ASH CONSTITUENTS' PROFICIENCY TESTING

REPORT SIXTY-FIVE

Revision: 00

Final report

30 MAY 2023

LABORATORY CODE: b

(signature)

R BABOOLAL (SCHEME MANAGER)

EXECUTIVE SUMMARY

1. Thirteen samples were sent to participants with 11 results reported back.
2. The total number of outliers found were as follows:

- K_2O x2
- MnO_2x2
- CaOx2
- MnO_2x1
- SO_3 x1
- P_2O_5 x1

3. Robust statistics were applied where ten or more results were available.
4. Use the z-score trend as an indication of the overall laboratory performance.

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Dear Participant

RE: PROFICIENCY TESTING RESULTS FOR THE MONTH OF MAY 2023

Thank you for your participation in the Coal Concepts Ash constituent's proficiency testing scheme.

Your laboratory code is as per the cover page.

All results are totally confidential. Any results in ***bold, italics, underlined*** are outliers. Where applicable, the most extreme outliers have been eliminated from calculation of averages using the Grubbs estimate for outliers.

Please take note of the following:

1. Z-scores between -1 and +1 is deemed acceptable

2. Z-scores between -2 and -3 should serve as a warning that the analysis result could get worse

3. Z-scores between +2 and +3 should also serve as a warning that analysis results could get worse.

4. Z- scores lower than -3 and exceeding +3 should warrant an investigation

6. All calculations can be made available upon request

The Coal Concepts scheme adheres to the requirements of ISO/IEC 17043:2010 – Conformity assessment – General requirements for proficiency testing.

Statistical analysis has been carried out using ISO/IEC 13528:2022-Statistical methods for use in proficiency testing by interlaboratory comparisons.

Please find results attached together with Z-score trends.

Best Regards

R Baboolal

LIST OF PARTICIPANTS IN ALPHABETICAL ORDER

AfriSam (South Africa) (Pty) Ltd - Dudfield
AfriSam (South Africa) (Pty) Ltd - Ulco
Alfred H Knight Richards Bay Lab
Bureau Veritas Inspectorate Laboratories Alton
Laboratory for solid fuels-Mining Institute Belgrade
Morupule Coal Mine - Botswana
Rio Tinto –Richards Bay
Ronewa Middelburg
SABS Commercial SOC - CSIR Laboratory
SABS Commercial SOC - Richards Bay Laboratory
Sibonisiwe Coal Laboratory Services
Siza Coal Services - Middelburg
Siza Minerals Lab - Palapye
South 32 -Hotazel Manganese Mines
UIS Analytical Services
Vinca Institute of Nuclear Sciences – Serbia

1. **TYPE OF SAMPLE USED**

   The ash used in this proficiency testing round was obtained from local thermal coal.

2. **PREPARATION OF SAMPLE**

   About 5kgs coal was pulverised to -212um. The coal was ashed in a furnace according to the ISO ashing programme. The bulk sample was transferred to a 5-litre container. The sample was homogenised by shaking the 5-litre container vigorously, for half an hour. Samples from the 5-litre container were then transferred into 100ml plastic bottles. Each sample weighed approximately 10 grams. Two hundred and seventy bottles of sample were weighed out. Five bottles were randomly selected and tested for homogeneity SO_3 as the analysed.

3. **HOMOGENEITY CHECK**

| SAMPLE NO.	TEST PORTION 1	TEST PORTION 2	sample av (Xt)	range (Wt)	range sqd
1	3,21	3,23	3,22	0,02	0,0004
2	3,25	3,31	3,28	0,06	0,0036
3	3,14	3,19	3,17	0,05	0,0025
4	3,40	3,36	3,38	0,04	0,0016
5	3,23	3,28	3,26	0,05	0,0025
GENERAL AVERAGE			3,26		
STANDARD DEVIATION			0,080		
WITHIN SAMPLE STANDARD DEVIATION			0,033		
BETWEEN SAMPLE STANDARD DEVIATION			0,076		

The between sample standard deviation must be ≤ 0.3 x σ

(σ = std deviation for the proficiency assessment)

σ = 0.103 was used (repeatability for SO3)

Hence 0.3 x 0.103 = 0.031

Since 0.007 < 0.031 the samples are homogenous

COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023		
ANALYTICAL PARAMETER: SiO2 (%)		
LAB ID	**SiO2 %**	**Z-SCORE**
1b	47,39	-1,16
3b	51,09	0,44
4b	49,69	-0,17
7b	49,22	-0,37
12b	48,34	-0,75
13b	55,37	2,28
20b	48,05	-0,87
23b	49,86	-0,09
24b	52,06	0,85
26b	49,71	-0,16
Number of results	-	**10**	-
OUTLIERS	-	**0**	-
AVERAGE	-	**50,08**	-
MEDIAN		**49,70**	
STD DEVIATION	-	**2,32**	-
ROBUST AVERAGE	-	**49,75**	-
ROBUST STD DEV	-	**2,22**	-
U,O,M	-	**0,88**	-

SiO2 Z-SCORE TREND
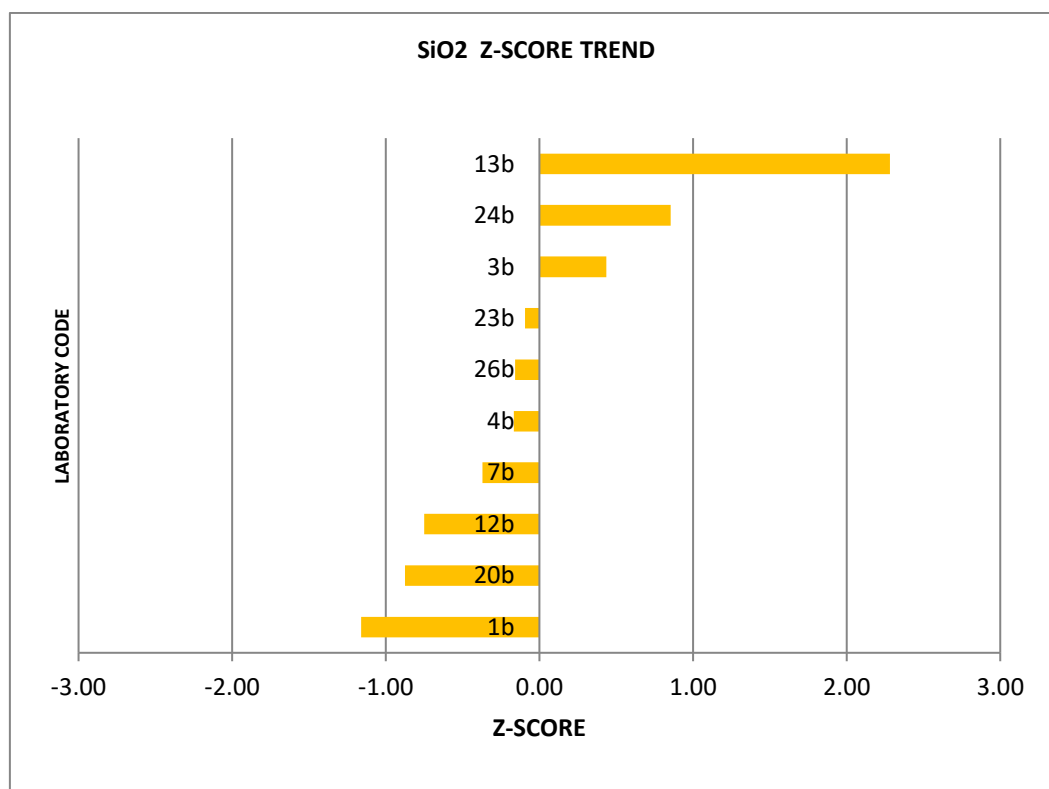
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023			
ANALYTICAL PARAMETER: Al2O3 (%)			
	LAB ID	Al2O3 %	Z-SCORE
	1b	31,27	-0,08
	3b	31,34	-0,06
	4b	29,33	-0,68
	7b	33,48	0,60
	12b	31,93	0,12
	13b	29,48	-0,64
	20b	36,98	1,68
	23b	35,34	1,17
	24b	25,51	-1,87
	26b	30,77	-0,24
Number of results	-	10	-
OUTLIERS	-	0	-
AVERAGE	-	31,54	-
MEDIAN	-	31,31	-
STD DEVIATION	-	3,23	-
ROBUST AVERAGE	-	31,62	-
ROBUST STD DEV	-	3,35	-
U.O.M	-	1,33	-

Al2O3 z-score trend
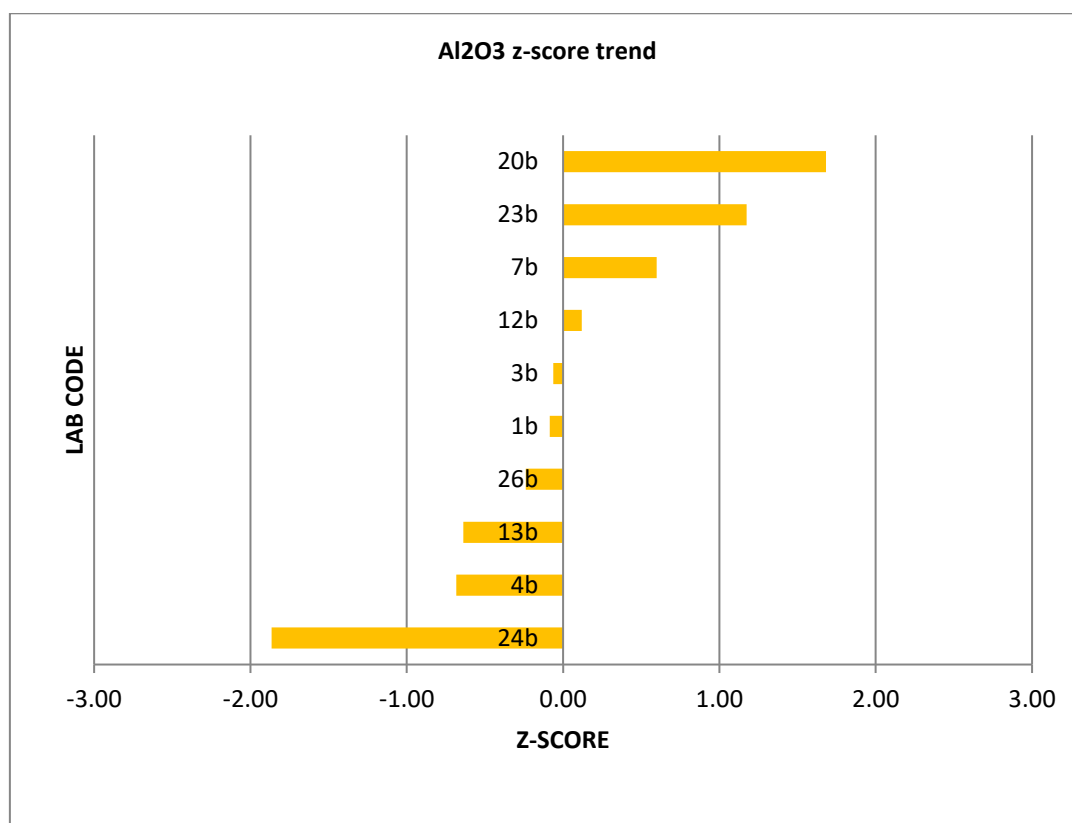
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023			
ANALYTICAL PARAMETER: K2O (%)			
	LAB ID	**K2O %**	**Z-SCORE**
	1b	0,54	0,68
	*3b***	*0,80*	*6,90*
	4b	0,52	0,21
	7b	0,45	-1,47
	*13b***	*0,06*	*-10,80*
	20b	0,46	-1,23
	23b	0,54	0,68
	24b	0,56	1,16
	26b	0,51	0,00
Number of results	-	**9**	-
OUTLIERS	-	**2**	-
AVERAGE	-	**0,51**	-
MEDIAN		**0,52**	-
STD DEVIATION	-	**0,04**	-
ROBUST AVERAGE	-	-	-
ROBUST STD DEV	-	-	-
U,O,M	-	-	-

K2O Z-SCORE TREND
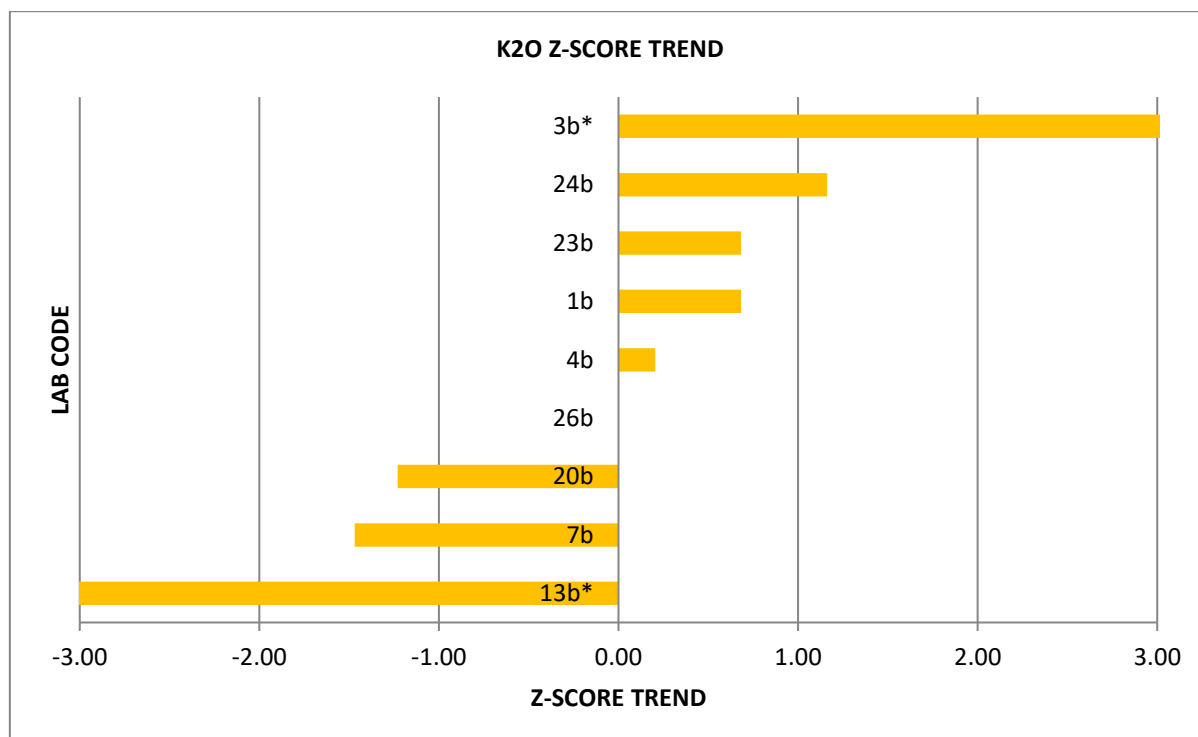
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023		
ANALYTICAL PARAMETER: MgO (%)		
LAB ID	**MgO %**	**Z-SCORE**
1b	1,64	0,28
3b	1,61	0,22
4b	1,69	0,37
7b	1,93	0,79
12b	1,69	0,37
13b	2,17	1,22
20b	2,02	0,95
22b	1,49	0,00
23b	0,41	-1,92
24b	0,64	-1,51
26b	1,05	-0,78
Number of results	-	**11**	-
OUTLIERS	-	**0**	-
AVERAGE	-	**1,49**	-
MEDIAN		**1,64**	
STD DEVIATION	-	**0,56**	-
ROBUST AVERAGE	-	**1,53**	-
ROBUST STD DEV	-	**0,67**	-
U,O,M	-	**0,25**	-

MgO Z-SCORE TREND

LAB CODE
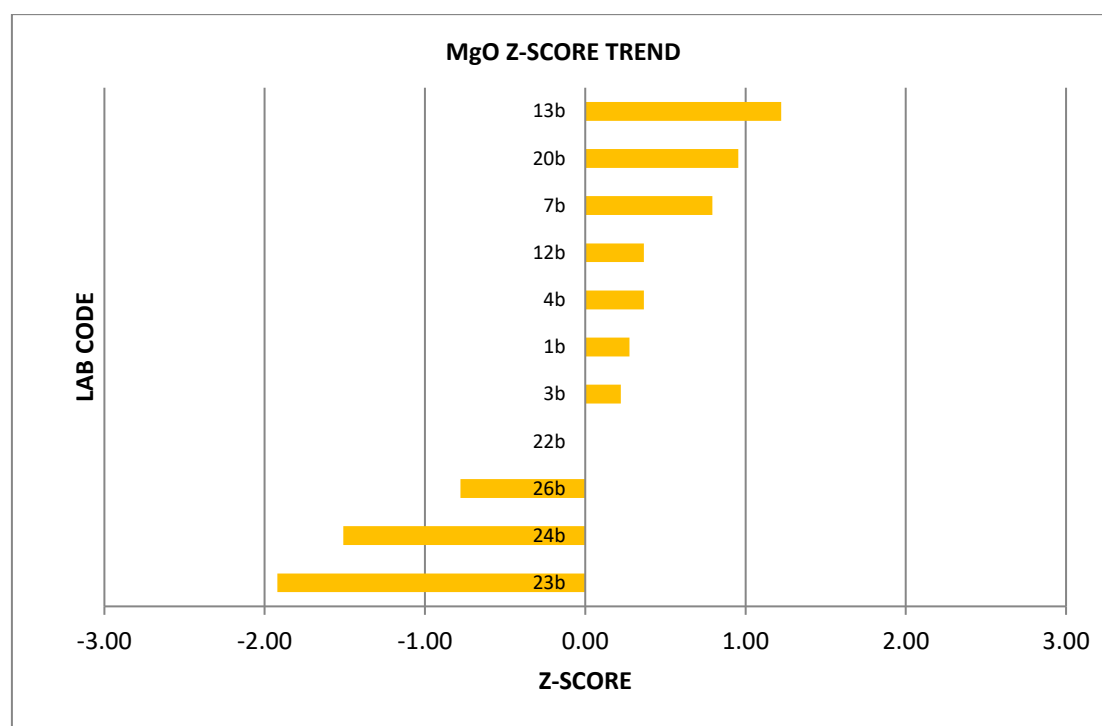
Z-SCORE

COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023		
ANALYTICAL PARAMETER : CaO (%)		
LAB ID	CaO %	Z-SCORE
1b	7,48	1,27
*3b**	*5,20*	*-6,30*
4b	7,08	-0,05
7b	7,34	0,81
12b	7,44	1,14
13b	6,87	-0,75
20b	6,57	-1,75
22b	7,05	-0,15
*23b**	*3,06*	*-13,39*
24b	7,19	0,31
26b	6,85	-0,82

Number of results	-	**11**	-
OUTLIERS	-	**2**	-
AVERAGE	-	**7,10**	-
MEDIAN	-	**7,08**	-
STD DEVIATION	-	**0,30**	-
ROBUST AVERAGE	-	-	-
ROBUST STD DEV	-	-	-
U.O.M	-	-	-

CaO Z-SCORE TREND
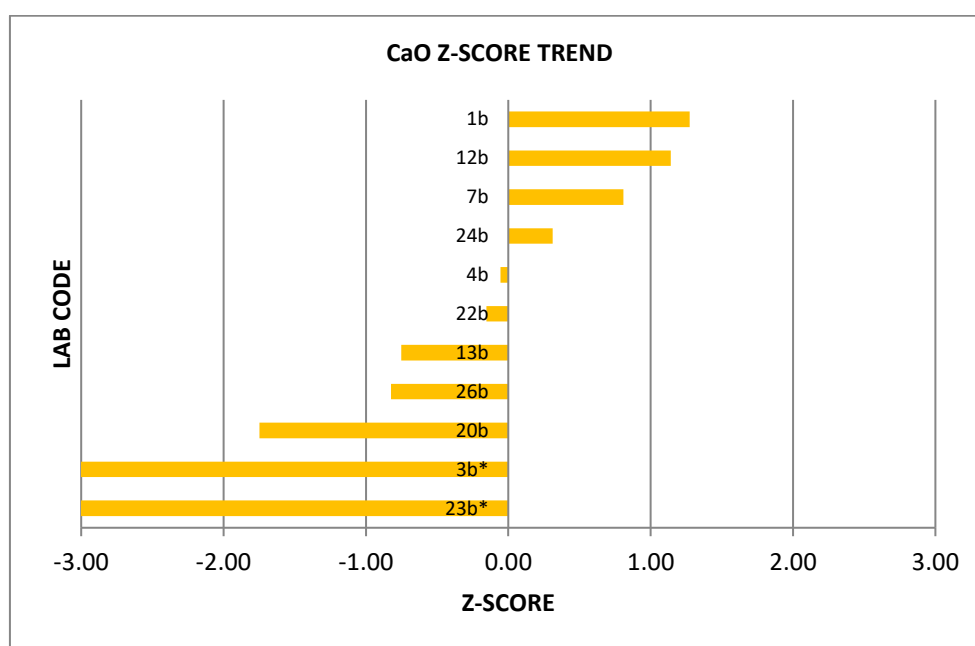
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023		
ANALYTICAL PARAMETER : MnO2 (%)		
LAB ID	MnO2 %	Z-SCORE
1b	0,056	0,28
3b	0,039	-1,54
4b	0,062	0,92
7b	0,070	1,78
12b	0,050	-0,36
*13b**	*3,870*	*408,89*
20b	0,050	-0,36
24b	0,050	-0,36
26b	0,050	-0,36
Number of results	-	9	-
OUTLIERS	-	1	-
AVERAGE	-	0,053	-
MEDIAN	-	0,050	-
STD DEVIATION	-	0,009	-
ROBUST AVERAGE	-	-	-
ROBUST STD DEV	-	-	-
U,O,M	-	-	-

MnO2 Z-SCORE TREND
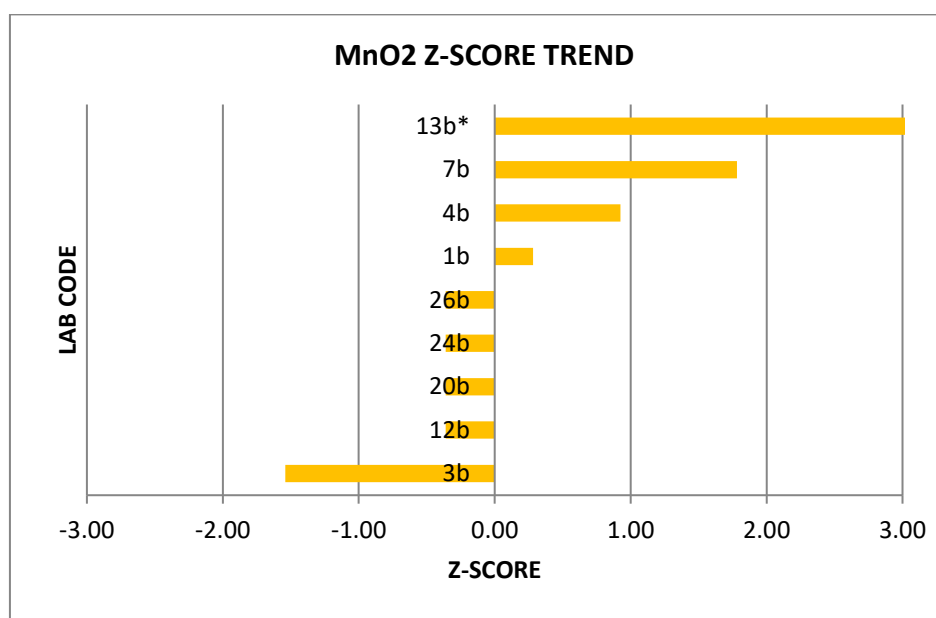
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023		
ANALYTICAL PARAMETER: Fe2O3 (%)		
LAB ID	Fe2O3 %	Z-SCORE
1b	3,51	-0,35
3b	3,33	-0,98
4b	3,42	-0,66
7b	3,85	0,84
12b	3,49	-0,42
13b	4,01	1,40
20b	3,28	-1,15
23b	4,12	1,78
24b	3,53	-0,28
26b	3,55	-0,20
Number of results	-	10	-
OUTLIERS	-	0	-
AVERAGE	-	3,61	-
MEDIAN	-	3,52	-
STD DEVIATION	-	0,29	-
ROBUST AVERAGE	-	3,59	-
ROBUST STD DEV	-	0,38	-
U.O.M	-	0,15	-

Fe2O3 Z-SCORE TREND
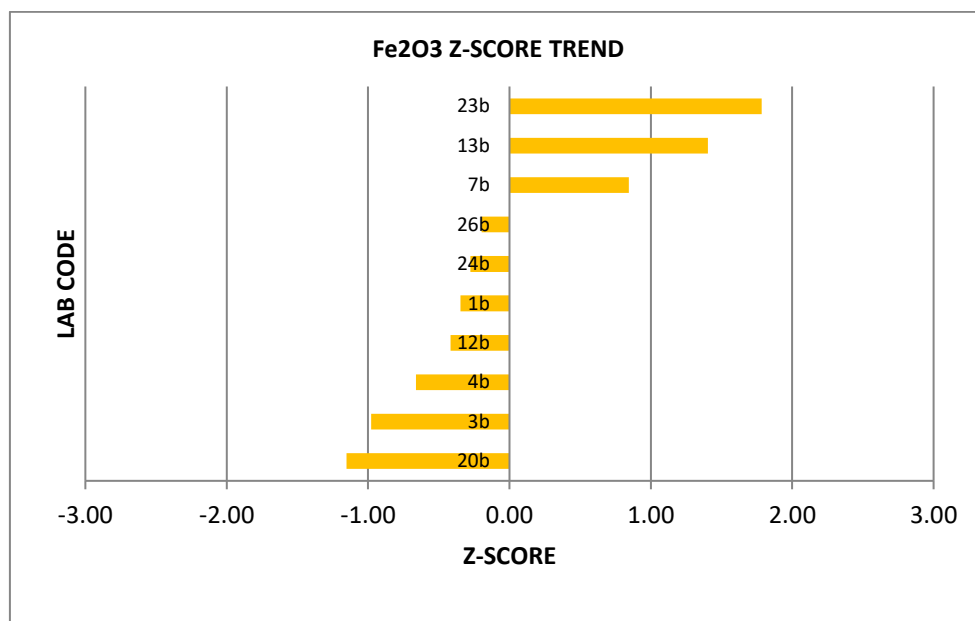
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023			
ANALYTICAL PARAMETER : Na2O (%)			
	LAB ID	**Na2O %**	**Z-SCORE**
	1b	0,11	-0,76
	3b	0,47	1,84
	4b	0,13	-0,61
	20b	0,28	0,47
	24b	0,16	-0,40
	26b	0,14	-0,54
Number of results	-	**6**	-
OUTLIERS	-	**0**	-
AVERAGE	-	**0,22**	-
MEDIAN	-	**0,15**	-
STD DEVIATION	-	**0,14**	-

NaO Z-SCORE TREND
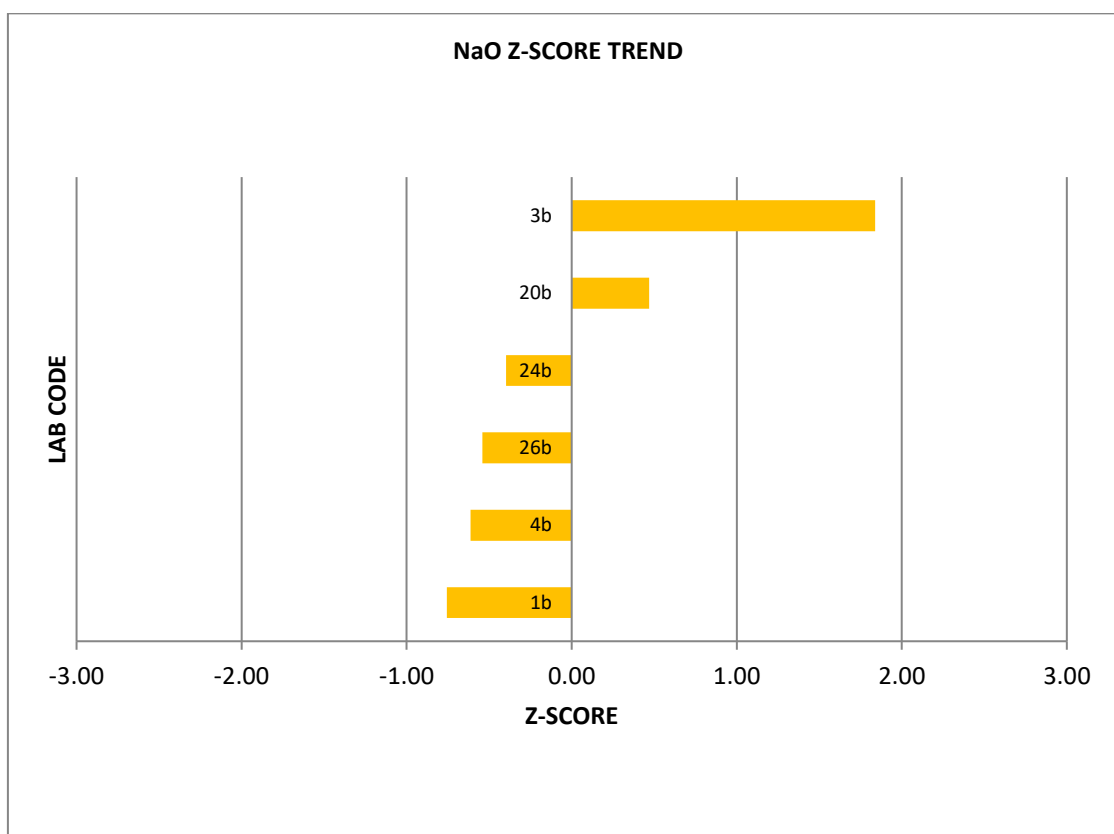
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023		
ANALYTICAL PARAMETER: TiO2 (%)		
LAB ID	**TiO2 %**	**Z-SCORE**
1b	1,66	0,00
3b	1,56	-1,16
4b	1,66	0,00
7b	1,62	-0,46
12b	1,65	-0,10
13b	1,81	1,79
20b	1,55	-1,28
23b	1,79	1,56
24b	1,66	0,00
26b	1,63	-0,39
Number of results	-	10	-
OUTLIERS	-	0	-
AVERAGE	-	1,66	-
MEDIAN	-	1,66	-
STD DEVIATION	-	0,08	-
ROBUST AVERAGE	-	-	-
ROBUST STD DEV	-	-	-
U.O.M	-	-	-

TiO2 Z-SCORE TREND
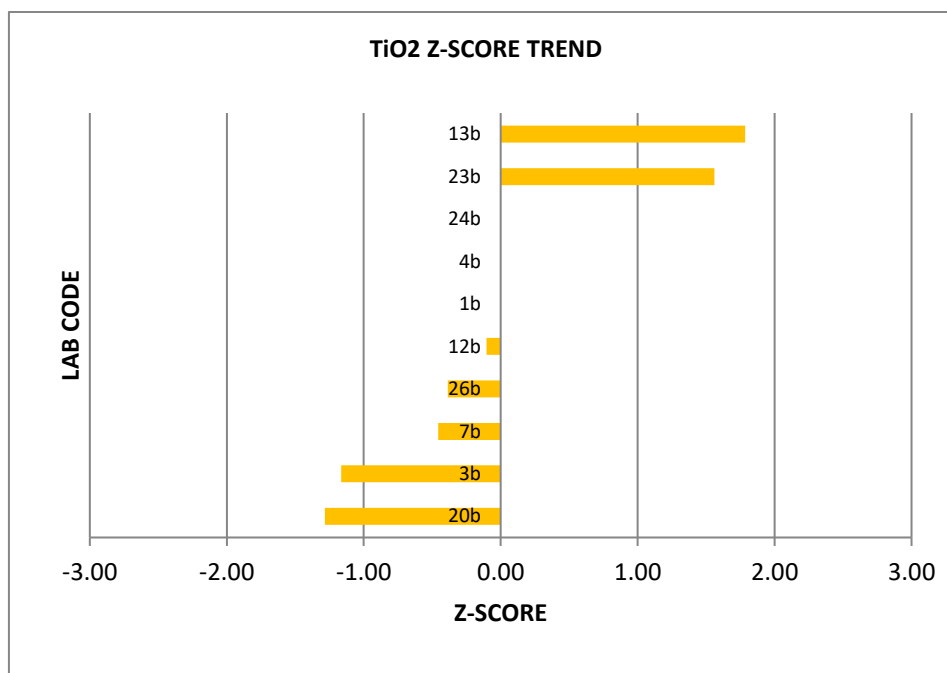
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023			
ANALYTICAL PARAMETER : SO3 (%)			
	LAB ID	SO3 %	Z-SCORE
	1b	3,49	0,80
	3b	3,93	1,15
	4b	3,22	0,58
	*13b**	*0,002*	*-2,02*
	20b	0,89	-1,30
	23b	0,77	-1,40
	24b	2,76	0,21
	26b	2,46	-0,03
Number of results	-	8	-
OUTLIERS	-	0	-
AVERAGE	-	2,50	-
MEDIAN	-	2,76	-
STD DEVIATION	-	1,24	-

SO3 Z-SCORE TREND
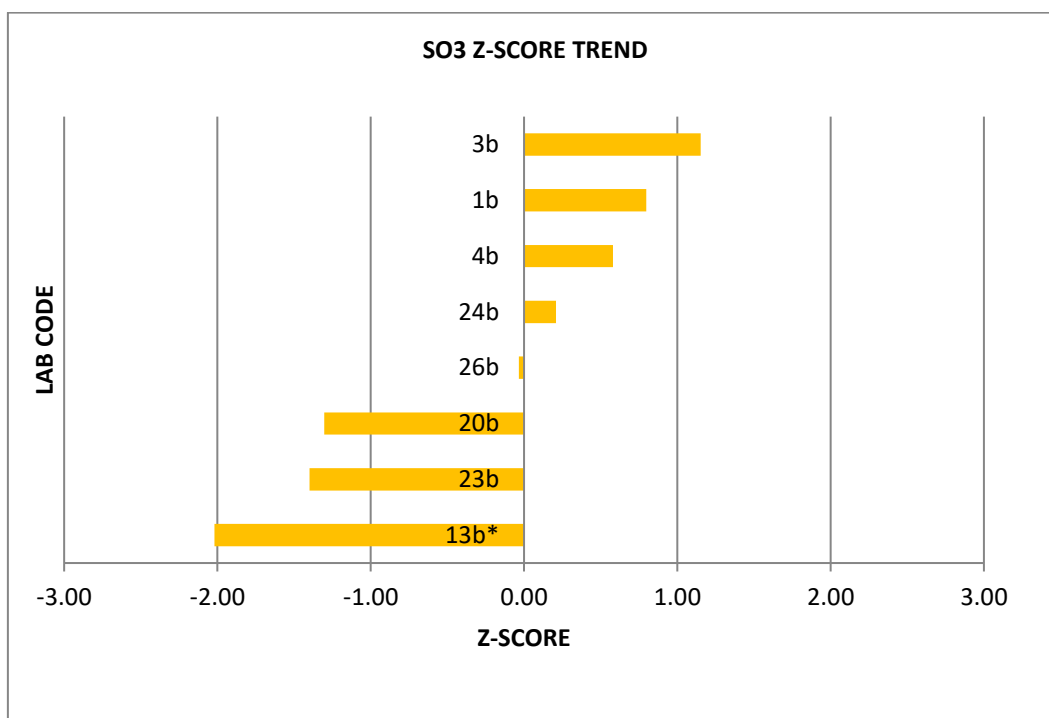
COAL CONCEPTS - PROFICIENCY TESTING - MAY 2023			
ANALYTICAL PARAMETER : P2O5 (%)			
	LAB ID	**P2O5 %**	**Z-SCORE**
	1b	1,30	0,90
	*3b**	*0,14*	*-41,55*
	4b	1,29	0,54
	*7b**	*1,60*	*11,88*
	13b	1,30	0,90
	20b	1,23	-1,66
	22b	1,26	-0,56
	*23b**	*3,03*	*64,18*
	*24b**	*1,91*	*23,23*
	26b	1,27	-0,12
Number of results	-	10	-
OUTLIERS	-	4	-
AVERAGE	-	1,28	-
MEDIAN		1,28	-
STD DEVIATION	-	0,03	-
ROBUST AVERAGE	-	-	-
ROBUST STD DEV	-	-	-
U.O.M	-	-	-

P2O5 Z-SCORE TREND
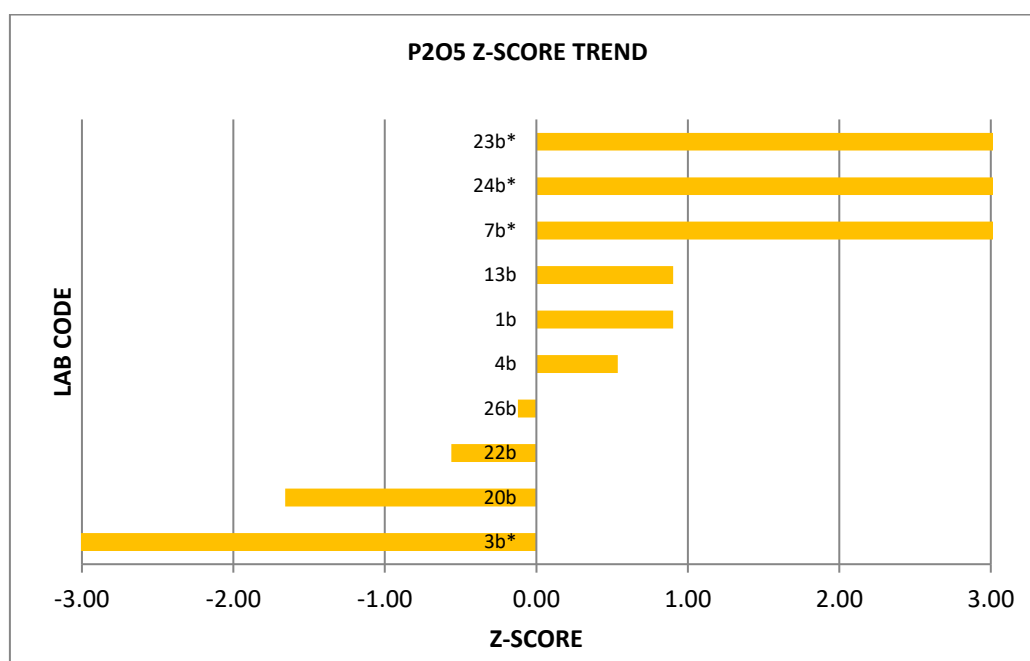
4. CONCLUSIONS

4.1 SiO_2 analysis had a negative z-score distribution. The average and median differed by 0.38% with the standard deviation at 2.32. Wide range of results received.

4.2 Al_2O_3 has a negative bias z-score distribution. The median and mean and differed from each other. No outlier detected.

4.3 K_2O Z-Score has a positive bias z-score distribution. Two outliers were detected. Results compare well.

4.4 MgO had no outliers. Z-score has positive bias distribution.

4.5 The z-score trend is widely distributed on CaO analysis. Mean and median differed by 0.02.

4.6 MnO_2: The median and average compared well. One outlier was detected.

4.7 Fe_2O_3 : The z-score trending is evenly distributed. Average and Median are similar.

4.8 Na_2O – trending was evenly spread. No outlier detected.

4.9 TiO_2 analysis was well done. Mean, Median compared well. No outlier detected. This was due to a high precision of the rest of the results.

4.10 SO_3 : Results received were acceptable, with a standard deviation of 1.24 %

4.11 P_2O_5: Average and median are the same.

End of report

COAL CONCEPTS: Terms and Conditions

<u>Return of results:</u>
Laboratories participate in proficiency testing programs on the understanding that they will be sharing their results and information **anonymously** with other laboratories performing the same analysis. No return of results compromises the spirit of the programs, and reports will not be sent to laboratories unless they return results. Payment in full is required from all laboratories enrolling whether they return results or not.

<u>Errors in Participant Proficiency Testing Results:</u>
Proficiency testing reports should reflect the level of accuracy that a regular testing client would receive.

If a participant finds an error in their proficiency testing results, they may notify us in writing and change their submission **PRIOR** to the due date for return. Changes after this time will not be accepted.

Coal Concepts' reports results *as submitted* by participants.

On occasion, it seems as though participants have mixed up the samples or not processed the samples according to the instructions. Coal Concepts cannot make assumptions of this nature and change results 'to suit'. We also cannot compromise the integrity of the programs by suggesting to some participants that they should review their results prior to the due date. (This is unfair to other participants) It is the responsibility of the participants to check all aspects of the program, including sample identification, preparation, testing instructions, calculations and reporting of the results prior to results submission.

If samples are not in good condition on arrival to the participant laboratory, Coal Concepts must be notified in writing IMMEDIATELY, as often samples can be replaced in good time. Claims about samples received in bad condition will not be accepted after the report has been issued.

<u>Late Enrolments and Late Results:</u>
Late enrolment requests cannot always be accommodated, as sample manufacture must be scheduled well in advance to the shipping date of the program to allow all necessary quality assurance activities to be carried out.

Shipping of PT materials and evaluating test results from PTPs out of cycle with the mainstream programs is considerably time consuming and therefore costly.

In order not to disadvantage participants able to comply with time frames, Coal Concepts may charge a late fee in the following circumstances:
Requests that Coal concepts staff enters results on behalf of participants.
Requests to record results after the due date.
Requests for PTP participation that is out of cycle with the scheduled dates.

<u>Shipping fees and Customs clearance:</u>
Costs incurred for shipping samples and clearance of same through customs are the responsibility of the participating laboratory unless otherwise indicated.

<u>Non-payment of fees:</u>
Coal Concepts retains the right to withhold reports and/or test materials and services when invoices are outstanding.

<u>Confidentiality of results:</u>
All data and information received by Coal Concepts from its clients are considered confidential unless the client has given express permission to pass on information.

<u>Definitions</u>:
The dictionary definitions of "collusion" and "falsification" are as follows.
· *Collusion:* A secret agreement or cooperation for a fraudulent or deceitful purpose.
· *Falsification:* Deliberately changing something to be false. In proficiency testing terms, collusion is comparing data (and perhaps changing data) to fit in with a believed "correct" result. This is contrary to the spirit of proficiency testing programs, which are issued with the intention of providing an objective comparison of a laboratory's performance with others. Coal Concepts tries to minimise the occurrence of collusion by being aware that laboratories should be objective when they report their results and should therefore not know the intended results at the time they are reporting to us.

Answers are not provided to clients until results have been submitted.
To prevent collusion and falsification our advice to clients is:
DON'T confer with others about PT samples or results.
DO accept the fact that everyone makes errors.
DON'T average the results or opinions of every person in the laboratory before selecting the answer to be submitted. Instead, use one of the answers AS SUBMITTED to you and take advantage of the Coal Concepts internal QA services and submit all answers generated by the technicians.
DO have confidence in your own results.
Proficiency Testing (PT) is a compulsory part of laboratory accreditation, but it is also an important tool for giving you confidence in your results.
"Enhancing" your PT results with assistance from another participant cannot increase.
confidence in your laboratory's performance.
Coal concepts' testing staff are not told what the expected results are, nor what we are expecting.
We subject ALL results to analysis, even if they are different.
The staff have the right to check that the results we enter on their behalf are correctly transcribed.
Clients are always welcome to contact Coal Concepts to seek advice or information about collusion or falsification of data.

<u>Policy for Participant Appeal of PT Performance Assessment:</u>
If participants disagree with their performance assessment in a proficiency report, they should inform Coal Concepts in writing.
The response will include Coal Concepts interpretation of the outcome of the reassessment and an explanation of that outcome. (For example, explanation of a calculation, or the rationale for the outcome of the evaluation.)
If a mistake has been made by Coal Concepts, it will be dealt with via Coal Concepts' non-conformance system.

<u>Liability</u>
In no event shall a party's liability to the other party for direct damages exceed an amount equal to the value of the amount for the PT Programme, under that specific month.