COMPARATIVE 3-D RESOURCE MODELLING APPROACHES AT MACRAES DEPOSIT IN NEW ZEALAND AND THEIR RECONCILIATION WITH PRODUCTION

By

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Macraes Mine, owned by Macraes Mining Company Limited, is situated near Macraes Flat 80 km north of Dunedin in South Island, New Zealand. It is located within a shallow dipping shear zone in the Haast Schist Group of the Otago Schist belt. Early workers (Lee et al[2]) described lode shears concordant with high strain zones, stockworks of high angle discordant veins and disseminated sulphide and weak stockwork zones. Pit mapping by site geologists has subsequently confirmed and expanded on this interpretation (Figure 1) to include west dipping ramp faults which roll over to the east as they approach the hangingwall and east dipping shears parallel to the hangingwall. A complex east-west ramp structure enhances the grades in the central area of Round Hill and is the locus of well developed stockwork.

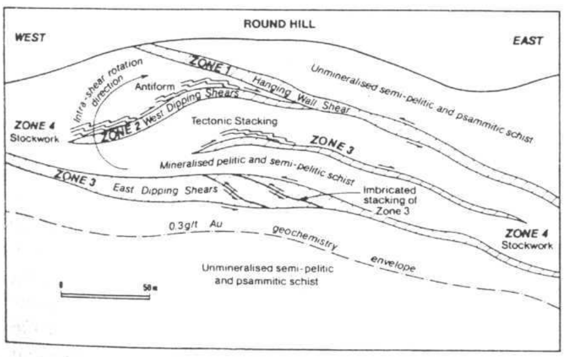

Figure 1 Schematic Cross Section Through Round Hill Ore Zones

Plant construction commenced in February 1990 and the first gold pour was made in October 1990. The six months to 30 June 1991 reported 750,000 tonnes of ore mined at 2 g/t.

A production review was undertaken at this stage and highlighted both grade control and resource modelling issues which led to significant revisions in methodology being adopted by management. The timely action taken allowed the production budget to be achieved and, indeed, exceeded despite ore presentation differing from expectation.

A key issue was the recognition that routine rehandle sampling of low grade material produced an apparent upgrading of the 0.7 – 1.0 g/t material estimated from grade control blast hole assays (Table 1). The typical proportions of reclassified material were:

37% to medium grade (0.9-1 g/t)
21% to low grade (0.7-0.9 g/t)
42% to waste (< 0.7 g/t)

Table 1
Summary of Truck Sample Rehandling Statistics

Bench	Grade Control Indicated		Truck Indicated	
	tonnes	g/t	tonnes	g/t
512.5	11789	0.85	12288	1.08
500.0	6665	1.06	9851	1.20
497.5	12498	0.94	11555	1.04
495.0	16909	0.89	17484	0.89
492.0	15462	0.81	16655	0.95
487.5	25409	0.92	22832	1.21
485.0	26614	0.78	29262	1.15
485.0	30055	0.73	33095	0.92
Total	14540	0.84	153022	1.05

The average grade of 0.7 – 1.0 g/t material in-situ was 0.84 g/t but, according to 3 kg truck samples this material averaged 1.05 g/t. This apparent upgrading of the low grade material could either have been due to sample bias or to a regression effect.

Grade control kriging was used to test whether the regression effect could explain the observed results. Two models using lognormal kriging and indicator kriging were interpolated using 8 benches of grade control data for which production results were known. Results are plotted as grade tonnage curves (Figure 2) and compared with grade control indicated estimates (polygonal outlines on assay cutoffs), stockpiled estimates based on truck tallies and after reclassification due to rehandling, and the back calculated mill production figure.

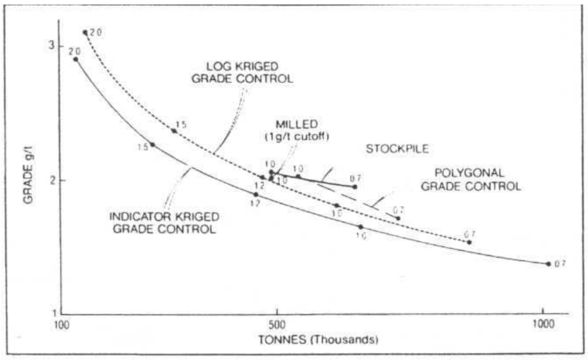

Figure 2 Reconciliation of Grade/Tonnage Estimates on Benches 480 – 500 mRL

This test illustrated that the production cutoff achieved was close to a 1.2 g/t kriged block grade. This lent support to the possibility that the observed rehandle statistics could be a manifestation of the volume-variance relationship leading to a regression effect. The actual block grades are less variable than blast hole assay grades. This means that where a blast hole grade is low the block grade will be higher and where a blast hole grade is high the block grade will be lower. In other words the block grades are 'smoother'. Thus when a low grade cutoff is set on the blast hole assay grade one effectively sets a higher cutoff on the true block grade. The material that appears to be 0.7 – 1.0 g/t on the basis of blast hole assays actually has true block grades which are higher than this.

This test also illustrated the comparative results for different methods of interpolation. Indicator kriging, based here on 7 indicators, is lower in grade and gives more low grade tonnage than log kriging. It sets a similar tonnage to log kriging at the production cutoff of interest. Subsequent tests showed that the two interpolation methods were equivalent when the number of indicators used was increased to 10.

The knowledge from this test work led to recommendations for remodelling of the resource model in June 1992. The geological model was refined by recognition of separate geological domains based on pit mapping (Figure 3) and reinterpretation of drillhole sections and plans. Indicator kriging with appropriate parameters for each domain was used to interpolate the stockwork and concordant lodes separately. Several test runs highlighted that there were significantly different results depending on how the geological boundaries were used and on the compositing technique employed.

Two methods of compositing were tested:

- Compositing within concordant lodes using partial composites at boundaries
- Fully diluted 2.5 m bench composites

Three interpolations were undertaken:

- For each domain using only the matching partial composites within the domain
- For each domain using all composites within the search ellipse
- For each domain using only the matching bench composites within the domain

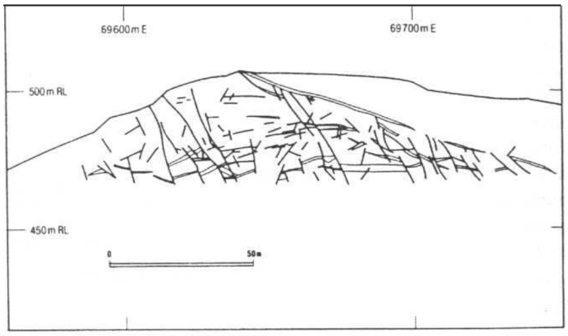

Figure 3 Pit Mapping on Section 15150 mN

It was intuitively expected that the first interpolation would be correct as the mining method involves careful selective mining of the hanging wall lode, removing overlying waste by excavator prior to bench mining the rest.

However the grade tonnage curves comparing grade control kriging with the exploration model show that this initial model severely overestimated grade (Figure 4). The second model relaxed the geological constraints and although the model showed good reconciliation in the well drilled area of the pit, when it was run for the entire model there was a large difference between the matched and unmatched models. The theory that where the drill density was low there may be insufficient definition provided by the sampling for the unmatched process to succeed in modelling the concordant lode was proved by undertaking a declustering test. The model for the declustered data significantly underestimated the resource where it had already been mined (Figure 5).

The final run allowed for geological matching, thus overcoming the drillhole density issue, but incorporated enough dilution at the geological boundaries to avoid overestimating grade. This model, named the "BCD" (termed for the so called backcoded composites) was duly accepted for forward planning (Figure 4).

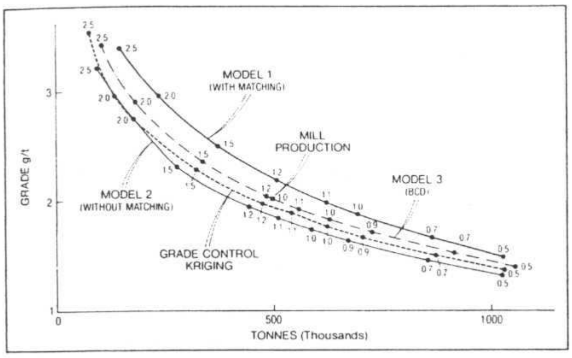

Figure 4 Reconciliation Area
Grade/Tonnage Estimates

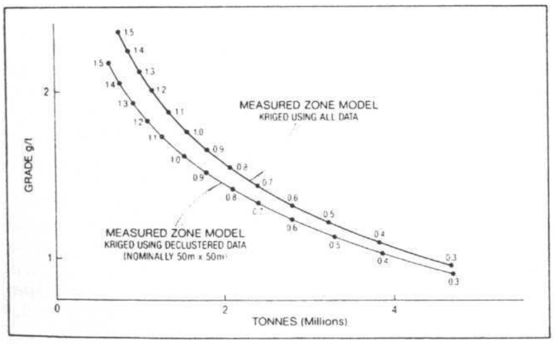

Figure 5 Grade/Tonnage Curves – Declustering Test

Subsequent grade control based on a nominal assay cutoff of 0.9 g/t (polygonal) is shown in Figure 6 to relate to a model cutoff of about 0.9 g/t down to bench 495 mRL. Thereafter a tightening up of control brought the production to a cutoff above 1 g/t (model) down to 475 mRL. At this point a sample bias began creeping in to the blast hole samples. This was subsequently tracked to the loss of fines from the rig but in the meantime led to an overestimation of pit grades. Tonnages went up and actual grades went down. This was initially blamed on the coincidental introduction of grade control kriging. But a review showed that the kriging was not at fault. When the bias was recognised a regression was introduced to counteract the problem until the rig has been replaced. From 450 mRL after sample recovery had been improved the original trend was resumed.

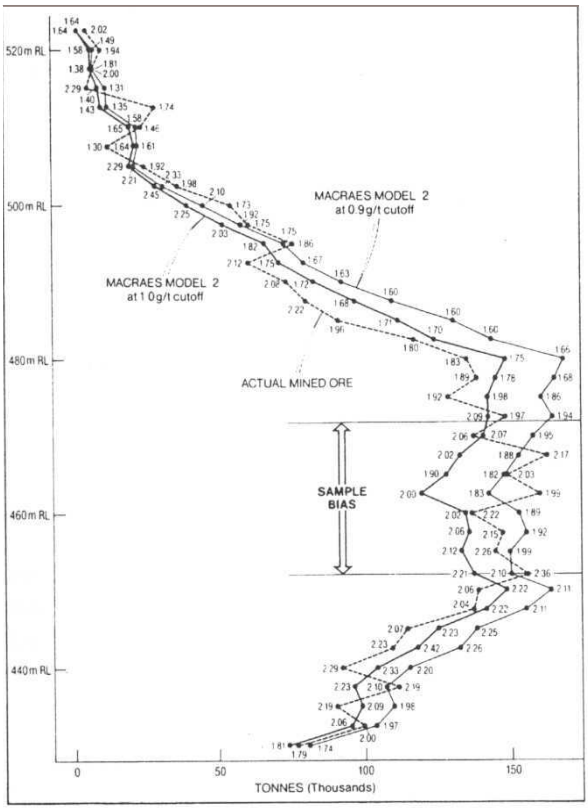

Figure 6 Tonnage and grade by RL

From November 1992 there was an intensive review of geological interpretation which resulted in further refinements to the geological model. The resource model was updated in April 1993.

This case study illustrates the iterative approach needed to refine geological models and resource estimates. It also shows that the most obvious interpolation techniques are surprisingly not always the ones that reconcile. The tool that illustrates most clearly the comparative relationships is the grade tonnage curve. It has been shown at Macraes that not only tonnes and grade above cutoff, but the definition of the cutoff itself needs to be analysed. In order to optimise production the cutoff should be set on the basis of a selective mining unit grade, not the grade of the single blast hole assay in the centre of the block. The recognition of within-block variability, the nugget effect, the semivariogram and its anisotropy, as well as the regression effect are all important. Not least, particularly in a complex geological environment, is the recognition of style of mineralisation and how it impacts on resource modelling.

Acknowledgements

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2. Lee, M.C., Batt, W.D. and Robinson, P.C. (1988). The Round Hill gold Scheelite Deposit, Macraes Flat, Otago, New Zealand, Mineral Deposits of New Zealand, AusIMM Monograph (1989) No 13.