New Exploration in NZ Stimulated by the Crown Minerals Prospectivity Modelling Studies for Gold

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ABSTRACT

The Epithermal and Mesothermal Gold Prospectivity modelling projects carried out by Crown Minerals provided explorers in New Zealand with a new compilation of historical exploration data combined with new geological information from the GNS QMap 1:250,000 scale mapping project. These data were used to produce predictive mineral potential maps for gold mineralisation in New Zealand. The aim of these projects, to stimulate mineral exploration and investment in exploration, has been successful with eight new companies acquiring new tenement positions and committing significant exploration expenditure to exploring in New Zealand in the coming years.

The projects were done at a national scale and consequently not all exploration data were compiled into the prospectivity models. Several of the new companies recognised the value of the prospectivity modelling work and committed exploration funds to continue the modelling process. They recognised a need to compile the remaining data and run the models again to allow detailed exploration targeting.

Detailed data compilations including digitising historic exploration stream sediment sample, rock chip sample, soil sample and drilling data has been completed. New models have been completed in Otago for mesothermal gold mineralisation and in the Coromandel and Northland for epithermal gold. The new models have been compared with the original regional scale models and used to target prospect scale exploration. This work has allowed exploration models for epithermal and mesothermal mineralisation in New Zealand to be refined. More importantly this work has identified significant areas with potential to host gold mineralisation with little or no systematic geochemical data including soil sampling or drilling. Exploration work programs have been designed to acquire these missing data and exploration funds have now been committed to test the areas highlighted by the prospectivity modelling.

In summary, the Epithermal and Mesothermal Gold Prospectivity modelling work has successfully attracted new investment and ideas to the exploration scene in New Zealand. The projects had an estimated cost of NA$250,000 and will in the next two years, just through exploration expenditure, attract more than NZ$10 M in investment. If a mine is discovered the return on investment will be considerably greater.

1 INTRODUCTION

The completion of the Epithermal and Mesothermal Gold Prospectivity modelling projects by Crown Minerals provided explorers in New Zealand with a new compilation of historical exploration data combined with new geological information from the QMap 1:250,000 scale mapping project (Nathan 1994; Nathan 1998). These data were used to produce predictive mineral potential maps for gold mineralisation in New Zealand (Partington and Smillie, 2002; Partington et al., 2002; Rattenbury and Partington, 2003). The aim of these projects was to stimulate mineral exploration and investment in exploration in New Zealand, which has been very successful, with new companies acquiring new tenement positions and committing significant exploration expenditure to exploring in New Zealand in the coming years

Both the mesothermal and epithermal projects were compiled at a national scale and consequently not all historic exploration data were included in the regional prospectivity models. Several of the new explorers, who have a significant exploration permit holding in New Zealand, recognised the value of the prospectivity modelling technologies and have committed exploration funds to continue the modelling process started by the government projects as part of their exploration planning process. To do this all remaining historic exploration data had to be compiled for each of the project areas and new prospect scale geological and geochemical data collected in the field. These data have been integrated with the data from Crown Minerals in a Geographic Information System (GIS) and detailed prospectivity models created for prospect scale exploration targeting and the development of ongoing exploration work programs and budgets.

This paper presents examples of the results of the follow-up work and how the new spatial modelling techniques have helped the companies to develop their exploration businesses in New Zealand.

2 EPITHERMAL AND MESOTHERMAL GOLD MINERALISATION IN NEW ZEALAND

Gold in New Zealand is found in deformed turbidite sequences of greywacke and schist in the South Island and the volcanic rocks of the North Island (Christie and Braithwaite, 1999; Cox, 2001; Christie, 2002; Christie 2003). The South Island deposits are similar to those found in Australia and Canada, and some deposits also have similarities to the intrusive related type found in Alaska, which have a mineralogy including molybdenum- and bisthmuth-bearing minerals. The gold deposits in the South Island of New Zealand can be divided into a number of subtypes, based on the host-rock lithologies and ages, and their structural and tectonic settings (Christie and Braithwaite, 1999; Christie, 2002). The Palaeozoic-age gold deposits occur in greywacke rocks of the western South Island, whereas the Mesozoic deposits are hosted by Mesozoic age schist of Marlborough and Otago. Gold has been historically produced from quartz lodes in these deposits, which are characterised by discrete, relatively undeformed veins of low tonnage and high gold grades (10-20 g/t Au). However, since the 1980s, significant disseminated mineralisation has been found in many of the deposits (e.g. Globe-Progress, Reefton; Macraes Flat, Carrick and Bullendale in Otago). In contrast to the lode gold deposits, these are characterised by more disseminated, deformed systems with high tonnage and low gold grades (1-5 g/t Au). The Macraes Mine, containing 5 million oz of gold, is typical of this type of deposit. There are also extensive Cenozoic gold placers in the West Coast, Nelson, Marlborough and Otago regions, with recorded production of about 500 t or 16 million oz of gold. The disparity in historic production between the lode gold deposits and the placer deposits (a ratio of about 1:6) suggests that the sources of much of the placer gold have yet to be discovered.

Epithermal Gold mineralisation was discovered in the Coromandel in the north Island of New Zealand 150 years ago, and continues to account for a significant proportion of New Zealand's mineral output (Christie and Braithwaite, 1999; Christie, 2003). The main deposits occur in Northland and in the Hauraki Goldfield and were formed in past geothermal systems associated with volcanism that was active 12 to 13 million years ago. More than 50 epithermal gold-silver and several porphyry copper style occurrences have been found to date in the Hauraki Goldfield, which includes the Waihi Gold Mine. Waihi has a resource of well over 10 million oz. Gold occurs as electrum in quartz veins (up to 15 g/t Au), which are epithermal in nature.

Because of land access issues in the late 1980s and the decline in the gold price in the mid 1990s New Zealand has missed out on the early 1990s boom in exploration experienced by Australia and Canada. This suggests that New Zealand is relatively under explored, particularly using new exploration techniques. Many areas with known production have no modern exploration, including drilling.

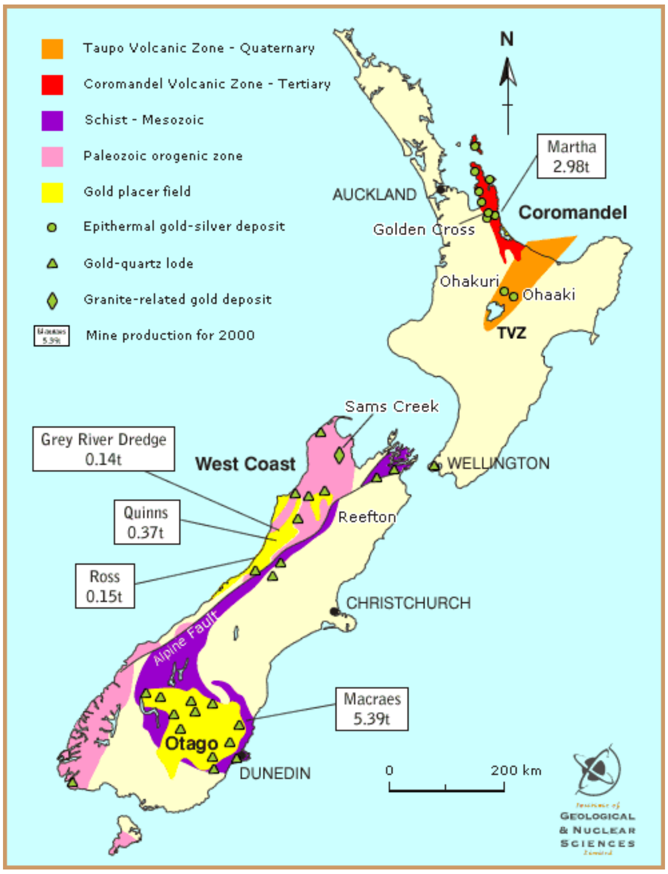

Figure 1 Location of major goldfields in New Zealand after Christie (2002).

3 SPATIAL DATA MODELLING METHODOLOGIES

Exploration targeting can only be effective if all data are compiled and integrated at an appropriate scale and in a way that matches the genetic orebody model being used for exploration. These data come from various modern day exploration campaigns, university and government research and government surveys. These data are usually diverse and voluminous, including regional geology, geochemistry, remote sensing and geophysical data. This makes the task of integration and interpretation at an appropriate scale for regional exploration difficult. New spatial data modelling techniques when combined with new computer technologies allows this to be done at all scales from international to prospect scale studies. These techniques are increasingly being used in geology (Bonham-Carter et al. 1988; Bonham-Carter 1997; Agterberg et al. 1993; Partington, 1999, Raines, 1999; Partington, 2000a; Partington 2000b; Partington et al., 2001, Rattenbury and Partington 2003; Tangestani and Moore, 2003), other spatially based sciences such as Archaeology (Mensing et al., 2000) and by government organisations such as Crown Minerals; the New Zealand Department of Mines (Partington et al., 2002; Partington and Smillie, 2002; Rattenbury and Partington, 2003), United States Geological Survey (Boleneus et al., 2001; Mihalasky, 2001) and the Canadian Geological Survey for resource assessment (Bonham-Carter et al., 1988).

A variety of new tools are available for use with computer aided geographic data management systems or Geographic Information Systems (GIS) for evaluating the distribution of spatial data in a statistical framework (e.g., Atterberg et al., 1993; Bonham-Carter, 1997; Looney, 1997; Kemp et al., 2001; Tangestani and Moore, 2003). These tools were initially developed for other uses such as pattern recognition by defence forces or medical diagnostic systems. Their use now in mineral exploration and other spatial data analyses is a classic example of technology transfer and how the mineral industry uses new technologies in an innovative way.

The key to creating successful mineral potential maps is the availability of spatial data such as geology, geochemistry and geophysics and the creation of derivative spatial data maps from these base data (Partington et al., 2001; Partington and Smillie 2002; Rattenbury and Partington 2003). For example, the creation of geochemical anomaly maps from point data values or digital terrane models from elevation point or contour data. GIS techniques such as buffering, grid extrapolation, grid interpolation, and the use of expert-assigned attributes of genetic significance were also used to create the derivative themes. Furthermore, these derivative datasets must be reclassified in a way that matches the mineralisation model being used, which is how an exploration companies geological experience and knowledge can be captured and used as its competitive advantage. These themes are then used to calculate spatial correlation statistics between the data themes and a training data set selected from historic areas of gold production. A more detailed description of some of the derivative data themes, their spatial correlation results and implications of these to exploration models used to explore for gold in New Zealand is given in Partington and Smillie, (2002) and Rattenbury and Partington, (2003).

The simplest type of predictive spatial analysis is where maps, on which the chosen input variables are represented by a series of integer values, are combined together using arithmetic operators. For example differing lithologies can be reclassified into numeric values or geochemical data can be modelled into a raster grid. This type of analysis takes no account of the relative importance of the variables being used and is based on expert opinion. Fuzzy Logic techniques address the problem of the relative importance of data being used, but this technique still relies on expert opinion to derive weights that rank the relative importance of the variable for the map combination. An example of the use of this technique in mineral exploration is given by Tangestani and Moore (2003). Weights of Evidence, in contrast uses statistical analysis of the map layers being used with a training data to make less subjective decisions on how the map layers in any model are combined. Bonham-Carter (1997) gives a good summary of the maths and algorithms used in Weights of Evidence and Partington (2000), Partington and Smillie (2002) and Rattenbury and Partington (2003) give examples of how this technique can be applied to geological datasets.

4 PROSPECTIVITY MODELS

Once the appropriate derivative data layers are created and their spatial correlations calculated, it is then possible to calculate a prospectivity model by combining the data layers that best predict the training dataset being used. The model is calculated by weighting the values of each cell in each data layer according to their prior probabilities and then adding the weighted values of each data layer together (Bonham-Carter 1997). Models for the prospectivity of mesothermal and epithermal gold mineralisation in New Zealand were constructed using the themes described in Partington and Smillie (2002) and Rattenbury and Partington (2003). The models were developed using ARC SDM software through spatial analyst in ArcView. Separate models were created for the various gold deposit types. These models provide an estimate of mineralisation potential over all New Zealand on a 200 metre by 200 metre grid. The themes were all converted into binary grid themes where possible to speed the processing time up.

Conditional dependence, where different themes with similar patterns cause an overestimate of the prior probability, as described by Bonham-Carter (1997) is usually a significant problem in most geological models, especially between geochemical themes where spatial patterns tend to be similar between pathfinder elements. Hence the model probabilities should be thought of as relative favourabilities rather than true probability values. Hence ranking areas of probability is a better way of viewing the data and provides a method for direct comparisons between models. Examples of the regional models at Macetown in Otago and Matauri Bay in Northland and are shown in Figure 2 and Figure 3. A more detailed description of the modelling techniques and copies of the data and prospectivity maps are provided in Partington and Smillie (2002) and Rattenbury and Partington (2003).

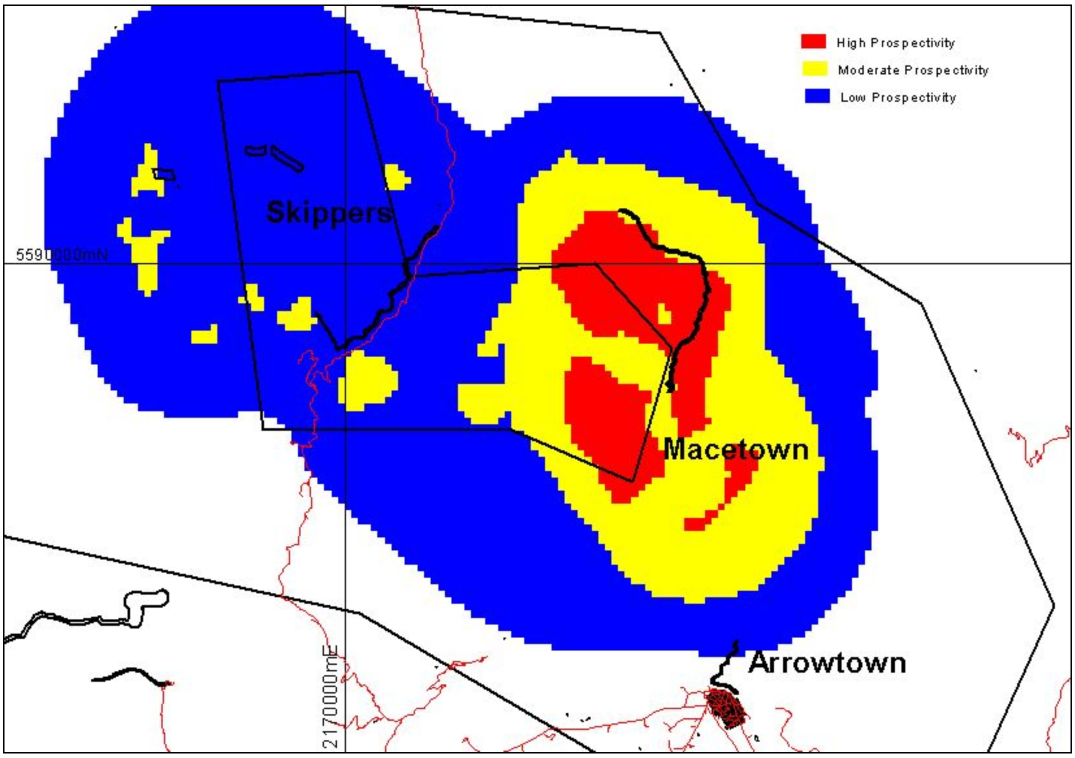

Figure 2 Prospectivity model from the Macetown area from the Crown Minerals Mesothermal Prospectivity model (Partington and Smillie 2002).

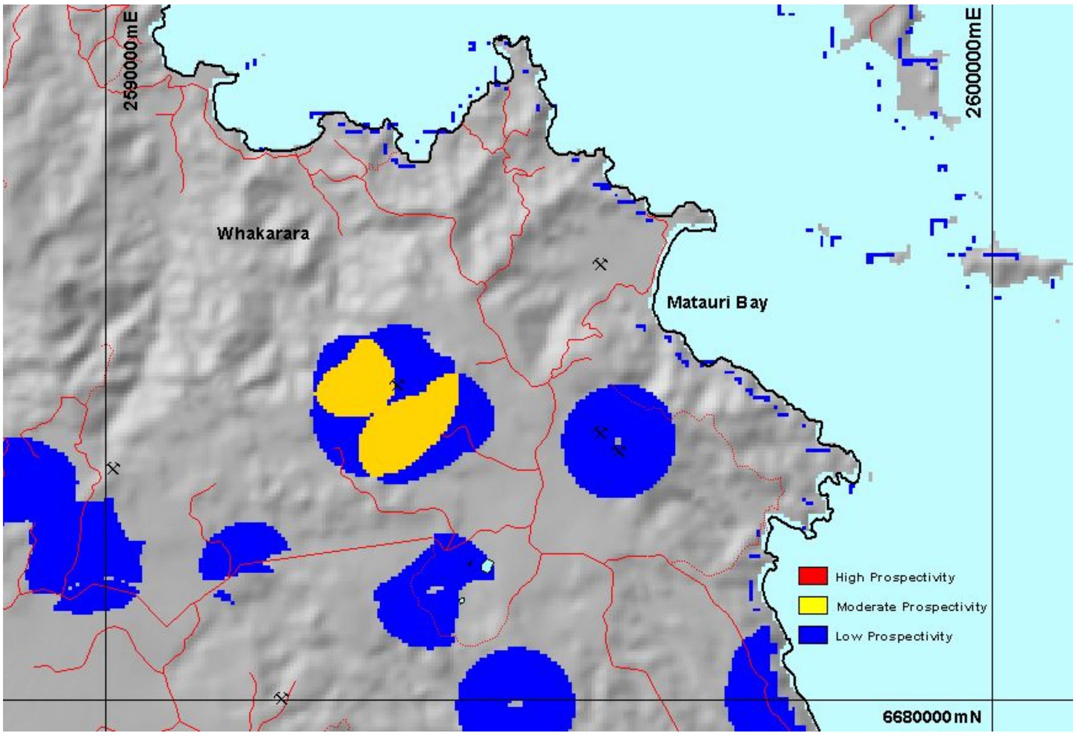

Figure 3 Prospectivity model from the Whakarara area from the Crown Minerals Epithermal Prospectivity model (Partington and Rattenbury 2003).

The models represent the beginning of a typical exploration program where regional data are acquired, especially geological mapping and stream sediment sampling. The next phase of exploration usually occurs at a prospect scale with more detailed geological mapping and soil and rock chip geochemistry. The regional prospectivity models provide a targeting tool for this next phase of exploration and for project and permit acquisition. The prospectivity models reduce the potential search areas significantly focussing on areas that have the greatest probability of exploration success due to the presence of key geological variables that match the exploration model. The next phase of any exploration program should further reduce the search area and hence any prospectivity map should provide a more focussed map pattern.

5 DEVELOPMENT AND MANAGEMENT USING PROSPECTIVITY MODELS

Three of the new exploration companies to New Zealand, Auzex Resources, HPD New Zealand and Aurora Minerals recognised the value of the prospectivity modelling work and committed exploration funds to continue the modelling process started by the projects. HPD New Zealand and Aurora Minerals followed the more traditional exploration models for mesothermal and epithermal gold mineralisation in New Zealand. Auzex Resources, in contrast, wanted to test the possibility of a new style of gold mineralisation in New Zealand and used the new data provided in an innovative way to assess this potential at a national scale.

The regional prospectivity models were initially used to confirm or acquire either exploration or prospecting permits over the most prospective areas in Otago, the West Coast and Northland. It was recognised that not all historic exploration data were in digital formats and that the prospectivity models could be further refined by compiling the remaining data and running the models again to allow detailed exploration targeting. The regional scale prospectivity models were also used to identify gaps in the exploration database, for example alteration mapping in Northland and detailed structural mapping in Otago. This analysis has helped the companies develop focussed and appropriate exploration programs for their projects, which means the new exploration data will increase their chances of success hence reducing exploration risk and costs. For example the new model for the Macetown area reduced the target area by 70% (compare Figure 1 and Figure 3). Also the acquisition of accurately surveyed locations of historic workings moved the prospective areas by up to 500 metres. An analysis of the model identified soil geochemistry, particularly for Au and As and detailed prospect scale geological data as missing from the model. An exploration program was therefore planned over the most prospective area to acquire these data. Figure 3 shows the results for Au from a composite soil sampling program, which returned highly anomalous results up to 900 ppb Au from areas not mined in the past.

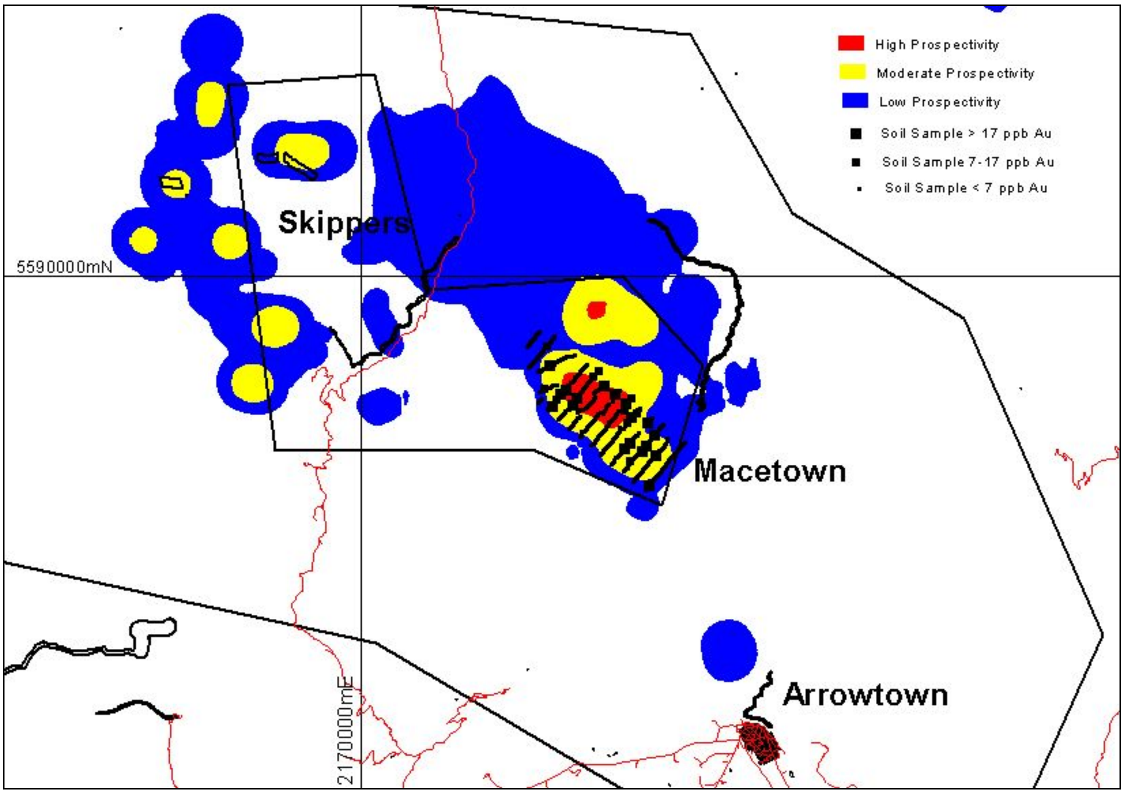

Figure 3 New prospectivity model of the Macetwon area showing prospective areas in relation to anomalous composite soil samples and permit outlines.

The new model for epithermal mineralisation in Northland significantly upgraded the areas prospectivity. This was mainly due to the identification of anomalous rock chip geochemistry and prospect scale geological mapping of epithermal quartz veins (Compare Figure 2 and Figure 4). The new model has been used to plan a focussed exploration program of prospect scale geological mapping and soil sampling (Figure 4). Again this has reduced the search area, resulting in costs savings by reducing the number of planned soil samples (Figure 4)

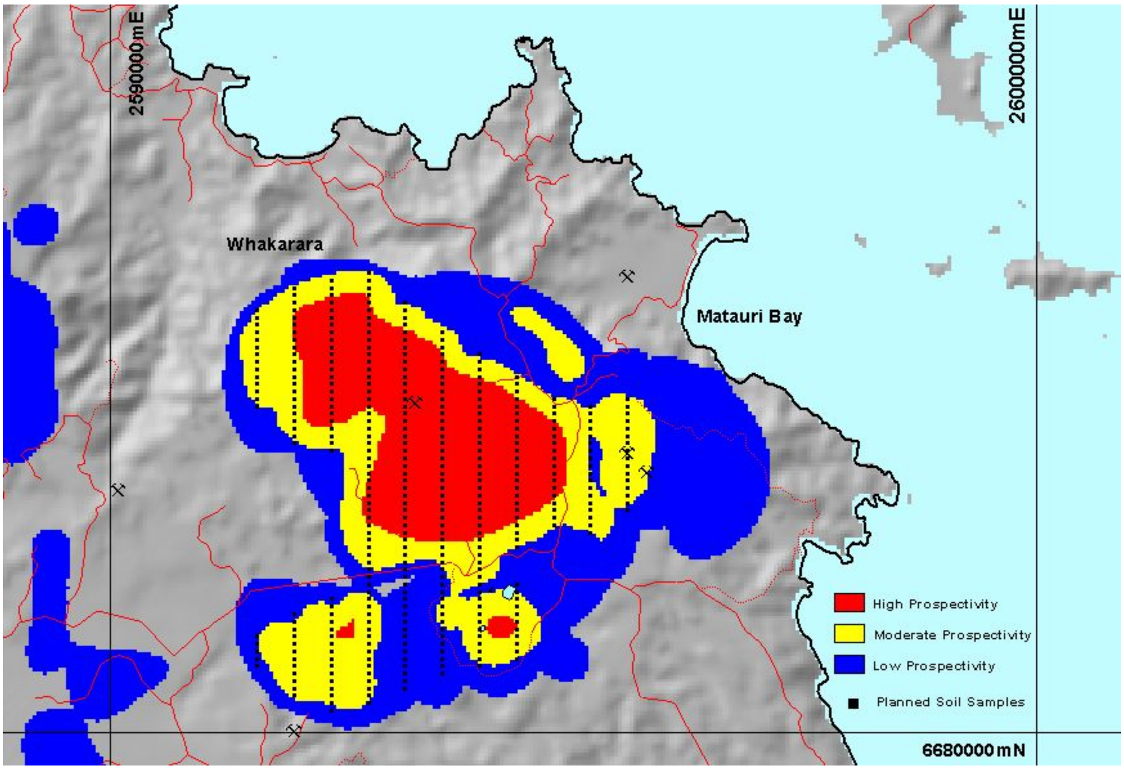

Figure 4 New prospectivity model of the Whakarara area showing prospective areas in relation to planned soil samples.

6 CONCLUSIONS

The prospectivity modelling projects by Crown Minerals successfully reduced the initial search area at a regional scale and focuses on the areas with similar combinations of geological and geochemical variables that have recorded gold production in the past. This has allowed companies wishing to invest in mineral exploration in New Zealand to immediately focus on those areas that will give them the best chance of success. The projects also provided the companies with digital data which has allowed them to plan the acquisition of new data. This has in effect reduced the time taken to acquire permits and therefore reduced risk and costs for those wishing to invest in mineral exploration in New Zealand.

All remaining historic exploration data need to be made available in digital form, including digitising prospect scale geology, stream sediment samples, rock chip samples, soil samples and drilling data. New models then need to be completed that can then be compared with the original models and used to target prospect scale exploration. This type of work will allow exploration models for epithermal and mesothermal mineralisation in New Zealand to be refined and new exploration ideas tested.

The most important results from the Crown Minerals projects is the identification of significant areas with potential to host gold mineralisation that have little or no systematic modern geochemical data including soil sampling or drilling. Exploration work programs have been designed to acquire these missing data and exploration funds have now been committed to test the areas highlighted by the prospectivity modelling.

In summary, Epithermal and Mesothermal Gold Prospectivity modelling work has successfully attracted and targeted new investment and ideas to the exploration scene in New Zealand. The project had an estimated cost of $250,000 and will in the next two years, just through HPD NZ, Auzex NZ and Aurora Minerals, attract more than $4.5 M in exploration investment. If a mine is discovered the return on investment will be considerably greater.

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