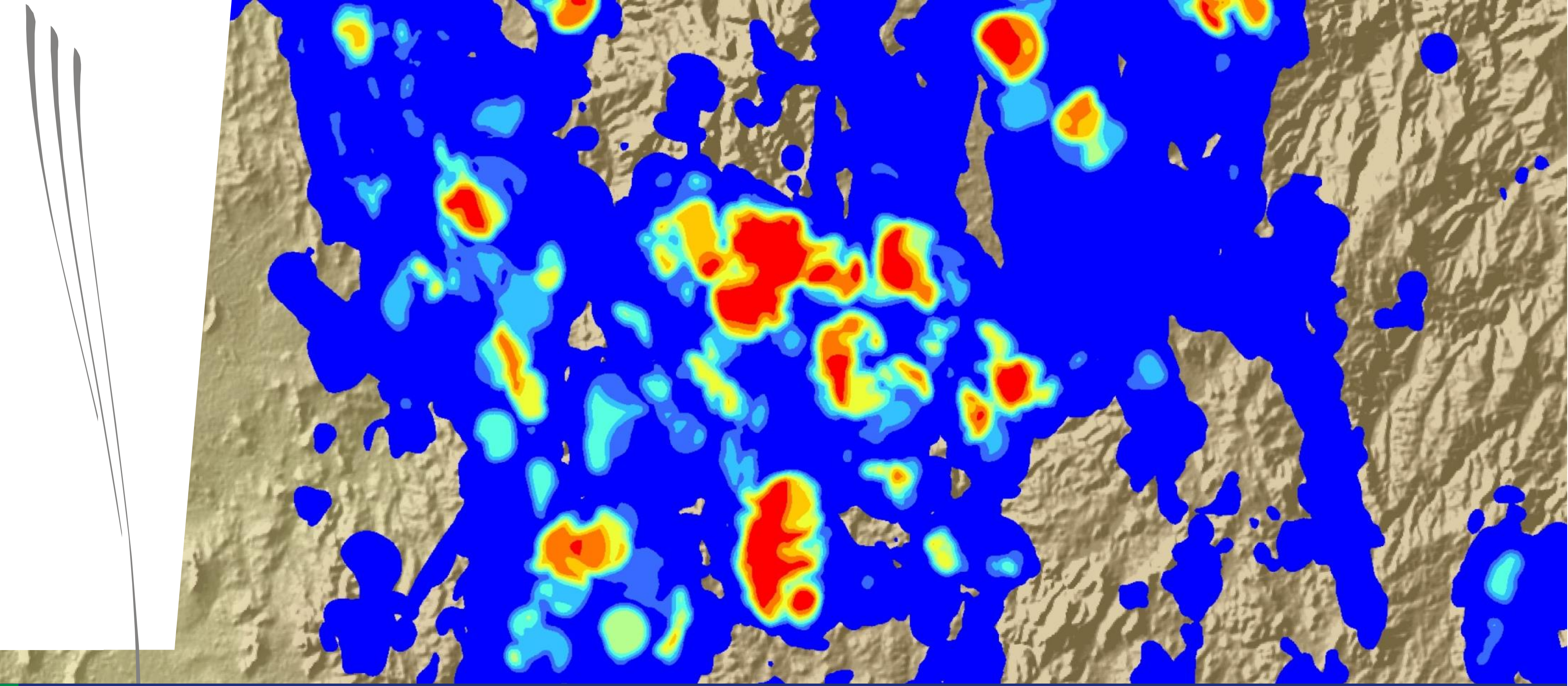

Comprehensive Prospectivity Analysis of the Lachlan Fold Belt in NSW Using the Mineral Systems Approach

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Kenex Ltd
3 June 2013

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Talk Outline

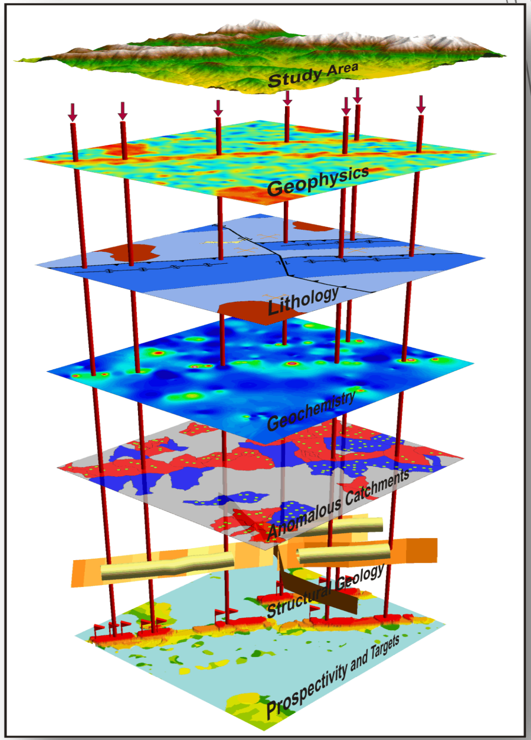
- Types of Spatial Modelling
- Weights of Evidence Technique
- The Lachlan Fold Belt (LFB)
- The Mineral Systems Approach
- Applying the Mineral Systems Approach to the LFB
- Predictive Maps From the LFB Porphyry Model
- Comparison of Prospectivity Maps From Each Model

Why undertake spatial modelling?

- It allows for the combination of **spatial data** and **knowledge** in a way to manage and **target more effectively**
- Modelling can be a **non-bias view** of data which in some cases is an important process in moving forward and away from preconceptions
- Takes advantage of the **wealth of digital data** available in the industry and deals with **data overload** issues that plague many explorers
- **Save time and money** by putting resources into the most likely places the first time and undertake value/**risk assessment** of assets.

Types of Models

- Kenex uses multi-variable GIS modelling techniques:
  - Fuzzy logic (knowledge driven)
  - Neural networking (data driven)
  - And **<u>weights of evidence</u>** (data driven) modelling



- Goal – To predict locations where there is a high probability of a mineral deposit occurring

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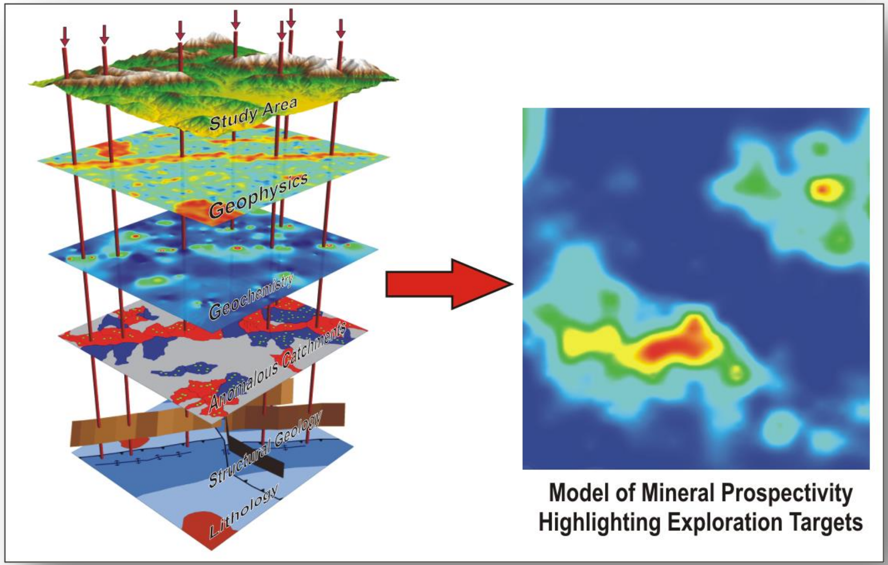
Weights of Evidence Modelling 1

- Basic Method:
  - Create a study area, identify training data and compile a GIS of all available spatial digital data.
  - Develop binary or multiclass predictive maps of data relevant to the mineralisation style being modelled
  - Use training data to test predictive maps for spatial correlation
  - Combine selective predictive maps together using weights of evidence operators to produce a map of probabilities (Prospectivity Map).



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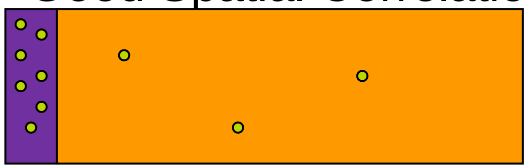
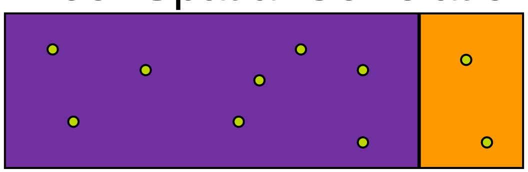
Weights of Evidence Modelling 2

Good Spatial Correlation



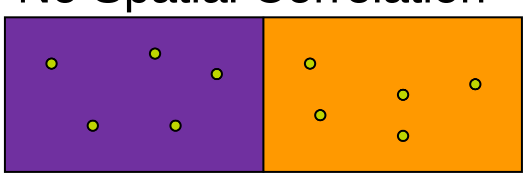
W+ = 3.0 | W- = -1.2 | C = 4.2

Poor Spatial Correlation



W+ = 0.15 | W- = -0.44 | C = 0.59

No Spatial Correlation



W+ = 0 | W- = 0 | C = 0

Strong correlation

C > 3.0; StudC > 1.5

Moderate correlation

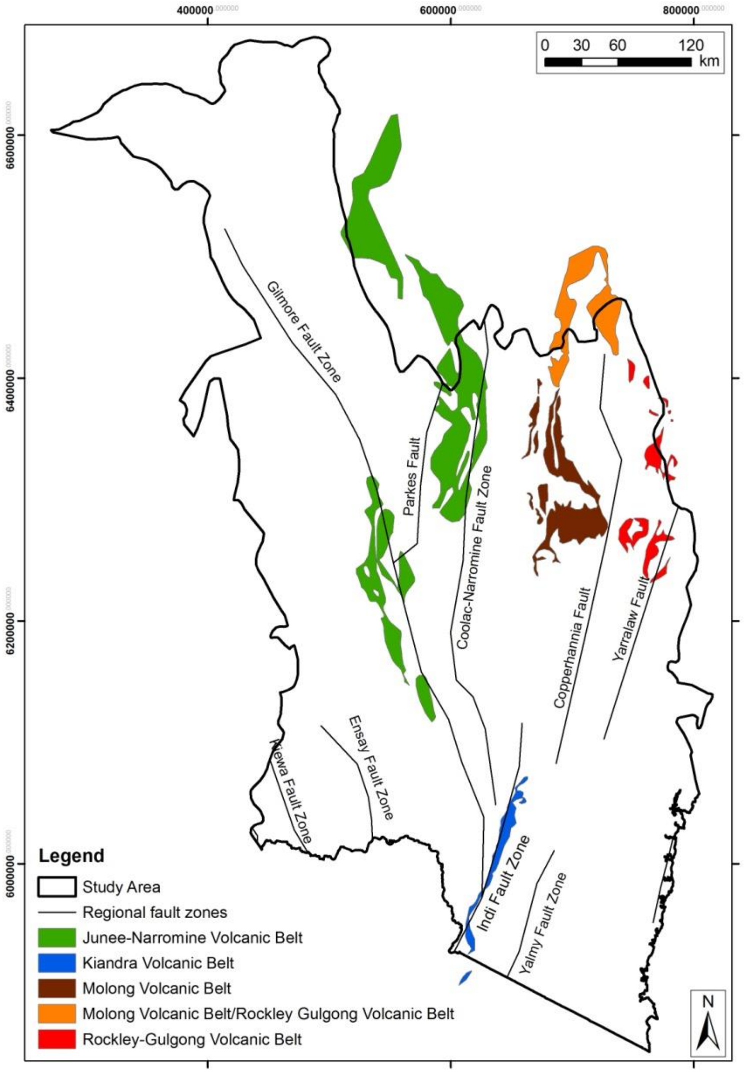
C > 1.0 – 3.0; StudC > 1.5

Weak to poor correlation

C < 1.0; StudC < 1.5

Lachlan Fold Belt in NSW

- Lower Paleozoic structural unit.
- First stage of eastwards-migrating tectonic activity, culminating in the Late Ordovician, when the Macquarie Arc accreted onto the Australian Plate.
- Four recognised volcanic belts
- Mineralisation types present imply the LFB developed in a complex oceanic accretion-subduction setting similar to the modern SW Pacific
- Numerous untested or incompletely tested exploration targets.



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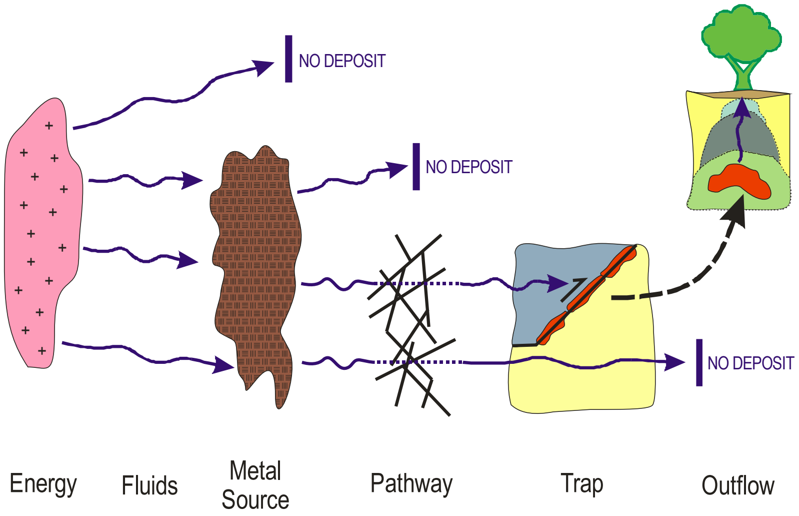
Mineral Systems Approach

- Identifies the mapable variables within a mineralised region that are critical to the ore forming process.

Source → fluid flow → transport pathways → trap/metal deposition → outflow

- Ensure that each part of the mineral system is represented by one or more predictive maps in the model.



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Mineralisation Styles in the LFB

	Porphyry	Skarn
Source	Sil-Ord felsic to intermediate intrusive lithologies	Sil-Ord granitoid plutons close to carbonate-bearing lithologies
Transport	Regional scale faults, especially transcurrent faults	Regional scale faults, especially transcurrent faults
Trap	Dilational regions in fault zones	Chemical variations in lithology
Deposition	Proximal Au, Cu, Mo and distal As, Ag mineralisation Breccias and sulphides Argillic/silica/potassium alteration	Proximal Au, Cu, Mo and distal As, Ag mineralisation Breccias and sulphides Argillic/silica/potassium alteration

Mineralisation Styles in the LFB

	VMS	Orogenic
Source	Intermediate to mafic volcanics or fine-grained clay-rich sediments	Greenschist facies lithologies/folded metasediments
Transport	Fault and fracture density Breccias	Regional scale faults
Trap	Hydrothermal vents Paleo-seafloor contacts	2^{nd} or 3^{rd} order fault structures Dilational regions in fault zones Reactive rock contrasts
Deposition	Sulphide mineralisation Cu, Pb, Zn and Au, Ag, Se and Cd mineralisation	Quartz veining Au, As, Cu, Ni, Mo, Pb, Sb, W and Zn mineralisation

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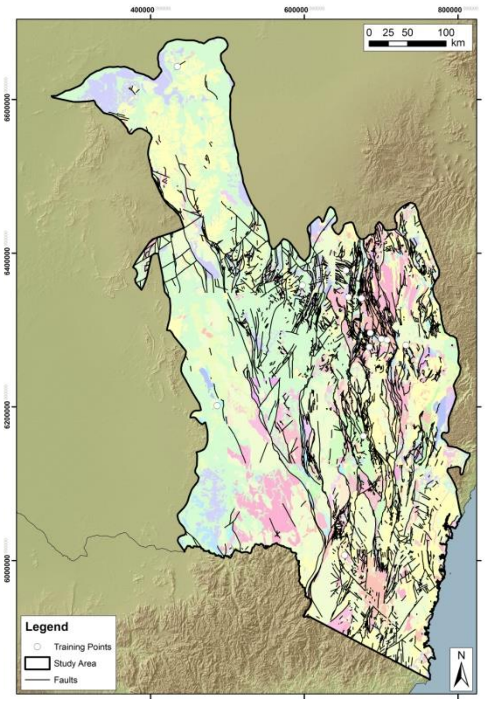
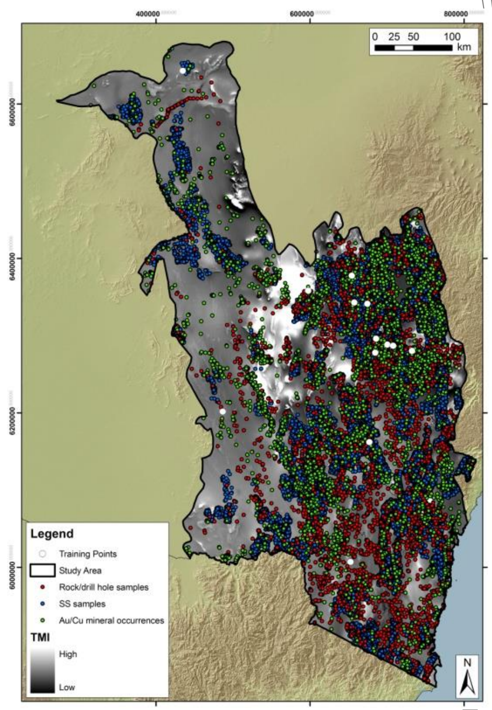
Digital Data

Integrated and assessed:

- 5,398 Au/Cu mineral occurrences
- 10,138 rock data
- 15,609 drill holes
- 176,212 stream sediment data
- 199,161 km² Bouger gravity
- 199,161 km² TMI
- 476,673 km² K/Th/U radiometrics
- 199,161 km² geology
- 30,413 km faults





Sources:
Geological Survey of NSW
Geoscience Australia
Terra Search
Kenex Ltd databases

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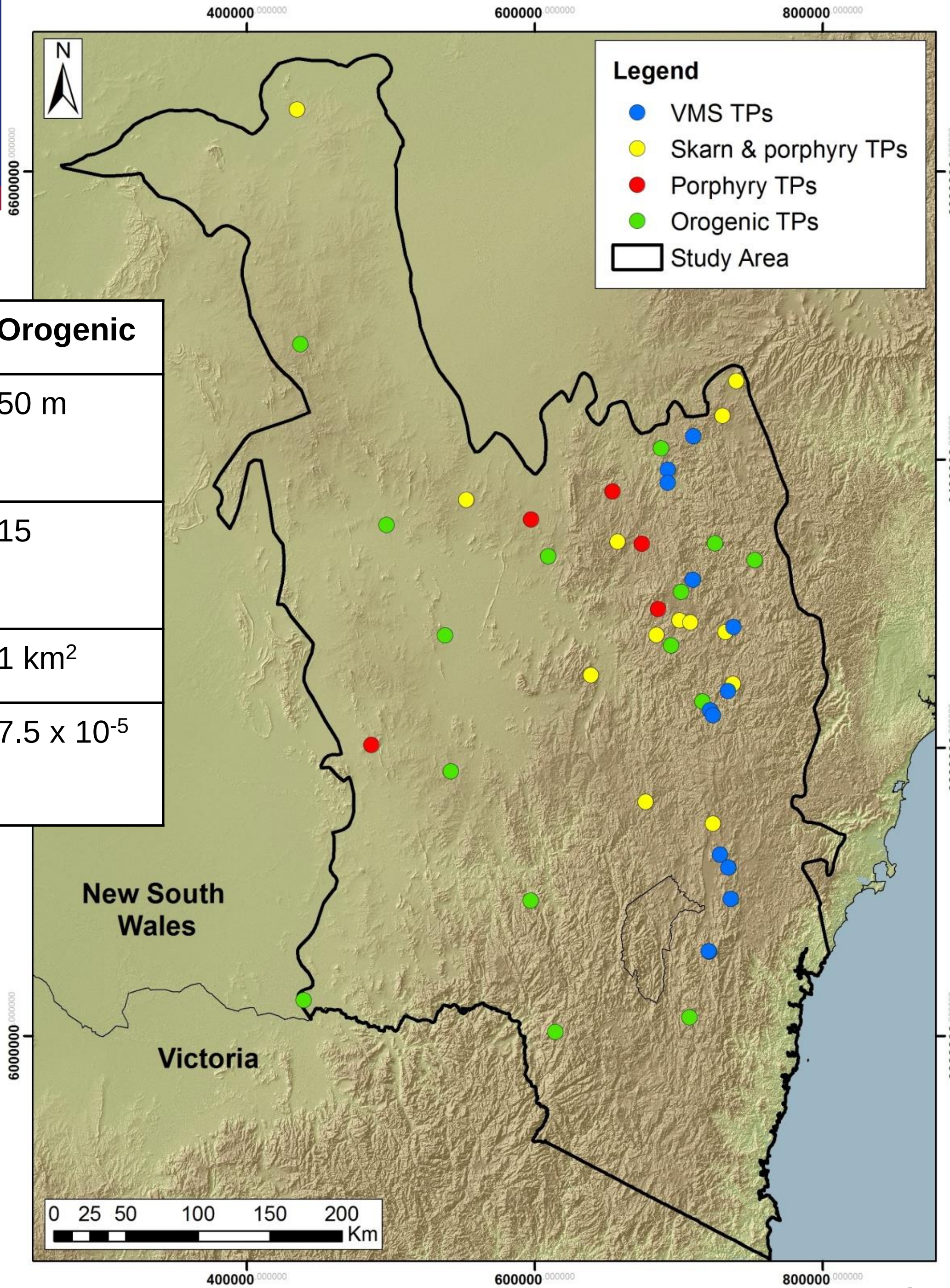
Model Inputs

	Porphyry	Skarn	VMS	Orogenic
Study area grid	50 m	50 m	50 m	50 m
Training points	13	7	13	15
Unit cell	2 km^2	2 km^2	1 km^2	1 km^2
Prior probability	1.31×10^{-4}	7×10^{-5}	6.5×10^{-6}	7.5×10^{-5}



Predictive Maps

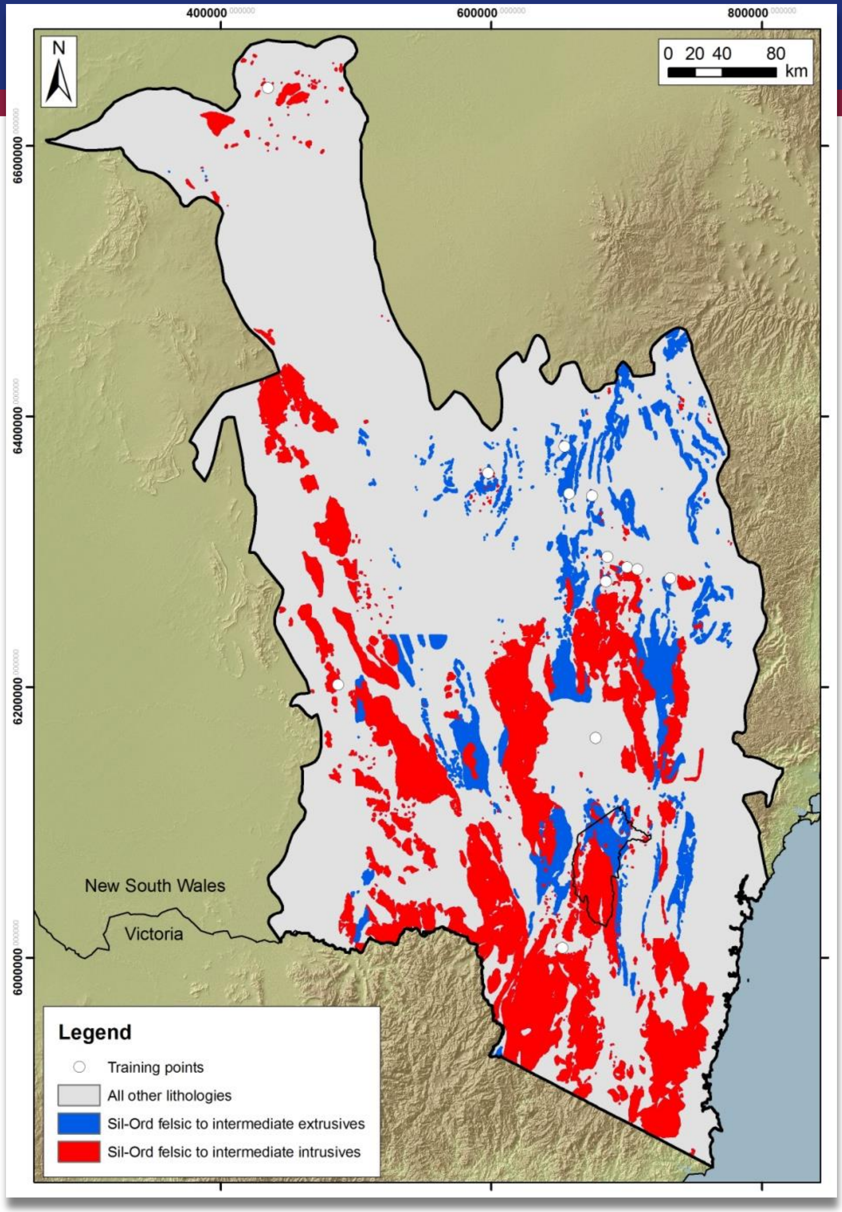
- 152 orogenic, 180 porphyry, 137 skarn and 183 VMS predictive maps were created for the LFB models
- These included lithological, structural, geophysical and geochemical maps
- Using weights of evidence, spatial correlations were determined between the training data and predictive maps
- 8 orogenic, 9 porphyry, 11 skarn and 15 VMS maps with the strongest correlations, best regional coverage and unique map patterns were combined after the map values for each cell were weighted by their spatial correlation
- Software – ArcSDM in ArcMap, ioGAS

Source

Porphyry Model
Predictive Map
Sil-Ord Felsic to Intermediate Lithologies

Intrusives (600 m buffer)
C = 1.6
StudC = 2.9
Good correlation

Extrusives (750 m buffer)
C = 0.8
StudC = 1.1
Medium correlation



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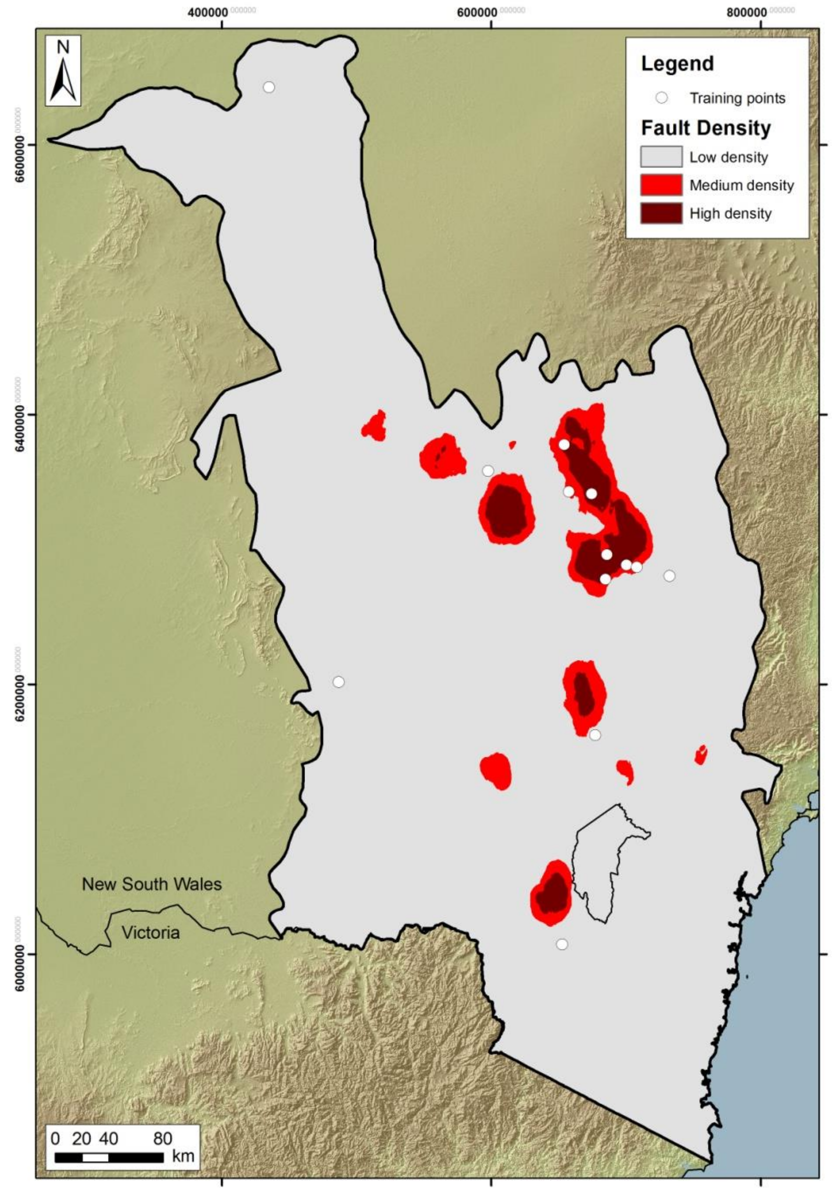
Transport

Porphyry Model
Predictive Map
Fault Density

Medium fault density
C = 1.6
StudC = 2.1
Good correlation

High fault density
C = 3.3
StudC = 5.7
Very good correlation



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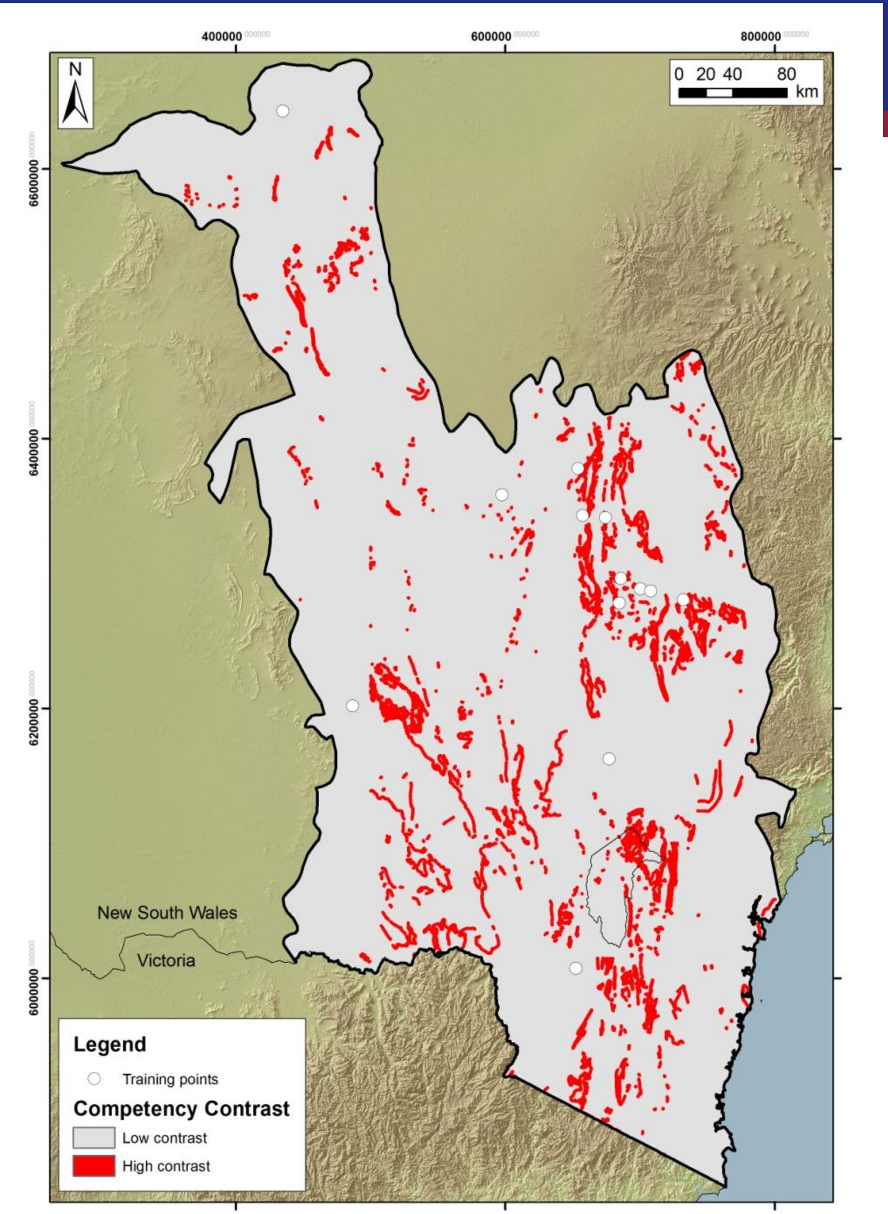
Trap

Porphyry Model
Predictive Map
Competency Contrast
(1200 m buffer)

C = 1.8
StudC = 3.2
Good correlation



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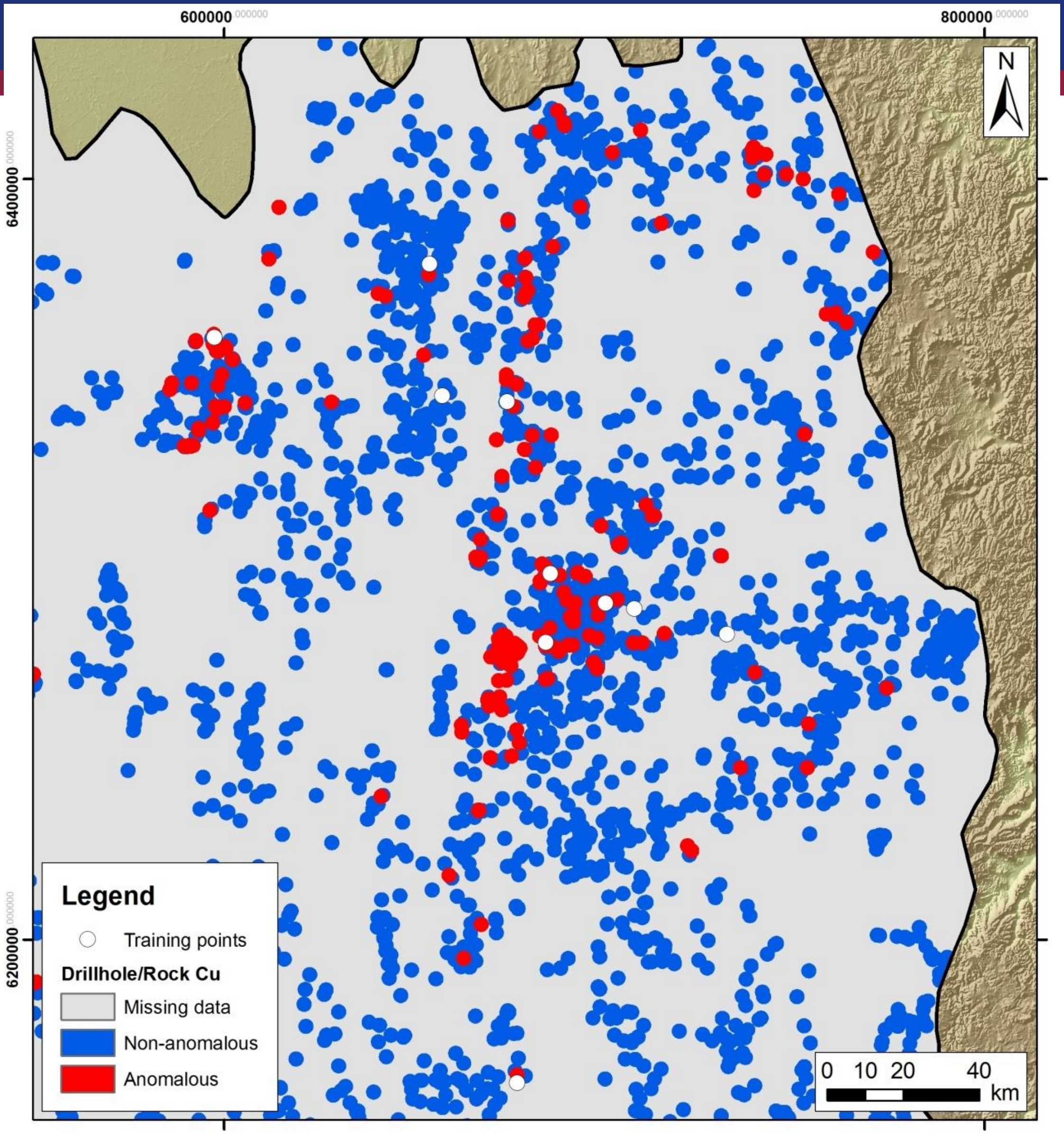
Deposition

Porphyry Model Predictive Map Streams Au
(1400 m buffer)

C = 3.0
StudC = 2.8
Good correlation



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Predictive Maps

Porphyry

Min. Sys.	Layer	Description	C	StudC
Source energy & fluids	SOFelIntComb	Proximity to Sil-Ord felsic and intermediate igneous intrusives	**1.6**	**2.9**
		Proximity to Sil-Ord felsic and intermediate igneous extrusives	**0.8**	**1.1**
Transport	FltDenComb	High fault density	**3.3**	**5.7**
		Medium fault density	**1.6**	**2.1**
	FltNTNS1300	N-S and NW-SE non-thrust faults	**2.5**	**3.7**
Traps	CompCon1200	Lithological competency contrast	**1.8**	**3.2**
	FltIn2400	Fault intersections on non-thrust faults	**2.4**	**4.1**
Deposition	StreamsAu3	Anomalous Au in stream samples (Au > 2.62 units in levelled data)	**3.0**	**2.8**
	DRCuFinal	Anomalous Cu in rock and drill samples (Cu > 200 ppm)	**3.8**	**4.6**
	GoldMinOcc	Anomalous porphyry mineral occurrences with gold	**1.2**	**1.6**
	MagSlp550	High gradient TMI slope	**2.6**	**4.5**

Skarn

Min. Sys.	Layer	Description	C	StudC
Source energy & fluids	LithLstBf2600	Proximity to calcareous lithologies	**2.5**	**4.3**
	CalIntBf2600	Proximity to contacts between calcareous and intrusive lithologies	**3.8**	**6.4**
	OrdSilComb2	Proximity to Sil-Ord intrusives	**1.0**	**2.0**
		Proximity to Sil-Ord extrusives	**2.1**	**3.4**
Transport	Flt3Buff1100	E-W non-thrust faults	**2.0**	**3.4**
Traps	NTFltJogB1700	Dilational jogs on non-thrust faults	**2.6**	**4.3**
Deposition	ReactBf300	Lithological reactivity	**2.0**	**3.4**
	DRAg1ppm	Anomalous Ag in rock and drill samples (Ag > 1 ppm)	**2.1**	**1.8**
	DRCu200ppm	Anomalous Cu in rock and drill samples (Cu > 200 ppm)	**2.4**	**3.0**
	StZn Mosaic	Anomalous Zn in stream samples (Zn > 105 ppm)	**1.6**	**2.0**
	GoldMinOcc	Anomalous skarn mineral occurrences with gold	**1.2**	**1.6**
	MagSlpBf600	High gradient TMI slope	**3.1**	**5.2**

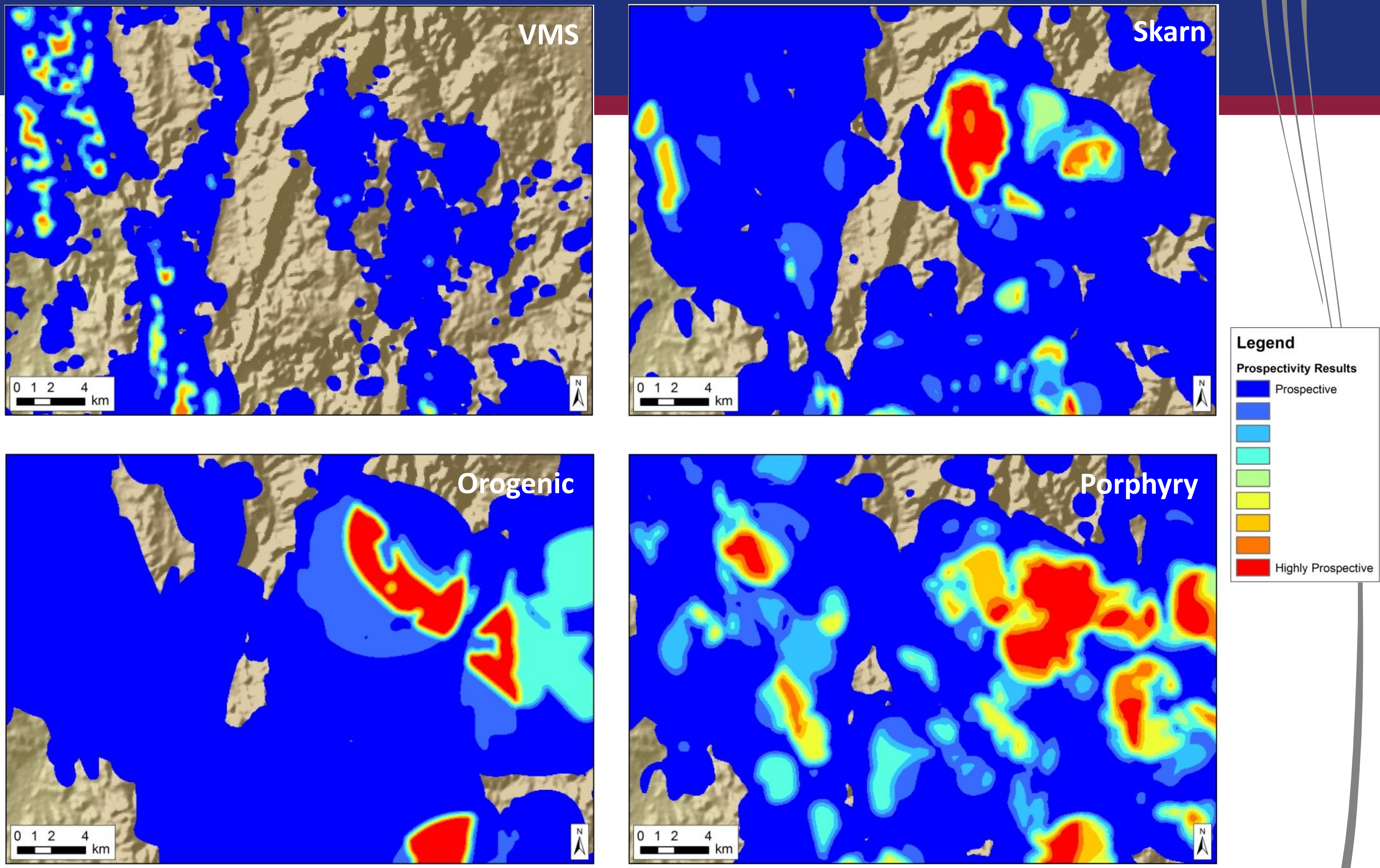
Predictive Maps

Orogenic

Min. Sys.	Layer	Description	C	StudC
Source energy & fluids	Ordsilur17	Ord-Sil clastic sediments	**1.5**	**2.7**
Transport	FaultsNSE12	N-S and NW-SE faults	**1.9**	**3.5**
	flt9k20	Third order faults (< 10 km length)	**1.9**	**3.5**
	10kflts33	Proximity to low order faults near known Au deposits	**2.2**	**4.2**
Traps	fltsplrite31	Proximity to right-oriented fault splays	**2.0**	**3.8**
Deposition	tmilo21	Proximity to areas of low TMI	**1.2**	**2.3**
	tmislp96	High gradient TMI slope	**2.2**	**4.1**
	oroclust	Anomalous orogenic mineral occurrences with gold	**3.7**	**6.4**

VMS

Min. Sys.	Layer	Description	C	StudC
Source energy & fluids	silbarhyo3	Silurian rhyolites and basalts	**4.0**	**6.9**
	vmsclust2	Anomalous VMS mineral occurrences with gold	**6.2**	**5.9**
Transport	faultsNNE6	N-S and NE-SW faults	**2.4**	**4.3**
	fltdens34	High fault density	**2.7**	**3.5**
	fltjog10	Proximity to fault jogs	**2.6**	**4.6**
	fltlotmi19	Faults associated with TMI lows	**2.8**	**4.6**
Traps	rcla30014	Pre-Carboniferous rhyolite/clastics lithological contacts	**3.4**	**5.9**
	synvolc3	Syn-volcanic lithologies containing both sediments and extrusives	**3.2**	**4.9**
	tmislpext23	Extrusive lithologies associated with high TMI slope	**2.9**	**4.4**
Deposition	tmi255lo90	Proximity to low TMI	**2.3**	**3.8**
	DRBi1ppm	Anomalous Bi in rock and drill samples (Bi > 1 ppm)	**2.6**	**3.6**
	DRAs122ppm	Anomalous As in rock and drill samples (As > 122 ppm)	**3.9**	**4.7**
	streamspb	Anomalous Pb in stream samples (Pb > 60 ppm)	**3.7**	**3.3**
	streamscu	Anomalous Cu in stream samples (Cu > 95 ppm)	**4.4**	**3.9**
	streamszn	Anomalous Zn in stream samples (Zn > 105 ppm)	**3.5**	**3.1**



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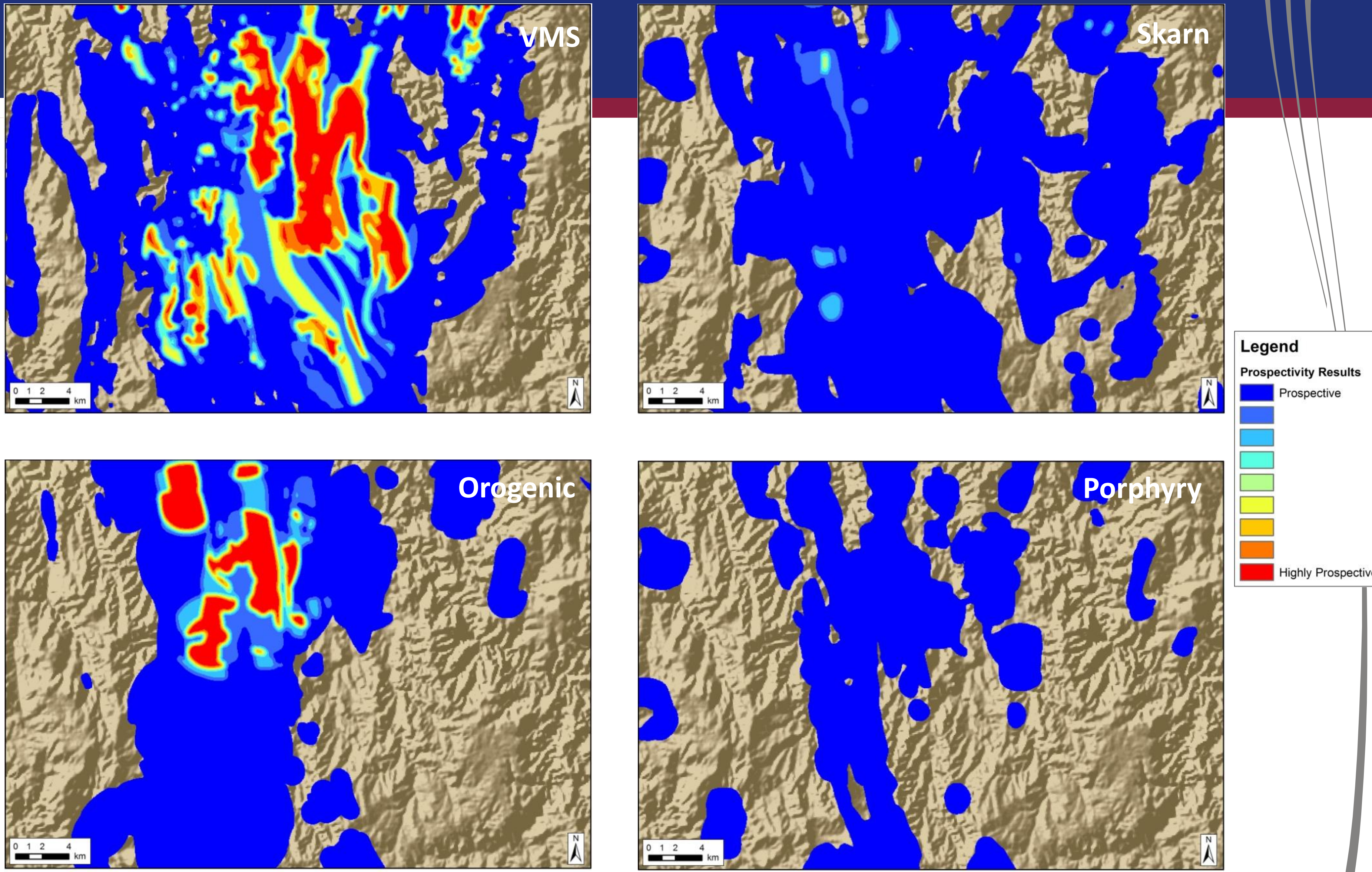

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Conclusions

- Successfully modelled the LFB for four different mineralisation styles
- All stages of the ore-forming process were included in the models
- For the porphyry model 1,779 exploration targets identified

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