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Geochemistry of northern Australia: putting it together

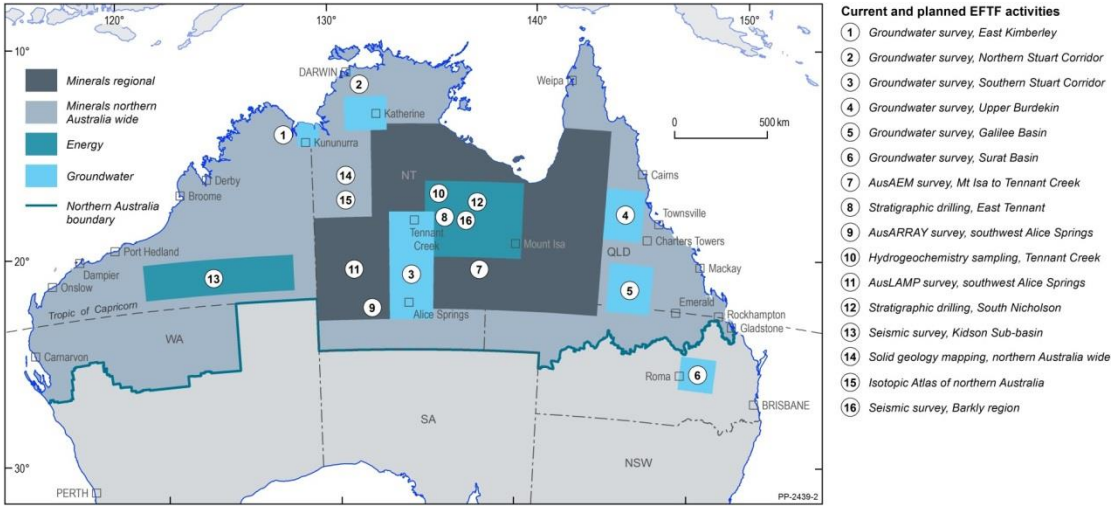
P. T. Main, E. N. Bastrakov, D. C. Champion, K. Czarnota, J. R. Wilford

Talk Outline

1. Northern Australia Geochemical Survey (NAGS)
2. Preliminary machine learning results
3. North Australian Craton geochemistry

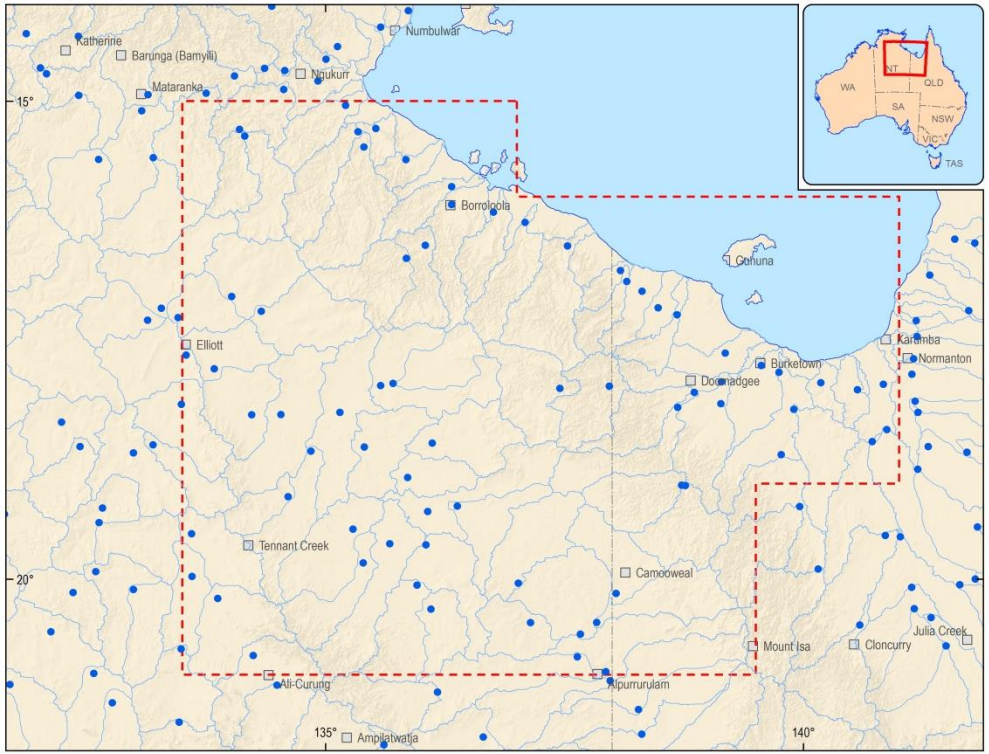
Background

- The Northern Australian Geochemical Survey (NAGS) is part of Geoscience Australia's Exploring for the Future program
- The geochemical survey is aimed at providing: environmental baseline data; geochemical data for agriculture; and regional scale geochemical data to aid mineral explorers
- The use of Mobile Metal Ion™ (MMI) analysis on this regional data allows us to identify areas of potential for mineralisation



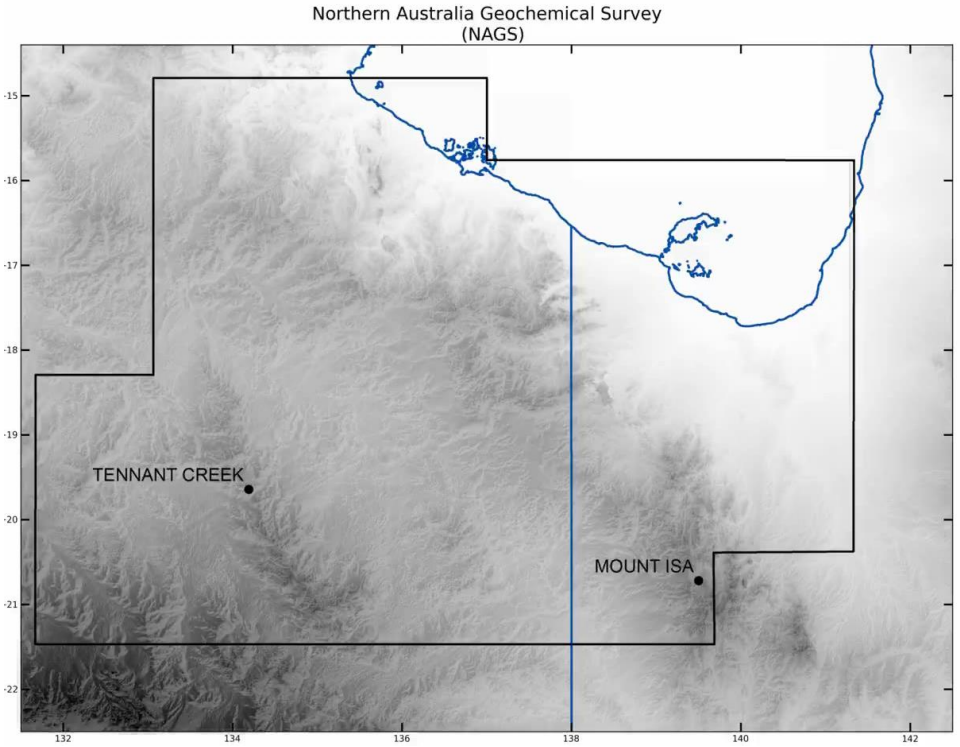
What is NAGS

- The NAGS is a regional low-density overbank sediment survey
- The study covers an area of 505,343 km^2 spanning from west of Tennant Creek to east of Mt Isa
- As part of this program 780 samples were collected
- The survey had an average catchment size of ~500 km^2



Sampling Procedure

- Sampling occurred on the overbank where available and in the topographic low in arid dessert regions (west of Tennant Creek)
- Only the top 10 cm of material is collected, after the surface has being scraped
- A 1x1m pit is dug to 10 cm and homogenised
- Samples are typically 5 kg
- For every tenth site a duplicate was collected, at minimum 100 m away



Data Preparation and Analysis

- Samples were riffle-split to create two size fractions a <2 mm and <75 µm fraction
- For MMI analysis a <2 mm fraction was used
- Aqua Regia and total digestion was performed on both size fractions
- Samples then underwent a rigorous QA/QC process in order to determine which elements could be used for advanced statistical analysis, or if they could be used on their own
- Imputation was then performed on the data using a KNN approach to provide a statistical approximation of values below the lower limit of detection

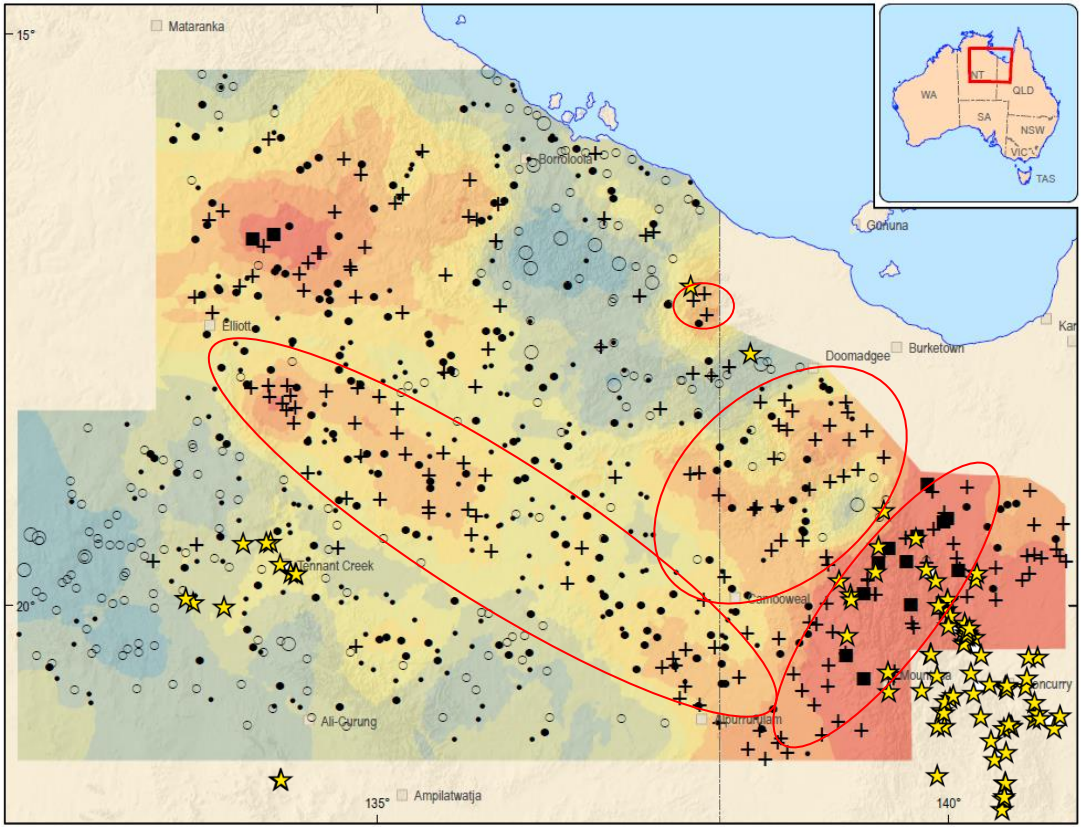
Data Preparation and Analysis cont.

- Following imputation a centred log ratio (CLR) transform was applied in order to open the data
- Principal component analysis was then performed on this opened data as a dimensionality reduction tool
- Machine learning was also applied for Cu

Why use MMI

- The use of a partial leach technique such as MMI has the potential to allow us to see through cover
- Theoretically leaches the adsorbed metal ions off the surfaces of predominantly clay minerals
- By collecting all the samples during the dry season the effect of seasonal variability on MMI results is mitigated

MMI Cu



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NORTHERN TERRITORY GOVERNMENT

Queensland Government

Tennant—Isa study area: Northern Australia Geochemical Survey

Top Outlet Sediment
0-10 cm
Fraction: 0-2 mm
Preparation: **MMI Digestion**
Analysis: ICP-MS
N: 776

Cu

Legend

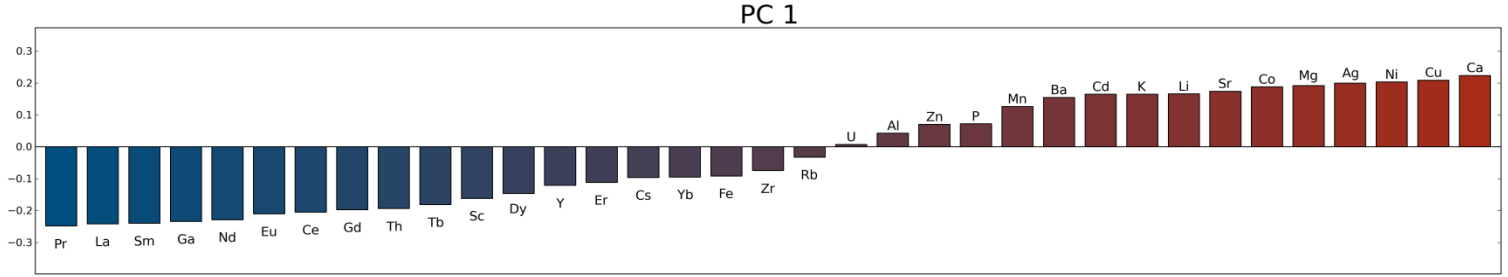
- Maximum: 19.2 mg/kg
- Upper Fence: 3.09 mg/kg
- 75%: 1.06 mg/kg
- Median: 0.75 mg/kg
- 25 %: 0.52 mg/kg
- Lower Fence: 0.18 mg/kg

0 — 250 km

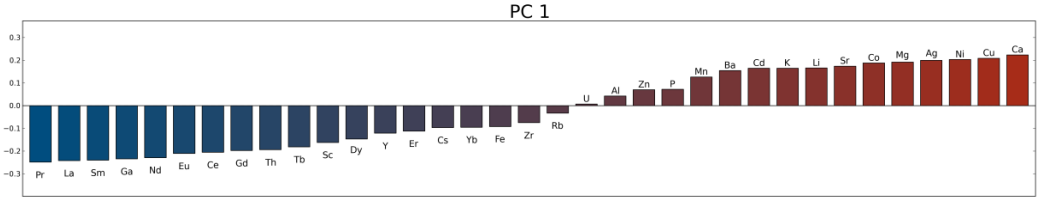
http://www.ga.gov.au/eftf/minerals/fis/nags

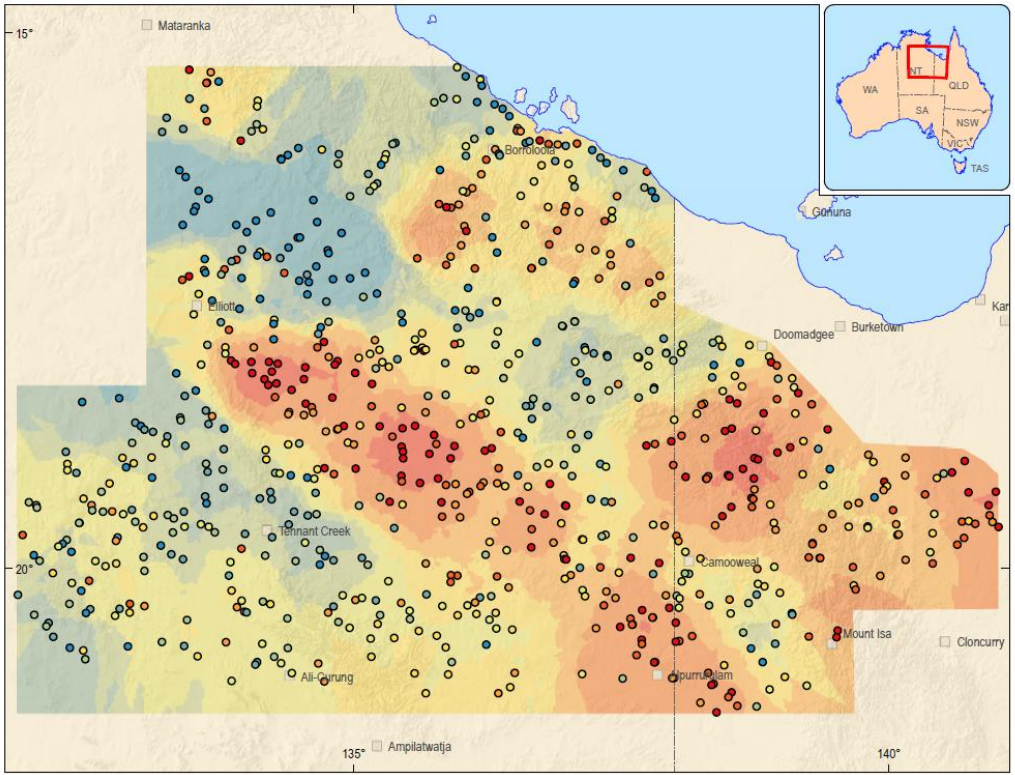
The Black Soil Problem

- The black soils are clay rich soils that cover a large percentage of the focus area
- Particularly problematic for the MMI data, as the black soils contain a high proportion of clay
- The high proportion of clays within the black soils leads to a greater adsorption potential for certain metal ions leading to it skewing the data
- Principal component information indicates that the black soils are relatively depleted in REEs but relatively high in Ca and certain metals



Black Soils cont.





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PC1

PC1

- -10 - -3.6
- -3.6 - -2.5
- -2.5 - -1.7
- -1.7 - -0.75
- -0.75 - 0.48
- 0.48 - 2.1
- 2.1 - 5.0
- 5.0 - 11.3

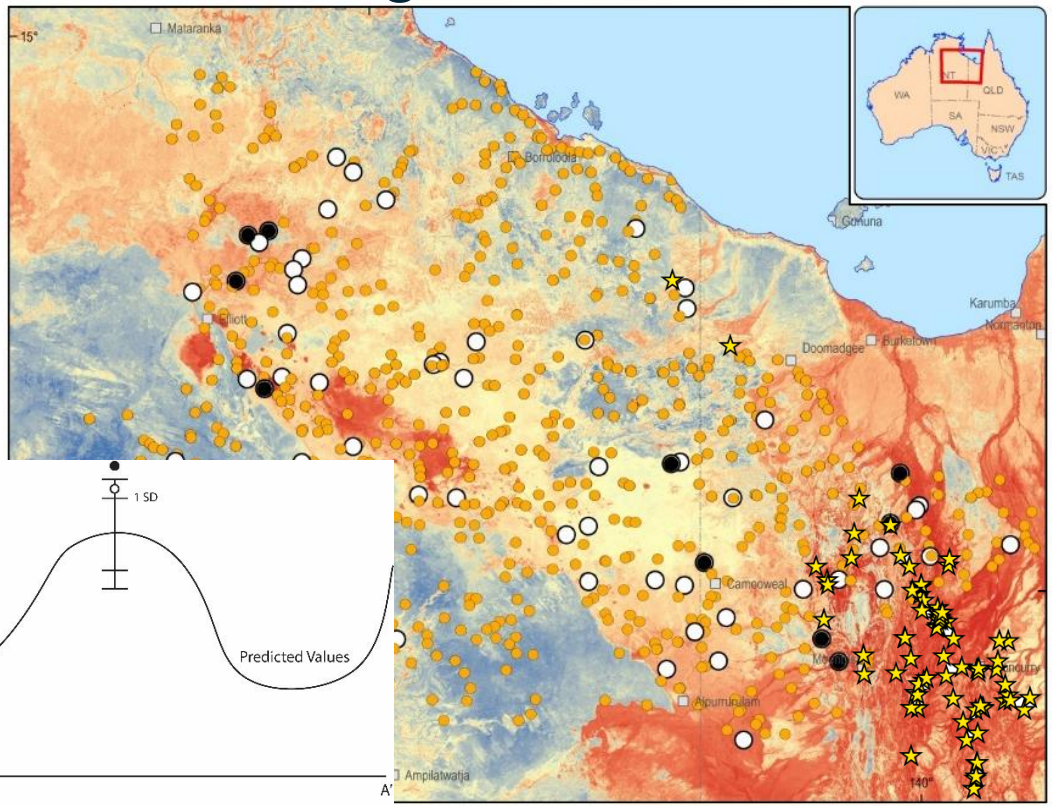
0 250 km

http://www.ga.gov.au/eftf/minerals/fis/nags

Machine Learning

- The machine learning prediction of MMI Cu was generated using both the NAGS MMI data and the NGSA MMI data
- A random forest approach was performed using the uncover-ML code on the NCI
- This map is assumed to be the baseline background value Cu for the region, with those values that diverge by more than two standard deviations considered anomalous
- These values that are higher than the “background” potentially represent prospective areas

Machine Learning Cu Results



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Legend

- MMI Points
- 1 Sigma
- 2 Sigma

High : 2.73 mg/kg

Low : 0.22 mg/kg

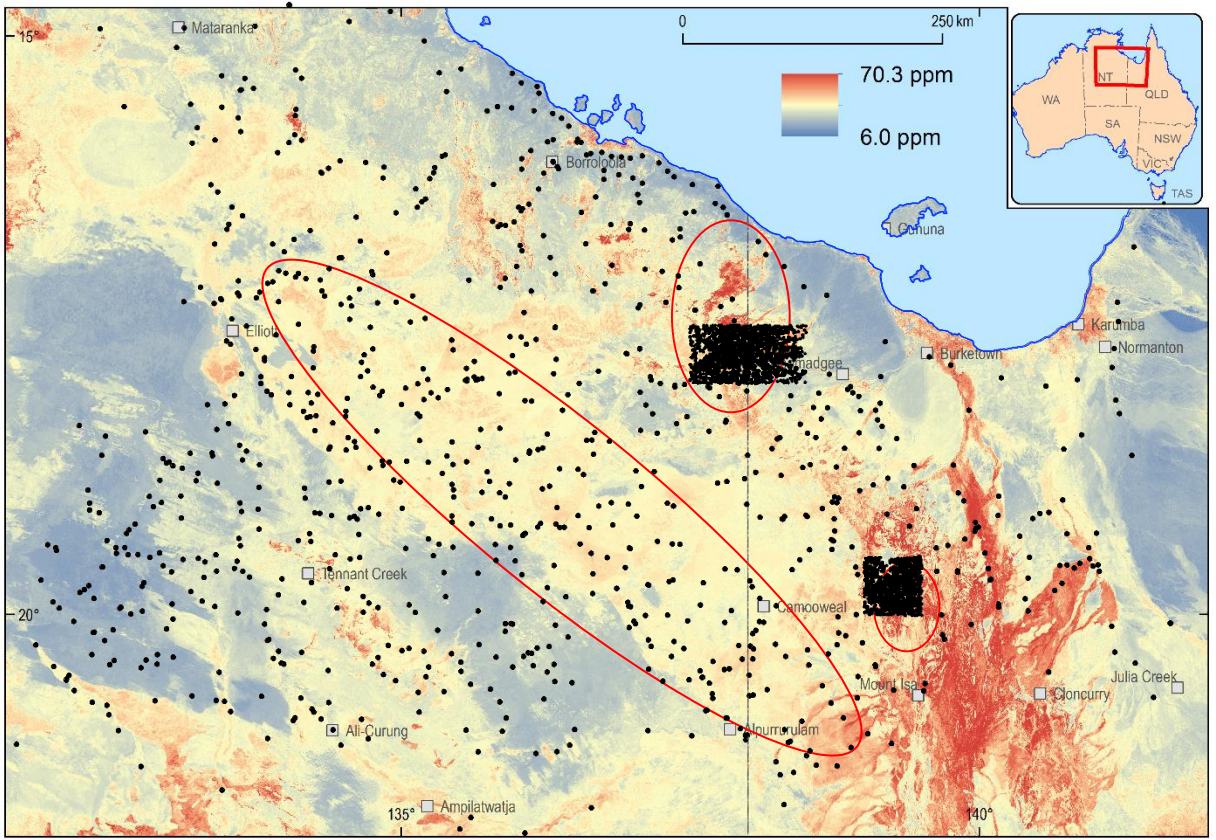
0 250 km

http://www.ga.gov.au/eftf/minerals/fis/nags

Total Digestion Cu Machine Learning

Two machine learning products for total digestion fine fraction Cu:

1. Using NAGS and NGSA data
2. Using NAGS, NGSA, and Hedley, Siegal, and Mammoth Mines data



North Australian Craton Geochemical Study

- The study is focused on regolith samples from the North Australian Craton
- The top layer of sediments from each survey are being used in this compilation, with only the fine fraction, total digestion, of this component used
- The samples represent various types, including: stream sediments, overbank sediments, colluvium, *etc.*

NAGS: 775

NGSA: 372

GSWA: 2490

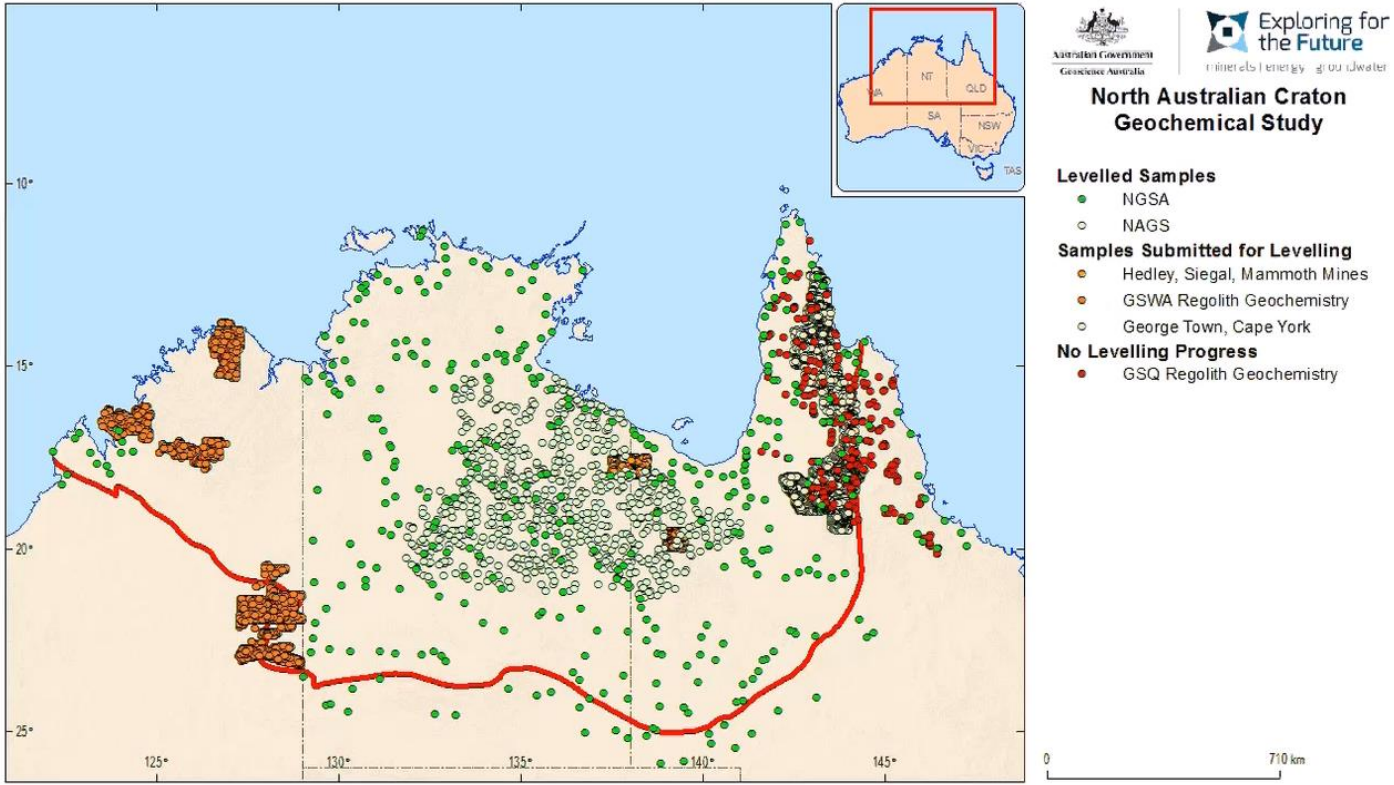
GSQ: 233

Hedley, Siegal, Mammoth Mines: 3946

George Town, Cape York: 8659

Total: 16475

North Australian Craton Locations



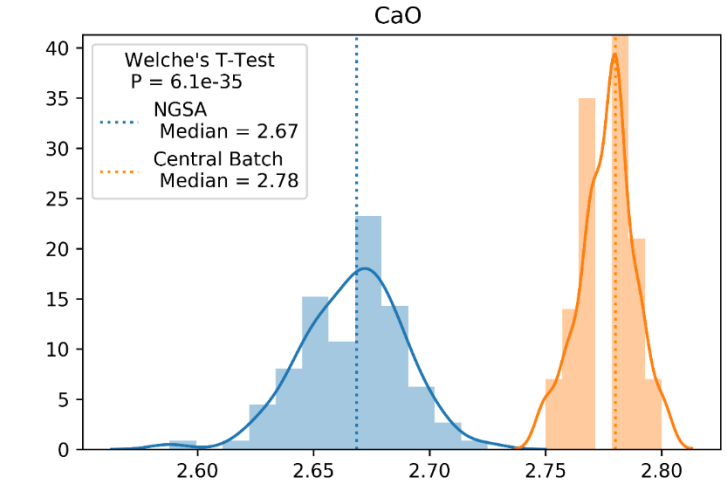
Levelling Process

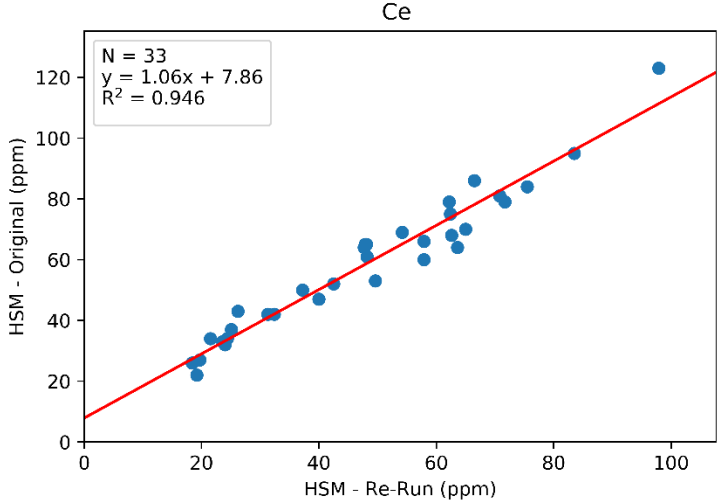
Multi-stage process depending on the survey

If there were enough standards analysed as part of the batch, and the same standards were analysed in the central batch, the following process was used:

- Check the normality of the data
- Test the populations using a Welch's t-test for normally distributed data and Wilcoxon signed-rank test for non-normal data
- If the populations are different (P < 0.05) then a correction factor is applied as a multiplier

For surveys where legacy samples were reanalysed, a linear regression was performed, and the samples corrected using $x = \frac{(y-intercept)}{slope}$





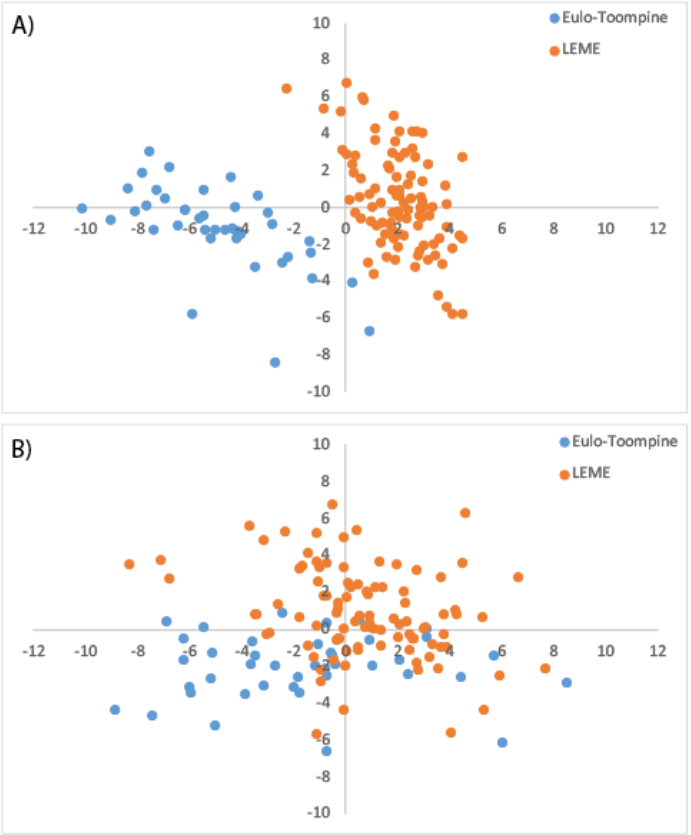
The Problem

Samples from the southern Thomson geochemical survey indicate a distinct difference in the PC 1 vs PC 2 plot (a)

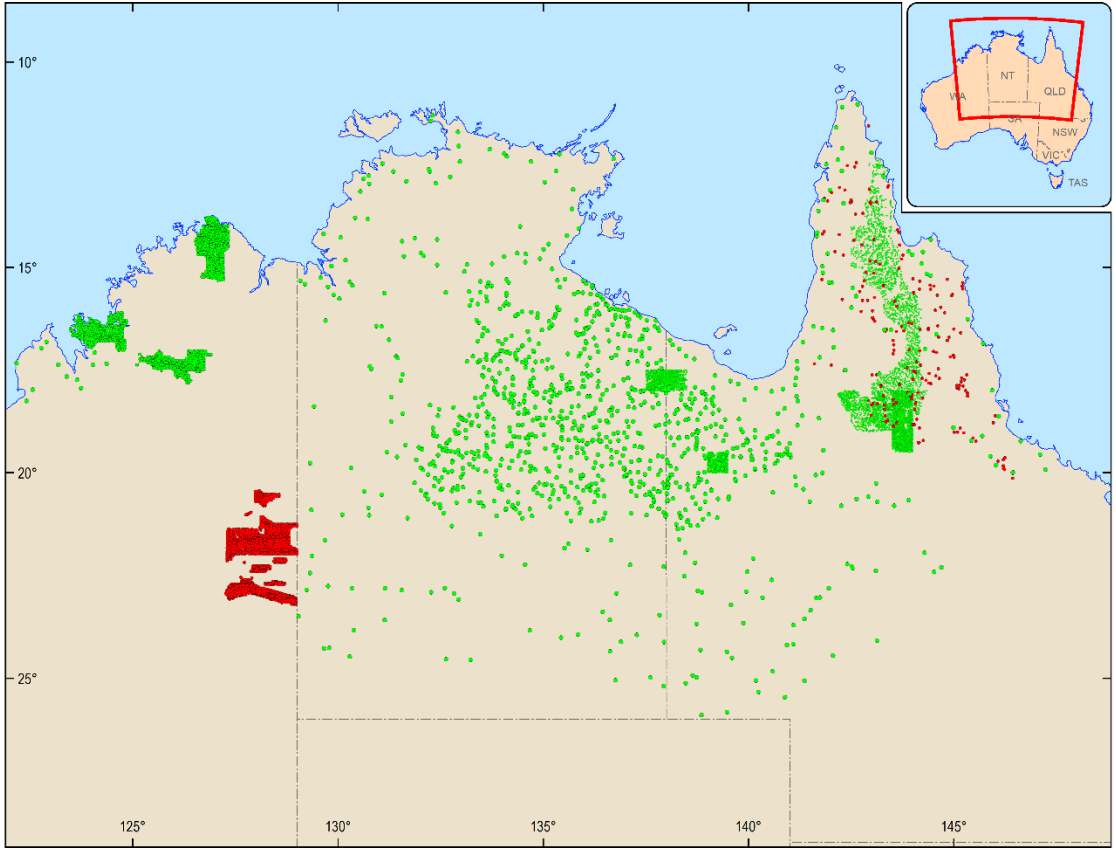
The levelling procedure was applied to these samples as a test case for the NAC

The levelling significantly reduces the effect of analysing the samples at different labs (b)

Levelling of samples is therefore required before any statistical analysis is done, particularly when samples have been analysed by different labs, different machines, or different calibration curves



Progress



Conclusions

- The NAGS data shows good correlation with known mineral deposits, and can potentially highlight new prospective regions
- Machine learning algorithms allow us to produce high resolution interpreted surfaces of the environmental levels of elements
- The use of machine learning allows us to determine if the data is anomalous to the environmental background, and is therefore potentially prospective for mineral exploration

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Thank You!

Questions?

Phone: +61 2 6249 9111
Web: www.ga.gov.au
Email: feedback@ga.gov.au
Address: Cnr Jerrabomberra Avenue and Hindmarsh Drive, Symonston ACT 2609
Postal Address: GPO Box 378, Canberra ACT 2601