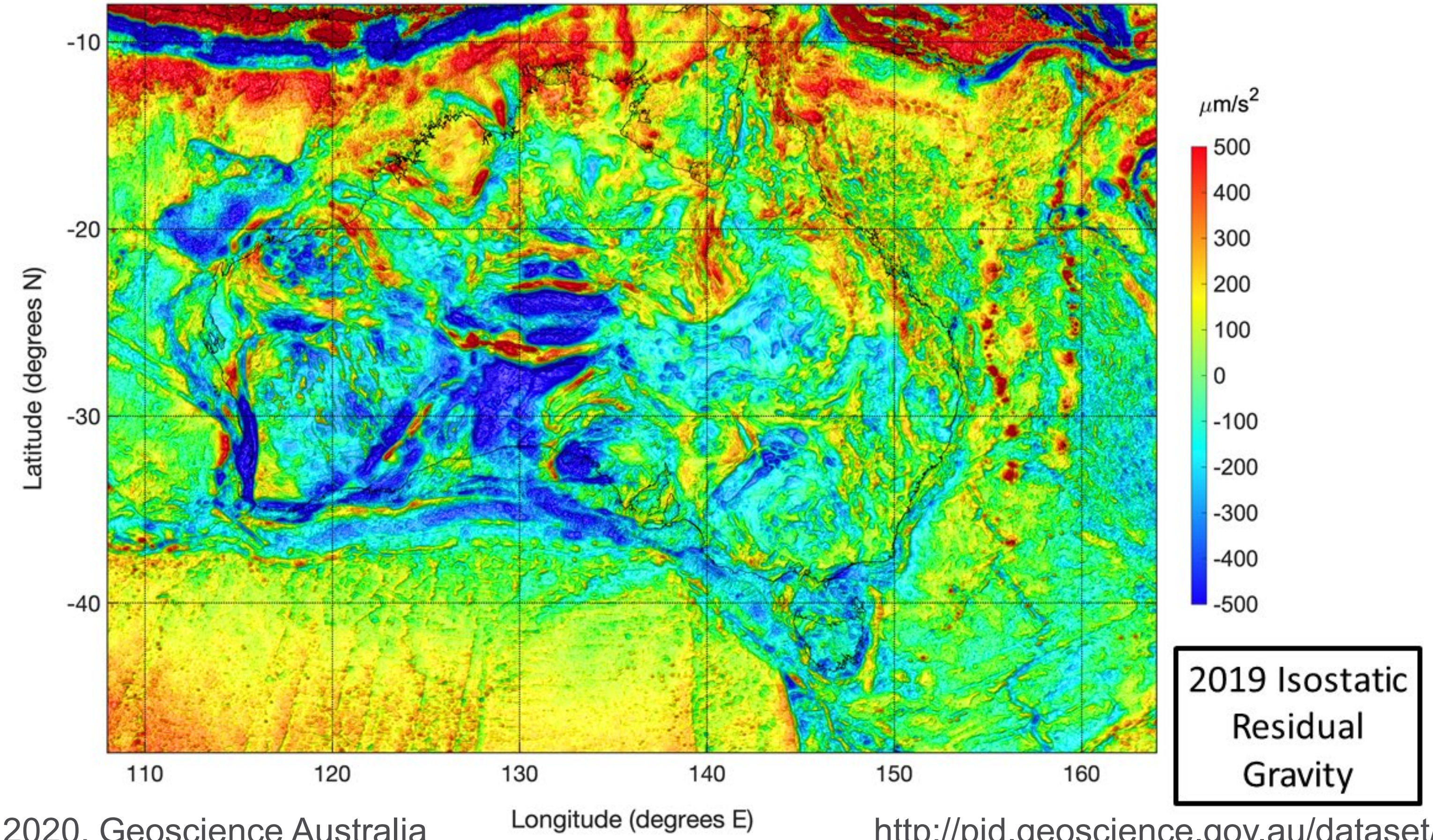
Geophysics – converting data to maps



Lane et al 2020, Geoscience Australia

http://pid.geoscience.gov.au/dataset/ga/144414

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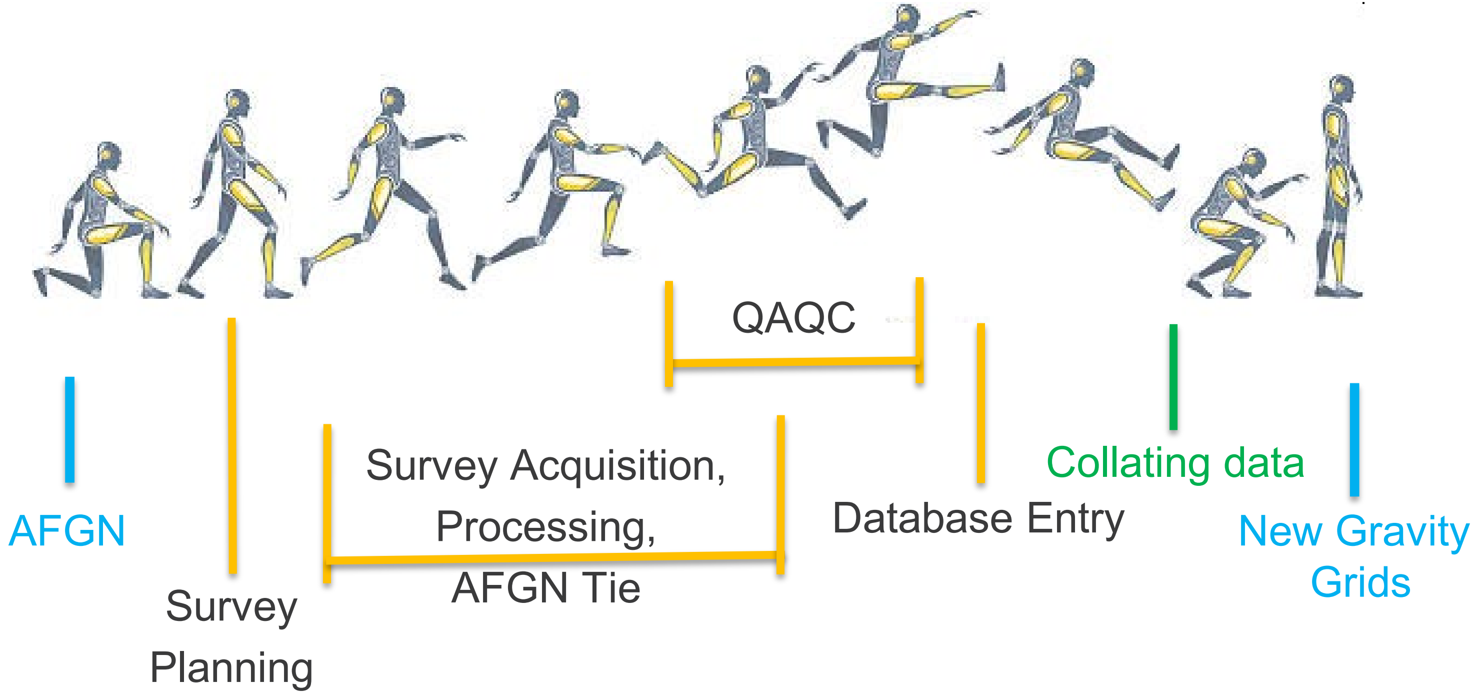
Example geophysics workflow:
Australian Fundamental Gravity Network (AFGN)



Creating accessible geoscience data is complex – but it can be done

Slide courtesy Phillip Wynne (GA)

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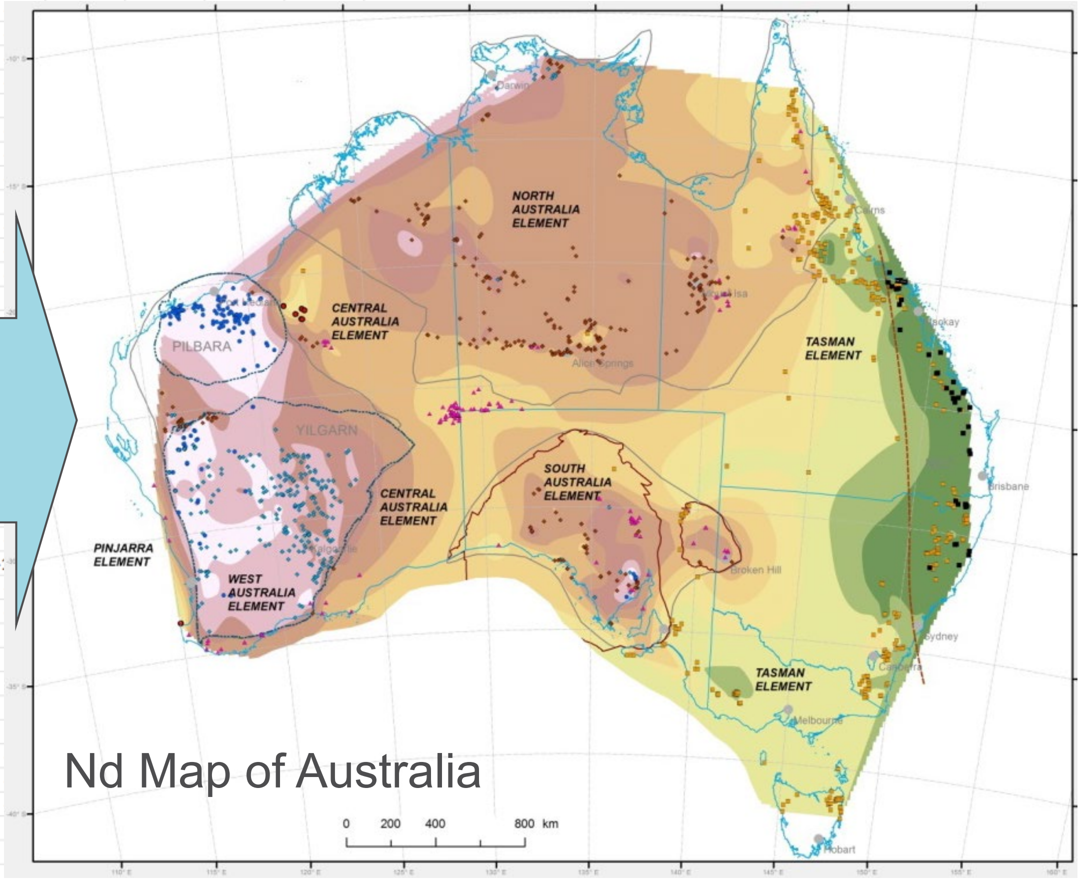
Isotope Geochemistry – converting data to maps

Sm_ppm	Nd_ppm	Sm147Nd1	Nd143_14	Err143_14	Std_nNd1	Std_LaJol	Std_BCR1	Isot_Comr	Nd143_14	Eps_Nd	Eps_Err	TDM	TDM_Err	T2DM
2.52	10.24	0.1488	0.512143	20	0	0.51186	0.512638	University	0.512155					
1.29	7.1	0.11	0.511491	30	0	0.511836	0	low value	0.511527					
8.03	43.17	0.1124	0.511457	20	0	0.51186	0	University	0.511469					
5.851	30.182	0.117	0.511538	20	0	0.51186	0		0.51155					
16.413	88.3	0.112	0.51151	20	0	0.51186	0		0.511522					
5.973	27.8	0.13	0.511663	20	0	0.51186	0		0.511675					
11.006	70.046	0.095	0.511346	20	0	0.51186	0		0.511358					
3.378	14.534	0.14	0.51187	20	0	0.51186	0		0.511882					
3.478	11.817	0.178	0.512428	20	0	0.51186	0		0.51244					
3.9	21.7	0.1083	0.51071	20	0	0	0	corrected	0.511525					
12	60	0.1205	0.51074	20	0	0	0	corrected	0.511555					
5.9	29.4	0.122	0.51123	5	0	0	0.512638	assumed t	0.511245					
8.6	49.4	0.1047	0.51113	30	0	0	0.512638	assumed t	0.511145					
2	14.3	0.0841	0.5112	10	0	0.511845	0	University	0.51122					
6.6	41.3	0.096	0.51077	7	0	0	0.512638	assumed t	0.51078					
3.8	24	0.098	0.51082	1	0	0	0.512638	assumed t	0.51083					
6.2	35.6	0.1	0.51096	30	0	0	0.512638	assumed t	0.51097					
7.9	41.3	0.12	0.51123	30	0	0	0.512638	assumed t	0.51124					
9.9	53.1	0.112	0.51106	8	0	0	0.512638	assumed t	0.51107					
6.5	31.1	0.1267	0.51136	30	0	0	0.512638	assumed t	0.51137					
0	0	0.1899	0.51197	30	0	0.511842	0.512638	University	0.51198					
0	0	0.1591	0.512346	20	0	0.51186	0	University	0.51235					
0	0	0.1183	0.512262	20	0	0.51186	0	University	0.512274					
8.67	44.74	0.1172	0.511193	34	0	0	0	corrected	0.512008					
12	70.13	0.1034	0.511111	28	0	0	0	corrected	0.511926					
4.6	19.19	0.143572	0.512018	30	0	0.51186	0	no analyti	0.51203					
5.51	32.05	0.1039	0.512642	20	0	0.51186	0	La Trobe U	0.512654					
4.58	21.98	0.126	0.512948	20	0	0.51186	0	University	0.51296					
5.59	26.25	0.1289	0.512727	20	0	0.51186	0	La Trobe U	0.512739					
3.3	13.92	0.1432	0.512799	20	0	0.51186	0	La Trobe U	0.512811					
4.27	20.14	0.1281	0.512626	20	0	0.51186	0	La Trobe U	0.512638					
6.82	25.83	0.1596	0.512384	20	0	0.51186	0	University	0.512396					
5.95	23.18	0.1553	0.512289	20	0	0.51186	0	University	0.512301					
5.51	18.7	0.1784	0.512383	20	0	0.51186	0	University	0.512395					
2.615	14.79	0.10685	0.51128	6	0	0	0		0.51128					
7	43	0.098	0.510193	20	0	0	0.51263		0.510216					



Nd Map of Australia

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Problems with isotopes in exploration & mining

- Data is hard to access
- High bar for non-experts
- Needs baseline datasets for context
- Not enough discovery examples (relative to potential)

Part I: increase access to data & knowledge

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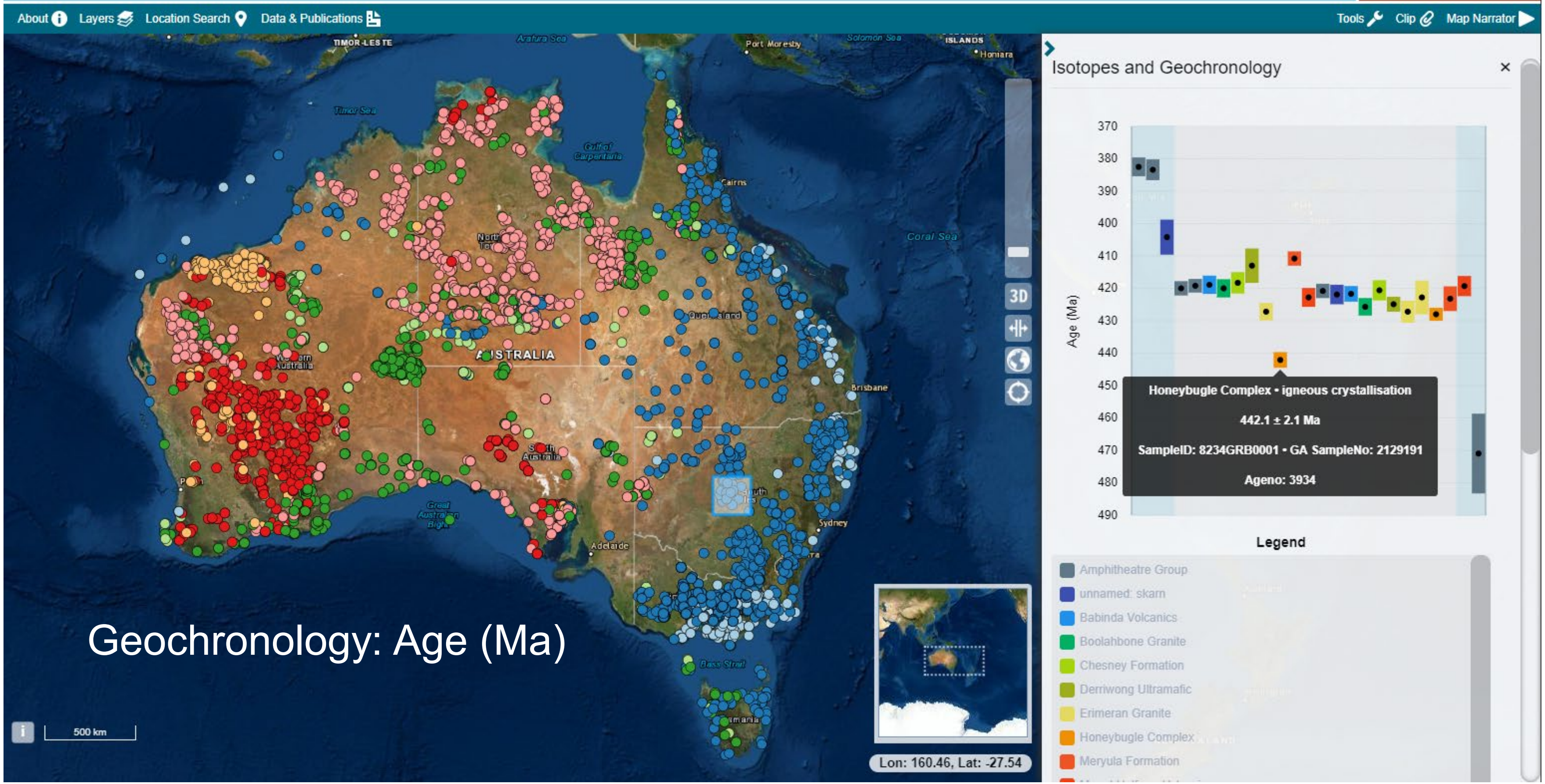
Geochronology and Isotopes Data Portal

portal.ga.gov.au/persona/geochronology



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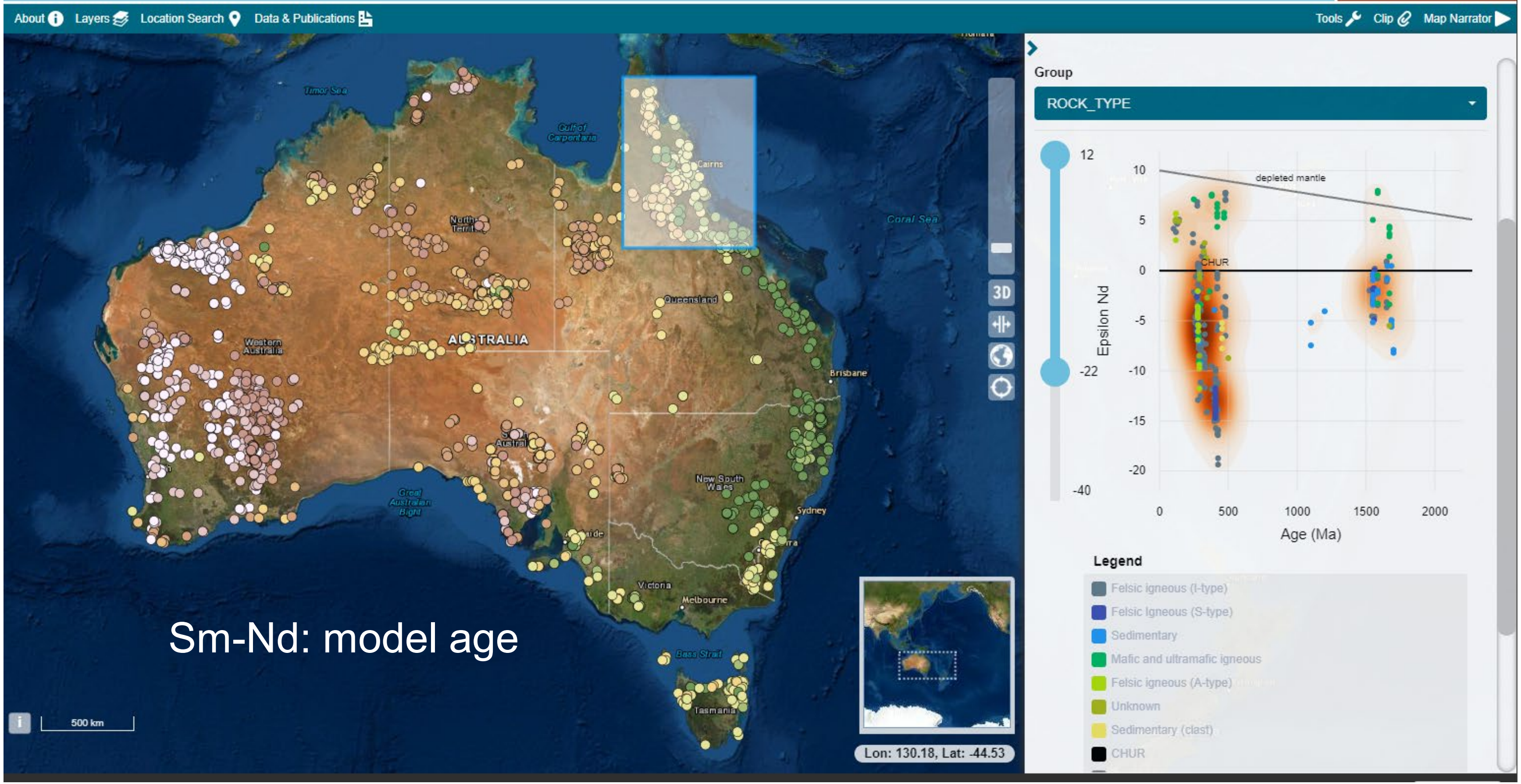

Sm-Nd: model age

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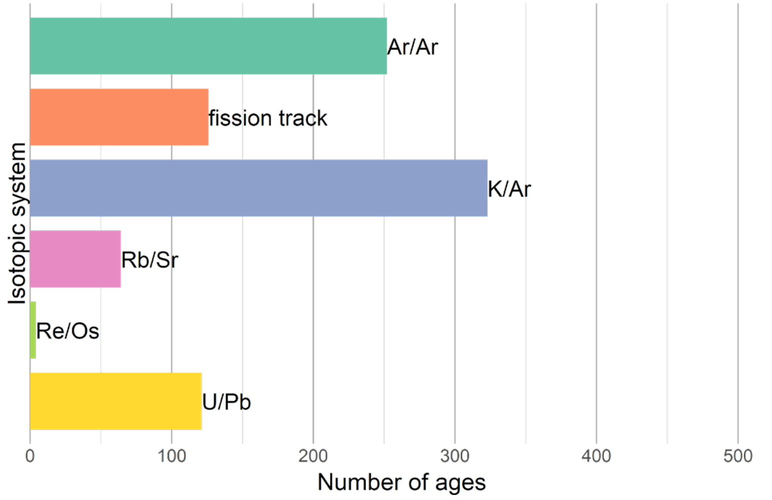
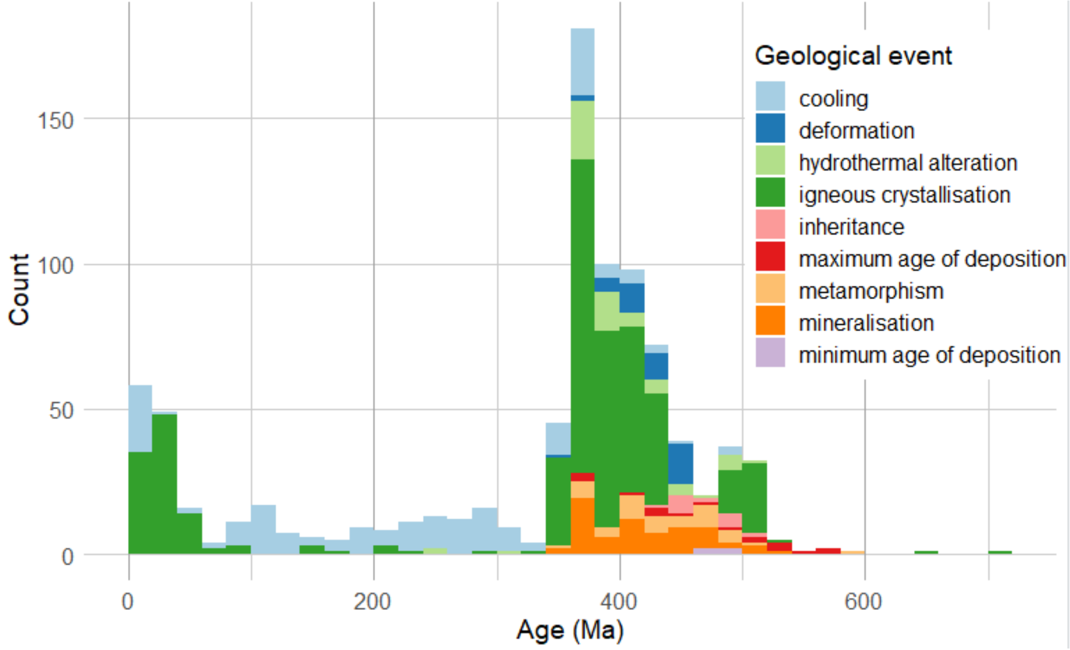
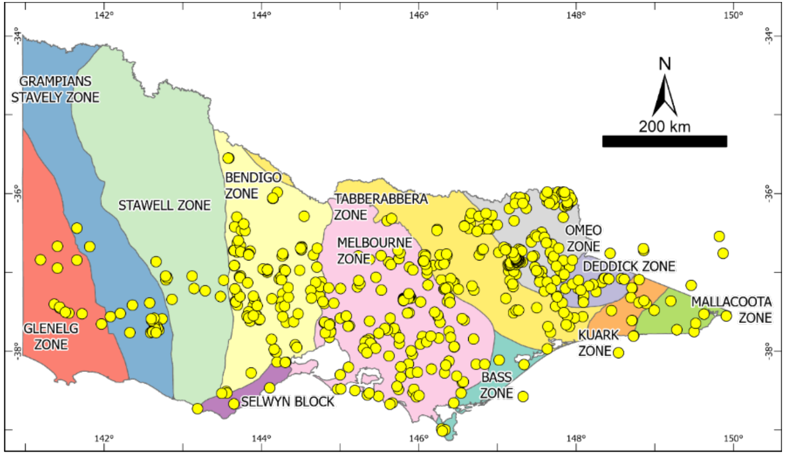
New GA-GSV geochronology compilation for Victoria

Available via portal.ga.gov.au &
doi: 10.11636/Record.2021.024







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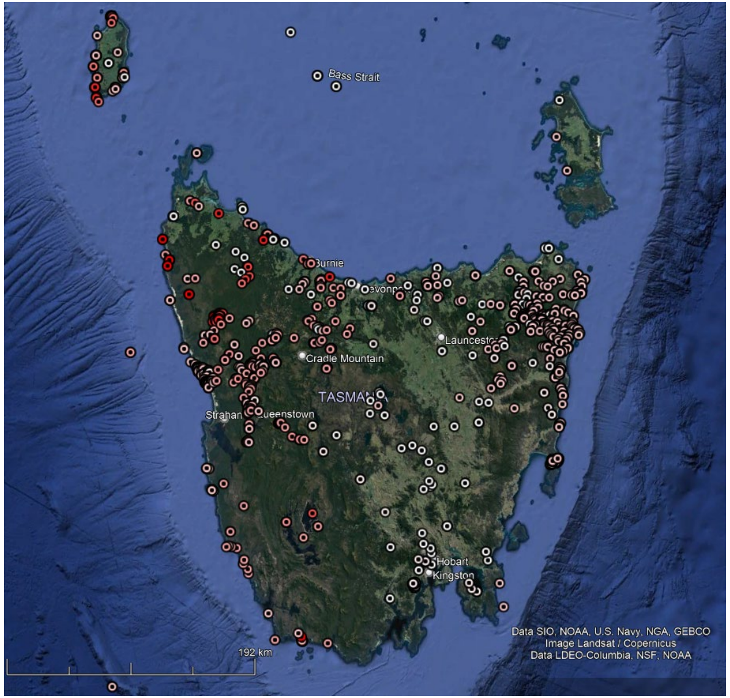
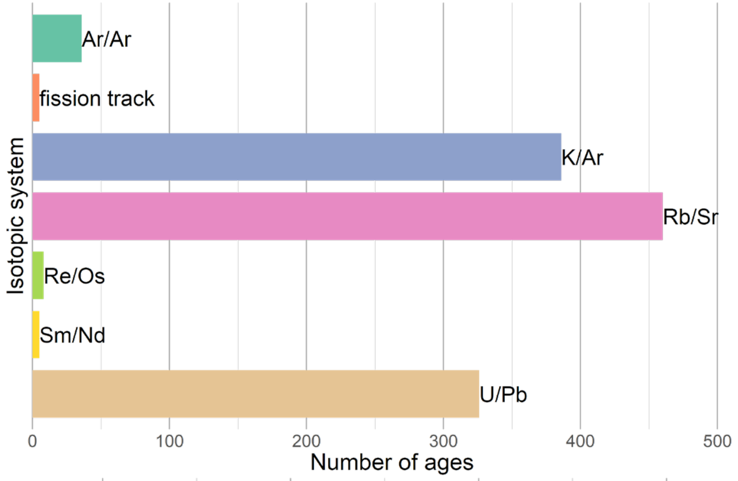
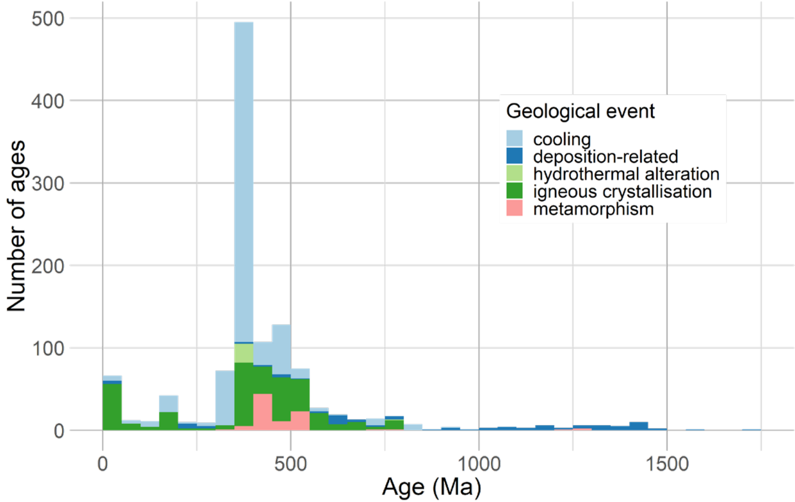
Next: GA/MRT geochronology compilation for Tasmania



Dark red = old (c. preCam.), pink = c. Cam-Sil, white = young (Cen.)





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Isotopes in economic geology, metallogenesis and exploration

Huston, D.L., and Gutzmer, J., eds ***Coming in 2022***

Part I – Radiogenic isotopes – age of mineralisation

- Overview, U-Pb, Re-Os & Pt-Os

Part II – Radiogenic isotopes – crustal and metallogenic mapping

- Sm-Nd, Pb-Pb, Lu-Hf

Part III – Light stable isotopes

- H, B, C, N, O, Si, S

Part IV – Metallic stable isotopes

- Iron, copper, zinc

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Problems with isotopes in exploration & mining

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Part II: more baseline datasets

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John de Laeter Centre

Curtin University
TIMESCALES OF MINERAL SYSTEMS

Lead Isotope Map of Australia (LIMA)

A Geoscience Australia – Curtin collaborative project

Janne Liebmann (Curtin)

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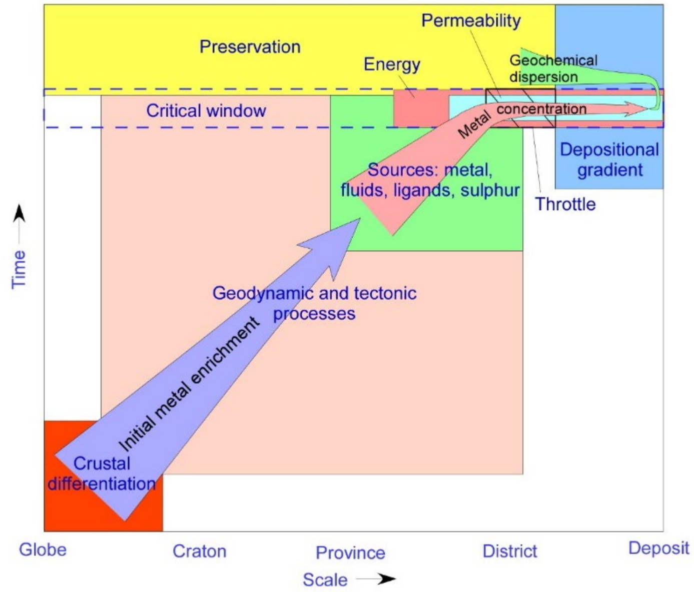
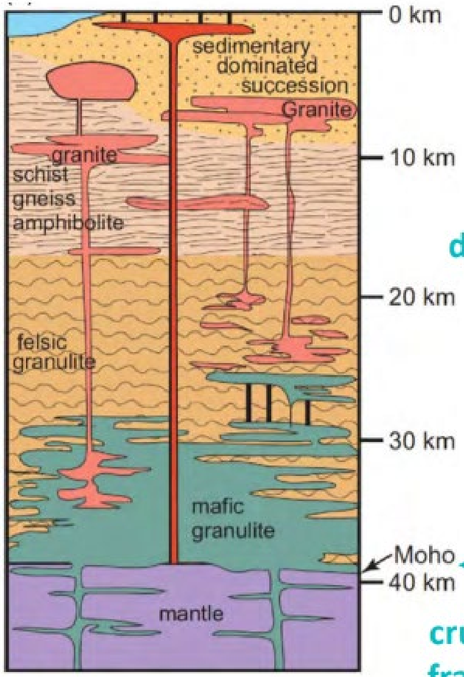
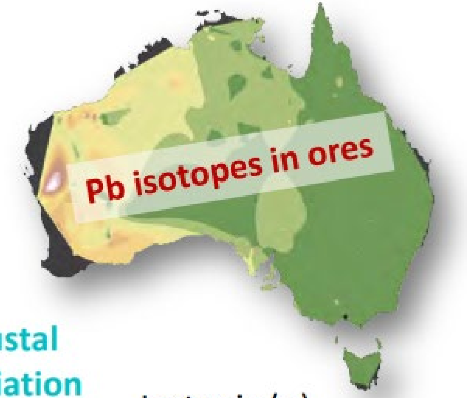
LIMA – Project motivation



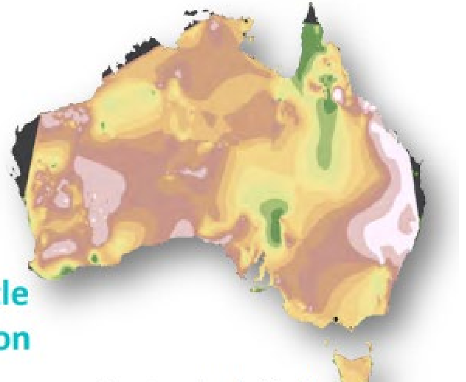


intracrustal differentiation

crust-mantle fractionation



Isotopic (μ)



Isotopic (εNd)

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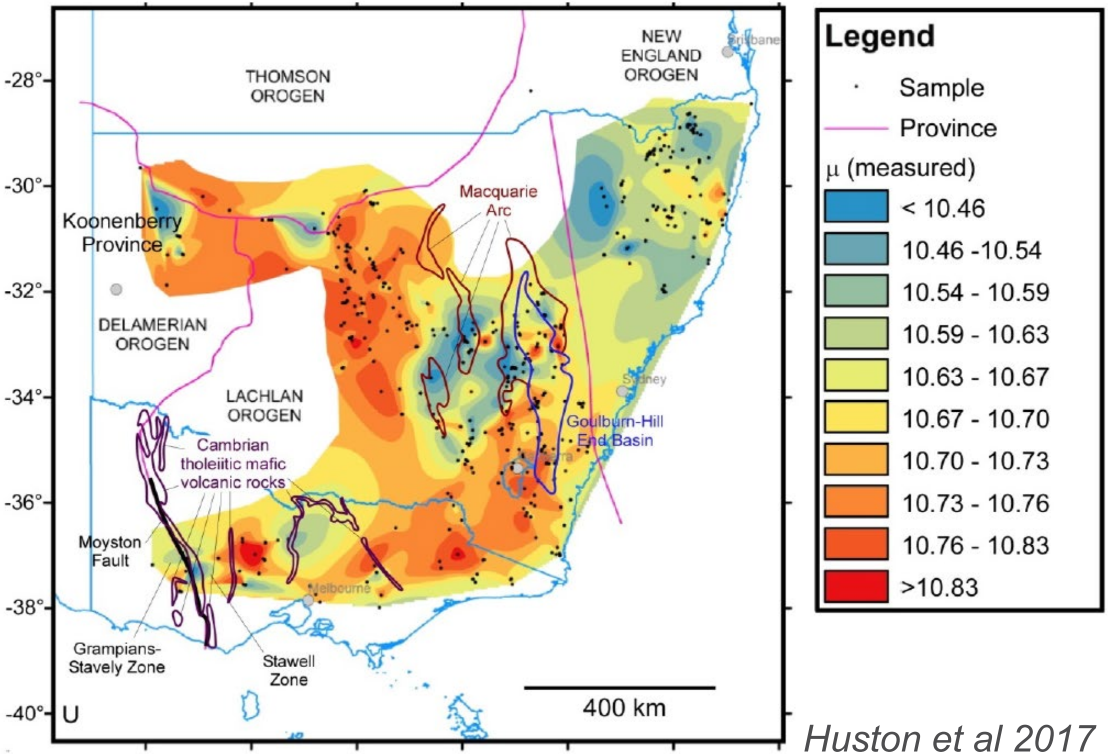
LIMA: Baseline data from basement rocks

- Give context for ore + water + soil data
- Map structures and terranes
- Can Pb-isotopes be used for pathfinding?
- Can you explore using Pb-isotopes in basement?
- Can reliable datasets be collected quicker and cheaper?

Map: Pb-isotopes in ore: Tasman Element



Huston et al 2017

DOI: 10.11636/Record.2017.009

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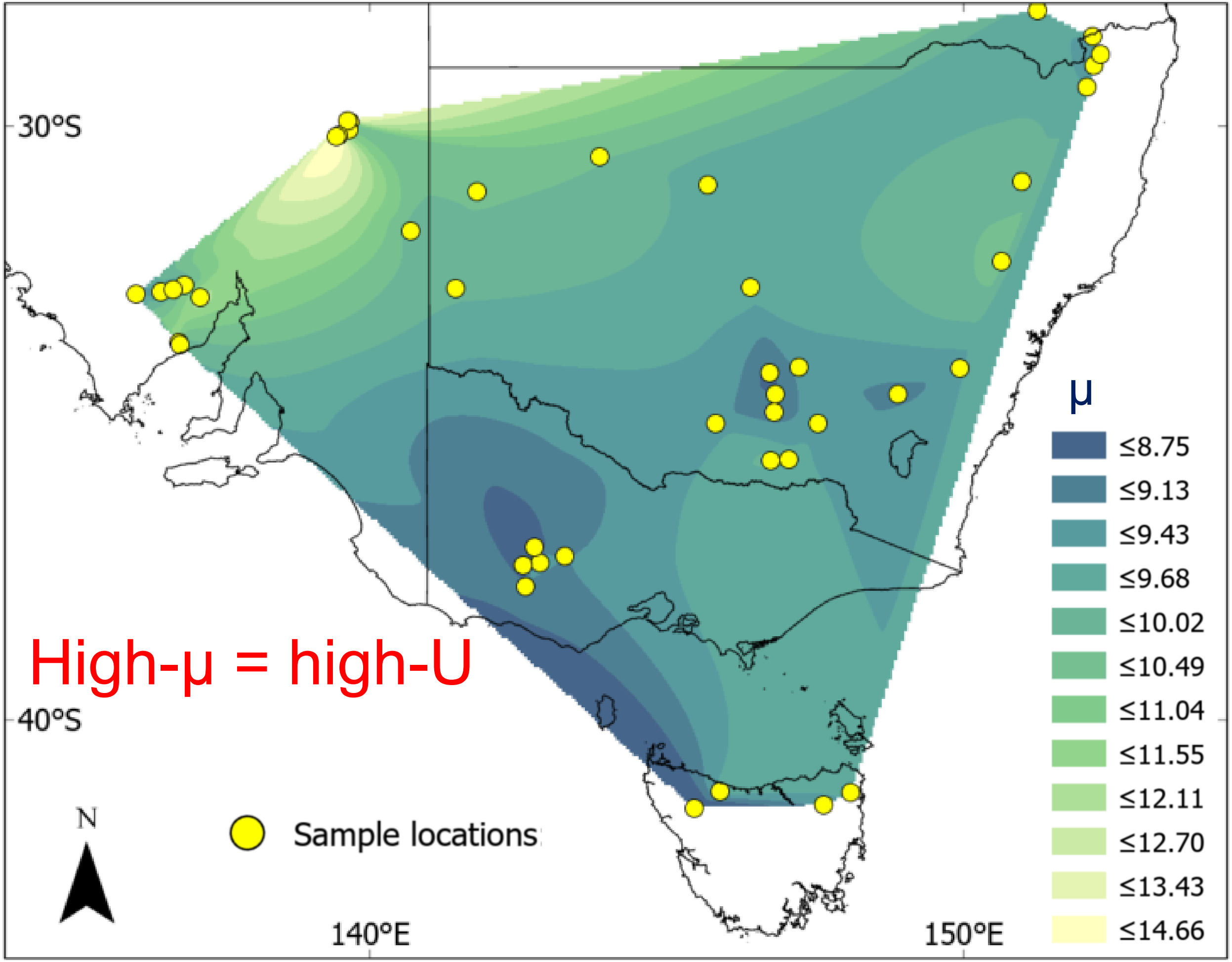
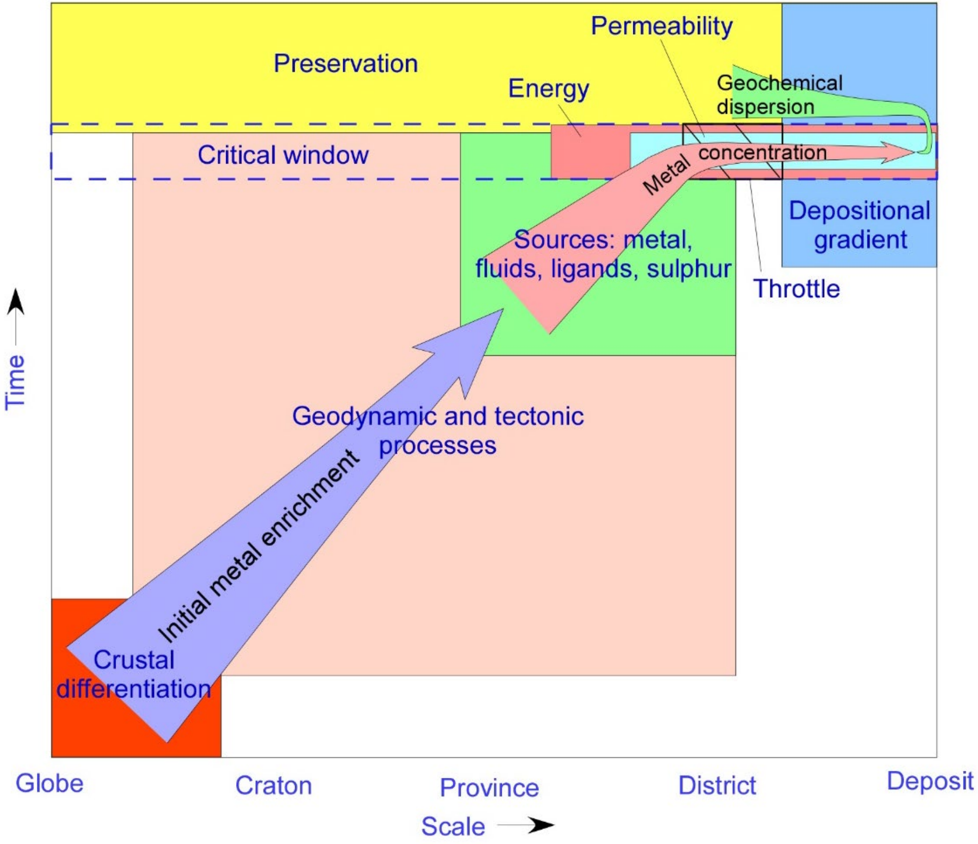
Pb in basement

- 43 samples so far
- Feldspar LA-ICPMS + Whole rock TIMS = similar results
- Initial results make sense – but lots of geological gaps



What we're doing

- ✓ Making it easier to access data
- ✓ Reducing barriers to isotopic understanding
- ✓ Providing baseline datasets
- What I hope to be talking about next time: discovery examples



Hagemann et al 2016
doi: 10.1016/j.oregeorev.2015.12.012

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Links to isotope compilations are in the extended abstract volume

Thanks to all the geological surveys for their data custodianship and collaboration

Thanks to the isotope geochemists and geochronologists – we stand on your shoulders

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Email: Kathryn.Waltenberg@ga.gov.au