Computer modelling of primary spiral circuit at South Crofty, Ltd., Cornwall, England

P. Tucker, K. A. Lewis and M. P. Hallewell

Synopsis
A practical application of computer modelling in metallurgical development work is presented. Computer modelling was used successfully at the tin-producing plant of South Crofty, Ltd., to optimize the primary stage of spiral concentration. The model was used to predict the best possible spiral operating conditions for production of a pre-specified concentrate. Details and results of this work are presented. The benefits achieved through modelling are also discussed in relation to operational practice, together with the scope and limitations of the technique. Background information includes details of the mathematical model used and a summary of the South Crofty operation.

Computer modelling and simulation techniques can assist in the design, specification and optimization of mineral processing plant. These techniques have the potential to reduce, and in some cases eliminate, costly and unpractical, large-scale experimental testwork. The present contribution reports on computer modelling methods applied at the tin-producing plant of South Crofty, Ltd., in Cornwall, England.

The modelling methods were developed at Warren Spring Laboratory in close cooperation with the mineral processing industry and have been verified in the industrial environment. One particular model, which represents the GEC-Elliott spiral concentrator, is described here. It is one of a suite of gravity process models developed as part of a mineral processing simulation package that includes materials balances, data-handling routines, further process models (magnetic separation, comminution, etc.) and flowsheet simulators. An expanded description was given by Tucker.

The GEC-Elliott spiral concentrator is used to separate heavy, 'valuable' minerals from gangue. It has a large number of concentrate take-off ports that are equally spaced down the inner radius of the spiral channel. The use of wash water is implicit. South Crofty, Ltd., employs four banks of GEC spirals for the preconcentration and first-stage cleaning of the circuit is closed by a ball-mill that feeds back to the primary stage of spiral concentration. The model was passed to eight double-start primary spirals, where the coarsely liberated, about 60% being at a particle size +1 mm and greater.

Primary grinding is by rod-mill, fed at 20 t/h and producing a product that is 80% - 900 µm. The rod-mill product is passed to eight double-start primary spirals, where the liberated cassiterite is recovered. The primary spiral tails are classified, the classifier fines (typically 80% - 175 µm) reporting to the table circuit. The classifier sands are treated by a secondary bank of spirals in which misplaced, liberated, coarse cassiterite is recovered prior to further size reduction. The circuit is closed by a ball-mill that feeds back to the classifier. The secondary spiral concentrates join the primary spiral concentrates for further upgrading in two stages of cleaning that comprise seven double-start cleaner spirals, the concentrate being passed to tables for regrading. The full spiral circuit is shown in Fig. 1.

Fig. 1 Flowsheet for South Crofty gravity circuit

A typical South Crofty ore containing minor amounts of arsenopyrite and chalcopyrite (ore A) gives 65% overall recovery of cassiterite in the spiral circuit, overall enrichment ratios being about 25-35. Maximum recovery occurs in the size range 53-110 µm (Fig. 2). However, recently treated ore types (ore B) have been much richer in sulphides, yielding up to 30%. As in the recleaner table concentrate—compared with
As for ore A. This results not only in lower spiral recoveries, sometimes as low as 30%, owing to increased locking but also in increased entrainment of free cassiterite in the sulphide as a result of the higher wash-water additions.

Fig. 2 Spiral circuit recovery

Regardless of ore type, it is essential that recovery of cassiterite in the spiral circuit is maximized. Also, the final gravity concentrate from the recleaner tables must have a combined Sn + S content of 45%. Tin and sulphur targets are set for high-grade concentrates (which are then treated in the sulphide flotation section prior to being filtered). Sulphides are removed to reduce smelter penalties.

At the time of the study spiral operation at South Crofty (on ore A) had become well defined, although some of the finer points remained to be finalized. For ore type B operation was not so clearly defined and work was needed to maximize performance when this ore was treated.

Of the four main operating variables for spiral operation—mass flow, pulp density, wash water and port settings—only the last two are usually adjusted as the others are maximized and running to plant limits. When the ore that is rich in sulphides (type B) is treated wash-water flow is increased to prevent the build-up of sulphides on cleaner spirals and recleaner tables. Spiral take-off ports may then need to be closed slightly to maintain concentrate grade within target limits. This is detrimental to the final recovery.

Mathematical model of spiral concentration

The Warren Spring Laboratory spiral concentrator model was designed as part of a general-purpose physical separation model (GMODEL) with application to a wide range of separation devices. GMODEL is constructed in modular form, the main block being device-independent. Each separation device is represented by a module that can be linked into the main model as required (Fig. 3(a)). The mathematical descriptions representing separation are contained entirely within the device module and fall into two main categories: (1) sound, physically based equations and well-defined empirical relationships; and (2) less firmly established relationships, which may depend on the mineralogy of the ore. The mathematical equations are formulated in terms of the probability of material being transferred from the spiral to each of the individual output flow streams. For the five-turn GEC-Elliot spiral these output streams are the 15 concentrate take-off ports plus the spiral tail. The general form of the model equations is

\[ A_{ij} \cdot T_{K}\text{i} = B_{K}\text{i} \]  

where \( A_{ij} \) is mass flow rate of the \( i \)th density fraction of the \( j \)th size fraction of the process feed and \( T_{K}\text{i} \) is material transfer coefficient describing the partition to the \( K \)th output flow stream, \( B_{K}\text{i} \). The material transfer coefficient is given by

\[ T_{K}\text{i} = f(\text{size, sp. gr.}, CP_{K}\text{i}, OV) \]  

where \( CP_{K}\text{i} \) refers to the machine setting controlling the \( K \)th output flow stream (cutter setting on a spiral concentrator) and \( OV \) refers to the other operating variables (throughput, pulp density, wash water, etc.). It has proved practical to separate equation 2 into two parts

\[ T_{K}\text{i} = f(\text{size, sp. gr.}, CP_{K}\text{i}, P) \]  

where \( P \) is a set of adjustable model parameters, and

\[ P = f(OV) \]  

representing the well-defined and less firmly established (auxiliary) relationships, respectively. The key to the use of the model lies in establishing the appropriate set of model parameters, \( P \).

Initial estimates of separation performance can be made by using parameter values that are either based on past experience or measured for a similar ore. (A data bank within the model allows reference parameter sets to be stored.) If measured performance data are available, the model allows for calibration, minimizing the least-squares difference between measured and calculated transfer coefficients by optimizing the parameter values, \( P \). Once calibrated the model equations 3 and 4 allow extrapolation beyond the range of calibration and, thus, enable predictions to be effected. These two aspects—calibration (by regression) and prediction—are shown schematically in Fig. 3(b).
Model validation

Prior to the main investigation the model was validated within the industrial environment. A sample of spiral feed was collected from the primary spiral circuit at South Crofty and characterized according to size and specific gravity. Sieving at 45, 90, 180 and 500 μm provided five fractions, each of which was separated by heavy liquids into three specific gravity fractions: <2.8, 2.8-3.3 and > 3.3 kg/m³. By using the results in conjunction with model parameters derived previously for a tungsten ore an estimative prediction was made for the performance of the primary spiral. At the same time concentrate and tailings samples were collected and the actual separation performance was determined. A comparison of the predicted and the measured data is given in Fig. 4 in terms of the recovery of each specific gravity fraction (summed over all sizes) to the concentrate and its distribution within the concentrate. Substantial agreement between the predicted and measured values was achieved. The root mean square (RMS) error on the prediction was ±4.8%.

Fig. 4 Model prediction of spiral performance

The model was calibrated against the measured data and a more precise set of model parameters, \( P_2 \), was obtained for the South Crofty ore. The results of this calibration (by regression) are shown in Fig. 4. The RMS error between model and measured data was reduced to ±3.8%. It includes not only the fitting errors but also a sizable contribution attributable to errors in the measurements.

Further validation studies were undertaken to assess how well the model—once calibrated under one set of operating conditions—predicted the performance for different conditions. The first test examined the model’s response to a change in feed flow conditions (throughput and pulp density), and a second investigated the response to an alteration in the sample cutter settings. The spirals were running at 1.43 t/h per start, the feed density being 29.9% solids. Only four of the 15 available ports were being utilized. In test (1) the mass flow was reduced to 1.30 t/h and the solids density was increased to 37.0%. In test (2) two further ports were opened. The predictions of the model were compared with the measurements (Fig. 5) obtained under the new conditions. The results, in terms of tin recovery and concentrate grade, show reasonable agreement, with relative errors of 4.3 and 4.2%, in grade and recovery, respectively, in test (1) and of 2.5 and 3.4%, respectively, in test (2). The agreement was sufficient close to indicate that predictions obtained from the model could be accepted with confidence.

Optimization of primary spiral performance at South Crofty

Although the spiral separators at South Crofty operated well within target limits, it was not known whether optimum performance had actually been achieved. This presented an opportunity for the use of modelling as an aid to further...
Modelling strategy
A full description of the basis of the GEC spiral model is beyond the scope of the present report and has been given elsewhere. For completeness, a brief résumé is reproduced here.

The modelling strategy was to construct a set of equations that describe the particle distribution profiles across the spiral track and to compute from these, together with the cutter settings, how much of each distribution was collected at each sample port. The mathematical functions were based on experimental measurements on synthetic ores compounded from materials of well-defined sizes and specific gravity. A good approximation to GEC spiral operation can be made by considering the spiral bed as consisting of two radial zones, the inner (spanning the whole range of sample cutter positions) extending to a radius \( R = R_0 (~0.4 \times \text{fractional bed width}) \) and the outer zone extending from \( R_0 \) to the outside of the bed. The probability of a particle of density \( \rho \) lying between a radius zero and \( R \) is well described by a function of the form

\[
\left( \frac{R}{R_0} \right)^a \tan \left( \frac{\rho - 1}{b_1} \right)^{b_2} R
\]

(5)

where \( P_1 \) is the first model parameter and \( b \) and \( a \) are scaling factors.

The probability of a particle being found within the outer zone is described by the function

\[
\phi = P_2 \exp \left[ - \left( \frac{K}{K_0} \right)^2 \left( \frac{d}{S} \right)^{n_1} + P_3 \left( \frac{S}{d} \right)^{-n_2} \right]
\]

(6)

where \( S \) is particle size, \( K \) is port number measured from the top of the spiral, \( P_2 \) and \( P_3 \) are model parameters and \( d \) and \( K_0 \) are scaling constants. The first term in equation 6 accounts for the trapping of fines close to the outer radius and includes dependence of this on distance down the spiral. The second term relates to the proportion of coarse material whose equilibrium radius lies within the outer radial zone. Thus, for a cutter setting \( CP_K \) the model equation becomes

\[
T_{CP_K} = \frac{\left( \frac{CP}{R_0} \right)^{a} \tanh \left( \frac{\rho - 1}{b_1} \right)^{b_2} \frac{CP_K}{\phi + \tanh \left( \frac{\rho - 1}{b_1} \right)^{b_2}}}{R_0}
\]

(7)

This equation forms the basis of the work presented here.

To use the model to predict the conditions for optimal performance repeat predictions that cover a range of operating conditions are essential. A facility (termed 'UDEF') is built into GMODEL for this application (Fig. 3(c)) and it figured prominently in the investigation reported here. The problem is set up in terms of (1) the operating conditions and the range of adjustment to be investigated; (2) any constraints on product specification—e.g. minimum grade acceptable, etc.; and (3) desired performance criteria—e.g. to maximize the recovery of coarse liberated material. The model prediction for each set of operating conditions is automatically assessed against the desired performance criteria and tested to see that it satisfies the specified constraints. The most closely matching solutions are presented to the engineer for final assessment.

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![Fig. 4 Model prediction of spiral performance](image)

The model was calibrated against the measured data and a more precise set of model parameters, \( P_1 \) was obtained for the South Crofty ore. The results of this calibration (by regression) are shown in Fig. 4. The RMS error between model and measured data was reduced to \( \pm 3.8\% \). It includes not only the fitting errors but also a sizable contribution attributable to errors in the measurements.

Further validation studies were undertaken to assess how well the model—one calibrated under one set of operating conditions—predicted the performance for different conditions. The first test examined the model's response to a change in feed flow conditions (throughput and pulp density), and a second investigated the response to an alteration in the sample cutter settings. The spirals were running at 1.43 t/h per start, the feed density being 29.9% solids. Only four of the 15 available ports were being utilized. In test (1) the mass flow was reduced to 1.30 t/h and the solids density was increased to 37.0%. In test (2) two further ports were opened. The predictions of the model were compared with the measurements (Fig. 5) obtained under the new conditions. The results, in terms of tin recovery and concentrate grade, show reasonable agreement, with relative errors of 4.3 and 4.2%, in grade and recovery, respectively, in test (1) and of 2.5 and 3.4%, respectively, in test (2). The agreement was sufficiently close to indicate that predictions obtained from the model could be accepted with confidence.

Optimization of primary spiral performance at South Crofty

Although the spiral separators at South Crofty operated well within target limits, it was not known whether optimum performance had actually been achieved. This presented an opportunity for the use of modelling as an aid to further
tuning of the plant. The number of take-off ports utilized had been reduced from the 15 provided to four or five open ports; whether to standardize on four or on five ports had yet to be resolved and it was considered that predictive modelling could help to formulate a solution. A reduction in the number of ports in use serves to ease operation and maintenance, though the penalties incurred if one of the ports were to become blocked would be correspondingly greater. Furthermore, it was not known how critical the actual port settings were. The problem was, thus, divisible into two main questions. First, could the recovery of coarse liberated tin be increased? If it were to be, the recovery of fine liberated tin should not fall significantly, but some reduction would be tolerable as misplaced fines would pass directly to the table circuit. A drop in concentrate grade of more than 1% would be unacceptable and the total material reporting to the concentrate should be within 10% of the current value. Second, was it preferable to operate the spiral with four or five (or six) ports open, and were the port settings themselves critical? The constraints that operated for this part of the problem were the same as for the first.

For the purposes of the present investigation 'liberated' tin was taken to mean tin-bearing material with a specific gravity greater than 3.3 kg/m³.

**Flow conditions**

A suite of computer predictions of tin recovery was made for a series of incremental changes of the dominant flow variables (i.e. mass flow and pulp density) about the current norm. The results for the three coarsest size fractions are presented in Fig. 6(a) and (b). Results summed over all sizes are shown in

![Fig. 5](image)

**Fig. 5** Comparison of predicted and measured results for changes in spiral operating conditions—(a) test (1): mass flow reduced from 1.43 to 1.30 t/h, pulp density increased from 29.9 to 37.0% (b) test (2); six ports used instead of four.

![Fig. 6](image)

**Fig. 6** Predictions of effect of changing flow conditions on Sn recovery: (a) effect of changing pulp density; (b) effect of changing mass flow; (c) effect of changing flow conditions on whole product (all sizes)

The results show clearly that South Crofty, Ltd., is operating its primary spirals close to the theoretical optimum. However, an increase in pulp density or a decrease in mass flow would produce a fine-tuning effect, boosting tin recovery, with a relatively small effect on concentrate grade (less than 1%). The GMODEL routine, UDEF, was then set up to search for the optimum set of conditions, subject to the imposed constraints. No solutions satisfying all the set constraints were found; any increase in coarse tin recovery was unavoidably linked with a drop in fine tin recovery. However, an increase in total recovery of liberated tin (i.e. summed over all sizes) was achievable under certain conditions: increased recovery at coarse sizes outweighed the loss of recovery at finer sizes. This apparent optimum solution, keeping within all constraints, requires a relative increase of 10–20% in pulp
density, coupled with a similar decrease in mass flow, over the current norm. The results are set out in Table 1. It was predicted that under these apparent 'optimum' conditions the total solids flow of concentrate would increase from 0.097 t/h (current) to 0.103 t/h—a relative increase of 6.2%.

Table 1 Model predictions of recovery and grade for change in flow conditions

<table>
<thead>
<tr>
<th>Particle size, µm</th>
<th>45</th>
<th>45-90</th>
<th>90-180</th>
<th>180-355</th>
<th>+355</th>
<th>All</th>
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<tbody>
<tr>
<td><strong>Sn recovery, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Norm</td>
<td>27.28</td>
<td>59.60</td>
<td>79.41</td>
<td>83.32</td>
<td>64.25</td>
<td>63.28</td>
</tr>
<tr>
<td>10% change (relative)</td>
<td>25.19</td>
<td>56.45</td>
<td>77.82</td>
<td>83.44</td>
<td>69.86</td>
<td>65.42</td>
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<tr>
<td>20% change (relative)</td>
<td>22.55</td>
<td>52.24</td>
<td>75.25</td>
<td>84.97</td>
<td>70.79</td>
<td>66.86</td>
</tr>
<tr>
<td><strong>Sn grade, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norm</td>
<td>4.91</td>
<td>7.01</td>
<td>7.07</td>
<td>7.12</td>
<td>11.30</td>
<td>8.01</td>
</tr>
<tr>
<td>10% change (relative)</td>
<td>4.27</td>
<td>6.34</td>
<td>6.06</td>
<td>6.30</td>
<td>10.51</td>
<td>7.50</td>
</tr>
<tr>
<td>20% change (relative)</td>
<td>3.78</td>
<td>5.90</td>
<td>5.86</td>
<td>6.03</td>
<td>10.33</td>
<td>6.89</td>
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</table>

Table 2 Model predictions of recovery and grade for change in number of take-off ports

<table>
<thead>
<tr>
<th>Particle size, µm</th>
<th>45</th>
<th>45-90</th>
<th>90-180</th>
<th>180-355</th>
<th>+355</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sn recovery, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norm (four ports)</td>
<td>27.28</td>
<td>59.60</td>
<td>79.41</td>
<td>83.32</td>
<td>64.25</td>
<td>63.28</td>
</tr>
<tr>
<td>Five ports (extra at top)</td>
<td>31.19</td>
<td>65.51</td>
<td>83.93</td>
<td>87.07</td>
<td>69.44</td>
<td>68.04</td>
</tr>
<tr>
<td>Five ports (extra at bottom)</td>
<td>32.66</td>
<td>67.34</td>
<td>84.91</td>
<td>87.43</td>
<td>69.55</td>
<td>68.65</td>
</tr>
<tr>
<td>Six ports</td>
<td>36.78</td>
<td>72.58</td>
<td>88.18</td>
<td>89.88</td>
<td>73.19</td>
<td>72.28</td>
</tr>
<tr>
<td>Three ports</td>
<td>21.00</td>
<td>49.10</td>
<td>70.48</td>
<td>76.20</td>
<td>56.43</td>
<td>55.41</td>
</tr>
<tr>
<td><strong>Sn grade, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norm (four ports)</td>
<td>4.91</td>
<td>7.01</td>
<td>7.07</td>
<td>7.12</td>
<td>11.30</td>
<td>8.01</td>
</tr>
<tr>
<td>Five ports (extra at top)</td>
<td>4.86</td>
<td>6.94</td>
<td>6.92</td>
<td>6.98</td>
<td>11.21</td>
<td>7.81</td>
</tr>
<tr>
<td>Five ports (extra at bottom)</td>
<td>4.83</td>
<td>6.90</td>
<td>6.90</td>
<td>6.97</td>
<td>11.23</td>
<td>7.77</td>
</tr>
<tr>
<td>Six ports</td>
<td>4.76</td>
<td>6.81</td>
<td>6.83</td>
<td>6.85</td>
<td>11.17</td>
<td>7.63</td>
</tr>
<tr>
<td>Three ports</td>
<td>4.78</td>
<td>7.18</td>
<td>7.21</td>
<td>7.17</td>
<td>11.30</td>
<td>8.11</td>
</tr>
</tbody>
</table>

The grade and recoveries quoted above relate to stable plant conditions. GMODEL was used to calculate the respective tolerances in product composition if gross instabilities were to occur. The computer model predicted these tolerances to be ±6% (absolute) in recovery and approximately ±0.8% (absolute) in grade for a maximum relative fluctuation in conditions of ±20%.

The relative merits and feasibility of implementation of the computer results were assessed on the plant. The proposed reduction in mass flow was rejected as it was considered that the predicted enhancement of recovery was marginal and could not be practically achieved or maintained without substantial plant alteration. The suggested increase in pulp density, however, was considered practical. An increase from 30% solids to the pumping limit of 36% solids has yielded a slight enhancement of recovery, close to the predicted value.

Port settings
The effect of opening one or more ports was predicted on the basis of a norm of four ports in operation (Table 2). It did not matter significantly which port was chosen—the use of ports at the top and bottom of the spiral resulted in only minor differences. Use of an additional port would increase recovery by 5–6% and reduce concentrate grade by approximately 0.2%. Further changes of the same magnitude were predicted on the opening of a sixth port.

The model was also used to predict the effect of port blockage. If one out of four operational ports were to block, recoveries would fall by nearly 8%, with little change in concentrate grade (Table 2).

Individual port settings were investigated. The model predicted that the adjustment of one port within a realistic range of ±20% about the current norm would have little effect. If all ports were adjusted simultaneously, the effect would be compounded. The model confirmed that current settings were very close to the optimum and that fine tuning would produce no significant return.

Following the assessment of these results South Crofty, Ltd., was able to standardize—with increased confidence—on five-port operation, the risks associated with port blockage for four-port operation being considered unacceptably high.

Treatment of more highly sulphidized ore
In earlier operation at South Crofty the highly sulphidized ore (ore B) was treated separately from ore A, but this resulted in unacceptably low spiral recoveries if the grade was maintained within the target limits. Thus, it was decided to blend the two ores for processing.

The computer model was used to predict the grade and recoveries that would be achieved if the two ores were blended. As individual data for both ores were available, they could be combined in the same ratio as the ores to simulate the blending. After introduction of the blending procedures on the plant the spirals were sampled and their performance was measured. The measured results show substantial agreement with the predictions (Table 3).

An optimization procedure similar to that described above showed that little improvement could be achieved by further
tuning of the operating conditions within current plant constraints. Increasing the wash-water flow and closing the ports slightly would, as suggested above, improve the grade (already on target), but would entail an unacceptable decrease in recovery.

Table 3 Model predictions and measured values of recovery and grade for blended ore

<table>
<thead>
<tr>
<th></th>
<th>Recovery, %</th>
<th>Grade, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted</td>
<td>50.41</td>
<td>8.66</td>
</tr>
<tr>
<td>Measured</td>
<td>50.11</td>
<td>9.03</td>
</tr>
<tr>
<td>Relative error, %</td>
<td>0.60</td>
<td>1.92</td>
</tr>
</tbody>
</table>

The question was raised as to whether recovery of tin from the blended ore could be significantly increased by increasing the number of spirals, thus reducing unit mass flow. Fig. 7 shows the effect of reducing the solids mass flow of the blend on concentrate grade and recovery. An addition of two double-start spirals would reduce the solids mass flow per unit by 25%. The predictive plot indicates an increase in tin recovery of 7% (relative) with a corresponding decrease in grade of approximately the same order. The grade would only be improved by an accompanying increase in pulp density, which is beyond the limits of the present pumps. It is unlikely, therefore, that increasing the number of primary spirals would be cost-effective when the expense of the equipment and the loss in concentrate grade are considered.

The modelling principles developed for the GEC spiral are readily applicable to other gravity concentration and classification devices, and a suite of models is now being built up. The models can be of value either in a stand-alone format (as used here) or when linked together to provide simulations of larger blocks of a process flowsheet. All models have been written in FORTRAN 77 and are available to run on the IBM PC class of computers.

Acknowledgement

The work forms part of a collaborative project between Warren Spring Laboratory, South Crofty, Ltd., Camborne School of Mines and the Wheal Jane operation of Carnon Consolidated, Ltd. The cooperation of individuals from all four organizations is gratefully acknowledged. The work was financed by the Raw Materials Program of the European Community (50%) and by the United Kingdom Department of Trade and Industry.

References


Authors

K. A. Lewis obtained the degree of B.Sc. in geology and computer science from the Council for National Academic Awards in 1975. She has been employed at Warren Spring Laboratory, Stevenage, England, since 1972. Her current position is that of higher scientific officer in the software development section of the Minerals and Metals Division of the Laboratory.

P. Tucker graduated in physics from Oxford University in 1974 and was awarded a Ph.D. from the University of Newcastle upon Tyne for research in geophysics in 1978. Since 1980 he has been employed at Warren Spring Laboratory, Stevenage, England. His current position is that of principal scientific officer in the software development section of the Minerals and Metals Division of the Laboratory.

M. P. Hallewell obtained the degree of B.Sc. in minerals engineering from the University of Birmingham in 1981 before joining the graduate metallurgical training scheme operated by Anglo American Corporation of South Africa, Ltd. He spent the year 1983–84 at the Western Deep Levels uranium plant in South Africa as senior plant metallurgist before joining South Crofty, Ltd., Cornwall, as plant metallurgist.