# MINERAL SANDS

# PROFICIENCY TESTING PROGRAM

# ROUND 1

# FEBRUARY 2006

# REPORT NO. 501

**ACKNOWLEDGMENTS**

Proficiency Testing Australia (PTA) wishes to acknowledge gratefully the technical assistance provided for this program by Mr Mike McGrath of Cable Sands Pty Ltd. This assistance included providing input into the design of the program, technical advice and discussion of the final report. PTA would also like to thank Cable Sands Pty Ltd for the supply of the samples.



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## 1. FOREWORD

This report summarises the results of a proficiency testing program mineral sands.

The program was conducted in October 2005 by NATA and is this is the first round of proficiency testing in this area of testing programs. Note that from 1 January 2006 the delivery of proficiency testing services was transferred to a new wholly owned subsidary called Proficiency Testing Australia (PTA).

The aim of the program was to assess laboratories' ability to competently perform the tests examined.

## 2. FEATURES OF THE PROGRAM

(a) Results were received from 7 laboratories. Each laboratory was randomly allocated a code number for the program to allow for the confidential treatment of results. Reference to any laboratory in this report is made by its code number.

(b) Two sand samples, one Zircon and the other Ilmenite were supplied to each participant.

(c) Laboratories were requested to perform the tests according to the "Instructions to Participants" and to record their results on the accompanying "Results Sheets", both of which were distributed to participants with the samples.

Copies of the "Instructions to Participants" and "Results Sheets" are given in Appendix C of this report.

(d) The results as reported by the laboratories are presented in Appendix A, together with calculated z-scores, summary statistics and graphical presentations of the data (for some tests).

## 3. FORMAT OF APPENDICES

(a) Appendix A is divided into two sections, one for Zircon and the other Ilmenite. For all tests the following information is given:

(i) a listing of the (robust) summary statistics; The list of summary statistics appears at the bottom of the table of results and consists of:

* the number of results for that test/sample (*No. of Results*);
* the median of laboratory's results - i.e. the middle value (*Median*);
* the normalised interquartile range of the results (*Normalised IQR*) - the interquartile range times 0.7413;
* the robust coefficient of variation, expressed as a percentage (*Robust CV*) - i.e. 100 x *Normalised IQR* ÷ *Median*;
* the minimum and maximum laboratory results; and
* the range (*Maximum* - *Minimum*).

For tests where the number of results received was 7 the following information is given:

(ii) a table of the results and the calculated z-scores .

Outliers are identified by a marker (**§**) next to the relevant score. Please see reference [1] for details on how these z-scores are calculated;

The median is a measure of the centre of the data and the Normalised IQR is a measure of the spread of the results.

Multiplying the IQR by the factor (0.7413) allows for the comparison between the old and new types of coefficients of variation. Please see reference [1] for further details on these robust summary statistics;

(iii) ordered z-score charts (robust z-score).

The displays the robust z-scores for results for each labs result. These charts contain solid lines at +3 and -3, so the outliers are clearly identifiable as those laboratories whose "bar" extends beyond these "cutoff" lines.

Further details of the z-score charts are given in reference [1]. Please also refer to this document for a glossary of terms.

(b) Appendix B contains details of the samples used in the program - including sample source, preparation, and homogeneity testing results.

(c) Appendix C contains a copy of the "Instructions to Participants" and "Results Sheets" as supplied to participants.

## 4. EXTREME RESULTS

In order to achieve the program's aim of assessing laboratories' testing performance, use has been made of a simple robust z-scores technique. These scores are used to detect results which are too high (positive z-score) or too low (negative z-score).

Any result which has an absolute z-score value greater than three
(i.e. $z < -3$ or $z > 3$) is classified as an outlier. A table listing all of the statistical outliers is provided on page 6 . For further details on the robust z-scores, please see reference [1].

## 5. TECHNICAL ADVISER'S COMMENTS

With only limited reliable certified reference samples available to mineral sands laboratories, it is often difficult to ensure that laboratories produce accurate results. Therefore, this proficiency testing program has been extremely valuable.

Overall, the results from the participating laboratories were quite good, particularly for the major and minor elements. However, there were some significant differences in a few of the trace elements.

## 7. REFERENCE

[1] "Guide to NATA Proficiency Testing" – 2004 (this document is located on the NATA website at www.nata.asn.au under "Publications – Proficiency Testing").

## TABLE A - SUMMARY STATISTICS

A similar summary of results was initially circulated amongst participants shortly after the due date or return of results, to provide them with "early information" about the results of the program.

## ILMENITE

| Test | No. Results | Median | Normalised IQR |
|---|---|---|---|
| $Cr_2O_3$ | 7 | 0.0800 | 0.0052 |
| $So_3$ (as S) | 7 | 0.0540 | 0.0067 |

| Test | No. Results | Median | Normalised IQR |
|---|---|---|---|
| $ThO_2$ | 5 | 100.0 | 14.1 |
| $U_3O_8$ | 5 | 14.0 | 3.7 |
| $SnO_2$ | 4 | 37.5 | 5.7 |
| $As_2O_5$ | 4 | 47.0 | 4.1 |
| PbO | 6 | 411.5 | 29.5 |
| Zn | 4 | 214.0 | 9.3 |

| Test | No. Results | Median | Normalised IQR |
|---|---|---|---|
| $TiO_2$ | 7 | 65.70 | 0.11 |
| $Fe_2O_3$ | 7 | 26.30 | 0.33 |
| $TiO_{2\ Wet}$ | 2 | 65.90 | 0.07 |
| FeO | 5 | 3.00 | 0.82 |

| Test | No. Results | Median | Normalised IQR |
|---|---|---|---|
| $Al_2O_3$ | 7 | 1.000 | 0.026 |
| $SiO_2$ | 7 | 0.590 | 0.015 |
| $ZrO_2$ | 7 | 0.060 | 0.007 |
| $Mn_3O_4$ | 7 | 2.300 | 0.056 |
| $V_2O_5$ | 7 | 0.220 | 0.007 |
| $Nb_2O_5$ | 7 | 0.210 | 0.004 |
| CaO | 6 | 0.025 | 0.007 |
| MgO | 7 | 0.180 | 0.022 |
| $CeO_2$ | 5 | 0.020 | 0.007 |
| $P_2O_5$ | 7 | 0.080 | 0.011 |
| $La_2O_3$ | 6 | 0.010 | 0.000 |
| LOI 1000°C | 7 | 2.940 | 0.122 |

**ZIRCON**

| Test | No. Results | Median | Normalised IQR |
|---|---|---|---|
| $ThO_2$ | 4 | 192.5 | 12.4 |
| $U_3O_8$ | 5 | 241.0 | 21.5 |
| $As_2O_5$ | 2 | 34.0 | 9.6 |
| PbO | 4 | 220.5 | 289.1 |

| Test | No. Results | Median | Normalised IQR |
|---|---|---|---|
| $ZrO_2$ | 7 | 64.20 | 0.30 |
| $SiO_2$ | 7 | 32.50 | 0.07 |

| Test | No. Results | Median | Normalised IQR |
|---|---|---|---|
| $HfO_2$ | 7 | 1.300 | 0.019 |
| $Al_2O_3$ | 7 | 1.080 | 0.026 |
| $TiO_2$ | 7 | 0.140 | 0.004 |
| $Fe_2O_3$ | 7 | 0.070 | 0.004 |
| $P_2O_5$ | 7 | 0.120 | 0.011 |
| CaO | 7 | 0.030 | 0.007 |
| $La_2O_3$ | 4 | 0.020 | 0.015 |
| $CeO_2$ | 6 | 0.020 | 0.011 |
| MgO | 4 | 0.025 | 0.009 |
| LOI 1000°C | 7 | 0.170 | 0.015 |

Please note:

1) The Median is the middle result. It is a measure of the centre of the data and replaces the previously used 'consensus mean'.

2) The Normalised IQR is a measure of the spread of the results and replaces the standard deviation. It is calculated by multiplying the interquartile range (IQR) by a factor (0.7413) which relates it to the 'normal' distribution.

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## TABLE B - SUMMARY OF OUTLIER RESULTS

The table below identifies the code numbers of the labs whose results have been identified as outliers (by the robust z-scores technique).

| OXIDE | Robust Z-score >3 |
|---|---|
| **ILMENITE** | |
| $Cr_2O_3$ | - |
| $So_3$ (as S) | 8 |
| $ThO_2$ | - |
| $U_3O_8$ | - |
| $SnO_2$ | - |
| $As_2O_5$ | - |
| PbO | - |
| Zn | - |
| $TiO_2$ | 5 |
| $Fe_2O_3$ | 3 |
| $TiO_{2\ wet}$ | - |
| FeO | - |
| $Al_2O_3$ | 1 |
| $SiO_2$ | 1, 6 |
| $ZrO_2$ | - |
| $Mn_3O_4$ | 5 |
| $V_2O_5$ | 2 |
| $Nb_2O_5$ | 1 |
| CaO | - |
| MgO | - |
| $CeO_2$ | - |
| $P_2O_5$ | - |
| $La_2O_3$ | - |
| LOI 1000℃ | - |
| **ZIRCON** | |
| $ThO_2$ | - |
| $U_3O_8$ | - |
| $As_2O_5$ | - |
| PbO | - |
| $SiO_2$ | - |
| $ZrO_2$ | - |
| $HfO_2$ | - |
| $Al_2O_3$ | - |
| $TiO_2$ | - |
| $Fe_2O_3$ | - |
| $P_2O_5$ | - |
| CaO | - |
| $La_2O_3$ | - |
| $CeO_2$ | - |
| MgO | - |
| LOI 1000℃ | 6 |

# APPENDIX A

# Tables of Results & Z-Scores

# Summary Statistics

# and

# Graphical Displays

# SECTION A1

# ILMENITE

A1.1

# ILMENITE RESULTS

Note 1: The robust z-score is calculated for tests where the no. of results is 7
Note 2: § denotes an outlier(i.e |z-score| >3)
Note 3: Lab 3 reported Fe(3+) as $Fe_2O_3$ rather than Fe(total) as $Fe_2O_3$.

| Lab Code Number | $Al_2O_3$ | Robust Z-score | $SiO_2$ | Robust Z-score | $ZrO_2$ | Robust Z-score | $Mn_3O_4$ | Robust Z-score | $V_2O_5$ | Robust Z-score | $Nb_2O_5$ | Robust Z-score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Expressed as % to 2 decimal places | | | | | | | | | | | |
| 1 | 0.76 | -9.25 § | 0.64 | 3.37 § | 0.06 | 0.00 | 2.34 | 0.72 | 0.22 | 0.00 | 0.21 | 0.00 |
| 2 | 1.01 | 0.39 | 0.58 | -0.67 | 0.05 | -1.35 | 2.35 | 0.90 | 0.25 | 4.05 § | 0.22 | 2.70 |
| 3 | 1.00 | 0.00 | 0.6 | 0.67 | 0.07 | 1.35 | 2.21 | -1.62 | 0.2 | -2.70 | 0.27 | 16.19 § |
| 5 | 0.99 | -0.39 | 0.59 | 0.00 | 0.07 | 1.35 | 2.12 | -3.24 § | 0.23 | 1.35 | 0.21 | 0.00 |
| 6 | 1.00 | 0.00 | 0.49 | -6.74 § | 0.06 | 0.00 | 2.30 | 0.00 | 0.21 | -1.35 | 0.2 | -2.70 |
| 7 | 1.05 | 1.93 | 0.58 | -0.67 | 0.07 | 1.35 | 2.30 | 0.00 | 0.22 | 0.00 | 0.21 | 0.00 |
| 8 | 1.05 | 1.93 | 0.6 | 0.67 | 0.06 | 0.00 | 2.28 | -0.36 | 0.22 | 0.00 | 0.21 | 0.00 |
| No. of Results | 7 | | 7 | | 7 | | 7 | | 7 | | 7 | |
| Median | 1.000 | | 0.590 | | 0.060 | | 2.300 | | 0.220 | | 0.210 | |
| Normalised IQR | 0.026 | | 0.015 | | 0.007 | | 0.056 | | 0.007 | | 0.004 | |
| Robust CV | 2.6% | | 2.5% | | 12.4% | | 2.4% | | 3.4% | | 1.8% | |
| Minimum | 0.76 | | 0.49 | | 0.05 | | 2.12 | | 0.20 | | 0.20 | |
| Maximum | 1.05 | | 0.64 | | 0.07 | | 2.35 | | 0.25 | | 0.27 | |
| Range | 0.29 | | 0.15 | | 0.02 | | 0.23 | | 0.05 | | 0.07 | |

| Lab Code Number | $Cr_2O_3$ | Robust Z-score | $SO_3$ | Robust Z-score | $TiO_2$ | Robust Z-score | $Fe_2O_3$ | Robust Z-score |
|---|---|---|---|---|---|---|---|---|
| | Expressed as % to 3 decimal places | | | | Expressed as % to 1 decimal place | | | |
| 1 | 0.051 | -5.59 § | 0.046 | -1.20 | 65.8 | 0.90 | 26.7 | 1.20 |
| 2 | 0.071 | -1.73 | 0.056 | 0.30 | 65.7 | 0.00 | 26.5 | 0.60 |
| 3 | 0.083 | 0.58 | 0.054 | 0.00 | 65.6 | -0.90 | 23.6 | -8.09 § |
| 5 | 0.076 | -0.77 | 0.062 | 1.20 | 64.5 | -10.79 § | 25.8 | -1.50 |
| 6 | 0.08 | 0.00 | 0.051 | -0.45 | 65.8 | 0.90 | 26.1 | -0.60 |
| 7 | 0.08 | 0.00 | 0.049 | -0.75 | 65.7 | 0.00 | 26.3 | 0.00 |
| 8 | 0.081 | 0.19 | 0.124 | 10.49 § | 66.0 | 2.70 | 26.3 | 0.00 |
| No. of Results | 7 | | 7 | | 7 | | 7 | |
| Median | 0.0800 | | 0.0540 | | 65.70 | | 26.30 | |
| Normalised IQR | 0.0052 | | 0.0067 | | 0.11 | | 0.33 | |
| Robust CV | 6.5% | | 12.4% | | 0.2% | | 1.3% | |
| Minimum | 0.051 | | 0.046 | | 64.5 | | 23.6 | |
| Maximum | 0.083 | | 0.124 | | 66.0 | | 26.7 | |
| Range | 0.032 | | 0.078 | | 1.5 | | 3.1 | |

A1.2

# ILMENITE RESULTS

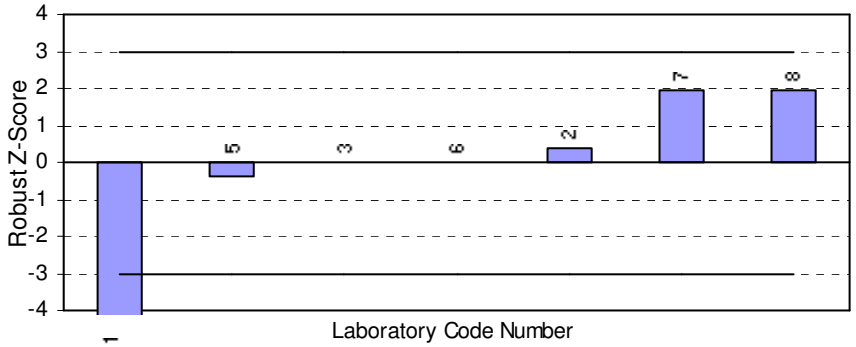
Note 1: The robust z-score is calculated for tests where the no. of results is 7
Note 2: § denotes an outlier(i.e |z-score| >3)

| Lab code Number | CaO | MgO | Robust Z-score | $CeO_2$ | $P_2O_5$ | Robust Z-score | $La_2O_3$ | LOI 1000°C | Robust Z-score |
|---|---|---|---|---|---|---|---|---|---|
| | Expressed as % to 2 decimal places | | | | | | | | |
| 1 | 0.02 | 0.13 | -2.25 | 0.02 | 0.09 | 0.90 | <0.01 | 2.87 | -0.57 |
| 2 | 0.02 | 0.2 | 0.90 | | 0.08 | 0.00 | - | 2.94 | 0.00 |
| 3 | 0.03 | 0.16 | -0.90 | 0.01 | 0.07 | -0.90 | <0.01 | 3.03 | 0.74 |
| 5 | 0.02 | 0.21 | 1.35 | <0.01 | 0.1 | 1.80 | <0.01 | 2.99 | 0.41 |
| 6 | <1.01 | 0.18 | 0.00 | 0.02 | 0.08 | 0.00 | <0.01 | 3.07 | 1.06 |
| 7 | 0.03 | 0.2 | 0.90 | 0.02 | 0.08 | 0.00 | 0.01 | 2.72 | -1.80 |
| 8 | 0.03 | 0.18 | 0.00 | 0.01 | 0.1 | 1.80 | 0.01 | 2.82 | -0.98 |
| No. of Results | 6 | 7 | | 5 | 7 | | 6 | 7 | |
| Median | 0.025 | 0.180 | | 0.020 | 0.080 | | 0.010 | 2.940 | |
| Normalised IQR | 0.007 | 0.022 | | 0.007 | 0.011 | | 0.000 | 0.122 | |
| Robust CV | 29.7% | 0.12355 | | 0.3707 | 13.9% | | 0.0% | 4.2% | |
| Minimum | 0.02 | 0.13 | | 0.01 | 0.07 | | 0.01 | 2.72 | |
| Maximum | 0.03 | 0.21 | | 0.02 | 0.10 | | 0.01 | 3.07 | |
| Range | 0.01 | 0.08 | | 0.01 | 0.03 | | 0 | 0.35 | |

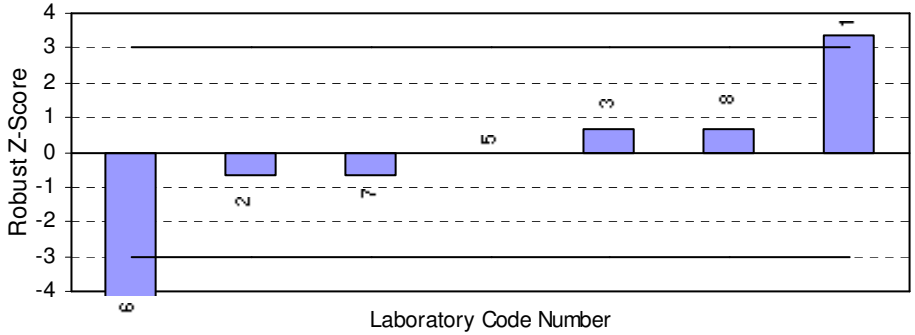
| Lab code Number | $ThO_2$ | $U_3O_8$ | $SnO_2$ | $As_2O_5$ | PbO | Zn | TiO2 (wet) | FeO |
|---|---|---|---|---|---|---|---|---|
| | Expressed as ppm | | | | | | Expressed as % to 2 dec. pl. | |
| 1 | 100 | 14 | 49 | 49 | 407 | 217 | - | - |
| 2 | | | | | 420 | | - | 4.3 |
| 3 | 96 | 12 | 40 | 45 | 370 | 190 | - | 2.8 |
| 5 | 170 | 30 | <10 | | 600 | | - | 3.9 |
| 6 | 119 | 12 | 33 | 53 | 339 | 222 | 65.8 | 1.8 |
| 7 | 100 | 17 | 35 | 43 | 416 | 211 | 66.0 | 3.0 |
| 8 | - | - | - | - | - | - | - | - |
| No. of Results | 5 | 5 | 4 | 4 | 6 | 4 | 2 | 5 |
| Median | 100.0 | 14.0 | 37.5 | 47.0 | 411.5 | 214.0 | 65.90 | 3.00 |
| Normalised IQR | 14.1 | 3.7 | 5.7 | 4.1 | 29.5 | 9.3 | 0.07 | 0.82 |
| Robust CV | 14.1% | 26.5% | 15.3% | 8.7% | 7.2% | 4.3% | 0.1% | 27.2% |
| Minimum | 96 | 12 | 33 | 43 | 339 | 190 | 65.8 | 1.8 |
| Maximum | 170 | 30 | 49 | 53 | 600 | 222 | 66 | 4.3 |
| Range | 74 | 18 | 16 | 10 | 261 | 32 | 0.2 | 2.5 |

# ILMENITE BAR CHARTS

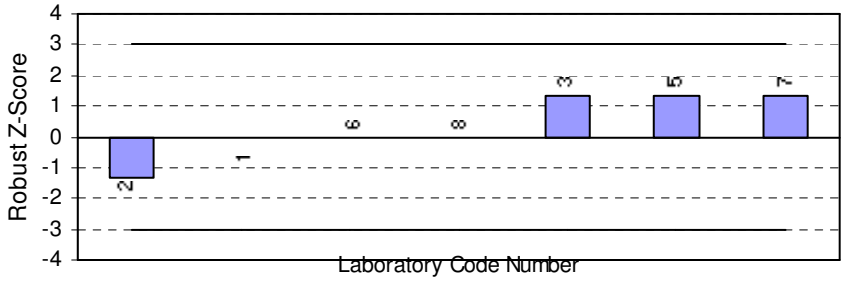
**$Al_2O_3$**



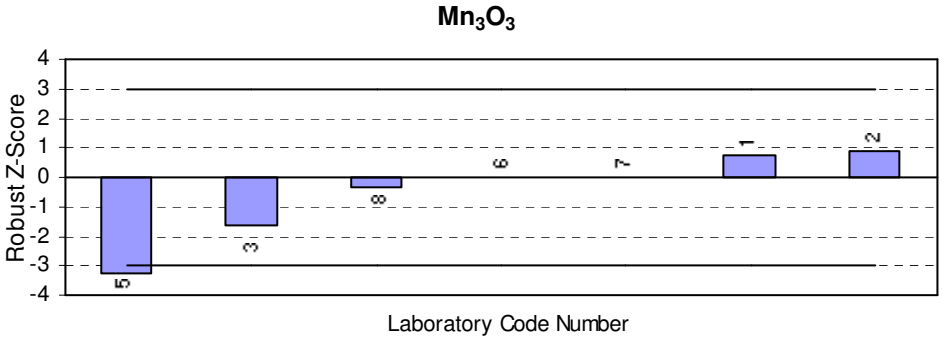

**$SiO_2$**




**$ZrO_2$**

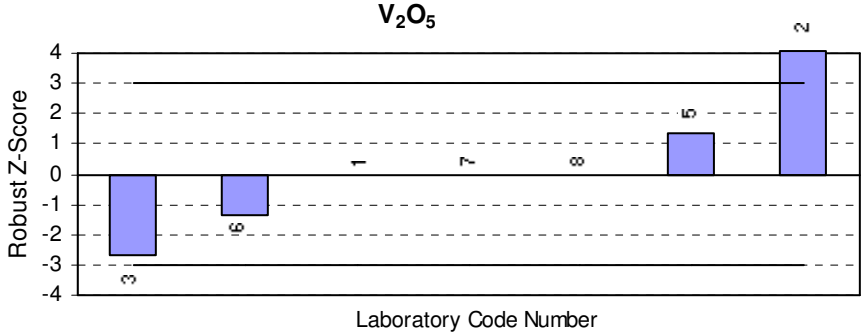



**$Mn_3O_3$**

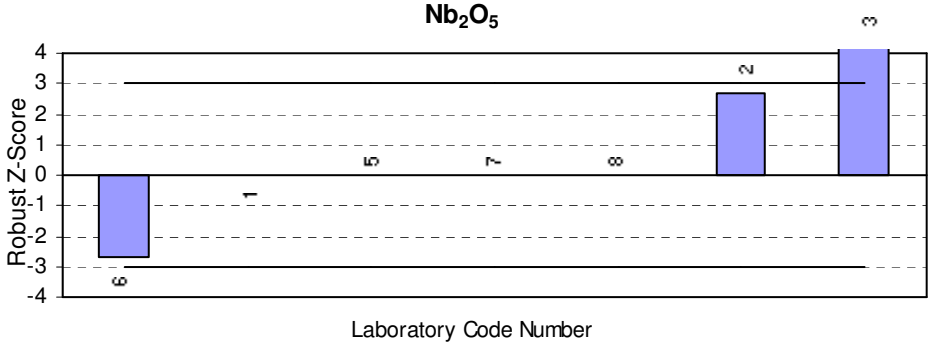


# ILMENITE BAR CHARTS

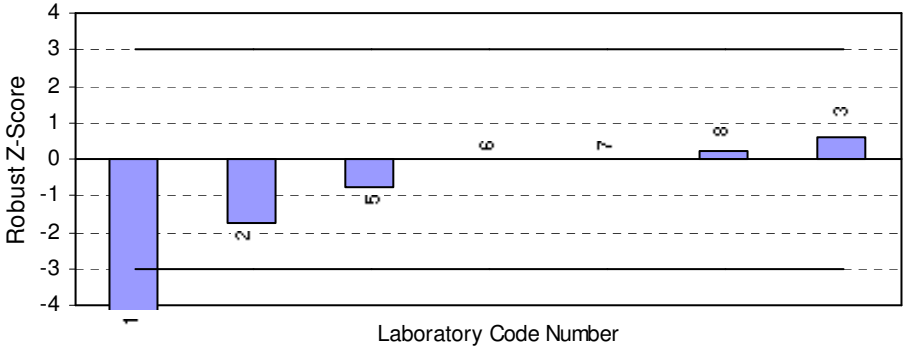
**$V_2O_5$**



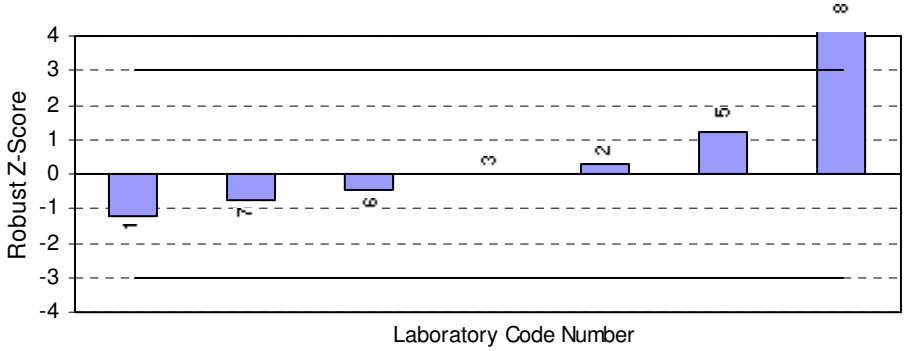

**$Nb_2O_5$**




**$Cr_2O_3$**

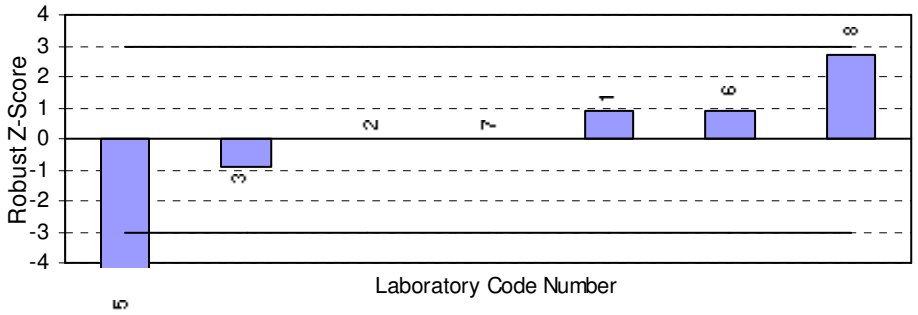



**$SO_3$**

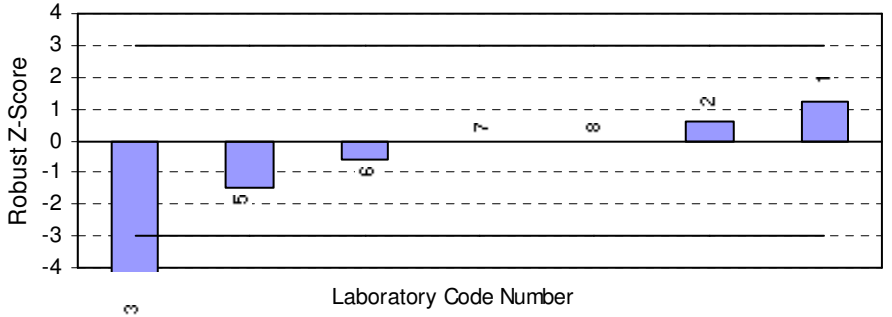


# ILMENITE BAR CHARTS

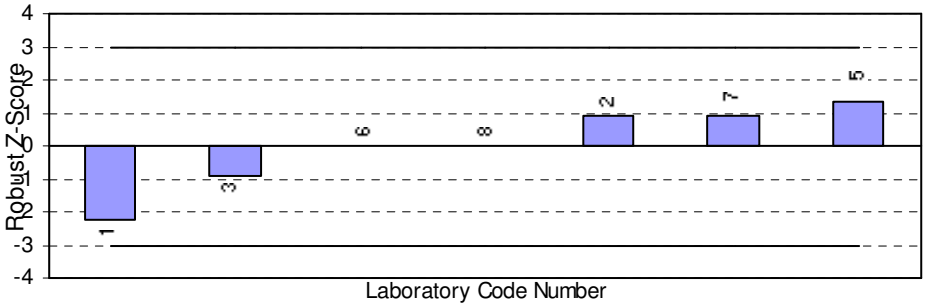
**$TiO_2$**



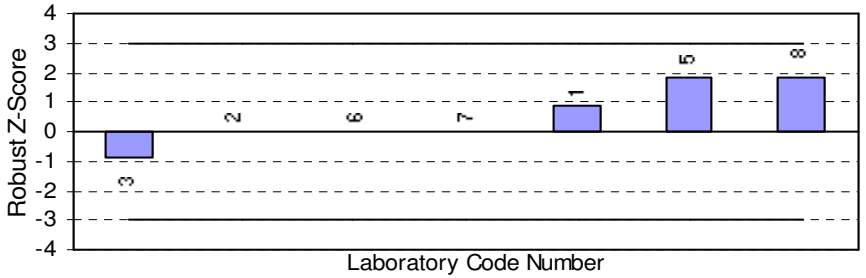

**$Fe_2O_3$**



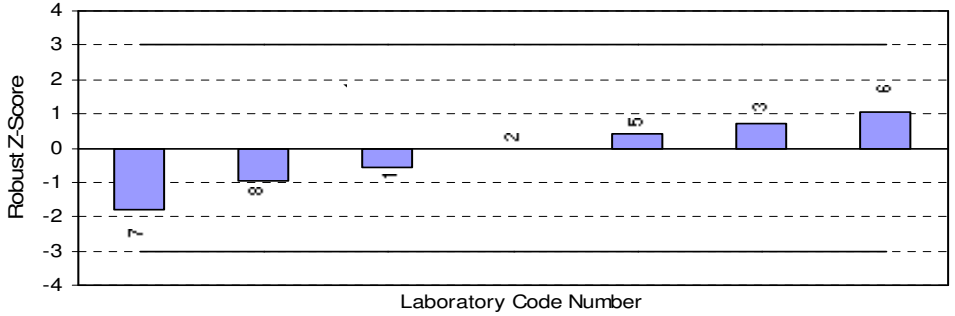

**MgO**




**$P_2O_5$**




**LOI 1000°C**



# APPENDIX A2

# ZIRCON

# ZIRCON RESULTS

Note 1:The robust z-score is caluculated for tests where the no. of results is 7
Note 2:§ denotes an outlier(i.e |z-score| >3)

| Lab Code Number | $ThO_2$ | $U_3O_8$ | $As_2O_5$ | PbO | $La_2O_3$ | $CeO_2$ | MgO |
|---|---|---|---|---|---|---|---|
| | Expresed as ppm | | | | Expressed as % to 2 dec. pl. | | |
| | Result | Result | Result | Result | Result | Result | Result |
| 1 | - | 554 | - | 321 | 0.03 | 1 | 0.03 |
| 2 | - | - | - | 1020 | - | - | nd |
| 3 | 176 | 240 | - | - | <0.01 | 0.02 | 0.01 |
| 5 | 210 | 230 | - | 120 | 0.03 | 0.02 | - |
| 6 | 198 | 269 | 47 | 63 | <0.01 | 0.03 | <0.02 |
| 7 | 187 | 241 | 21 | nd | 0.01 | 0.01 | 0.03 |
| 8 | - | - | - | - | 0.01 | 0 | 0.02 |
| No. of Results | 4 | 5 | 2 | 4 | 4 | 6 | 4 |
| Median | 192.5 | 241.0 | 34.0 | 220.5 | 0.020 | 0.020 | 0.025 |
| Normalised IQR | 12.42 | 21.50 | 9.64 | 289.11 | 0.015 | 0.011 | 0.009 |
| Robust CV | 6.5% | 8.9% | 28.3% | 131.1% | 74.1% | 55.6% | 37.1% |
| Minimum | 176 | 230 | 21 | 63 | 0.01 | 0 | 0.01 |
| Maximum | 210 | 554 | 47 | 1020 | 0.03 | 1 | 0.03 |
| Range | 34 | 324 | 26 | 957 | 0.02 | 1 | 0.02 |

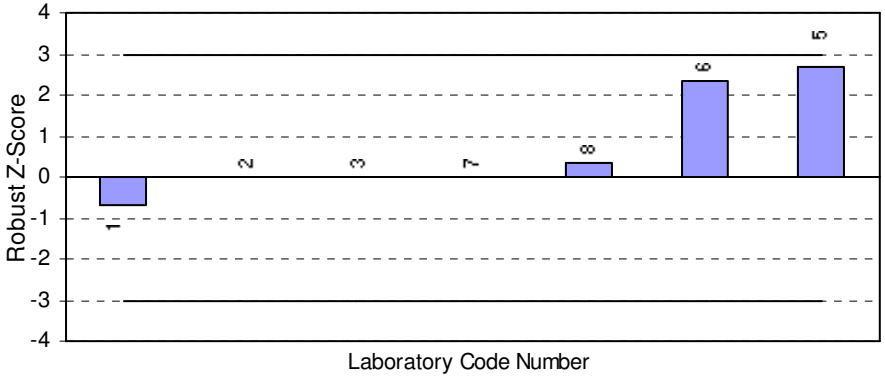
| Lab Code Number | $ZrO_2$ | | $SiO_2$ | | CaO | | LOI 1000°C | | |
|---|---|---|---|---|---|---|---|---|---|
| | Expressed as % to 1 decimal place | | | | Expressed as % to 2 decimal places | | | | |
| | Result | Robust Z-score | Result | Robust Z-score | Result | Robust Z-score | Result | Robust Z-score | |
| 1 | 64 | -0.67 | 32.5 | 0.00 | 0.03 | 0.00 | 0.16 | -0.67 | |
| 2 | 64.2 | 0.00 | 32.6 | 1.35 | 0.03 | 0.00 | 0.17 | 0.00 | |
| 3 | 64.2 | 0.00 | 32.7 | 2.70 | 0.02 | -1.35 | 0.19 | 1.35 | |
| 5 | 65 | 2.70 | 32.3 | -2.70 | 0.03 | 0.00 | 0.16 | -0.67 | |
| 6 | 64.9 | 2.36 | 32.5 | 0.00 | 0.02 | -1.35 | 0.24 | 4.72 | § |
| 7 | 64.2 | 0.00 | 32.5 | 0.00 | 0.02 | -1.35 | 0.13 | -2.70 | |
| 8 | 64.3 | 0.34 | 32.6 | 1.35 | 0.03 | 0.00 | 0.17 | 0.00 | |
| No. of Results | 7 | | 7 | | 7 | | 7 | | |
| Median | 64.20 | | 32.50 | | 0.030 | | 0.170 | | |
| Normalised IQR | 0.30 | | 0.07 | | 0.007 | | 0.015 | | |
| Robust CV | 0.5% | | 0.2% | | 24.7% | | 8.7% | | |
| Minimum | 64 | | 32 | | 0.02 | | 0.13 | | |
| Maximum | 65 | | 33 | | 0.03 | | 0.24 | | |
| Range | 1 | | 0.4 | | 0.01 | | 0.11 | | |

# ZIRCON RESULTS

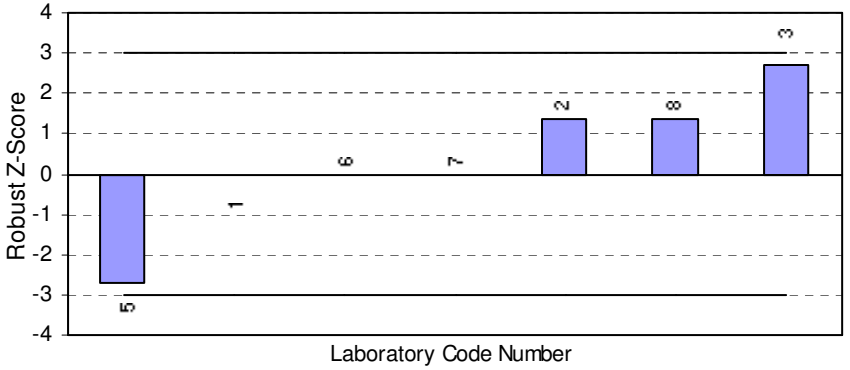
| Lab Code Number | $HfO_2$ | | $Al_2O_3$ | | $TiO_2$ | | $Fe_2O_3$ | | $P_2O_5$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Expressed as % to 2 decimal places | | | | | | | | | |
| | Result | Robust Z-score | Result | Robust Z-score | Result | Robust Z-score | Result | Robust Z-score | Result | Robust Z-score |
| 1 | 1.32 | 1.08 | 1.08 | 0.00 | 0.15 | 2.70 | 0.08 | 2.70 | 0.14 | 1.80 |
| 2 | 1.27 | -1.62 | 1.08 | 0.00 | 0.15 | 2.70 | 0.07 | 0.00 | 0.11 | -0.90 |
| 3 | 1.25 | -2.70 | 1.03 | -1.93 | 0.14 | 0.00 | 0.07 | 0.00 | 0.13 | 0.90 |
| 5 | 1.31 | 0.54 | 1.01 | -2.70 | 0.14 | 0.00 | 0.07 | 0.00 | 0.12 | 0.00 |
| 6 | 1.3 | 0.00 | 1.07 | -0.39 | 0.14 | 0.00 | 0.07 | 0.00 | 0.11 | -0.90 |
| 7 | 1.29 | -0.54 | 1.09 | 0.39 | 0.14 | 0.00 | 0.07 | 0.00 | 0.11 | -0.90 |
| 8 | 1.3 | 0.00 | 1.09 | 0.39 | 0.14 | 0.00 | 0.08 | 2.70 | 0.12 | 0.00 |
| No. of Results | 7 | | 7 | | 7 | | 7 | | 7 | |
| Median | 1.300 | | 1.080 | | 0.140 | | 0.070 | | 0.120 | |
| Normalised IQR | 0.019 | | 0.026 | | 0.004 | | 0.004 | | 0.011 | |
| Robust CV | 1.4% | | 2.4% | | 2.6% | | 5.3% | | 9.3% | |
| Minimum | 1.25 | | 1.01 | | 0.14 | | 0.07 | | 0.11 | |
| Maximum | 1.32 | | 1.09 | | 0.15 | | 0.08 | | 0.14 | |
| Range | 0.07 | | 0.08 | | 0.01 | | 0.01 | | 0.03 | |

# ZIRCON BAR CHARTS

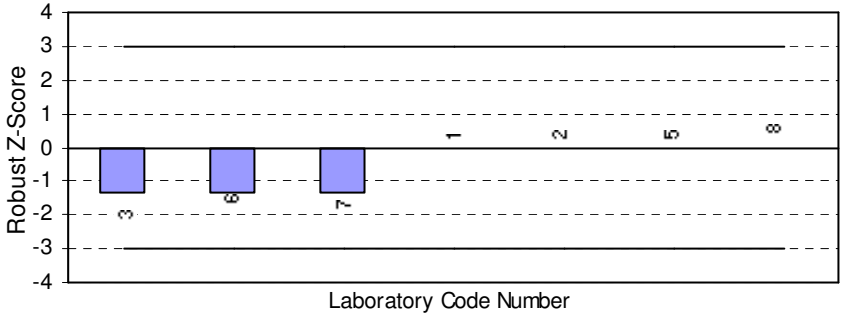
**$ZrO_2$**



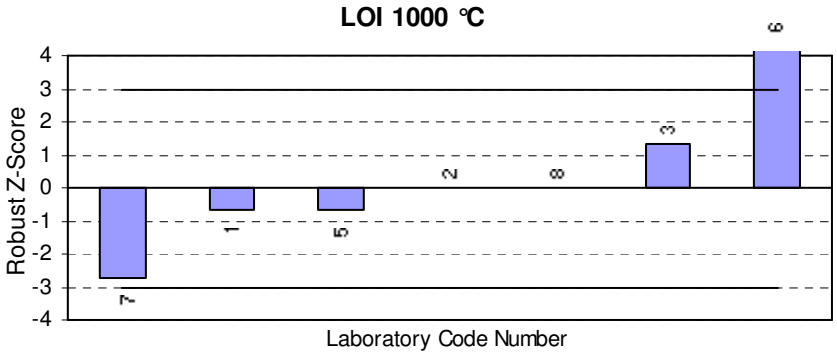

**$SiO_2$**




**CaO**



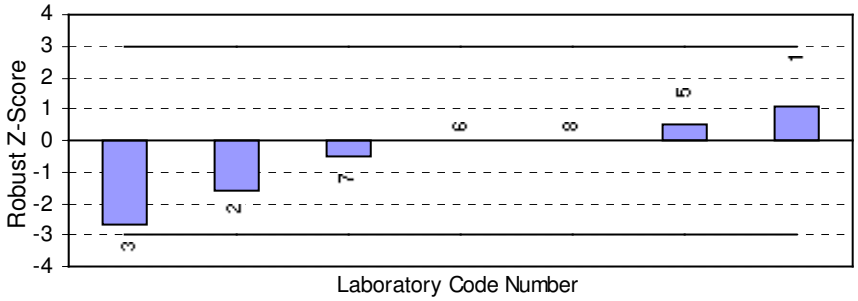

**LOI 1000 °C**



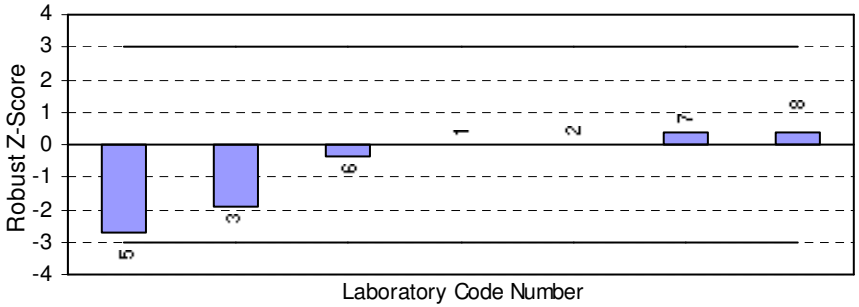
A2.4

ZIRCON BAR CHARTS

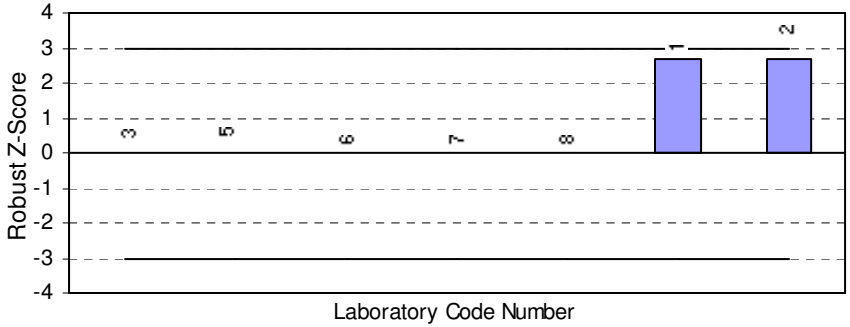
**$HfO_2$**



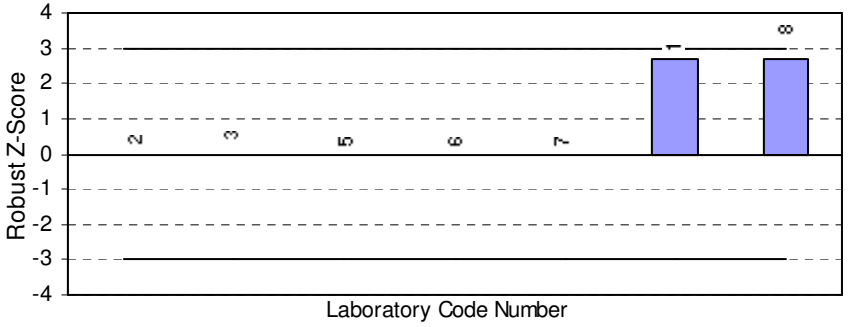

**$Al_2O_3$**



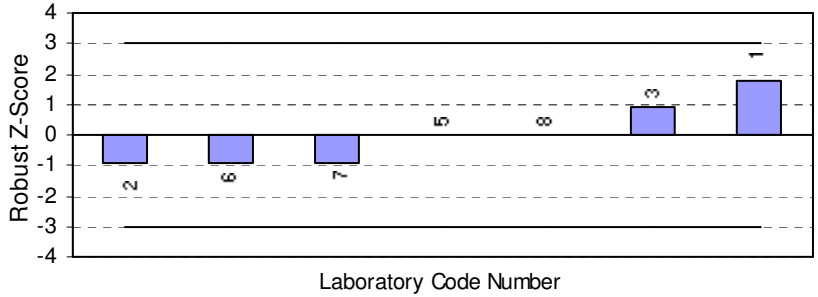

**$TiO_2$**




**$Fe_2O_3$**




**$P_2O_5$**



# APPENDIX B

# Sample Preparation

# and

# Homogeneity Testing

## SAMPLE PREPARATION

The samples were supplied by Bemax Resources Incorporating Cable Sands. They were sent out by NATA to all laboratories on 12 October 2005.

## HOMOGENEITY TESTING

As mentioned in the introduction of this report, a number of samples were selected for quality control sample analyses to ensure that sample variability was not a contributing factor to the performance of the participants.

During sample preparation for this program, ten Zircon samples (numbers: 6, 10, 11, 13, 14, 16, 18, 21, 25, 27) and ten Ilmenite samples (numbers: 20, 38, 59, 86, 94, 148, 155, 166, 180, 185) were set aside for homogeneity testing. These numbers represented the order of sample preparation.

The Zircon samples were analysed for $TiO_2$, $Fe_2O_3$, $Al_2O_3$, $P_2O_5$, $ZrO_2$, $SiO_2$, U and Th. The Ilmenite samples were analysed for $TiO_2$, $Fe_2O_3$, $Cr_2O_3$, $Al_2O_3$, $P_2O_5$, $ZrO_2$ and $SiO_2$. The results and summary statistics for the homogeneity samples are summarised on pages B2 & B3.

The analysis of these results concluded that the samples were homogenous, therefore any results identified as extreme cannot be attributed to sample variability.

### RESULTS FOR HOMOGENEITY TESTING (5 October 2005 )

### ZIRCON

| Sample No. | $TiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | $P_2O_5$ | $ZrO_2$ | $SiO_2$ | U | Th |
|---|---|---|---|---|---|---|---|---|
| 6 | 0.130 | 0.067 | 1.084 | 0.114 | 65.60 | 32.39 | 241 | 181 |
| | 0.136 | 0.078 | 1.092 | 0.113 | 65.50 | 32.47 | 253 | 181 |
| 10 | 0.137 | 0.068 | 1.063 | 0.110 | 65.54 | 32.46 | 241 | 174 |
| | 0.130 | 0.066 | 1.077 | 0.119 | 65.53 | 32.40 | 246 | 173 |
| 11 | 0.134 | 0.066 | 1.072 | 0.116 | 65.53 | 32.44 | 243 | 175 |
| | 0.138 | 0.064 | 1.082 | 0.110 | 65.49 | 32.46 | 247 | 175 |
| 13 | 0.130 | 0.078 | 1.079 | 0.119 | 65.58 | 32.38 | 250 | 175 |
| | 0.139 | 0.071 | 1.078 | 0.115 | 65.45 | 32.51 | 246 | 165 |
| 14 | 0.134 | 0.067 | 1.096 | 0.115 | 65.52 | 32.44 | 240 | 175 |
| | 0.152 | 0.081 | 1.064 | 0.117 | 65.51 | 32.44 | 249 | 177 |
| 16 | 0.130 | 0.074 | 1.088 | 0.118 | 65.55 | 32.40 | 245 | 178 |
| | 0.139 | 0.073 | 1.098 | 0.116 | 65.43 | 32.51 | 243 | 167 |
| 18 | 0.136 | 0.062 | 1.088 | 0.116 | 65.55 | 32.43 | 239 | 168 |
| | 0.137 | 0.077 | 1.073 | 0.115 | 65.47 | 32.48 | 239 | 170 |
| 21 | 0.137 | 0.070 | 1.084 | 0.112 | 65.54 | 32.42 | 241 | 174 |
| | 0.131 | 0.066 | 1.086 | 0.112 | 65.51 | 32.44 | 248 | 174 |
| 25 | 0.132 | 0.079 | 1.085 | 0.114 | 65.59 | 32.39 | 246 | 170 |
| | 0.134 | 0.069 | 1.100 | 0.113 | 65.48 | 32.47 | 247 | 176 |
| 27 | 0.139 | 0.074 | 1.083 | 0.112 | 65.54 | 32.42 | 249 | 173 |
| | 0.140 | 0.072 | 1.063 | 0.116 | 65.47 | 32.50 | 247 | 179 |
| **Summary Statistics** | | | | | | | | |
| **Median** | **0.136** | **0.071** | **1.084** | **0.115** | **65.52** | **32.44** | **246** | **175** |
| **Min** | **0.130** | **0.062** | **1.063** | **0.110** | **65.43** | **32.38** | **239** | **165** |
| **Max** | **0.152** | **0.081** | **1.100** | **0.119** | **65.60** | **32.51** | **253** | **181** |

ILMENITE

| Sample No. | $TiO_2$ | $Fe_2O_3$ | $Cr_2O_3$ | $Al_2O_3$ | $P_2O_5$ | $ZrO_2$ | $SiO_2$ |
|---|---|---|---|---|---|---|---|
| 20 | 65.28 | 26.11 | 0.079 | 1.022 | 0.081 | 0.064 | 0.560 |
| | 65.63 | 26.27 | 0.077 | 1.033 | 0.080 | 0.069 | 0.566 |
| 38 | 65.38 | 26.18 | 0.076 | 1.008 | 0.082 | 0.067 | 0.558 |
| | 65.45 | 26.25 | 0.078 | 1.036 | 0.082 | 0.064 | 0.542 |
| 59 | 65.47 | 26313 | 0.079 | 1.033 | 0.081 | 0.064 | 0.549 |
| | 65.47 | 26.31 | 0.076 | 1.056 | 0.084 | 0.063 | 0.554 |
| 86 | 65.52 | 26.18 | 0.078 | 1.026 | 0.080 | 0.065 | 0.530 |
| | 65.36 | 26.16 | 0.078 | 1.044 | 0.081 | 0.079 | 0.569 |
| 94 | 65.24 | 26.04 | 0.080 | 1.026 | 0.079 | 0.066 | 0.548 |
| | 65.36 | 26.14 | 0.078 | 1.052 | 0.084 | 0.065 | 0.532 |
| 148 | 65.41 | 26.21 | 0.077 | 1.040 | 0.082 | 0.063 | 0.555 |
| | 65.65 | 26.31 | 0.080 | 1.038 | 0.083 | 0.073 | 0.564 |
| 155 | 65.35 | 26.17 | 0.076 | 1.025 | 0.082 | 0.065 | 0.547 |
| | 65.56 | 26.26 | 0.081 | 1.025 | 0.082 | 0.067 | 0.554 |
| 166 | 65.36 | 26.19 | 0.076 | 1.025 | 0.081 | 0.065 | 0.558 |
| | 65.39 | 26.20 | 0.080 | 1.030 | 0.082 | 0.061 | 0.548 |
| 180 | 65.65 | 26.30 | 0.081 | 1.027 | 0.082 | 0.064 | 0.580 |
| | 65.39 | 26.18 | 0.078 | 1.017 | 0.082 | 0.065 | 0.548 |
| 185 | 65.45 | 26.21 | 0.078 | 1.016 | 0.081 | 0.068 | 0.558 |
| | 65.55 | 26.24 | 0.079 | 1.051 | 0.081 | 0.065 | 0.566 |
| **Summary Statistics** | | | | | | | |
| **Median** | **65.43** | **26.20** | **0.078** | **1.029** | **0.082** | **0.065** | **0.555** |
| **Min** | **65.24** | **26.04** | **0.076** | **1.008** | **0.079** | **0.061** | **0.530** |
| **Max** | **65.65** | **26.31** | **0.081** | **1.056** | **0.084** | **0.079** | **0.580** |

# APPENDIX C

# Instructions to Participants

# and

# Results Sheets

**NATIONAL ASSOCIATION OF TESTING AUTHORITIES, AUSTRALIA**

**MINERAL SANDS PROFICIENCY TESTING PROGRAM**

# INSTRUCTIONS TO PARTICIPANTS

**ROUND 1 - OCTOBER 2005**

Please read instructions carefully **BEFORE** commencing testing.

To ensure that the results of this program can be analysed properly, participants are asked to adhere carefully to the following instructions.

1. For this round each participant will be supplied with one Ilmenite and one Zircon sample. These samples should be dried at 105° – 110°C prior to assay (around 2 hours).

2. The Ilmenite sample is to be tested in accordance with AS4392.1 and the Zircon sample is to be tested in accordance with AS4392.2

3. NATA accredited laboratories are expected to carry out tests for which they are accredited for, but may also attempt tests not included in their terms of accreditation.

4. Please submit your results on the *Results Sheets* provided. NATA accredited laboratories are also required to submit an endorsed test report.

5. All laboratories are to return their results **BY FRIDAY 28 October 2005 to**:

Ms Karen Cividin
National Association of Testing Authorities, Australia
7 Leeds Street
RHODES NSW 2138 Fax: (02) 9743 6664 or (02) 9743 5311
Telephone: (02) 9736 8222 email : kcividin@nata.asn.au

6 To allow for the confidential treatment of your results in the final report, you have been allocated a code number which appears on your results sheet.

**NATIONAL ASSOCIATION OF TESTING AUTHORITIES, AUSTRALIA**

**MINERAL SANDS PROFICIENCY TESTING PROGRAM - ROUND 1 – OCTOBER 2005**

**RESULTS SHEET - ILMENITE**

Laboratory Code

| Oxide | Usually as | Express as % to 3 decimal places |
|---|---|---|
| $Cr_2O_3$ | $Cr_2O_3$ | |
| $So_3$ (as S) | $So_3$ (as S) | |

| Oxide | Usually as | Express as ppm |
|---|---|---|
| $ThO_2$ | Th | |
| $U_3O_8$ | U | |
| $SnO_2$ | Sn | |
| $As_2O_5$ | As | |
| PbO | Pb | |
| N/A | Zn | |

| Oxide | Usually As | Express as % to 1 decimal place |
|---|---|---|
| | | |
| $TiO_2$ | TiO2 | |
| $Fe_2O_3$ | Fe2O3 | |
| AS4614.1 – 1999 | TiO2 wet | |
| N/A | FeO | |

| Oxide | Usually As | Express as % to 2 decimal places |
|---|---|---|
| $Al_2O_3$ | $Al_2O_3$ | |
| $SiO_2$ | $SiO_2$ | |
| $ZrO_2$ | $ZrO_2$ | |
| $Mn_3O_4$ | $Mn_3O_4$ | |
| $V_2O_5$ | $V_2O_5$ | |
| $Nb_2O_5$ | $Nb_2O_5$ | |
| CaO | Cao | |
| MgO | MgO | |
| $CeO_2$ | $CeO_2$ | |
| $P_2O_5$ | $P_2O_5$ | |
| $La_2O_3$ | $La_2O_3$ | |
| N/A | LOI 1000℃ | |

Date Sample Tested .....……..

Comments .....

**NATIONAL ASSOCIATION OF TESTING AUTHORITIES, AUSTRALIA**

**MINERAL SANDS PROFICIENCY TESTING PROGRAM - ROUND 1 – OCTOBER 2005**

**RESULTS SHEET - ZIRCON**

Laboratory Code ☐

| Oxide | Usually as | Express as ppm |
|---|---|---|
| $ThO_2$ | Th | |
| $U_3O_8$ | U | |
| $As_2O_5$ | As | |
| PbO | Pb | |

| Oxide | Usually As | Express as % to 1 decimal place |
|---|---|---|
| $ZrO_2$ | $ZrO_2$ | |
| $SiO_2$ | $SiO_2$ | |

| Oxide | Usually As | Express as % to 2 decimal places |
|---|---|---|
| $HfO_2$ | $HfO_2$ | |
| $Al_2O_3$ | $Al_2O_3$ | |
| $TiO_2$ | $TiO_2$ | |
| $Fe_2O_3$ | $Fe_2O_3$ | |
| $P_2O_5$ | $P_2O_5$ | |
| CaO | CaO | |
| $La_2O_3$ | $La_2O_3$ | |
| $CeO_2$ | $CeO_2$ | |
| N/A | MgO | |
| N/A | LOI 1000℃ | |

Date Sample Tested .....……...

Comments .....

……