PROSPECTIVITY OF THE GLEN INNES REGION, NEW TECHNIQUES, NEW MINERAL SYSTEMS AND NEW IDEAS.

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ABSTRACT

Recent research into granite related gold systems has provided new targeting criteria that can be applied to many areas in Australia that have been considered unprospective for gold mineralisation in the past. These new ideas when combined with recently developed spatial data modelling techniques have opened up a number of new areas for exploration in the near surface environment. Exploration targeting was carried out by developing prospectivity models in a GIS database for both Eastern Australia and New Zealand. The GIS database contained a total of 79,000 mineral occurrences, 9,324,000 rock geochemical data analyses, 21,912,000 stream sediment geochemical data analyses, 26,360,592 soil geochemical data analyses, 109,000 drill holes and 2,537,522 km2 of geological information. The models were developed using the Weight of Evidence technique to identify prospective tracts of land for granite related mineralisation for tenement acquisition. The Glen Innes region ranked highly compared to other prospective regions in North Queensland, Tasmania and New Zealand and five tenements were applied for over the most prospective areas. These covered the Kingsgate Leucogranite and its immediate contact zone, including the historic Kingsgate Bi-Mo pipes and the Deepwater greisen. Follow-up exploration including detailed geological mapping, geochemical sampling, geophysics and drilling where carried out in these areas. This work is ongoing, but results at Kingsgate are sufficiently encouraging that a feasibility study has been commissioned. Possibly, more significantly for the region, economic intersections of gold mineralisation were made in the Seven Hills region, confirming the exploration model and the prospectivity of the area for gold. The discovery of a gold greisen association at Seven Hills may also be particularly significant as it is a new variant of the granite gold model. This new style of mineralisation may open up additional new areas for exploration not only in the New England Fold Belt but in other similar geological environments world wide.

1 INTRODUCTION

There has been ongoing debate in Australia about the problems facing explorers in what is considered a mature exploration terrane and that exploration now has to focus on deeper targets to be successful. The fact that new exploration models that allow the discovery of ore deposits in environments considered to be unprospective in the past can change the perception of exploration maturity has been ignored in this debate. The recent discovery of the Tropicana gold deposit in a new geological setting in Western Australia is a perfect example of how the perception of exploration maturity can be changed. Recent research into granite related gold systems has provided new targeting criteria that can be applied to many areas in Australia that have been considered unprospective for gold mineralisation in the past. These new ideas when combined with recently developed spatial data modelling techniques have opened up a number of new areas for exploration in the near surface environment. The discovery of a new mineral deposit is based on probability of about 1 in 3000, making the discovery of new mineral resources a rare event (e.g., Henley, 1997). Therefore for any company to be successful in exploration they have to be able to increase their chances of success. Spatial data modelling is a rapidly developing predictive technique that is increasingly being used in geology (Bonham-Carter 1994; Partington et al., 2002). There are a growing number of mineral exploration companies who now believe that by using such modern statistical techniques and new ore deposit models it is possible to increase the probability of discovery of new mineral resources (Partington and Sale, 2004; Partington and Mustard, 2005).

A large historic geological database was integrated using spatial data modelling techniques with new information on granite gold mineral systems to develop national and regional scale prospectivity models for the East Coast of Australia and the West Coast of New Zealand to assess the potential for new discoveries of metallic deposits associated with granite intrusions. The modelling highlighted the New England region and locally the Kingsgate Leucogranite in the Glen Innes area as particularly prospective (Figure 1). The area is well known for it's mineral potential, especially for molybdenum and bismuth mineralisation, but the modelling and follow-up fieldwork have identified areas that are also highly prospective for gold, silver, tin, tungsten and basemetal mineralisation. This paper describes the modelling techniques and exploration model used to target exploration in the Glen Innes region, the results of the spatial data modelling and subsequent field checking.

2 MINERALISATION MODEL

In the last ten years a new, globally widespread, economically important class of intrusion related metal deposit has been recognised (Thompson et al., 1999; Lang et al., 1997; Lang et al., 2000). These deposits have always been recognised for their potential to host tin and tungsten mineralisation, but now are believed to be prospective for other metals, including gold mineralisation. Examples of deposits that belong to the intrusion-related deposit class include: Donlin Creek (10.4 M Oz Au), Vasilkovskoe (9.5 M Oz Au), Pogo (4.9 M Oz Au), Kidston (4.5 M Oz Au), and Fort Knox (4.1 M Oz Au). Recent rises in metal prices mean that these deposits now have the advantage that they have other high value metals associated with gold mineralisation, such as molybdenum, bismuth, silver, tungsten and tin, which can significantly add to the economic value of the mineral deposit.

There is a systematic relationship between degree of fractionation, oxidation state and ore element ratios in these type of granite systems, which can be used to assess the prospectivity for Ag-Au-Bi-Mo-Sn-W mineralisation (Thompson et al., 1999; Lang et al., 1997; Lang et al., 2000; Mustard, 2001; Mustard, 2004; Mustard et al., 2006). This type of mineralisation tends to be associated with granite intrusions that occur in a continental tectonic setting and are Phanerozoic in age (<410 Million years). Importantly, the deposits exhibit a distinctive metallogenic signature, namely Au, Bi, Sn, W, Mo, As, Te, Sb ± (Pb, Cu), with a strong relationship between economic mineralisation such as Au, Sn and W and Bi and a negative correlation with basemetal and particularly copper mineralisation (Mustard, 2001; Mustard, 2004). The intrusions have an intermediate oxidation state which spans the boundary between the ilmenite and magnetite series. The metals of interest are associated with the more evolved phases of igneous suites, granodiorite to granite in composition and specifically associated with late stage vein-dykes, aplites and pegmatites. Also, associated plutons commonly contain textures indicative of the transition from magmatic to hydrothermal conditions (e.g. miarolitic cavities, interconnected miarolitic cavities, unidirectional solidification textures, aplite-pegmatite layers and vein-dykes). Intrusion-related metal deposits can form over a range of crustal depths (1 to 10 km) and at various proximities to the source intrusion (0 to ~3 km). Despite a set of unifying characteristics that define the deposit class as a group and separate them from other magmatic-hydrothermal systems, they can display a wide range of styles, varying from disseminated mineralisation, sheeted vein, flat lying veins, breccia and replacement types. Mineralisation has comparatively restricted zones of hydrothermal alteration and a low sulphide content. The lack of alteration, veining and sulphides makes detection by conventional prospecting very difficult, and many explorers have literally walked over ore-bodies of this type and dismissed the host rocks as unprospective. Spatial data modelling techniques, where individual predictor themes of geology geochemistry and geophysical data are combined into a single prospectivity map, are therefore particularly effective at targeting this type of mineral deposit.

3 PROSPECTIVITY MODELLING

Spatial data modelling requires a geological database from which predictive evidence for a particular deposit, based on an exploration model, and training data sets can be drawn (e.g., Bonham-Carter, 1994; Partington and Sale, 2004). The relative weights for each predictive map then has to be statistically calculated or inferred from either expert knowledge or a training data set usually based on historical mining data. The geologic predictor themes are then combined according to the weights to predict the location of undiscovered mineral resources (e.g., Bonham-Carter 1994). The simplest type of predictive spatial analysis is where an expert visually inspects a variety of predictive maps and then manually chooses target areas according to subjective criteria. A less subjective approach would be to create maps, on which the chosen input variables are represented by a series of integer values that are then combined together using arithmetic operators. This type of analysis takes no account of the relative importance of the variables being used and the resultant prospectivity map 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. 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 1994; Partington et al., 2002; Partington and Sale, 2004).

The first stage of exploration targeting in this study involved the development of an international scale prospectivity model from a GIS database of known mineral occurrences, regional geology and geochemistry for both Eastern Australia and New Zealand. The GIS database contained a total of 79,000 mineral occurrences, 9,324,000 rock geochemical data analyses, 21,912,000 stream sediment geochemical data analyses, 26,360,592 soil geochemical data analyses, 109,000 drill holes and 2,537,522 km2 of geological information. Digital data were reclassified prior to the prospectivity modelling stage and adapted and combined in accordance with the mineralisation model described above. Polygonal themes of geochemistry, geophysics and geology were developed. Derivative datasets were generated using GIS modelling techniques such as buffering, theme intersections, interpolation using inverse distance weighting or density algorithms. Statistical analyses of all geophysical, geological and geochemical data were completed using probability and percentile plots to identify anomalous populations to allow the reclassification of the data sets. Sixty seven predictive map themes were analysed for their spatial relationship to a training data set using the Weights of Evidence technique. The key geological concepts tested included: relationship to granite lithology, granite texture, granite series, granite age, granite geochemistry, proximity to major faults and relationship to fault orientation, correlation with density of quartz veins, proximity to aplite or pegmatite dykes or veins and correlation with As, Au, Bi, Cu, Mo, Sn, U and W geochemistry. Significant spatial correlations were found between Au, Bi, Mo and W geochemistry, granite geology including composition, type and series, indicators of granite fractionation and with faults and fractures. Permian age I-type leucogranite, adamellite and granite had the best spatial correlations with the training data. The more leucocratic or fractionated the granite the better the spatial correlation as highlighted by maps of granites containing pegmatite, aplite or miarolitic cavities. Other indicators of granite fractionation such as SiO2 content, U content and Rb/Sr ratios also gave significant spatial correlations. The spatial correlation of uranium with the training data possibly provides a good regional scale tool for exploration of this deposit type using airborne radiometric techniques.

A model was then developed using the Weight of Evidence spatial correlation values to identify prospective tracts of land for granite related mineralisation for tenement acquisition. The Glen Innes region ranked highly compared to other prospective regions in North Queensland, Tasmania and New Zealand and five tenements were applied for over the most prospective areas. These covered mainly the Kingsgate Leucogranite and its immediate contact zone, including the historic Kingsgate Bi-Mo pipes and the Deepwater greisen. All the tenements had little or no modern exploration, especially for gold, and importantly no drilling.

4 GEOLOGICAL SETTING AND MINERALISATION IN THE TARGET REGION

The tenements acquired on the basis of the prospectivity modelling in the Southern New England region cover rocks of the Upper Carboniferous to Triassic New England Batholith that intrudes accretionary prism complexes. The batholith is composed of synorogenic, Late Carboniferous to Early Permian peraluminous S-type granitoids, and post-orogenic Permo-Triassic I-type intrusions. The I-type intrusions form a NNE trending 300 km long by 60 km wide belt. The New England Batholith has been subdivided into the Bundarra, Hillgrove, Moonbi, Uralla and Clarence River suites based on distinct mineralogical, geochemical, isotopic and age criteria. The Moonbi Supersuite (Leucogranites) represent the most significant group of mineralised granites, having produced Sn, W, Mo, Ag, As, Bi, Cu, Pb, Zn, Au, fluorite, beryl and topaz. The Wards Mistake Adamellite occurs extensively throughout the Glen Innes tenements and comprises coarse to medium-grained monzogranite-granodiorite. It has been intruded by the Kingsgate Leucogranite and the Red Range Microleucogranite. The Kingsgate Leucogranite is very coarse-grained, equigranular biotite granite whereas the Red Range Microleucogranite is a fine- to very fine-grained saccharoidal, pink, equigranular microleucogranite, which is believed to be the carapace to the Kingsgate Leucogranite. Mo-Bi-Ag±Au quartz pipes and veins are developed in clusters along the margins of the Kingsgate Leucogranite and the Red Range Microleucogranite and are historically the most significant mineral occurrences in the region.

5 FOLLOW-UP EXPLORATION

Prospectivity modelling was successfully used in the initial targeting to reduce the search area so speeding up the land acquisition process, minimising costs and increasing the chances of discovery. However, there is no substitute for fieldwork in exploration. This is especially true in the Glen Innes region due to the lack of modern prospect scale geological, geophysical and geochemical data, which limit the scale at which the prospectivity models can be used. The modelling highlighted the Kingsgate prospect, the Deepwater prospect and a new area in the Seven Hills region as highly prospective for the metals of interest, including gold. Consequently, follow-up exploration including detailed geological mapping, geochemical sampling, geophysics and drilling where carried out in these areas. This work is ongoing, but results at Kingsgate are sufficiently encouraging that a feasibility study has been commissioned. Possibly, more significantly for the region, economic intersections of gold mineralisation were made in the Seven Hills region, confirming the exploration model and the prospectivity of the area for gold.

The Kingsgate Mine, located 20km east of Glen Innes, is the second largest producer of molybdenum in Australia (Figure 1). A total concentrate of 350t molybdenum, 200t bismuth, and 12t wolframite-bismuth was mined during the early 1880’s to late 1920’s. Much of the ore was mined from 54 pipes up to 20m diameter that were worked to a depth generally not exceeding 50 metres. Assays of ore samples in 1884 returned 2.6-69.3% Bi, 12-194.5 ppm Au and 149-4442 ppm Ag. Geological mapping highlighted more than 94 Mo-Bi-rich pipes located along a 4.75 km N-S trending belt. The pipes are hosted in medium-grained biotite granite, with the majority located within 300m from its contact with sediments and plunge 20° to 30° east parallel to an aplite carapace. Rock chip sampling of the pipes returned grades up to 7.3% Mo, 2.2% Bi, 2.0 g/t Au and 100 g/t Ag (Figure 2A). A Scoping Study has been completed, which suggests that the Kingsgate project could be a high grade operation with a low processing rate, a mine life between 5-10 years and an operating cost of $60.33 per tonne of ore processed. Capital expenditure and infrastructure related to development is estimated to be $39.76M. A conservative diluted head grade of 0.23% Mo and 0.23% Bi is being targeted and based on a 250,000 tpa processing operation, a total of 911 tonnes of Mo in concentrate and 698 tonnes of Bi in concentrate would be produced annually. This represents revenue of $158.12 per tonne of ore processed, using the study’s long term assumptions of a US$22/lb Mo concentrate price, US$13/lb Bi concentrate price and a US$0.80 exchange rate.

The Seven Hills prospect lies within the Glen Elgin tenement (EL 6408) approximately 45km northeast of Glen Innes (Figure 1). Geology of the area around the Seven Hills prospect comprises Wandsworth Volcanic Group rocks to the west, Kingsgate Leucogranite in the central parts and Mount Mitchell Monzogranite with inliers of Glen Garry Microleucogranite to the east. Three samples of quartz veins in granite were collected during reconnaissance geological mapping of the tenement area assayed 2.52 g/t Au, 2.43 g/t Au and 2.11 g/t Au. Mapping identified a number of historical sluiced creeks and shafts in an area where there has been no significant modern exploration for gold. The gold mineralisation sampled on the surface is associated with zones of greisen with quartz-sulphide veins forming several broad areas up to 500m by 200m in size (Figure 2B). Several phases of detailed exploration were conducted, including prospect scale geological mapping and rock-chip sampling, soil, auger and costean sampling, geophysical dipole-dipole IP line surveys and RAB and RC drilling that have progressed the Seven Hills prospect to an advanced gold drill target. Geophysical dipole-dipole IP line surveys defined coincident zones of relatively weak chargeability highs (inferred sulphide bodies) and relatively weak resistivity lows (inferred altered zones) that appeared to coincide with mapped anomalous zones of surface geology and geochemistry. Initial shallow RAB results targeting anomalous surface geochemistry intercepted several intervals of high-grade gold mineralisation such as 9m at 12.19ppm Au, including one interval at 32.70ppm Au. Follow-up RC drilling of the geophysical targets was disappointing although sulphide mineralisation was intercepted. The RC drilling of the geochemical targets was more promising with several intersections of up to 11m averaging 2.05ppm Au made. Fresh mineralisation was intersected in a variably hydrothermally altered and mineralised medium to coarse grained, biotite leucogranite. There has been partial to complete replacement of the primary rock by a greisen assemblage of muscovite-sericite, with associated quartz, minor chlorite and sulphides and a trace of rutile. The main geochemical association in the fresh material is Au, Bi, Ag and Te, which is typical of a granite gold system. However the gold mineralisation is also associated with Pb and As, which is not typical.

6 NEW MINERAL SYSTEMS AND NEW IDEAS

The initial aim of the prospectivity modelling was to use a probabilistic approach to exploration targeting to develop a portfolio of prospects that have an increased probability of discovery and development. The spatial modelling successfully identified a number of targets, reducing the initial search area by several orders of magnitude. The benefits of carrying out spatial data modelling include: Effective data compilation, QC of digital data, Understanding of critical geological factors to be used in follow-up exploration, Ranking of prospects, Prioritising exploration, Exploration budgeting and management, Understanding of risk, and Cost reduction. Geological data have proved to be fundamental predictors of mineral occurrences in all models developed to date. An understanding of the structure and temporal development of the geology of the area is critical, especially at a prospect scale. This means more fieldwork, but specifically targeted at a prospect scale.

The Glen Innes region was identified as particularly prospective for the style of mineralisation and metal assemblages required. Work to date has shown the new ideas coming from research into granite gold systems have opened up old and new areas in Australia that were not considered prospective for gold in the past. More importantly these areas are not under significant depths of cover and therefore represent low cost exploration targets that can effectively be explored using modern geochemical and geophysical techniques. The recent rise in metal prices also means that these ideas can also be applied to exploration for a range of metals including molybdenum, bismuth, tin, tungsten, silver and gold. The discovery of a gold greisen association at Seven Hills may also be particularly significant as it is a new variant of the granite gold model. This new style of mineralisation may open up additional new areas for exploration not only in the New England Fold Belt but in other similar geological environments world wide.

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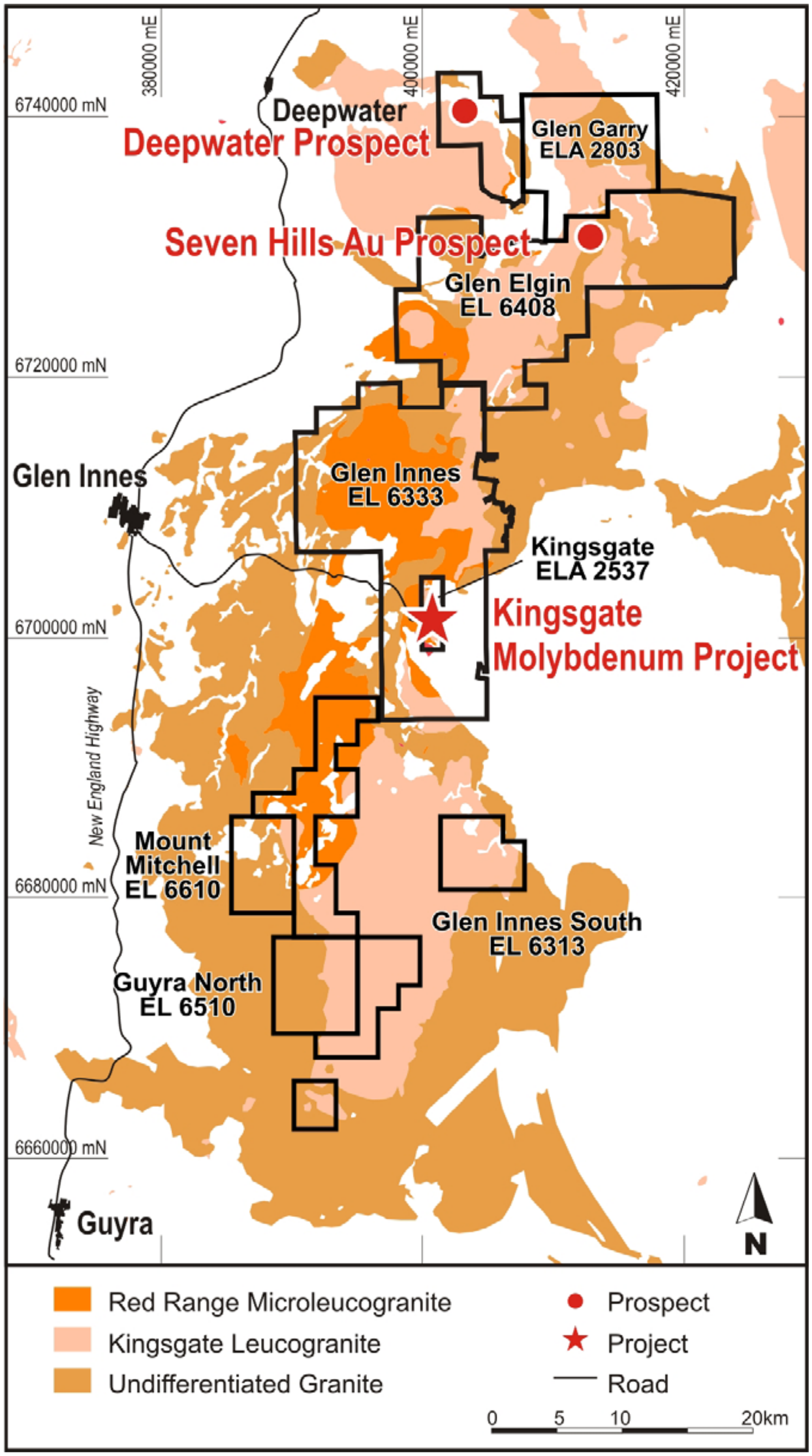

Figure 1. Simplified geology of the Glen Innes region with Auzex Resources Limited tenement holding and key projects.

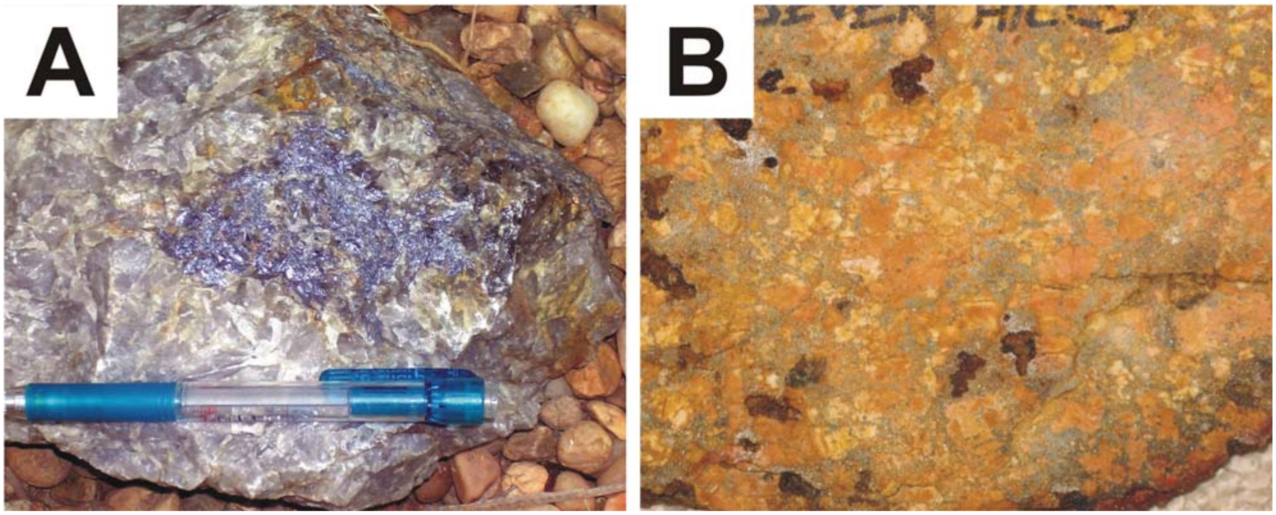

Figure 2A. Quartz pipe material from the Kingsgate Mo-Bi Project containing coarse molybdenum. 2B. Gold bearing greisenised granite from the Seven Hills gold prospect (Field of view 10cm x 15cm).

REFERENCES

Bonham-Carter, G. F., 1994, Geographic Information Systems for geoscientists - Modelling with GIS Elsevier Science, New York, 398 p.

Henley, R.W., 1997, Risky business: The essential blending of financial and scientific skills in the modern resource sector: Proceedings of the 1997 New Zealand Minerals and Mining Conference, Crown Minerals, Ministry of Commerce, p. 29-33.

Lang, J. R., Thompson, J. F. H., Mortensen, J. K., and Baker, T., 1997, Intrusion-related Au mineralisation associated with lithophile elements: an under-recognised metallogenic association: Geol. Soc. Am. Abstr. Prog 29, p. 211-244.

Lang, J. R., Baker, T., Hart, C. J. R., Mortensen, J. K., 2000, An exploration model for intrusion-related gold systems. SEG Newsletter 40, p. 1-11.

Mustard, R., 2001, Granite-hosted Gold Mineralisation at Timbarra, northern New South Wales, Australia: Min. Dep. V. 36, p. 542-562.

Mustard, R., 2004, Textural, Mineralogical and Geochemical Variation in the Zoned Timbarra Tablelands Pluton, New South Wales: Aust. J. Earth Sci., v. 51, p. 385-405.

Mustard, R., Ulrich, T., Kamenetsky, V. S. and Mernagh, T. 2006. Gold and metal enrichment in natural granitic melts during fractional crystallization. Geology, v. 34; no. 2; p. 85–88.

Partington, G. A., Christie, A. B., Cox, S. C., Rattenbury, M., Smillie, R. and Stigley P., 2002, Prospectivity modelling for mesothermal gold in New Zealand using spatial analysis in GIS: Australasian Institute of Mining and Metallurgy Conference Volume, Annual Conference, Auckland, p. 123-128.

Partington, G. A., and Sale, M. J., 2004, Prospectivity mapping using GIS with publicly available earth science data - a new targeting tool being successfully used for exploration in New Zealand: Australasian Institute of Mining and Metallurgy, Pacrim 2004 Congress Volume, Adelaide, p. 239-250.

Partington, G., A., and Mustard, R., 2005, Granite Gold Mineral Systems in New Zealand: Australasian Institute of Mining and Metallurgy Conference Volume, New Zealand Branch Annual Conference, Auckland, p. 160-167.

Thompson, J. F. H., Sillitoe, R. H., Baker, T., Lang, J. R., and Mortensen, J. K., 1999, Intrusion-related gold deposits associated with tungsten-tin provinces: Mineralium Deposita, v. 34, p. 323-334.