Geological potential for magmatic and orogenic mineral systems in the southern New England Orogen

Discoveries in the Tasmanides
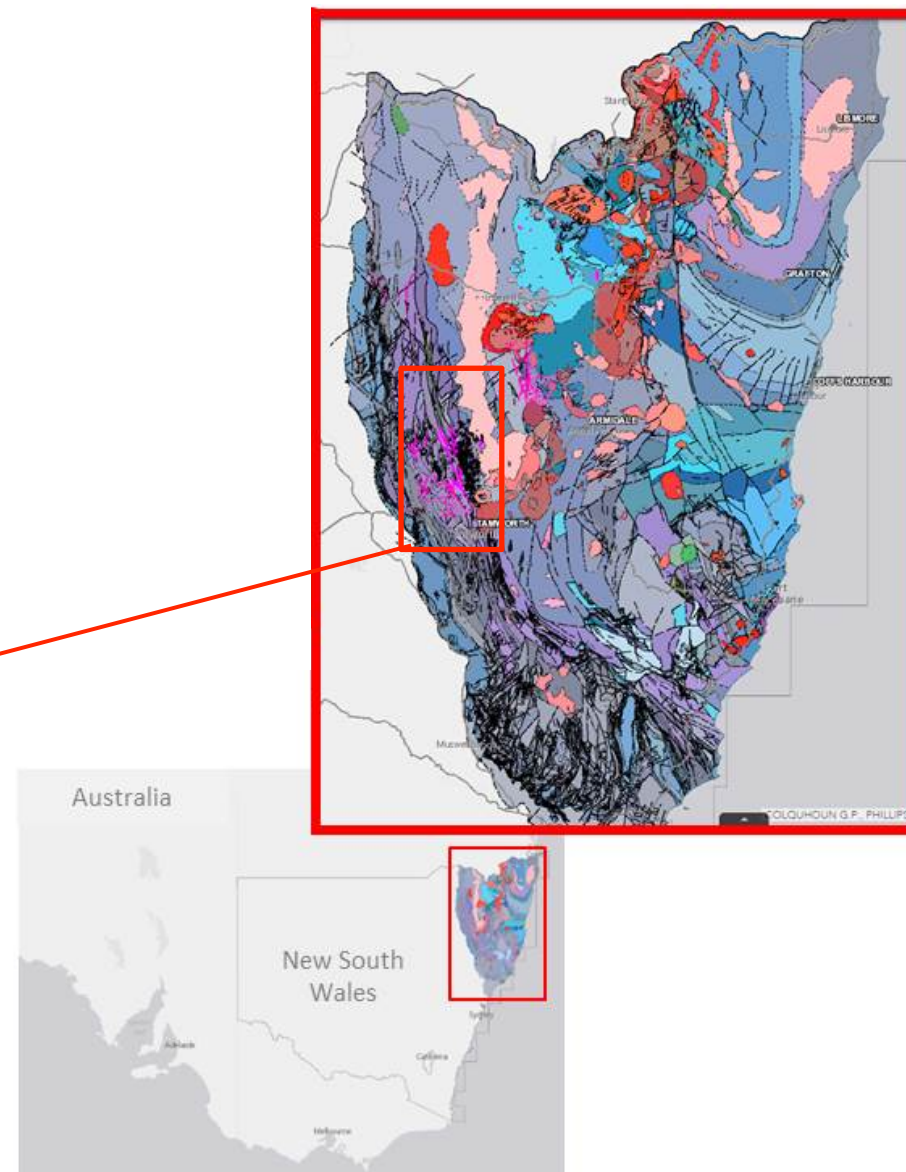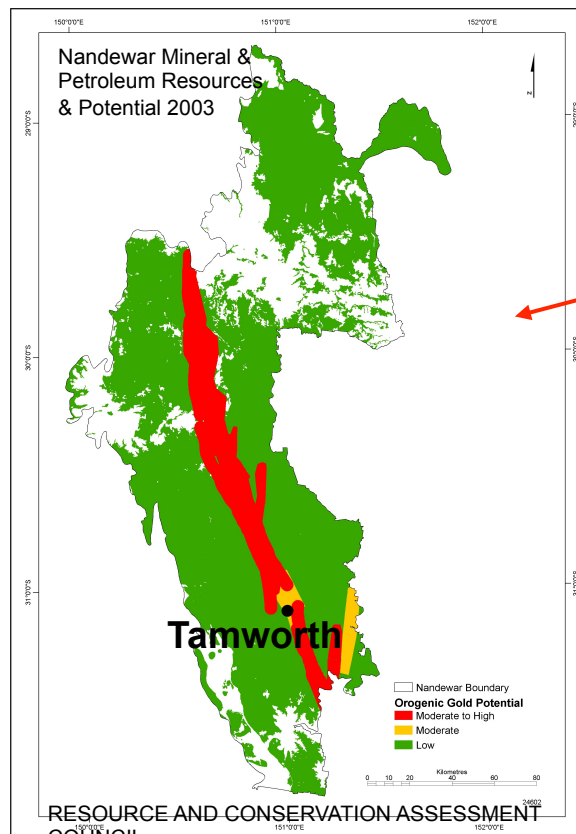2017
8 September 2017

John Greenfield on behalf of:

Phil Blevin, Katie Peters, Greg Partington, Peter M. Downes, Michael Nelson & Brad Williams

Introduction

- GSNSW is embarking on a statewide mineral potential mapping project

- The results will be used to trigger land-use referrals

- Will replace the 'potential' layer in the current Mineral Resource Audit mapping

- Kenex won bid for spatial analysis (Partington et al. 2007 Mines & Wines – IR Au)

A similar process was done in SNEO by GSNSW in the 90's

Nandewar Mineral & Petroleum Resources & Potential 2003

Tamworth

Nandewar Boundary
Orogenic Gold Potential
Moderate to High
Moderate
Low

RESOURCE AND CONSERVATION ASSESSMENT COUNCIL

Australia

New South Wales

Why Southern New England Orogen?

- Economic potential exists for key mineral systems

- Land-use pressure

- Good metallogenic mapping, 25k series geo mapping

- Seamless Geology and derivative maps available
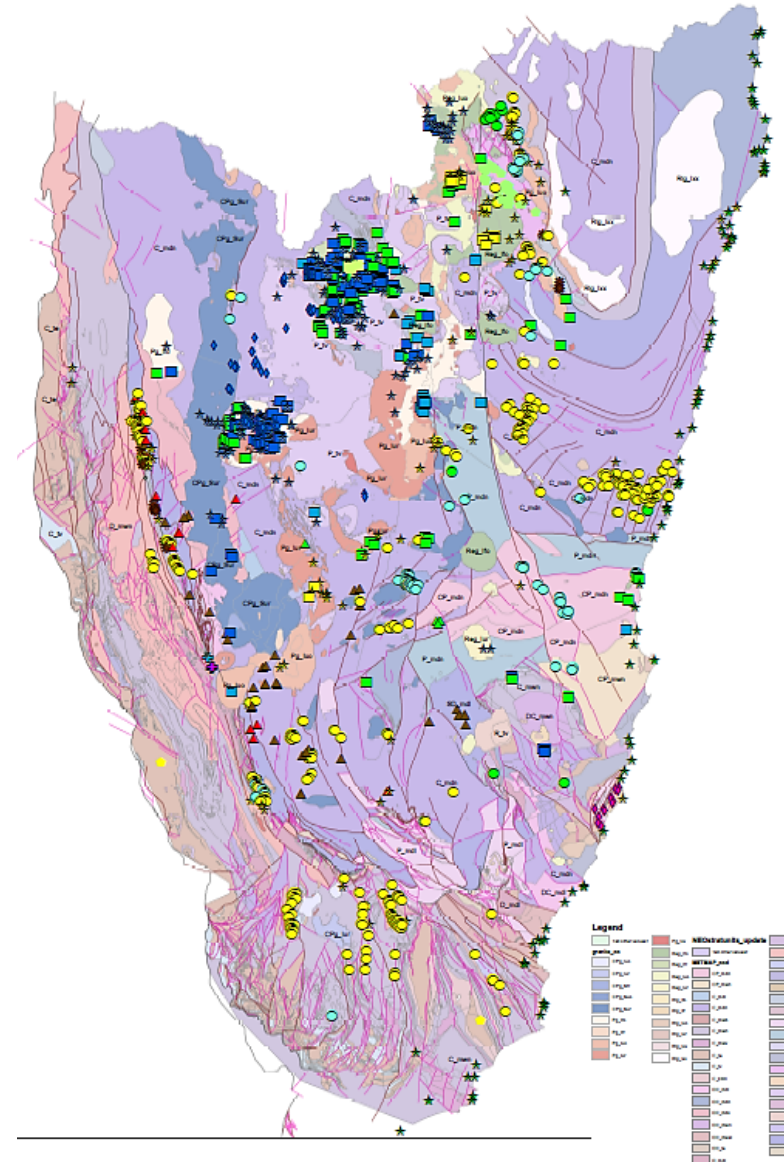
Which Mineral Systems?

Recipe books:

1. **Intrusion-related tin-tungsten** (IR Sn-W)

   GS2017/0617

2. **Intrusion-related gold** (IR Au)

   GS2017/0618

3. **Orogenic gold-antimony** (orogenic Au-Sb)

   GS2017/0619

Data: map-based

Seamless- **reactive rocks**

Seamless- **igneous metal fertility**

Seamless- **fault attribution**

Seamless- **Metamorphic map**

Seamless geology

Geophysics- rad, gravity, mag + worms
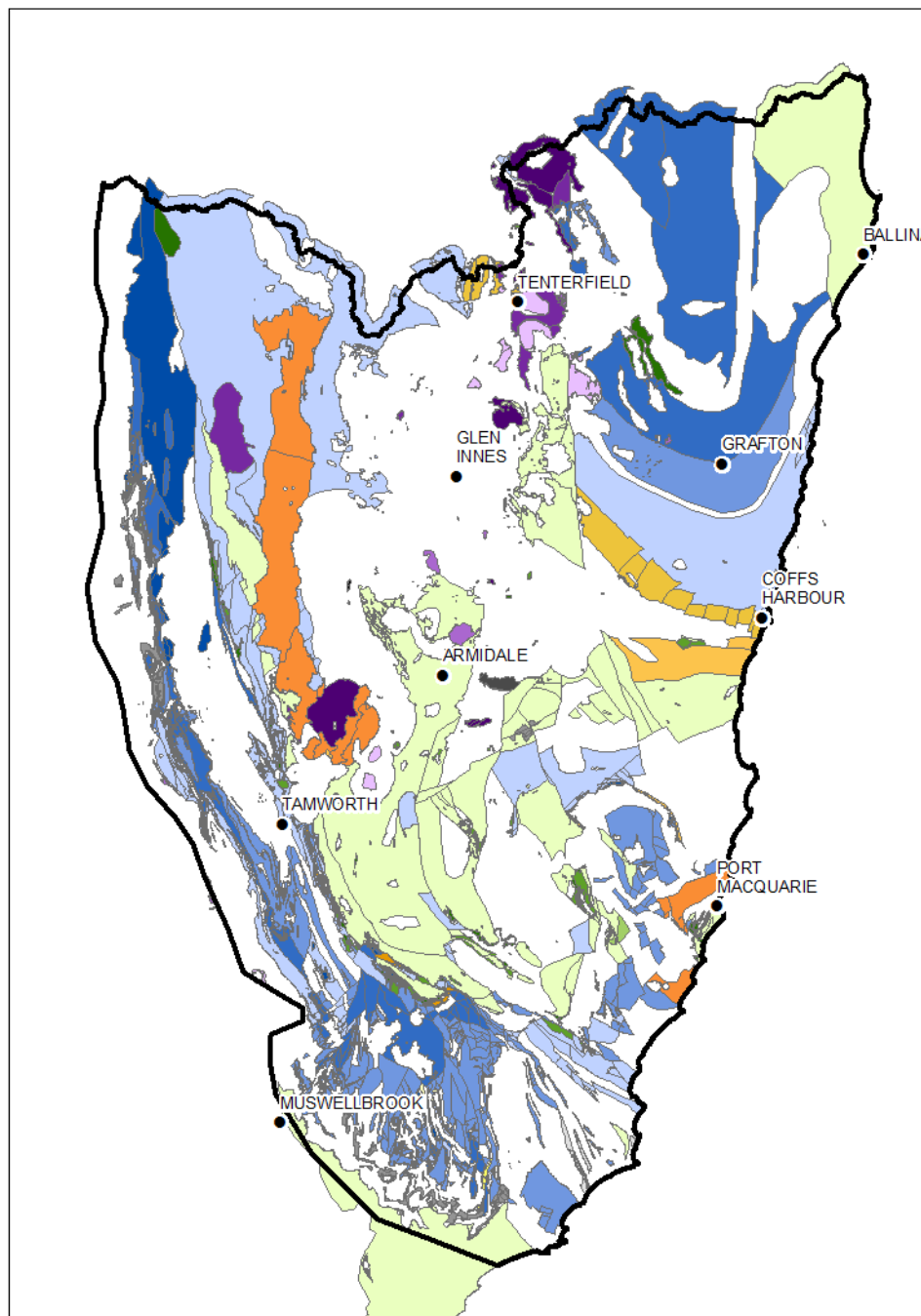
REACTIVE ROCKS

Carbonates
- Dominant: >20%
- Major: 5-20%
- Minor: 1-5%
- Trace: <1%

Mg-Fe Redox
- Dominant: >20%
- Major: 5-20%
- Minor: 1-5%
- Trace: <1%

Oxidising Environment
- Dominant: >20%
- Major: 5-20%
- Minor: 1-5%
- Trace: <1%

Reducing Environment
- Dominant: >20%
- Major: 5-20%
- Minor: 1-5%
- Trace: <1%

pH Buffers
- Neutral to Alkaline, Dominant: >20%
- Neutral to Alkaline, Major: 5-20%
- Neutral to Alkaline, Minor: 1-5%
- Neutral to Alkaline, Trace: <1%
- Neutral, Dominant: >20%
- Neutral, Major: 5-20%
- Neutral, Minor: 1-5%
- Neutral, Trace: <1%

Data:point-based

783 Radiometric ages

6,788 Whole-rock geochem

11,160 Mineral occurrences

12,150 Thin-section descriptions

17,703 Structural readings (including vein-sets)

28,719 Drilling lithology logs

42,633 Field obs

241,478 Assays (drillhole, stream sed, rock-chip, soil)
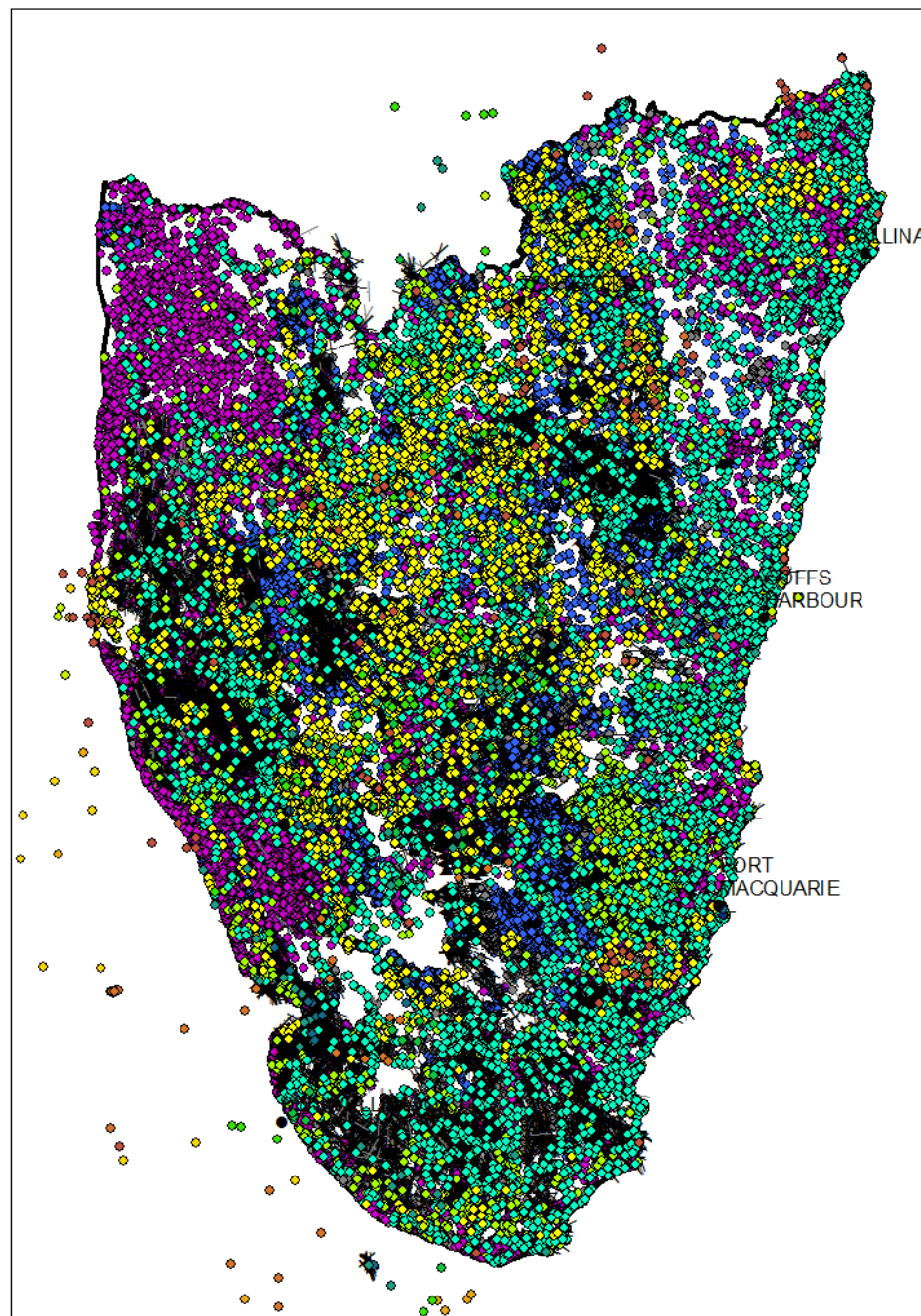
Spatial Analysis: weight of evidence

- Create study area – extent of seamless geology – 50 x 50 m grid

- Select **training points** (10-20 for NEO; full spectrum of mineral system)

- Select unit cell – **1 km^2 for all models** (~ extent of mineral system)

  -- This equates to a **province to camp scale** analysis --

- Determine **prior probability** (odds of a training deposit in a unit cell)

  IR Sn-W = 0.000101; **IR Au** = 0.00011; **orogenic Au-Sb** = 0.000236

- Create predictive maps and perform spatial analysis

- Select predictive maps

- Run mineral potential model
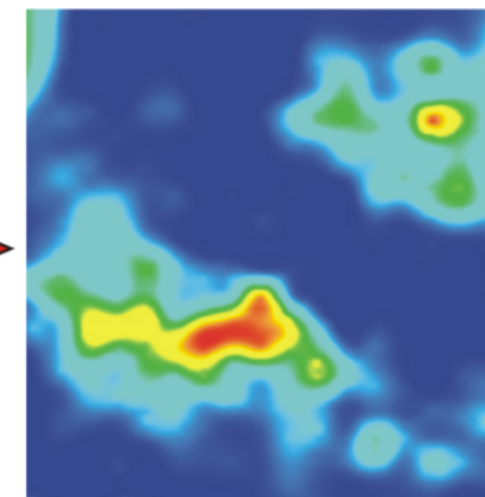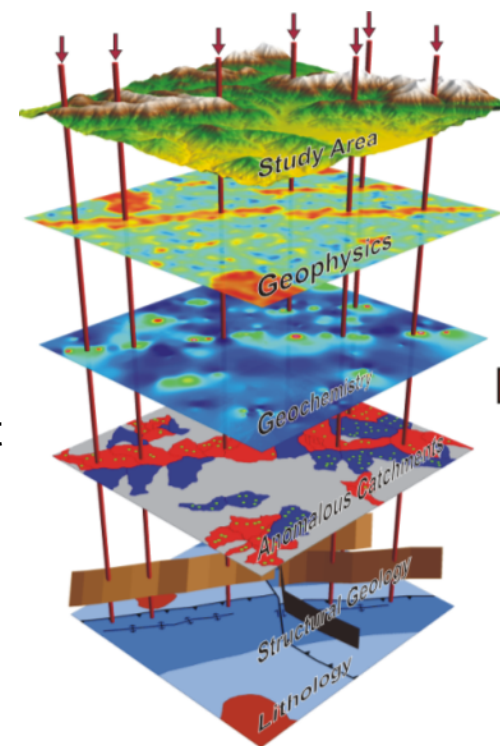
Model of Mineral Prospectivity
Highlighting Exploration Targets

Intrusion-related Sn-W in SNEO: mineral system model

Mineralisation types

- Stockwork/Sheeted vein style — Torrington (eg. Taronga, Great Britain), Pound Flat
- Disseminated greisen – Fielders Hill
- Breccia pipe – Glen Eden
- Skarn/carbonate replacement – Attunga (Kensington W)

Found in the apical regions of strongly fractionated, reduced I-type felsic granitoids of Permo-Triassic age (254-245 Ma)
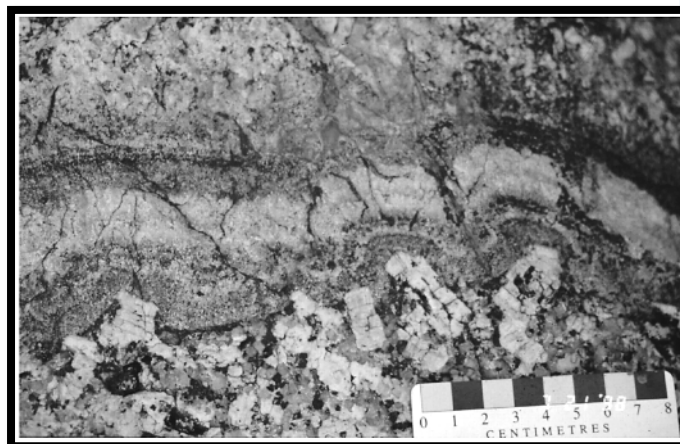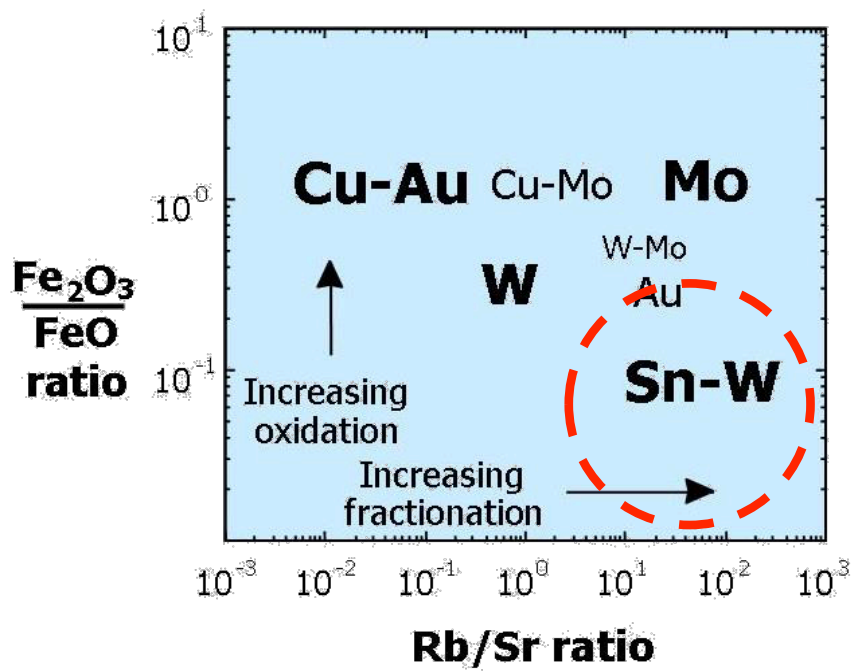
Stockscheiders (Haapala et al. 2007)

IR Sn-W training points

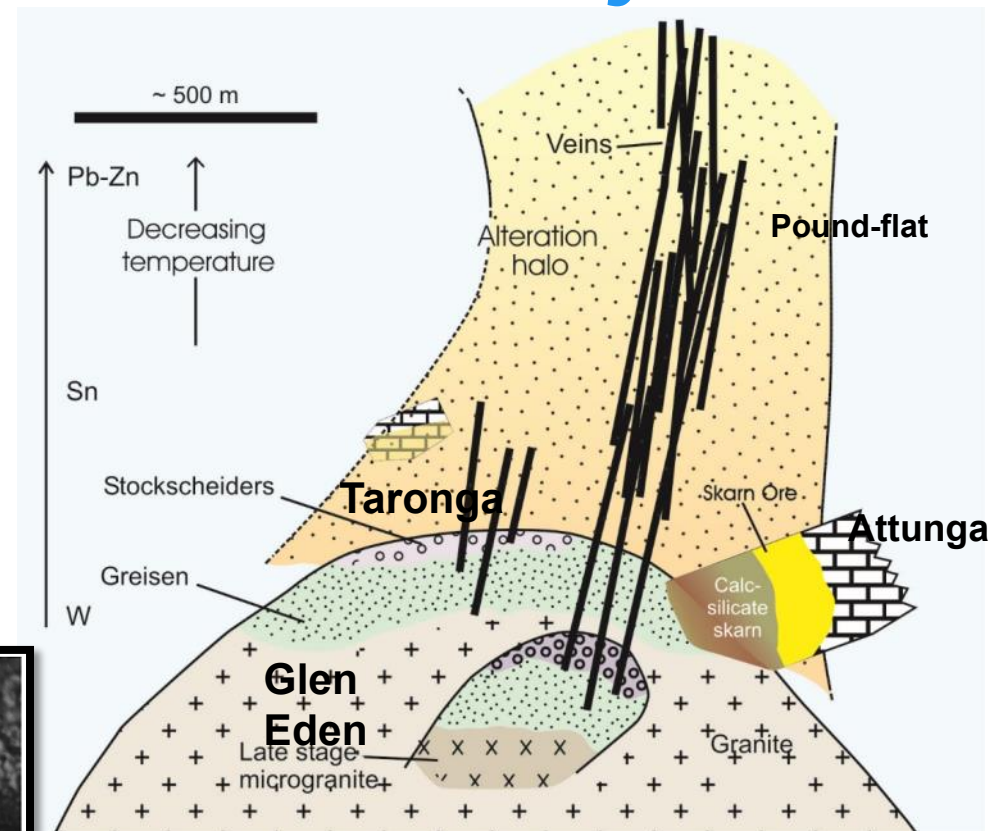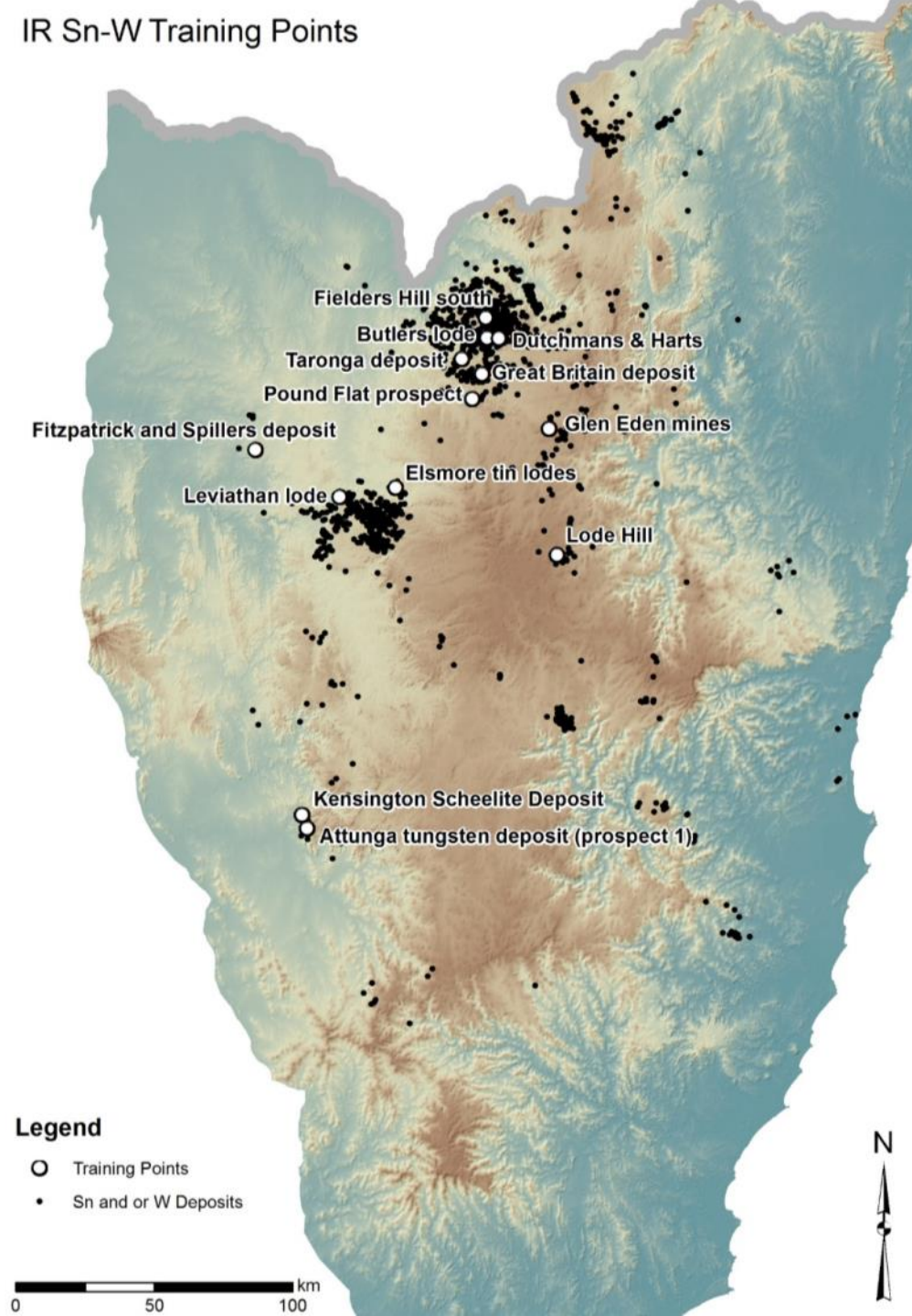|	Name	Metal District	Commodity Major	Commodity Minor	Mineralisation Style
1	Attunga tungsten deposit (prospect 1)	Attunga	Au, W, Mo		W skarn
2	Butlers lode	Torrington	Sn, W	Pb, monazite, Ag, Zn	Sn-(W) vein
3	Dutchmans & Harts	Torrington	Sn		Sn-(W) vein
4	Elsmore tin lodes	Elsmore	Sn	Bi, W, Ag, Au	Sn-(W) vein/greisen
5	Fielders Hill south	Torrington	W, Bi, topaz - industrial	Sn, Cu, fluorite, cryolite, U, Au	topaz-W greisen
6	Fitzpatrick and Spillers deposit	Bingara extended	Sn		Sn-(W) vein
7	Glen Eden mines	not assigned	Mo, W	Sn, Bi, fluorite, cryolite, Cu, beryl - industrial	Mo porphyry
8	Great Britain deposit	Emmaville	Sn		Sn-(W) vein
9	Kensington Scheelite Deposit	Attunga	W		W skarn
10	Leviathan lode	Tingha	Sn	As, Cu, W	Sn-(W) vein
11	Lode Hill	not assigned	Sn		Sn-(W) vein
12	Pound Flat prospect	not assigned	Sn, As	Zn, Pb, W, Cu	Granite-related polymetallic veins
13	Taronga deposit	Emmaville	Sn	Cu, As, Ag, Zn, W, Pb, Mo, Bi	Sn-(W) vein

IR Sn-W Training Points

Fielders Hill south
Butlers lode
Dutchmans & Harts
Taronga deposit
Great Britain deposit
Pound Flat prospect
Fitzpatrick and Spillers deposit
Glen Eden mines
Elsmore tin lodes
Leviathan lode
Lode Hill
Kensington Scheelite Deposit
Attunga tungsten deposit (prospect 1)

Legend
○ Training Points
• Sn and or W Deposits

km
0   50   100

N

IR Sn-W: Taronga/ Emmaville district

Resource:
36.3Mt @ **0.16%Sn** for **57,200t Sn, 0.07%Cu for 26,400t Cu**, **3.8g/t Ag for 4,400,000oz Ag**

AusTin Mining Annual Report 2016
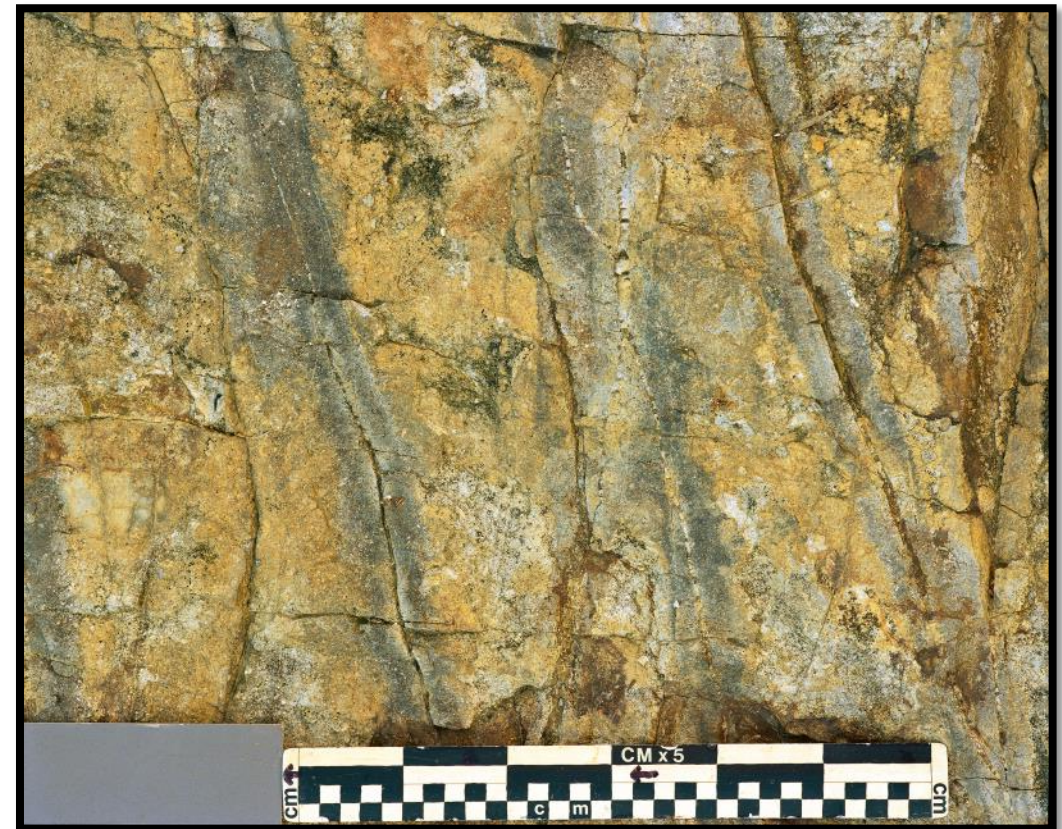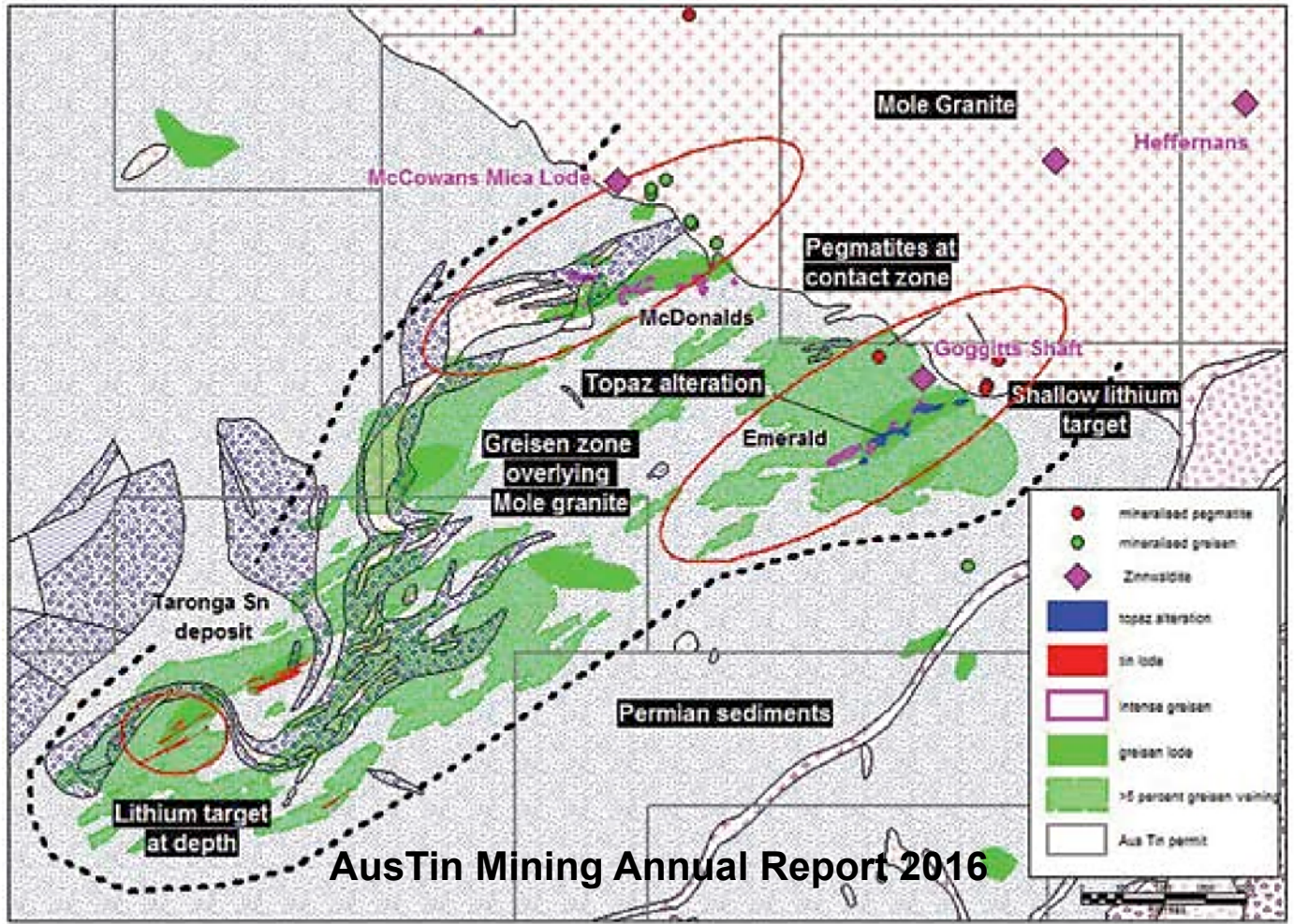
Great Britain: Quartz-cassiterite veins

Glen Eden mines

- Mo-W-(Sn-Bi) pipe-like felsic porphyry
- Brecciated, greisenised
- Intruded by mineralised quartz-vein stockwork
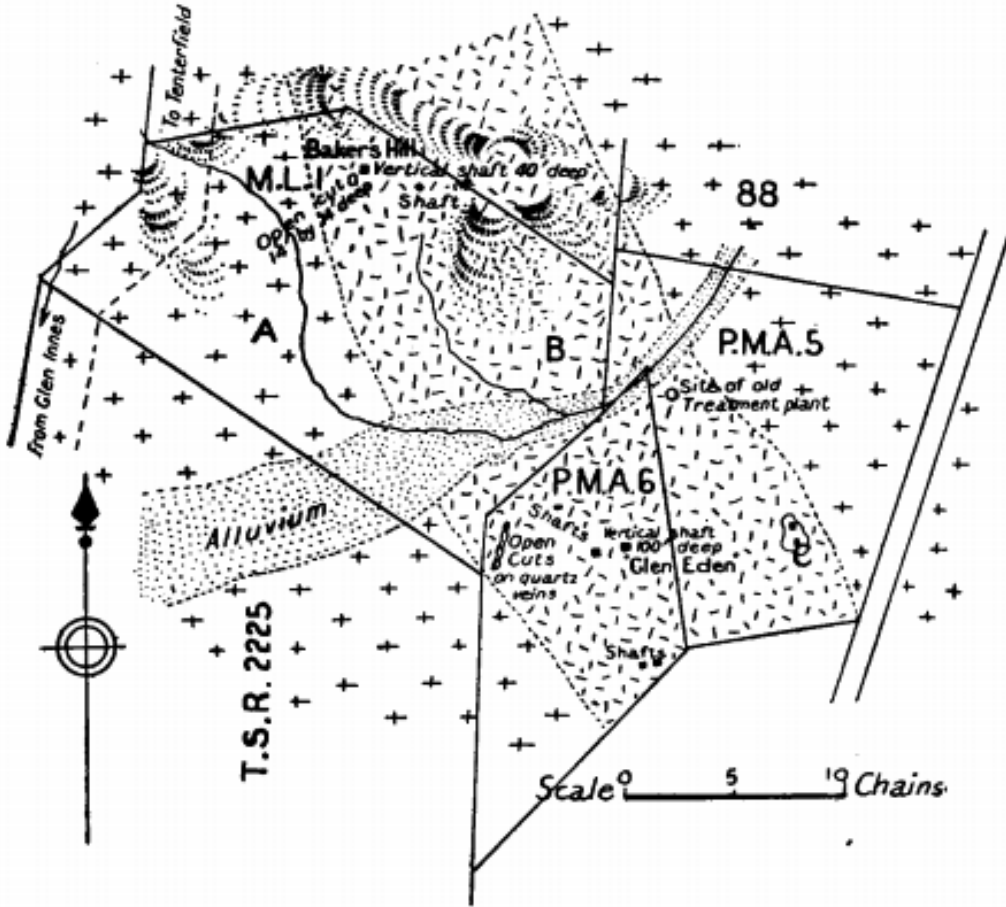
Fig. 10.

Sketch plan of Baker's Hill and Glen Eden molybdenite deposits, Parish of Boyd, County of Gough.

A—Quartz felspar porphyry.
B—Quartz felspar porphyry altered to greisen and impure silica, containing numerous quartz veins with tinstone, wolfram, and molybdenite.
C—Open cut and shafts with wolfram, tinstone, and molybdenite.

EC Andrews 1916

IR Sn-W: Spatial Correlation Results

- 88 spatial variables identified

- Resulting in 98 predictive maps being created and tested

- The spatial correlations were mostly positive with 91 predictive maps having contrast values > 1

- 24 maps were chosen for possible inclusion in the final model

- The final model used 18 of these maps

- All contrasting parts of the mineral system represented

- Other models can be run using different combinations of the 24 maps selected or including others with positive correlations
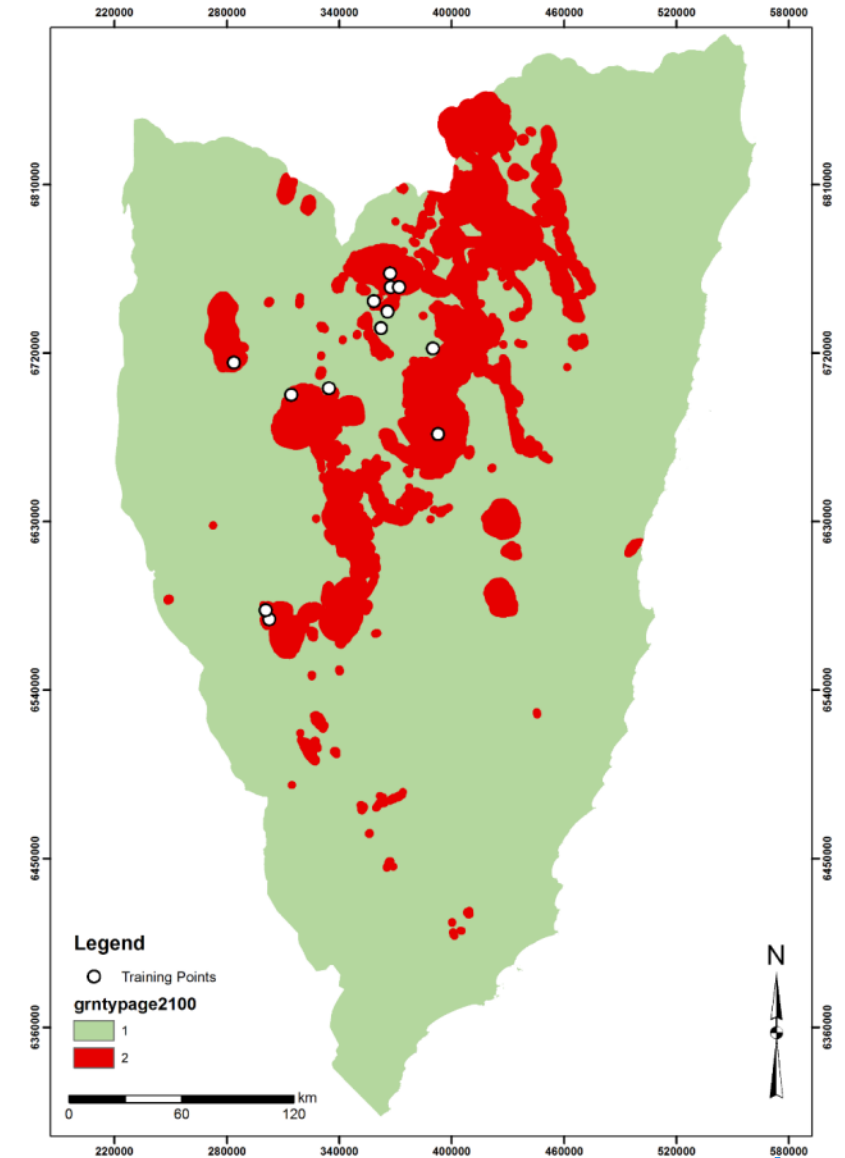
IR Sn-W: final predictive maps
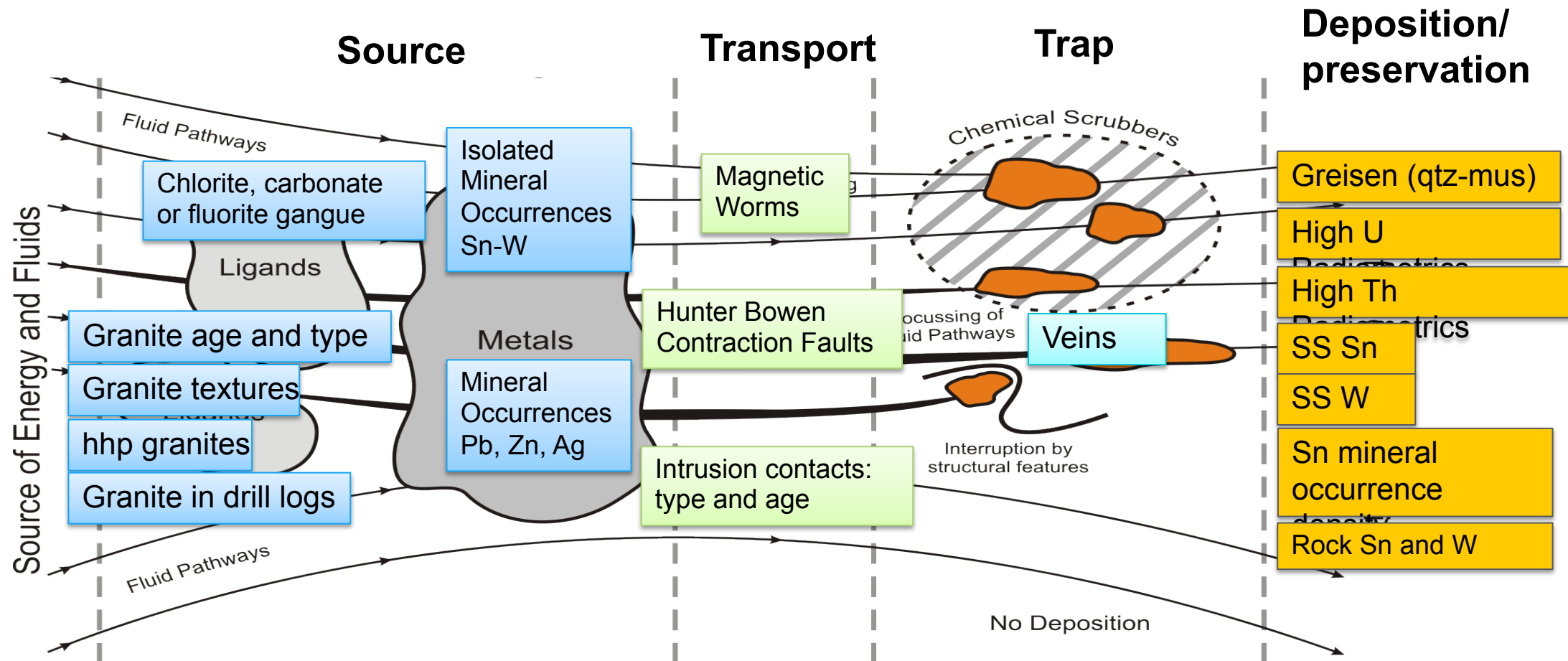
Knox-Robinson & Wyborn 1997

IR Sn-W: results

- Prospective areas are defined as having a post probability higher than the prior probability (0.000101)

- Prospective area covers 6% of the study area

- Success rate = 99.5

- Training points all fall in the highly prospective area (lowest post probability is 0.736587)

- Highly prospective area (above 0.736587) covers 1.2% of the study area

Intrusion Related Sn-W Mineral Potential

IR Sn-W Model 7
- Not Prospective
- Prospective
- Highly Prospective
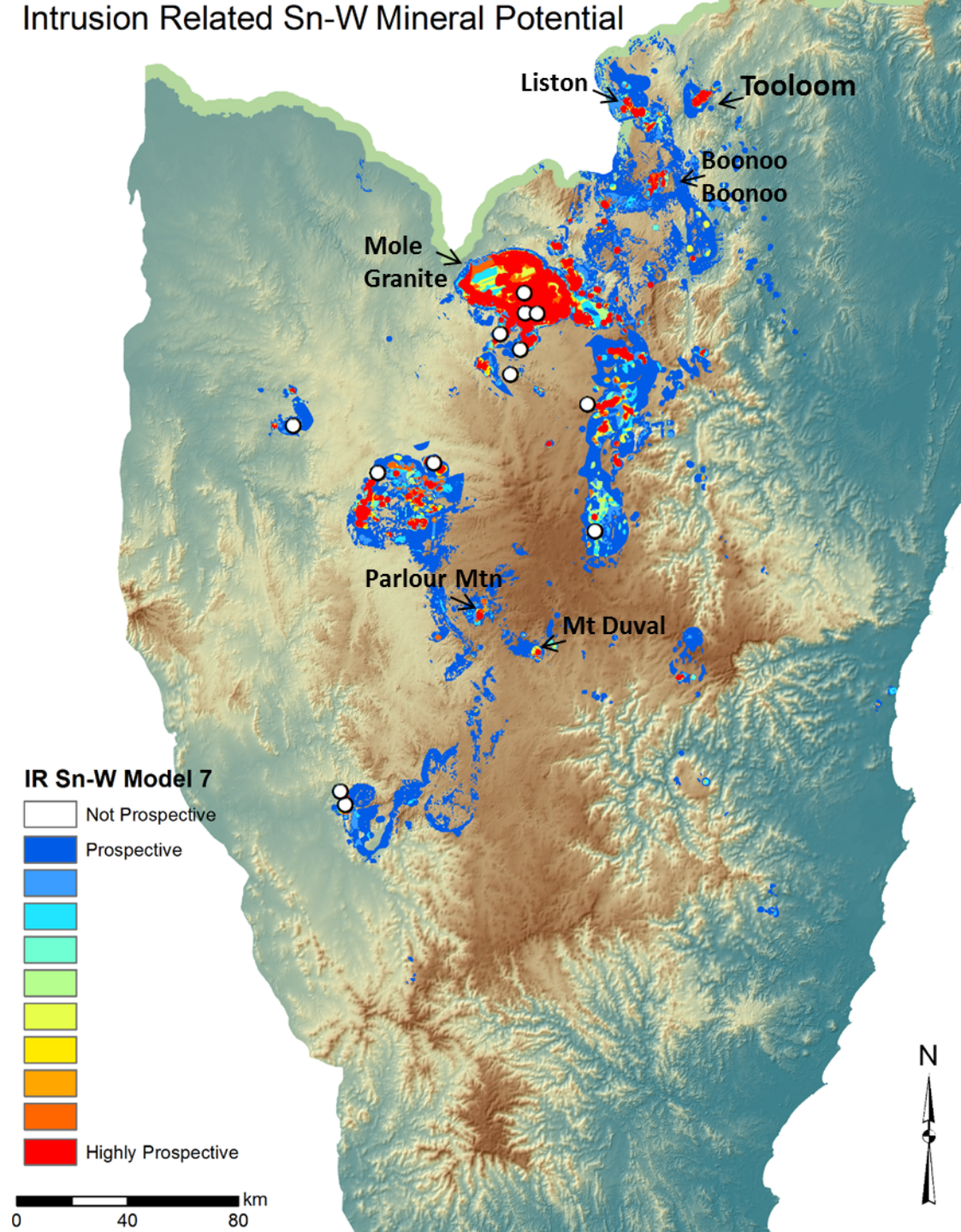
Intrusion-related Au in SNEO: mineral system model

- Associated with W-Mo mineralised suites

- Au occurring within a distal metallogenic zonation

- weakly to moderately oxidised I-types , high-K, low K/Rb ratios and show strong fractionation trends, low S magmas keep Au in melt

- not oxidised enough and too evolved and/or felsic to be associated with Cu; too oxidised to be associated with significant Sn

- Sheeted veins, disseminated greisen zones, dykes: associated with minor W-Mo±Sn occurrences and W-scheelite mineralisation
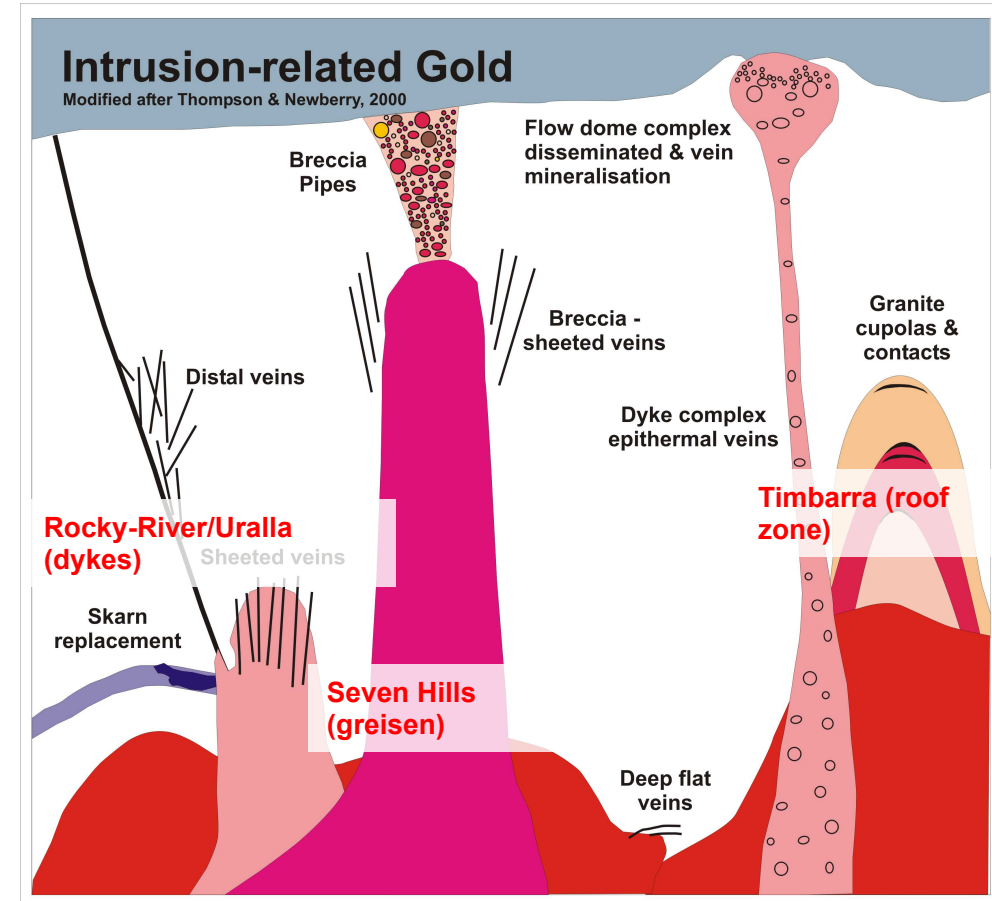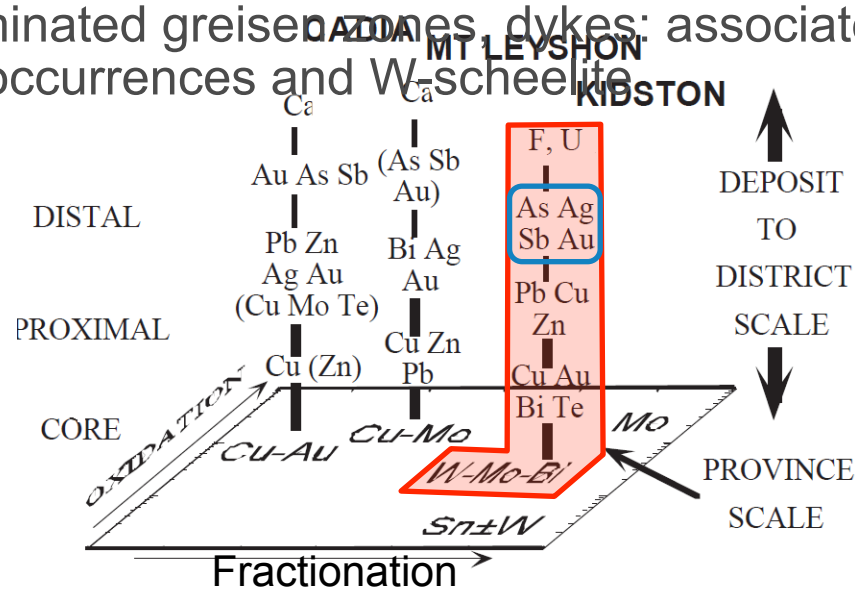
IR Au training deposits

	Name	Metal District	Commodity Major	Commodity Minor	Mineralisation Style
1	Brown's Reef	Rocky River	Au		Granite-related gold
2	Frazers Find	Rocky River	Au	Ag, Sb	Structurally controlled Sb-Au
3	Hortons mine	Timbarra	Au		Granite-related gold
4	Hudsons's/McCrossin'	Rocky River	Au		Granite-related gold
5	Klondyke reef	not assigned	Au, As		Granite-related polymetallic veins
6	Martin's Shaft	Rocky River	Au	Sb	Structurally controlled Sb-Au
7	Poverty Point mine	Timbarra	Au	Mo, Bi	Granite-related gold
8	RMT	Timbarra	Au		Granite-related gold
9	Timbarra (Big Hill mine)	Timbarra	Au		Granite-related gold
10	Seven Hills South 1	not assigned	Au		Granite-related gold
11	Seven Hills South 2	not assigned	Au		Granite-related gold
12	Seven Hills Central	not assigned	Au		Granite-related gold
13	Seven Hills North	not assigned	Au		Granite-related gold

NSW GOVERNMENT | Planning & Environment
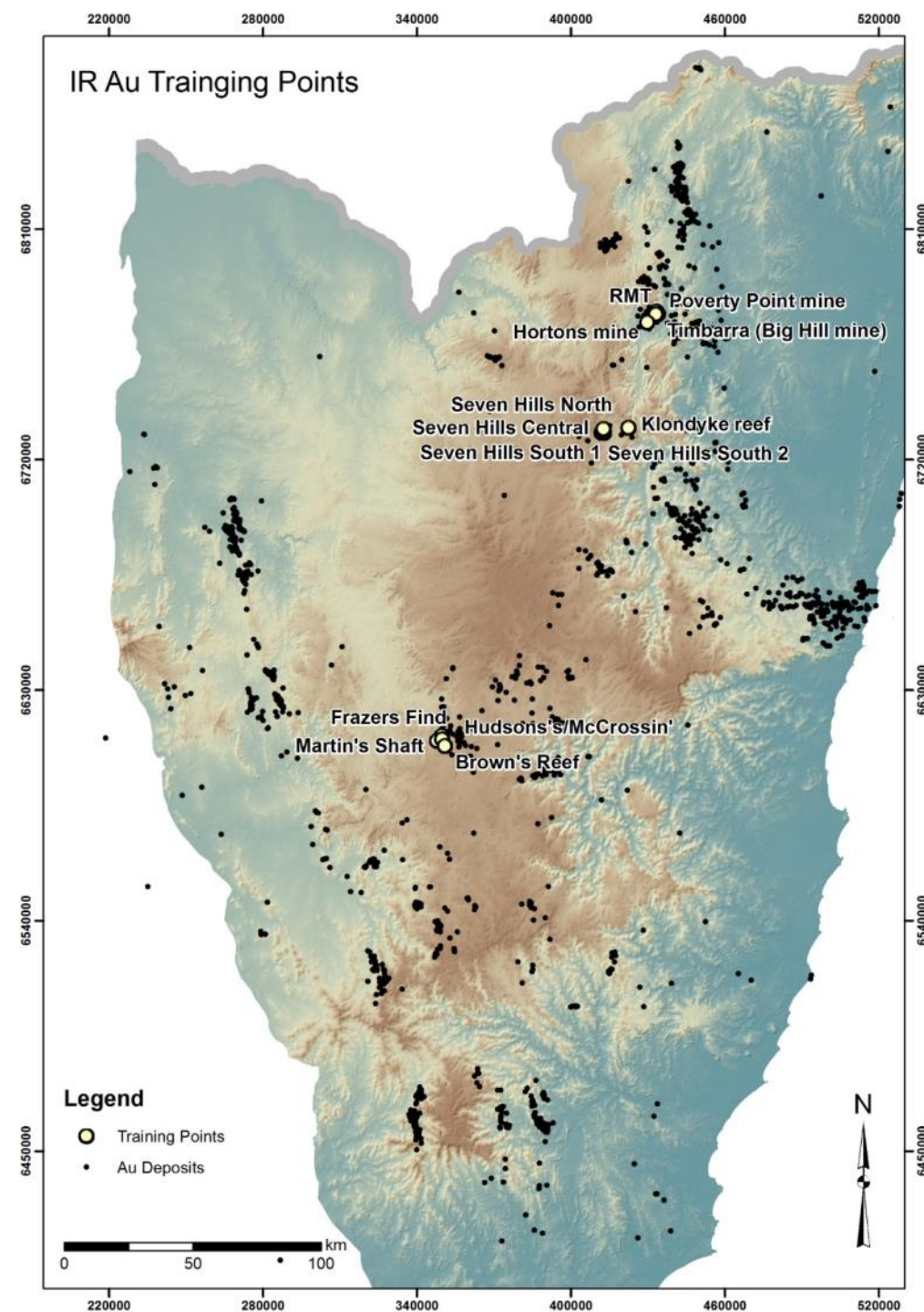
Timbarra

- Disseminated gold in the roof zone of a highly fractionated, high-K, calc-alkaline, I-type granite
- Mineralisation and alteration capped by microgranite and aplite
- negligible quartz veining, minimal sulphides

Resource:
13.65 Mt @ 0.95 g/t gold (417000 oz)
Mustard, et al., 1998

Mustard 2004
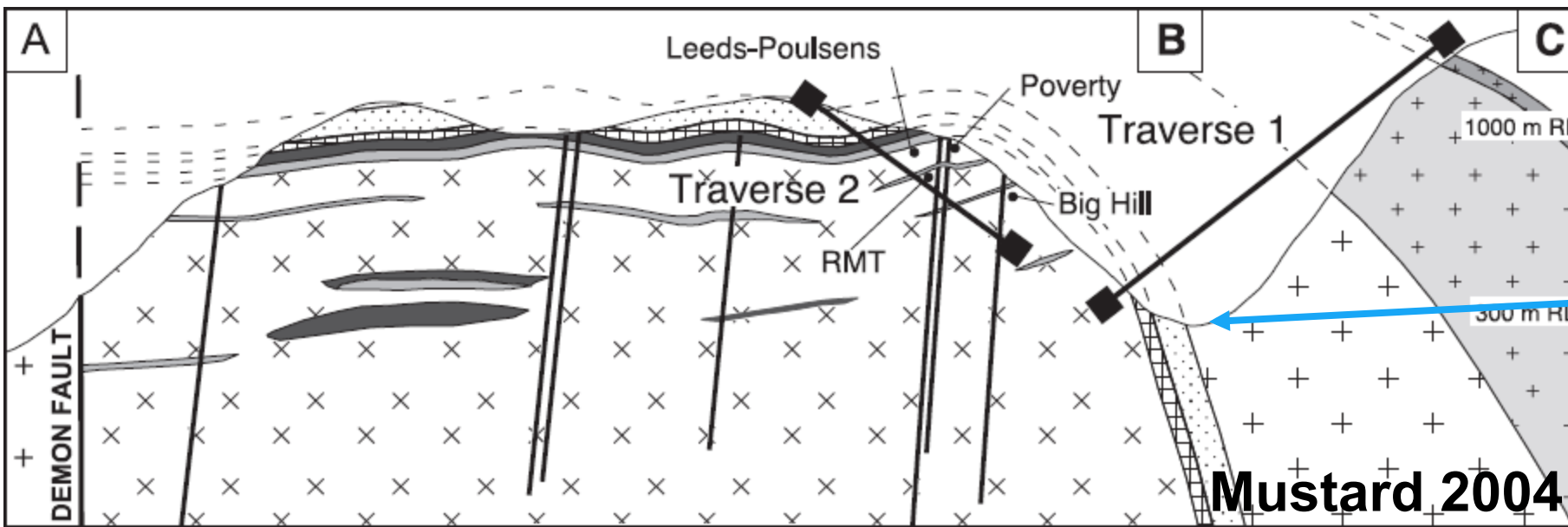
Seven Hills/Kingsgate
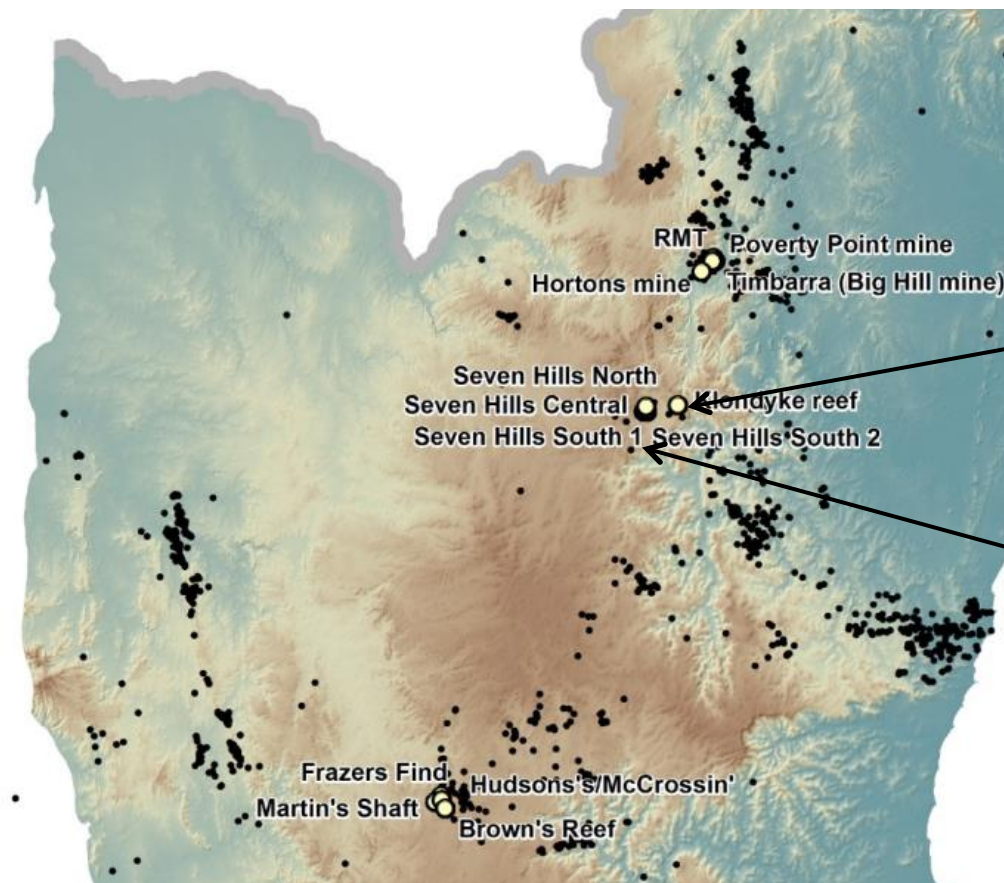
Gold-bearing greisenised granite from Seven Hills

Moly in Qtz pipe from Kingsgate Mo-Bi prospect

IR Au: final predictive maps
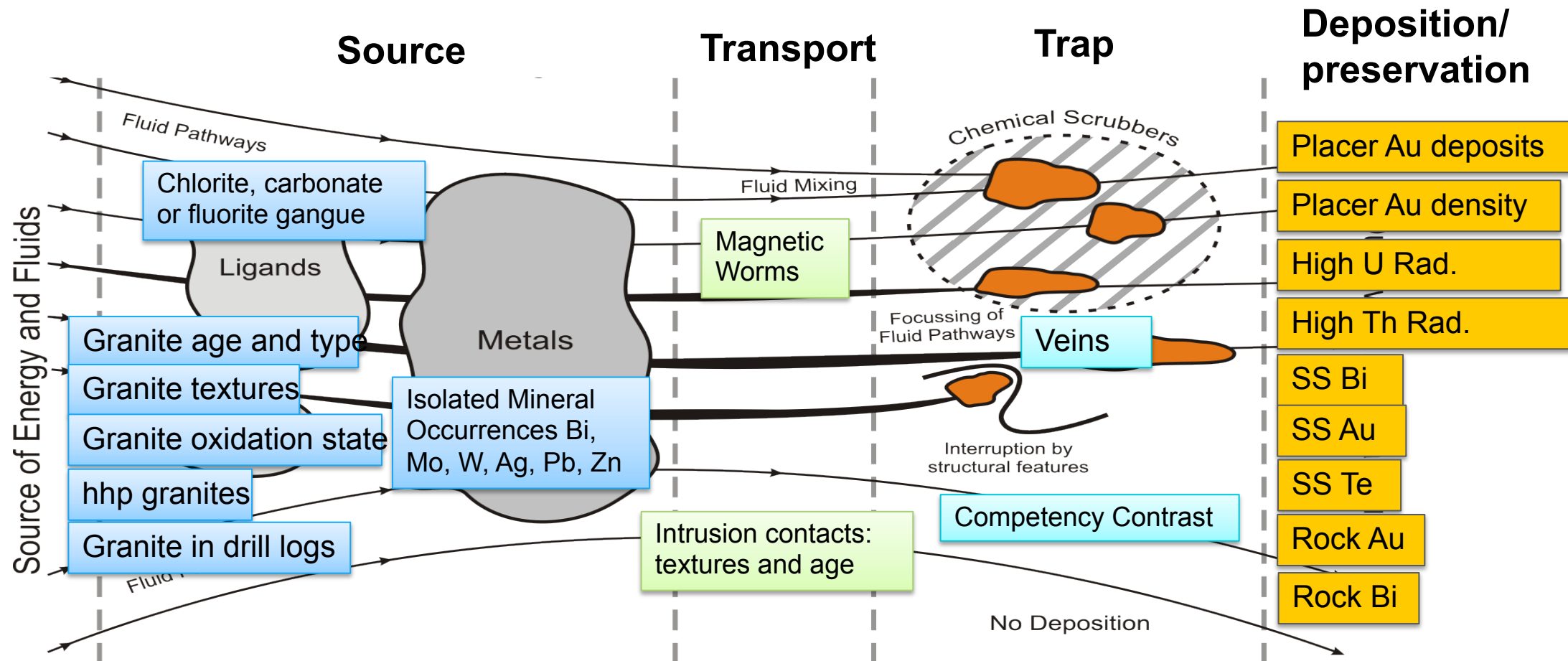
Knox-Robinson & Wyborn 1997

IR Au: results

- Prospective areas are defined as having a post probability higher than the prior probability (0.00011)

- Prospective area covers 8% of the study area

- Success rate = 99.5

- Training points all fall above the prior probability (lowest post probability is 0.000723; next lowest is 0.999992)

- Highly prospective area (above 0.937254902) covers 1.4% of the study area

Intrusion Related Au Mineral Potential
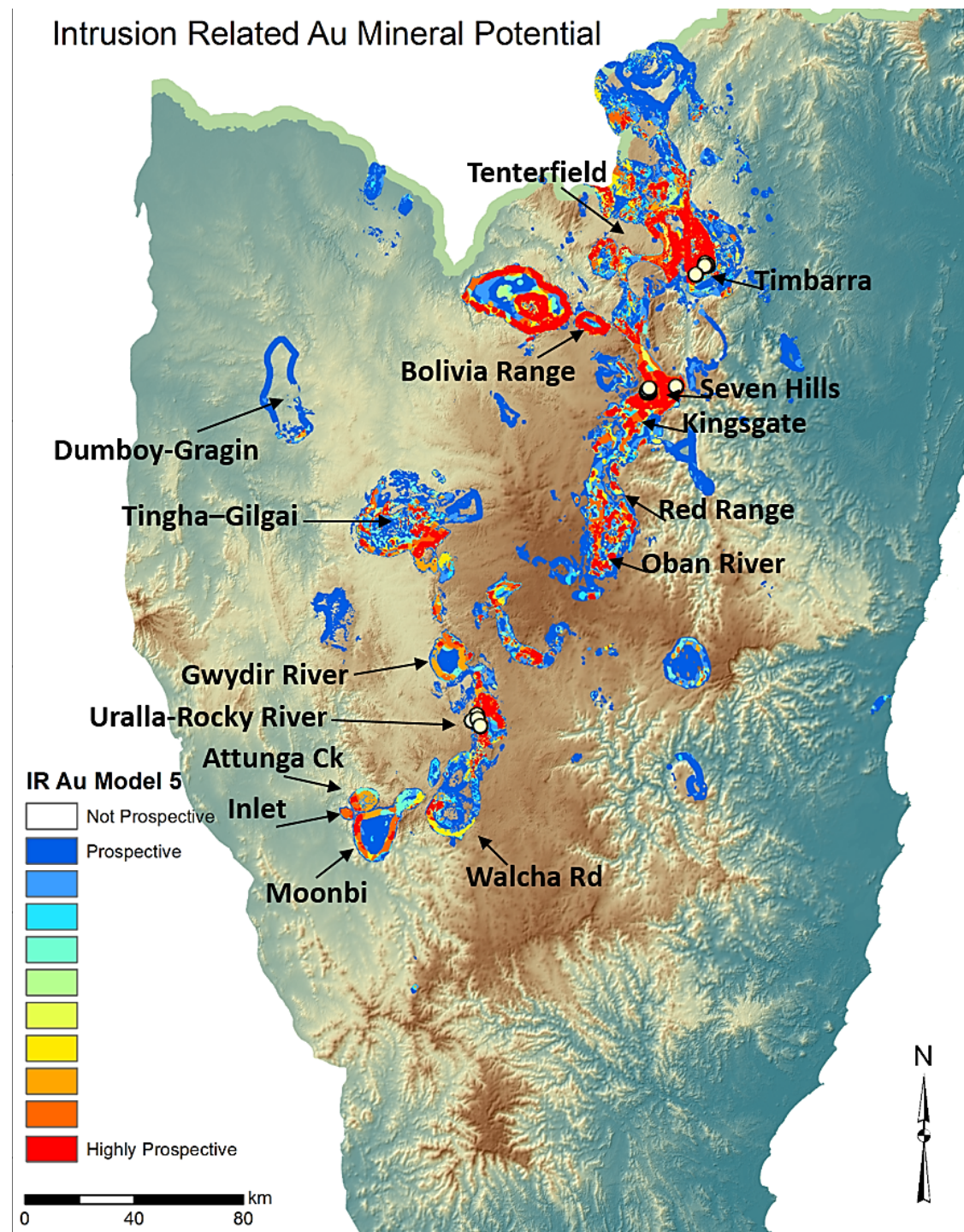
Orogenic Au-Sb: mineral

- Structurally-controlled vein deposits
- A feature of the SNEO is the change in metal endowment from Au–As, to Sb–Au–As–W to Sb–W–(Hg)-dominant systems
- Two gold mineralising orogenic events- Late Permian Hunter-Bowen, mid-Triassic Esk Cycle
- mineralisation ~syn- to post-peak metamorphism
- Peel and Demon faults important 1st order structures
- Great serpentinite belt and deep marine pyritic shales are potential sulfur/gold sources

OROGENIC GOLD DEPOSITS

Wild Cattle Creek — Sb–W–(Hg) <250°C

Hillgrove

Sulfide Content increases

Sb–Au–As–W

Nundle
Copeland
Teatree — Au–As <350°C
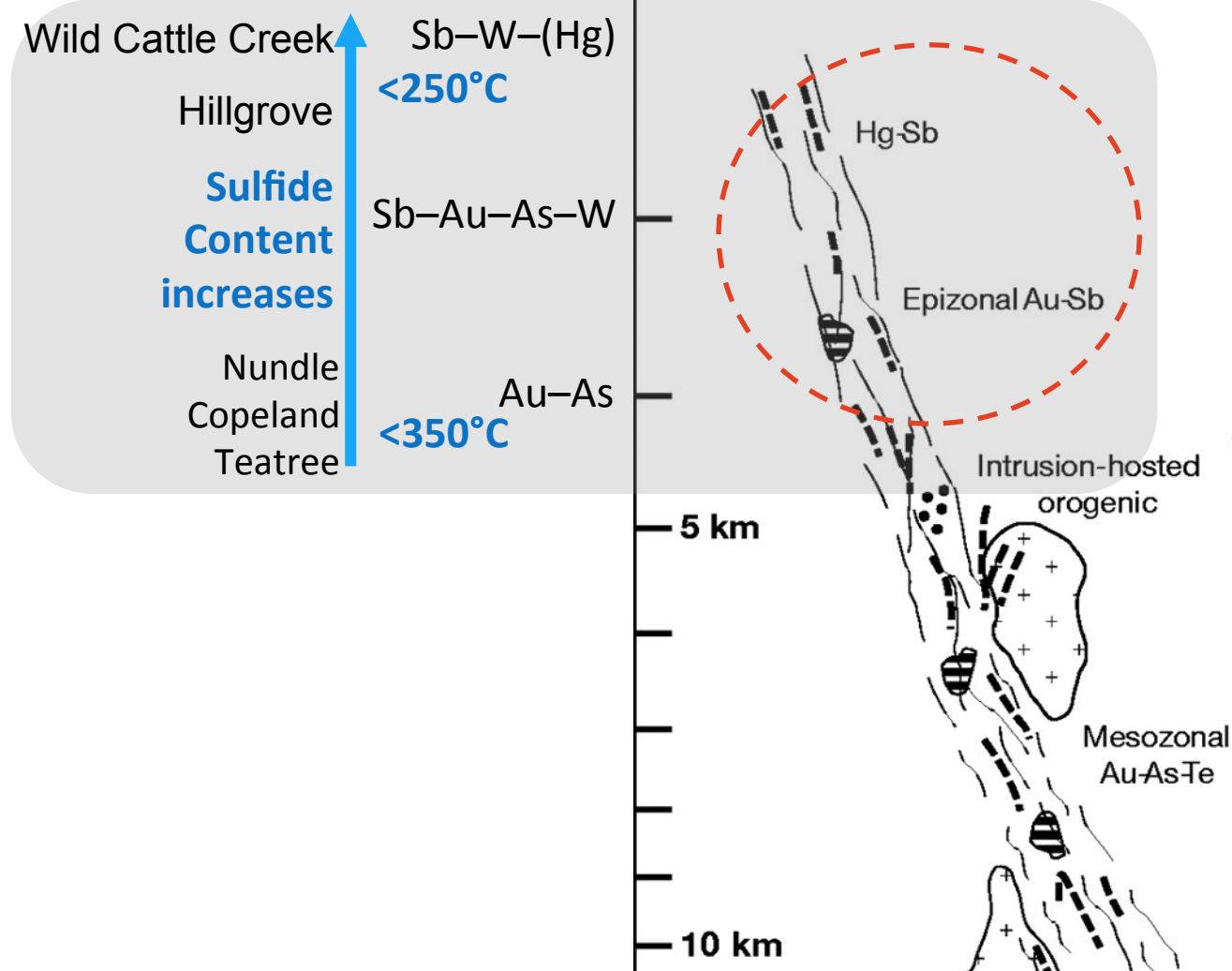
Groves et al. (2003)

Orogenic Au-Sb example in SNEO: Hillgrove

Hillgrove 31.961t Au, 108975t Sb, 2037t W

Hooper et al. 2007
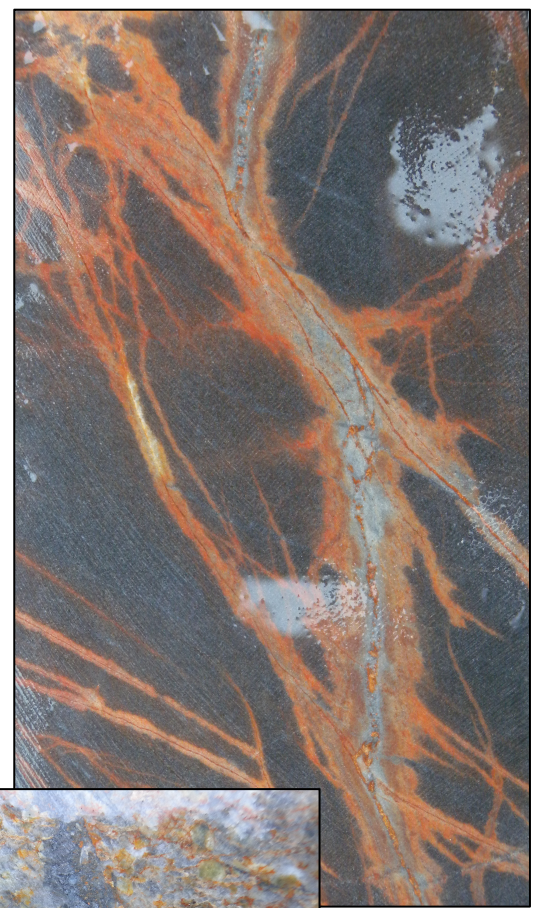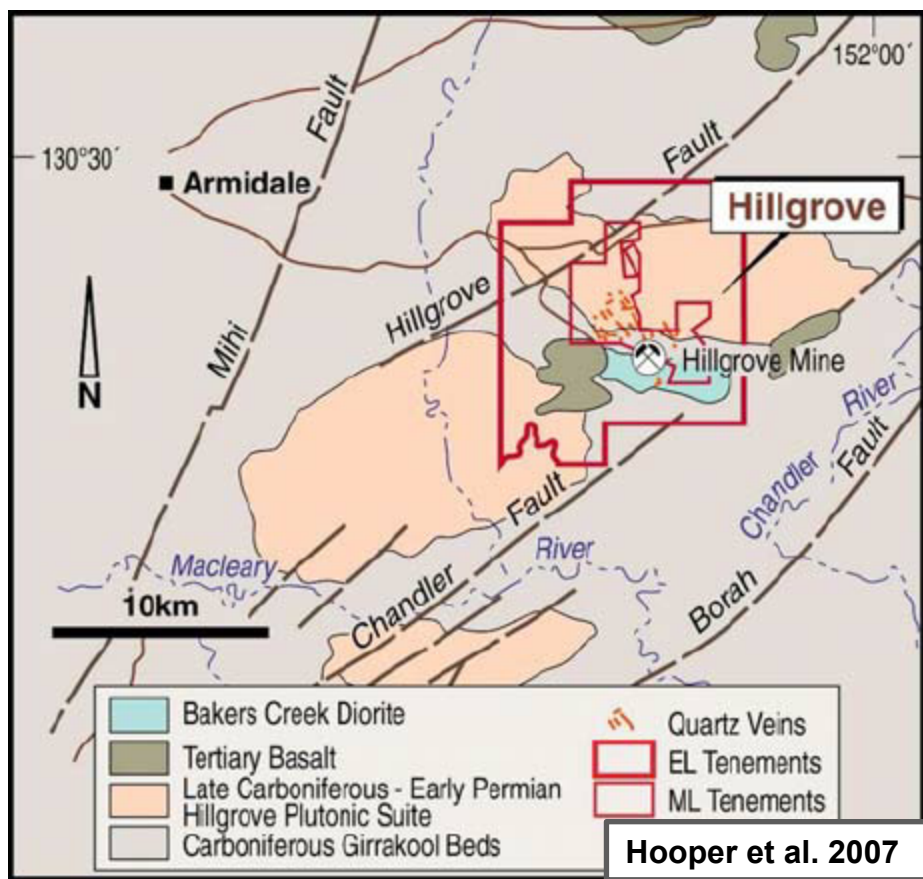
Orogenic Au-Sb training deposits

Name	Metal District	Commodity Major
All Nations gold mine	Bingara Gold Field	Au
Heffernans deposit	Bingara Gold Field	Au
Spring Creek Cinnabar mine	Bingara Gold Field	Hg
Kanaka Reef	Nundle Gold field	Au
Marquis Of Lorne	Nundle Gold field	Au
Opossum Reef	Nundle Gold field	Au
Zwers Scheelite Mine	Nundle Gold field	W (Sb)
Fullers Reef	Upper Hunter	Au
Hidden Treasure Reef	Upper Hunter	Au
Scotchmans Reef	Upper Hunter	Au
Standard Reef	Upper Hunter	Au (Ag)
Beacon Group	Coramba-Orara	Au
Red Flag Mine	Crow Mountain	Au
Taylors deposit	Dalmorton	Au
Tower Hill	Dalmorton	Au
Pine Creek lode	Dalmorton	Au (Ag, Fe)

Name	Metal District	Commodity Major
Bakers Creek Mine	Hillgrove	Au (Sb)
Brackins Spur	Hillgrove	Au, Sb (W)
Clarks Gully prospect	Hillgrove	Au, Sb (W)
Hillgrove mine	Hillgrove	Au, Sb (W)
Solferino reef	not assigned	Au
Garibaldi mine	not assigned	Au, calcite (Ag)
Magword Sb Mine	not assigned	Sb
The Burnt Down	not assigned	Sb
Baxters Mine	not assigned	Sb (Au, Bi, Ag)
Pucka antimony deposit	not assigned	Sb (W)
Manusus prospect	Taylors Arm	Sb, Au
Wild Cattle Creek Sb	Wild Cattle Creek	Sb, Au (Hg, W)

Legend
- ○ Training Points
- · Au Sb Deposits

Orogenic Au-Sb: final predictive maps

Source | **Transport** | **Trap** | **Deposition/preservation**

Association with mafic and ultramafic rocks

Association with deep marine units

Vein Density

Fault dip orientation

Thrust faults

4th order faults and veins

Veins

Fault bends

Competency contrast

Intersection between faults and reactive rocks

Felsic intrusion size

Magnetic lows along structural lineaments

Placer Au deposits

Placer Au source

Mineral occurrence density: Au, Sb, Stibnite, W, Hg

SS Au

Rock Au

Rock As, Sb, W

Knox-Robinson & Wyborn 1997

Orogenic Au-Sb: Results

- Prospective areas are defined as having a post probability higher than the prior probability (0.000236)
- Prospective area covers 4.5% of the study area
- Success rate = 97.6
- 2 training points are below the prior probability
- 26 training points fall above the prior probability (lowest post probability is 0.00073)
- 20 training points fall in the highly prospective area (above 0.9117671) that covers 0.5% of the study area

Orogenic Au Mineral Potential

Oro Au Model 4
- Not Prospective
- Prospective
- Highly Prospecitve
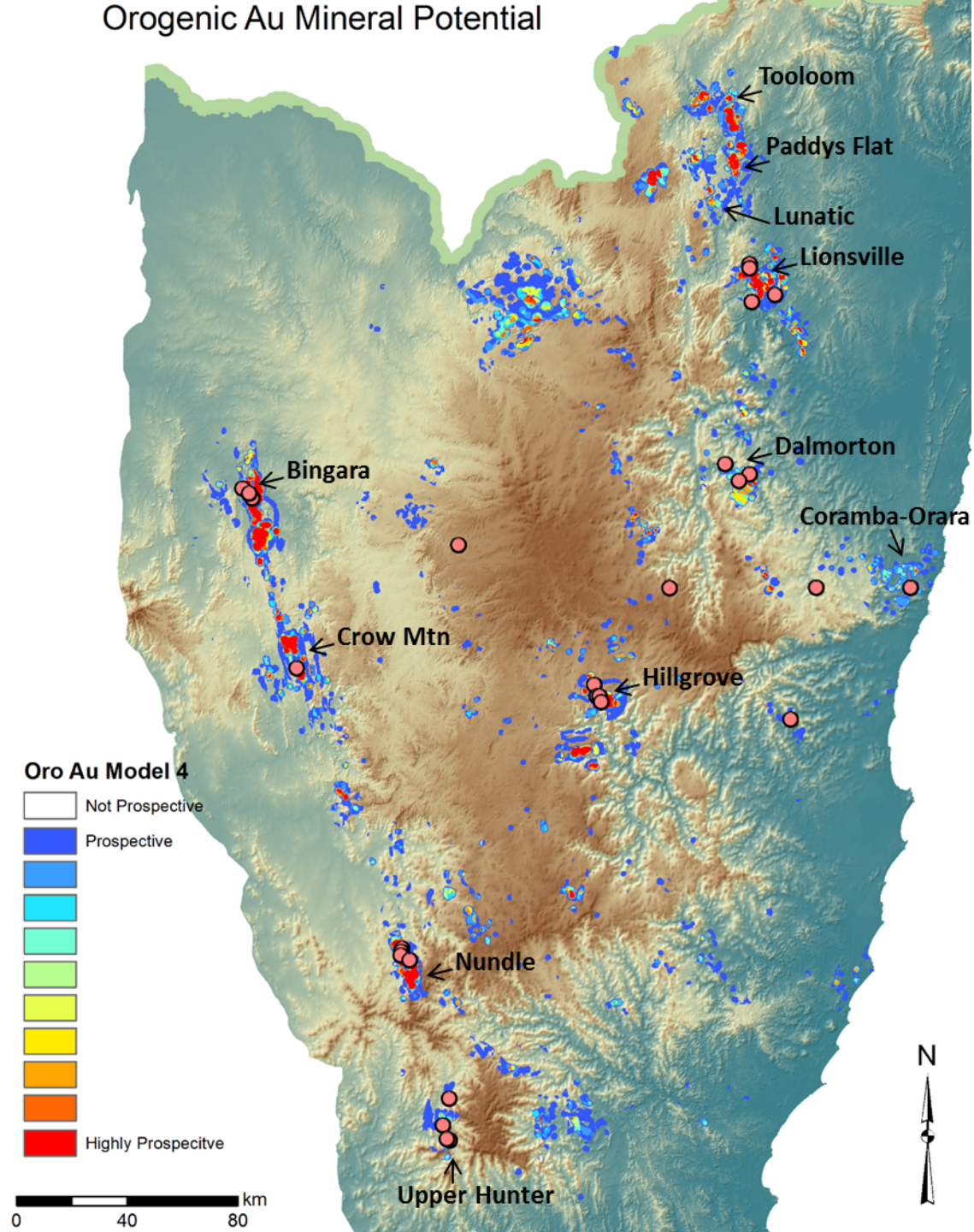
Comparison:

EL heat map vs mineral potential
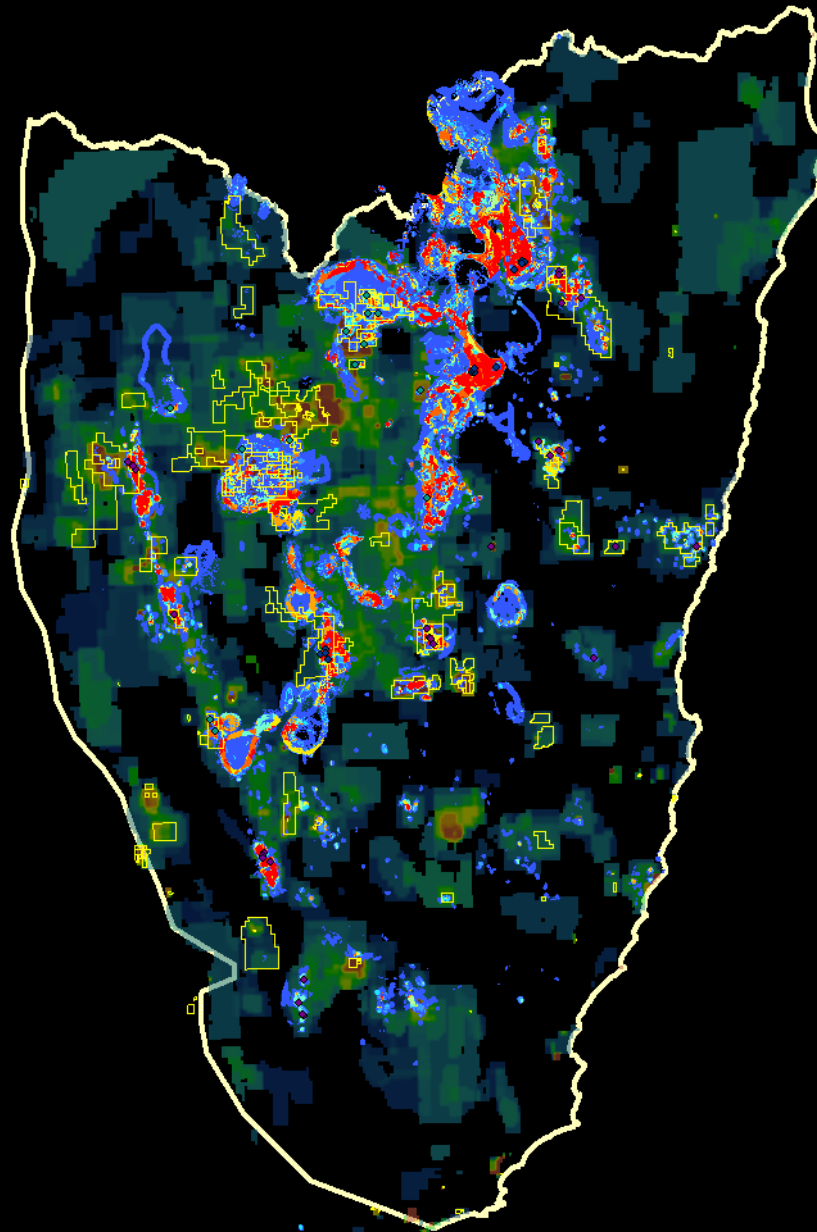
EL Heat map

Orogenic Au-Sb

IR Sn-W

IR Au

Current ELs

Final model results: What are the odds?

The odds of randomly finding a unit cell that contains the training site

The odds of finding the training sites using the model

How well the training sites are classified by the model

	IR Sn-W	IR Au	Orogenic Au-Sb
Prior Probability	0.0001	0.0001	0.0024
Post Probability (highly-prospective)	0.7366	0.9373	0.9412
Prospective area (highly-prospective)	6% (1.2%)	8% (1.4%)	4.5% (0.5%)
Efficiency	99.5%	99.5%	97.6%
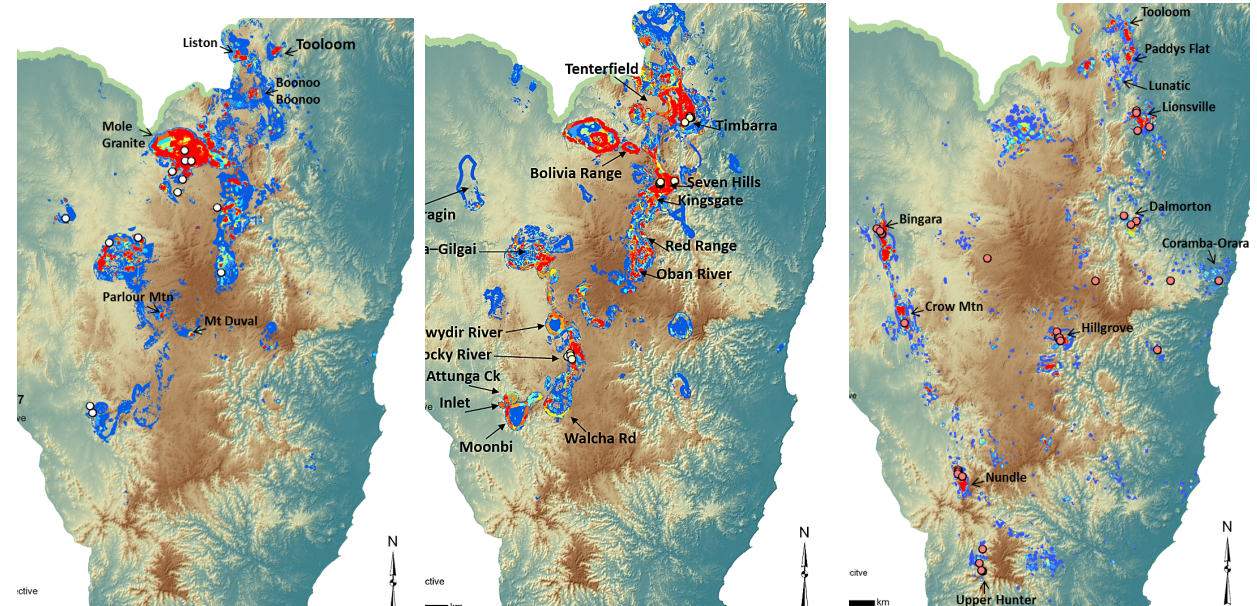
Where next?

- Zone 54:
  - Broken Hill Type
  - IOCG
  - VAMS
  - Orogenic gold

- Other commodities

- Online version

- 3D mineral potential

Conclusions: who should use these maps?

Geological Survey:

- Provide simple yet robust predictive maps to inform land-use planning

- Distil mineral system knowledge, expressed spatially

- Improve data quality- shows data gaps (quality and coverage)

Explorers:

- Who are new to the province

- Who want to test new ideas

Where do ya geddit?

Mineral System models:

IR Sn-W GS2017/0617

IR Au GS2017/0618

Orogenic Au-Sb GS2017/0619

Project Report:

GS2017/0619

Data Package:

https://search.geoscience.nsw.gov.au/product/9222

Or use search term "southern new" in DIGS (publications)

New England 750k Metallogenic coming soon

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