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GIS Modelling of Gold Prospectivity in New Zealand

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ABSTRACT

Gold production in New Zealand has been significant since the mid 1800s, totalling 900 t (29 Moz) to 2005. In addition, there is potential for a further 1230 t (39.5 Moz) of gold in known and undiscovered deposits. Most of the gold has originated from epithermal and mesothermal (orogenic) hydrothermal systems. Epithermal gold occurs in the Northland, Coromandel and Taupo volcanic zones in quartz veins formed by shallow hydrothermal systems. All past production has been from the Coromandel region. Mesothermal gold occurs in Marlborough, West Coast and Otago in low-medium metamorphic grade sedimentary and schist host rocks, typically within quartz veins or shear zones that were formed during deformation. Placer gold mining has occurred downstream of mesothermal gold deposits in Otago and the West Coast of the South Island, and on some West Coast beaches.

Considerable data are available in digital formats to assist exploration for new gold deposits using Geographic Information Systems (GIS) software. These data include modern geological mapping, geochemistry, geophysics, mineral occurrences, topographic data and cultural data, as well as derivative themes such as geophysical interpretation, metamorphic grade and structural trends. Key data components of epithermal and mesothermal Au mineral deposit models were extracted from these data sets, including host rocks, proximity to structures, lithofacies, quartz veins, alteration, metamorphic grade, geochemistry and volcanic features. The spatial relationships between these data and known gold deposits have been statistically quantified using the weights of evidence technique within GIS software. Stronger correlating data have been combined to create map models that quantify prospectivity. Many areas of elevated prospectivity with little previous mineral exploration have been identified suggesting that there is considerable potential for future gold discoveries in New Zealand.

Keywords: gold, epithermal, volcanic, mesothermal, orogenic, hydrothermal, metamorphic, GIS, digital data, prospectivity, exploration, modelling, weights of evidence, Northland, Coromandel, Taupo Volcanic Zone, Marlborough, Westland, Otago.

INTRODUCTION

Gold has played a significant part in the historic economic and social development of New Zealand and recent GIS prospectivity modelling projects by Crown Minerals and GNS Science (GNS) (Anon, 2002, 2003) were aimed at stimulating further investment in gold exploration in New Zealand. The projects provided explorers with a new compilation of historical exploration data, which have been combined with new geological information from the QMAP 1:250 000 Geological Map of New Zealand and other GNS Science analytical databases. These data were used with current mineral deposit models to produce predictive mineral potential maps for gold mineralisation in New Zealand. The success of the project has been demonstrated by several new companies acquiring tenement positions and committing significant exploration expenditure to exploring in New Zealand.

This paper presents a summary of the results of the modelling projects. The results have helped refine exploration models for gold mineralisation in New Zealand. More importantly, new exploration targets have been developed using the gold potential maps and prospective areas that require follow-up exploration identified.

GOLD IN NEW ZEALAND

The discovery of gold in Driving Creek, Coromandel in 1852, opened the way to several major gold rushes in the 1860s (Figure 1), resulting in a major influx of people into New Zealand and rapid growth of the economy. In the late 1800s, hard rock gold mines began to play a significant role in New Zealand gold production, in particular, the quartz reefs of the North Island's Coromandel goldfield, together with those at Reefton in the South Island. The first commercial use of cyanide leaching in the processing of gold ores at Karangahake in the Coromandel, in 1889, greatly enhanced gold recovery and contributed to the development of many deposits that would have been unprofitable using earlier methods. Renewed exploration in the 1980s resulted in hard rock gold mining at Waihi and Golden Cross in the Coromandel, and Macraes in Otago, as well as a large number of placer gold mining operations in the South Island. New Zealand's total gold production to 2005 was about 902 000 kg (29 million oz), and current annual production is some 10 000 kg (10 151 kg or 315 696 oz in 2004), from Waihi, Macraes and several small and medium sized placer mines (Figures 1 and 2). New hard-rock gold mining projects being developed at Favona, Waihi and Globe-Progress, Reefton and increased regional exploration activity from 2003, attest to New Zealand's continuing gold prospectivity.

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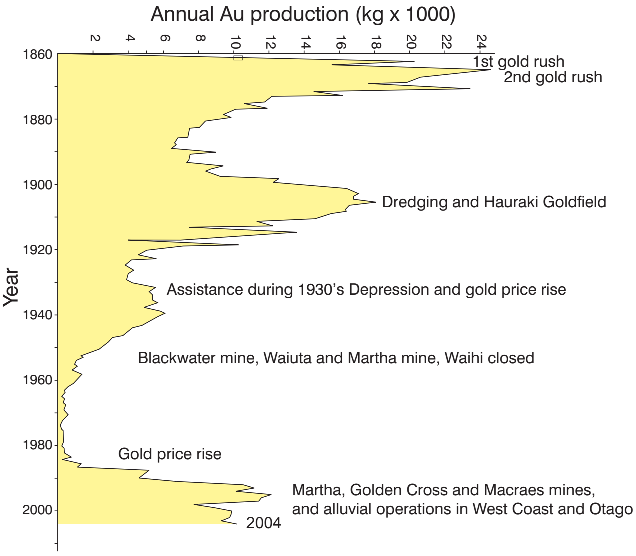

FIG 1 - New Zealand gold production.

Estimates of gold resources have been determined for some specific mining operations and advanced prospects (Table 1). Additionally, more speculative estimates have been made of potential resources associated with known gold prospects and undiscovered deposits (eg Christie and Brathwaite, 1999; Christie *et al*, 2001a) using mineral deposit and grade tonnage models. For undiscovered deposits, the methodology involves making an estimate of the percentage chance of the occurrence of an as yet undiscovered economic deposit of a specific type, given knowledge of the local geology, local past production, mineral exploration data and mineral deposit models (Singer, 1993). Thus, Christie and Brathwaite (1999) suggested that there were approximately 373 000 kg (12 Moz) of gold as defined resources in epithermal, mesothermal, placer and intrusion-related gold deposits. They also estimated an additional potential of 1230 t (39.5 Moz) of gold in known and undiscovered deposits in these four mineral deposit types, plus Carlin and skarn types.

MINERAL DEPOSIT MODELS

A mineral deposit model is a critical component of a mineral prospectivity analysis. The mineral deposit model identifies key geological and other elements that need to come together to form

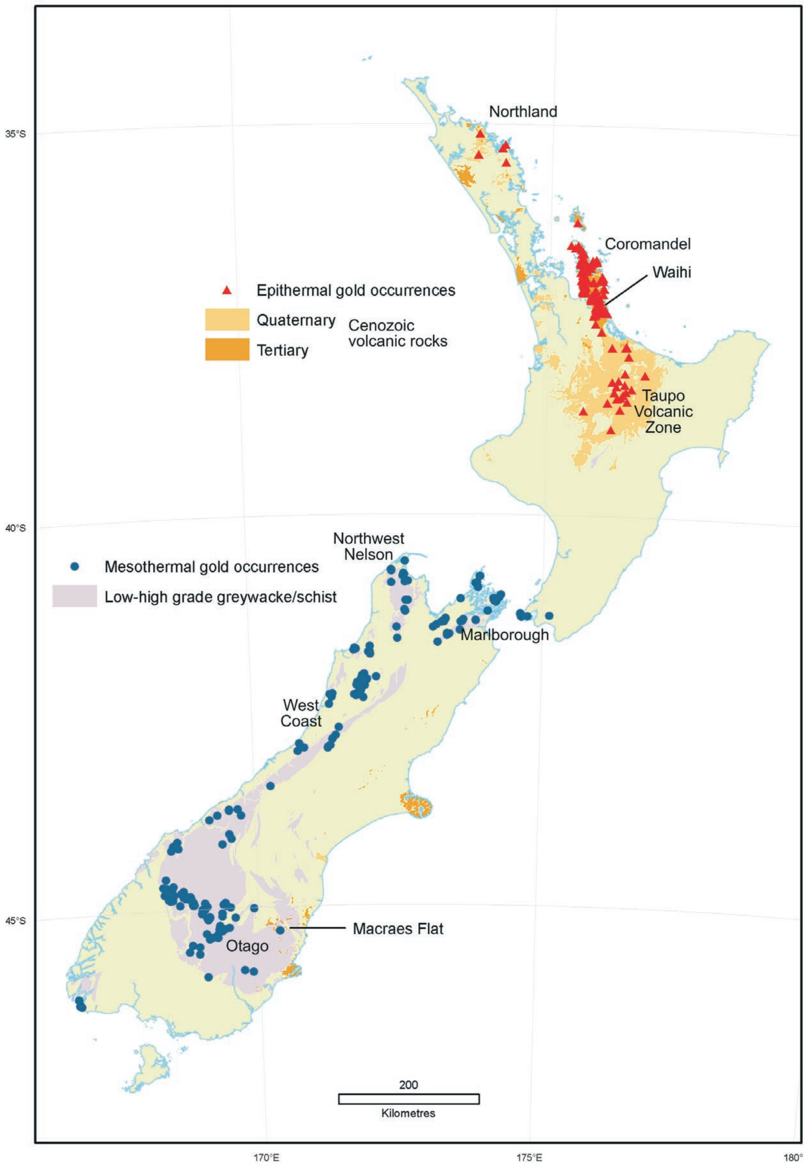

FIG 2 - Major exploration areas for epithermal and mesothermal gold deposits in New Zealand.

TABLE 1

Estimated gold resources classified in accordance with the JORC code.

Deposit type	Deposit	Measured		Indicated		Inferred		Total		
		Mt	Au g/t	Mt	Au g/t (Ag g/t)	Mt	Au g/t (Ag g/t)	Mt	Au g/t (Ag g/t)	Au Moz (Ag Moz)
Epithermal	Karangahake (June 2004)			0.180	11.0 (10.9)	0.156	9.2 (40.3)	0.335	10.2 (40.7)	0.11 (0.438)
	Martha (Dec 2005) (resources + reserves)			3.24	3.4 (45)			3.24	3.4 (45)	0.360 (4.7)
	Favona (Dec 2005) (resources + reserves)			1.5	9.7 (35)	0.287	13.7 (72)	1.793	10.3 (40)	0.596 (2.359)
	Trio- Amaranth (Dec 2005)			0.78	7.3 (36)	0.05	5.6 (28)	0.83	7.2 (36)	0.19 (1.0)
Intrusion-related	Sams Creek (Dec 2005)					13.5	1.78	13.5	1.78	0.776
Mesothermal	Reefton (Dec 2005)	1.95	2.63	10.44	2.34	6.41	3.35	18.8	2.72	1.641
	Macraes Flat (Dec 2005)	27.1	1.22	52.1	1.22	32.7	1.41	111.9	1.27	4.580

a specific type of ore deposit. Two mineral deposit models have been used in the recent prospectivity analyses; epithermal gold and mesothermal gold.

Epithermal gold

Epithermal gold deposits comprise quartz vein, stockwork quartz vein, breccia and disseminated mineralisation formed at depths varying from near surface (hot-spring subtype) down to about 1500 m. These deposits form from hydrothermal fluids at temperatures between 180 - 300°C, with salinities generally less than three equivalent weight per cent NaCl (Christie and Brathwaite, 2003). Known deposits are found in Northland and the Coromandel region associated with Miocene-Pliocene volcanism, whereas in the Taupo Volcanic Zone, deposits are associated with Quaternary volcanism, and in this region, gold is currently being deposited in some active geothermal systems (eg Waiotapu and Ohaaki). Christie and Brathwaite (2003) noted that the key features of the epithermal gold deposit model include:

- *Tectonic-volcanic setting:* Associated with calc-alkalic magmas, generally in subaerial volcanic arcs.
- *Structural controls:* Localised in extensional fault/fracture systems, with dilational fault jogs providing favourable sites for large deposits. Individual quartz veins occupy steeply dipping normal or oblique-slip faults that show only very minor displacements. Vein stockworks are localised by joints in andesite lava in the upper part of some deposits (eg Golden Cross).
- *Lithological controls:* Andesite lavas host thicker and higher grade veins, whereas less competent flow breccias and pyroclastic rocks carry thinner less persistent veins. Rhyolite lavas and pyroclastic rocks and greywacke are minor hosts in the Coromandel Volcanic Zone, but may be important hosts in Northland and the Taupo Volcanic Zone.
- *Hydrothermal alteration signature:* Quartz + adularia + sericite or quartz + sericite adjacent to quartz veins, with propylitic and argillic alteration in outer zones.
- *Geochemistry:* Au and Ag are the main geochemically anomalous elements; many deposits also have anomalous Zn, Pb and Cu, some also have As, Sb, or Mo.

Mesothermal gold

Mesothermal or orogenic gold deposits are typically associated with multiple quartz veins formed in fault and shear zone systems within and above the brittle-ductile transition zone, at depths of 3 - 12 km and temperatures from 200° to 400°C. New Zealand mesothermal gold deposits occur in greywacke rocks of Paleozoic age in western South Island (eg Reefton deposits, including Globe-Progress and Blackwater), and in Mesozoic age schist of Marlborough, Otago (eg Macraes Flat), and the Southern Alps (Christie, 2002). Disseminated gold is found associated with some deposits (Christie *et al*, 2001b). Key features of the mesothermal gold deposit model include:

- *Structural controls:* The lode deposits are associated with shear zones that are typically discordant to bedding/ schistosity, and may be laterally extensive (eg Hyde-Macraes Shear Zone). The quartz lode length may be related to the apparent fold wavelength intersected by the shear zone. The different vein deposits in a specific goldfield generally have the same strike. Nevertheless, strike directions normal to the main direction (eg Globe-Progress) also offer potential.
- *Lithological controls:* Ore shoots are localised by lithological features, particularly the intersection of bedding with structures. There is potential for some influence from different source and host rock types (eg sandstone/psammite versus mudstone/argillite). Gold deposits occur in greenschist facies and lower-grade metamorphic grade rocks. Also, regional shear zone deposits may juxtapose schist of different metamorphic grades and/or structural history.
- *Hydrothermal alteration signature:* Although generally not prominent, alteration is characterised by sericite, carbonate and disseminated arsenopyrite and pyrite.
- *Geochemistry:* As and Au are the main geochemically anomalous elements; many deposits have anomalous Sb, and, for the Mesozoic deposits, some have anomalous W.

DATA RESOURCES FOR EXPLORATION

Another critical component of a mineral prospectivity analysis is good quality, areally extensive spatial data that can be used to represent the key geological and other elements identified in the mineral deposit model. Over the last decade there has been considerable growth in the use and diversity of applications of Geographic Information Systems (GIS) software and a corresponding growth in the number, diversity, accuracy and accessibility of digital spatial datasets. Many of these spatial datasets are relevant to gold exploration in New Zealand (Table 2) and are described below.

Geological

Geological spatial data include a wide range of themes that are associated with traditional geological maps, as well as more

TABLE 2

Key exploration datasets and themes available for mineral prospectivity modelling.

Theme	Key attributes to search by and model	Type	Digital availability[†]
	Geological		
Geological mapping unit	Rock type, stratigraphic age or association, metamorphism	Poly	QMAP, GMNZ@1M
Geological boundaries	Type, accuracy	Line	QMAP, GMNZ@1M
Faults	Sense or age of movement, total slip, strike, dip, type, activity, accuracy	Line	QMAP, GMNZ@1M
Folds (axial plane surface trace)	Type, accuracy, trend, plunge, vergence, activity, age	Line	QMAP
Horizons (important thin layers)	Rock type, stratigraphic age or association, thickness, accuracy	Line	QMAP
Veins (macroscopic)	Accuracy, mineralogy, strike, dip, age	Line	QMAP
Dikes (macroscopic)	Accuracy, rock type, strike, dip, age	Line	QMAP
Lineaments	Accuracy, type	Line	QMAP
Structural measurements	Type, azimuth, inclination, generation	Point	QMAP
	Rock and mineral		
Whole rock geochemistry (XRF)	Standard element suite	Point	PETLAB, CM
Exploration geochemistry	Selected metals suite, analytical method, sampling method	Point	REGCHEM, CM
Other geochemistry, eg microprobe mineral analyses, isotopes	Various elements	Point	PETLAB, CM
Geochronology	Dating method, age, interpretation	Point	GSNZ, PETLAB
Rock lithology	Rock type, key minerals	Point	PETLAB
Mineral occurrence	Type, age, host rock, production	Point	GERM
Mineral production	Type, current and past production	Point	CM, PCD
	Geophysical		
Aeromagnetic	Total force and derivatives, eg gradient	Raster	CM, GNS, UNI
Gravity	Total anomaly and derivative, eg gradient	Raster	CM, GNS, UNI
Resistivity	Anomaly	Raster	CM, GNS, UNI
Geophysical interpretation	Various	Poly, Line	GNS
Rock properties	Magnetisation, density, conductivity	Point	PETLAB
	Topographic and cultural		
Digital terrain models	Height, slope, aspect, catchment	Raster, Poly	LINZ
Contours	Elevation	Line	LINZ
Rivers, lakes and coast		Line	LINZ
Roads		Line	LINZ
Cadastral	Landuse, zoning	Poly	LINZ
Mineral tenement		Poly	CM
Governance	Local or regional boundaries, electorates, conservation estate, iwi	Poly	LINZ

[†] CM = Crown Minerals; GNS = GNS Science; LINZ = Land Information New Zealand; UNI = Universities; GSNZ = Geological Societyof New Zealand.

Specific databases managed by GNS Science are: GERM = Geological Resource Map database; GMNZ@1M = 1:1 million Geological Map of New Zealand; PETLAB = PETLAB national rock and geoanalytical database; QMAP = 1:250 000 Geological Map of New Zealand database; REGCHEM = Regional Geochemistry database.

exploration-specific datasets such as alteration zones and quartz vein occurrences. GNS Science's QMAP 1:250 000 Geological Map of New Zealand is a national GIS-based geological mapping project that has in part been designed for GIS analysis from a mineral exploration perspective. For example, geological themes such as stratigraphic mapping units can be classified in terms of age, main or subsidiary rock type, degree of metamorphism, stratigraphic affiliation, and boundary contacts (conformable, unconformable, intrusive, or faulted). Faults can be classified in terms of age of movement(s), sense of movement, strike and/or dip, total displacement and type (eg brittle-ductile and brecciated). Similarly, veins and dikes can be expressed by orientation, age and type, as well as mineralogy. Folds (fold axial traces) have age, orientation and type attributes. Structural measurement data can be manipulated into derivative themes such as orientation variability, or generalised trend.

Geophysical

Geophysical data appropriate for gold exploration in New Zealand include aeromagnetic, gravity and resistivity surveys. These data have widely varying survey specifications, and are held in a variety of formats by a number of government, university and industry organisations. They can be used directly in GIS applications, for instance, identifying anomalously high or low values, or changes in gradient, or they can also be interpreted, for example to determine depth to basement, fault dip, or solid geology. There are fewer geophysical data available for exploration compared to Australia, especially for mesothermal gold mineralisation. Acquisition of regional scale geophysical data, especially using new geophysical techniques such as airborne gravity, would greatly facilitate future exploration, especially for locating exploration targets beneath cover.

Geochemical

Considerable advances have recently been made in data capture, organisation and access to geochemical data by way of the PETLAB and REGCHEM databases maintained by GNS Science. These data include whole rock geochemistry (XRF) and mineral chemistry (XRD, ion microprobe) from largely science research projects, as well as mineral industry data (stream sediment, soil and rock chip geochemistry) acquired from previous mineral exploration activities and lodged with Crown Minerals. Geochemical data can be used directly by identifying anomalously high Au or related indicator elements, or indirectly through averaging techniques for specific rock units.

Gold occurrence and production

Historic mineral occurrence datasets are a fundamental starting point for analysing regions prospectivity. Databases such as GERM (GEological Resource Map, maintained by GNS Science) record location, mineralisation style, mineralisation type and historic production and can be used as training datasets in prospectivity analyses.

Topographic and cultural

Topographic data, available from Land Information New Zealand, are important for two reasons in a mineral exploration GIS. Firstly, topographic data (including rivers, roads, contours and buildings) provide geographic context for location and presentation of other data. Secondly, topographic data can be used for analysis. For example, a slope model derived from a digital terrain model (DTM) can help constrain the source direction of anomalous soil geochemistry. Stream sediment geochemistry can be sourced to specific catchments identified from river data and/or a DTM. Analysis of DTMs can also be used to interpret the location of faults. Topographic data are also useful for planning soil or stream sediment sampling surveys.

Cultural data include mineral tenement, land ownership and land use datasets. These help identify external constraints on exploration and mining, for instance exploring on Department of Conservation land has different requirements to that in private ownership or with spiritual significance to Maori.

SPATIAL DATA MODELLING

Spatial data modelling is increasingly being used in geological applications for research (Bonham-Carter, 1994; Looney, 1997; Raines, 1999; Knox-Robinson, 2000; Kemp *et al,* 2001; Partington *et al*, 2002; Tangestani and Moore, 2003), and by government organisations (Partington and Smillie, 2002; Rattenbury and Partington, 2003). These techniques are also increasingly being used by leading exploration and mining companies (Partington and Sale, 2004) for synthesising large spatial data sets for reconnaissance-level exploration. Their application aids targeting and results in risk reduction at an early stage of exploration (eg Henley, 1997).

The most commonly used spatial modelling techniques applied to mineral exploration are 'data-driven'. These techniques analyse the relationship between known mineral occurrences or deposits (training data) and various geological and other datasets (evidential themes). The techniques vary in their degree of subjectivity and statistical quantification. The weights of evidence technique uses Bayes Rule of Probability to establish conditional probabilities of occurrence of, in the context of this paper, gold occurrences with respect to a number of different geological themes (Bonham-Carter, 1994). The statistical approach reduces the subjectivity on how the evidential themes are combined in the resulting prospectivity model. The weights of evidence technique is ideally applied in a GIS and the following analyses used ArcSDM software (Kemp *et al*, 2001), an extension of ESRI® ArcView software.

Identifying key data

Data compiled within the GIS were reclassified where necessary to approximate as closely as possible the components identified in the epithermal and mesothermal mineral deposit models described above. The training dataset in this case are historic occurrences of hard rock gold mineralisation with significant production, extracted from the GERM database. These training data were tested against key exploration data identified in the mineral deposit models including:

- host rock and terrain preference of known deposits,
- proximity to regional structures,
- proximity to local structures,
- quartz veins,
- alteration,
- metamorphic grade,
- geochemistry of host rocks, and
- volcanic features.

As a first step in the spatial correlation calculation, a computational unit cell size was chosen based on the assumption that the known deposits have a 0.7 km^2 sphere of influence, about the smallest footprint for economic mineralisation. The spatial correlation between the number of training data points (expressed as an area) occurring within the area defined by the evidential theme is then tested (Bonham-Carter, 1994). As an example, the spatial correlation could be tested between the number of gold occurrences (training data) within the area underlain by andesite (evidential theme). The result of this correlation analysis is the probability of finding a gold occurrence given the presence of andesite. The probability is known as the posterior probability, and where the spatial correlation is positive, the presence of the evidential theme is given a positive weighting based on the posterior probability value. Equally significant are the number of training data that occur outside the evidential theme (eg not underlain by andesite). The difference between the two weights is known as the contrast value (C) and this gives a quantitative measure of the significance of each evidential theme. Negative C values can occur where an inverse relationship exists between the training data and the evidential theme. In practise, the C value is best used as a relative indicator of spatial correlation, rather than an absolute sense. Table 3 summarises the results of the analysis, provides a summary of the methodology used to create the map themes, and compares the spatial correlation results for the epithermal and mesothermal models.

Mineral prospectivity modelling

Mineral prospectivity models were calculated by combining the stronger correlating (higher contrast) evidential themes (Table 3). Each evidential theme is weighted according to their prior posterior probabilities and then added through a raster-based computational grid (Bonham-Carter, 1994). Examples of the prospectivity models for epithermal and mesothermal gold that were developed are shown in Figures 3 and 4.

Conditional dependence, as described by Bonham-Carter (1994), is generally a significant problem in most mineral prospectivity models. This is because many geological,

TABLE 3

Key geological and geochemical criteria for exploration for mesothermal and epithermal gold mineralisation based on stronger spatial correlation.

Exploration data	GIS technique	Result
Mineralised structures C values (3 - 5)	Model density of epithermal or mesothermal veins and breccia in a defined area.	Give high spatial correlations for both types of gold deposit. Simple and effective exploration tool to be collected during geological mapping.
Geochemistry of rocks, stream sediments and soils C values (2 - 4)	Integrate all data. Use nearest neighbourhood model to create geochemical surface for rock and soil data. Aggregate stream data into catchment areas sampled. Derive statistically anomalous subsets at a regional scale and test spatial correlation of anomalous data.	Mesothermal mineral systems geochemically simple with strong spatial correlations with Au and As in all sample media. Epithermal systems are more complex with good spatial associations with Au, Ag, As, Hg and Sb and a negative association with Pb and Zn.
Regional structure C values (2 - 3)	Buffer various presyn mineralisation age fault orientations, fault intersections fold orientations and fold fault intersections.	Both types of mineralisation have strong spatial associations with regional structure, especially NW second order ductile faults for mesothermal Au and N-NE brittle normal fault sets for epithermal Au. Structural intersections have a lower spatial association.
Geology C values (1 - 5)	Use digital geological map attribute data to create reclassified maps and to test spatial association with rock type and rock age. Other features such as competency contrast and chemical contrast can be modelled from these data.	Geological features such as rock type and rock age are significant predictors of mineralisation for both epithermal and mesothermal gold. Detailed prospect-scale mapping and temporal data would greatly improve the use of these data in prospectivity models.
Alteration C values (1 - 5)	Use mapped alteration to create categorised alteration themes to be tested for spatial association.	There is no clear association with mapped alteration and mesothermal gold mineralisation. Epithermal mineralisation has good spatial correlations with clay and silica alteration. In general the alteration data density for both types of mineralisation is poor and should be focused on during any new mapping programs.
Volcanic features (epithermal only) C values (1 - 3)	Use mapped volcanic features such as sinters, breccia and hydrothermal centres to test for spatial association with known mineralisation. Buffer around mapped feature.	Hydrothermal breccia and sinters have strong regional spatial correlations with epithermal mineralisation.
Metamorphism (mesothermal only) C values (1 - 3)	Use various measures of metamorphism, eg schist type, foliation style or fold style as reclassified map themes to test spatial correlation with various map categories.	Good spatial association with most measures of metamorphism. Mineralisation appears to be associated with areas of higher grade metamorphism and deformation around the ductile brittle transition.

geophysical and geochemical themes are in reality interrelated. For example, alteration zones are commonly areas of low magnetic intensity and gold is commonly associated with elevated arsenic concentrations. In the epithermal and mesothermal models the potential for conditional dependence has been minimised by limiting the number of variables, particularly those from closely related evidential themes, for example combining Au and As evidential themes for use in the model rather than separate Au and As themes. The effect of conditional dependence is to overestimate the combined posterior probabilities, and thus the probabilities should be thought of as relative favourabilities rather than true probability values. The resulting prospectivity models for epithermal and mesothermal gold (Figures 3 and 4) show significant areas of prospective ground. The areas of higher probability reflect the spatial coincidence of several evidential themes that in some places have known gold occurrences or mines. Many of these areas have not been systematically or extensively explored and thus have promise for new exploration. The most obvious conclusion that comes from this type of analysis is that New Zealand has a large number of areas that could host epithermal or mesothermal gold mineralisation, but have not been tested with detailed geochemical sampling and drilling. The veracity of the prospectivity models are highly dependent on the quality of the evidential theme data. The weights of evidence technique can identify areas of lower prospectivity resulting from missing data as opposed to unfavourable geological variables. If the data are missing then appropriate exploration programs can be designed to collect the data that may enhance the prospectivity of a region. Many areas in New Zealand fall into this category because of the lack of modern exploration since the early 1980s.

These prospectivity models are relevant for a typical regional scale exploration program, or at the project generation and permit or tenement acquisition stage, where the area acquired tends to be larger than the target area. Any follow-up exploration programs should be designed to further reduce the target area. The probability values derived from the model also allow a ranking of any prospect area, which allows efficient exploration programs to be developed that have the best chance for success.

CONCLUSIONS

The prospectivity models derived from the weights of evidence technique place the genetic models for epithermal and mesothermal gold mineralisation in New Zealand into an exploration context. The spatial correlation data from both prospectivity models demonstrate the value contained in traditional geological maps organised in a GIS.

New Zealand is highly prospective for gold. Historical production, together with known resources and reserves, are significant by world standards. The regional prospectivity models developed for mesothermal and epithermal gold mineralisation in New Zealand indicate considerable potential exists in under-explored areas, allowing new local and international companies to effectively prioritise their exploration efforts, and acquire additional prospective areas for these types of mineralisation. Prospectivity analyses for other types of gold deposits, such as intrusion-related gold are the next logical step.

ACKNOWLEDGEMENTS

Crown Minerals are acknowledged for their foresight to commit to new technologies and ways of marketing New Zealand to the exploration industry. This paper has built on considerable investment by Crown Minerals and GNS Science in making data accessible for mineral exploration in New Zealand. The paper has benefited from reviews by Richard Jongens and Richard Barker. Gary Raines and Graham Bonham-Carter are thanked for discussions and developing the spatial data modelling software.

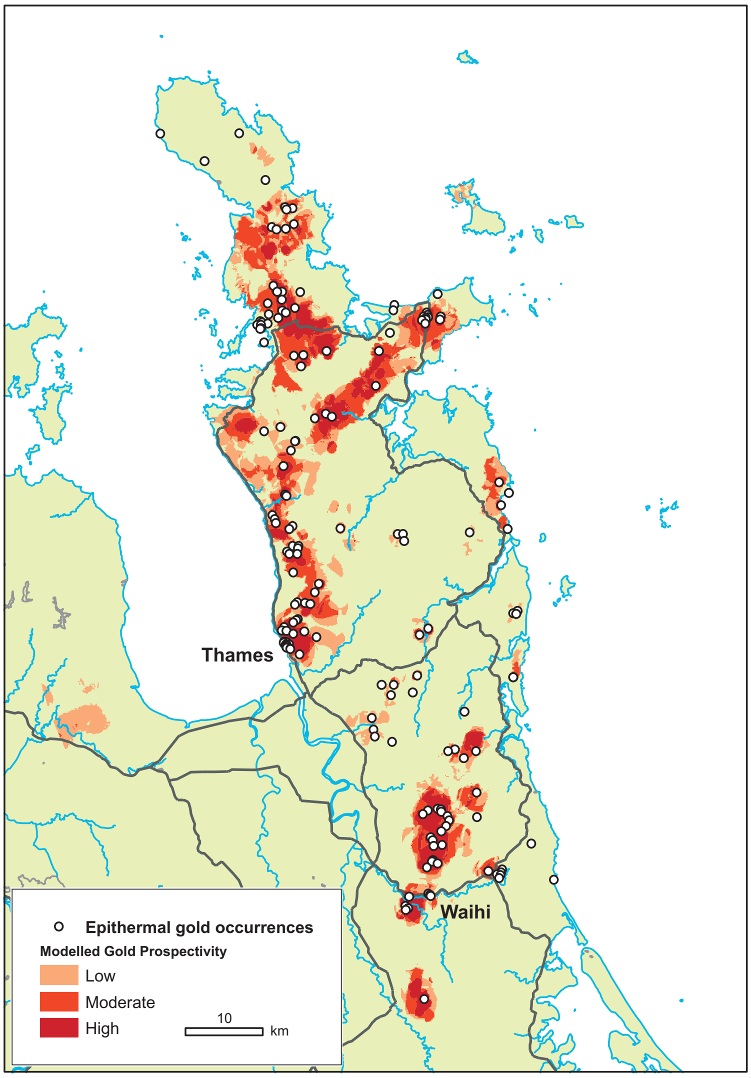

FIG 3 - Epithermal gold prospectivity of the Coromandel region.

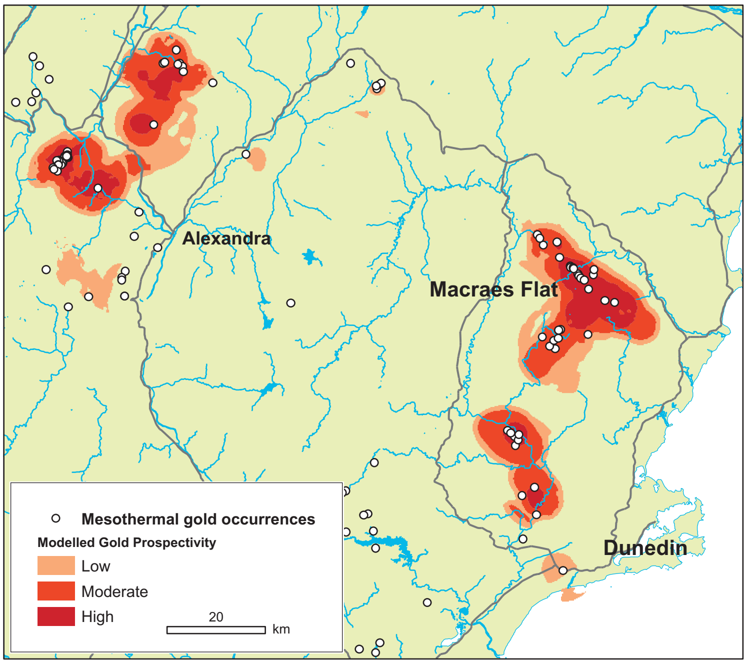

FIG 4 - Mesothermal gold prospectivity of central and eastern Otago.

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