Exploration Targeting from Prospectivity Modelling of Multiple Deposit Types in the Lachlan Fold Belt, NSW

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Abstract

Prospectivity modelling has been completed over the Lachlan Fold Belt, New South Wales, Australia, using the GIS based weights of evidence modelling technique to target porphyry Cu-Au, associated skarn Cu-Au, orogenic Au and VMS Au mineralisation. The Lachlan Fold Belt is a 700 km wide belt of Paleozoic accretionary terrains, stretching from Queensland to Tasmania. Porphyry and skarn mineralisation was associated with Ordovician shoshonitic magmatism, which was followed by Silurian regional metamorphism and deposition of orogenic gold deposits. Contemporaneous VMS-style mineralisation resulted in deposits in intra-arc rift basins of the Macquarie Arc.

In preparation for the prospectivity modelling, lithological and structural data, extensive geophysical surveys and stream, drill-hole and rock chip geochemistry were used to create predictive maps that represent various parts of the mineral systems being modelled. Included in the models are maps that identify possible sources of heat and mineralised fluids, structures used for fluid migration, mineral trap zones, and outflow zones that may indicate a subsurface deposit. Prospectivity maps have been created for each mineralisation style and new areas of each deposit type located. The models have also independently identified areas of proven mineralisation, including Cadia, Northparkes, Woodlawn and other large producing mines.

The prospectivity maps were reclassified to generate targets by delineating highly prospective areas from each model. Targets were compared and overlap examined among the four models, before further analysis of high priority targets. Single targets or clusters of targets were individually assessed by incorporating information such as tenure, geology, geochemistry and geophysical signature. Economic and risk factors were assessed and the targets ranked and mapped according to high and low exploration risk. Following this analysis, targets of interest can be highlighted as potential projects for acquisition, or used to prioritise new exploration data collection.

Keywords: mineral prospectivity modelling, exploration targeting, mineral systems approach, skarn deposits, orogenic gold, porphyry copper-gold, VMS, Lachlan Fold Belt.

Introduction

Mineral prospectivity modelling with GIS (Bonham-Carter, 1994) is increasingly being used by geoscientists in industry, government and academia to assess exploration areas and produce effective exploration targeting methodologies. A number of prospectivity modelling techniques have been developed, including weights of evidence, fuzzy logic and artificial neural networks, which have been applied to a wide range of mineral deposit types, from prospect to nationwide scales and in data-rich and data-poor study areas. More recently, prospectivity modelling has expanded into the 3D domain. The outputs of these models are mineral potential maps, which although useful can be improved for use in exploration targeting by incorporating economic or social data. It is important to realise that these maps are a starting point for further investigations, and that additional targeting techniques need to be applied including determining post probability cut-offs for targets and reclassification.

In this paper we present an example of how GIS-based prospectivity models may be used as input for further exploration targeting. By comparing prospectivity modelling of four mineral

deposit types, porphyry copper-gold, skarn, orogenic gold and volcanogenic massive sulphide (VMS) gold, over the Lachlan Fold Belt in New South Wales, Australia. The models use the mineral systems approach (McCuaig et al., 2010) to determine key predictive variables that define each mineralisation style. The mineral potential maps from each model have then been used to delineate the most prospective areas and define high priority targets. The targets either represent existing prospects or mines or areas where new mineralisation could be discovered with further exploration and development.

Regional geology

The model area contains the Macquarie Arc within the Lower Paleozoic Lachlan Fold Belt (LFB) of New South Wales (NSW) (Figure 1). The Macquarie Arc is one of several ancient intra-oceanic island arcs that accreted onto the Australian tectonic plate, accompanied by mineralising magmatism and orogenic gold deposition. The LFB hosts some of Australia's highest productivity mines, including Cadia, Woodlawn and Northparkes, with an estimated total of greater than 80 Moz Au and 13 Mt Cu (Cooke et al., 2007).

The Lower Paleozoic LFB is one of the five orogenic belts in the Tasman Fold Belt System that makes up the eastern third of the Australian continent (Walshe et al, 1995). The LFB extends from eastern Tasmania through Victoria and has much of its best exposure in NSW (Figure 1). The LFB is a complex orogenic belt that developed from the Late Cambrian to Carboniferous (Crawford et al., 2007). These accretionary processes began with the collision of the Macquarie Arc with the proto-Pacific margin of Gondwanaland during the sustained Benambran Orogeny in the Late Ordovician to Early Silurian. The Macquarie Arc was accreted as a single arc that has since been disrupted and dismembered by E-W extension and arc-parallel strike-slip faulting (Cooke et al., 2007). Prior to and during collision, the Macquarie Arc hosted numerous small VMS-style mineralised deposits in intra-arc rift basins.

The rocks constituting the now-dislocated Macquarie Arc now occur in four structural belts in the Eastern sub-province of the Lachlan Orogen, which have been correlated using stratigraphic and trace element geochemical methods (Glen et al., 2011). These belts are the western Junee-Narromine Volcanic Belt, the central Molong Volcanic Belt, the eastern Rockley-Gulgong Volcanic Belt and the southern Kiandra Volcanic Belt. Four different phases of magmatism are related to the episodic evolution of the Macquarie Arc over approximately 50 million years from Early Ordovician to Early Silurian. This is supported by geochronological, geochemical and stratigraphic evidence (Fergusson, 2009). The earliest three phases in the Early, Middle and Late Ordovician are characterised by high-K calc-alkaline and shoshonitic magmatism over several of the four structural belts. The final phase in the Early Silurian emplaced dominantly shoshonitic intrusions and lavas, and is closely associated with several key skarn and porphyry copper-gold deposits in the Macquarie Arc. The Early Silurian saw the end of arc-related magmatism during the Benambran Orogeny.

Deformation continued in the Late Silurian to Early Devonian with the Bindian Orogeny, and in the Middle Devonian with crustal melting and granitoid emplacement during the Tabberabberan Orogeny. Within this timeframe, Silurian regional metamorphism and Devonian remobilisation, together with constant crustal heating, resulted in the deposition of orogenic-style mineralisation. The spatial focus of these deposits is in the west of the LFB, away from the west-dipping subduction zone beneath the Gondwana plate. Further tectonic activity occurred in the Early Carboniferous Kanimblan Orogeny, after which the pre-cratonic phase was terminated and the area became neocratonic (Suppel and Scheibner, 1990).

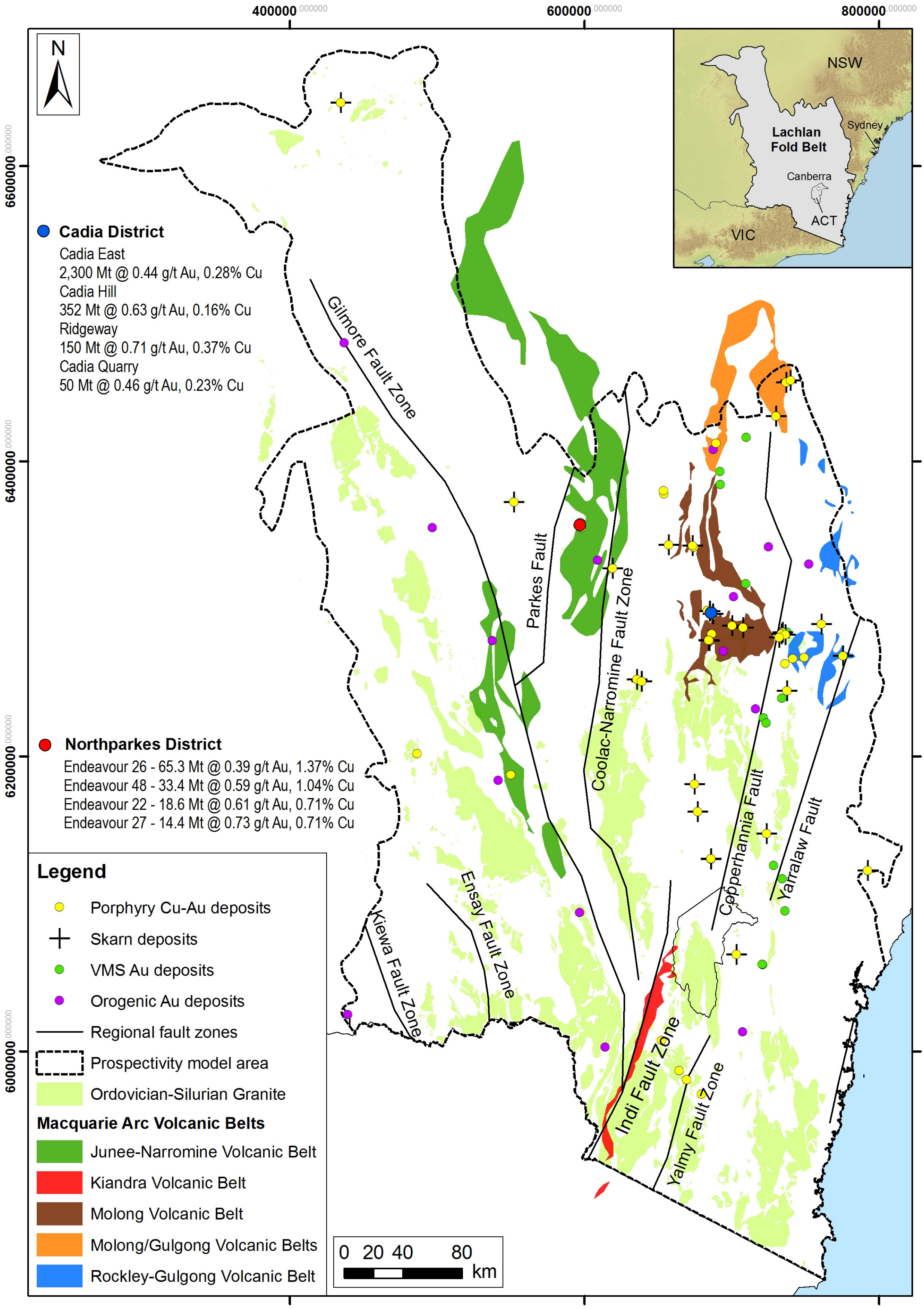

Figure 1. Lachlan Fold Belt and Macquarie Arc study area with Macquarie Arc volcanic belts, regional fault zones and training data for porphyry, skarn, orogenic and VMS prospectivity models.

Mineral System Models

Porphyry-related metal deposits are large-tonnage, generally low-grade, hydrothermal mineralisation related to igneous intrusions emplaced at high crustal levels. Porphyry metal deposits are significant repositories of copper, gold, and molybdenum and account for over one half of the world's copper production. They are characterised by widespread alkaline or calc-alkaline volcanism that is underlain by extensive intrusions of a similar basaltic to rhyolitic composition. Porphyry copper-gold deposits were first discovered in the LFB in 1976 with the Endeavour 22 deposit, which was followed by discovery of porphyries at Cadia (c. 40 Moz Au, 8 Mt Cu) and Northparkes (c. 2.1 Moz Au, 1.5 Mt Cu). Together, these districts constitute the largest porphyry province in Australia (Cooke et al, 2007).

Skarn deposits are important sources of precious metals as well as base metals, tungsten and iron. Skarns are coarse-grained metamorphic rocks composed of calcsilicate minerals that form by high-temperature replacement of carbonate-bearing rocks, in most cases during contact or regional metamorphism and metasomatism in orogenic tectonic settings. Skarn genesis is intimately related to that of porphyry systems, with skarns frequently located proximal to porphyry deposits. Both calc-alkaline and alkaline skarns are present in the LFB, usually located within metasomatic alteration halos where porphyry intrusions intersect carbonate-bearing lithologies. Many skarn deposits were discovered as a result of historic prospecting, with more located in the 1970s following increased focus on porphyry-style deposits using new exploration methods, including the Doradilla and Red Hill skarns.

Orogenic gold deposits are an integral component of many metamorphic belts (Groves et al., 2003). These deposits are believed to form from late-stage fluids mobilised by metamorphic dehydration reactions, specifically across the greenschist-amphibolite facies boundary (Groves, 2003). Orogenic gold deposits are diverse in terms of their age, geometry, structural controls, host rocks, temperature and pressure of formation and consequent alteration assemblages and metal associations. In the LFB, metamorphism of the dislocated Macquarie Arc resulted in orogenic gold deposition, including the Old Reef/Challenger Line and the Cowel Project. Orogenic mineral occurrences in the LFB are hosted by a variety of lithologies but all contain disseminated and sheeted vein complexes within mineralised stockworks.

VMS deposits consist of massive accumulations of sulphide minerals (usually more than 60%) associated with the seafloor as lens-like or tabular bodies parallel to stratigraphy. The host rock varies widely but is predominantly intermediate to mafic volcanic rocks or fine-grained clays. VMS host rocks often have very strong hydrothermal alteration to chlorite, clay minerals and epidote. In the eastern LFB, seafloor hydrothermal activity created strata-bound kuroko-style VMS deposits hosted within ancient intra-arc rift basins of the Macquarie Arc prior to and during its accretion onto the Australian Plate. The major VMS deposits in the LFB include the Captains Flat Mine and the Woodlawn Mine.

Mineral Systems Approach

This study used a mineral systems approach to identify and constrain the predictive variables for prospectivity analysis (Wyborn et al., 1994). The mineral systems approach includes all elements and processes that are necessary to generate and preserve mineral-rich deposits. These are sources of energy to drive the system, as well as fluids, metals and ligands; transport pathways along which fluids containing ore components can migrate towards trap zones; trap zones along which fluid flow becomes focused into channels and fluid

composition is modified; deposition of ore components from fluids passing through the trap zones; and last, outflow zones for discharge of residual fluids and melts. Being process-based, the application of the mineral systems approach is neither restricted to a particular geological setting nor limited to a specific ore deposit type.

The results of the above processes can be mapped directly, or more commonly, identified indirectly using geoscience datasets, and are perfectly suited for analysis and display using GIS. Predictive maps of individual variables serve as proxies for each of the elements of the mineral system, allowing the critical ore-forming processes to be mapped. Ore deposit formation is precluded where a mineral system lacks one or more of these essential components. Therefore where the probability of occurrence of a particular ore-forming process is zero, it is expected that no mineral deposit will be present.

Predictive maps have been developed that describe possible source, transport, trap and metal deposition. The review focussed on testing the validity of using porphyry, skarn, orogenic and VMS mineral system models for modelling the area, and for prioritisation of follow-up exploration planning. In the LFB, each of the above criteria has been mapped using various geological, geophysical and geochemical data, sourced mainly from the Geological Survey of New South Wales. Complete coverage of geological mapping and structural data at a scale of 1:250,000 was published by the Survey in 2003 and used extensively in this study, in conjunction with geophysical TMI and gravity data, and geochemical data sourced from Geoscience Australia and the Geological Survey of New South Wales.

Weights of Evidence (WoE) Method

In this study, a study area of the Lachlan Orogen within NSW was created and, following validation, training data selected for each of four mineral systems from the Kenex mineral occurrence database (Table 1). The training data were selected from historical or current mines or mineral occurrences, with priority given to those with recorded production. The study area was gridded according to the maximum data resolution, and a unit cell size assigned to each mineral system that represents the average deposit size of each mineralisation style. This allowed prior probabilities to be calculated, which indicate the probability of a deposit existing in a predetermined area before applying any knowledge about geology or geochemistry. All relevant GIS data were also clipped to the study area extent and imported with the same projection into the GIS.

Table 1. Model parameters for porphyry, skarn, VMS and orogenic mineral systems.

	Porphyry Cu-Au	**Skarn Au**	**VMS Au**	**Orogenic Au**
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 x 10^{-4}	7 x 10^{-5}	6.5 x 10^{-6}	7.5 x 10^{-5}

Spatial analysis was carried out prior to the development of the prospectivity models, using the weights of evidence technique developed by Bonham-Carter of the Canadian Geological Survey, using the Spatial Data Modeller extension developed for ESRI's ArcGIS software. The details of this method are described fully by Bonham-Carter (1994). To summarise, Deng (2009) explains the WoE modelling method as the creation of numerous binary predictive maps of geological variables and their spatial comparison with known mineral deposits, also known as training data. Selected predictive maps are combined into one final prospectivity

map of estimated posterior probabilities of the occurrence of known or unknown ore deposits of the mineral system being analysed.

The maps used in the final prospectivity models were chosen mainly due to their high contrast (C) weighting coefficient, indicating a close spatial relationship between the variable and the training data. The studentised contrast value (StudC) is another important value, calculating the ratio of the standard deviation of the contrast to the contrast value itself, and gives an informal test of the uncertainty. If the ratio is relatively large then the contrast is more likely to be real. Other factors were considered, including good regional data coverage and minimal duplication of predictive map patterns. A key advantage of the WoE approach is that it is data-driven, although particular predictive maps can introduce an element of bias to the analysis because of conditional dependence issues.

Prospectivity Modelling

Source

Evidence for appropriate sources of metal ligands, fluid and energy to drive a mineral system mainly comes from geological mapping and geophysics. Among other properties, the mapped geology is attributed with age information, allowing analysis of temporal relationship between rock units. Skarn and porphyry deposits have a close relationship with felsic to intermediate, porphyritic intrusive rocks (Table 2), which provide the main source of heat, fluids and metals in these systems. Calcareous units are key to skarn formation, providing additional reactive components to the ore fluid. Orogenic deposits are more closely associated with greenschist facies metasediments, whereas VMS mineralisation is linked to intermediate to mafic volcanic lithologies or fine-grained clay-rich sediments. Mapped bedrock geology has been used to interpret the location of those lithological units relevant to each mineralisation style. Where rocks are buried under cover, magnetic geophysical data is useful for identifying source rocks.

Table 2. Predictive maps used in the porphyry (green), orogenic (red), VMS (orange) and skarn (blue) prospectivity models. A contrast value > 1 is considered significant, as is a StudC value > 1.5.

Min. Sys.	Porphyry Map Description	C	Stud C	Orogenic Map Description	C	Stud C
Source energy & fluids	Proximity to Sil-Ord felsic and intermediate igneous intrusives / extrusives	**1.6 / 0.8**	**2.9 / 1.1**	Ord-Sil clastic sediments	**1.5**	**2.7**
Transport	High / medium fault density	**3.3 / 1.6**	**5.7 / 2.1**	N-S and NW-SE faults	**1.9**	**3.5**
	N-S and NW-SE non-thrust faults	**2.5**	**3.7**	Third order faults (< 10 km length)	**1.9**	**3.5**
				Proximity to low order faults near known Au deposits	**2.2**	**4.2**
Traps	Lithological competency contrast	**1.8**	**3.2**	Proximity to right-oriented fault splays	**2.0**	**3.8**
	Fault intersections on non-thrust faults	**2.4**	**4.1**			
Deposition	Anomalous stream Au	**3.0**	**2.8**	Proximity to areas of low TMI	**1.2**	**2.3**
	Drill hole/rock Cu > 200 ppm	**3.8**	**4.6**	High gradient TMI slope	**2.2**	**4.1**
	Porphyry mineral occurrences with gold	**1.2**	**1.6**	Orogenic mineral occurrences with gold	**3.7**	**6.4**
	High gradient TMI slope	**2.6**	**4.5**			

Min. Sys.	VMS Map Description	C	Stud C	Skarn Map Description	C	Stud C
Source energy & fluids	Silurian rhyolites and basalts	**4.0**	**6.9**	Proximity to limestones	**2.5**	**4.3**
	Anomalous VMS mineral occurrences with gold	**6.2**	**5.9**	Proximity to limestone/ intrusive igneous contacts	**3.8**	**6.4**
				Proximity to Sil-Ord intrusives / extrusives	**1.0 / 2.1**	**2.0 / 3.4**
Transport	N-S and NE-SW faults	**2.4**	**4.3**	E-W non-thrust faults	**2.0**	**3.4**
	High fault density	**2.7**	**3.5**			
	Proximity to fault jogs	**2.6**	**4.6**			
	Faults associated with low TMI	**2.8**	**4.6**			
Traps	Pre-Carboniferous rhyolite/clastics contacts	**3.4**	**5.9**	Dilational jogs on non-thrust faults	**2.6**	**4.3**
	Syn-volcanic lithologies with sediments and extrusives	**3.2**	**4.9**			
	Extrusive lithologies associated with high TMI slope	**2.9**	**4.4**			
Deposition	Proximity to low TMI	**2.3**	**3.8**	High lithological reactivity	**2.0**	**3.4**
	Drill hole/rock Bi > 1 ppm	**2.6**	**3.6**	Drill hole/rock Ag > 1 ppm	**2.1**	**1.8**
	Drill hole/rock As > 122 ppm	**3.9**	**4.7**	Drill hole/rock Cu > 200 ppm	**2.4**	**3.0**
	Stream Pb > 60 ppm	**3.7**	**3.3**	Stream Zn > 105 ppm	**1.6**	**2.0**
	Stream Cu > 95 ppm	**4.4**	**3.9**	Skarn Au mineral occurrences	**1.2**	**1.6**
	Stream Zn > 105 ppm	**3.5**	**3.1**	High gradient TMI slope	**3.1**	**5.2**

Transport

The source fluids and metals within a mineral system must be able to migrate in a focused way to a deposition site to allow formation of an economic ore body. The evidence for fluid migration comes from regional-scale geological mapping using evidence for structural control and presence of hydrothermal fluid. Faults of different orientations and lengths were considered as potential pathways for the mineralisation styles in the LFB. Other indicators of fluid pathways including brecciation, vein stockworks, and mapped alteration would also ideally be considered. VMS deposits are often located close to brecciated and therefore permeable units (Table 2), and orogenic mineralisation is frequently associated with regional scale deformation structures. Many porphyry and skarn deposits occur in extensional tectonic environments dominated by normal faulting.

Trap

The formation and type of trap is one of the most important variables in any mineral system as the trap will determine the size and continuity of any resulting ore body. The type of trap present in a mineral system can be assessed using geological data to look for lithological or structural controls on mineralisation (Table 2). The distribution of alteration zones may also provide information on the scale of the mineral system. Dilation zones mapped from fault data may occur at fault jogs, intersections, and bends may provide structural controls for deposition of metals from rising hydrothermal fluids. Potential trap sites can also be modelled using vein density and type where these variables record hydrothermal fluid trapping. Lithological trap controls occur where contrasts in rock competency or reactivity result in

metal deposition. Regional scale geological mapping can be used to distinguish these brittle-ductile rock unit contacts, as well as the location of reactive lithologies such as limestone.

Deposition

The efficiency of the processes controlling metal deposition in a mineral system is critical to the grade and continuity of economic mineralisation in any ore deposit. Many of the controls on metal grade are also directly and indirectly related to the lithological and structural traps present as well as fluid chemistry and physics. The best evidence for the efficiency of metal distribution comes from geochemical anomalism for gold, silver, copper, arsenic, molybdenum, lead, zinc and other trace metals (Table 2). Geochemical anomaly maps were developed for each mineral system by deriving anomalous threshold values for all relevant elements by examining percentile breaks and probability plots of log-normalised data. Stream sediment and combined drill hole-rock chip samples provide good geochemical coverage in the Lachlan Fold Belt. Soil geochemistry data has poor regional coverage so was not used in the modelling, but is an important dataset for consideration during exploration targeting.

Evidence for the presence of alteration, and therefore ore deposition, can be indirectly gained from the available high resolution aeromagnetic data collected over the LFB. These data can be used to identify magnetic highs or lows that may represent magnetite or phyrrotite alteration zones. Magnetic highs may also represent magnetic rock types such as buried igneous intrusions, which are relevant to skarn and porphyry mineral system models. A map of high gradients in magnetic intensity was created to map lithology contacts, structures, alteration zones and contrasting competencies that help focus fluids and deposit metals.

Results

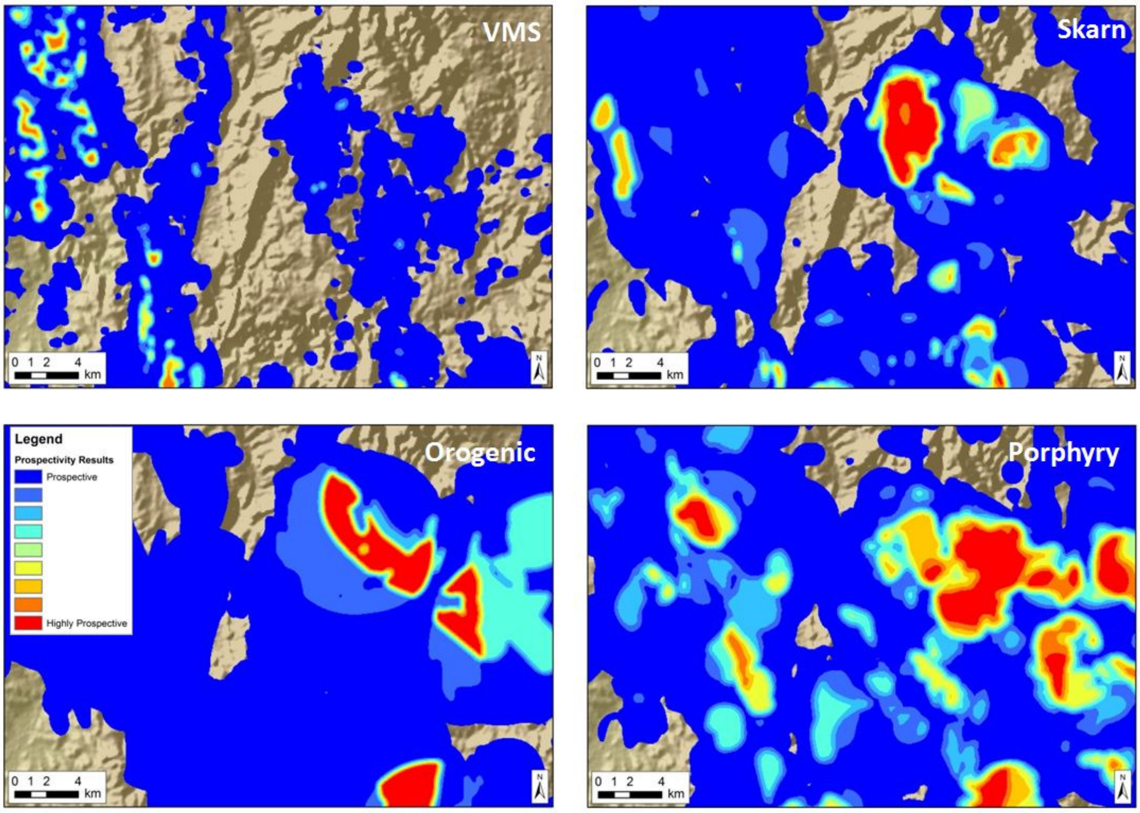

Figure 2. Prospectivity maps for a part of the LFB comparing porphyry, skarn, orogenic and VMS mineral systems. Blue is prospective (above prior probability), red is highly prospective.

Among the four prospectivity models over 200 binary and multiclass predictive maps of geological variables in total were tested for their spatial associations with the relevant training data from the four prospectivity models. The selected predictive maps for each mineral system (Table 2) were combined into a prospectivity map using the model parameters listed in Table 1. The result of the prospectivity models for a small section of the LFB is shown in Figure 2. Some high prospectivity areas (in red) from different mineral systems coincide, whereas other areas may be highly prospective for one deposit type but not prospective for another. This is a result of using different training data to test the spatial correlation with geological variables.

Target Analysis

The initial outcome of the prospectivity models reduces the potential target area to between 7.7% (skarn model) and 10.2% (porphyry model) of the study area. However, further constraint and analysis of the prospectivity model is necessary to define targets on prospect scale (Partington, 2010).

A simple way of ranking exploration targets is to set cut-off values greater than or equal to the post probability of large producing mines, and a potential second cut-off as above the post probability of smaller mines and prospects (Figure 3). Targets are thereby ranked by maximum and mean post probability values, ensuring that targets that meet the desired cut-off are adequately covered by exploration data from a purely spatial statistical perspective. For the LFB models, setting the post-probability cut-off value to that of the large Cadia Hill mine reduces the target area of the porphyry model to 0.9% of the total study area. This is equivalent to increasing the likelihood of find a deposit by between 1-2 orders of magnitude, or having a 1:110 chance of finding a deposit in any 2 km^2 area compared to the 1:7600 chance before modelling was undertaken.

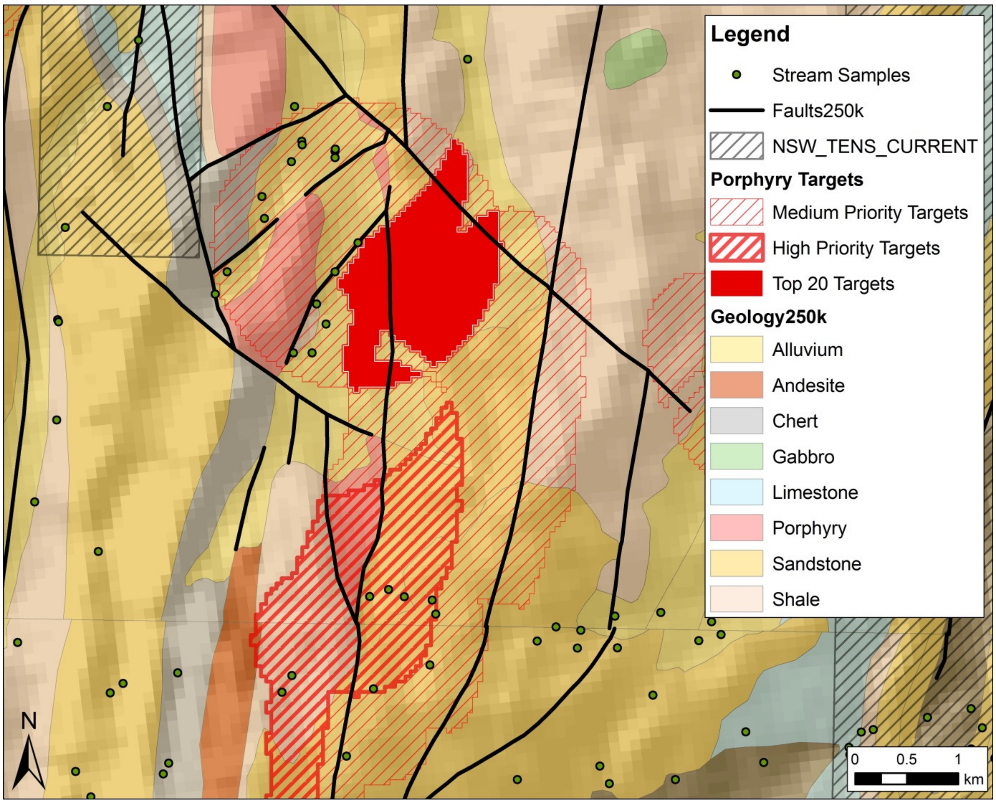

Figure 3. Example of a target area (solid red) with high rank among non-tenemented targets. Data missing that could improve its rank include stream sediment sampling and drilling.

A more detailed target ranking system includes the current status and nature of the target area. Tenement and ownership data can be extracted from public databases and overlain onto the target maps, showing whether the area is already claimed for mineral extraction purposes, as well as who owns the land for access purposes. More detailed geological and geophysical mapping can be sought out, and existing mineral occurrences can be explored in detail. Geochemical data including precious metal anomalies can also add to the final target ranking. Using the Cadia Hill Mine area as an example, the associated prospectivity model target is completely covered by tenements. Comparing existing mines to the target maps can then assist further exploration, potentially increasing life of mine expectancy. If the goal is to pick up new ground, tenemented targets can be excluded before the target analysis is undertaken.

In well studied regions, the targets with the highest post probability will likely be currently active or historical mines, as these are areas with most dense data coverage. An important outcome of the prospectivity modelling is to determine what data are missing from lower ranked targets, especially those that are freely available or previously undiscovered, which would improve their prospectivity. Typically, such targets may have geophysical and structural data available from regional mapping and remote sensing studies, but may lack detailed drilling, structural analysis or geochemical sampling. To complete a detailed analysis of each target or target cluster, a unique conditions grid has been created in association with each prospectivity model. This grid is a response map containing the intersection of all of the input variables as a single integer, effectively combining the predictive maps while maintaining a record of the spatial distribution of each variable. The unique conditions grid allows targets to be easily identified and grouped according to what data is missing that could be collected to upgrade the target, and prioritised accordingly. This is a critical part of the post-modelling analysis carried out using GIS, yet is often not realised to its full potential.

Conclusions

Mineral prospectivity modelling has been used to define exploration targets for several mineral systems in the Lachlan Orogen. Four prospectivity maps have been produced using weights of evidence techniques over the LFB in NSW that assess the probability of finding porphyry Cu-Au, skarn Au, orogenic Au or VMS Au deposits based on input predictive maps that represent all stages of the mineral system model defined for each deposit type. The prospectivity maps have been reclassified to define areas above the prior probability that are prospective or highly prospective for gold and copper mineralisation. For each model, over three quarters of the training data are found within the prospective or highly prospective areas, indicating that all four models have correctly predicted areas with a high probability of intersecting mineralisation.

The WoE methodology is not without limitations. The main area of potential error is introducing conditional dependence of the input predictive maps for the prospectivity model due to overlapping map patterns. This can be analysed using the Agterberg-Cheng test. Although conditional independence can be a significant problem, it is not unusual when using geological datasets as the processes acting in a mineral system are rarely independent of each other. Therefore, the results should be viewed as a relative measure of favourability for the factors controlling mineralisation rather than an accurate calculation of the probability of mineralisation. The probability values, however, provide an objective way of ranking an area's prospectivity and highlight those areas where mineralisation may be present. These areas require field checking and more detailed data collected to allow drill targeting.

The LFB models have been reclassified to generate target areas with posterior probabilities above a certain threshold identified by spatial statistics. The strength of the approach is not only in reducing potentially prospective ground by up to two orders of magnitude, but can also be seen in the approach to the final targeting. Economic and risk factors have been assessed and the targets sorted and mapped according to positive and negative exploration risk. Single targets or clusters of targets can be individually assessed using information such as tenure, geology, geochemistry and magnetic signature. By applying post prospectivity cut-offs as well as ownership and data quality criteria, the final target ranking can be tailored to the needs of the client: a prospecting program may benefit from knowledge about where additional sampling and drilling can upgrade existing targets, while existing mining operations can use targets over their tenement areas to intelligently plan future exploration and extend mine life expectancy.

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