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Scale-integrated Concepts to Targets of a Gold Mineral System

SCALE 2: DISTRICT ANALYSIS

How to identify the location of major mineral camps (60 km x 60 km area selection)

K. Czarnota, R.S. Blewett, B. Goscombe, T. Brennen, P. Henson, D. Champion, and N. Kositcin

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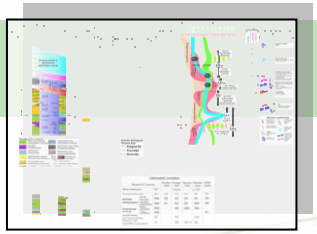

Mineral System Understanding

Geodynamic Episodes

Geochemical Gradients

Pre-ore endowment (<2665 Ma)	Lithospheric extension Au (~2665-2655 Ma)	Inversion Au (≥2660 Ma)	
			Identification of mappable mineral system process proxies for each subdivision
• Crustal endowment	• Extensional SZ • Metasomatised mantle melts • Deep pathways	• Domes • Major faults • Upper plate	• Redox gradients • Hydrothermal system indicator
Pre-ore Targets	D3 Targets	D4-D5 Targets	Geochem Targets

Au mineral camp (60x60 km area) selection

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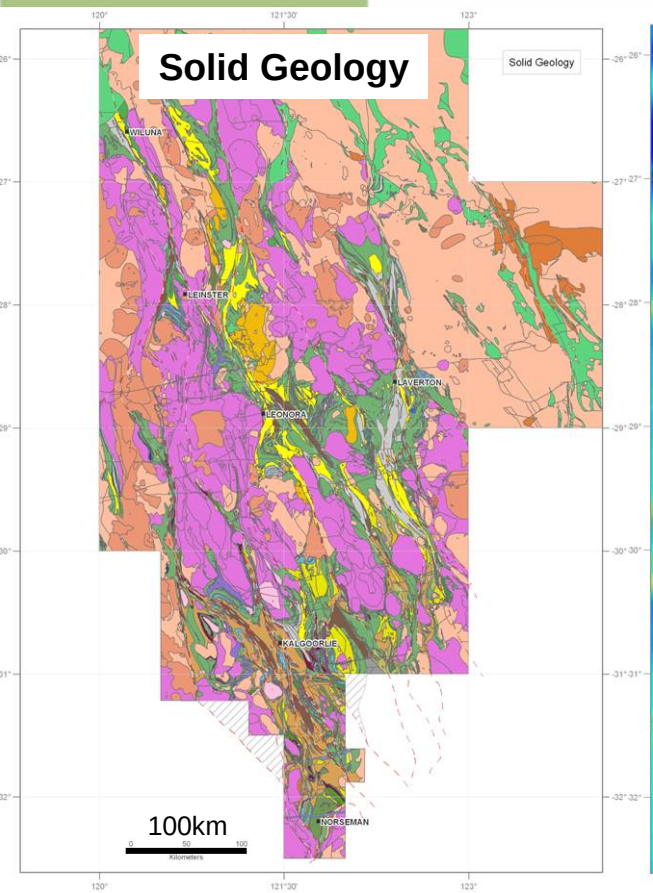
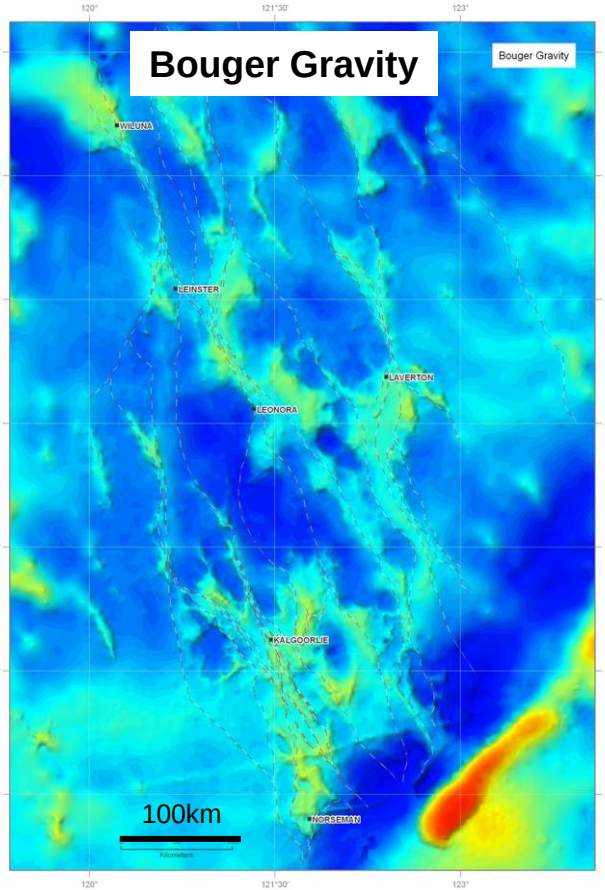
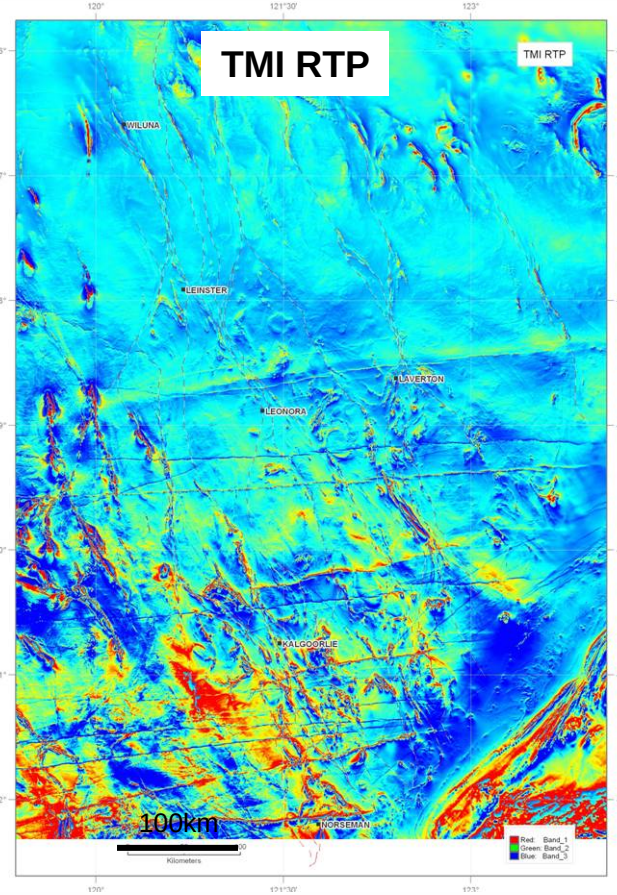
Weighting Factors and Essential Base Layer Data Sets

Weighting Factor (WF):

1. Uncertain significance of process, large spatial uncertainty
2. Desirable process, moderate spatial data uncertainty
3. Essential process, high data spatial accuracy







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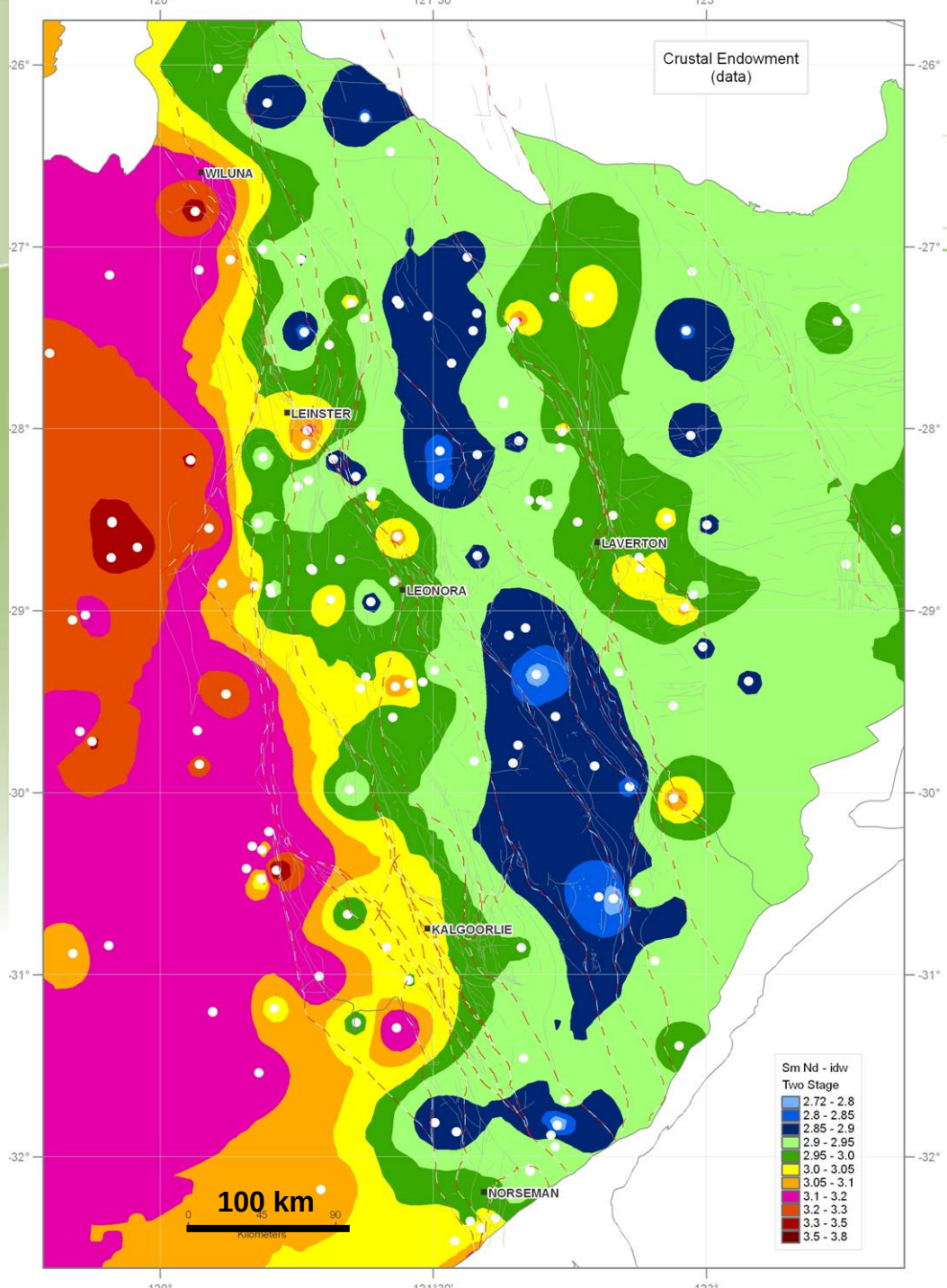

Pre-ore endowment

Crustal Endowment

(WF 2-3)

Data layer

- **Nd T_{DM} model age reflects crustal architecture at ~2.8-2.72 Ga**

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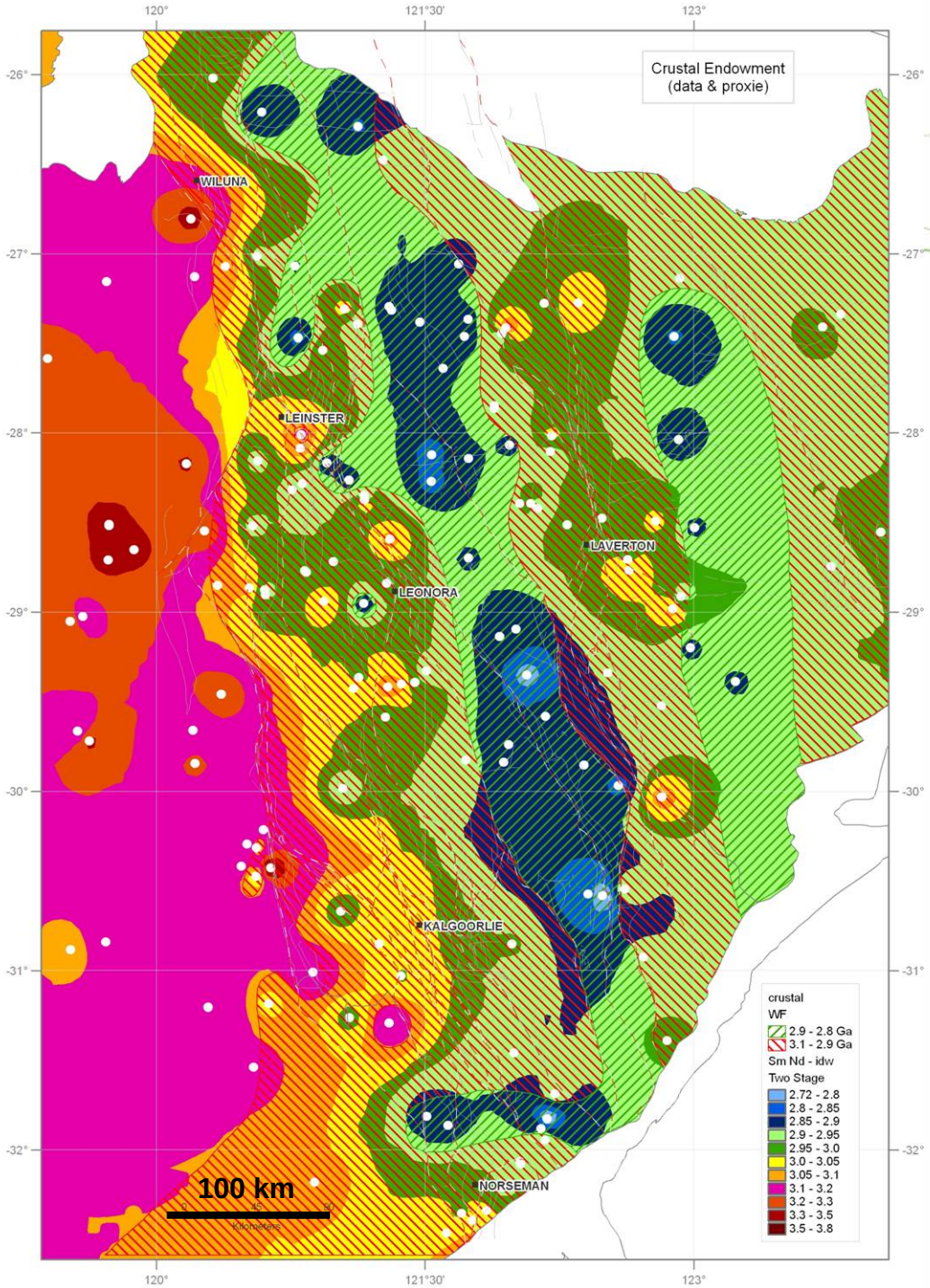

Pre-ore endowment

Crustal Endowment

(WF 2-3)

Data + proxy layer

- **Nd T_{DM} Reflects crustal architecture at ~2.8-2.72 Ga**
- **WF 3 (Nd T_{DM} 2.9-2.8 Ga)**
- **WF 2 (2.9-2.8 Ga)**

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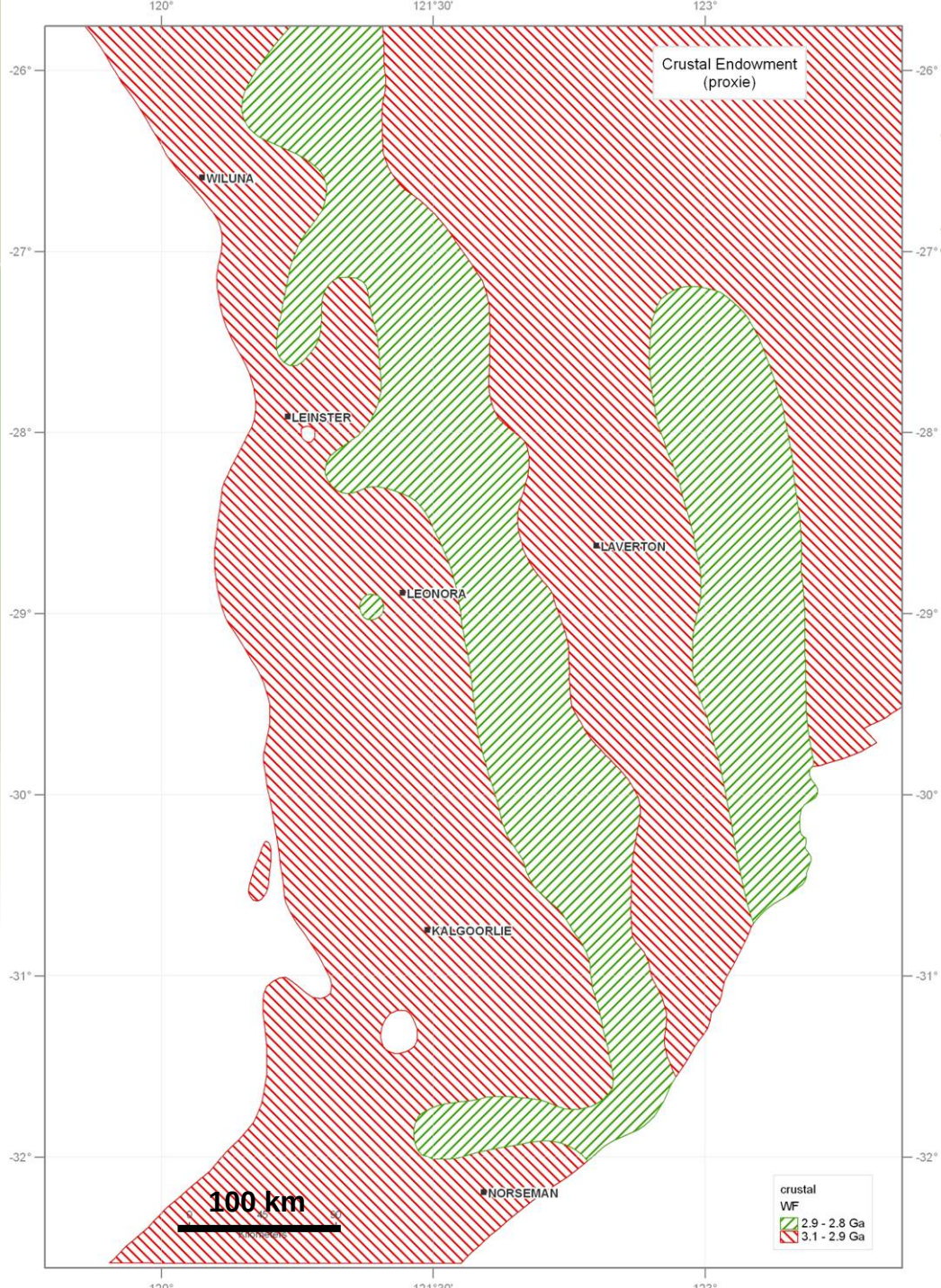

Pre-ore endowment

Crustal Endowment

(WF 2-3)

proxy layer

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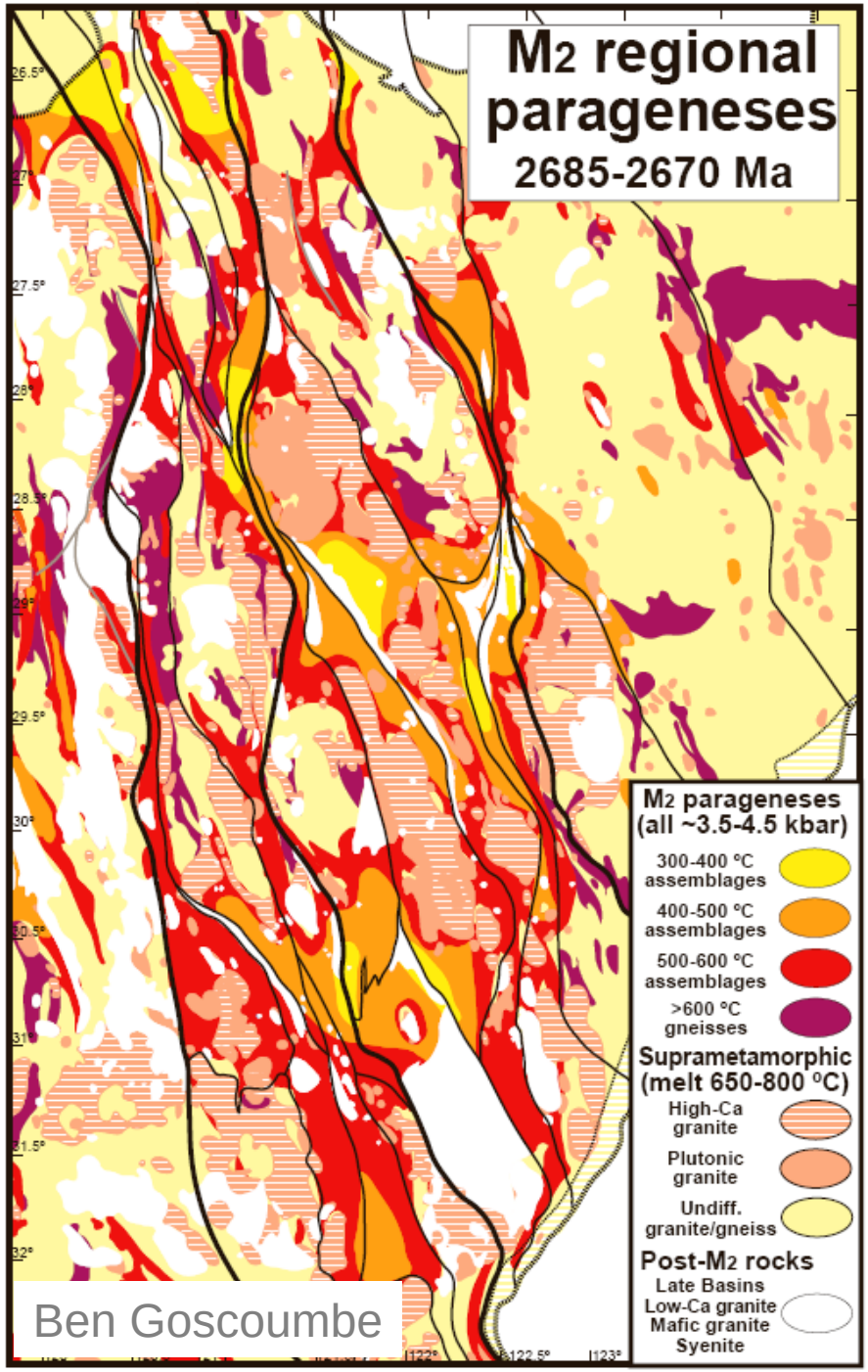


Ben Goscoumbe

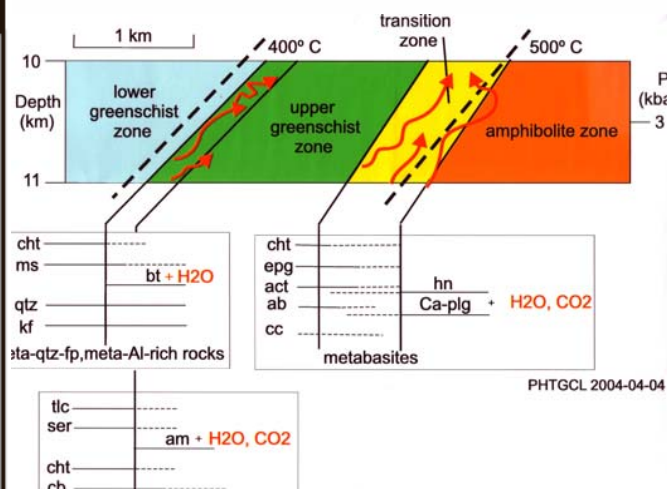
Pre-ore endowment

M2 maximum fluid release

(WF 2)

Data layer

400-500˚C assemblages represent zones of greatest metamorphic devolatalisation



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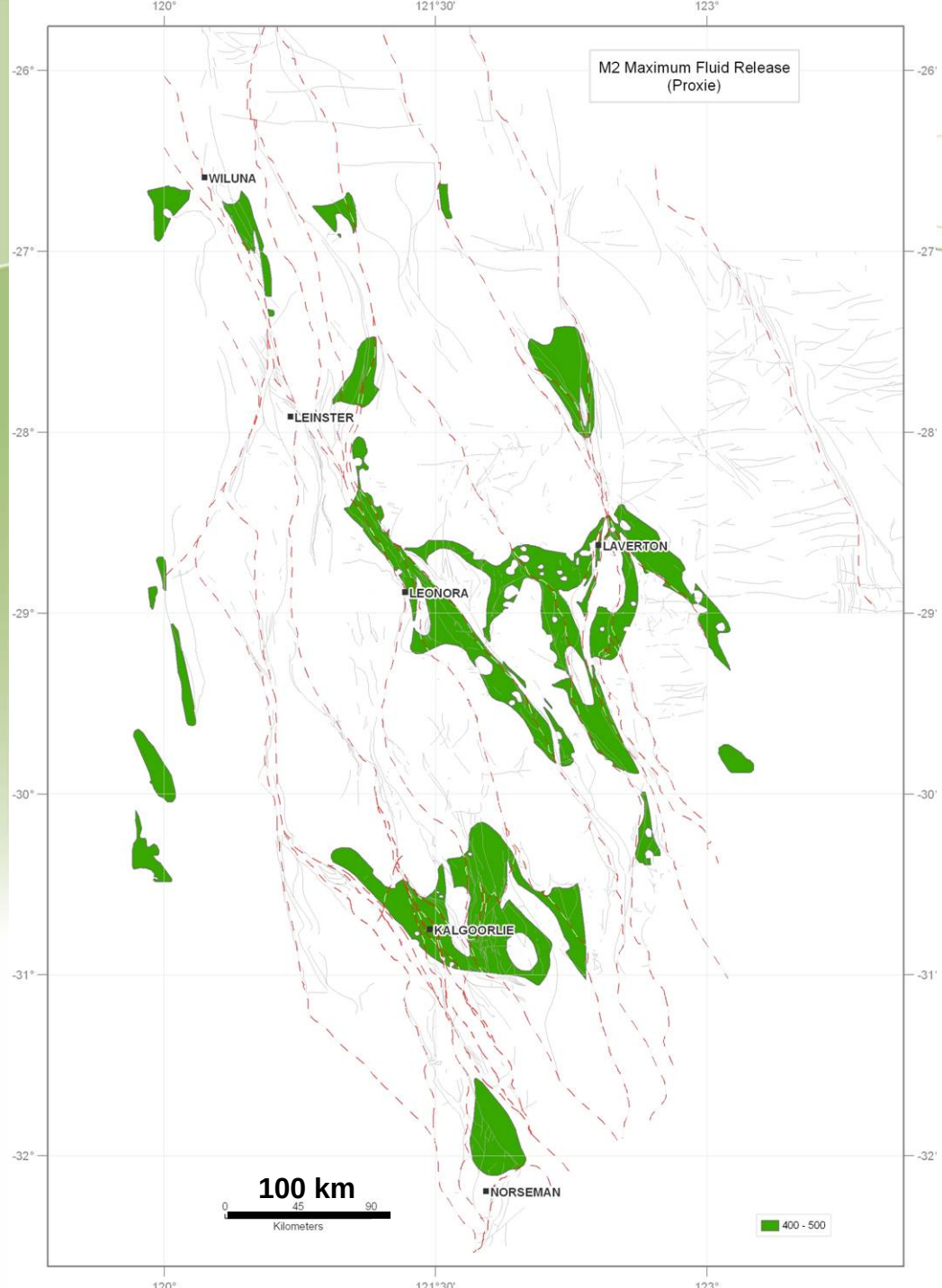

Pre-ore endowment

M2 maximum fluid release (WF 2)

proxy layer

- **400-500˚C assemblages**

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Pre-ore Au prospectivity

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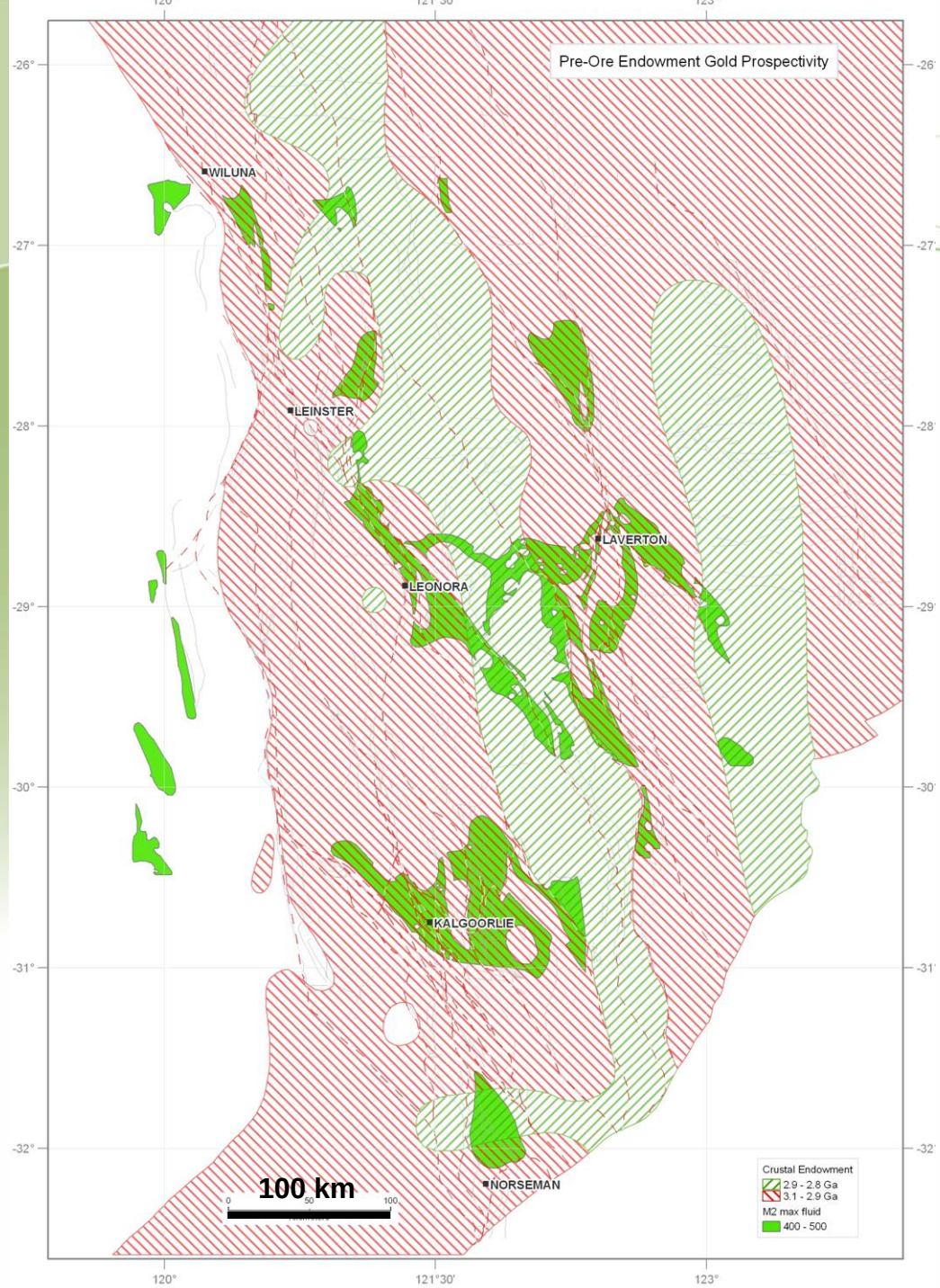

Inputs

Combination of:

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Pre-ore Au prospectivity

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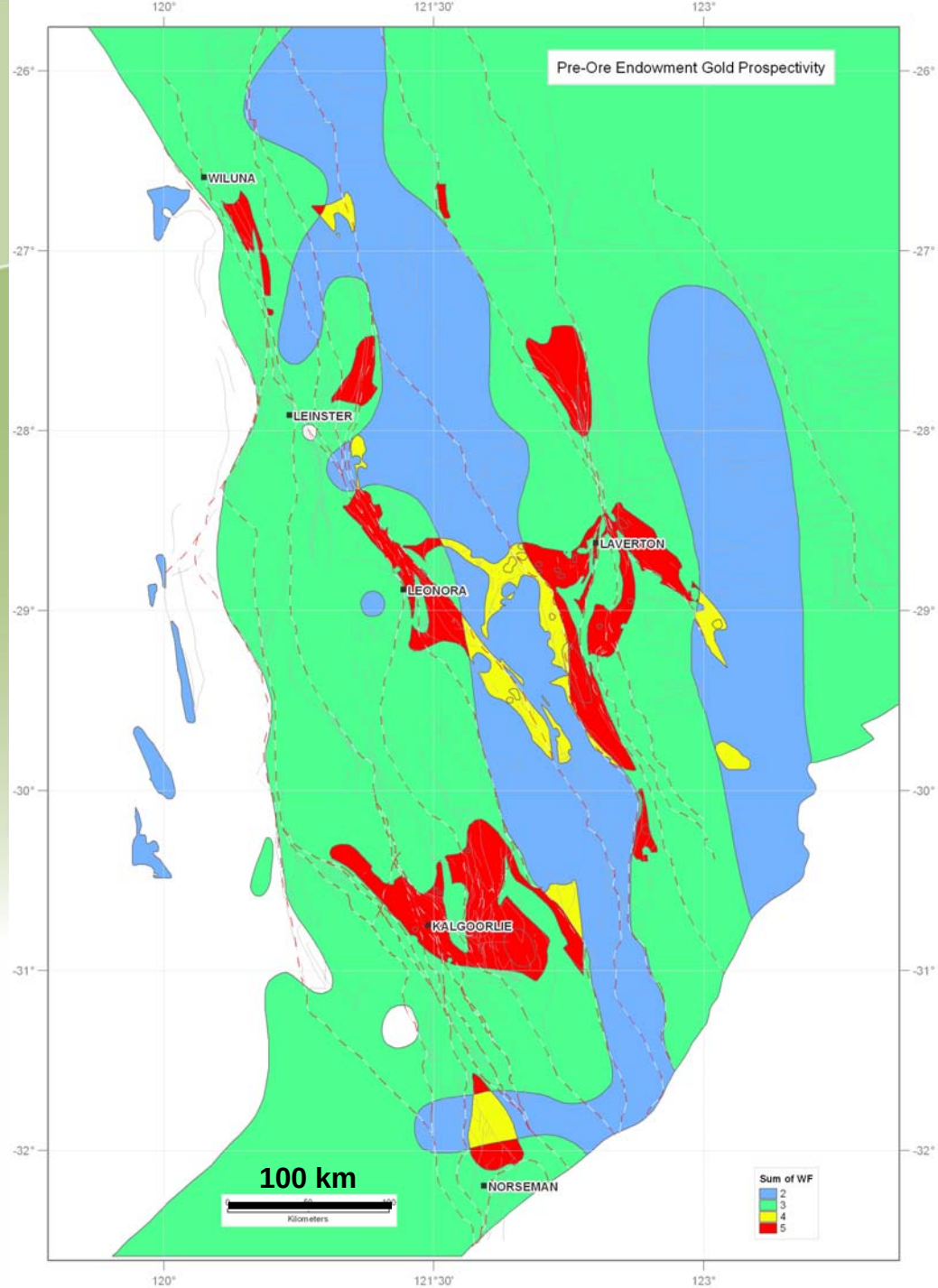

Targets

Combination of:

- Crustal endowment
- M2 maximum fluid release

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Mineral System Understanding

Geodynamic Episodes

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- Redox gradients
- Hydrothermal system indicator

Pre-ore Targets

D3 Targets

D4-D5 Targets

Geochem Targets

Au mineral camp (60x60 km area) selection

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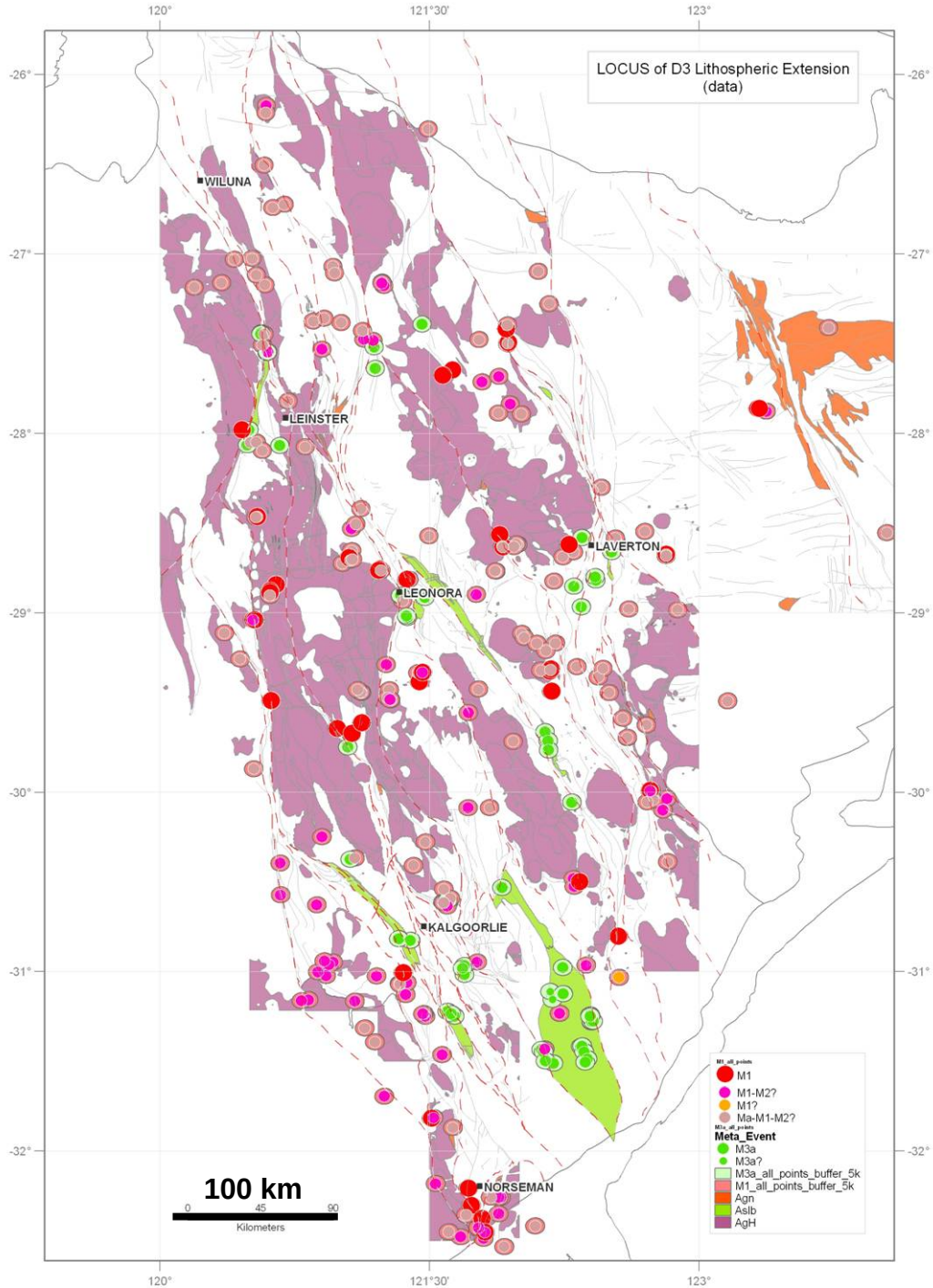

Locus of lithospheric extension

(WF 3)

Data layer

- **Au in extensional shear zones between upper and lower plate**

Upper plate:

- M3 data points
- Location of Late Basins

Lower plate:

- M1 data points

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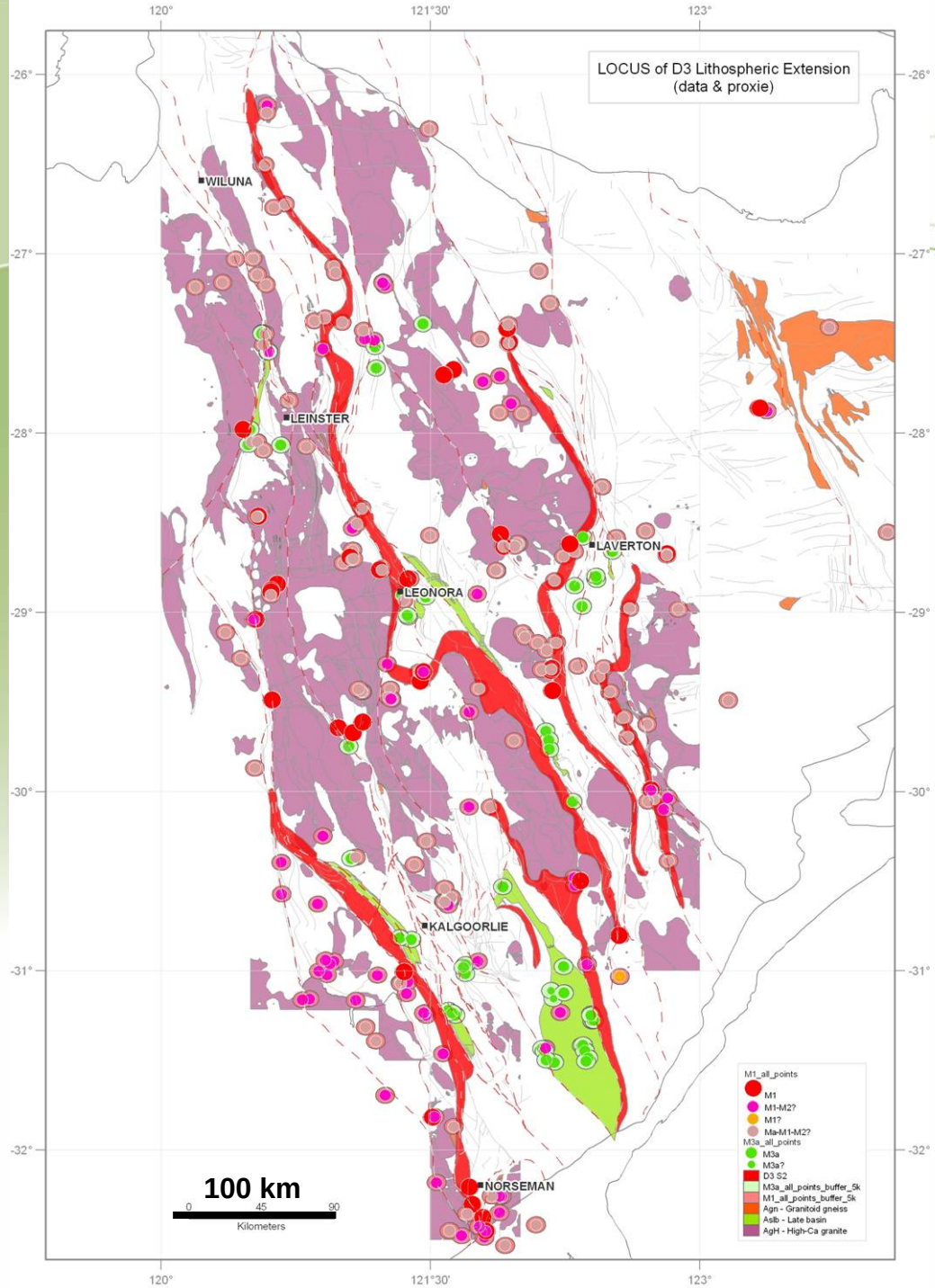
Locus of lithospheric extension (WF 3)



Data + proxy layer

- **Au in extensional shear zones between upper and lower plate**
- **Upper plate:**
  - M3 data points
  - Location of Late Basins
- **Lower plate:**
  - M1 data points

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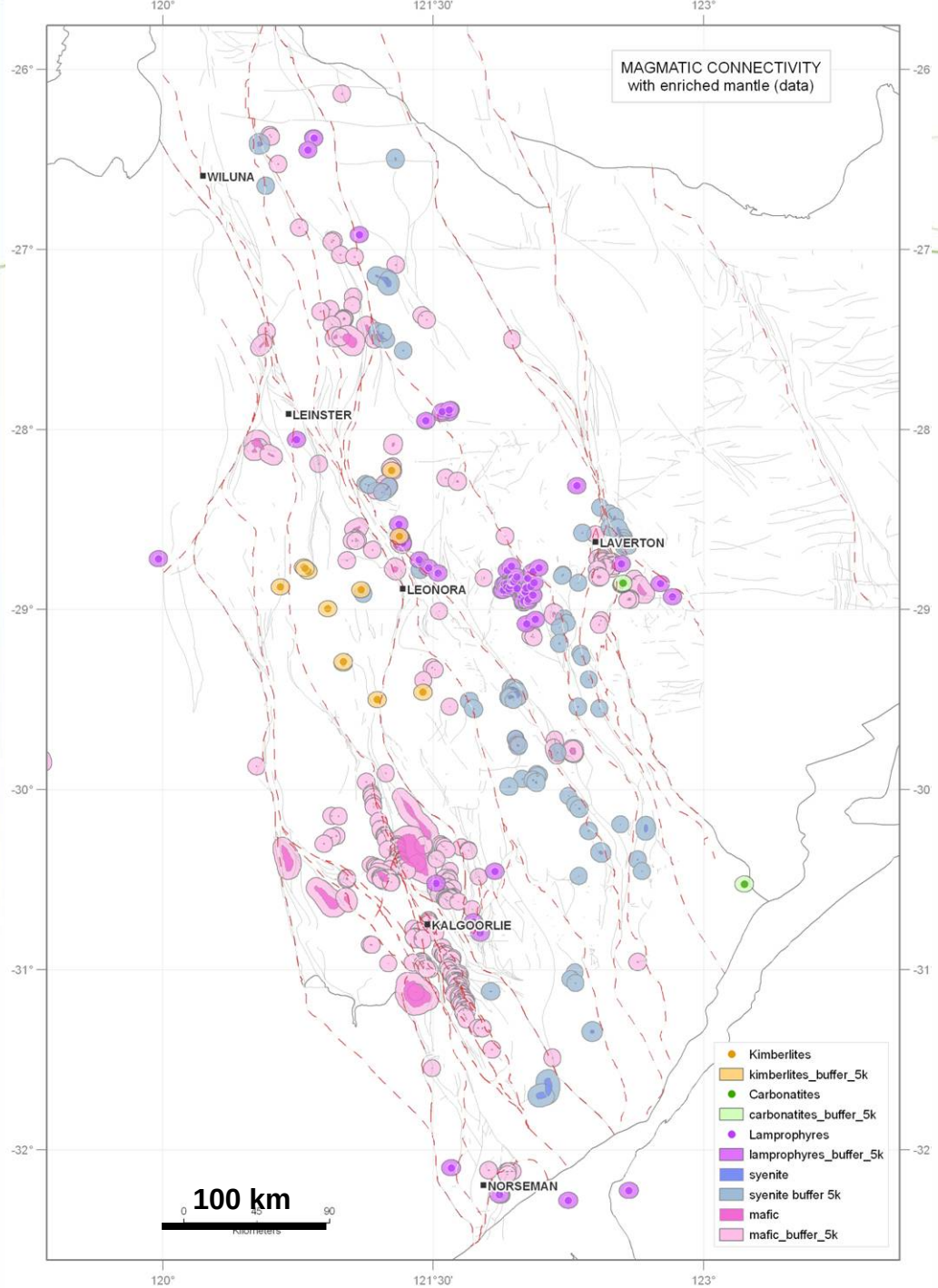

Magmatic connectivity with enriched mantle (WF 3)

Data layer

- **Au in metasomatised mantle melts**
- **Mafic granites**
- **Syenites (not monzonite syenites)**
- **Kimberlites**
- **Carbonatites**
- **Lamprophyres**

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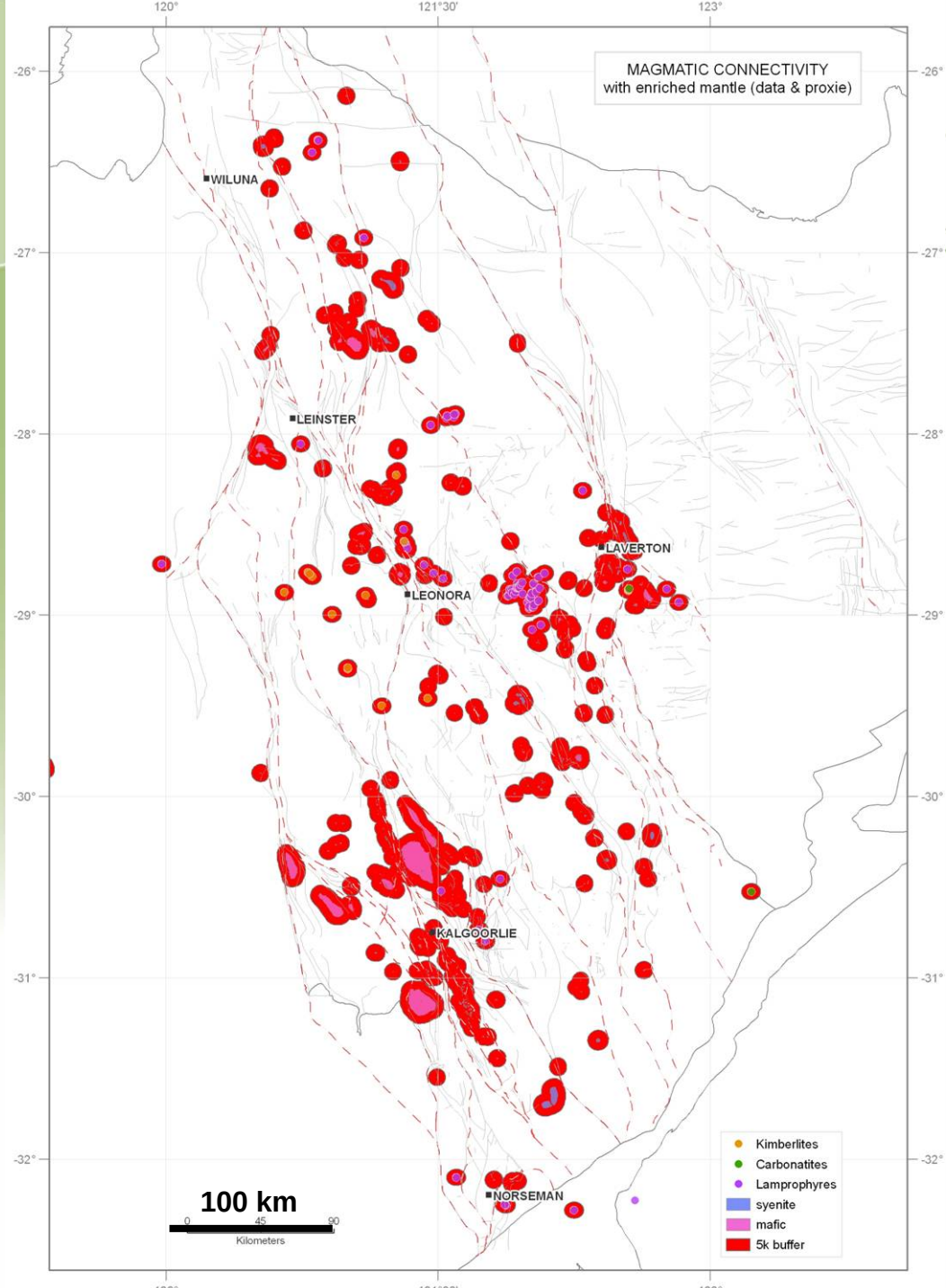

Lithosperic extension Au

Magmatic connectivity with enriched mantle (WF 3)

Data + proxy layer

- Au in metasomatised mantle melts
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- Syenites (not monzonite syenites)
- Kimberlites
- Carbonatites
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Deep pathways - tomography (WF 1)

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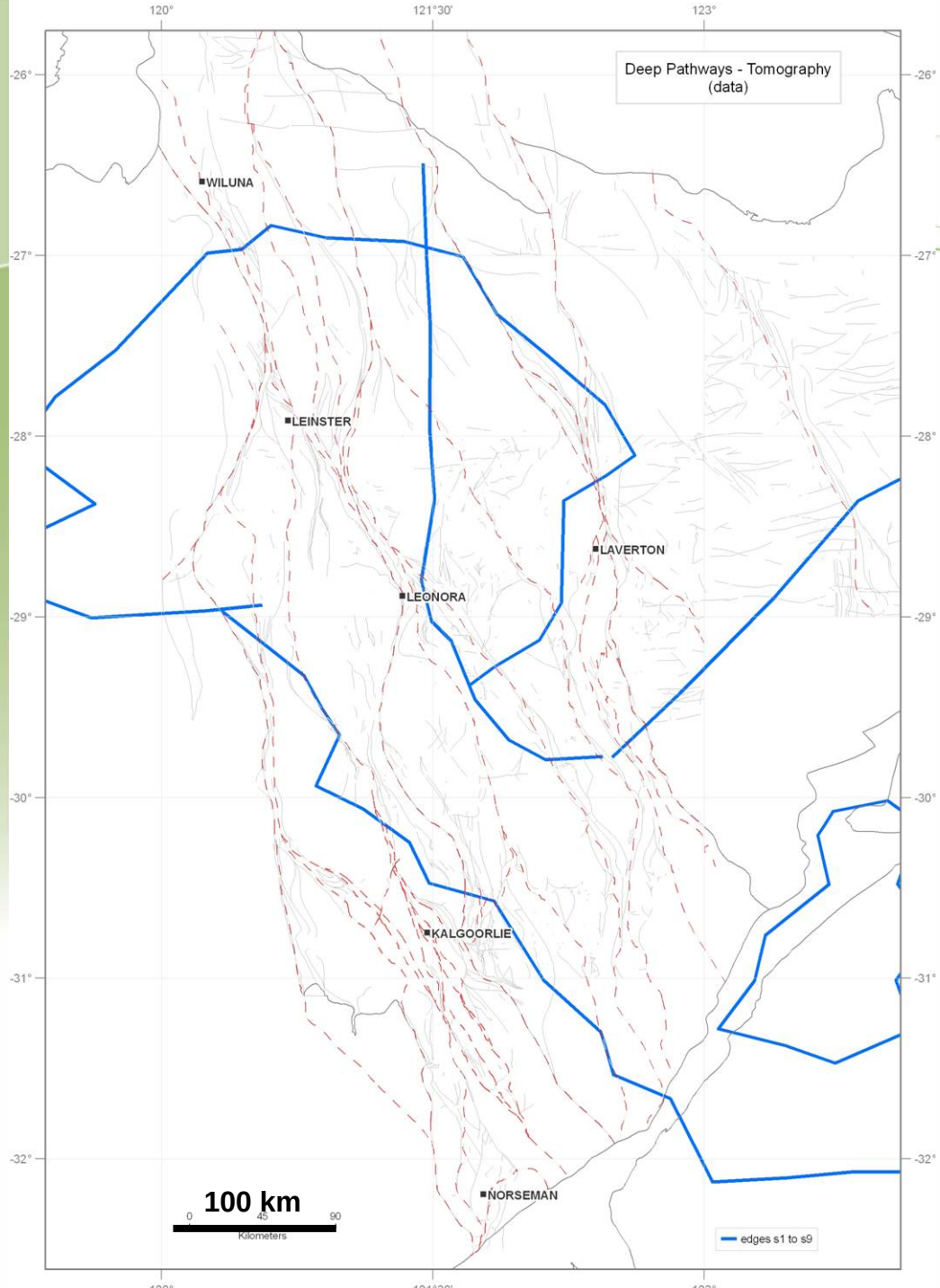

Data layer

- **Deep pathways established during delamination**

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Deep pathways - tomography (WF 1)

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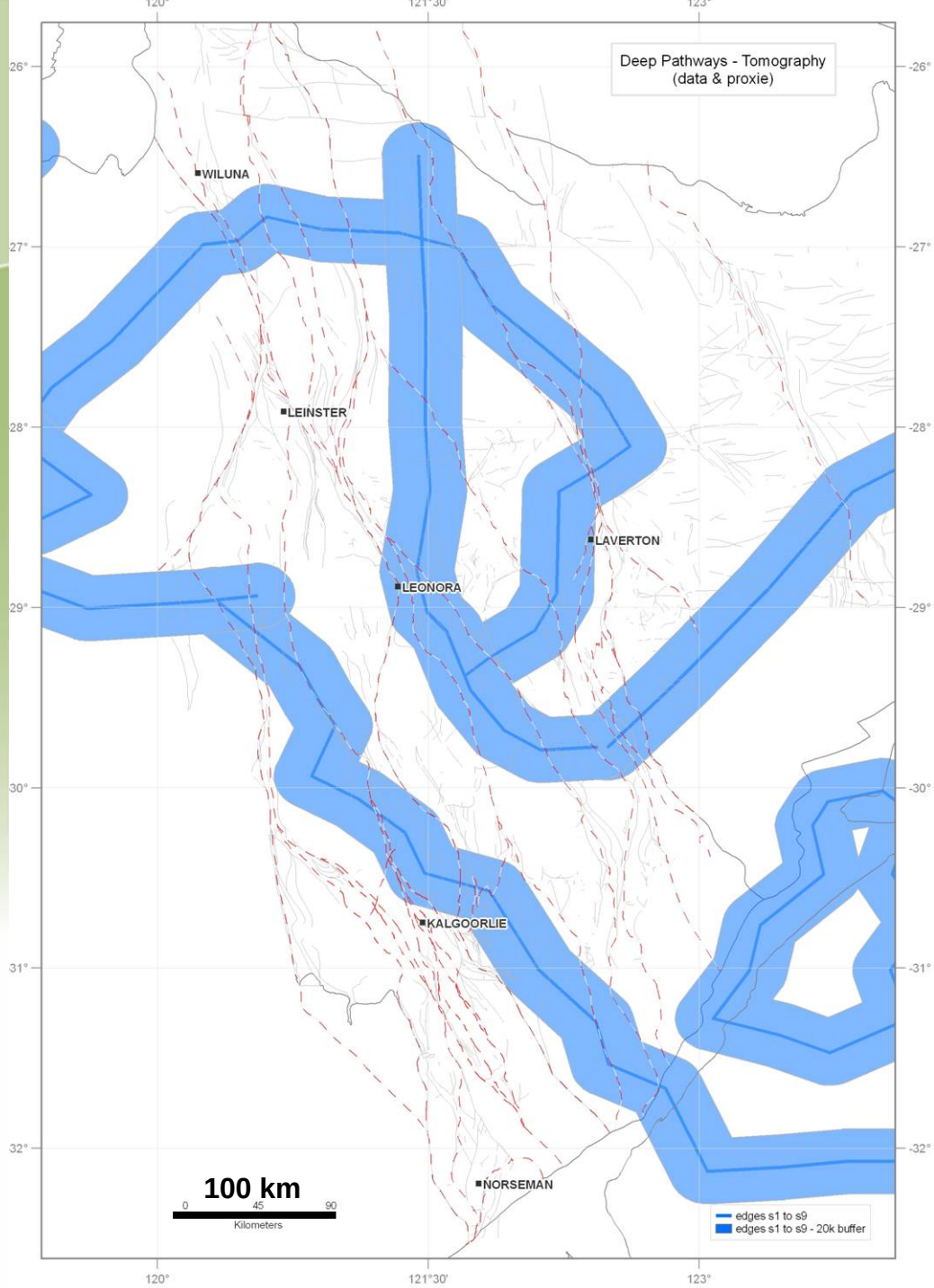
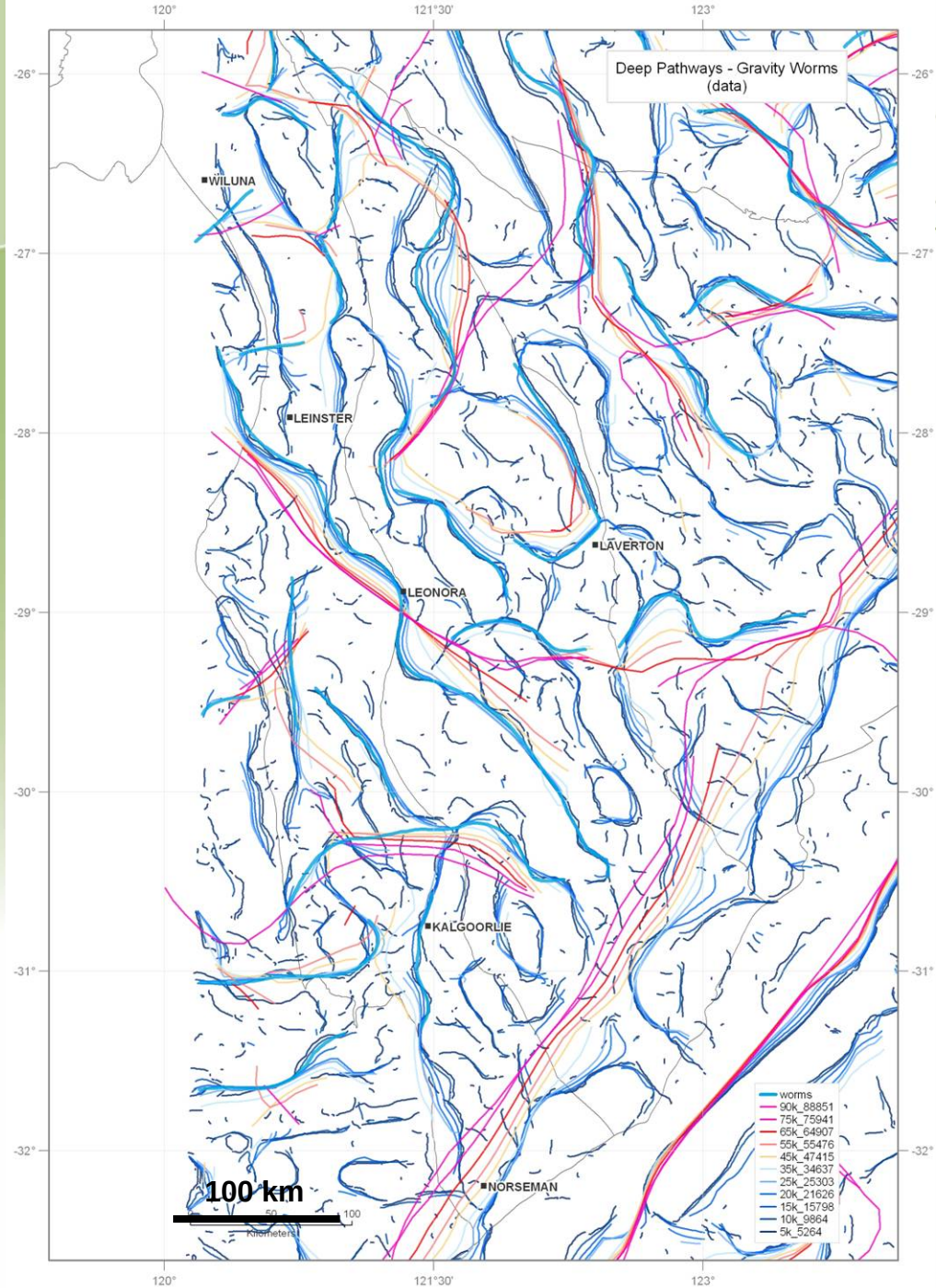


Data + proxy layer

- Deep pathways established during delamination

Deep pathways – gravity worms (WF 1)



Data layer

- **Gravity worms >45km upward continued**
- Reflect deep pathways established during the D3 lithospheric extension which established the gross architecture of the EGST

Deep pathways – gravity worms (WF 1)

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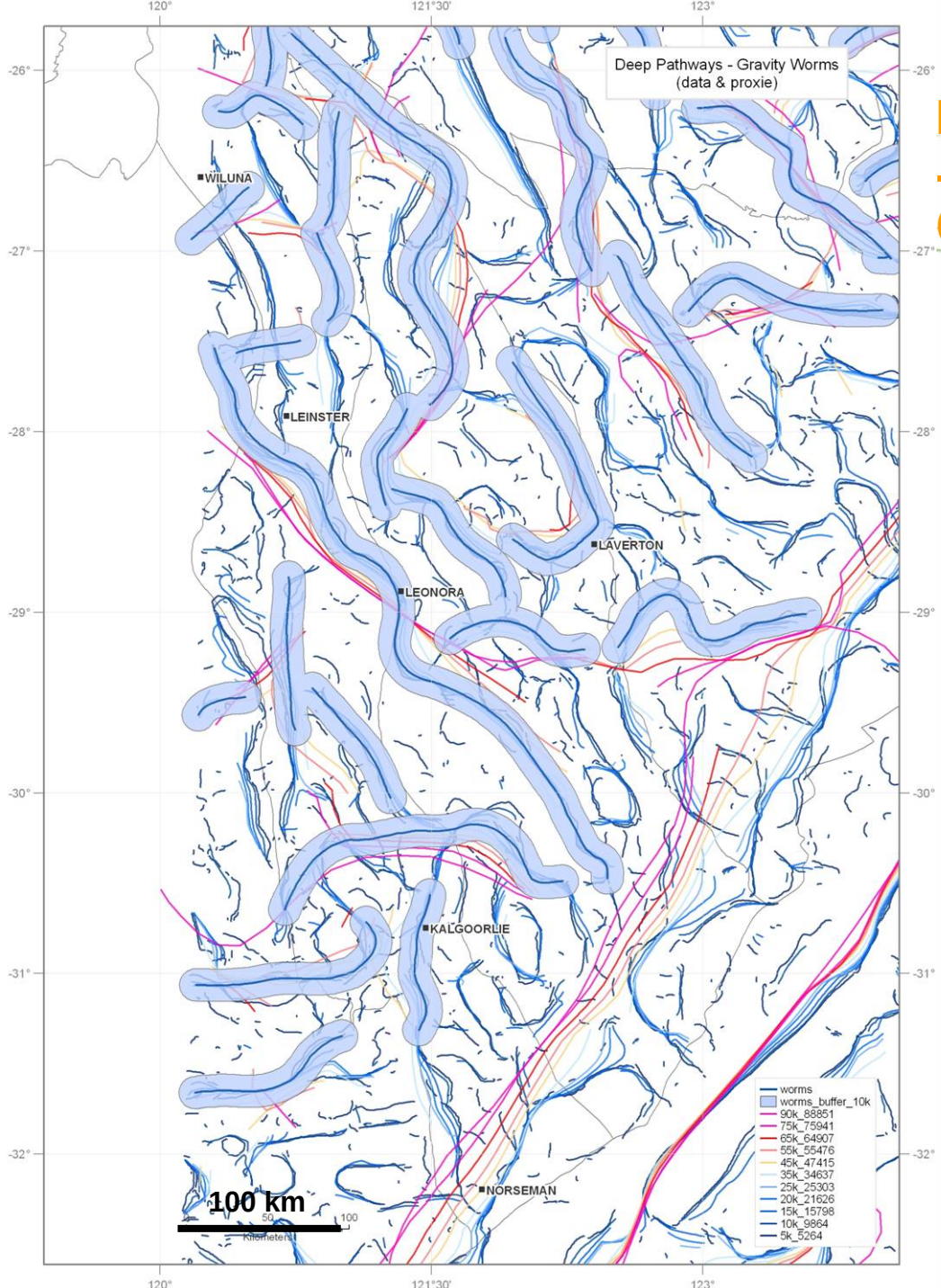

Data + proxy layer

- **Gravity worms >45km upward continued**
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Lithospheric extension Au prospectivity

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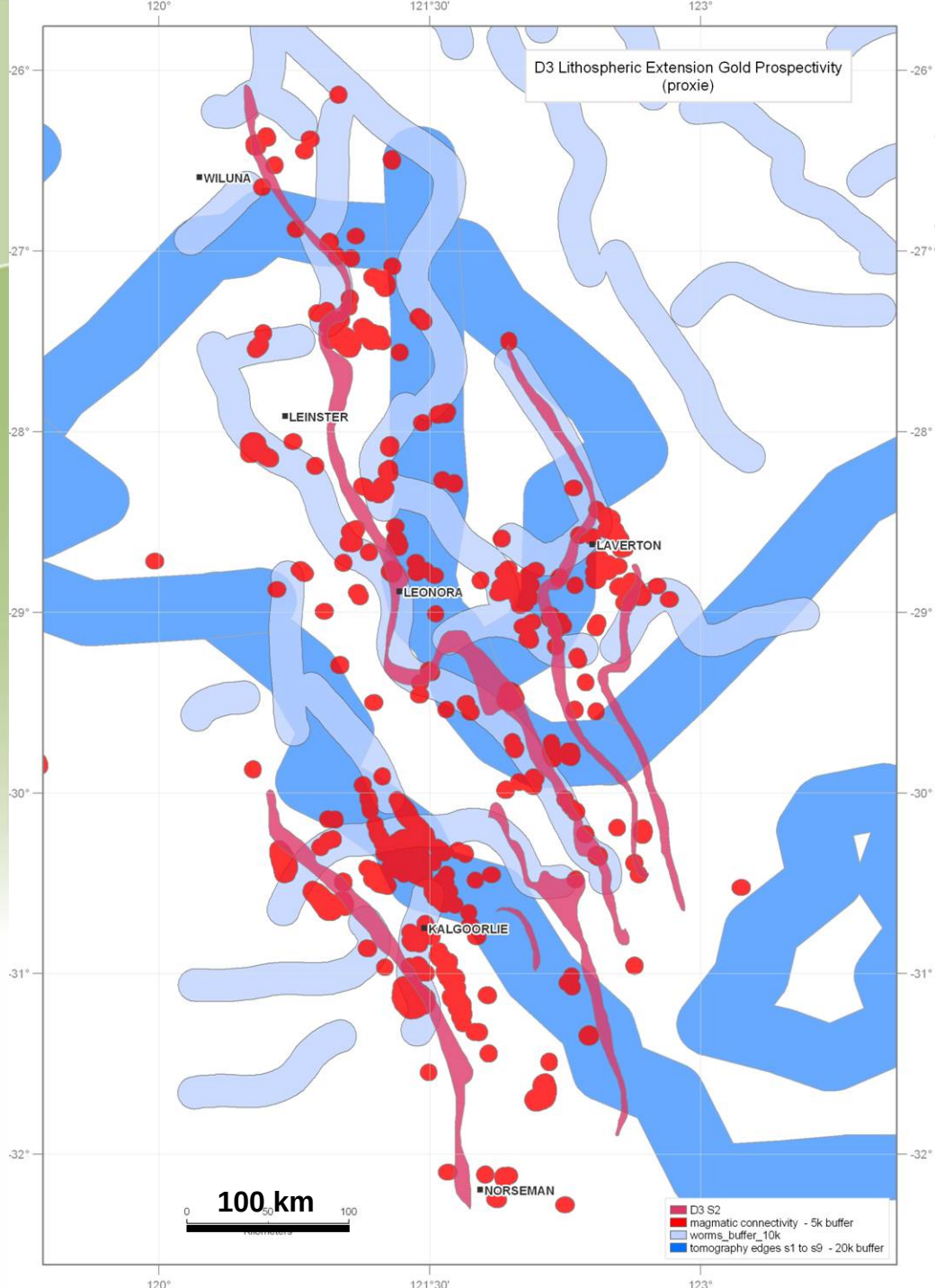

Inputs

Combination of:

- Locus of lithospheric extension
- Magmatic connectivity with enriched mantle
- Deep pathways – tomography
- Deep pathways – gravity worms

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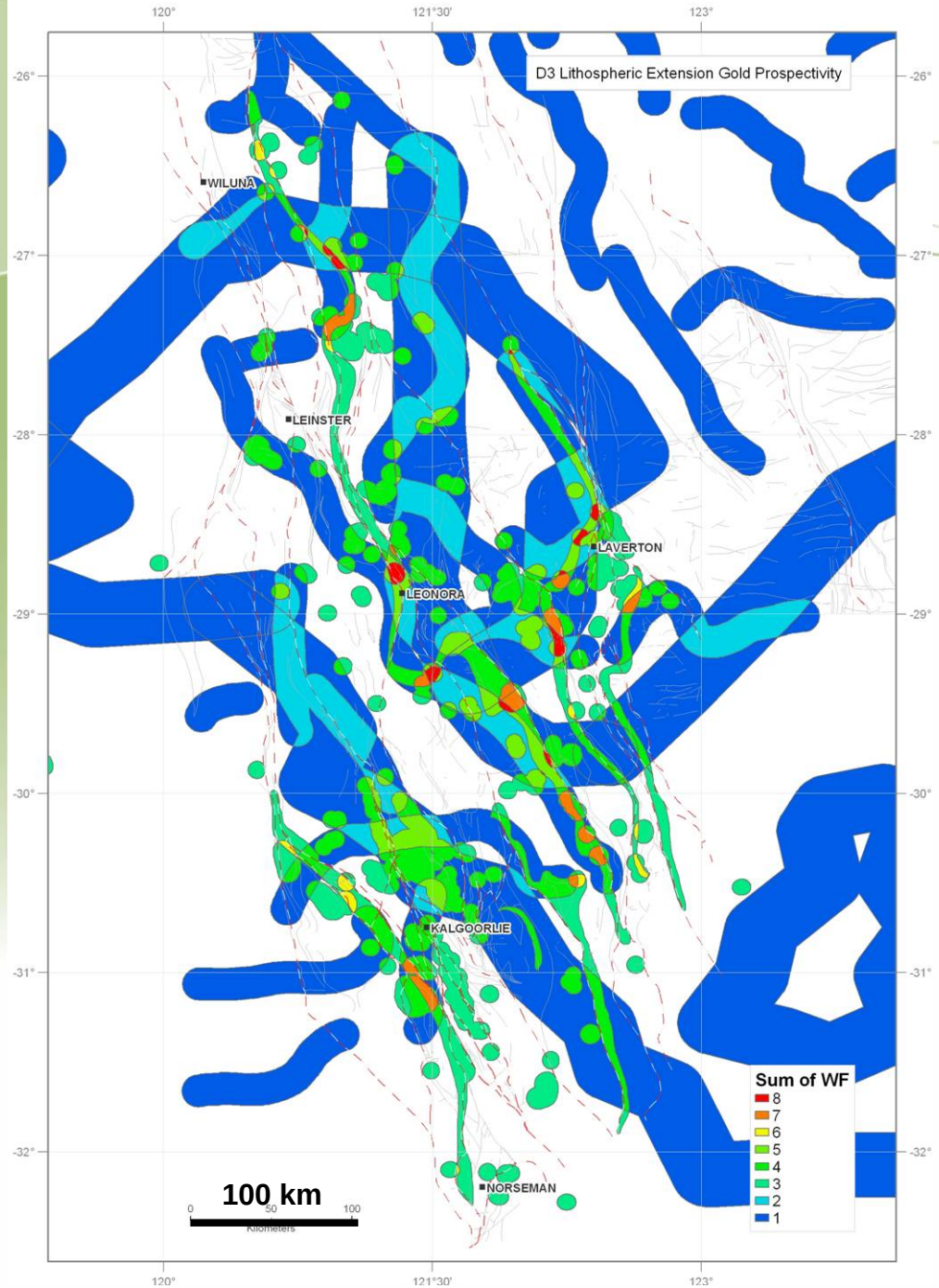

Lithospheric extension Au prospectivity

Targets

Combination of:

- Locus of lithospheric extension
- Magmatic connectivity with enriched mantle
- Deep pathways – tomography
- Deep pathways – gravity worms

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Pre-ore Targets	D3 Targets	D4-D5 Targets	Geochem Targets

Au mineral camp (60x60 km area) selection

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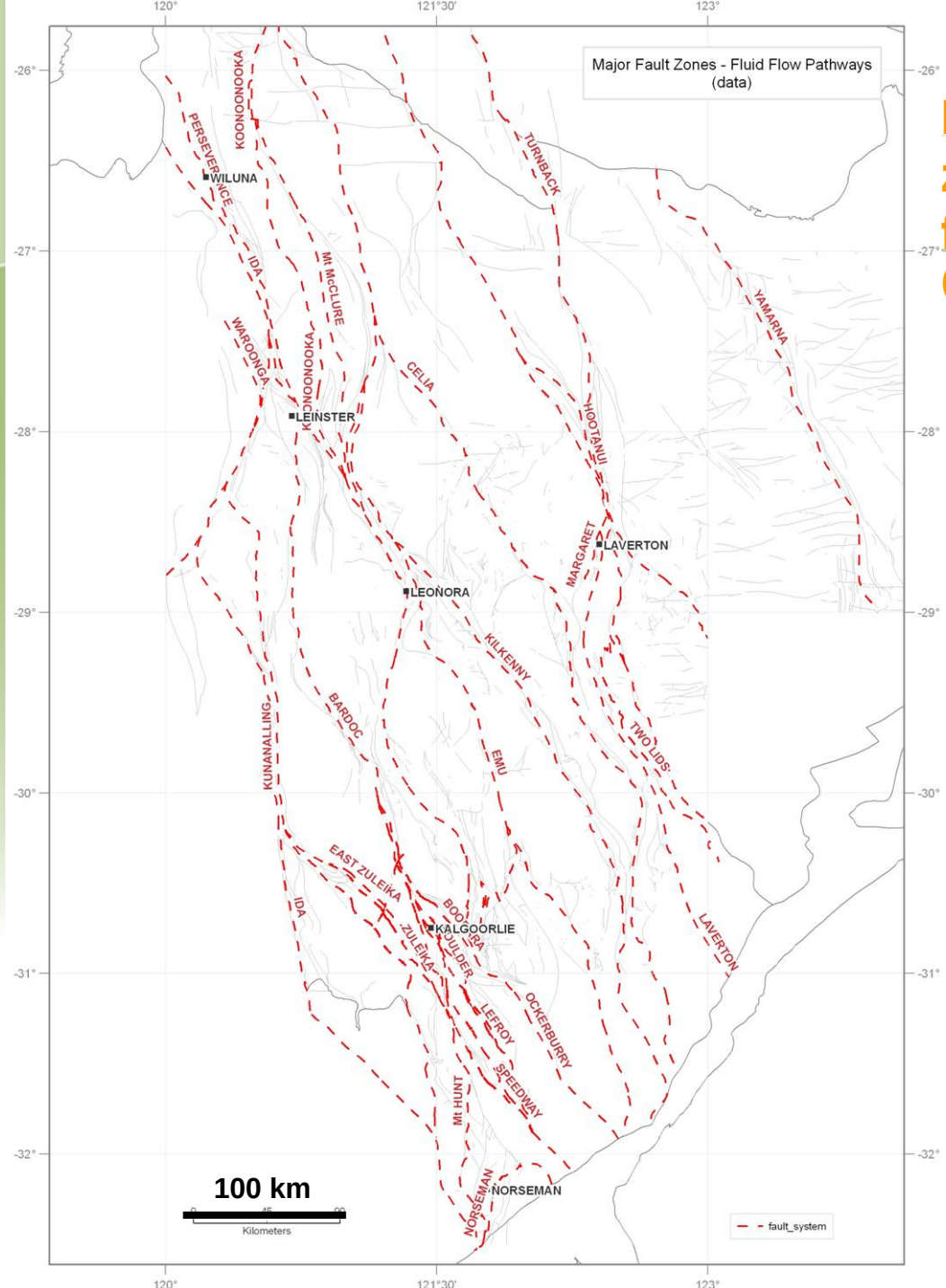
Major fault zones – fluid flow pathways (WF 3)



Data layer

- **Major faults zones are sites of strain location and dilation which facilitate fluid flow**

Major fault zones – fluid flow pathways (WF 3)

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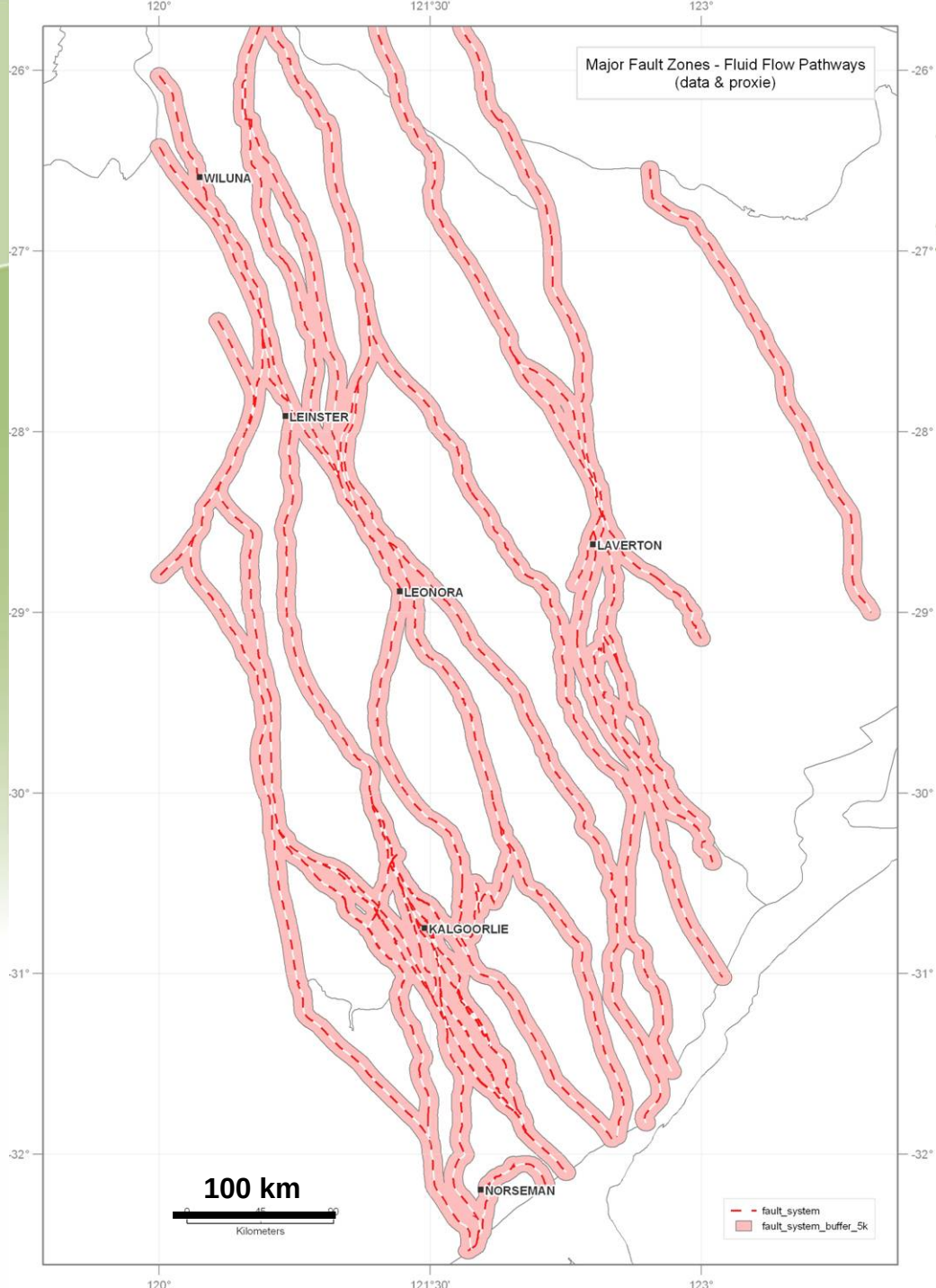

Data + proxy layer

- **Major faults zones are sites of strain location and dilation which facilitate fluid flow**
- 5km buffers have been used around the major fault systems to account for 2nd and 3rd order structures and damage zones around the faults.

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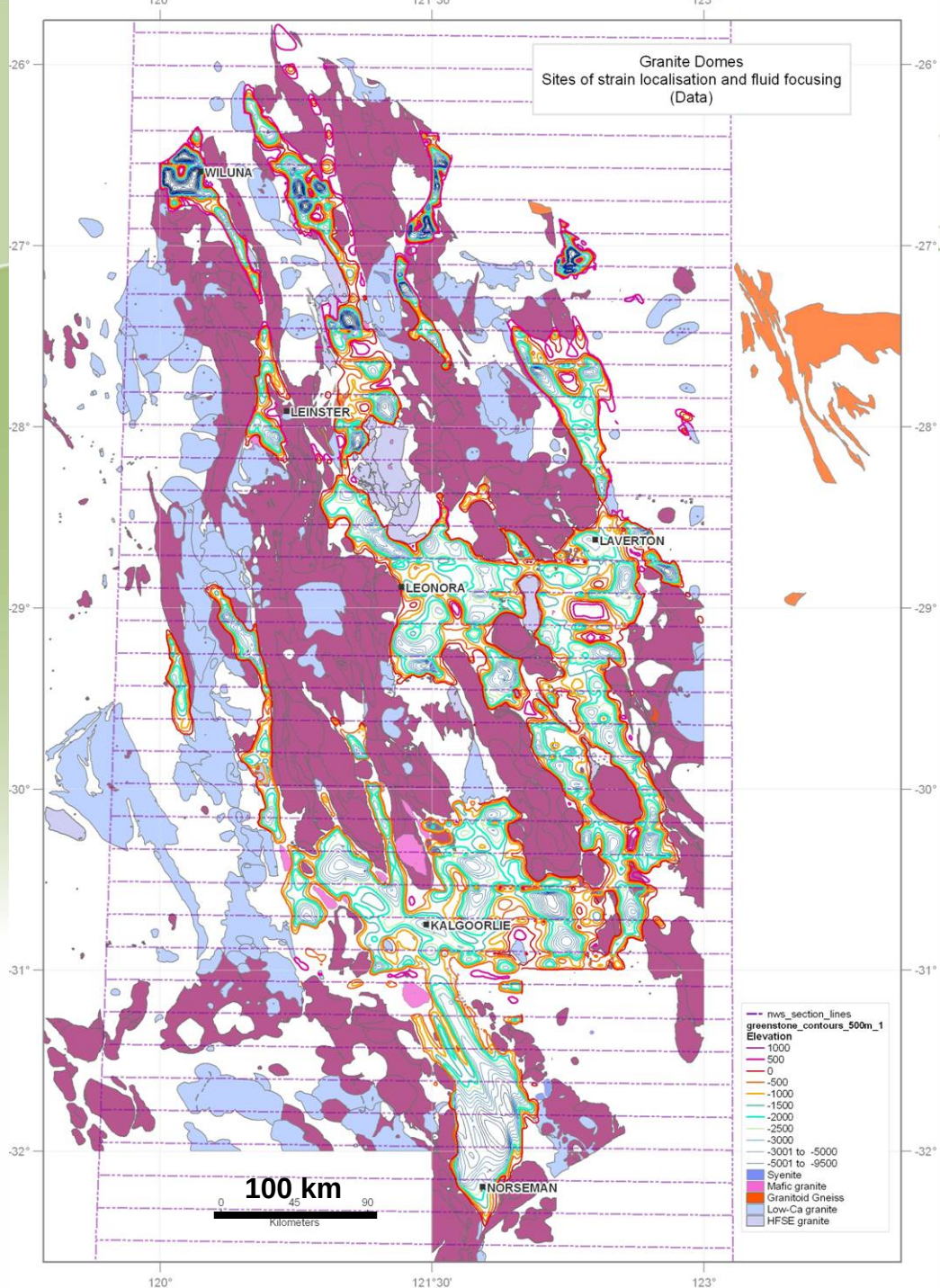
Granite domes – sites of strain localisation and fluid focusing (WF 1)

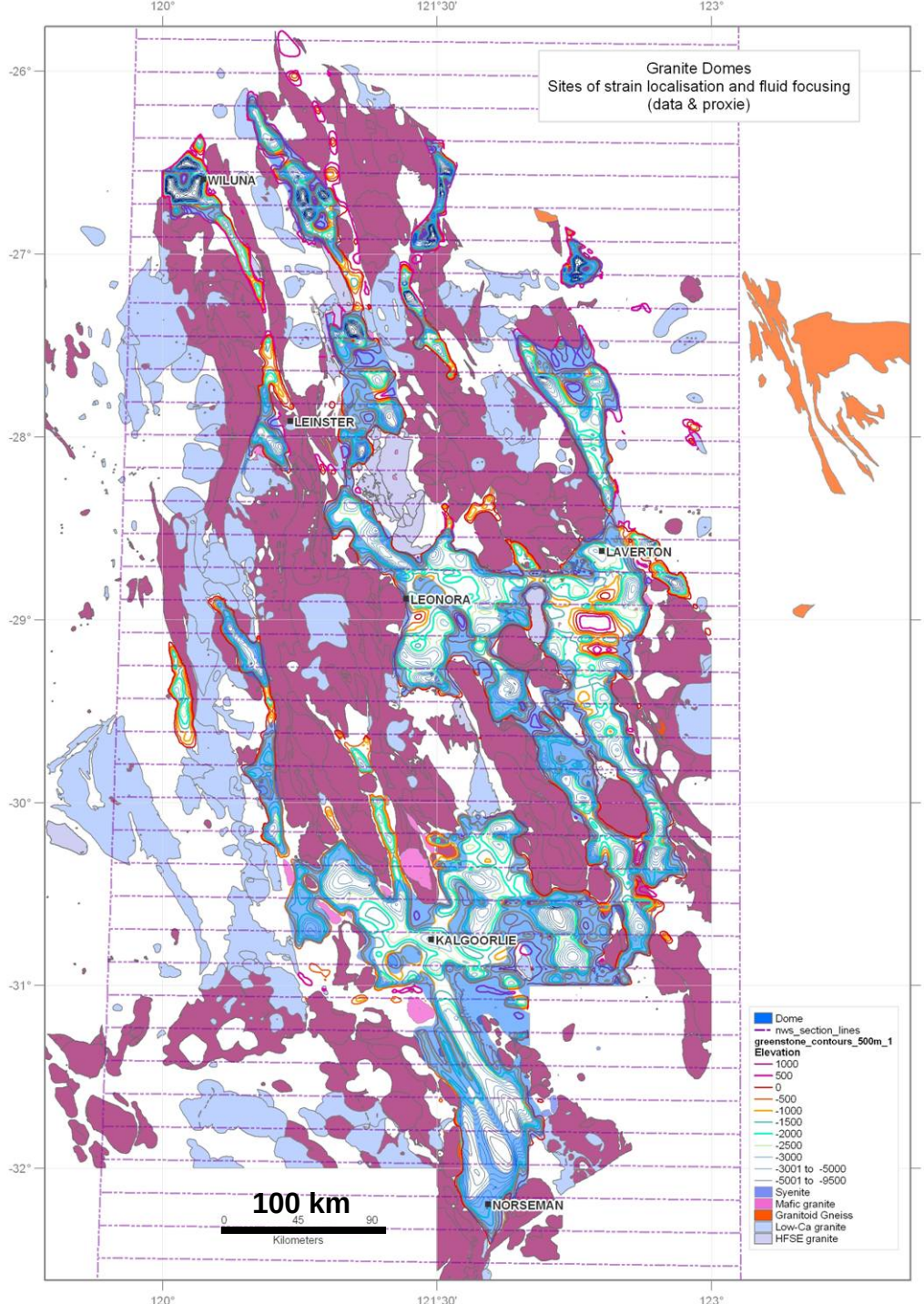
Data layer



- **Granites domes localise strain along their flanks and focus fluid flow to their apex if overlain by a seal.**
- Used a projection of the base of greenstone derived from a 3D gravity inversion constrained using forward modelled cross-sections. There are many anomalies in this product resulting from the inversion thereby reducing the weighting factor of this product to 1.

Granite domes – sites of strain localisation and fluid focusing (WF 1)

Data + proxy layer



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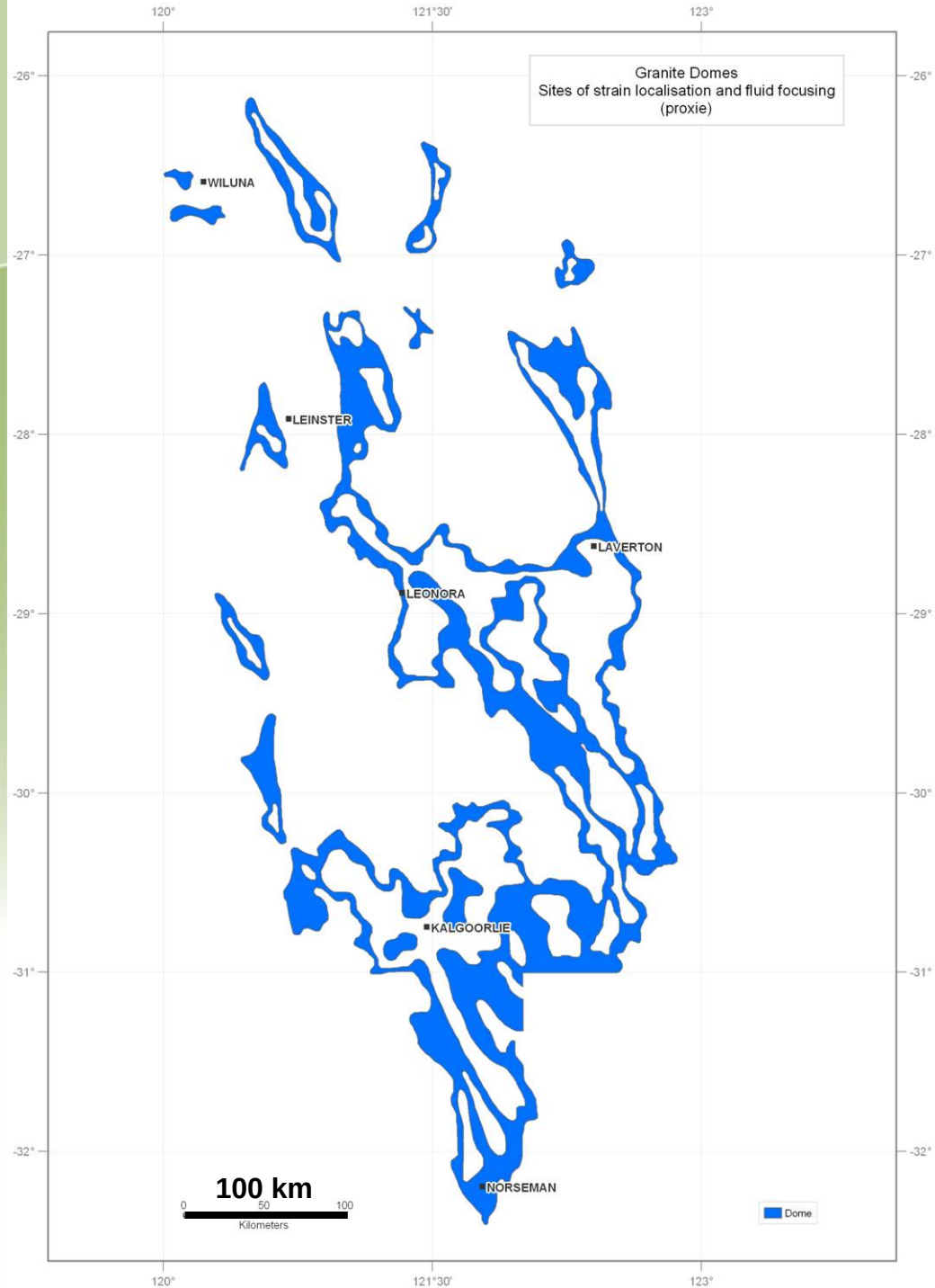
proxy layer



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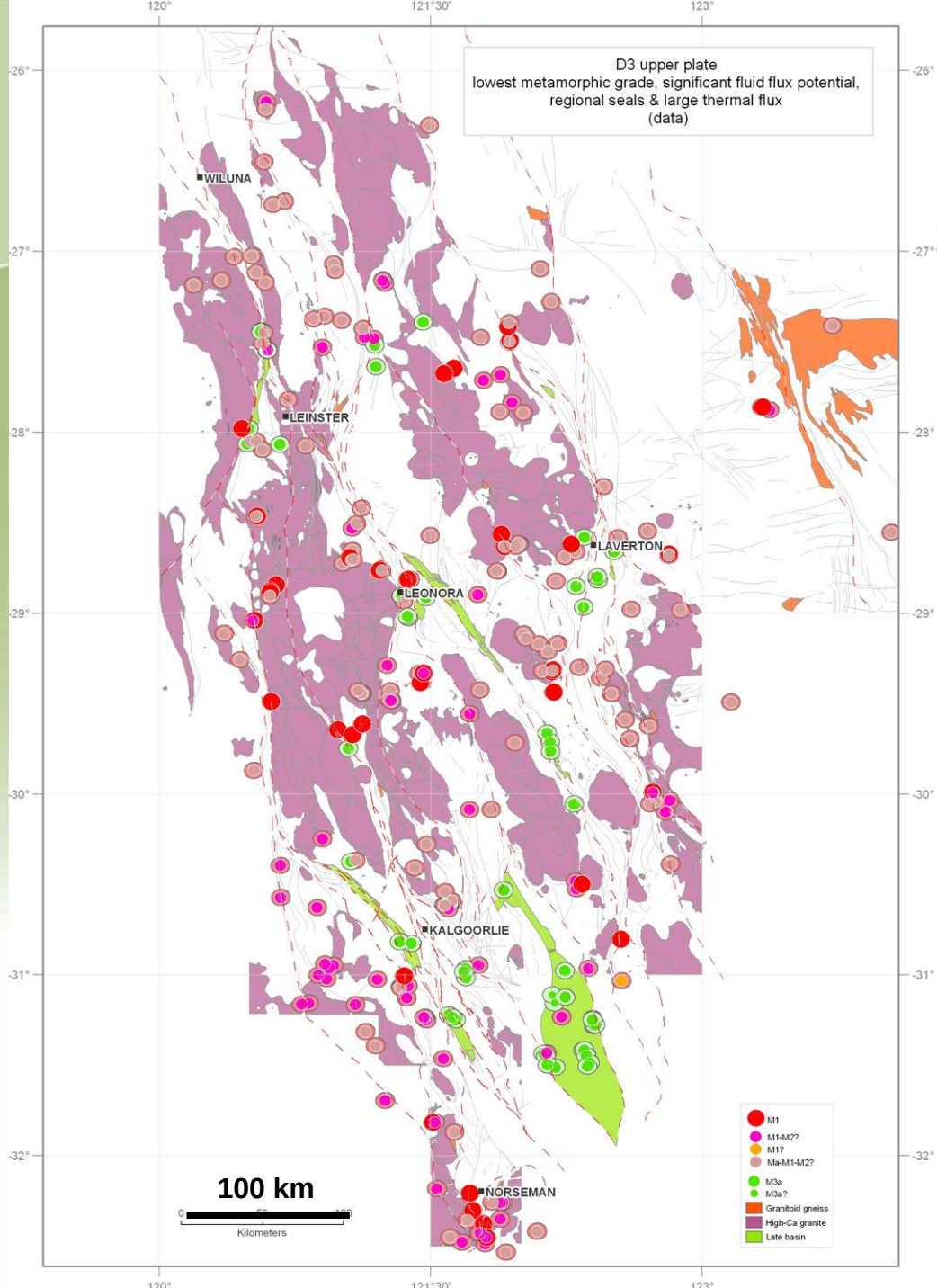

D3 upper plate – lowest metamorphic grade, significant fluid flux potential, regional seals & large thermal flux (WF 3)

Data + proxy layer

Upper plate:

- M3 data points
- Location of Late Basins

Lower plate:

- M1 data points

The D3 upper plate maps out:

- Approximate distribution of lower grade rocks and hence more brittle regimes which facilitate fluid flow
- The possible distribution of Late Basins and hence regional seals
- Distribution of extensional fluid reservoirs especially from the late basins
- Regions of high heat flux since they correspond to regions of maximum crustal thinning.

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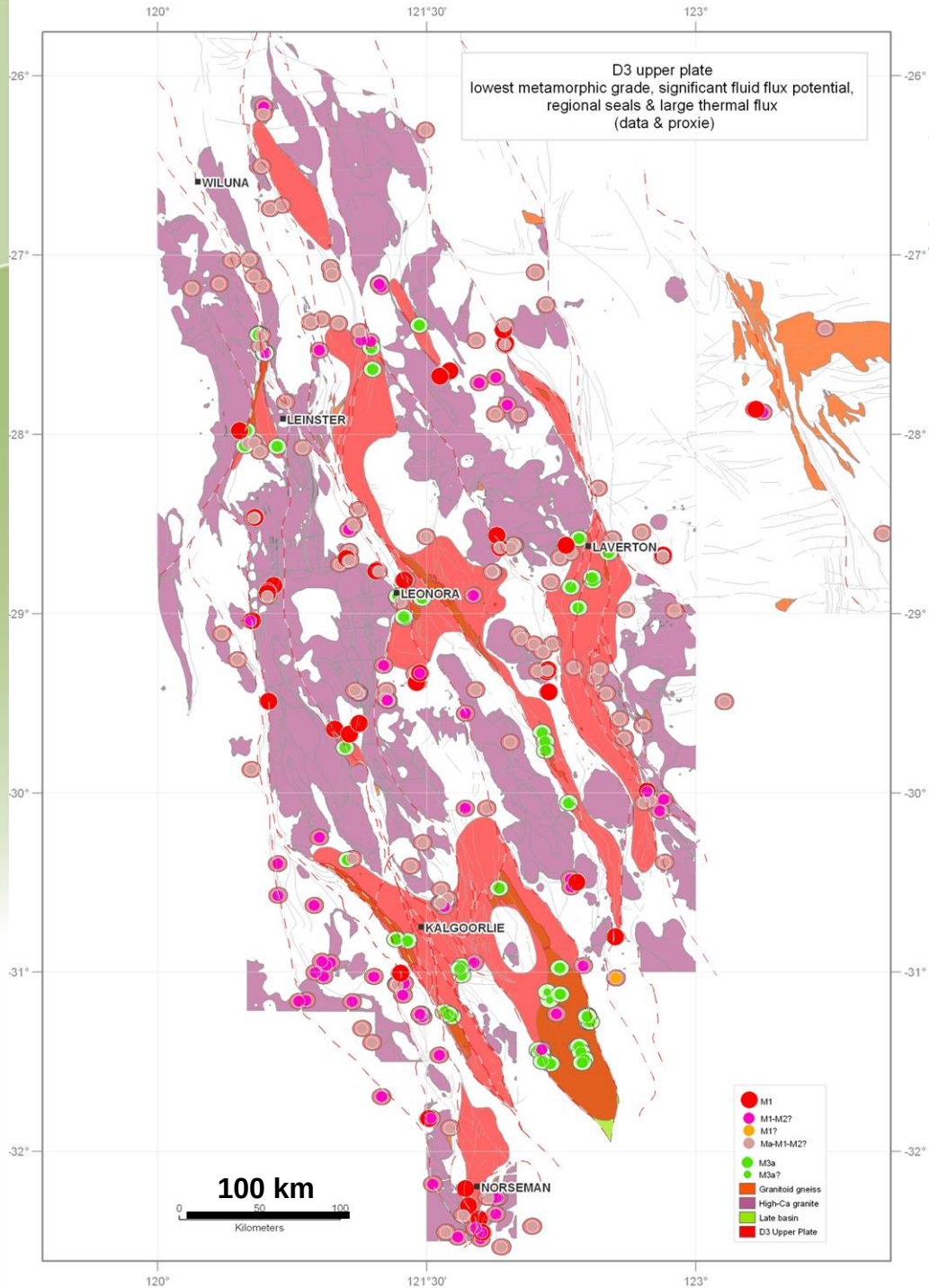

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- The possible distribution of Late Basins and hence regional seals and reductants
- Distribution of extensional fluid reservoirs especially from the late basins
- Regions of high heat flux since they correspond to regions of maximum crustal thinning

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Inversion Au prospectivity

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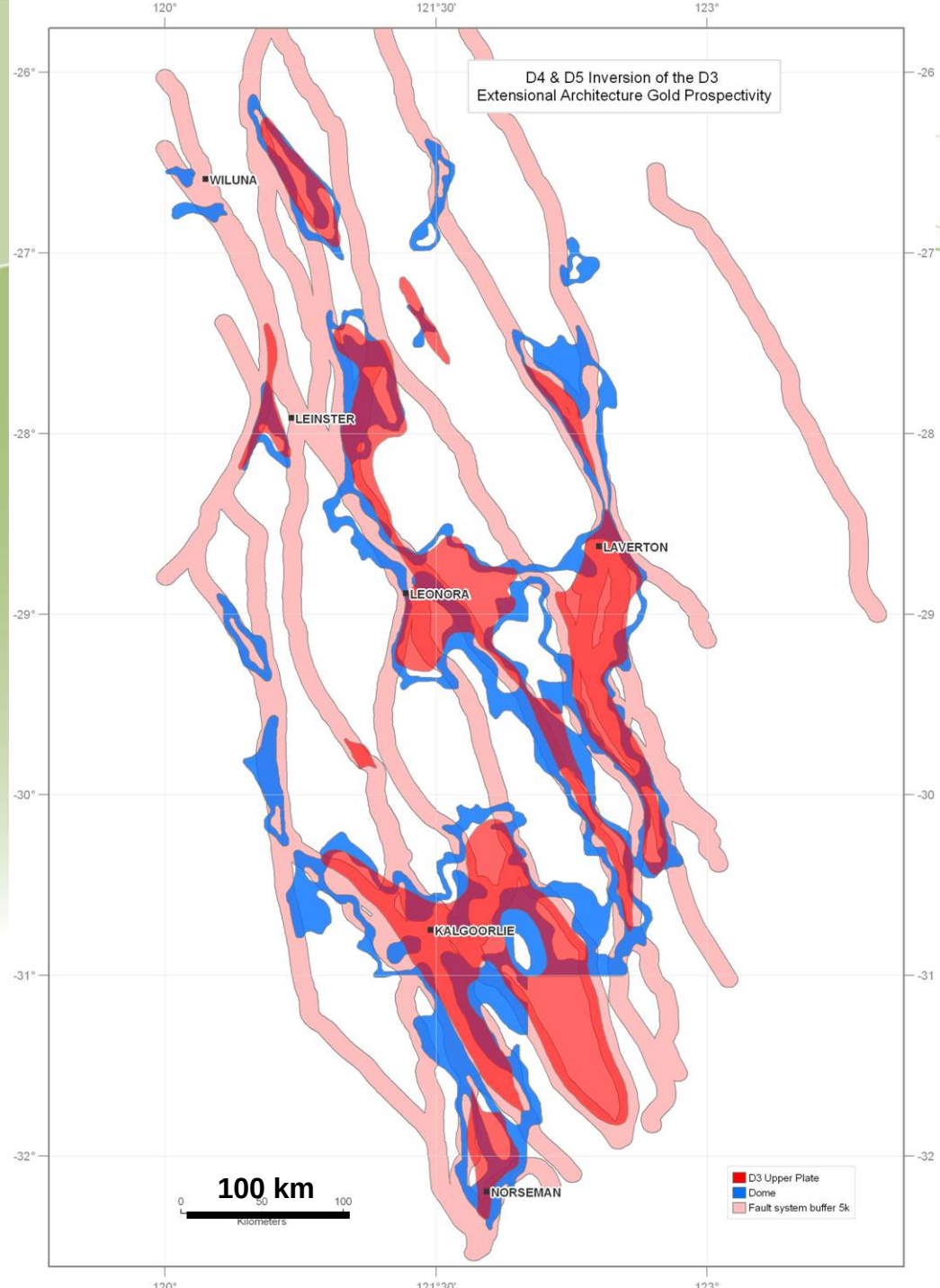

Inputs

Combination of:

- Major fault zones
- Granite Domes
- D3 Upper plate

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Inversion Au prospectivity

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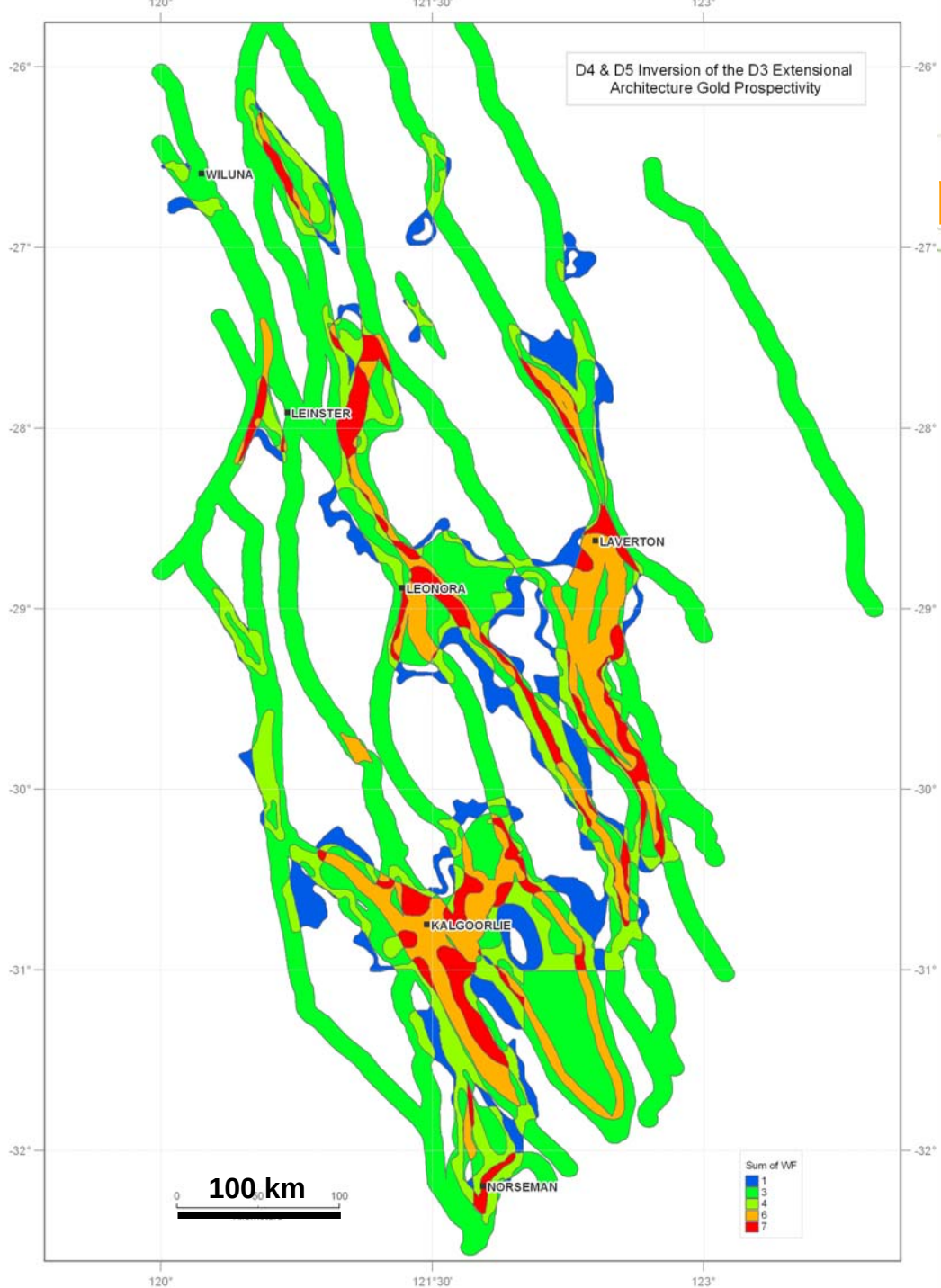

Targets

Combination of:

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- Granite Domes
- D3 Upper plate

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Au mineral camp (60x60 km area) selection

Hydrothermal system indicator (WF 1)

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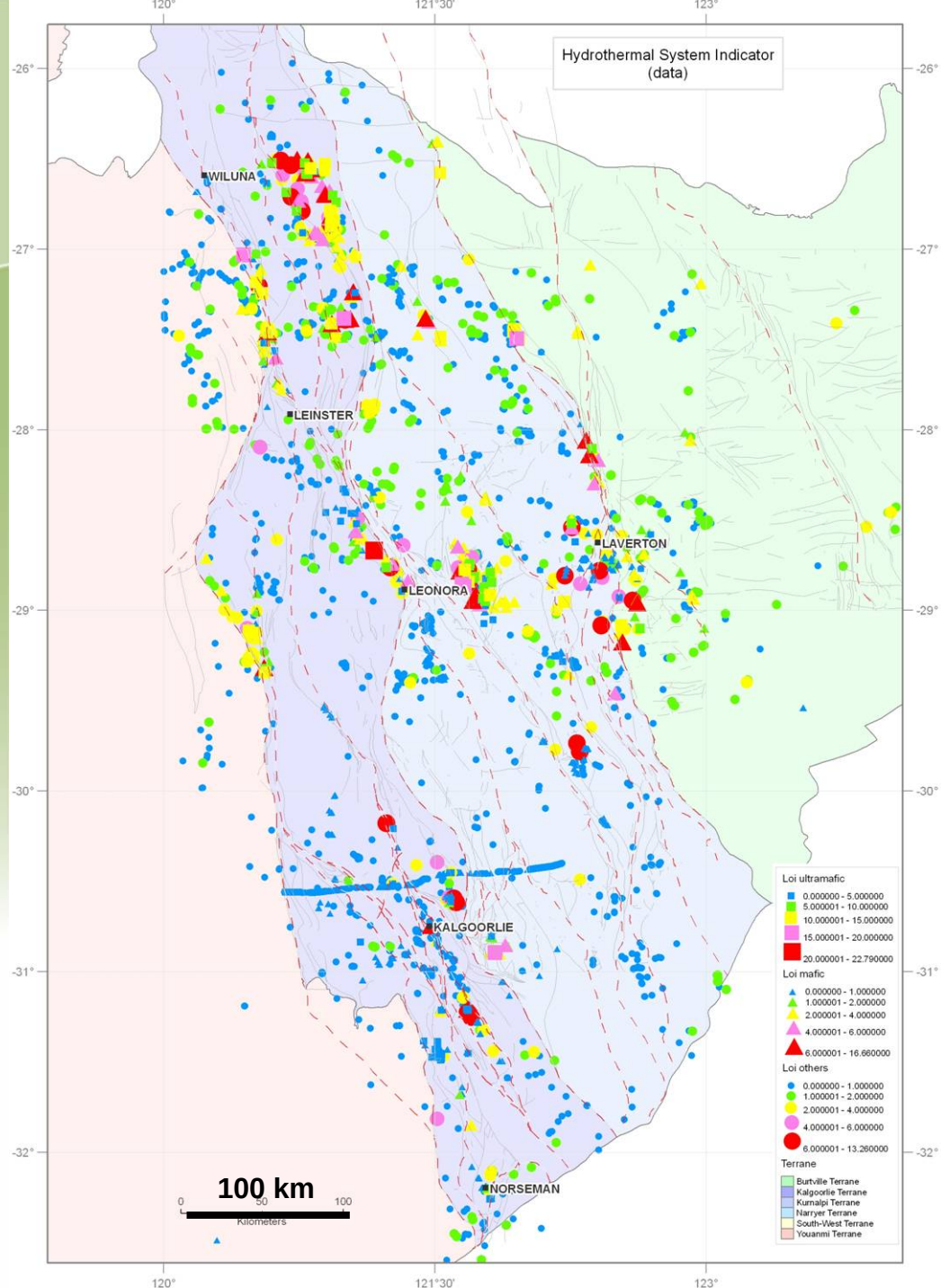

Data layer

- **Hydrothermal systems are associated with the transport of volatile elements eg. H_2O and CO_2..** Therefore hydrothermal systems can be detected from regional geochemical data as Loss on Ignition (LOI)

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Hydrothermal system indicator (WF 1)

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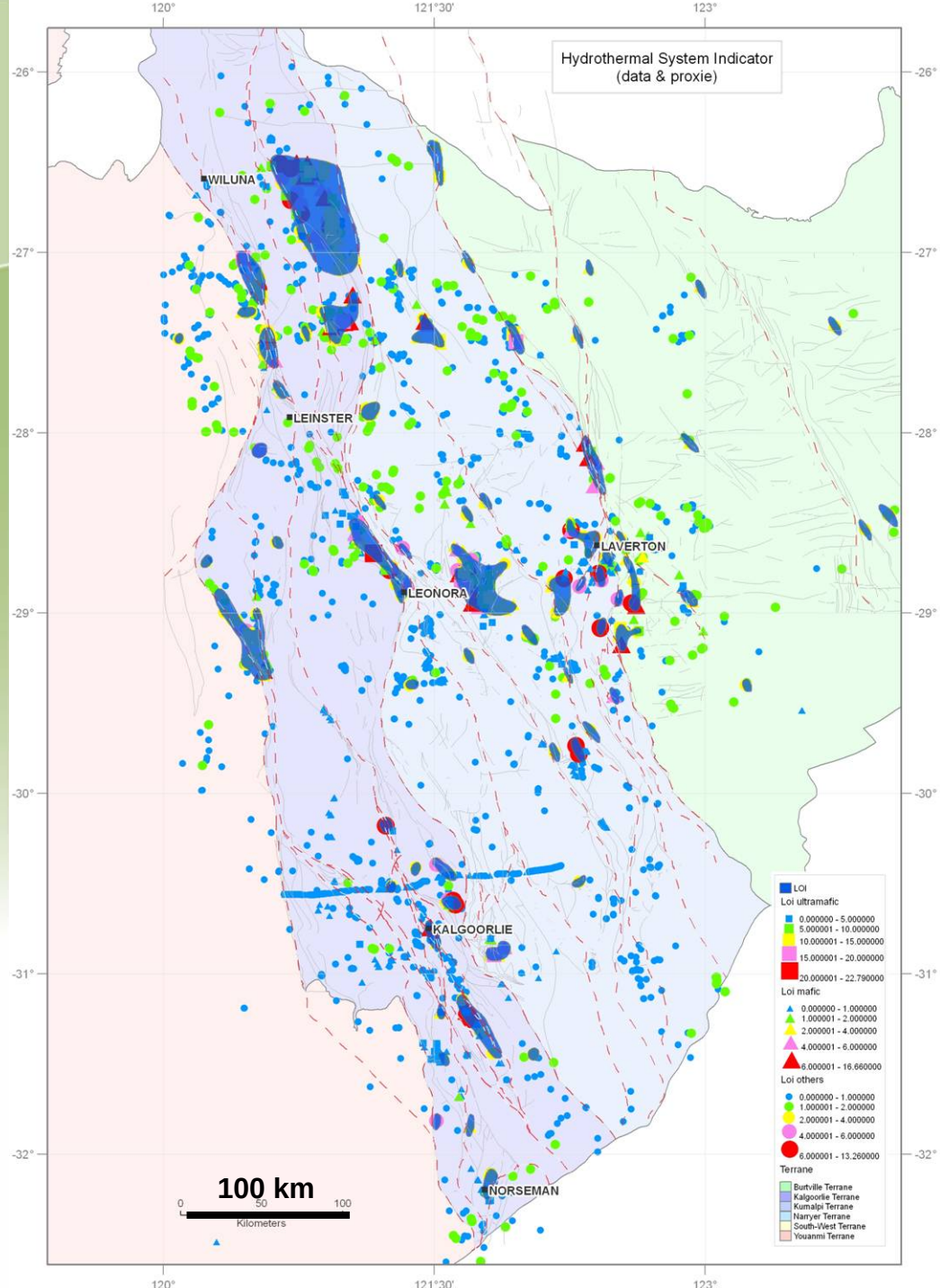

Data + proxy layer

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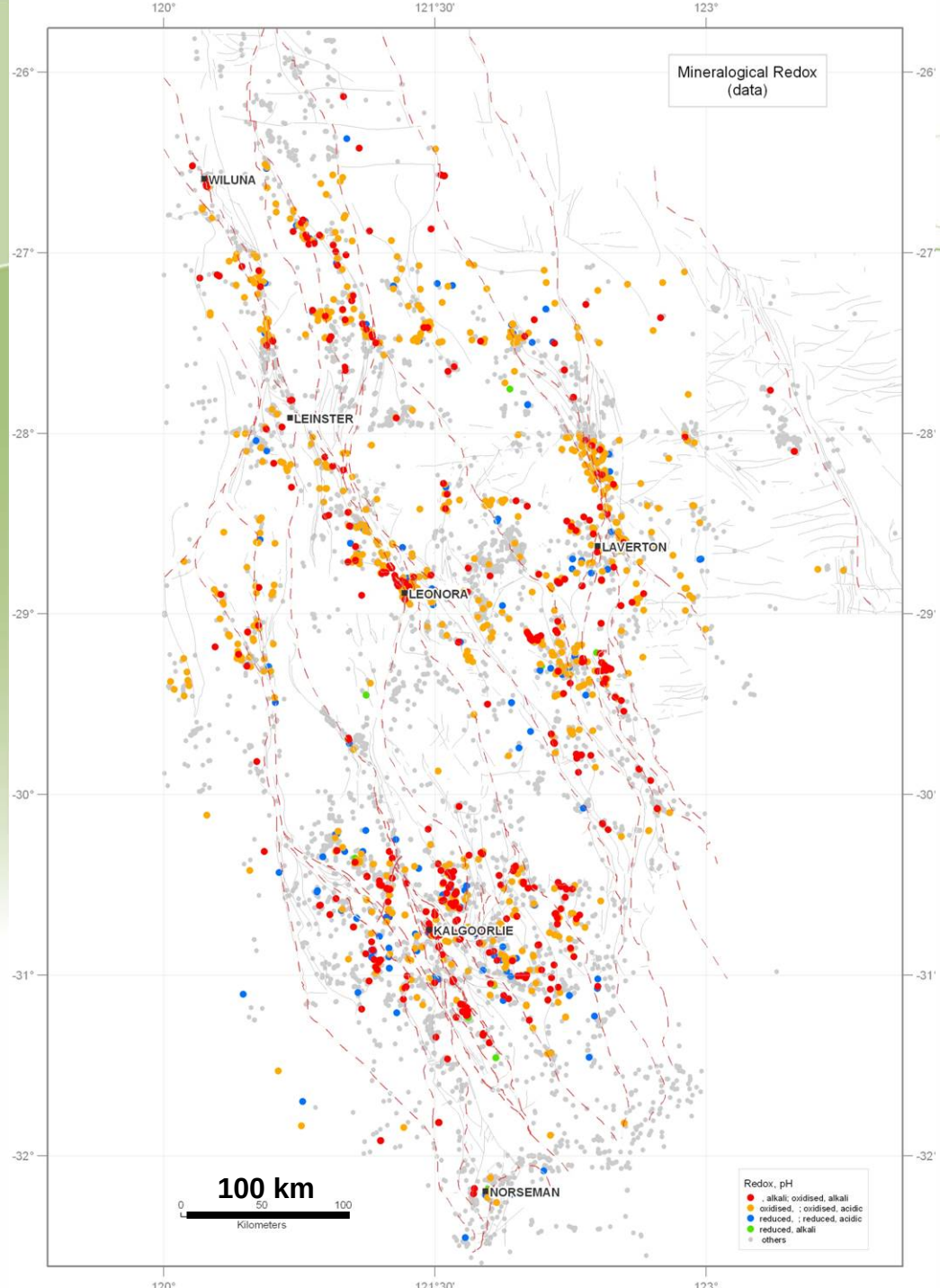
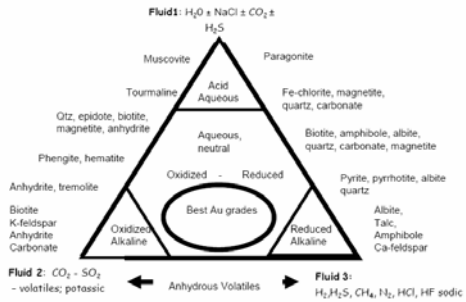


Geochemical Gradient Au

Mineralogical Redox Gradients (WF 2)

Data layer

- Walsh et al. transfer their understanding of redox based on mine scale isotopic data into variations in mineralogy



- Ben Goscombe then mapped out regional reduced and oxidised domains using his point mineralogical data set (>12,000pts)

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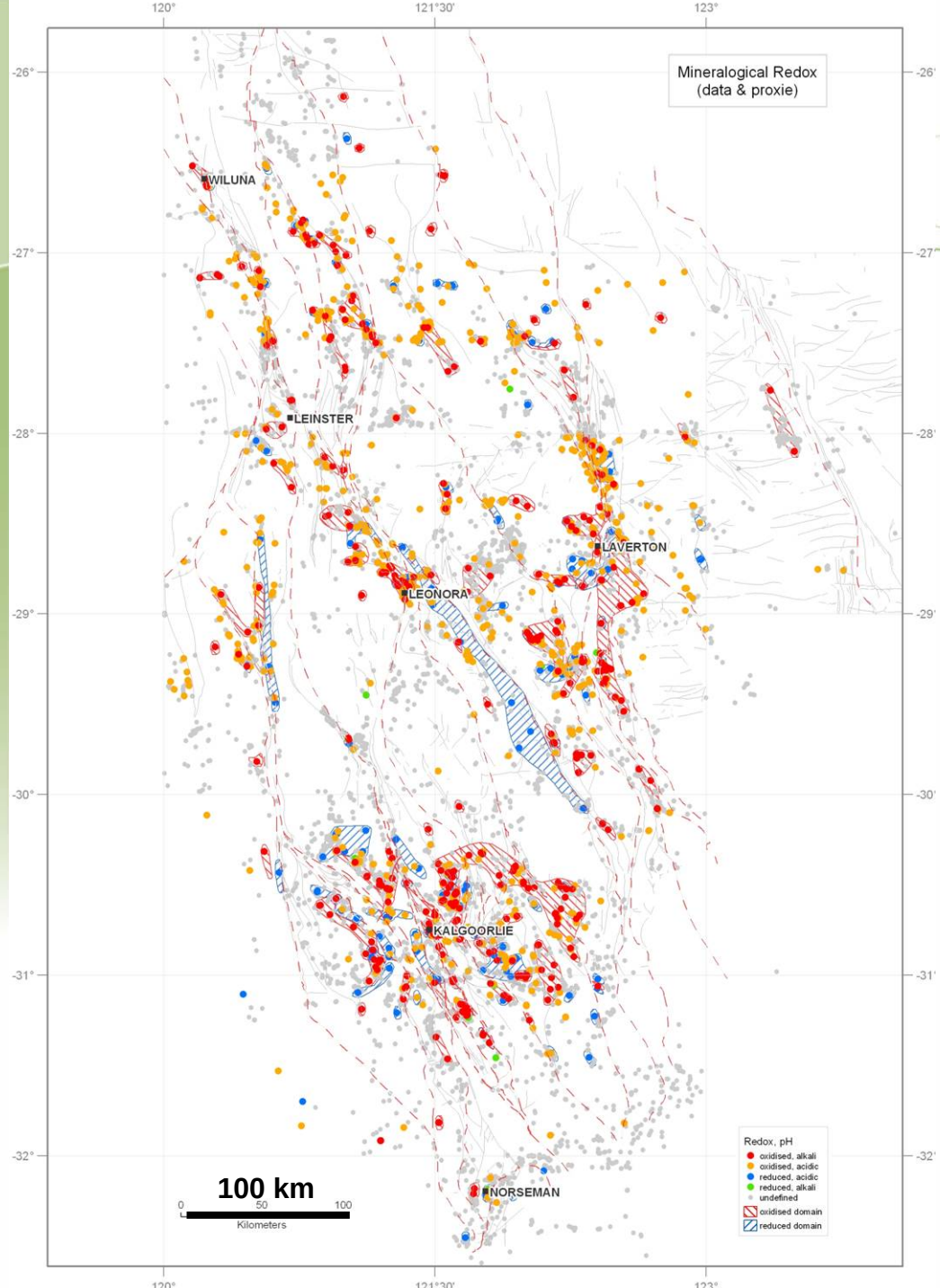
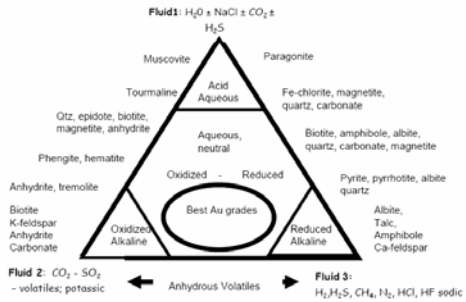


Mineralogical Redox Gradients (WF 2)

Data layer + interp

- Walsh et al. transferred their understanding of redox based on mine scale isotopic data into variations in mineralogy



- Ben Goscombe then mapped out regional reduced and oxidised domains using his point mineralogical data set (>12,000pts)

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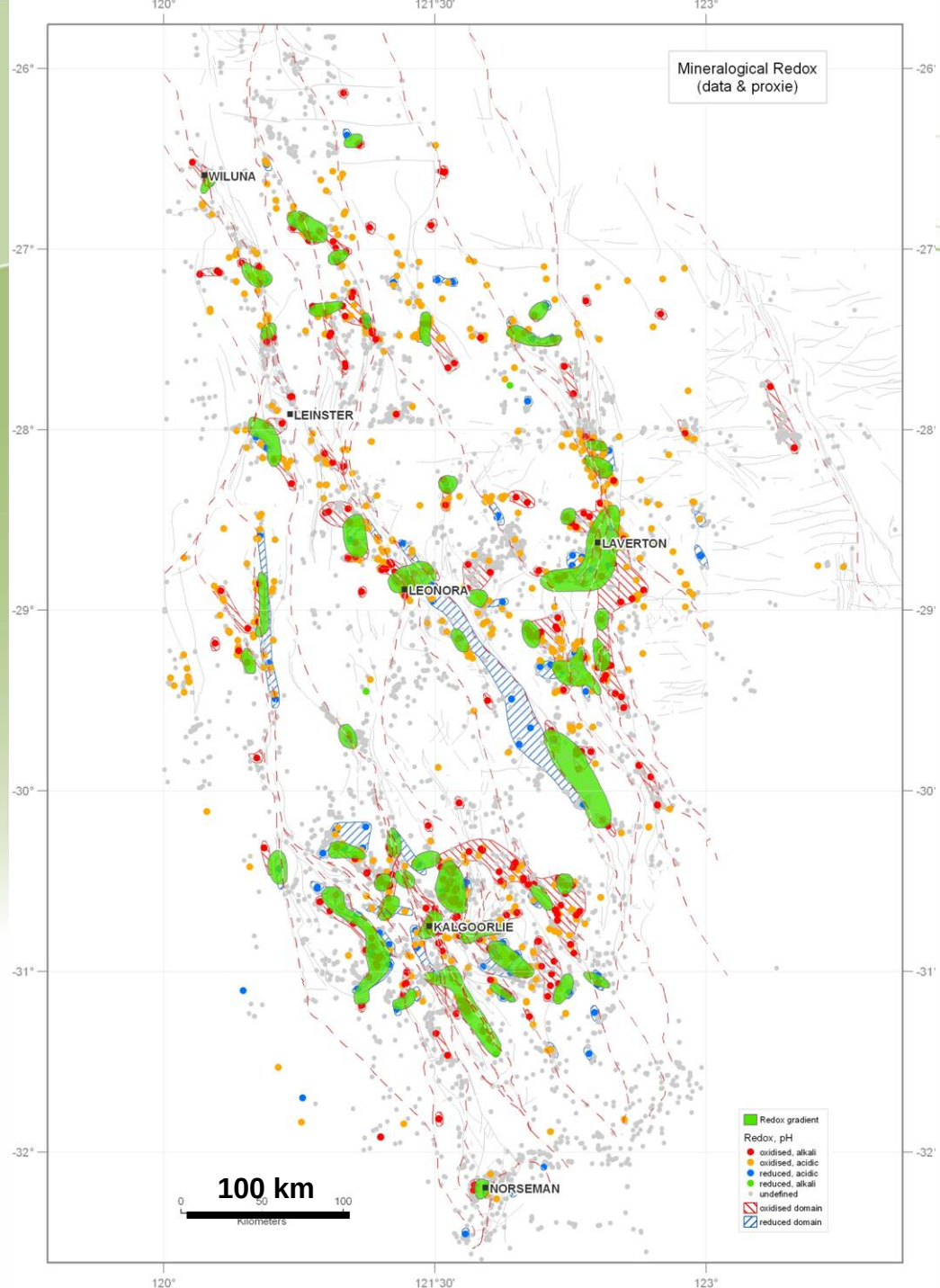
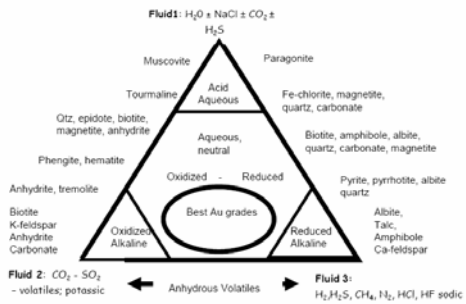


Mineralogical Redox Gradients (WF 2)

Data + proxy layer

- Walsh et al. transfer their understanding of redox based on mine scale isotopic data into variations in mineralogy



- Ben Goscombe then mapped out regional reduced and oxidised domains using his point mineralogical data set (>12,000pts)

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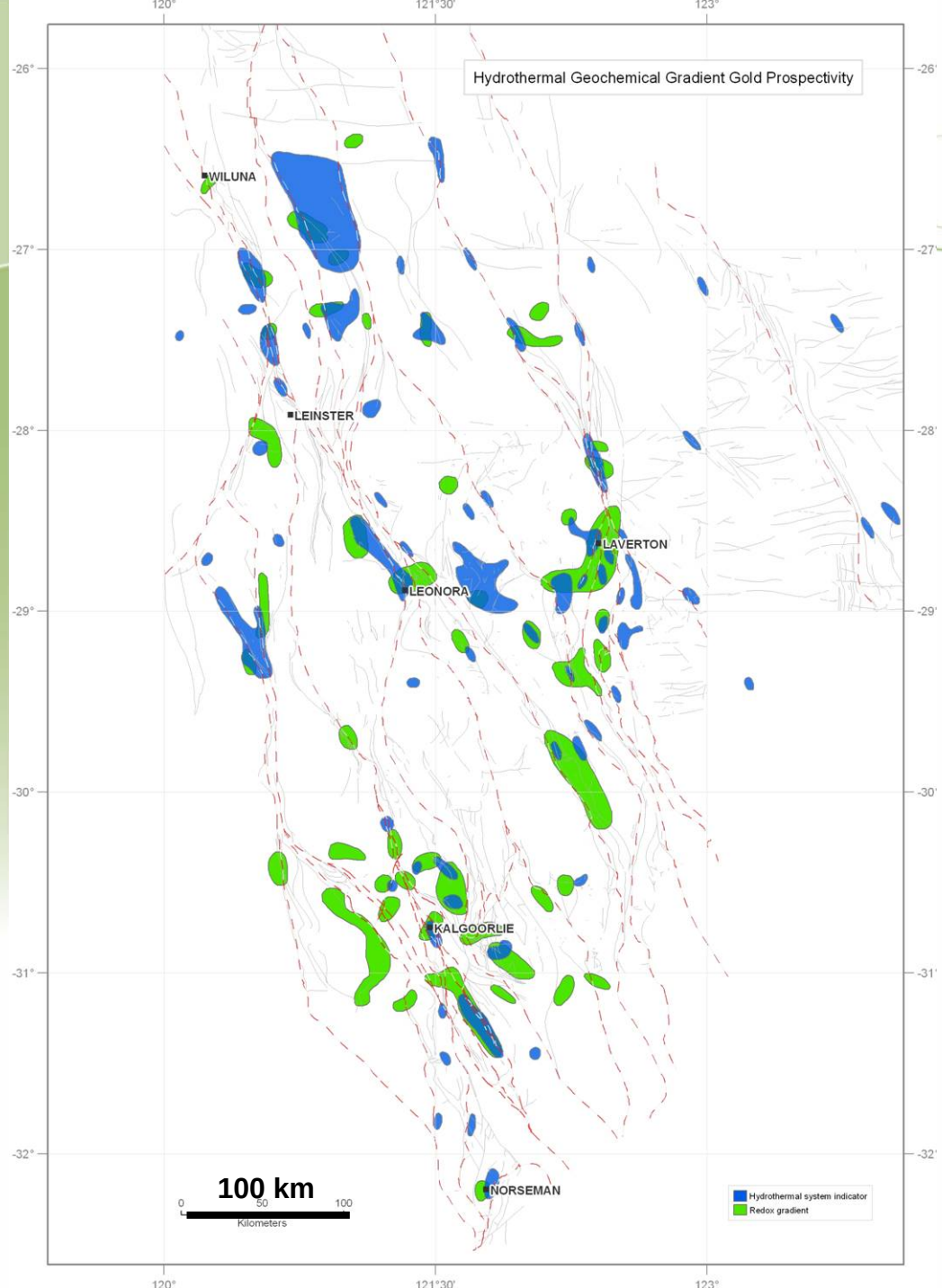
Geochemical Gradient Au prospectivity



Inputs

Combination of:

- Hydrothermal system indicator
- Mineralogical redox gradients

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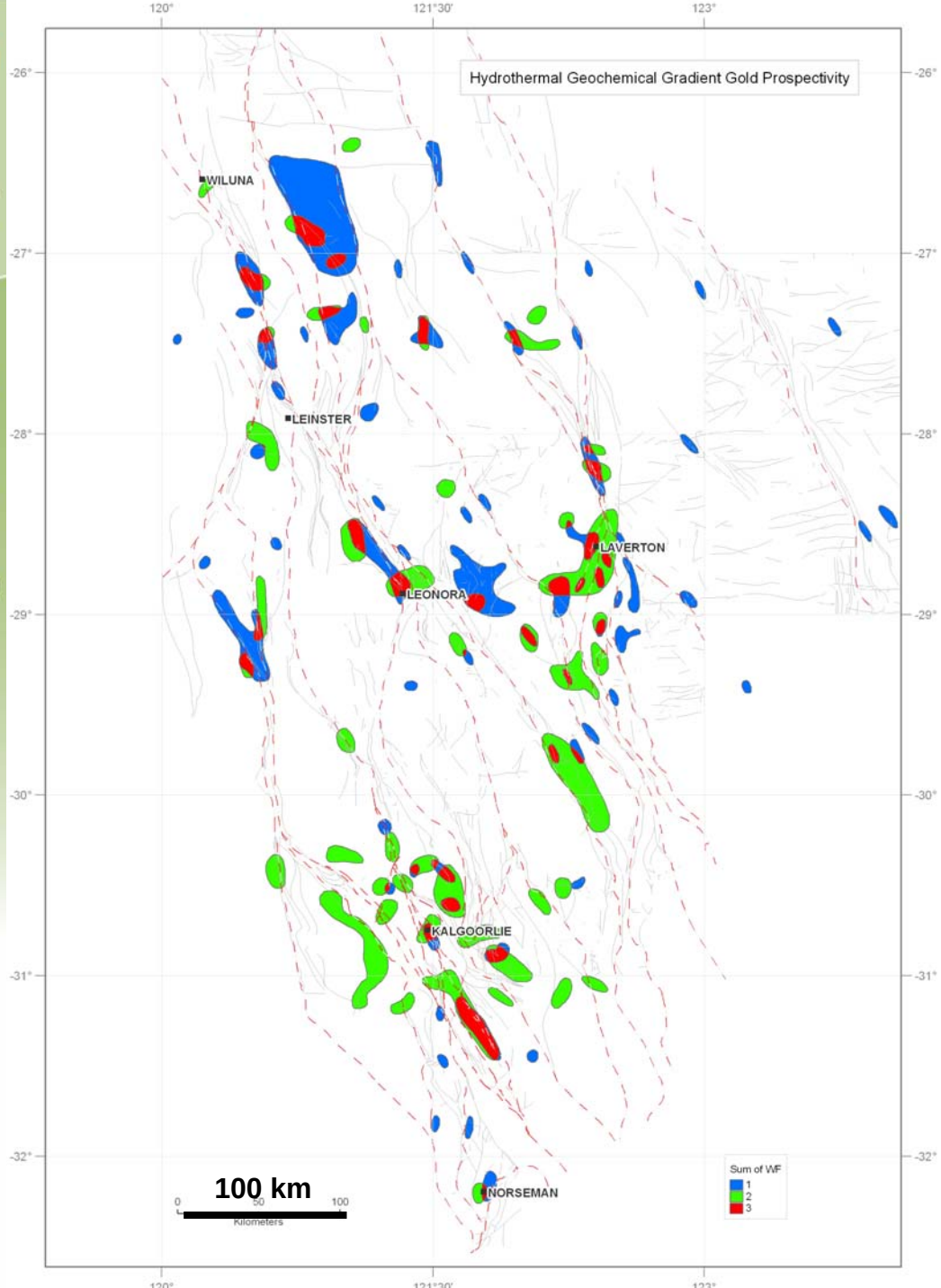
Geochemical Gradient Au prospectivity



Targets

Combination of:

- Hydrothermal system indicator
- Mineralogical redox gradients

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Mineral System Understanding

Geodynamic Episodes

Geochemical Gradients

Pre-ore endowment (<2665 Ma)	Lithospheric extension Au (~2665-2655 Ma)	Inversion Au (≥2660 Ma)

Identification of mappable mineral system process proxies for each subdivision

• Crustal endowment	• Extensional SZ • Metasomatised mantle melts • Deep pathways	• Domes • Major faults • Upper plate	• Redox gradients • Hydrothermal system indicator
Pre-ore Targets	D3 Targets	D4-D5 Targets	Geochem Targets

Au mineral camp (60x60 km area) selection

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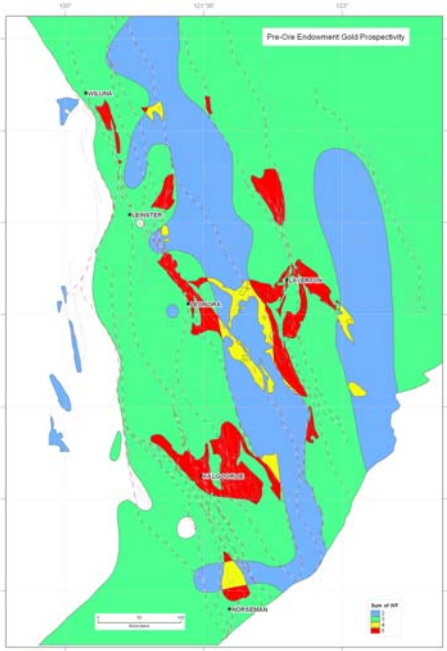

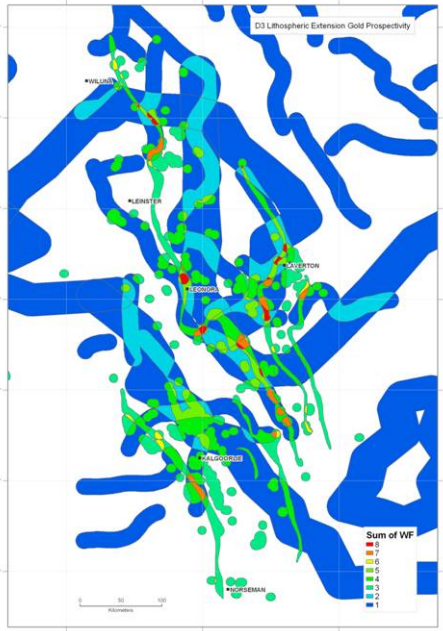

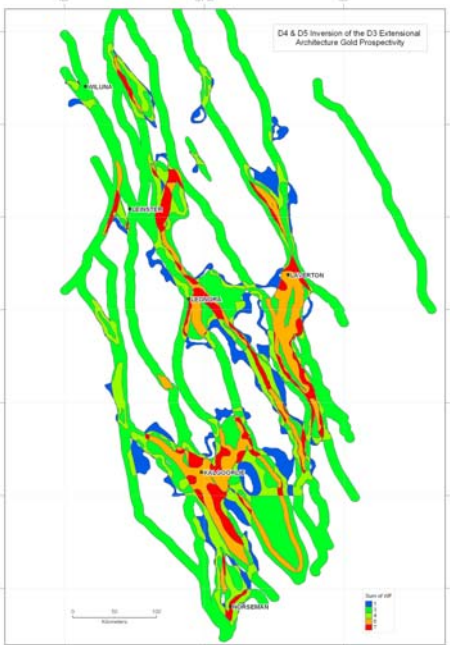

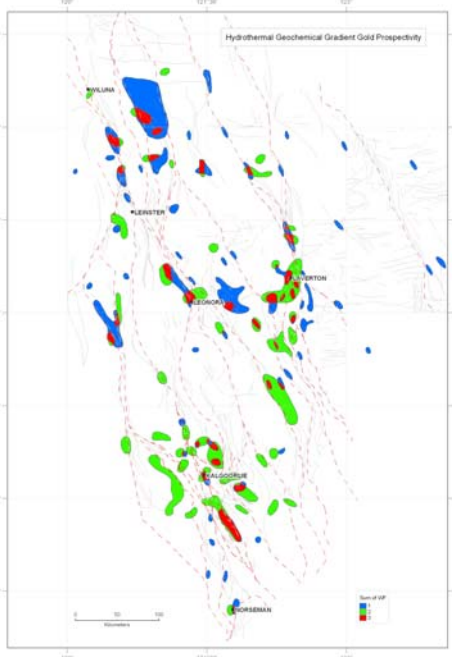

All combined

District Targeting Inputs

Large gold deposits reflect long live mineral systems affected my multiple gold events therefore a combination of the prospectivity maps related to discrete mineralisation events can be used to target regional area selection.

Combination of :

- Pre-ore endowment
- D3 Lithospheric extension Au
- D4-5 Inversion Au
- Geochemical gradient Au

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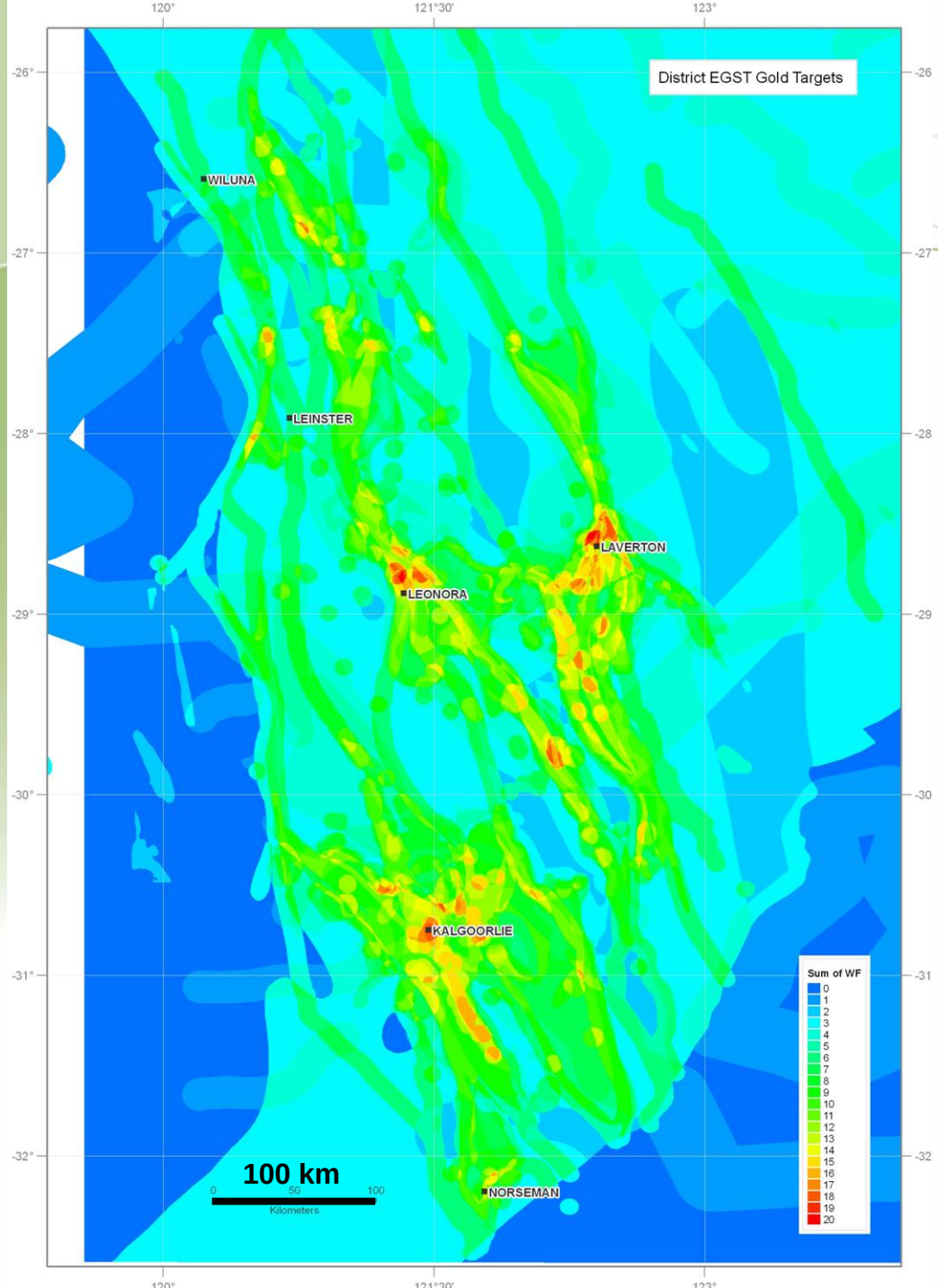

All combined

District Au Targets

Large gold deposits reflect long live mineral systems affected my multiple gold events therefore a combination of the prospectivity maps related to discrete mineralisation events can be used to target regional area selection.

Combination of :

- Pre-ore endowment
- D3 Lithospheric extension Au
- D4-5 Inversion Au
- Geochemical gradient Au

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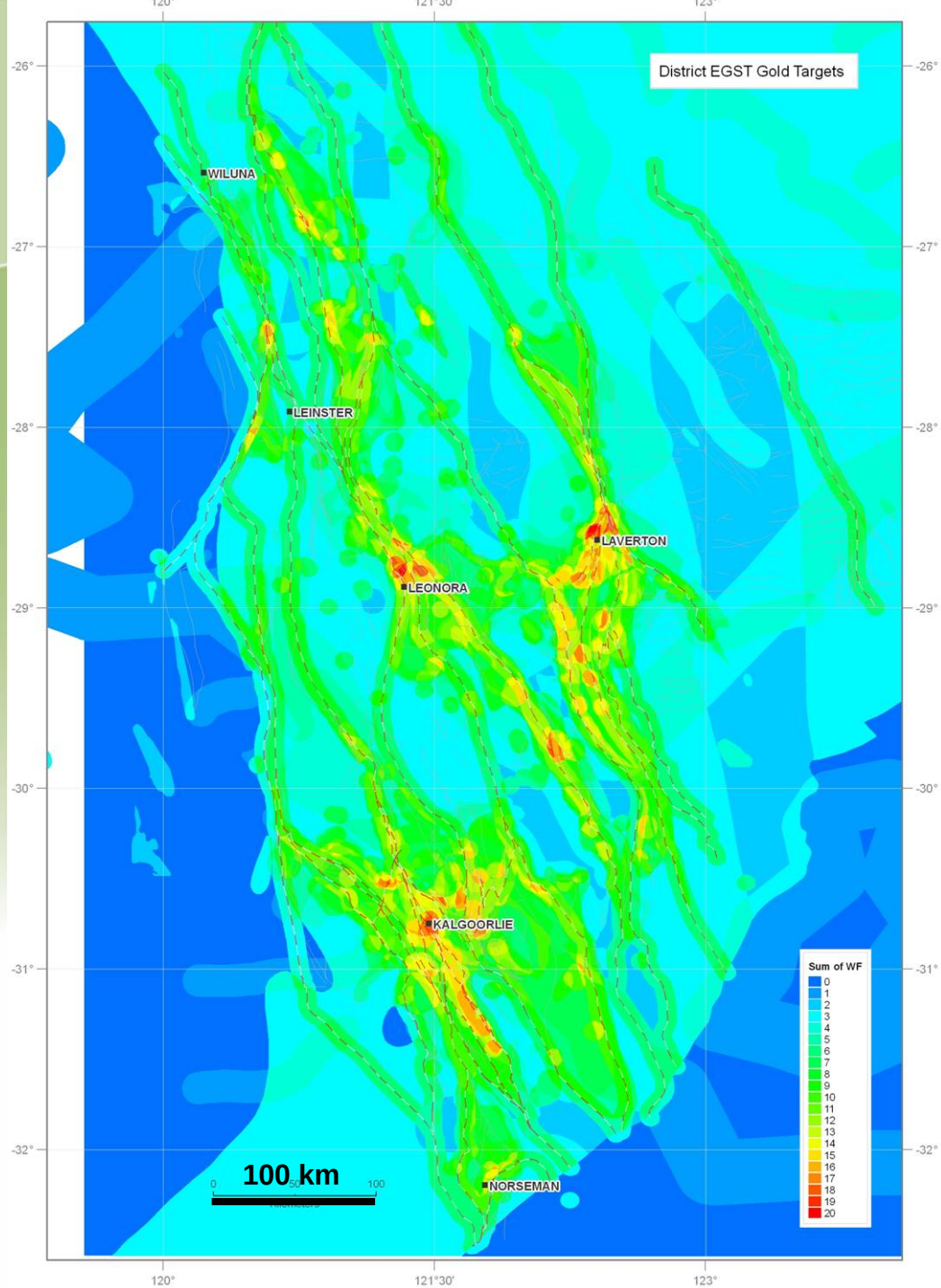

All combined

District Au Targets

Targets & Fault systems

Large gold deposits reflect long live mineral systems affected my multiple gold events therefore a combination of the prospectivity maps related to discrete mineralisation events can be used to target regional area selection.

Combination of :

- Pre-ore endowment
- D3 Lithospheric extension Au
- D4-5 Inversion Au
- Geochemical gradient Au

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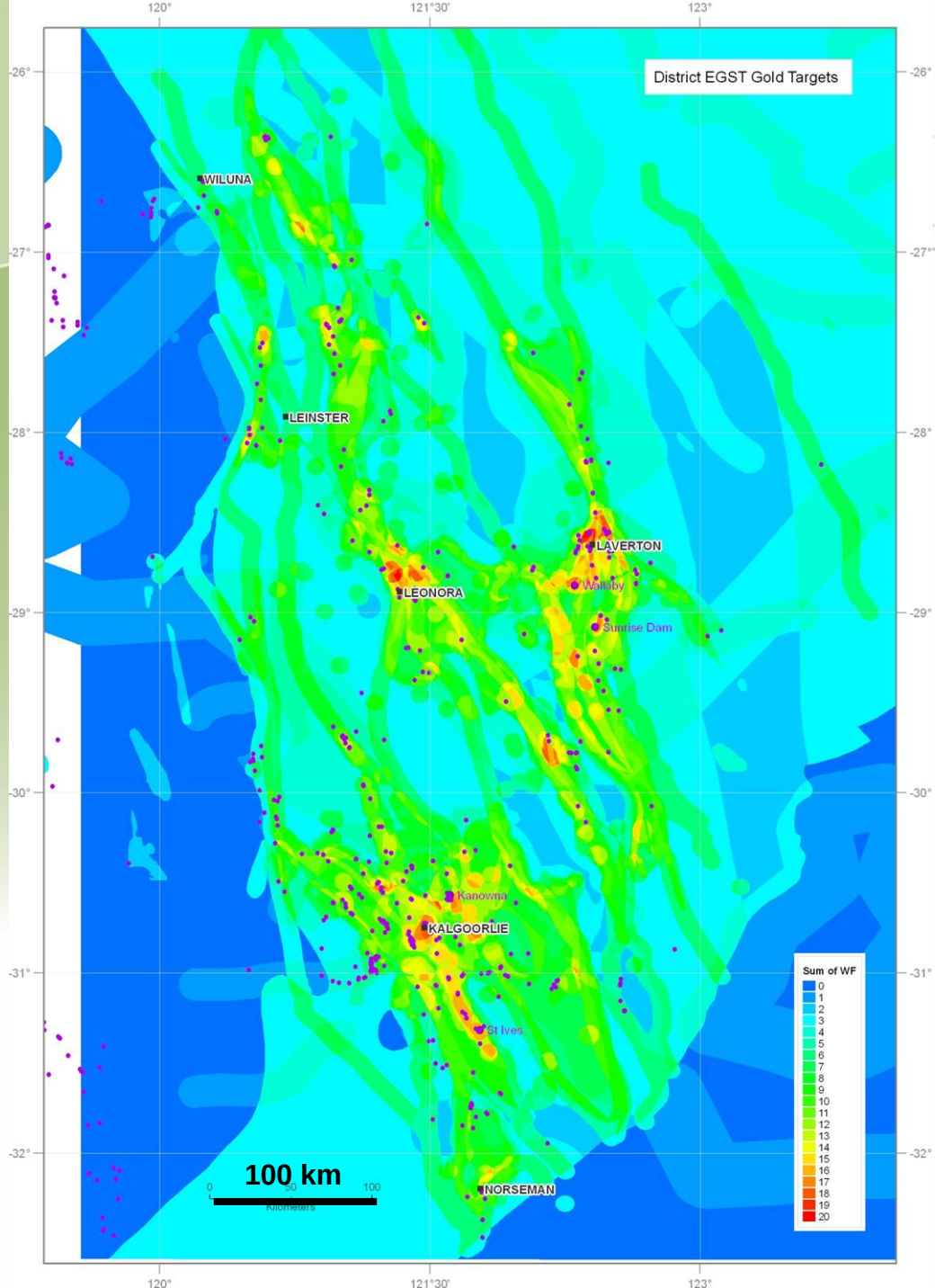

All combined

District Au Targets

Targets & known deposit locations

Large gold deposits reflect long lived mineral systems affected my multiple gold events therefore a combination of the prospectivity maps related to discrete mineralisation events can be used to target regional area selection.

Combination of :

- Pre-ore endowment
- D3 Lithospheric extension Au
- D4-5 Inversion Au
- Geochemical gradient Au

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What is most important for targeting?

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The **most important and useful factor** for regional targeting was our **understanding of the geodynamic history through time and space**. This is because mineral systems are the direct products of this history and hence can not be viewed in isolation. It is from this understanding that critical parameters can be derived. This understanding is achieved through an integration of:

- Stratigraphy
- Magmatism
- Structure
- Metamorphism
- Alteration

In the above exercise **the following data sets were most useful:**

- Base layer data sets:
  - Solid geology
  - Gravity
  - Magnetics
- Mappable mineral system proxys with WF=3
  - Sm-Nd on granites
  - Regional metamorphic study
  - Structural interpretation (i.e. structural model & fault distribution map)
  - Distribution of metasomatised mantle melts

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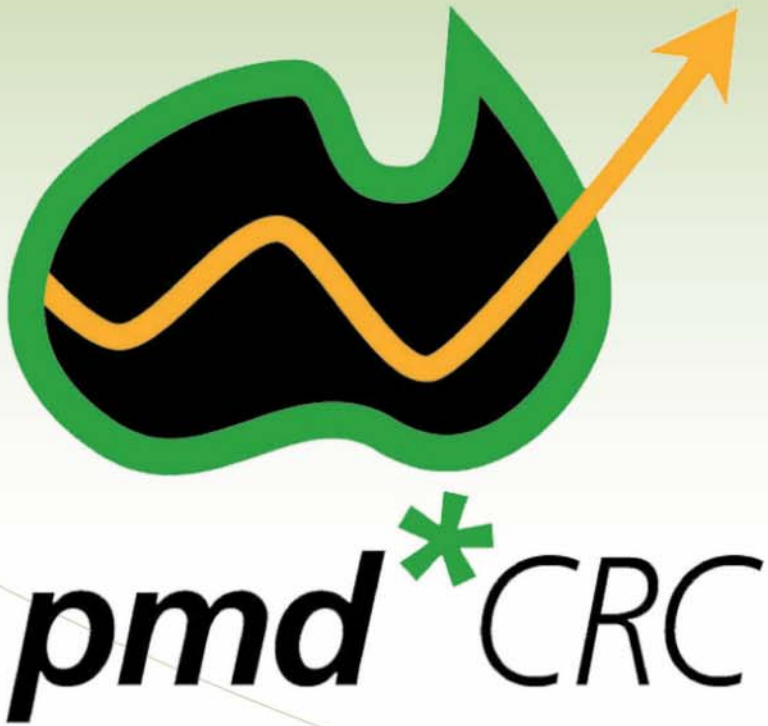

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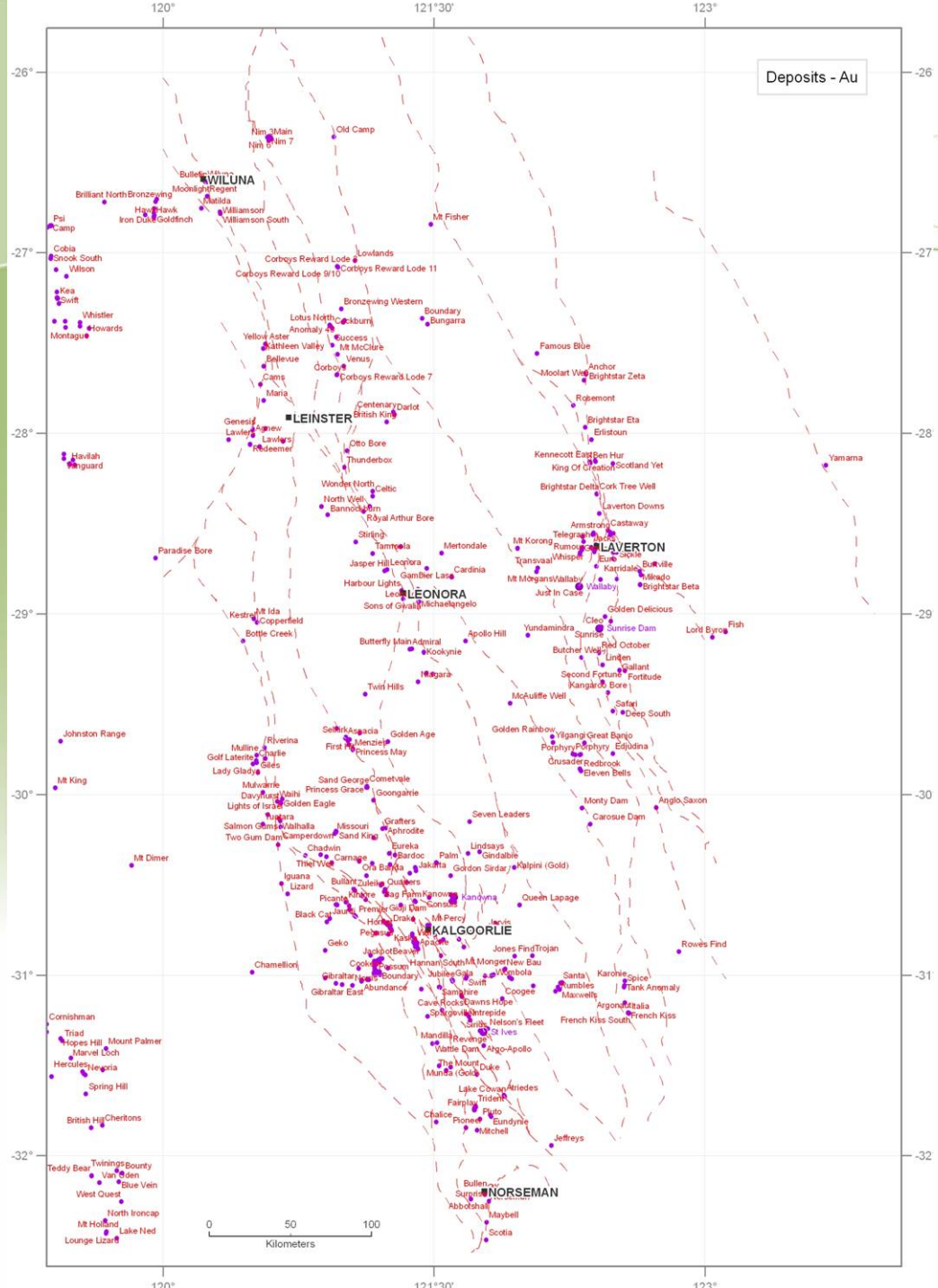

OzMin

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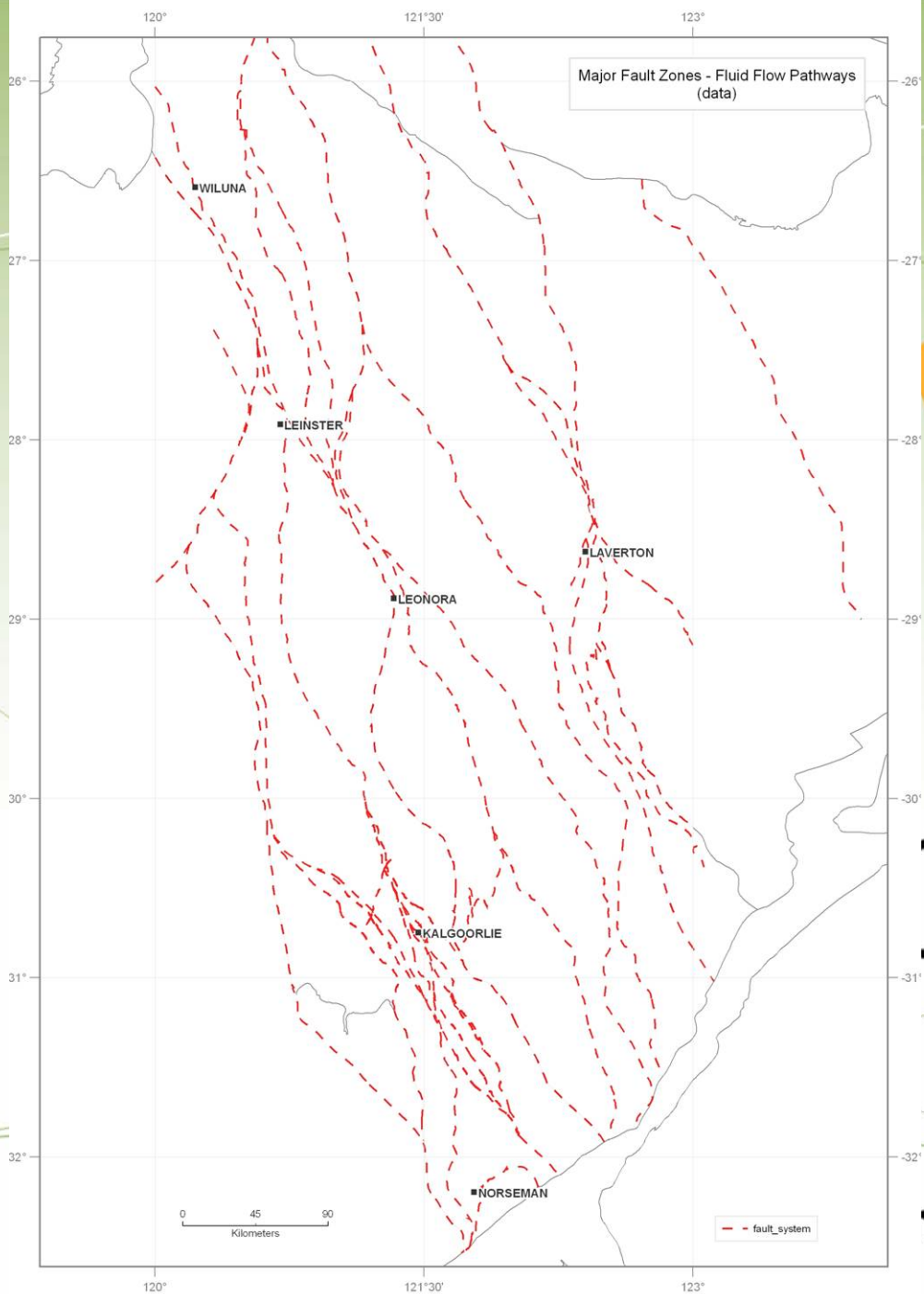

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