

**CERTIFICATE OF ANALYSIS FOR**

**LOW GRADE COPPER ORE**

**REFERENCE MATERIAL**

**OREAS 161**

Summary Statistics for OREAS 161

| Constituent                           | Certified Value | Absolute Standard Deviations |         |          |         |          | Relative Standard Deviations |       |       | 5% window |       |
|---------------------------------------|-----------------|------------------------------|---------|----------|---------|----------|------------------------------|-------|-------|-----------|-------|
|                                       |                 | 1SD                          | 2SD Low | 2SD High | 3SD Low | 3SD High | 1RSD                         | 2RSD  | 3RSD  | Low       | High  |
| <b>SP Fusion ICP</b>                  |                 |                              |         |          |         |          |                              |       |       |           |       |
| Cu (wt.%)                             | 0.400           | 0.013                        | 0.374   | 0.427    | 0.361   | 0.440    | 3.30%                        | 6.59% | 9.89% | 0.380     | 0.420 |
| Fe (wt.%)                             | 4.32            | 0.17                         | 3.97    | 4.67     | 3.80    | 4.84     | 4.03%                        | 8.06% | 12.1% | 4.11      | 4.54  |
| S (wt.%)                              | 2.96            | 0.05                         | 2.86    | 3.07     | 2.81    | 3.12     | 1.71%                        | 3.41% | 5.12% | 2.82      | 3.11  |
| CaO (wt.%)                            | 0.16            | 0.02                         | 0.12    | 0.20     | 0.09    | 0.22     | 13.3%                        | 26.5% | 39.8% | 0.15      | 0.17  |
| MgO (wt.%)                            | 3.59            | 0.17                         | 3.26    | 3.93     | 3.09    | 4.09     | 4.64%                        | 9.28% | 13.9% | 3.41      | 3.77  |
| Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.51            | 0.05                         | 2.40    | 2.62     | 2.35    | 2.67     | 2.17%                        | 4.33% | 6.50% | 2.38      | 2.63  |
| SiO <sub>2</sub> (wt.%)               | 84.2            | 2.6                          | 79.0    | 89.5     | 76.4    | 92.1     | 3.11%                        | 6.23% | 9.34% | 80.0      | 88.5  |
| Ag (ppm)                              | <5              | IND                          | IND     | IND      | IND     | IND      | IND                          | IND   | IND   | IND       | IND   |
| Pb (ppm)                              | 109             | 21                           | 67      | 152      | 45      | 173      | 19.5%                        | 39.0% | 58.6% | 104       | 115   |
| Zn (ppm)                              | 19              | 4                            | 11      | 27       | 7       | 31       | 21.5%                        | 43.0% | 64.5% | 18        | 20    |
| Co (ppm)                              | 119             | 11                           | 98      | 141      | 87      | 152      | 9.08%                        | 18.2% | 27.2% | 113       | 125   |
| <b>4-Acid ICP</b>                     |                 |                              |         |          |         |          |                              |       |       |           |       |
| Cu (wt.%)                             | 0.409           | 0.012                        | 0.385   | 0.432    | 0.374   | 0.444    | 2.88%                        | 5.76% | 8.64% | 0.388     | 0.429 |
| Fe (wt.%)                             | 4.26            | 0.12                         | 4.01    | 4.50     | 3.89    | 4.63     | 2.90%                        | 5.79% | 8.69% | 4.05      | 4.47  |
| S (wt.%)                              | 3.06            | 0.17                         | 2.72    | 3.39     | 2.56    | 3.56     | 5.48%                        | 11.0% | 16.4% | 2.91      | 3.21  |
| CaO (wt.%)                            | 0.158           | 0.009                        | 0.140   | 0.176    | 0.132   | 0.185    | 5.58%                        | 11.2% | 16.7% | 0.150     | 0.166 |
| MgO (wt.%)                            | 3.72            | 0.07                         | 3.57    | 3.86     | 3.50    | 3.93     | 1.94%                        | 3.87% | 5.81% | 3.53      | 3.90  |
| Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.49            | 0.12                         | 2.25    | 2.74     | 2.12    | 2.86     | 4.92%                        | 9.83% | 14.7% | 2.37      | 2.62  |
| Ag (ppm)                              | 1.10            | 0.11                         | 0.88    | 1.31     | 0.77    | 1.43     | 9.97%                        | 19.9% | 29.9% | 1.04      | 1.15  |
| Pb (ppm)                              | 135             | 10                           | 115     | 156      | 105     | 166      | 7.58%                        | 15.2% | 22.7% | 129       | 142   |
| Zn (ppm)                              | 22              | 6                            | 9       | 35       | 3       | 41       | 28.8%                        | 57.5% | 86.3% | 21        | 23    |
| Co (ppm)                              | 119             | 3                            | 112     | 125      | 109     | 128      | 2.56%                        | 5.12% | 7.68% | 113       | 124   |

Note - intervals may appear asymmetric due to rounding; IND – indeterminate

Prepared by:  
*Ore Research & Exploration Pty Ltd*  
 May 2009

## INTRODUCTION

OREAS reference materials (RM) are intended to provide a low cost method of evaluating and improving the quality of precious and base metal analysis of geological samples. To the explorationist, they provide an important control in analytical data sets related to exploration from the grass roots level through to resource definition. To the analyst, they provide an effective means of calibrating analytical equipment, assessing new techniques and routinely monitoring in-house procedures.

OREAS 161 is a low grade copper ore certified reference material (CRM) prepared and certified by Ore Research & Exploration Pth Ltd. The material was sourced from Xstrata's Mt Isa copper ore deposits located near the township of Mt Isa in north-west Queensland. The ore deposits are hosted by brecciated siliceous and dolomitic rock masses within the Urquhart Shale comprising complex and dissociated veins with chalcopyrite, pyrite and pyrrhotite with grades of 3-4% copper. OREAS 161 is one of a suite of seven CRMs characterised for Cu, Fe, S, CaO, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Ag, Pb, Zn and Co by both sodium peroxide fusion ICP and 4-acid ICP methods.

## COMMUNITION AND HOMOGENISATION PROCEDURES

The material was prepared in the following manner:

- a) *drying at 65<sup>o</sup> C to constant mass;*
- b) *crushing and screening;*
- c) *multi-stage milling to 100% minus 50 microns;*
- d) *preliminary blending;*
- e) *check assaying;*
- f) *adjustment of grades as necessary;*
- g) *final homogenisation;*
- h) *packaging into 10g units sealed under nitrogen in laminated foil pouches.*

## ANALYSIS OF OREAS 161

Ten commercial laboratories participated in the analytical program to characterise Cu, Fe, S, CaO, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Ag, Pb, Zn and Co by both sodium peroxide fusion ICP and 4-acid ICP methods. To maintain anonymity laboratories were randomly designated the letter codes A through J. In some instances laboratories determined one or more analytes using an alternative method to sodium peroxide fusion. These instances include: Lab D and Lab H where infra red combustion furnace was used to determine sulphur and Lab H used lithium borate fusion to determine all analytes except Cu and Zn. Other exceptions include instances where laboratories used an alternative method to 4-acid digest. These include Lab G where a modified aqua regia digest was used to determine all analytes and Lab J where an acid digest (non specified) with AAS finish was used for Ag only. All results together with uncorrected means, medians, one sigma standard deviations, relative standard deviations and percent deviation of lab means from the corrected mean of means (PDM<sup>3</sup>) are presented in Tables A2 to A22 (Appendix). The parameter PDM<sup>3</sup> is a measure of laboratory accuracy while the relative standard deviation is an effective measure of analytical precision where homogeneity of the test material has been confirmed. The analytical methods employed by each laboratory are explained, together with other abbreviations used, in Table A1 (Appendix). Each participating laboratory received 5 samples of 50g each. Each set of subsamples submitted to each laboratory was taken at regular intervals during packaging of the standard in order to maximise their representation. Laboratories were instructed to assay samples as received.

# STATISTICAL EVALUATION OF ANALYTICAL DATA FOR OREAS 161

## Certified Value and Confidence Intervals

The certified value is the mean of means of accepted replicate values of accepted participating laboratories computed according to the formulae

$$\bar{x}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} x_{ij}$$

$$\bar{\bar{x}} = \frac{1}{p} \sum_{i=1}^p \bar{x}_i$$

where

$x_{ij}$  is the  $j$ th result reported by laboratory  $i$ ;

$p$  is the number of participating laboratories;

$n_i$  is the number of results reported by laboratory  $i$ ;

$\bar{x}_i$  is the mean for laboratory  $i$ ;

$\bar{\bar{x}}$  is the mean of means.

The confidence intervals were obtained by calculation of the variance of the consensus value (mean of means) and reference to Student's- $t$  distribution with degrees of freedom ( $p-1$ ).

$$\hat{V}(\bar{\bar{x}}) = \frac{1}{p(p-1)} \sum_{i=1}^p (\bar{x}_i - \bar{\bar{x}})^2$$

$$\text{Confidence Interval} = \bar{\bar{x}} \pm t_{1-x/2}(p-1)(\hat{V}(\bar{\bar{x}}))^{1/2}$$

where

$t_{1-x/2}(p-1)$  is the  $1-x/2$  fractile of the  $t$ -distribution with  $(p-1)$  degrees of freedom.

The distribution of the values is assumed to be symmetrical about the mean in the calculation of the confidence interval.

The test for rejection of individual outliers from each laboratory data set was primarily based on  $z$  scores (rejected if  $|z_i| > 2.5$ ) computed from the robust estimators of location and scale,  $T$  and  $S$ , respectively, according to the formulae:

$$S = 1.483 \frac{\text{median}_{j=1, \dots, n} |x_j - \text{median}_{i=1, \dots, n}(x_i)|}{}$$

$$z_i = \frac{x_i - T}{S}$$

where

$T$  is the median value in a data set;

$S$  is the median of all absolute deviations from the sample median multiplied by 1.483, a correction factor to make the estimator consistent with the usual parameter of a normal distribution.

Table 1. Certified values and 95% confidence intervals for OREAS 161

| Constituent  | Certified Value | 95% Confidence Interval |       |
|--|-----------------|-------------------------|-------|
|  |                 | Low                     | High  |
| <b>Sodium Peroxide Fusion ICP</b>                      |                 |                         |       |
| Copper, Cu (wt.%)                                      | 0.400           | 0.391                   | 0.409 |
| Iron, Fe (wt.%)  | 4.32            | 4.20                    | 4.44  |
| Sulphur, S (wt.%)                                      | 2.96            | 2.94                    | 2.99  |
| Calcium oxide, CaO (wt.%)                              | 0.16            | 0.13                    | 0.18  |
| Magnesium oxide, MgO (wt.%)                            | 3.59            | 3.47                    | 3.72  |
| Aluminium oxide, Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.51            | 2.48                    | 2.54  |
| Silicon dioxide, SiO <sub>2</sub> (wt.%)               | 84.2            | 82.2                    | 86.3  |
| Silver, Ag (ppm)                                       | <5              | IND                     | IND   |
| Lead, Pb (ppm)   | 109             | 93                      | 125   |
| Zinc, Zn (ppm)   | 19              | 6                       | 32    |
| Cobalt, Co (ppm)                                       | 119             | 111                     | 127   |
| <b>4-Acid* ICP</b>                                     |                 |                         |       |
| Copper, Cu (wt.%)                                      | 0.409           | 0.402                   | 0.416 |
| Iron, Fe (wt.%)  | 4.26            | 4.17                    | 4.35  |
| Sulphur, S (wt.%)                                      | 3.06            | 2.92                    | 3.20  |
| Calcium oxide, CaO (wt.%)                              | 0.158           | 0.152                   | 0.164 |
| Magnesium oxide, MgO (wt.%)                            | 3.72            | 3.67                    | 3.77  |
| Aluminium oxide, Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.49            | 2.40                    | 2.58  |
| Silver, Ag (ppm)                                       | 1.10            | 1.02                    | 1.17  |
| Lead, Pb (ppm)   | 135             | 128                     | 143   |
| Zinc, Zn (ppm)   | 22              | 15                      | 29    |
| Cobalt, Co (ppm)                                       | 119             | 117                     | 120   |

\*Lab G used a modified aqua regia digest. Note - intervals may appear asymmetric due to rounding; IND – indeterminate

The z-score test is used in combination with a second method of individual outlier detection that determines the percent deviation of the individual value from the median. Outliers in general are selected on the basis of z-scores > 2.5 and with percent deviations > 1.5%. In certain instances statistician's prerogative has been employed in discriminating outliers. Each laboratory data set is tested for outlying status based on z-score discrimination and rejected if  $|z| > 2.5$ . After individual and lab data set outliers have been eliminated a non-iterative 3 standard deviation filter is applied, with those values lying outside this window also relegated to outlying status.

Individual outliers and, more rarely, laboratory means deemed to be outlying are shown left justified and in bold in the tabulated results (see Appendix) and have been omitted in the determination of certified values. The magnitude of the confidence interval is inversely proportional to the number of participating laboratories and interlaboratory agreement. It is a measure of the reliability of the certified value, i.e. the narrower the confidence interval the greater the certainty in the certified value. A 95% confidence interval indicates a 95% probability that the interval includes the true value of the analyte under consideration.

### Statement of Homogeneity

The standard deviation of each laboratory data set includes error due to both the imprecision of the analytical method employed and to possible inhomogeneity of the material analysed. The standard deviation of the pooled individual analyses of all participating laboratories includes error due to the imprecision of each analytical method,

to possible inhomogeneity of the material analysed and, in particular, to deficiencies in accuracy of each analytical method.

In determining tolerance intervals that component of error attributable to measurement inaccuracy was eliminated by transformation of the individual results of each data set to a common mean (the uncorrected grand mean) according to the formula

$$x'_{ij} = x_{ij} - \bar{x}_i + \frac{\sum_{i=1}^p \sum_{j=1}^{n_i} x_{ij}}{\sum_{i=1}^p n_i}$$

where

$x_{ij}$  is the  $j$ th raw result reported by laboratory  $i$ ;

$x'_{ij}$  is the  $j$ th transformed result reported by laboratory  $i$ ;

$n_i$  is the number of results reported by laboratory  $i$ ;

$p$  is the number of participating laboratories;

$\bar{x}_i$  is the raw mean for laboratory  $i$ .

The homogeneity of each constituent was determined from tables of factors for two-sided tolerance limits for normal distributions (ISO 3207) in which

Lower limit is  $\bar{x} - k'_2(n, p, 1 - \alpha) s''_g$

Upper limit is  $\bar{x} + k'_2(n, p, 1 - \alpha) s''_g$

where

$n$  is the number of results;

$1 - \alpha$  is the confidence level;

$p$  is the proportion of results expected within the tolerance limits;

$k'_2$  is the factor for two – sided tolerance limits ( $m, \alpha$  unknown);

$s''_g$  is the corrected grand standard deviation.

The meaning of these tolerance limits may be illustrated for Cu by 4-acid digest, where 99% of the time at least 95% of subsamples will have concentrations lying between 0.402 and 0.416 wt.%. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99% of the tolerance intervals so constructed would cover at least 95% of the total population, and 1% of the tolerance intervals would cover less than 95% of the total population (ISO Guide 35).

Table 2. Certified values and tolerance intervals for OREAS 161.

| Constituent  | Certified Value | Tolerance Interval<br>1- $\alpha$ =0.99, $\rho$ =0.95 |       |
|--|-----------------|---|-------|
|  |                 | Low   | High  |
| <b><u>Sodium Peroxide Fusion ICP</u></b>               |                 |   |       |
| Copper, Cu (wt.%)                                      | 0.400           | 0.387   | 0.413 |
| Iron, Fe (wt.%)  | 4.32            | 4.21  | 4.43  |
| Sulphur, S (wt.%)                                      | 2.96            | 2.89  | 3.04  |
| Calcium oxide, CaO (wt.%)                              | 0.16            | IND   | IND   |
| Magnesium oxide, MgO (wt.%)                            | 3.59            | 3.52  | 3.66  |
| Aluminium oxide, Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.51            | 2.42  | 2.60  |
| Silicon dioxide, SiO <sub>2</sub> (wt.%)               | 84.2            | 82.0  | 86.5  |
| Silver, Ag (ppm)                                       | <5              | IND   | IND   |
| Lead, Pb (ppm)   | 109             | 100   | 118   |
| Zinc, Zn (ppm)   | 19              | IND   | IND   |
| Cobalt, Co (ppm)                                       | 119             | 114   | 124   |
| <b><u>4-Acid* ICP</u></b>                              |                 |   |       |
| Copper, Cu (wt.%)                                      | 0.409           | 0.402   | 0.416 |
| Iron, Fe (wt.%)  | 4.26            | 4.19  | 4.32  |
| Sulphur, S (wt.%)                                      | 3.06            | 3.01  | 3.10  |
| Calcium oxide, CaO (wt.%)                              | 0.158           | 0.150   | 0.167 |
| Magnesium oxide, MgO (wt.%)                            | 3.72            | 3.66  | 3.78  |
| Aluminium oxide, Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.49            | 2.45  | 2.54  |
| Silver, Ag (ppm)                                       | 1.10            | IND   | IND   |
| Lead, Pb (ppm)   | 135             | 130   | 141   |
| Zinc, Zn (ppm)   | 22              | 19  | 26    |
| Cobalt, Co (ppm)                                       | 119             | 116   | 121   |

\*Lab G used a modified aqua regia digest. Note - intervals may appear asymmetric due to rounding; IND – indeterminate

The corrected grand standard deviation,  $s_g''$ , used to compute the tolerance intervals is the weighted means of standard deviations of all data sets for a particular constituent according to the formula:

$$s_g'' = \frac{\sum_{i=1}^p (s_i (1 - \frac{s_i}{s_g'}))}{\sum_{i=1}^p (1 - \frac{s_i}{s_g'})}$$

where

$1 - (\frac{s_i}{s_g'})$  is the weighting factor for laboratory  $i$ ;

$s_g'$  is the grand standard deviation computed from the transformed (i.e. means - adjusted) results

according to the formula

$$s'_g = \left[ \frac{\sum_{i=1}^p \sum_{j=i}^{n_i} (x'_{ij} - \bar{x}'_i)^2}{\sum_{i=1}^p n_i - 1} \right]^{1/2}$$

where  $\bar{x}'_i$  is the transformed mean for laboratory  $i$

The weighting factors were applied to compensate for the considerable variation in analytical precision amongst participating laboratories. Hence, weighting factors for each data set have been constructed so as to be inversely proportional to the standard deviation of that data set. It should be noted that estimates of tolerance by this method are considered conservative as a significant proportion of the observed variance, even in those laboratories exhibiting the best analytical precision, can presumably be attributed to measurement error.

### Performance Gates

Performance gates provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. They take into account errors attributable to measurement and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. Sources of measurement error include inter-lab bias, analytical precision (repeatability) and inter-batch bias (reproducibility).

Two methods have been employed to calculate performance gates. The first method uses the same filtered data set used to determine the certified value, i.e. after removal of all individual, lab dataset (batch) and 3SD outliers. These outliers can only be removed after the absolute homogeneity of the CRM has been independently established, i.e. the outliers must be confidently deemed to be analytical rather than arising from inhomogeneity of the CRM. The standard deviation is then calculated for each analyte from the pooled individual analyses generated from the certification program. Table 3 shows performance gates calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned. A second method utilises a 5% window calculated directly from the certified value. Standard deviation is also shown in relative percent for one, two and three relative standard deviations (1RSD, 2RSD and 3RSD) to facilitate an appreciation of the magnitude of these numbers and a comparison with the 5% window. Caution should be exercised when concentration levels approach lower limits of detection of the analytical methods employed as performance gates calculated from standard deviations tend to be excessively wide whereas those determined by the 5% method are too narrow.

Table 3. Performance Gates for OREAS 161

| Constituent                           | Certified Value | Absolute Standard Deviations |         |          |         |          | Relative Standard Deviations |       |       | 5% window |       |
|---------------------------------------|-----------------|------------------------------|---------|----------|---------|----------|------------------------------|-------|-------|-----------|-------|
|                                       |                 | 1SD                          | 2SD Low | 2SD High | 3SD Low | 3SD High | 1RSD                         | 2RSD  | 3RSD  | Low       | High  |
| <b>SP Fusion ICP</b>                  |                 |                              |         |          |         |          |                              |       |       |           |       |
| Cu (wt.%)                             | 0.400           | 0.013                        | 0.374   | 0.427    | 0.361   | 0.440    | 3.30%                        | 6.59% | 9.89% | 0.380     | 0.420 |
| Fe (wt.%)                             | 4.32            | 0.17                         | 3.97    | 4.67     | 3.80    | 4.84     | 4.03%                        | 8.06% | 12.1% | 4.11      | 4.54  |
| S (wt.%)                              | 2.96            | 0.05                         | 2.86    | 3.07     | 2.81    | 3.12     | 1.71%                        | 3.41% | 5.12% | 2.82      | 3.11  |
| CaO (wt.%)                            | 0.16            | 0.02                         | 0.12    | 0.20     | 0.09    | 0.22     | 13.3%                        | 26.5% | 39.8% | 0.15      | 0.17  |
| MgO (wt.%)                            | 3.59            | 0.17                         | 3.26    | 3.93     | 3.09    | 4.09     | 4.64%                        | 9.28% | 13.9% | 3.41      | 3.77  |
| Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.51            | 0.05                         | 2.40    | 2.62     | 2.35    | 2.67     | 2.17%                        | 4.33% | 6.50% | 2.38      | 2.63  |
| SiO <sub>2</sub> (wt.%)               | 84.2            | 2.6                          | 79.0    | 89.5     | 76.4    | 92.1     | 3.11%                        | 6.23% | 9.34% | 80.0      | 88.5  |
| Ag (ppm)                              | <5              | IND                          | IND     | IND      | IND     | IND      | IND                          | IND   | IND   | IND       | IND   |
| Pb (ppm)                              | 109             | 21                           | 67      | 152      | 45      | 173      | 19.5%                        | 39.0% | 58.6% | 104       | 115   |
| Zn (ppm)                              | 19              | 4                            | 11      | 27       | 7       | 31       | 21.5%                        | 43.0% | 64.5% | 18        | 20    |
| Co (ppm)                              | 119             | 11                           | 98      | 141      | 87      | 152      | 9.08%                        | 18.2% | 27.2% | 113       | 125   |
| <b>4-Acid* ICP</b>                    |                 |                              |         |          |         |          |                              |       |       |           |       |
| Cu (wt.%)                             | 0.409           | 0.012                        | 0.385   | 0.432    | 0.374   | 0.444    | 2.88%                        | 5.76% | 8.64% | 0.388     | 0.429 |
| Fe (wt.%)                             | 4.26            | 0.12                         | 4.01    | 4.50     | 3.89    | 4.63     | 2.90%                        | 5.79% | 8.69% | 4.05      | 4.47  |
| S (wt.%)                              | 3.06            | 0.17                         | 2.72    | 3.39     | 2.56    | 3.56     | 5.48%                        | 11.0% | 16.4% | 2.91      | 3.21  |
| CaO (wt.%)                            | 0.158           | 0.009                        | 0.140   | 0.176    | 0.132   | 0.185    | 5.58%                        | 11.2% | 16.7% | 0.150     | 0.166 |
| MgO (wt.%)                            | 3.72            | 0.07                         | 3.57    | 3.86     | 3.50    | 3.93     | 1.94%                        | 3.87% | 5.81% | 3.53      | 3.90  |
| Al <sub>2</sub> O <sub>3</sub> (wt.%) | 2.49            | 0.12                         | 2.25    | 2.74     | 2.12    | 2.86     | 4.92%                        | 9.83% | 14.7% | 2.37      | 2.62  |
| Ag (ppm)                              | 1.10            | 0.11                         | 0.88    | 1.31     | 0.77    | 1.43     | 9.97%                        | 19.9% | 29.9% | 1.04      | 1.15  |
| Pb (ppm)                              | 135             | 10                           | 115     | 156      | 105     | 166      | 7.58%                        | 15.2% | 22.7% | 129       | 142   |
| Zn (ppm)                              | 22              | 6                            | 9       | 35       | 3       | 41       | 28.8%                        | 57.5% | 86.3% | 21        | 23    |
| Co (ppm)                              | 119             | 3                            | 112     | 125      | 109     | 128      | 2.56%                        | 5.12% | 7.68% | 113       | 124   |

\*Lab G used a modified aqua regia digest. Note - intervals may appear asymmetric due to rounding; IND – indeterminate

## PARTICIPATING LABORATORIES

Acme Analytical Laboratories Ltd, Vancouver, BC, Canada

Activation Laboratories, Ancaster, ON, Canada

Activation Laboratories, Perth, WA, Australia

ALS Chemex, Brisbane, QLD, Australia

ALS Chemex, Vancouver, BC, Canada

Amdel Limited, Adelaide, SA, Australia

Genalysis Laboratory Services Pty Ltd, Perth, WA, Australia

SGS Mineral Services Australia, Perth, WA, Australia

SGS Mineral Services, Lakefield, ON, Canada

Ultra Trace Pty Ltd, Perth, WA, Australia



## PREPARER AND SUPPLIER OF THE REFERENCE MATERIAL

Reference material OREAS 161 has been prepared and certified and is supplied by:

*Ore Research & Exploration Pty Ltd*  
*37A Hosie Street*  
*Bayswater North VIC 3153*  
*AUSTRALIA*

*Telephone (03) 9729 0333*  
*Facsimile (03) 9761 7878*  
*Email info@ore.com.au*

*International +613-9729 0333*  
*International +613-9761 7878*  
*Web www.ore.com.au*

OREAS 161 is available in 10g units sealed in nitrogen-purged laminated foil pouches.

## INTENDED USE

OREAS 161 is a reference material intended for the following:

- i) for the monitoring of laboratory performance in the analysis of Cu, Fe, S, CaO, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Ag, Pb, Zn and Co in geological samples;
- ii) for the calibration of instruments used in the determination of the concentration of Cu, Fe, S, CaO, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Ag, Pb, Zn and Co;
- iii) for the verification of analytical methods for Cu, Fe, S, CaO, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Ag, Pb, Zn and Co.

## STABILITY AND STORAGE INSTRUCTIONS

OREAS 161 is a reference material made from low grade copper ore material from the Mt Isa Copper Operations. In its unopened state in the nitrogen-purged laminated foil pouches and under normal conditions of storage it has a shelf life beyond five years.

## INSTRUCTIONS FOR THE CORRECT USE OF THE REFERENCE MATERIAL

The certified values for OREAS 161 refer to the concentration level of Cu, Fe, S, CaO, MgO, Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Ag, Pb, Zn and Co in its packaged state. The CRM should not be dried prior to weighing and analysis.

## LEGAL NOTICE

Ore Research & Exploration Pty Ltd has prepared and statistically evaluated the property values of this reference material to the best of its ability. The Purchaser by receipt hereof releases and indemnifies Ore Research & Exploration Pty Ltd from and against all liability and costs arising from the use of this material and information.

## **CERTIFYING OFFICER:**

Craig Hamlyn (B.Sc. Hons - Geology)

## **REFERENCES**

ISO Guide 35 (2006), Certification of reference materials - General and statistical principals.  
ISO Guide 3207 (1975), Statistical interpretation of data - Determination of a statistical tolerance interval.

## **APPENDIX**

### **Analytical Data for OREAS 161**

Table A1. Explanation of abbreviations used in Tables A2 – A11.

| Abbreviation     | Explanation  |
|------------------|--|
| Std.Dev.         | one standard deviation   |
| Rel.Std.Dev.     | one relative standard deviation (%)                            |
| PDM <sup>3</sup> | percent deviation of lab mean from corrected mean of means     |
| NR               | not reported   |
| AD               | acid digest (unspecified)                                      |
| 4A               | four acid digest (HF-HNO <sub>3</sub> -HClO <sub>4</sub> -HCl) |
| MAR              | modified aqua regia digest                                     |
| PF               | sodium peroxide fusion   |
| AAS              | atomic absorption spectrometry                                 |
| OES              | inductively coupled plasma optical emission spectrometry       |
| MS               | inductively coupled plasma mass spectrometry                   |
| ICP              | unspecified/combination of ICP-OES and ICP-MS                  |

Table A2. Fusion results for Cu in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*OES | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*MS | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>PF*OES | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1                | 0.442           | 0.412           | 0.405           | <b>0.002</b>    | 0.399          | 0.385           | 0.407           | 0.380           | 0.432           | 0.390           |
| 2                | 0.442           | 0.431           | 0.400           | 0.422           | 0.395          | <b>0.403</b>    | 0.411           | 0.390           | 0.419           | 0.410           |
| 3                | 0.445           | 0.423           | 0.400           | 0.391           | <b>0.380</b>   | 0.382           | 0.386           | 0.400           | 0.441           | 0.390           |
| 4                | 0.447           | 0.426           | 0.395           | 0.402           | 0.401          | 0.385           | 0.385           | 0.390           | 0.429           | 0.410           |
| 5                | 0.439           | 0.417           | 0.390           | 0.415           | 0.400          | 0.394           | 0.399           | 0.390           | 0.431           | 0.410           |
| Mean             | <b>0.443</b>    | 0.422           | 0.398           | 0.326           | 0.395          | 0.390           | 0.398           | 0.390           | <b>0.430</b>    | 0.402           |
| Median           | 0.442           | 0.423           | 0.400           | 0.402           | 0.399          | 0.385           | 0.399           | 0.390           | 0.431           | 0.410           |
| Std.Dev.         | 0.003           | 0.008           | 0.006           | 0.182           | 0.009          | 0.009           | 0.012           | 0.007           | 0.008           | 0.011           |
| Rel.Std.Dev.     | 0.70%           | 1.84%           | 1.43%           | 55.7%           | 2.20%          | 2.22%           | 3.03%           | 1.81%           | 1.83%           | 2.72%           |
| PDM <sup>3</sup> | 10.7%           | 5.40%           | -0.55%          | -18.4%          | -1.30%         | -2.60%          | -0.67%          | -2.55%          | 7.54%           | 0.45%           |

Table A3. Fusion results for Fe in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*OES | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*OES | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>BF*OES | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1                | 4.13            | 4.52            | 4.45            | 4.15            | <b>4.09</b>     | 4.31            | 4.44            | 4.20            | 4.44            | 4.40            |
| 2                | 4.15            | 4.62            | 4.36            | 4.14            | 4.31            | 4.13            | 4.53            | 4.21            | <b>4.31</b>     | 4.30            |
| 3                | 4.21            | 4.59            | 4.42            | 4.18            | 4.23            | 4.07            | 4.79            | 4.15            | 4.47            | 4.30            |
| 4                | 4.16            | 4.65            | 4.47            | 4.12            | 4.25            | 4.05            | 4.43            | 4.15            | 4.37            | 4.40            |
| 5                | <b>4.29</b>     | 4.47            | 4.36            | <b>4.33</b>     | 4.24            | 4.27            | 4.56            | 4.08            | 4.44            | 4.40            |
| Mean             | 4.19            | 4.57            | 4.41            | 4.18            | 4.22            | 4.17            | 4.55            | 4.16            | 4.41            | 4.36            |
| Median           | 4.16            | 4.59            | 4.42            | 4.15            | 4.24            | 4.13            | 4.53            | 4.15            | 4.44            | 4.40            |
| Std.Dev.         | 0.06            | 0.07            | 0.05            | 0.08            | 0.08            | 0.12            | 0.14            | 0.05            | 0.07            | 0.05            |
| Rel.Std.Dev.     | 1.53%           | 1.62%           | 1.15%           | 2.02%           | 1.92%           | 2.83%           | 3.16%           | 1.24%           | 1.48%           | 1.26%           |
| PDM <sup>3</sup> | -3.09%          | 5.75%           | 2.10%           | -3.18%          | -2.25%          | -3.60%          | 5.30%           | -3.78%          | 1.96%           | 0.89%           |

Table A4. Fusion results for S in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*OES | Lab C<br>PF*OES | Lab D<br>IRC | Lab E<br>PF*OES | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>IRC | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|-----------------|--------------|-----------------|-----------------|
| 1                | <b>2.89</b>     | 3.04            | 3.00            | <b>3.18</b>  | 3.36            | 2.88            | 3.07            | 2.96         | 2.57            | 2.94            |
| 2                | 2.96            | 2.98            | 3.04            | 2.89         | 3.40            | 2.95            | 3.03            | 2.92         | 2.53            | 3.00            |
| 3                | 2.97            | 2.94            | 2.95            | 3.02         | 3.29            | 2.94            | 3.00            | 2.88         | 2.63            | 2.98            |
| 4                | 2.96            | 2.94            | 2.91            | 2.98         | 3.19            | 2.92            | 3.03            | 2.90         | 2.55            | 3.03            |
| 5                | 2.98            | 3.06            | 2.93            | 2.91         | 3.23            | 2.92            | 2.95            | <b>2.75</b>  | 2.58            | 2.98            |
| Mean             | 2.95            | 2.99            | 2.97            | 3.00         | <b>3.29</b>     | 2.92            | 3.02            | 2.88         | <b>2.57</b>     | 2.99            |
| Median           | 2.96            | 2.98            | 2.95            | 2.98         | 3.29            | 2.92            | 3.03            | 2.90         | 2.57            | 2.98            |
| Std.Dev.         | 0.04            | 0.06            | 0.05            | 0.12         | 0.09            | 0.03            | 0.04            | 0.08         | 0.04            | 0.03            |
| Rel.Std.Dev.     | 1.21%           | 1.87%           | 1.79%           | 3.85%        | 2.65%           | 0.92%           | 1.41%           | 2.76%        | 1.47%           | 1.10%           |
| PDM <sup>3</sup> | -0.41%          | 0.93%           | 0.06%           | 1.07%        | 11.1%           | -1.43%          | 1.74%           | -2.78%       | -13.2%          | 0.73%           |

Table A5. Fusion results for CaO in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>- | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*OES | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>BF*OES | Lab I<br>- | Lab J<br>- |
|------------------|-----------------|------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------|------------|
| 1                | 0.15            | NR         | 0.30            | 0.30            | 0.16            | 0.15            | 0.07            | 0.15            | NR         | NR         |
| 2                | 0.15            | NR         | 0.30            | 0.30            | 0.16            | 0.21            | 0.08            | 0.15            | NR         | NR         |
| 3                | 0.16            | NR         | 0.30            | 0.30            | 0.12            | 0.18            | 0.08            | 0.15            | NR         | NR         |
| 4                | 0.17            | NR         | 0.30            | 0.30            | 0.13            | <b>0.26</b>     | 0.08            | 0.15            | NR         | NR         |
| 5                | 0.19            | NR         | 0.30            | 0.30            | 0.13            | 0.16            | 0.08            | 0.15            | NR         | NR         |
| Mean             | 0.16            |            | <b>0.30</b>     | <b>0.30</b>     | 0.14            | 0.19            | <b>0.08</b>     | 0.15            |            |            |
| Median           | 0.16            |            | 0.30            | 0.30            | 0.13            | 0.18            | 0.08            | 0.15            |            |            |
| Std.Dev.         | 0.02            |            | 0.00            | 0.00            | 0.02            | 0.04            | 0.00            | 0.00            |            |            |
| Rel.Std.Dev.     | 10.2%           |            | 0.00%           | 0.00%           | 13.4%           | 23.1%           | 3.84%           | 0.00%           |            |            |
| PDM <sup>3</sup> | 4.29%           |            | 90.8%           | 90.8%           | -11.0%          | 22.1%           | -50.9%          | -4.61%          |            |            |

Table A6. Fusion results for MgO in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*OES | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*OES | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>BF*OES | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1                | 3.50            | 3.75            | 3.70            | 3.69            | 3.60            | 3.33            | 4.55            | 3.52            | 3.42            | 3.80            |
| 2                | 3.52            | 3.93            | 3.70            | 3.55            | 3.60            | 3.40            | 4.45            | 3.54            | 3.40            | 4.00            |
| 3                | 3.51            | 3.81            | 3.65            | 3.68            | 3.56            | 3.36            | 4.44            | 3.53            | 3.38            | 3.80            |
| 4                | 3.49            | 3.88            | 3.61            | 3.50            | 3.55            | 3.41            | 4.47            | 3.55            | 3.37            | 3.70            |
| 5                | <b>3.68</b>     | 3.80            | 3.65            | 3.81            | 3.55            | 3.35            | 4.57            | <b>3.42</b>     | 3.48            | 3.70            |
| Mean             | 3.54            | 3.83            | 3.66            | 3.65            | 3.57            | 3.37            | <b>4.50</b>     | 3.51            | 3.41            | 3.80            |
| Median           | 3.51            | 3.81            | 3.65            | 3.68            | 3.56            | 3.36            | 4.47            | 3.53            | 3.40            | 3.80            |
| Std.Dev.         | 0.08            | 0.07            | 0.04            | 0.12            | 0.03            | 0.03            | 0.06            | 0.05            | 0.04            | 0.12            |
| Rel.Std.Dev.     | 2.23%           | 1.87%           | 1.05%           | 3.37%           | 0.72%           | 1.01%           | 1.31%           | 1.50%           | 1.28%           | 3.22%           |
| PDM <sup>3</sup> | -1.46%          | 6.71%           | 1.93%           | 1.49%           | -0.57%          | -6.20%          | 25.1%           | -2.24%          | -5.08%          | 5.77%           |

Table A7. Fusion results for Al<sub>2</sub>O<sub>3</sub> in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*OES | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*OES | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>BF*OES | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1                | 2.51            | 2.49            | 2.53            | 2.90            | 2.52            | 2.43            | 2.25            | 2.47            | 2.57            | 2.60            |
| 2                | 2.49            | <b>2.70</b>     | 2.61            | 2.80            | 2.48            | 2.49            | 2.20            | 2.48            | 2.51            | 2.50            |
| 3                | 2.51            | 2.51            | 2.53            | 2.90            | 2.46            | 2.41            | 2.10            | 2.48            | 2.49            | 2.50            |
| 4                | 2.51            | 2.63            | 2.44            | 2.70            | 2.45            | 2.46            | 2.12            | 2.51            | 2.53            | 2.60            |
| 5                | 2.58            | 2.55            | 2.48            | 3.00            | 2.46            | 2.44            | 2.19            | 2.43            | 2.56            | 2.60            |
| Mean             | 2.52            | 2.58            | 2.52            | <b>2.86</b>     | 2.47            | 2.45            | <b>2.17</b>     | 2.47            | 2.53            | 2.56            |
| Median           | 2.51            | 2.55            | 2.53            | 2.90            | 2.46            | 2.44            | 2.19            | 2.48            | 2.53            | 2.60            |
| Std.Dev.         | 0.03            | 0.09            | 0.06            | 0.11            | 0.03            | 0.03            | 0.06            | 0.03            | 0.03            | 0.05            |
| Rel.Std.Dev.     | 1.37%           | 3.34%           | 2.53%           | 3.99%           | 1.13%           | 1.25%           | 2.92%           | 1.16%           | 1.32%           | 2.14%           |
| PDM <sup>3</sup> | 0.45%           | 2.73%           | 0.37%           | 14.0%           | -1.39%          | -2.50%          | -13.4%          | -1.39%          | 0.93%           | 2.04%           |

Table A8. Fusion results for SiO<sub>2</sub> in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*OES | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*OES | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>BF*OES | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1                | 68.2            | 85.7            | 83.0            | 92.0            | 86.7            | 84.0            | 81.7            | 83.2            | 84.4            | 86.0            |
| 2                | 57.4            | <b>88.7</b>     | 82.6            | 94.3            | 86.3            | 85.3            | 82.2            | 83.3            | 85.8            | 89.0            |
| 3                | 75.1            | 86.6            | 81.9            | 91.5            | 85.5            | 83.6            | 77.7            | 83.2            | <b>87.4</b>     | 85.0            |
| 4                | 46.9            | 86.0            | 83.4            | <b>60.6</b>     | 85.3            | 85.9            | 77.8            | 83.2            | 85.2            | 87.0            |
| 5                | 89.8            | 85.5            | 82.4            | 94.4            | 85.3            | 84.7            | 77.3            | 83.0            | 85.1            | 89.0            |
| Mean             | <b>67.5</b>     | 86.5            | 82.7            | <b>86.6</b>     | 85.8            | 84.7            | 79.3            | 83.2            | 85.6            | 87.2            |
| Median           | 68.2            | 86.0            | 82.6            | 92.0            | 85.5            | 84.7            | 77.8            | 83.2            | 85.2            | 87.0            |
| Std.Dev.         | 16.5            | 1.3             | 0.6             | 14.6            | 0.6             | 0.9             | 2.4             | 0.1             | 1.1             | 1.8             |
| Rel.Std.Dev.     | 24.4%           | 1.50%           | 0.69%           | 16.8%           | 0.75%           | 1.10%           | 3.00%           | 0.11%           | 1.34%           | 2.05%           |
| PDM <sup>3</sup> | -19.9%          | 2.68%           | -1.88%          | 2.75%           | 1.87%           | 0.54%           | -5.84%          | -1.27%          | 1.59%           | 3.51%           |

Table A9. Fusion results for Ag in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>- | Lab C<br>PF*MS | Lab D<br>PF*MS | Lab E<br>- | Lab F<br>- | Lab G<br>PF*OES | Lab H<br>- | Lab I<br>- | Lab J<br>- |
|------------------|-----------------|------------|----------------|----------------|------------|------------|-----------------|------------|------------|------------|
| 1                | <10             | NR         | <5             | 1.0            | NR         | NR         | <2              | NR         | NR         | NR         |
| 2                | <10             | NR         | <5             | 1.0            | NR         | NR         | <2              | NR         | NR         | NR         |
| 3                | <10             | NR         | <5             | 1.0            | NR         | NR         | 3.5             | NR         | NR         | NR         |
| 4                | <10             | NR         | <5             | 1.0            | NR         | NR         | <2              | NR         | NR         | NR         |
| 5                | <10             | NR         | <5             | 1.0            | NR         | NR         | <2              | NR         | NR         | NR         |
| Mean             |                 |            |                | 1.0            |            |            | 3.5             |            |            |            |
| Median           |                 |            |                | 1.0            |            |            | 3.5             |            |            |            |
| Std.Dev.         |                 |            |                | 0.0            |            |            |                 |            |            |            |
| Rel.Std.Dev.     |                 |            |                | 0.00%          |            |            |                 |            |            |            |
| PDM <sup>3</sup> |                 |            |                | -55.6%         |            |            | 55.6%           |            |            |            |

Table A10. Fusion results for Pb in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*OES | Lab C<br>PF*MS | Lab D<br>PF*OES | Lab E<br>PF*MS | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>- | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|-----------------|----------------|-----------------|----------------|-----------------|-----------------|------------|-----------------|-----------------|
| 1                | 100             | 123             | 130            | 140             | 114            | <100            | 77              | NR         | 100             | 96              |
| 2                | 100             | 121             | 120            | 160             | 120            | 100             | 86              | NR         | <b>200</b>      | 100             |
| 3                | 100             | 126             | 120            | 150             | 115            | <100            | 57              | NR         | 100             | 99              |
| 4                | 100             | 116             | 130            | 140             | 119            | <100            | 89              | NR         | 100             | 100             |
| 5                | 100             | 125             | 120            | 140             | 116            | 100             | 63              | NR         | <100            | 100             |
| Mean             | 100             | 122             | 124            | 146             | 117            | 100             | 74              |            | 125             | 99              |
| Median           | 100             | 123             | 120            | 140             | 116            | 100             | 77              |            | 100             | 100             |
| Std.Dev.         | 0               | 4               | 5              | 9               | 3              | 0               | 14              |            | 50              | 2               |
| Rel.Std.Dev.     | 0.00%           | 3.24%           | 4.42%          | 6.13%           | 2.22%          | 0.00%           | 18.9%           |            | 40.0%           | 1.75%           |
| PDM <sup>3</sup> | -8.39%          | 12.0%           | 13.6%          | 33.8%           | 7.00%          | -8.39%          | -31.8%          |            | 14.5%           | -9.30%          |

Table A11. Fusion results for Zn in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>- | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*MS | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>PF*OES | Lab I<br>- | Lab J<br>PF*OES |
|------------------|-----------------|------------|-----------------|-----------------|----------------|-----------------|-----------------|-----------------|------------|-----------------|
| 1                | <100            | NR         | <50             | 20              | <20            | <100            | NR              | <100            | NR         | <30             |
| 2                | <100            | NR         | <50             | 20              | <20            | <100            | NR              | <100            | NR         | <30             |
| 3                | <100            | NR         | <50             | 20              | <20            | <100            | <50             | <100            | NR         | <30             |
| 4                | <100            | NR         | <50             | 20              | 20             | <100            | <50             | <100            | NR         | <30             |
| 5                | <100            | NR         | <50             | 10              | <20            | <100            | NR              | <100            | NR         | <30             |
| Mean             |                 |            |                 | 18              | 20             |                 |                 |                 |            |                 |
| Median           |                 |            |                 | 20              | 20             |                 |                 |                 |            |                 |
| Std.Dev.         |                 |            |                 | 4               |                |                 |                 |                 |            |                 |
| Rel.Std.Dev.     |                 |            |                 | 24.8%           |                |                 |                 |                 |            |                 |
| PDM <sup>3</sup> |                 |            |                 | -5.26%          | 5.26%          |                 |                 |                 |            |                 |

Table A12. Fusion results for Co in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>PF*ICP | Lab B<br>PF*MS | Lab C<br>PF*OES | Lab D<br>PF*OES | Lab E<br>PF*MS | Lab F<br>PF*OES | Lab G<br>PF*OES | Lab H<br>PF*OES | Lab I<br>PF*ICP | Lab J<br>PF*OES |
|------------------|-----------------|----------------|-----------------|-----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1                | 120             | 112            | 120             | 130             | 114            | 100             | NR              | 121             | 140             | 120             |
| 2                | 120             | 110            | 120             | 140             | 113            | 100             | NR              | 104             | 130             | 110             |
| 3                | 120             | 113            | 120             | 130             | 115            | 90              | 134             | 111             | 130             | 110             |
| 4                | 120             | 111            | 120             | 130             | 115            | 100             | 137             | 106             | 130             | 120             |
| 5                | 120             | 113            | 120             | 130             | 115            | 110             | NR              | 115             | <100            | 120             |
| Mean             | 120             | 112            | 120             | 132             | 114            | 100             | 136             | 111             | 133             | 116             |
| Median           | 120             | 112            | 120             | 130             | 115            | 100             | 136             | 111             | 130             | 120             |
| Std.Dev.         | 0               | 1              | 0               | 4               | 1              | 7               | 2               | 7               | 5               | 5               |
| Rel.Std.Dev.     | 0.00%           | 1.17%          | 0.00%           | 3.39%           | 0.66%          | 7.07%           | 1.57%           | 6.09%           | 3.77%           | 4.72%           |
| PDM <sup>3</sup> | 0.57%           | -6.30%         | 0.57%           | 10.6%           | -4.29%         | -16.2%          | 13.6%           | -6.84%          | 11.0%           | -2.78%          |

Table A13. 4-acid results for Cu in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*OES | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*OES | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 0.398           | <b>0.439</b>    | 0.392           | 0.384           | 0.410           | <b>0.452</b>    | 0.427            | 0.411           | 0.411           | 0.400           |
| 2                | 0.403           | 0.419           | 0.383           | 0.380           | 0.411           | 0.413           | 0.426            | <b>0.401</b>    | 0.414           | 0.390           |
| 3                | 0.407           | 0.427           | 0.401           | 0.391           | <b>0.420</b>    | 0.409           | 0.424            | 0.415           | 0.415           | 0.400           |
| 4                | 0.400           | 0.422           | 0.409           | 0.395           | 0.409           | 0.405           | 0.422            | 0.413           | 0.414           | 0.410           |
| 5                | 0.405           | 0.418           | 0.408           | 0.407           | 0.415           | 0.405           | 0.428            | 0.413           | 0.414           | 0.420           |
| Mean             | 0.403           | 0.425           | 0.399           | 0.391           | 0.413           | 0.417           | 0.425            | 0.411           | 0.414           | 0.404           |
| Median           | 0.403           | 0.422           | 0.401           | 0.391           | 0.411           | 0.409           | 0.426            | 0.413           | 0.414           | 0.400           |
| Std.Dev.         | 0.004           | 0.009           | 0.011           | 0.011           | 0.005           | 0.020           | 0.002            | 0.006           | 0.002           | 0.011           |
| Rel.Std.Dev.     | 0.91%           | 2.05%           | 2.77%           | 2.68%           | 1.10%           | 4.79%           | 0.57%            | 1.35%           | 0.37%           | 2.82%           |
| PDM <sup>3</sup> | -1.55%          | 3.95%           | -2.53%          | -4.29%          | 0.99%           | 1.92%           | 4.03%            | 0.41%           | 1.14%           | -1.21%          |

Table A14. 4-acid results for Fe in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*OES | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 4.31            | <b>4.89</b>     | 4.40            | 4.01            | 4.26           | 4.33            | 4.07             | 4.21            | 4.31            | 4.30            |
| 2                | 4.28            | 4.70            | 4.30            | 4.07            | 4.28           | 4.25            | 4.05             | 4.16            | 4.31            | 4.40            |
| 3                | 4.32            | 4.78            | 4.44            | 4.25            | 4.27           | 4.26            | 4.03             | 4.22            | 4.30            | 4.40            |
| 4                | 4.26            | 4.73            | 4.48            | 4.30            | <b>4.16</b>    | 4.25            | 4.01             | 4.30            | 4.30            | 4.40            |
| 5                | 4.31            | 4.69            | 4.46            | 4.15            | 4.19           | 4.25            | 3.98             | 4.23            | 4.30            | 4.40            |
| Mean             | 4.30            | <b>4.76</b>     | 4.42            | 4.16            | 4.23           | 4.27            | 4.03             | 4.22            | 4.30            | 4.38            |
| Median           | 4.31            | 4.73            | 4.44            | 4.15            | 4.26           | 4.25            | 4.03             | 4.22            | 4.30            | 4.40            |
| Std.Dev.         | 0.03            | 0.08            | 0.07            | 0.12            | 0.05           | 0.03            | 0.03             | 0.05            | 0.01            | 0.04            |
| Rel.Std.Dev.     | 0.58%           | 1.72%           | 1.61%           | 2.91%           | 1.27%          | 0.82%           | 0.85%            | 1.19%           | 0.13%           | 1.02%           |
| PDM <sup>3</sup> | 0.89%           | 11.7%           | 3.71%           | -2.39%          | -0.61%         | 0.24%           | -5.41%           | -0.80%          | 1.08%           | 2.87%           |

Table A15. 4-acid results for S in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*OES | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>- | Lab I<br>4A*OES | Lab J<br>- |
|------------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|------------------|------------|-----------------|------------|
| 1                | 3.37            | 3.22            | 2.90            | 2.88            | 2.87           | 3.00            | 3.13             | NR         | 3.17            | NR         |
| 2                | 3.37            | 3.15            | 2.89            | 2.87            | 2.87           | 2.90            | 3.13             | NR         | 3.18            | NR         |
| 3                | 3.38            | 3.11            | 3.01            | 2.95            | 2.84           | 2.90            | 3.12             | NR         | 3.16            | NR         |
| 4                | 3.35            | 3.09            | 2.99            | 3.05            | 2.84           | 2.90            | 3.10             | NR         | 3.17            | NR         |
| 5                | 3.38            | 2.97            | 3.03            | 3.09            | 2.80           | 2.90            | 3.15             | NR         | 3.17            | NR         |
| Mean             | 3.37            | 3.11            | 2.96            | 2.97            | 2.84           | 2.92            | 3.13             |            | 3.17            |            |
| Median           | 3.37            | 3.11            | 2.99            | 2.95            | 2.84           | 2.90            | 3.13             |            | 3.17            |            |
| Std.Dev.         | 0.01            | 0.09            | 0.06            | 0.10            | 0.03           | 0.04            | 0.02             |            | 0.01            |            |
| Rel.Std.Dev.     | 0.36%           | 2.95%           | 2.18%           | 3.34%           | 1.01%          | 1.53%           | 0.53%            |            | 0.22%           |            |
| PDM <sup>3</sup> | 10.2%           | 1.61%           | -3.10%          | -2.97%          | -7.02%         | -4.53%          | 2.19%            |            | 3.64%           |            |



Table A16. 4-acid results for CaO in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*OES | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 0.160           | 0.154           | 0.170           | 0.154           | 0.150          | 0.250           | 0.150            | 0.154           | <b>0.196</b>    | 0.160           |
| 2                | 0.160           | 0.154           | 0.150           | 0.153           | 0.150          | 0.250           | 0.151            | 0.140           | 0.168           | 0.160           |
| 3                | 0.160           | 0.154           | 0.170           | 0.157           | 0.150          | 0.250           | <b>0.142</b>     | 0.154           | 0.168           | 0.160           |
| 4                | 0.150           | 0.168           | <b>0.200</b>    | 0.158           | 0.150          | 0.250           | 0.148            | 0.154           | 0.182           | 0.160           |
| 5                | 0.160           | 0.154           | 0.180           | 0.163           | 0.150          | 0.240           | 0.149            | 0.154           | 0.168           | 0.170           |
| Mean             | 0.158           | 0.157           | 0.174           | 0.157           | 0.150          | <b>0.248</b>    | 0.148            | 0.151           | 0.176           | 0.162           |
| Median           | 0.160           | 0.154           | 0.170           | 0.157           | 0.150          | 0.250           | 0.149            | 0.154           | 0.168           | 0.160           |
| Std.Dev.         | 0.004           | 0.006           | 0.018           | 0.004           | 0.000          | 0.004           | 0.003            | 0.006           | 0.013           | 0.004           |
| Rel.Std.Dev.     | 2.83%           | 3.99%           | 10.4%           | 2.51%           | 0.00%          | 1.80%           | 2.33%            | 4.14%           | 7.10%           | 2.76%           |
| PDM <sup>3</sup> | -0.07%          | -0.89%          | 10.04%          | -0.71%          | -5.13%         | 56.8%           | -6.48%           | -4.43%          | 11.5%           | 2.46%           |

Table A17. 4-acid results for MgO in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*OES | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 3.72            | 3.93            | 3.63            | 3.67            | 3.48           | 3.41            | 3.00             | 3.63            | 3.73            | 3.70            |
| 2                | 3.71            | 3.73            | <b>3.56</b>     | 3.64            | 3.48           | 3.38            | 3.05             | 3.60            | 3.71            | 3.80            |
| 3                | 3.72            | 3.76            | 3.68            | 3.72            | 3.47           | 3.39            | 3.03             | 3.65            | <b>3.65</b>     | 3.70            |
| 4                | 3.66            | 3.85            | 3.71            | 3.77            | 3.45           | 3.36            | 2.95             | 3.66            | 3.75            | 3.70            |
| 5                | 3.68            | 3.81            | 3.71            | 3.84            | <b>3.40</b>    | 3.39            | 3.02             | 3.63            | 3.73            | 3.80            |
| Mean             | 3.70            | 3.82            | 3.66            | 3.73            | <b>3.46</b>    | <b>3.39</b>     | <b>3.01</b>      | 3.63            | 3.71            | 3.74            |
| Median           | 3.71            | 3.81            | 3.68            | 3.72            | 3.47           | 3.39            | 3.02             | 3.63            | 3.73            | 3.70            |
| Std.Dev.         | 0.03            | 0.08            | 0.06            | 0.08            | 0.03           | 0.02            | 0.04             | 0.02            | 0.04            | 0.05            |
| Rel.Std.Dev.     | 0.73%           | 2.02%           | 1.74%           | 2.14%           | 0.97%          | 0.54%           | 1.26%            | 0.68%           | 1.05%           | 1.46%           |
| PDM <sup>3</sup> | -0.56%          | 2.64%           | -1.63%          | 0.25%           | -7.06%         | -8.95%          | -19.0%           | -2.26%          | -0.12%          | 0.57%           |

Table A18. 4-acid results for Al<sub>2</sub>O<sub>3</sub> in OREAS 161 (abbreviations as in Table A1; values in wt.%).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*OES | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 2.25            | 2.68            | 2.46            | 2.59            | 2.40           | 2.48            | 2.12             | 2.65            | 2.51            | 2.40            |
| 2                | 2.22            | 2.55            | <b>2.38</b>     | <b>2.53</b>     | 2.40           | 2.46            | 2.14             | 2.57            | 2.51            | 2.50            |
| 3                | 2.26            | 2.55            | 2.49            | 2.60            | 2.38           | 2.48            | 2.08             | 2.63            | 2.55            | 2.50            |
| 4                | 2.20            | 2.63            | 2.51            | 2.61            | 2.38           | 2.46            | 2.08             | 2.61            | 2.57            | 2.50            |
| 5                | 2.22            | 2.59            | 2.51            | <b>2.66</b>     | 2.36           | 2.48            | 2.10             | 2.57            | 2.55            | 2.60            |
| Mean             | 2.23            | 2.60            | 2.47            | 2.60            | 2.38           | 2.47            | <b>2.10</b>      | 2.60            | 2.54            | 2.50            |
| Median           | 2.22            | 2.59            | 2.49            | 2.60            | 2.38           | 2.48            | 2.10             | 2.61            | 2.55            | 2.50            |
| Std.Dev.         | 0.02            | 0.06            | 0.05            | 0.05            | 0.02           | 0.01            | 0.02             | 0.03            | 0.03            | 0.07            |
| Rel.Std.Dev.     | 1.10%           | 2.16%           | 2.20%           | 1.79%           | 0.70%          | 0.44%           | 1.11%            | 1.30%           | 1.00%           | 2.83%           |
| PDM <sup>3</sup> | -10.5%          | 4.36%           | -0.85%          | 4.28%           | -4.31%         | -0.77%          | -15.5%           | 4.51%           | 1.93%           | 0.35%           |

Table A19. 4-acid results for Ag in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*MS | Lab C<br>4A*MS | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>AD*AAS |
|------------------|-----------------|----------------|----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 1.3             | 1.0            | 1.0            | 1.1             | 1.0            | 2.0             | <2               | <2              | 1.2             | 1.2             |
| 2                | 1.1             | 1.0            | 1.0            | 1.1             | 1.1            | 1.0             | 2.9              | <2              | 1.2             | 1.3             |
| 3                | 1.1             | 1.0            | 1.0            | 1.1             | 1.1            | 2.0             | <2               | 2.0             | 1.2             | 1.2             |
| 4                | 1.2             | 1.0            | 1.0            | 1.2             | 1.1            | <1              | <2               | 2.0             | 0.8             | 1.3             |
| 5                | 1.0             | 1.0            | 1.0            | 1.2             | 1.1            | 3.0             | <2               | 3.0             | 1.1             | 1.1             |
| Mean             | 1.1             | 1.0            | 1.0            | 1.1             | 1.1            | <b>2.0</b>      | <b>2.9</b>       | <b>2.3</b>      | 1.1             | 1.2             |
| Median           | 1.1             | 1.0            | 1.0            | 1.1             | 1.1            | 2.0             | 2.9              | 2.0             | 1.2             | 1.2             |
| Std.Dev.         | 0.1             | 0.0            | 0.0            | 0.1             | 0.0            | 0.8             |                  | 0.6             | 0.2             | 0.1             |
| Rel.Std.Dev.     | 10.0%           | 0.00%          | 0.00%          | 4.80%           | 2.41%          | 40.8%           |                  | 24.7%           | 15.7%           | 6.86%           |
| PDM <sup>3</sup> | 4.01%           | -8.76%         | -8.76%         | 4.01%           | -2.19%         | 82.5%           | 165%             | 113%            | 0.36%           | 11.3%           |

Table A20. 4-acid results for Pb in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*MS | Lab C<br>4A*MS | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|----------------|----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 140             | 144            | 127            | 135             | 120            | 160             | 250              | <200            | 151             | 130             |
| 2                | 140             | 140            | 128            | 131             | 122            | 130             | 210              | <200            | 139             | 130             |
| 3                | 140             | 143            | 124            | 133             | 122            | 140             | 170              | <200            | 147             | 130             |
| 4                | 140             | 143            | 125            | 139             | 120            | 130             | 160              | <200            | 155             | 140             |
| 5                | 130             | 144            | 125            | 140             | 118            | 140             | 140              | <200            | 155             | 130             |
| Mean             | 138             | 143            | 126            | 136             | 120            | 140             | <b>186</b>       |                 | 149             | 132             |
| Median           | 140             | 143            | 125            | 135             | 120            | 140             | 170              |                 | 151             | 130             |
| Std.Dev.         | 4               | 2              | 2              | 4               | 1              | 12              | 44               |                 | 7               | 4               |
| Rel.Std.Dev.     | 3.24%           | 1.15%          | 1.31%          | 2.84%           | 1.23%          | 8.75%           | 23.6%            |                 | 4.48%           | 3.39%           |
| PDM <sup>3</sup> | 1.87%           | 5.42%          | -7.13%         | 0.10%           | -11.3%         | 3.35%           | 37.3%            |                 | 10.3%           | -2.56%          |

Table A21. 4-acid results for Zn in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*OES | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|-----------------|-----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 22              | 30              | 16              | 26              | 17             | <20             | <50              | <100            | 23              | <30             |
| 2                | 21              | 33              | 14              | 23              | 17             | <20             | <50              | <100            | 21              | <30             |
| 3                | 20              | 31              | 16              | 26              | 17             | <20             | <50              | <100            | 18              | <30             |
| 4                | 21              | 37              | 16              | 29              | 16             | <20             | <50              | <100            | 21              | <30             |
| 5                | 19              | 35              | 16              | 28              | 16             | <20             | <50              | <100            | 19              | <30             |
| Mean             | 21              | 33              | 16              | 26              | 17             |                 |                  |                 | 20              |                 |
| Median           | 21              | 33              | 16              | 26              | 17             |                 |                  |                 | 21              |                 |
| Std.Dev.         | 1               | 3               | 1               | 2               | 1              |                 |                  |                 | 2               |                 |
| Rel.Std.Dev.     | 5.53%           | 8.63%           | 5.73%           | 8.72%           | 3.30%          |                 |                  |                 | 9.56%           |                 |
| PDM <sup>3</sup> | -6.93%          | 50.0%           | -29.5%          | 19.3%           | -25.0%         |                 |                  |                 | -7.83%          |                 |

Table A22. 4-acid results for Co in OREAS 161 (abbreviations as in Table A1; values in ppm).

| Replicate No.    | Lab A<br>4A*OES | Lab B<br>4A*MS | Lab C<br>4A*OES | Lab D<br>4A*OES | Lab E<br>4A*MS | Lab F<br>4A*OES | Lab G<br>MAR*OES | Lab H<br>4A*OES | Lab I<br>4A*OES | Lab J<br>4A*OES |
|------------------|-----------------|----------------|-----------------|-----------------|----------------|-----------------|------------------|-----------------|-----------------|-----------------|
| 1                | 120             | 118            | 124             | 128             | 119            | 120             | 112              | 120             | 104             | 120             |
| 2                | 120             | 119            | 124             | 124             | 120            | 110             | 113              | 110             | 105             | 120             |
| 3                | 120             | 117            | 128             | 130             | 120            | 120             | 113              | 120             | 103             | 120             |
| 4                | 120             | 117            | 126             | 126             | 120            | 110             | 110              | 120             | 104             | 120             |
| 5                | 120             | 118            | 128             | 122             | 119            | 120             | 112              | 120             | 104             | 120             |
| Mean             | 120             | 118            | <b>126</b>      | <b>126</b>      | 120            | 116             | <b>112</b>       | 118             | <b>104</b>      | 120             |
| Median           | 120             | 118            | 126             | 126             | 120            | 120             | 112              | 120             | 104             | 120             |
| Std.Dev.         | 0               | 1              | 2               | 3               | 1              | 5               | 1                | 4               | 1               | 0               |
| Rel.Std.Dev.     | 0.00%           | 0.71%          | 1.59%           | 2.51%           | 0.59%          | 4.72%           | 1.09%            | 3.79%           | 0.68%           | 0.00%           |
| PDM <sup>3</sup> | 1.22%           | -0.63%         | 6.28%           | 6.28%           | 0.80%          | -2.15%          | -5.53%           | -0.46%          | -12.3%          | 1.22%           |