

## AMIS0475

### *Certified Reference Material*

**Copper ore, Sulphide,  
Kansanshi Mine, Zambia**

### *Certificate of Analysis*

**Recommended Concentrations and Limits<sup>1</sup>  
(at two Standard Deviations)**

#### ***Certified Concentrations<sup>2</sup>***

|                  |       |   |       |               |
|------------------|-------|---|-------|---------------|
| Au Pb Collection | 0.060 | ± | 0.015 | g/t           |
| Co 4A_MICP       | 46.3  | ± | 4.9   | ppm           |
| Cu FUS           | 5449  | ± | 393.6 | ppm           |
| Cu 2A_MICP       | 5229  | ± | 356.1 | ppm           |
| Cu 4A_MICP       | 5316  | ± | 534.0 | ppm           |
| SG               | 2.78  | ± | 0.06  | Dimensionless |

1. Manufacturers recommended limits for use of the material as control samples, based on two standard deviations, calculated using "Between Laboratory" statistics for treatment of the data for trivial, non-trivial and technically invalid results. See sections 1, 9 and 12
2. There is additional certified major element data presented on page 2 and uncertified trace elements data presented as an appendix.

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#### AMIS

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(Reg. No. 1989/000201/07)

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Directors: C E Pettit (British), R Naidoo, N N Robinson, K V Gerber, M Padayachee

**Major Element  
 Recommended Concentrations and Limits  
 (at two Standard Deviations)**

***Certified Concentrations***

|                                    |       |   |      |   |
|------------------------------------|-------|---|------|---|
| LOI                                | 6.9   | ± | 0.51 | % |
| Al <sub>2</sub> O <sub>3</sub> XRF | 8.81  | ± | 0.14 | % |
| CaO XRF                            | 8.3   | ± | 0.17 | % |
| Cr <sub>2</sub> O <sub>3</sub> XRF | 0.16  | ± | 0.02 | % |
| Fe <sub>2</sub> O <sub>3</sub> XRF | 4.9   | ± | 0.16 | % |
| K <sub>2</sub> O XRF               | 1.42  | ± | 0.04 | % |
| MgO XRF                            | 1.8   | ± | 0.13 | % |
| MnO XRF                            | 0.065 | ± | 0.02 | % |
| Na <sub>2</sub> O XRF              | 2.1   | ± | 0.25 | % |
| P <sub>2</sub> O <sub>5</sub> XRF  | 0.11  | ± | 0.01 | % |
| SiO <sub>2</sub> XRF               | 61.8  | ± | 0.87 | % |

***Provisional Concentrations***

|                      |      |   |      |     |
|----------------------|------|---|------|-----|
| Co 2A_MICP           | 43.6 | ± | 7.2  | ppm |
| U 4A_MICP            | 7.2  | ± | 1.7  | ppm |
| TiO <sub>2</sub> XRF | 0.74 | ± | 0.03 | %   |

***Informational Concentration***

|             |     |   |      |   |
|-------------|-----|---|------|---|
| S Comb/LECO | 1.2 | ± | 0.05 | % |
|-------------|-----|---|------|---|

**1. Intended Use:** AMIS0475 is a certified reference material which may be used to demonstrate the validity of measurement results of a single analysis of sulphide copper ores with a similar grade and matrix.

It is a matrix matched Certified Reference Material, fit for use as control samples in routine assay laboratory quality control when inserted within runs of samples and measured in parallel to the unknown. Its purpose is to monitor inter-laboratory or instrument bias and within lab precision. It can be used, indirectly, to establish the traceability of results to an SI system of units.

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The recommended concentrations and limits for this material are property values based on a measurement campaign (round robin) and reflect consensus results from the laboratories that participated in the round robin.

Slight variations in analytical procedures between laboratories will reflect as slight biases to the recommended concentrations (see 19). Good laboratories will report results within the two standard deviation levels with a failure rate of <10 %.

The material can also be used for method development and for the calibration of equipment.

**2. Origin of Material:** This standard was made using sulphide ore sourced from the Kansanshi Mine, located in the North Western Province of Zambia, The mine is located approximately 10 kilometres north of the town of Solwezi, 180 kilometres to the northwest of the Copperbelt town of Chingola and 16 kilometres south of the Democratic Republic of Congo border. Kansanshi, Africa's largest copper mine, is 80% owned by Kansanshi Mining PLC, a First Quantum subsidiary. The remaining 20% is owned by a subsidiary of ZCCM.

The Kansanshi deposit occurs within the Lufilian arc, a major tectonic province characterized by broadly north directed fold and thrust structures, which hosts the world class Central African Copperbelt. The deposit at Kansanshi occurs within a broad, northwest trending, north-west closing antiform, which can be traced for approximately 12 kilometres. Kansanshi is a vein deposit developed within a tectonised rock sequence and, as such, constitutes a major mineralization control. The main veins and vein swarms dip sub vertically, perpendicular to the fold axes, in the plane of maximum extension.

**3. Mineral and Chemical Composition:** Deep tropical weathering has resulted in supergene enrichment and subsequent partial oxidation of the deposit. Primary copper sulphide mineralization is dominated by chalcopyrite, with very minor bornite, accompanied by relatively minor pyrite and pyrrhotite. Oxide mineralization is dominated by chrysocolla with malachite, limonite and cupriferous goethite. The mixed zone includes both oxide and primary mineralization but also carries significant chalcocite, minor native copper and tenorite. Some copper appears to be carried in clay and mica minerals, where it is essentially refractory.

**4. Appearance:** The material is a very fine powder. It is colored medium Dark Grey.

**5. Handling instructions:** The material is packaged in Laboratory Packs and Explorer Packs that must be shaken or otherwise agitated before use. Normal safety precautions for handling fine particulate matter are suggested, such as the use of safety glasses, breathing protection, gloves and a laboratory coat.

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**6. Method of Preparation:** The material was crushed, dry-milled and air-classified to <54µm. Wet sieve particle size analysis of random samples confirmed the material was 98.5% <54µm. It was then blended in a bi-conical mixer, systematically divided and then sealed into 1kg Laboratory Packs. Explorer Packs are subdivided from the Laboratory packs as required. Samples were randomly selected for homogeneity testing and third party analysis. Statistical analysis of both homogeneity and the consensus test results were carried out by independent statisticians.

**7. Methods of Analysis requested:**

1. Au – Pb collection, ICP-OES/ICP-MS.
2. Cu. Fusion AAS or ICP-OES.
3. Cu. Acid soluble: AAS or ICP-OES.
4. Multi-acid digest multi-element scan - (to include Cu). ICP-OES or ICP-MS.
5. Aqua regia digest multi-element scan - (to include Cu). ICP-OES or ICP-MS.
6. Majors (Al<sub>2</sub>O<sub>3</sub>, CaO, Cr<sub>2</sub>O<sub>3</sub>, Fe<sub>2</sub>O<sub>3</sub>, K<sub>2</sub>O, MgO, MnO, Na<sub>2</sub>O, SiO<sub>2</sub>, TiO<sub>2</sub>, P<sub>2</sub>O<sub>5</sub>, LOI) XRF fusion
7. SG – gas pycnometer

**8. Information requested:**

1. State aliquots used for all determinations.
2. All results for major elements to be reported as oxides in percentages.
3. All results for multi-element scans to be reported in ppm.
4. All results for Au to be reported in ppb.
5. Report all QC data, to include replicates, blanks and certified reference materials used.
6. State and provide brief description of analytical techniques used.
7. Send a PDF, excel and CSV of the results. (CSV template format was sent to the labs.)

**9. Method of Certification:** Sixteen laboratories were each given eight randomly selected packages of sample. Fourteen submitted results in time for the certification.

Final limits were calculated after first determining if all data was compatible within a spread normally expected for similar analytical methods done by reputable laboratories. Data from any one laboratory was then removed from further calculations when the mean of all analyses from that laboratory failed a “t test” of the global means of the other laboratories. The means and standard deviations were then re-calculated using all remaining data. Any analysis that fell outside of the new two standard deviations was removed from the ensuing data base. The mean and standard deviations were again calculated using the remaining data.

The “between-laboratory” standard deviation is used in the calculation to eliminate technically and statistically invalid data.

Upper and lower limits are based on the standard deviation of the remaining data, which reflect individual analyses and can be used to monitor accuracy in routine laboratory quality control. This is different to limits based on standard deviations derived from grouped set of analyses (see 12), which provide important measures for precision and trueness, but which are less useful for routine QC.

Standards with an RSD of near or less than 5 % are termed “Certified”, RSD’s of between near 5 % and 15 % are termed “Provisional”, and RSD’s over 15 % are termed “Informational”.

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**10. Participating Laboratories:** The 14 out of 16 laboratories that provided results timeously were (not in same order as in the table of assays):

1. BV Namibia
2. BV Ultratrace Australia
3. Dundee Precious Metals Tsumeb Laboratory (Namibia)
4. First Quantum Minig Lab
5. Genalysis Perth
6. Intertek Indonesia
7. Intertek South Africa
8. Palabora Mining Company
9. Setpoint Lab Isando
10. SGS Callao Peru
11. SGS Lakefield
12. SGS South Africa (Randfontein)
13. SGS Vancouver Canada
14. Shiva Analytics

**11. Assay Data:** Data as received from the laboratories for the important certified elements listed on p1 and 2 are set out below. A proficiency report has been sent to the managers of the participating laboratories. Additional digital data from this round robin is available on request.

**Table 1: Elemental Composition**

| Pb Coll<br>Au<br>g/g | Pb Coll<br>Au<br>g/g | 4A_MICP<br>Co<br>g/g | 4A_MICP<br>Co<br>g/g | FJUS<br>Cu<br>g/g | 2A_MICP<br>Cu<br>g/g | 4A_MICP<br>Cu<br>g/g | 4A_MICP<br>Cu<br>g/g | SG<br>SG<br>No Unit | LOI<br>LOI<br>% | LOI<br>LOI<br>% |
|----------------------|----------------------|----------------------|----------------------|-------------------|----------------------|----------------------|----------------------|---------------------|-----------------|-----------------|
| 0.06                 | 0.06                 | 48.00                | 43.00                | 5400.00           | 5487.10              | 5340.00              | 5124.00              | 2.79                | 6.85            | 6.76            |
| 0.06                 | 0.06                 | 49.00                | 43.00                | 5400.00           | 5451.20              | 5389.00              | 4971.00              | 2.78                | 6.87            | 6.83            |
| 0.06                 | 0.07                 | 48.00                | 45.00                | 5400.00           | 5437.20              | 5440.00              | 5148.00              | 2.78                | 6.81            | 6.81            |
| 0.06                 | 0.06                 | 47.00                | 42.00                | 5400.00           | 5443.60              | 5410.00              | 4938.00              | 2.78                | 6.84            | 6.81            |
| 0.06                 | 0.07                 | 49.00                | 42.00                | 5300.00           | 5439.20              | 5420.00              | 5060.00              | 2.77                | 6.86            | 6.92            |
| 0.06                 | 0.07                 | 49.00                | 42.00                | 5300.00           | 5469.20              | 5420.00              | 5132.00              | 2.77                | 6.84            | 7.21            |
| 0.06                 | 0.07                 | 48.00                | 44.00                | 5300.00           | 5445.20              | 5440.00              | 4978.00              | 2.78                | 6.80            | 6.97            |
| 0.06                 | 0.06                 | 49.00                | 47.00                | 5500.00           | 5456.10              | 5430.00              | 5260.00              | 2.78                | 6.81            | 6.94            |
| 0.07                 | 0.06                 | 46.00                | 46.00                | 5372.00           | 5999.00              | 5230.00              | 5890.00              | 2.75                | 6.70            | 6.97            |
| 0.06                 | 0.06                 | 47.00                | 50.00                | 5382.00           | 5118.00              | 5180.00              | 5720.00              | 2.77                | 6.70            | 7.12            |
| 0.06                 | 0.06                 | 48.00                | 49.00                | 5347.00           | 5133.00              | 5200.00              | 5920.00              | 2.78                | 6.70            | 7.19            |
| 0.07                 | 0.06                 | 48.00                | 47.00                | 5142.00           | 5147.00              | 5240.00              | 5780.00              | 2.78                | 6.69            | 6.93            |
| 0.06                 | 0.06                 | 48.00                | 48.00                | 5263.00           | 5127.00              | 5410.00              | 5730.00              | 2.74                | 6.60            | 6.89            |
| 0.07                 | 0.07                 | 48.00                | 46.00                | 5257.00           | 5141.00              | 5370.00              | 5950.00              | 2.78                | 6.60            | 6.91            |
| 0.07                 | 0.05                 | 49.00                | 48.00                | 5331.00           | 5643.00              | 5300.00              | 5870.00              | 2.78                | 6.60            | 6.97            |
| 0.06                 | 0.06                 | 49.00                | 43.30                | 5211.00           | 5074.00              | 5690.00              | 5780.00              | 2.75                | 6.70            | 6.83            |
| 0.06                 | 0.07                 | 45.88                | 44.20                | 5177.00           | 4991.00              | 5308.00              | 5502.30              | 2.84                | 7.22            | 6.92            |
| 0.06                 | 0.06                 | 45.71                | 43.70                | 5704.00           | 4862.00              | 5324.00              | 5542.40              | 2.79                | 7.00            | 6.90            |
| 0.06                 | 0.06                 | 44.78                | 43.20                | 5136.00           | 4949.00              | 5396.00              | 5536.60              | 2.86                | 6.73            | 6.94            |
| 0.06                 | 0.06                 | 44.11                | 48.20                | 5904.00           | 5024.00              | 5278.00              | 5533.30              | 2.88                | 7.32            | 6.86            |
| 0.06                 | 0.06                 | 45.55                | 43.80                | 5662.00           | 4834.00              | 5405.00              | 5511.10              | 2.78                | 6.93            | 6.84            |
| 0.06                 | 0.06                 | 45.21                | 42.80                | 5730.00           | 4858.00              | 5331.00              | 5585.50              | 2.80                | 6.97            | 6.81            |
| 0.06                 | 0.06                 | 46.29                | 44.30                | 5149.00           | 5200.00              | 5264.00              | 5513.00              | 2.80                | 7.13            | 6.81            |
| 0.06                 | 0.06                 | 46.66                |                      | 5451.00           | 5130.00              | 5342.00              | 5533.40              | 2.79                | 7.06            | 6.75            |
| 0.05                 | 0.06                 | 48.40                |                      | 5459.00           | 5180.00              | 5479.00              | 5031.00              | 2.78                | 7.35            | 6.76            |
| 0.07                 | 0.07                 | 48.79                |                      | 5388.00           | 5150.00              | 5480.00              | 5142.00              | 2.79                | 7.41            | 6.78            |
| 0.05                 | 0.07                 | 48.66                |                      | 5338.00           | 5110.00              | 5459.00              | 4857.00              | 2.79                | 7.48            | 6.82            |
| 0.05                 | 0.06                 | 48.00                |                      | 5427.00           | 5170.00              | 5600.00              | 5002.00              | 2.78                | 7.49            | 6.82            |
| 0.07                 | 0.07                 | 47.80                |                      | 5310.00           | 5200.00              | 5430.00              | 4929.00              | 2.77                | 7.53            |                 |
| 0.07                 | 0.06                 | 47.30                |                      | 5337.00           | 5180.00              | 5470.00              | 5014.00              | 2.77                | 7.60            |                 |
| 0.06                 | 0.06                 | 47.00                |                      | 5369.00           | 5281.00              | 5480.00              | 4951.00              | 2.77                | 7.57            |                 |
| 0.06                 | 0.06                 | 47.30                |                      | 5810.00           | 5686.00              | 5480.00              | 5012.00              | 2.77                | 7.53            |                 |
| 0.06                 | 0.06                 | 50.00                |                      | 5670.00           | 5282.00              | 5600.00              | 5030.00              | 2.77                | 6.78            |                 |
| 0.06                 | 0.06                 | 49.00                |                      | 5670.00           | 5115.00              | 5800.00              | 5000.00              | 2.77                | 6.77            |                 |
| 0.06                 | 0.05                 | 50.00                |                      | 5690.00           | 5112.00              | 5300.00              | 5140.00              | 2.77                | 6.78            |                 |
| 0.06                 | 0.06                 | 49.00                |                      | 5630.00           | 5316.00              | 5600.00              | 5220.00              | 2.78                | 6.78            |                 |
| 0.05                 | 0.06                 | 49.00                |                      | 5780.00           | 5403.00              | 5500.00              | 5140.00              |                     | 6.81            |                 |
| 0.05                 | 0.06                 | 49.00                |                      | 5350.00           | 5554.00              | 5480.00              | 5480.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 50.00                |                      | 5340.00           | 5293.00              | 5500.00              | 5220.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 50.00                |                      | 5290.00           | 5364.00              | 5500.00              | 5560.00              |                     |                 |                 |
| 0.05                 | 0.05                 | 42.00                |                      | 5320.00           | 5476.00              | 5020.00              | 5138.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 42.00                |                      | 5340.00           | 5430.00              | 5480.00              | 4981.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 46.00                |                      | 5550.00           | 5248.00              | 5000.00              | 4975.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 42.00                |                      | 5330.00           | 5360.00              | 4990.00              | 5105.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 44.00                |                      | 5340.00           | 5351.00              | 4910.00              | 5155.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 45.00                |                      | 5380.00           | 5388.00              | 5014.00              | 5044.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 43.00                |                      | 5388.00           | 5100.00              | 5088.00              | 5088.00              |                     |                 |                 |
| 0.06                 | 0.06                 | 42.00                |                      | 5490.00           | 4997.00              | 4997.00              | 4997.00              |                     |                 |                 |

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**Table 2: Major Oxides**

| XRF<br>Al2O3<br>% | XRF<br>CaO<br>% | XRF<br>Cr2O3<br>% | XRF<br>Fe2O3<br>% | XRF<br>K2O<br>% | XRF<br>MgO<br>% | XRF<br>MnO<br>% | XRF<br>Na2O<br>% | XRF<br>P2O5<br>% | XRF<br>SiO2<br>% |
|-------------------|-----------------|-------------------|-------------------|-----------------|-----------------|-----------------|------------------|------------------|------------------|
| 8.96              | 8.11            | 0.15              | 4.69              | 1.41            | 1.94            | 0.06            | 2.19             | 0.11             | 81.05            |
| 8.92              | 8.15            | 0.15              | 4.66              | 1.42            | 1.89            | 0.07            | 2.19             | 0.10             | 81.08            |
| 8.92              | 8.09            | 0.15              | 4.70              | 1.42            | 1.87            | 0.07            | 2.16             | 0.10             | 80.95            |
| 8.96              | 8.16            | 0.15              | 4.66              | 1.42            | 1.90            | 0.07            | 2.21             | 0.11             | 81.12            |
| 8.83              | 8.31            | 0.15              | 4.70              | 1.42            | 1.86            | 0.06            | 2.18             | 0.11             | 81.55            |
| 8.89              | 8.31            | 0.15              | 4.84              | 1.39            | 1.88            | 0.07            | 2.19             | 0.10             | 81.79            |
| 8.92              | 8.28            | 0.15              | 4.85              | 1.42            | 1.92            | 0.07            | 2.19             | 0.10             | 81.72            |
| 8.91              | 8.30            | 0.15              | 4.83              | 1.43            | 1.88            | 0.06            | 2.19             | 0.10             | 81.64            |
| 8.84              | 8.28            | 0.16              | 4.85              | 1.41            | 1.83            | 0.06            | 2.09             | 0.11             | 81.60            |
| 8.84              | 8.28            | 0.16              | 4.81              | 1.41            | 1.82            | 0.06            | 2.10             | 0.11             | 81.58            |
| 8.86              | 8.36            | 0.16              | 4.83              | 1.41            | 1.81            | 0.06            | 2.11             | 0.11             | 81.51            |
| 8.83              | 8.27            | 0.16              | 4.83              | 1.41            | 1.83            | 0.06            | 2.10             | 0.11             | 81.56            |
| 8.83              | 8.29            | 0.16              | 4.82              | 1.41            | 1.81            | 0.06            | 2.08             | 0.11             | 81.58            |
| 8.86              | 8.31            | 0.16              | 4.88              | 1.41            | 1.85            | 0.06            | 2.08             | 0.11             | 81.58            |
| 8.80              | 8.27            | 0.16              | 4.90              | 1.41            | 1.81            | 0.06            | 2.10             | 0.11             | 81.59            |
| 8.83              | 8.29            | 0.16              | 4.91              | 1.40            | 1.81            | 0.06            | 2.10             | 0.11             | 81.68            |
| 8.87              | 8.30            | 0.16              | 4.90              | 1.42            | 1.79            | 0.06            | 1.93             | 0.11             | 81.72            |
| 8.75              | 8.29            | 0.17              | 4.89              | 1.43            | 1.79            | 0.05            | 1.96             | 0.11             | 81.70            |
| 8.84              | 8.38            | 0.17              | 4.91              | 1.42            | 1.78            | 0.06            | 1.98             | 0.11             | 81.85            |
| 8.87              | 8.30            | 0.17              | 4.86              | 1.42            | 1.81            | 0.06            | 1.93             | 0.11             | 81.74            |
| 8.86              | 8.36            | 0.16              | 4.87              | 1.42            | 1.80            | 0.06            | 1.95             | 0.11             | 81.88            |
| 8.81              | 8.39            | 0.16              | 4.89              | 1.41            | 1.78            | 0.06            | 1.95             | 0.11             | 81.84            |
| 8.80              | 8.36            | 0.16              | 4.87              | 1.42            | 1.79            | 0.06            | 1.94             | 0.11             | 81.86            |
| 8.73              | 8.37            | 0.16              | 4.90              | 1.42            | 1.80            | 0.06            | 1.94             | 0.11             | 81.92            |
| 8.76              | 8.38            | 0.17              | 4.87              | 1.45            | 1.85            | 0.08            | 2.29             | 0.11             | 82.31            |
| 8.75              | 8.38            | 0.17              | 4.87              | 1.45            | 1.85            | 0.08            | 2.27             | 0.10             | 82.10            |
| 8.74              | 8.38            | 0.17              | 4.88              | 1.45            | 1.86            | 0.08            | 2.26             | 0.10             | 82.14            |
| 8.75              | 8.39            | 0.17              | 4.88              | 1.45            | 1.84            | 0.08            | 2.31             | 0.10             | 82.24            |
| 8.73              | 8.30            | 0.17              | 4.88              | 1.45            | 1.85            | 0.08            | 2.30             | 0.10             | 82.10            |
| 8.74              | 8.27            | 0.17              | 4.91              | 1.46            | 1.86            | 0.08            | 2.31             | 0.10             | 82.29            |
| 8.74              | 8.33            | 0.17              | 4.90              | 1.45            | 1.86            | 0.08            | 2.32             | 0.10             | 82.19            |
| 8.70              | 8.29            | 0.17              | 5.03              | 1.45            | 1.86            | 0.08            | 2.32             | 0.10             | 82.50            |
| 8.70              | 8.31            | 0.15              | 4.95              | 1.41            | 1.70            | 0.06            | 2.14             | 0.10             | 82.80            |
| 8.70              | 8.31            | 0.15              | 4.96              | 1.46            | 1.70            | 0.06            | 2.14             | 0.10             | 82.80            |
| 8.70              | 8.30            | 0.15              | 4.94              | 1.42            | 1.70            | 0.06            | 2.12             | 0.10             | 82.70            |
| 8.80              | 8.30            | 0.14              | 4.94              | 1.46            | 1.70            | 0.07            | 2.10             | 0.10             | 82.70            |
| 8.80              | 8.31            | 0.14              | 4.95              | 1.45            | 1.70            | 0.06            | 2.12             | 0.10             | 82.80            |
| 8.80              | 8.28            | 0.15              | 4.91              | 1.46            | 1.70            | 0.07            | 2.16             | 0.10             | 81.90            |
| 8.80              | 8.16            | 0.15              | 4.78              | 1.43            | 1.70            | 0.06            | 2.13             | 0.10             | 81.80            |
| 8.75              | 8.17            | 0.16              | 4.73              | 1.46            | 1.74            | 0.06            | 2.19             | 0.10             | 82.10            |
| 8.73              | 8.14            | 0.15              | 4.71              | 1.42            | 1.74            | 0.05            | 2.09             | 0.10             | 82.10            |
| 8.72              | 8.33            | 0.16              | 4.72              | 1.39            | 1.72            | 0.06            | 1.98             | 0.10             | 82.30            |
| 8.74              | 8.32            | 0.15              | 4.81              | 1.42            | 1.69            | 0.06            | 1.95             | 0.10             | 81.70            |
| 8.70              | 8.33            | 0.16              | 4.82              | 1.40            | 1.71            | 0.06            | 1.95             | 0.10             | 81.80            |
| 8.75              | 8.38            | 0.15              | 4.82              | 1.41            | 1.74            | 0.05            | 1.95             | 0.10             | 82.10            |
| 8.82              | 8.41            | 0.15              | 4.93              | 1.42            | 1.82            | 0.06            | 2.02             | 0.10             | 81.80            |
| 8.83              | 8.38            | 0.15              | 4.91              | 1.44            | 1.83            | 0.06            | 1.95             | 0.10             | 81.60            |
| 8.91              | 8.41            | 0.15              | 4.90              | 1.42            | 1.80            | 0.06            | 1.95             | 0.10             | 81.50            |
| 8.83              | 8.44            | 0.15              | 4.91              | 1.41            | 1.81            | 0.06            | 1.95             | 0.10             | 81.60            |
| 8.85              | 8.44            | 0.15              | 4.92              | 1.42            | 1.82            | 0.06            | 1.95             | 0.10             | 81.50            |
| 8.88              | 8.42            | 0.15              | 4.90              | 1.42            | 1.84            | 0.06            | 1.95             | 0.10             | 81.60            |
| 8.83              | 8.42            | 0.15              | 4.90              | 1.42            | 1.84            | 0.06            | 1.95             | 0.10             | 81.50            |
| 8.80              | 8.41            | 0.15              | 4.91              | 1.41            | 1.81            | 0.06            | 1.95             | 0.10             | 81.60            |
| 8.85              |                 |                   |                   |                 |                 |                 |                  |                  |                  |
| 8.88              |                 |                   |                   | 1.43            |                 |                 |                  |                  |                  |
|                   |                 |                   |                   | 1.43            |                 |                 |                  |                  |                  |

**12. Measurement of Uncertainty ;(ref Dr Hugh Bartlett, Hugh Bartlett Consulting CC.)**

The samples used in this certification process have been selected in such a way as to represent the entire batch of material and were taken from the final packaged units; therefore all possible sources of uncertainty (sample uncertainty and measurement uncertainty) are included in the final combined standard uncertainty determination.

The uncertainty measurement takes into consideration the between lab and the within lab variances and is calculated from the square roots of the variances of these components using the formula:

$$\text{Combined standard uncertainty} = \sqrt{(\text{between lab.var/no of labs}) + (\text{mean square within lab.var /no of assays})}$$



MATRIX REFERENCE MATERIALS

A Part of ► Torre Industries

| Analyte                        | Method        | Unit          | S <sup>1</sup> | $\sigma$ L <sup>2</sup> | SW <sup>3</sup> | CSU <sup>4</sup> |
|--------------------------------|---------------|---------------|----------------|-------------------------|-----------------|------------------|
| Au                             | Pb Collection | g/t           | 0.008          | 0.004                   | 0.005           | 0.001            |
| Co                             | 4A_MICP       | ppm           | 2.450          | 2.211                   | 1.041           | 0.747            |
| Cu                             | FUS           | ppm           | 196.800        | 218.118                 | 79.377          | 89.829           |
| Cu                             | 2A_MICP       | ppm           | 178.050        | 206.159                 | 58.064          | 84.598           |
| Cu                             | 4A_MICP       | ppm           | 267.000        | 225.127                 | 97.111          | 68.663           |
| SG                             | SG            | Dimensionless | 0.030          | 0.033                   | 0.014           | 0.015            |
| LOI                            | LOI           | %             | 0.255          | 0.255                   | 0.092           | 0.091            |
| Al <sub>2</sub> O <sub>3</sub> | XRF           | %             | 0.070          | 0.065                   | 0.039           | 0.025            |
| CaO                            | XRF           | %             | 0.085          | 0.082                   | 0.039           | 0.031            |
| Cr <sub>2</sub> O <sub>3</sub> | XRF           | %             | 0.010          | 0.009                   | 0.004           | 0.004            |
| Fe <sub>2</sub> O <sub>3</sub> | XRF           | %             | 0.080          | 0.087                   | 0.026           | 0.033            |
| K <sub>2</sub> O               | XRF           | %             | 0.020          | 0.016                   | 0.011           | 0.006            |
| MnO                            | XRF           | %             | 0.065          | 0.013                   | 0.004           | 0.007            |
| MgO                            | XRF           | %             | 0.010          | 0.070                   | 0.016           | 0.029            |
| Na <sub>2</sub> O              | XRF           | %             | 0.125          | 0.171                   | 0.020           | 0.076            |
| P <sub>2</sub> O <sub>5</sub>  | XRF           | %             | 0.005          | 0.007                   | 0.002           | 0.004            |
| SiO <sub>2</sub>               | XRF           | %             | 0.435          | 0.447                   | 0.160           | 0.171            |

1 S - Std Dev for use on control charts.

2  $\sigma$ L - Betw Lab Std Dev, for use to calculate a measure of accuracy.

3 SW - Within Lab Std Dev, for use to calculate a measure of precision.

4 CSU - Combined Standard Uncertainty, a component for use to calculate the total uncertainty in method validation.

These uncertainty measurements may be used, by laboratories, as a component for calculating the total uncertainty for method validation according to the relevant ISO guidelines.

**13. Certified values:** The Certified, Provisional and Informational values listed on page 1 and page 2 of this certificate fulfill the AMIS statistical criteria regarding agreement for certification and have been independently validated by Mr Allan W. Fraser.

**14. Metrological Traceability:** The values quoted herein are based on the consensus values derived from statistical analysis of the data from an inter laboratory measurement program. Traceability to SI units is via the standards used by the individual laboratories the majority of which are accredited and who have maintained measurement traceability during the analytical process.

**15. Certification:** AMIS0475 is a new material.

**16. Period of validity:** The certified values are valid for this product, while still sealed in its original packaging, until notification to the contrary. The stability of the material will be subject to continuous testing for the duration of the inventory. Should product stability become an issue, all customers will be notified and notification to that effect will be placed on the [www.amis.co.za](http://www.amis.co.za) website.

**17. Minimum sample size:** The majority of laboratories reporting used a 0.5g sample size for the ICP and a 30g sample size for the fire assay. These are the recommended minimum sample sizes for the use of this material.

**18. Availability:** This product is available in Laboratory Packs containing 1kg of material and Explorer Packs containing custom weights (from 50 to 250g) of material. The Laboratory Packs are sealed bottles delivered in sealed foil pouches. The Explorer Packs contain material in standard geochem envelopes, nitrogen flushed and vacuum sealed in foil pouches.

## AMIS

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**19. Recommended use:** The data used to characterize this CRM has been scrutinized using outlier treatment techniques. This, together with the number of participating laboratories, should overcome any “inter-laboratory issues” and should lead to a very accurate measure for the given methods, notwithstanding the underlying assumption that what the good inter-laboratory labs reported was accurate. However an amount of bad data might have had an effect, resulting in limits which in some situations might be too broad for the effective monitoring of a single analytical method, laboratory or production process. Users should set their own limits based on their own data quality objectives and control measurements, after determining the performance characteristics of their own particular method, using a minimum of 20 analyses using this CRM. User set limits should normally be within the limits recommended on p1 and 2 of this certificate.


**20. Legal Notice:** This certificate and the reference material described in it have been prepared with due care and attention. However AMIS, a part of Torre Industries, Nozibele Mbangula and Allan W. Fraser; accept no liability for any decisions or actions taken following the use of the reference material.

**10 August 2016**

**Certifying Officers:**



**African Mineral Standards:** \_\_\_\_\_  
**Nozibele Mbangula**



**Geochemist:** \_\_\_\_\_  
**Allan W. Fraser**  
**M.Sc. (Geology), N.D. (Analytical Chem.), Pr.Sci.Nat.**

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## Appendix – uncertified element statistics

| Element | Gen Method | Std. Mean | N  | SD      | 2SD     | RSD, % | Unit |
|---------|------------|-----------|----|---------|---------|--------|------|
| Ag      | 2A MCP     | 0.09      | 8  | 0.01    | 0.02    | 31.07  | ppm  |
| Ag      | 3A ICPMS   | 0.11      | 8  | 0.01    | 0.01    | 5.89   | ppm  |
| Ag      | 4A MCP     | 0.15      | 32 | 0.05    | 0.09    | 30.89  | ppm  |
| Al      | 2A MCP     | 6292.38   | 32 | 1026.29 | 2052.58 | 11.12  | ppm  |
| Al      | 3A ICPMS   | 10200.00  | 7  | 230.94  | 461.88  | 2.28   | ppm  |
| Al      | 4A MCP     | 45906.10  | 72 | 2430.79 | 4861.59 | 5.30   | ppm  |
| As      | 4A MCP     | 8.11      | 7  | 0.08    | 0.13    | 0.70   | ppm  |
| As      | FUS        | 8.57      | 24 | 0.23    | 0.57    | 3.32   | %    |
| As      | 2A MCP     | 1.59      | 24 | 0.44    | 0.88    | 27.70  | ppm  |
| As      | 4A MCP     | 4.74      | 32 | 7.14    | 14.28   | 124.49 | ppm  |
| Ba      | 2A MCP     | 57.08     | 32 | 3.25    | 6.50    | 5.70   | ppm  |
| Ba      | 3A ICPMS   | 55.57     | 7  | 0.79    | 1.57    | 1.42   | ppm  |
| Ba      | 4A MCP     | 140.26    | 63 | 20.08   | 40.16   | 10.51  | ppm  |
| Ba      | FUS        | 187.29    | 7  | 0.95    | 1.90    | 0.41   | ppm  |
| Ba      | 3A ICPMS   | 0.33      | 8  | 0.05    | 0.09    | 14.24  | ppm  |
| Be      | 4A MCP     | 1.40      | 26 | 0.23    | 0.47    | 16.64  | ppm  |
| Be      | 2A MCP     | 0.38      | 24 | 0.03    | 0.07    | 8.68   | ppm  |
| Be      | 3A ICPMS   | 0.34      | 7  | 0.03    | 0.06    | 8.32   | ppm  |
| B       | 4A MCP     | 0.35      | 40 | 0.04    | 0.08    | 11.40  | ppm  |
| Ca      | 2A MCP     | 5219.75   | 32 | 1619.84 | 3239.68 | 2.85   | ppm  |
| Ca      | 3A ICPMS   | 58112.50  | 8  | 2071.50 | 4143.00 | 3.54   | ppm  |
| Ca      | 4A MCP     | 58921.30  | 63 | 1909.47 | 3818.94 | 3.24   | ppm  |
| CaO     | 4A MCP     | 35.26     | 8  | 0.71    | 1.42    | 1.81   | ppm  |
| CaO     | FUS        | 7.71      | 24 | 0.47    | 0.94    | 6.12   | %    |
| CaO     | 3A ICPMS   | 0.03      | 8  | 0.01    | 0.02    | 34.47  | ppm  |
| CaO     | 4A MCP     | 0.09      | 18 | 0.02    | 0.03    | 23.50  | ppm  |
| CaO     | 2A MCP     | 59.43     | 16 | 13.36   | 26.72   | 22.48  | ppm  |
| CaO     | 3A ICPMS   | 55.03     | 8  | 1.40    | 2.80    | 2.54   | ppm  |
| CaO     | FUS        | 45.25     | 24 | 0.85    | 1.70    | 3.09   | ppm  |
| CaO     | 3A ICPMS   | 42.85     | 8  | 0.69    | 1.38    | 1.61   | ppm  |
| CaO     | 2A MCP     | 43.60     | 47 | 3.59    | 7.18    | 8.24   | ppm  |
| CaO     | 3A ICPMS   | 154.33    | 40 | 15.06   | 30.12   | 11.12  | ppm  |
| CaO     | 4A MCP     | 129.88    | 8  | 8.31    | 12.62   | 8.86   | ppm  |
| CaO     | 4A MCP     | 588.09    | 64 | 288.42  | 576.83  | 49.04  | ppm  |
| CaO     | FUS        | 0.15      | 16 | 0.01    | 0.02    | 7.88   | %    |
| CaO     | 2A MCP     | 1.15      | 8  | 0.02    | 0.04    | 1.55   | ppm  |
| CaO     | 3A ICPMS   | 1.09      | 8  | 0.02    | 0.04    | 1.93   | ppm  |
| CaO     | 4A MCP     | 1.28      | 40 | 0.21    | 0.42    | 16.36  | ppm  |
| Cu      | 3A AAS     | 123.38    | 8  | 0.74    | 1.48    | 0.60   | ppm  |
| Cu      | 3A ICPMS   | 101.25    | 8  | 6.41    | 12.82   | 6.33   | ppm  |
| Cu      | 3A ICPMS   | 5224.29   | 7  | 105.97  | 211.93  | 2.03   | ppm  |
| Cu      | 4A AAS     | 5538.93   | 15 | 51.83   | 103.66  | 0.84   | ppm  |
| Cu      | XRF        | 5600.00   | 8  | 75.59   | 151.19  | 1.35   | ppm  |
| Dy      | 4A MCP     | 1.50      | 16 | 1.03    | 2.05    | 22.82  | ppm  |
| Dy      | 4A MCP     | 3.03      | 16 | 0.43    | 0.85    | 14.01  | ppm  |
| Dy      | 4A MCP     | 1.05      | 16 | 0.37    | 0.73    | 34.87  | ppm  |
| Fe      | 2A MCP     | 2871.88   | 32 | 886.59  | 1773.19 | 3.14   | ppm  |
| Fe      | 3A ICPMS   | 28912.50  | 8  | 978.88  | 1957.75 | 3.39   | ppm  |
| Fe      | 4A MCP     | 33193.86  | 77 | 1519.53 | 3039.06 | 4.58   | ppm  |
| Fe      | FUS        | 29000.00  | 8  | 529.92  | 1059.84 | 3.14   | ppm  |
| FeO     | FUS        | 4.76      | 16 | 0.26    | 0.51    | 5.34   | %    |
| Ga      | 2A MCP     | 3.47      | 16 | 0.66    | 1.32    | 18.99  | ppm  |
| Ga      | 3A ICPMS   | 3.40      | 8  | 0.40    | 0.79    | 2.22   | ppm  |
| Ga      | 4A MCP     | 10.89     | 40 | 3.77    | 7.54    | 34.63  | ppm  |
| Gd      | 4A MCP     | 0.36      | 16 | 1.87    | 3.73    | 33.89  | ppm  |
| Gd      | 4A MCP     | 0.91      | 24 | 0.58    | 1.16    | 64.03  | ppm  |
| Hf      | 2A MCP     | 0.42      | 7  | 0.00    | 0.01    | 0.90   | ppm  |
| Hf      | 3A ICPMS   | 0.51      | 8  | 0.01    | 0.02    | 3.38   | ppm  |
| Hf      | 4A MCP     | 2.32      | 39 | 1.02    | 2.03    | 43.82  | ppm  |
| Hf      | 2A MCP     | 2.29      | 7  | 1.11    | 2.23    | 48.68  | ppm  |
| Hf      | 4A MCP     | 0.91      | 16 | 0.70    | 1.39    | 14.27  | ppm  |
| Hf      | 3A ICPMS   | 0.16      | 8  | 0.01    | 0.01    | 3.16   | ppm  |
| Ind     | 4A MCP     | 0.18      | 39 | 0.01    | 0.03    | 7.65   | ppm  |
| K       | 2A MCP     | 4414.88   | 32 | 225.33  | 450.66  | 4.83   | ppm  |
| K       | 3A ICPMS   | 4282.50   | 8  | 184.88  | 369.75  | 4.33   | ppm  |
| K       | 4A MCP     | 11745.03  | 64 | 675.55  | 1351.09 | 5.75   | ppm  |
| K       | FUS        | 11.47     | 16 | 0.03    | 0.06    | 2.15   | %    |
| La      | 2A MCP     | 29.15     | 32 | 5.34    | 10.67   | 18.30  | ppm  |
| La      | 3A ICPMS   | 25.40     | 8  | 0.71    | 1.41    | 2.78   | ppm  |
| La      | 4A MCP     | 32.35     | 48 | 19.81   | 39.61   | 39.57  | ppm  |
| Li      | 2A MCP     | 8.33      | 32 | 1.39    | 2.77    | 16.64  | ppm  |
| Li      | 4A MCP     | 8.88      | 8  | 0.64    | 1.28    | 7.22   | ppm  |
| Li      | 4A MCP     | 11.64     | 71 | 1.74    | 3.49    | 14.58  | ppm  |
| Lu      | 3A ICPMS   | 0.45      | 8  | 0.01    | 0.02    | 2.21   | ppm  |
| Lu      | 4A MCP     | 0.55      | 24 | 0.06    | 0.11    | 10.05  | ppm  |
| Mg      | 2A MCP     | 8985.63   | 32 | 583.99  | 1167.97 | 6.51   | ppm  |
| Mg      | 3A ICPMS   | 9425.00   | 8  | 319.60  | 639.20  | 3.43   | ppm  |
| Mg      | 4A MCP     | 10370.94  | 78 | 443.64  | 887.28  | 4.28   | ppm  |
| MgO     | FUS        | 1.79      | 23 | 0.05    | 0.12    | 3.22   | %    |
| Mn      | 2A MCP     | 396.53    | 32 | 16.86   | 33.71   | 4.25   | ppm  |
| Mn      | 3A ICPMS   | 401.75    | 8  | 13.60   | 27.21   | 3.39   | ppm  |
| Mn      | 4A MCP     | 427.13    | 71 | 19.84   | 39.67   | 4.34   | ppm  |
| MnO     | FUS        | 0.07      | 15 | 0.00    | 0.01    | 5.79   | %    |
| MnO     | 2A MCP     | 15.35     | 30 | 1.01    | 2.02    | 6.58   | ppm  |
| MnO     | 3A ICPMS   | 15.40     | 7  | 0.59    | 1.18    | 3.84   | ppm  |
| Mo      | 4A MCP     | 16.01     | 63 | 0.87    | 1.75    | 5.46   | ppm  |
| Na      | 2A MCP     | 675.00    | 32 | 87.99   | 175.98  | 13.04  | ppm  |

| Element | Gen Method | Std. Mean | N  | SD     | 2SD     | RSD, % | Unit |
|---------|------------|-----------|----|--------|---------|--------|------|
| Na      | 4A MCP     | 16140.77  | 64 | 892.81 | 1785.63 | 5.52   | ppm  |
| Na2O    | FUS        | 2.28      | 8  | 0.06   | 0.11    | 2.50   | %    |
| Nb      | 2A MCP     | 1.98      | 8  | 0.09   | 0.18    | 4.49   | ppm  |
| Nb      | 3A ICPMS   | 1.29      | 8  | 0.04   | 0.07    | 2.83   | ppm  |
| Nb      | 4A MCP     | 10.05     | 48 | 1.25   | 2.49    | 12.51  | ppm  |
| Nb      | FUS        | 29.88     | 8  | 0.99   | 1.98    | 3.32   | ppm  |
| Ni      | 4A MCP     | 29.72     | 16 | 14.68  | 29.36   | 49.39  | ppm  |
| Ni      | 2A MCP     | 76.27     | 45 | 5.54   | 11.07   | 7.26   | ppm  |
| Ni      | 3A ICPMS   | 81.75     | 8  | 3.29   | 6.58    | 4.02   | ppm  |
| Ni      | 4A MCP     | 69.37     | 69 | 4.37   | 8.75    | 6.12   | ppm  |
| P       | 2A MCP     | 403.37    | 27 | 25.48  | 50.96   | 6.32   | ppm  |
| P       | 3A ICPMS   | 397.50    | 8  | 11.65  | 23.30   | 2.93   | ppm  |
| P       | 4A MCP     | 445.11    | 56 | 42.20  | 84.41   | 9.28   | ppm  |
| P2O5    | FUS        | 0.10      | 8  | 0.01   | 0.01    | 5.38   | %    |
| Pb      | 2A MCP     | 2.36      | 20 | 0.63   | 1.25    | 26.57  | ppm  |
| Pb      | 3A ICPMS   | 2.51      | 8  | 0.15   | 0.29    | 5.80   | ppm  |
| Pb      | 4A MCP     | 1.26      | 48 | 2.98   | 5.95    | 69.87  | ppm  |
| Pd      | 4A MCP     | 0.02      | 8  | 0.01   | 0.01    | 26.45  | ppm  |
| Pd      | Collection | 0.02      | 8  | 0.00   | 0.01    | 15.27  | ppm  |
| Pd      | 4A MCP     | 0.69      | 16 | 0.31   | 0.62    | 50.63  | ppm  |
| Pd      | 2A MCP     | 27.31     | 8  | 0.22   | 0.43    | 0.79   | ppm  |
| Pd      | 3A ICPMS   | 30.24     | 8  | 0.57   | 1.14    | 1.89   | ppm  |
| Pd      | 4A MCP     | 25.79     | 40 | 0.95   | 1.90    | 3.29   | ppm  |
| Pd      | 2A MCP     | 1.11      | 39 | 0.08   | 0.17    | 7.55   | ppm  |
| Pd      | 3A ICPMS   | 1.23      | 7  | 0.02   | 0.04    | 1.44   | %    |
| Pd      | FUS        | 1.21      | 52 | 0.09   | 0.11    | 4.41   | ppm  |
| Pd      | 4A MCP     | 1.17      | 16 | 0.05   | 0.09    | 3.95   | %    |
| Pd      | XRF        | 1.11      | 15 | 0.02   | 0.04    | 1.76   | %    |
| Pd      | 4A MCP     | 1.21      | 29 | 0.09   | 0.18    | 2.92   | ppm  |
| Pd      | 2A MCP     | 0.09      | 8  | 0.00   | 0.01    | 7.09   | ppm  |
| Pd      | 3A ICPMS   | 0.09      | 28 | 0.02   | 0.05    | 24.50  | ppm  |
| Pd      | 4A MCP     | 0.63      | 64 | 0.35   | 0.69    | 4.66   | ppm  |
| Pd      | 4A ICPMS   | 7.16      | 8  | 0.09   | 0.18    | 1.28   | ppm  |
| Pd      | 4A MCP     | 12.81     | 56 | 1.10   | 2.20    | 8.58   | ppm  |
| Pd      | 3A ICPMS   | 1.16      | 16 | 0.46   | 0.93    | 4.03   | %    |
| Pd      | 4A MCP     | 8.66      | 32 | 0.87   | 1.73    | 10.00  | ppm  |
| Pd      | 4A MCP     | 61.25     | 8  | 0.97   | 1.95    | 1.59   | %    |
| Pd      | 4A MCP     | 1.42      | 16 | 0.42   | 0.83    | 2.16   | %    |
| Pd      | 4A MCP     | 5.56      | 16 | 2.35   | 4.70    | 42.29  | ppm  |
| Pd      | 2A MCP     | 0.74      | 8  | 0.07   | 0.15    | 10.09  | ppm  |
| Pd      | 3A ICPMS   | 2.25      | 8  | 0.00   | 0.11    | 2.38   | ppm  |
| Pd      | 4A MCP     | 2.41      | 32 | 0.25   | 0.51    | 10.55  | ppm  |
| SO3     | XRF        | 2.90      | 8  | 0.04   | 0.09    | 1.52   | ppm  |
| Sr      | 2A MCP     | 174.16    | 31 | 5.69   | 10.19   | 2.93   | ppm  |
| Sr      | 3A ICPMS   | 183.00    | 8  | 6.33   | 12.65   | 3.46   | ppm  |
| Sr      | 4A MCP     | 223.96    | 67 | 12.38  | 24.76   | 5.53   | ppm  |
| Sr      | FUS        | 230.25    | 8  | 2.25   | 4.50    | 0.98   | ppm  |
| Ta      | 4A MCP     | 0.50      | 40 | 0.29   | 0.57    | 56.78  | ppm  |
| Tb      | 3A ICPMS   | 0.59      | 8  | 0.01   | 0.02    | 1.42   | ppm  |
| Tb      | 4A MCP     | 0.78      | 24 | 0.20   | 0.40    | 25.95  | ppm  |
| Tb      | 2A MCP     | 1.12      | 16 | 0.10   | 0.20    | 8.87   | ppm  |
| Tb      | 3A ICPMS   | 1.14      | 8  | 0.10   | 0.20    | 6.93   | ppm  |
| Tb      | 4A MCP     | 1.15      | 31 | 0.15   | 0.30    | 13.07  | ppm  |
| Tb      | 2A MCP     | 5.99      | 15 | 0.08   | 0.12    | 0.99   | ppm  |
| Tb      | 3A ICPMS   | 5.16      | 8  | 0.09   | 0.18    | 1.78   | ppm  |
| Tb      | 4A MCP     | 7.05      | 40 | 1.31   | 2.62    | 18.53  | ppm  |
| Tb      | 2A MCP     | 0.07      | 32 | 0.02   | 0.03    | 21.22  | %    |
| Tb      | 4A MCP     | 0.29      | 64 | 0.05   | 0.04    | 7.70   | %    |
| Tb      | FUS        | 0.69      | 15 | 0.02   | 0.04    | 3.19   | %    |
| TiO2    | XRF        | 0.74      | 48 | 0.01   | 0.03    | 1.78   | %    |
| Ti      | 2A MCP     | 0.13      | 16 | 0.01   | 0.03    | 10.92  | ppm  |
| Ti      | 3A ICPMS   | 0.12      | 8  | 0.01   | 0.01    | 4.45   | ppm  |
| Ti      | 4A MCP     | 0.16      | 40 | 0.02   | 0.04    | 12.67  | ppm  |
| Ti      | 4A MCP     | 0.48      | 16 | 0.08   | 0.12    | 17.59  | ppm  |
| Ti      | 2A MCP     | 6.37      | 16 | 0.18   | 0.35    | 2.77   | ppm  |
| Ti      | 3A ICPMS   | 5.78      | 7  | 0.23   | 0.45    | 3.91   | ppm  |
| Ti      | FUS        | 3.35      | 8  | 0.41   | 0.82    | 5.59   | ppm  |
| Ti      | 4A MCP     | 7.19      | 40 | 0.85   | 1.71    | 11.50  | ppm  |
| Ti      | 2A MCP     | 35.28     | 32 | 3.04   | 6.08    | 8.62   | ppm  |
| Ti      | 3A ICPMS   | 35.88     | 7  | 0.68   | 1.36    | 1.92   | ppm  |
| Ti      | 4A MCP     | 108.14    | 64 | 7.37   | 14.73   | 6.81   | ppm  |
| V2O5    | XRF        | 0.03      | 16 | 0.01   | 0.01    | 19.99  | %    |
| V       | 2A MCP     | 0.16      | 13 | 0.05   | 0.10    | 31.85  | ppm  |
| V       | 3A ICPMS   | 0.16      | 8  | 0.05   | 0.10    | 31.85  | ppm  |
| V       | 4A MCP     | 0.84      | 40 | 0.34   | 0.69    | 40.81  | ppm  |
| V       | 2A MCP     | 2.77      | 32 | 1.14   | 2.29    | 8.46   | ppm  |
| V       | 3A ICPMS   | 18.59     | 7  | 1.19   | 2.37    | 1.00   | ppm  |
| V       | 4A MCP     | 21.20     | 61 | 1.31   | 2.62    | 6.18   | ppm  |
| V       | FUS        | 22.75     | 8  | 0.71   | 1.41    | 2.16   | ppm  |
| Yb      | 3A ICPMS   | 3.24      | 8  | 0.05   | 0.10    | 1.60   | ppm  |
| Yb      | 4A MCP     | 3.57      | 24 | 0.37   | 0.74    | 10.29  | ppm  |
| Zn      | 2A MCP     | 12.11     | 31 | 1.95   | 3.90    | 16.09  | ppm  |
| Zn      | 4A MCP     | 14.14     | 56 | 4.12   | 8.24    | 29.12  |      |