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SY–2, SY–3 AND MRG–1 REPORT ON THE COLLABORATIVE ANALYSIS OF THREE CANADIAN ROCK SAMPLES FOR USE AS CERTIFIED REFERENCE MATERIALS - SUPPLEMENT I

Sydney Abbey
Geological Survey of Canada

NOVEMBER 1976

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SY-2, SY-3 AND MRG-1
A REPORT ON THE COLLABORATIVE ANALYSIS OF THREE CANADIAN ROCK SAMPLES FOR USE AS CERTIFIED REFERENCE MATERIALS - SUPPLEMENT 1.

Sydney Abbey*

ABSTRACT

Additional data received since the original report, MRP/MSL 75-132(TR), was prepared, are presented. New recommended values are assigned to several constituents.

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* Geological Survey of Canada, Ottawa.

RESUME

On présente des données additionnelles, reçues depuis la préparation du compte rendu original, MRP/MSL 75-132(TR). On recommande des valeurs nouvelles pour quelques composants.

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* Commission géologique du Canada, Ottawa.

CONTENTS

Foreword iii
Introduction 1

Collaborative analysis 1
Derivation of assigned values 1
Conclusion 2
Acknowledgements 2
References 3

Table 1: Reported Values for Major and Minor Components, per cent 5
Table 2: Reported Values for "Trace" Elements 12
Table 5A: Recommended Values - "Trace" Elements 20
Table 9A: Laboratory Ratings - Major Contributors 21
Table 10A: Laboratory Ratings - Minor Contributors 22
Table 12A: Recommended Values - "Complete Analysis (per cent, Dry Basis)" 23
Table 13: Contributing Institutions, Analysts and Reporting Officers 24

FOREWORD

The work described in this report contributes to the Canadian Certified Reference Materials Project (CCRMP). The CCRMP in turn, contributes to the Utilization Activity (Quality Control Sub-Activity) of CANMET's Minerals Research Program by producing mineralogical and metallurgical reference materials (RM's) for use in industrial, commercial and government laboratories in Canada.

The CCRMP was initiated in the early seventies in response to a demand from such laboratories for RM's that were not previously available. Many laboratories now work on their own behalf by willingly contributing to the CCRMP analytical information which is ultimately used in the certification of the RM's.

Now that a relatively large number of reference ores and related materials have been made available, they are being used in a "feed-back" fashion to critically assess analytical methods that are essential for quality-control and research in Canadian enterprises.

INTRODUCTION

Report MRP/MSL 75-132(TR) outlined the history of the Canadian reference rock samples SY-2, SY-3 and MRG-1, listed all results then available from a worldwide collaborative analytical program, and recommended values of varying degrees of reliability for many of the constituents of the three samples. Since those values were calculated, many additional results have been received, the quantity of data now available being about 50 per cent greater than before. This supplement is intended to provide the latest information on the three samples and to correct errors in the original report.

For this supplement, certain modifications have been introduced, both in the presentation of data and in the method of deducing recommended values. As a result of these changes and of the availability of additional data, it is now possible to assign values to several additional constituents and to correct or enhance the reliability of some values already assigned. Recommended values must therefore be considered as an improvement over those in the original report, but it must be emphasized that they are not as well established as those recommended in reports on reference samples of ores.

In the second paragraph of the introduction to the original report, on line 9, Fe_2O_3 should be inserted between Al_2O_3 and FeO.

COLLABORATIVE ANALYSIS

Corrections and additions to results listed in Tables 1 and 2 are listed in correspondingly numbered tables in this supplement. As before, values marked with an asterisk were received too late for inclusion in the calculations.

Because of the availability of additional data it is now possible to make some distinction between "carbon dioxide" results obtained by acid evolution and by combustion in a stream of oxygen. The following results clearly indicate a significant difference between the two techniques. Normally, one would expect the difference to be due to the presence of non-carbonate carbon. However, there is no direct evidence of the presence of such matter in any of the samples, other than from possible contamination. All of the following values are expressed as per cent carbon dioxide:

SY-2		SY-3		MRG-1	
Acid	Combust.	Acid	Combust.	Acid	Combust.
0.48	0.66	0.47	0.60	1.22	1.22
0,47	0.59	0.42	0.55	1.08	1.14
0.46	0.59	0.41	0.50	1.03	1.14
0.46	0.57	0.41	0.50	1.03	1.13
0.46	0.55	0.40	0.46	1.02	1.11
0.46	0.55	0.40	0.41	1.00	1.06
0.44	0.53	0.35	0.33	0.98	1.05
0.43		0.34		0.90	
0.42		0.26		0.90	
0.32		0.18		0.88	

The two sets of results for carbon dioxide in each sample were treated as though they were two different determinations. Results for which there was insufficient information on the method used were ignored. The final recommended value for "carbon dioxide" is derived from the acid-evolution results. "Carbon" represents the difference between the derived values by both methods, recalculated to the element.

Additional results received for uranium, thorium, lead and copper, and work done in CANMET laboratories on several rare earth elements did not confirm the suspicion of inhomogeneous distribution of the added minerals in the autogenous grinding that produced sample SY-3. However, the evidence of inhomogeneity was not refuted either. The issue therefore remains in doubt although the weight of evidence suggests that the one observed example of inhomogeneity may have been fortuitous.

DERIVATION OF ASSIGNED VALUES

Two changes have been made in the method of deriving assigned values:

(1) Any outlying result differing from its nearest neighbor by more than that neighbor differed from the opposite extreme was rejected before any calculations were begun. Similar outliers among results from "select laboratories" were rejected before "select means" were calculated. In some cases, subjective considerations led to the rejection of some outliers that did not quite meet the above requirement.

(2) The select mean is used as a recommended value for all trace elements for which at least 10 results are available. The "adjusted mean" is used only where fewer than five results are available from select laboratories and such recommended values indicated with question marks. The median is used only where fewer than ten results are available from all sources, and the resulting value also listed with a question mark.

This supplement does not include tables corresponding to Tables 3, 4, 6, 7, 8 and 11 in the original report, but the detailed information is available on request.

Table 5a is the updated version of Table 5. It will be noticed that eight more elements have been added, at least for some of the samples, and that nearly two dozen listed values have been "upgraded", although a few have been "downgraded".

In the original report, MRP/MSL (75-132R), recommended values without question marks were assumed to be firmly established. However, results received since then suggest there was unwarranted optimism in that conclustion. It was therefore decided in this supplement to categorize all recommended values as "A", "B", or "?". The "A" is reserved for those constituents for which at least 20 results were reported, where there is no evidence of bias in the histogram and where there is close agreement between mode, median, mean, adjusted mean and select mean. It follows that any further results received are not likely to affect such values beyond one or two units in the last significant figure. The "?" category includes the values mentioned above, and also others where erratic distribution or other factors cast doubt on the derived value. The "B" is intended for values intermediate between the other two.

Tables 9a and 10a are updated versions of Tables 9 and 10 respectively. They include a number of additional laboratories which have reported results for the first time since the original report was prepared. Ratings of individual contributing laboratories have changed as a result of the reporting of additional data, or as a result of changed distribution and changed intervals within each histogram. The results used in calculating the quantities in Tables 9a and 10a include those for major, minor and trace elements.

In Table 12a, the revised version of Table 12, the item "Others" is the sum of the concentrations of all "trace-element" oxides, each of which is 0.01 per cent or more. These individual oxide contents were combined to save space and avoid duplication of information already given in Table 5a. It will be noticed, however, that "carbon" (non-carbonate) is now listed as a separate item.

CONCLUSION

Although some of the negative aspects referred to in the conclusion to the original report persist in this supplement, there have been some improvements:

(1) In addition to the number of assigned values that have been "upgraded" (e.g. from "?" to "B"), values are now available for some elements formerly listed in Table 6. Even where the category has not changed, there is reason to believe that revised values are probably superior to those previously recommended, if only because they are based on a greater volume of raw data.

(2) The high summations in Table 12 have not changed appreciably, but there has been a great improvement in the compatability of the two total iron oxide values in sample MRG-1.

(3) Some progress has been made towards resolving discrepancies between the two techniques used in determining carbon dioxide, and towards eliminating the suspicion of inhomogeneity in SY-3, but neither question has been settled conclusively.

Further supplements to the original report will be published only if additional results bring about significant changes in recommended values or provide usable values for elements for which none could previously be assigned.

ACKNOWLEDGEMENTS

In acknowledging the debt owed the many contributors of analytical data, the original report failed to mention individual names. Table 13 in this supplement accordingly is an alphabetical listing of all contributing laboratories with names of analysts and reporting officers, where available, in alphabetical order under their respective institutions.

REFERENCES

The following corrections should be made in the listed references in report MRP/MSL 75-132(TR):

11. Change to read: Idem., 74-41 (1975)

14. For Abalysis, read Analysis

43. Change to read: Appl. Spectrosc. 29, 82-85 (1975)

46. For Szechoslovakia, read Czechoslovakia

57. Change to read: DELAETER, J.R., ABERCROMBIE, I.D., and DATE, R., Earth Plan. Sci. Lett. 7, 64-66 (1969)

72a Change to read: DELAETER, J.R., and ABERCROMBIE, I.D., Earth Plan. Sci. Lett. 9, 327-330 (1970)

78. For INGRAM, L., read INGRAM, B.L.

81. Change to read ibid. 39, 535-537 (1975)

100. For FANZINI, read FRANZINI

Add the following references:

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TABLE 1: REPORTED VALUES FOR MAJOR AND MINOR COMPONENTS, PER CENT

(SEE PP 2-4 OF ORIGINAL REPORT)

Corrections and Additions

		SY-2	SY-3	MRG-1	Method	Reference
SiO_2	Add	60.31	59.72	39.44	FPG	Wiik[126]
		58.80(3)	58.35(3)	39.50(3)	FOJ	Pinta[124]
		59.99	59.35	39.18	FPG	Engleman [Norton[127]]
		60.13	59.73	39.35	FPG	Anon.[128], Cioni[129]
		60.19	60.40	37.90	OOX	Anon.[128], Franzini[100]
		59.89	59.49	39.23	FPG	Onuki [Ueda[131]]
		59.90	59.52	38.90	FPG	Kato [Ueda[131]]
		60.92	60.02		FOX	Otto[132]
		60.84	60.52	38.20	FPG	Guédon[133, 134]
		60.34	59.56	38.89	FOA	Guédon[133, 135]
		60.71	60.39	38.75	FOX	Guédon[133, 136]
		59.80(2)	59.34(2)	38.78	FPG	Thomas [Moore[130]]
		60.08(2)	59.50(2)	39.33(2)	FPG	Friese [Schmidt[149]]
Al_2O_3	Add	11.91	11.93	8.49	FPG	Wiik[126]
		11.60(3)	11.33(3)	9.31(3)	FOJ	Pinta[124]
		12.27	12.50	8.80	FPG	Engleman [Norton[127]]
		11.99	12.06	8.52	OOT	Anon.[128], Cioni[129]
		12.76	12.20	8.52	OOX	Anon.[128], Franzini[100]
		12.08	12.09	8.04	FPG	Onuki [Ueda[131]]
		12.18	12.05	8.57	OOA	Kato [Ueda[131]]
		12.03	11.58		FOX	Otto[132]
		11.86	11.43		HOA	
		12.20	12.10	8.46	OOT	Guédon[133, 134]
		12.16	11.81	8.82	FOA	Guédon[133, 135]
		12.05	11.71	8.38	FOX	Guédon[133, 136]
		12.12(2)	11.62(2)	8.52(2)	FPG	Thomas [Moore[130]]
				8.57(2)	FPT	Friese [Schmidt[149]]
		12.10(2)	11.88(2)	8.50(2)	HYT	
Fe_2O_3	Add	2.54	2.75	8.54	Dif	Wiik[126]
		2.33	2.45	8.12	Dif	Engleman [Norton[127]]
		2.48	2.59	7.88	Dif	Anon[128]
		2.40	2.48	7.74	Dif	

Table 1 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Fe_2O_3 (cont'd)	Add	2.43	2.33	8.69	Dif	Onuki [Ueda[131]]
		2.26	2.16	8.63	Dif	Kato [Ueda[131]]
		2.20(2)	2.30(2)	8.00(2)	Dif	Thomas [Moore[130]]
				8.00	Dif	
		2.03(2)	2.39(2)	7.70(2)	Dif	Friese [Schmidt[149]]
FeO	For	3.63(5)	3.66(5)	8.76	OOO	Johnson[79]
				8.78	OOO	Johnson[79]
	Read	3.63(5)	3.66(5)	8.76(5)	HOT	Johnson[79]
				8.78(5)	HOT	
	Add	3.33	3.39	8.45	HOT	Wiik[126]
		3.53	3.56	8.66	HOT	Engleman [Norton[127]]
		3.45	3.54	8.71	HOT	Anon[128], Cioni[129]
		3.69	3.98	8.62	HOT	Onuki [Ueda[131]]
		3.68	4.06	8.65	HOT	Kato [Ueda[131]]
		3.58(2)	3.64(2)	8.72(2)	HOT	Thomas [Moore[130]]
		3.59(5)			HOT	Voldet[145]
		3.66(2)	3.56(2)	9.02(2)	OOT	Friese [Schmidt[149]]
			3.40(5)	7.88(5)	HOT	Voldet[147]
MgO	For	2.86(5)	2.83(3)	13.00(5)	OVS	Fabbri [Emiliani[34]] Bonarelli-Marzocchi[101]
	Read	2.86(5)	2.83(5)	13.00(5)	OVS	Fabbri [Emiliani[34]] Bonarelli-Marzocchi[101]
	Add	2.74	2.72	13.52	FPG	Wiik[126]
		2.54(3)	2.56(3)	13.77(3)	FOA	Pinta[124]
		2.67	2.61	13.54	FPG	Engleman [Norton[127]]
		2.69	2.68	13.91	OOA	Anon[128], Cioni[129]
		2.64	2.59	13.41	FPG	Onuki [Ueda[131]]
		2.60	2.55	13.30	OOA	Kato [Ueda[131]]
		1.83	2.53		HOA	Otto[132]
		2.71	2.79	14.07	OOT	Guédon[133,134]
		2.85	2.83	13.32	FOA	Guédon[133,135]
		3.50	3.55	13.23	FOX	Guédon[133,136]
		2.76(2)	2.72(2)	13.17(2)	FPT	Thomas [Moore[130]]
		2.82(2)	2.79(2)		FOT	Friese [Schmidt[149]]
		2.77(2)	2.73(2)	13.61(2)	FCT	

Table 1 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
CaO	Add	7.91	8.13	14.59	FPG	Wiik[126]
		8.05(3)	8.20(3)	14.08(3)	FOA	Pinta[124]
		7.99	8.33	14.70	FPG	Engleman [Norton[127]]
		7.82	8.09	14.70	OOA	Anon.[128], Cioni[129]
		7.47	7.89	16.38	OOX	Anon.[128], Franzini[100]
		7.91	8.19	14.49	FPT	Onuki [Ueda[131]]
		7.87	8.15	14.52	OOA	Kato [Ueda[131]]
		7.93	8.15		FOX	Otto[132]
		7.96	8.09		HOA	
		8.00	8.10	14.64	OOT	Guédon[133,134]
		8.24	8.35	15.06	FOA	Guédon[133,135]
		8.22	8.44	14.49	FOX	Guédon[133,136]
		8.08(2)	8.42(2)	14.82(2)	FPG	Thomas [Moore[130]]
		7.86(2)	8.10(2)	14.36(2)	FOT	Friese [Schmidt[149]]
		7.87(2)	8.10(2)	14.36(2)	FCT	
Na_2O	For	4.04(2)	3.92(2)	0.72(3)	HOE	Nanetti [Emiliani[134]], Biagi[103]
	Read	4.04(2)	3.92(2)	0.76(3)	HOE	Nanetti [Emiliani[134]], Biagi[103]
	Add	4.40	4.17	0.74	HOE	Wiik[126]
		4.53(3)	4.34(3)	0.74(3)	FOE	Pinta[124]
		4.30	4.08	0.73	FPG	Engleman [Norton[127]]
		4.31	4.07	0.73	OOA	Anon.[128], Cioni[129]
		4.28	4.22	0.95	OOA	Onuki [Ueda[131]]
		4.33	4.24	0.92	OOA	Kata [Ueda[131]]
		4.38	4.12		HOA	Otto[132]
		4.02	4.02	0.94	OOE	Guédon[133,134]
		4.36	4.05	0.84	FOE	Guédon[133,135]
		4.36(2)	4.18(2)	0.67(2)	HPE	Thomas [Moore[130]]
		4.38(2)	4.17(2)	0.64(2)	HOE	Friese [Schmidt[149]]
		4.32(2)	4.14(2)	0.67(2)	HOE	
K_2O	Add	4.53	4.32	0.16	HOE	Wiik[126]
		5.25	4.96	0.12	FOE	Pinta[124]
		4.52	4.21	0.17	FPG	Engleman [Norton[127]]
		4.52	4.25	0.18	OOA	Anon.[128], Cioni[129]
		4.50	4.44	0.19	OOX	Anon.[128], Franzini[100]

		SY-2	SY-3	MRG-1	Method	Reference
K_2O (cont'd)	Add	4.42	4.25	0.23	OOA	Onuki [Ueda[131]]
		4.40	4.22	0.18	OOA	Kato [Ueda[131]]
		4.32	4.02		FOX	Otto[132]
		4.47	4.04		HOA	
		3.94	3.84	0.24	OOE	Guédon[133,134]
		4.35	4.18	0.24	FOE	Guédon[133,135]
		3.99	3.68	0.09	FOX	Guédon[133,136]
		4.30(2)	4.08(2)	0.20(2)	HPE	Thomas [Moore[130]]
		4.51(2)	4.25(2)	0.15(2)	HOE	Friese [Schmidt[149]]
		4.46(2)	4.20(2)	0.09(2)	HOE	
H_2O^+	Add	0.58	0.59	1.07	FVG	Wiik[126]
		0.94	1.02	1.08	OOO	Pinta[124]
		0.25	0.27	0.94	FVG	Engleman [Norton[127]]
		1.53	1.18	1.98	OVG	Onuki [Ueda[131]]
		1.47	1.33	2.12	OVG	Kato [Ueda[131]]
		0.38(2)	0.38(2)	0.96(2)	OVG	Thomas [Moore[130]]
		0.62(5)			FVG	Voldet[145]
		0.48(2)	0.38(2)	0.91(2)	OOG	Friese [Schmidt[149]]
			0.63(5)	0.99(4)	FVG	Voldet[147]
H_2O^-	Add	0.16	0.19	0.13	OVG	Wiik[126]
		0.13	0.18	0.07	OVG	Pinta[124]
		0.15	0.16	0.05	OVG	Engleman [Norton[127]]
		0.13	0.15	0.06	OVG	Anon.[128]
		0.11	0.29	0.09	OVG	Onuki [Ueda[101]]
		0.28	0.28	0.10	OVG	Kato [Ueda[131]]
		0.20(2)	0.20(2)	0.17(2)	OVG	Thomas [Moore[130]]
		0.135(10)			OVG	Voldet[145]
		0.19(2)	0.21(2)	0.20(2)	OOG	Friese [Schmidt[149]]
			0.16(5)	0.08(5)	OVG	Voldet[147]
CO_2	For	0.53(5)	0.41(5)	1.06(5)	OOO	Johnson[79]
				1.05(5)	OOO	Johnson[79]
	Read	0.53(5)	0.41(5)	1.06(5)	FVK	Johnson[79]
				1.05(5)	FVK	
	Add	0.42	0.38	1.05	OOG	Wiik[126]
		0.48	0.42	1.03	HVG	Engleman [Norton[127]]
		0.46(2)	0.40(2)	1.02(2)	HVG	Thomas [Moore[130]]
		0.47	0.41	1.08	HVK	Valloni [Emiliani[143]], Fabbri[144]

Table 1 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
CO_2 (cont'd)	Add	0.43(5)			HVK	Voldet[145]
		0.50(2)	0.46(2)	1.14(2)	OOT	Friese [Schmidt[149]]
			0.47(5)	1.22(5)	HVK	Voldet[145]
		0.57	0.46	1.11	FVL	Tillman[155]
L.O.I.	Add	1.27	1.26	1.92	OVG	Anon.[128]
		0.99	1.16	1.32	OVG }	Guédon[133,134]
		1.08			OVG }	
TiO_2	For	0.14_4(5)	0.16_5(3)	4.03(3)	OVS	Fabbri [Emiliani[34]]
	Read	0.14_4(5)	0.16_5(5)		OVS	{ Fabbri [Emiliani[34]] Emiliani[99] }
	For	0.14(2)	0.14(2)	3.86(3)	BOX	Lucchini [Emiliani[34]] Franzini[100]
	Read	0.14(2)	0.14(2)	4.03(3)	BOX	{ Lucchini [Emiliani[34]] Franzini[100] }
	Add			3.86(3)	HOJ	Lucchini [Emiliani[34]]
		0.15	0.16	3.61	OOJ }	Wiik[126]
		0.18	0.20	2.50	OOS }	
		0.15(3)	0.16(3)	4.28(3)	FOJ	Pinta[124]
		0.15	0.16	3.77	FPJ	Engleman [Norton[127]]
		0.18	.17	3.74	OOJ	Anon.[128], Cioni[129]
		0.12	0.12	3.75	OOX	Anon.[128], Franzini[100]
		0.21	0.23	3.91	OOJ	Onuki [Ueda[131]]
		0.19		3.86	OOJ }	Kato [Ueda[131]]
			0.22		OOA }	
		0.15	0.16		FOX	Otto[132]
		0.26	0.18	4.08	OOJ	Guédon[133,134]
		0.33	0.29	3.81	FOA	Guédon[133,135]
		0.13	0.14	3.56	FOX	Guédon[133,136]
		0.14(2)	0.14(2)	3.63(2)	FPJ	Thomas [Moore[130]]
		0.16	0.16	3.41	HCM }	Jackson[121]
			0.15		HCM }	Strelow[122]
		0.14_7(2)	0.16_8(2)		FPJ }	Friese [Schmidt[149]]
		0.14_8(2)	0.16_6(2)	3.82(2)	HOJ }	
P_2O_5	Add	0.43	0.52	0.18	OOJ	Wiik[126]
		0.43(3)	0.48(3)	0.06	FOJ	Pinta[124]
		0.41	0.53	0.06	FPJ	Engleman [Norton[127]]

Table 1 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
P_2O_5 (cont'd)	Add	0.50	0.58	0.08	OOJ	Anon.[128], Cioni[129]
		0.45	0.45	0.14	OOT	Onuki [Ueda[131]]
		0.42	0.44	0.13	OOJ	Kato [Ueda[131]]
		0.42(2)	0.51(2)		HOJ	Thomas [Moore[130]]
				0.05(2)	FOJ	
		0.45	0.50	0.074	HCM	Jackson[121],
			0.55		HCM	Strelow[122]
		0.40_8(2)	0.52_9(2)	0.05_9(2)	FPJ	Friese [Schmidt[149]]
		0.41_1(2)	0.53_1(2)		HOJ	
		0.39(3)	0.50(3)	<0.20(6)	OVS	Johnson[151]
F	Add	0.54	0.76	0.03	FVJ	Engleman [Norton[127]]
		0.52(2)	0.66(2)	0.02(2)	FVL	Thomas [Moore[130]]
		0.49	0.70	0.015	HCM	Jackson[121]
			0.72		HCM	Strelow[122]
		0.54(2)	0.76(2)	0.03(2)	FVJ	Friese [Schmidt[149]]
S	For	0.011(5)	0.041(5)	0.062(5)	000	Johnson[79]
				0.066(5)	000	Johnson[79]
	Read	0.011(5)	0.041(5)	0.062(5)	FVT	Johnson[79]
				0.066(5)	FVT	
	Add	0.01	0.05	0.06	FPG	Engleman [Norton[127]]
		0.01_2(2)	0.04_6(2)	0.06_2(2)	FVT	Thomas [Moore[130]]
MnO	Add	0.31	0.32	0.17	OOJ	Wiik[126]
		0.31	0.33	0.18	OOX	
		0.31	0.31	0.11_6	OOS	
		0.31(3)	0.33(3)	0.17(3)	FOA	Pinta[124]
		0.31	0.32	0.17	FPJ	Engleman [Norton[127]]
		0.33	0.34	0.17	OOA	Anon.[128], Cioni[129]
		0.34	0.34	0.17	OOX	Anon.[128], Franzini[100]
		0.31	0.34	0.19	OOJ	Onuki [Ueda[131]]
		0.32	0.33	0.17	OOA	Kato [Ueda[131]]
		0.33	0.33		FOX	Otto[132]
		0.33	0.34		HOA	
		0.34	0.35	0.19	OOA	Guédon[133,135]
		0.32(2)	0.33(2)	0.14(2)	HOJ	Thomas [Moore[130]]
		0.37(6)	0.37(6)	0.16(6)	OVS	Flanagan[138]

Table 1 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
MnO (cont'd)	Add	0.33_8	0.37	0.19	HCM	Jackson[121],
			0.36_5		HCM	Strelow[122]
		$0.33_o(2)$	$0.33_2(2)$	$0.16_1(2)$	FPJ	Friese [Schmidt[149]]
		$0.33_5(2)$	$0.33_2(2)$		HOJ	
		$0.32_8(4)$	$0.31_9(4)$	0.162(4)	OOX	Fuchs [Schmidt[149]]
		0.30(4)*	0.29(4)*		OVS	Rösler [Schrön[158]]
Fe_2O_3T	Add	6.24	6.52	17.93	OOJ	Wiik[126]
		6.26(3)	6.47(3)	17.79	FOJ	Pinta[124]
		6.15	6.31	17.78	HOT	Engleman [Norton[127]]
		6.31	6.52	17.56	OOJ	Anon.[128], Cioni[129]
		6.23	6.41	17.42	OOX	Anon.[128], Franzini[100]
		6.53	6.75	18.27	HOT	Onuki [Ueda[131]]
		6.35	6.67	18.24	OOA	Kato [Ueda[131]]
		6.36	6.50		FOX	Otto[132]
		6.48	6.75	17.92	OOJ	Guēdon[133,134]
		6.37	6.52	17.57	FOA	Guēdon[133,135]
		6.07	6.29	17.30	FOX	Guēdon[133,136]
		6.18(2)	6.34(2)	17.68(2)	FPJ	Thomas [Moore[130]]
				17.68	FOJ	
		6.09(2)	6.36(2)	17.75(2)	FPT	Friese [Schmidt[149]]
		6.11(2)	6.35(2)	17.71(2)	HYT	
RE_2O_3T	For	0.06			OOJ	Voldet[106]
	Read	0.06			HPJ	Voldet[106]
	Add		0.48(2)	0.007(2)	HPJ	Voldet[147]

TABLE 2: REPORTED VALUES FOR "TRACE" ELEMENTS

(SEE PP 2-4 OF ORIGINAL REPORT)

Corrections and Additions

		SY-2	SY-3	MRG-1	Method	Reference
Ag ppm	Add	<10	<10	<10	OOO	Pinta[125]
		< 0.5	< 0.5	< 0.5	OVS	Flanagan[138]
		< 0.25	< 0.25	< 0.25	OVS	Johnson[151]
As ppm	Add	<68	<68	<68	OVS	Flanagan[138]
		17.8(7)	19.7(7)	0.46(7)	HVA	Aslin[150]
		18.0(7)	19.8(7)	0.50(7)	HVA	
Au ppm	Add	<10	<10	<10	OVS	Flanagan[138]
B ppm	Add	61	77	<15	OOS	Wiik[126]
		98(6)	119(6)	<15	OVS	Flanagan[138]
		105	100	4	HCM	Jackson[121],
			98		HCM	Strelow[122]
		84(4)*	104(4)*		OVS	Rösler [Schrön[158]]
Ba ppm	Add	500	400		OOX	Wiik[126]
		430	420		HOA	Otto[132]
		527(6)	523(6)		OVS	Flanagan[138]
		480	410	66	HCM	Jackson[121],
			420		HCM	Strelow[122]
		420(4)		<40(4)	OOX	Fuchs [Schmidt[149]]
		450(3)	425(3)	55(3)	OVS	Johnson[151]
				55(3)	OVS	
		510(3)	480(3)	57(3)	HOA	Rantala[152] [Loring[153]]
		460(4)*	410(4)*		OVS	Rösler [Schrön[158]]
Be ppm	Add	21	20	< 5	OOS	Wiik[126]
		<30	<30	<30	OOO	Pinta[125]
		30(6)	32(6)	< 1	OVS	Flanagan[138]
		10.25	10.20	0.38	HOA	Korkisch[139]
		10.70	11.60	0.50	HCA	
		10.45	11.85	0.55	HCA	
		18	17	0.5	HCM	Jackson[121],
			18		HCM	Strelow[122]

Table 2 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Be (cont'd)	Add	22.0	21.5	0.97	HOA	Rantala[152] [Loring[153]]
		24(4)*	22(4)*		OVS	Rösler [Schrön[158]]
Bi ppm	Add	<10	<10	<10	000	Pinta[125]
		8.2(6)	13(6)	< 5	OVS	Flanagan[138]
Cd ppm	Add	<10	<10	<10	OVS	Flanagan[138]
			0.176	0.123	HCM	DeLaeter[141]
Ce ppm	Add	214(6)	2640(6)	<63	OVS	Flanagan[138]
		150	950	24.6	HCM }	Jackson[121],
			980		HCM }	Strelow[122]
Cl ppm	Add	200	200	200	FPJ	Engleman [Norton[127]]
		150	120	170	HCM }	Jackson[121]
			130		HCM }	Strelow[122]
		98(2)	125(2)	150	00X	Gagnon[146]
Co ppm	Add	<17	<17	98	00S	Wiik[126]
		<10	<10	100(3)	000	Pinta[125]
		10.5(6)	12(6)	108(6)	OVS	Flanagan[138]
		15	13	90	HCM }	Jackson[121]
			15		HCM }	Strelow[122]
		21(2)	20(2)	102(2)	HOA	Thomas [Moore[130]]
		10(3)	12(3)	97(3)	OVS }	Johnson[151]
				98(3)	OVS }	
		10(3)	9(3)	88(3)	HOA	Rantala[152] [Loring[153]]
		6.5(4)*	6.6(4)*		OVS	Rösler [Schrön[158]]
Cr ppm	Add	10(3)	<10	800(3)	000	Pinta[125]
		32	24		HOA	Otto[132]
		10(6)	6.1(6)	466(6)	OVS	Flanagan[138]
		10	9	410	HCM }	Jackson[121]
			8		HCM }	Strelow[122]
				900(2)	FPJ	Thomas [Moore[130]]
		12(3)	10(3)	460(3)	OVS }	Johnson[151]
				465(3)	OVS }	
		7.2(3)	6.6(3)	317(3)	HOA	Rantala[152] [Loring[153]]
		<12(4)*	<12(4)*		OVS	Rösler [Schrön[158]]

Table 2 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Cs ppm	Add	3(3)	2.5(3)	1(6)	OVS	Johnson(151)
Cu ppm	Add	<15	<15	190	OOS	Wiik(126)
		<10	<10	100(3)	OOO	Pinta(125)
		2.5(6)	22(6)	116(6)	OVS	Flanagan(138)
		< 5	6(2)	127(2)	BOX	Robinson(137)
		5	34	160	HCM }	Jackson(121)
			26		HCM }	Strelow(122)
		6(2)	12(2)	138(2)	HOA	Thomas [Moore(130)]
		2.0	21.4	132	HCA	Uchida(148)
		5(3)	19(3)	131(3)	OVS }	Johnson(151)
				131(3)	OVS }	
		3.0(3)	14.1(3)	130(3)	HOA	Rantala(152) [Loring(153)]
		6.1(4)*	10.9(4)*		OVS	Rösler [Schrön(158)]
Dy ppm	Add	32(6)	145(6)		OVS	Flanagan(138)
		16	68	2.6	HCM }	Jackson(121),
			62		HCM }	Strelow(122)
		27.31	125	4.6	HP,CR	Voldet(147)
Er ppm	Add	24(6)	107(6)		OVS	Flanagan(138)
		11	40	0.95	HCM }	Jackson(121),
			38		HCM }	Strelow(122)
Eu ppm	Add	3.1(6)	22(6)		OVS	Flanagan(138)
		2.0	11	1.3	HCM }	Jackson(121),
			11		HCM }	Strelow(122)
		2.74	20	2.4	HP,CR	Voldet(147)
Ga ppm	For	24.6	25.6		HCM	DeLaeter(69)
	Read	24.7	25.6		HCM	DeLaeter(69)
	Add	30	36	18	OOS	Wiik(126)
		27(3)	27(3)	20(2)	OOO	Pinta(125)
		40(6)	36(6)	17(6)	OVS	Flanagan(138)
		30(2)	27(2)	24(2)	BOX	Robinson(137)
		27(4)*	27(4)*		OVS	Rösler [Schrön(158)]
Gd ppm	Add	22(6)	140(6)	<15	OVS	Flanagan(138)
		11	54	3.4	HCM }	Jackson(121),
			53		HCM }	Strelow(122)

Table 2 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Ge ppm	Add	<10	<10	<10	OOO	Pinta[125]
		< 3	< 3	< 3	OVS	Flanagan[138]
		1.56(2)*	1.55(2)*		HYS	Rösler [Schrön[158]]
Hf ppm	Add	<22	<22	<22	OVS	Flanagan[138]
Ho ppm	Add	2.9	12	0.48	HCM	Jackson[121],
			14		HCM	Strelow[122]
In ppm	Add	< 5	< 5	< 5	OVS	Flanagan[138]
Ir ppb	Add	< 7	< 7	< 7	OVS	Flanagan[138]
La ppm	Add	92(6)	1530(6)	<10	OVS	Flanagan[138]
		57	550	8.1	HCM	Jackson[121],
			575		HCM	Strelow[122]
Li ppm	Add	100	93		HOA	Otto[132]
		95	96	6	HCM	Jackson[121],
			90		HCM	Strelow[122]
		95(2)	98(2)	7(2)	HOA	Thomas [Moore[130]]
		106(3)	104(3)	< 5(6)	OVS	Johnson[151]
		97(3)	94(3)	5.2(3)	HOA	Rantala[152] [Loring[153]]
Lu ppm	For	8.2	2.9		OOM	DeLaeter[72a]
	Read	2.9	8.2		OOM	DeLaeter[72a]
	Add	< 3	7(6)	< 3	OVS	Flanagan[138]
		2.0	3.5	0.065	HCM	Jackson[121],
			2.9		HCM	Strelow[122]
		3.00(2)	8.5(2)		HCM	McCulloch[156]
Mo ppm	Add	< 6	< 6	< 6	OOS	Wiik[126]
		<10	<10	<10	OOO	Pinta[125]
		3(4)*	3(4)*		OVS	Rösler [Schrön[158]]
Nb ppm	Add	21(6)	195(6)	12(6)	OVS	Flanagan[138]
		14.9(4)*	93.8(4)*		OVS	Rösler [Schrön[158]]

Table 2 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Nd ppm	Add	70(6)	520(6)	68	OVS	Flanagan[138]
		55	420	18.0	HCM	Jackson[121],
			430		HCM	Strelow[122]
Ni ppm	Add	<15	<15	240	OOS	Wiik[126]
		<10	<10	150	OOO	Pinta[125]
		9.2(6)	8.5(6)	211(6)	OVS	Flanagan[138]
		7	8	190	HCM	Jackson[121],
			7		HCM	Strelow[122]
		16(2)	16(2)	205(2)	HOA	Thomas [Moore[130]]
		9.5(3)	10(3)	195(3)	OVS	Johnson[151]
				195(3)	OVS	
		< 5(3)	< 5(3)	173(3)	HOA	Rantala[152] [Loring[153]]
		7.5(4)*	6.9(4)*		OVS	Rösler [Schrön[158]]
Os ppm	Add	< 7	< 7	< 7	OVS	Flanagan[138]
Pb ppm	Add	150(3)	110(3)	10(3)	OOO	Pinta[125]
		136(6)	214(6)	14(6)	OVS	Flanagan[138]
		118(2)	136(2)	12(2)	BOX	Robinson[137]
		93(2)	148(2)	18(2)	HOA	Thomas [Moore[130]]
		78(3)	124(3)	10(3)	OVS	Johnson[151]
				11(3)	OVS	
		86(3)	135(3)	<10(3)	HOA	Rantala[152] [Loring[153]]
		71(4)*	151(4)*		OVS	Rösler [Schrön[158]]
Pd ppm	Add	0.7(6)	< 0.7	< 0.7	OVS	Flanagan[138]
Pr ppm	Add	18(6)	346(6)	9(6)	OVS	Flanagan[138]
		14	118	3.6	HCM	Jackson[121],
			120		HCM	Strelow[122]
Pt ppm	Add	< 7	< 7	< 7	OVS	Flanagan[138]
Rb ppm	Add	210	210	<100	OOX	Wiik[126]
		220	195		HOA	Otto[132]
		236(2)	213(2)	8(2)	BOX	Robinson[137]
		204(4)	196(4)	12(4)	OOX	Fuchs [Schmidt[149]]

Table 2 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Rb	Add	190(3)	210(3)	< 10(6)	OVS	Johnson[151]
(cont'd)		194(3)	188(3)	10	HOA	Rantala[152] [Loring[153]]
Re ppm	Add	< 10	< 10	< 10	OVS	Flanagan[138]
Rh ppm	Add	< 0.7	< 0.7	< 0.7	OVS	Flanagan[138]
Sb ppm	Add	< 68	< 68	< 68	OVS	Flanagan[138]
		0.20(7)	0.20(7)	0.38(7)	HVA	Aslin[150]
		0.20(7)	0.20(7)	0.39(7)	HVA	
Sc ppm	Add	10.6(6)	12(6)	42(6)	OVS	Flanagan[138]
		6.3	3.5	41	HCM	Jackson[121],
			4.0		HCM	Strelow[122]
Sm ppm	Add	14(6)	221(6)	< 5	OVS	Flanagan[138]
		13	75	4.2	HCM	Jackson[121],
			73		HCM	Strelow[122]
Sn ppm	Add	3	4	28	OOS	Wiik[126]
		10(3)	< 10	< 10	OOO	Pinta[125]
		< 15	< 15	< 15	OVS	Flanagan[138]
		5.7	6.5	3.6	HCM	DeLaeter[142]
		3.1(3)	4.8(3)	2.1(3)	OVS	Johnson[151]
				2.2(3)	OVS	
		4	6		FVA	Guimont[154]
		4.4(4)*	2.9(4)*		OVS	Rösler [Schrön[158]]
Sr ppm	Add	220	250	230	OOX	Wiik[126]
		270	310		HOA	Otto[132]
		447(6)	472(6)	322(6)	OVS	Flanagan[138]
		285(2)	300(2)	285(2)	BOX	Robinson[137]
		255(4)	273(4)	276(4)	OOX	Fuchs [Schmidt[149]]
				255(3)	OVS	Johnson[151]
				260(3)	OVS	
		278(3)	322(3)	290(3)	HOA	Rantala[152] [Loring[153]]
Ta ppm	Add	<500	<500	<500	OVS	Flanagan[138]

Table 2 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Tb ppm	Add	< 10	15(6)	< 10	OVS	Flanagan[138]
		1.85	9	0.46	HCM	Jackson[121],
			9		HCM	Strelow[122]
Th ppm	Add	300	850		OOX	Wiik[126]
		521(6)	1180(6)	< 2	OVS	Flanagan[138]
Tl ppm	Add	< 5	< 5	< 5	OVS	Flanagan[138]
Tm ppm	Add	< 3	12(6)	< 3	OVS	Flanagan[138]
		2.1	5.6	0.095	HCM	Jackson[121]
			5.2		HCM	Strelow[122]
U ppm	Add	300	540		OOX	Wiik[126]
		270	600	1	OOJ	
		262(6)	863(6)	< 150	OVS	Flanagan[138]
		246	634	0.30	HCJ	Korkisch[140]
		250	630	0.25	HCJ	
		250	600	0.21	HCJ	
		255	623	0.19	HCJ	
V ppm	Add	< 50	< 50	460	OOS	Wiik[126]
		20(3)	12(3)	300(3)	OOO	Pinta[125]
		66(6)	68(6)	384(6)	OVS	Flanagan[138]
		48	50	520	HCM	Jackson[121],
			50		HCM	Strelow[122]
				540	OOA	Beccaluva [Emiliani[143]]
		50(3)	48(3)	493	HOA	Rantala[152] [Loring[153]]
		55(4)*	54(4)*		OVS	Rösler [Schrön[158]]
W ppm	Add	< 10	< 10	< 50	OVS	Flanagan[138]
Y ppm	Add	150	880	< 12	OOS	Wiik[126]
		100	670	< 100	OOX	
		131	610		OOA	Otto[132]
		130(6)	696(6)	16(6)	OVS	Flanagan[138]
		116(2)	696(2)	12(2)	BÓX	Robinson[137]
		150	800	20	HCM	Jackson[121],
			800		HCM	Strelow[122]

Table 2 (continued)

		SY-2	SY-3	MRG-1	Method	Reference
Yb ppm	Add	29	92	< 7	OOS	Wiik[126]
		19	73		OOA	Otto[132]
		19(6)	80(6)	1.9(6)	OVS	Flanagan[138]
		17.4	62.5	0.6	HCM	DeLaeter[141]
		17	41	0.44	HCM }	Jackson[121]
			41		HCM }	Strelow[122]
Zn ppm	For	258	257		HCM	Rosman[74]
	Read	255	256		HCM	Rosman[74]
	For	254	256		HCA	Rosman[74]
	Read	254	259		HCA	Rosman[74]
	Delete	255	256		OOO	DeLaeter[72a]
	Add			<1000	OOO	Pinta[125]
		380	320		HOA	Otto[132]
		257(6)	247(6)	193(6)	OVS	Flanagan[138]
		256(2)	236(2)	197(2)	BOX	Robinson[137]
				180	HCM	DeLaeter[141]
		205	280	190	HCM }	Jackson[121],
			260		HCM }	Strelow[122]
		274(2)	266(2)	204(2)	HOA	Thomas [Moore[130]]
		254(4)	238(4)	155(4)	OOX	Fuchs [Schmidt[149]]
		222(3)	216(3)	177(3)	OVS }	Johnson[151]
				178(3)	OVS }	
		237(3)	232(3)	212(3)	HOA }	Rantala[152]
				182(3)	HOA }	[Loring[153]]
Zr ppm	Add	250	360	79	OOS }	Wiik[126]
		250	300	120	OOX }	
		<100	<100	<100	OOO	Pinta[125]
		293(6)	392(6)	147(6)	OVS	Flanagan[138]
		297(4)	373(4)	89(4)	OOX	Fuchs [Schmidt[149]]
		255(3)	295(3)	99(3)	OVS }	Johnson[151]
				101(3)	OVS }	

TABLE 5A - RECOMMENDED VALUES - "TRACE" ELEMENTS*

	SY-2		SY-3		MRG-1		
	ppm	Oxide pct	ppm	Oxide pct	ppm	Oxide pct	
As	18?		20?		1?		
B	86?	0.03	100?	0.03	5?		B_2O_3
Ba	460A	0.05	440B	0.05	55?	0.01	BaO
Be	23B	0.01	19B	0.01	1?		BeO
Ce	210?	0.03	2000?	0.25	25?		CeO_2
Cl	140?	0.01	135?	0.01	150?	0.02	Cl*
Co	10?		12B		87A	0.01	CoO
Cr	10B		8B		420B	0.06	Cr_2O_3
Cs	2.5?		2.5?		0.5?		
Cu	4B		17B		135B	0.02	CuO
Dy	21?		120?	0.01			Dy_2O_3
Er			50?	0.01			Er_2O_3
Eu	2.2?		15?		1.4?		
Ga	26B		28B		18B		
La	85?	0.01	1400?	0.16	10?		La_2O_3
Li	90B	0.02	90B	0.02	4?		Li_2O
Lu	3?		8?				
Nb	25?		145?	0.02	20?		Nb_2O_5
Nd	70?	0.01	500?	0.06			Nd_2O_3
Ni	10B		11B		200A	0.03	NiO
Pb	86A	0.01	130A	0.01	10B		PbO
Rb	220A	0.02	210B	0.02	8B		Rb_2O
Sb	0.2?		0.3?		0.5?		
Sc	7?		11?		48?	0.01	Sc_2O_3
Sm	16?		95?	0.01			Sm_2O_3
Sn	5B		6B		3B		
Sr	270A	0.03	300A	0.04	260B	0.03	SrO
Tb			15?				
Th	370?	0.04	980?	0.11			ThO_2
Tm			10?				
U	280B	0.03	640B	0.08	0.4?		U_3O_8
V	50B	0.01	51B	0.01	520B	0.09	V_2O_5
Y	130B	0.02	740B	0.09	20?		Y_2O_3
Yb	17B		60?	0.01	1?		Yb_2O_3
Zn	250B	0.03	250A	0.03	185B	0.02	ZnO
Zr	270B	0.04	340B	0.05	100B	0.01	ZrO_2
		0.01?		0.04?			Other RE_2O_3

* See text for explanation of symbols A, B, ?.
Cl reported as element in "complete analysis".

TABLE 9A - LABORATORY RATINGS - MAJOR CONTRIBUTORS

Lab. No.	*No. of Results	Per Cent Good	Per Cent Fair	Per Cent Poor	Rating
34	95	92	8	0	92
79	33	85	12	3	82
3	69	82	14	4	78
22	72	84	8	8	76
12	57	80	16	4	76
53	70	77	20	3	74
31	85	78	16	6	72
43	33	73	18	9	64
36	68	65	29	6	59
66	81	69	21	10	59
32	85	70	18	12	58
7	49	76	6	18	58
104	205	67	21	12	55
9	92	66	23	11	55
23	94	70	13	17	53
4	75	66	21	13	53
26	79	69	15	16	53
29	60	65	22	13	52
113	42	69	10	21	48
30	39	64	13	23	41
52	62	60	19	21	39
38	110	59	19	22	37
16	57	59	18	23	36
15	131	58	19	23	35
39	56	59	16	25	34
55	83	55	20	25	30
28	143	52	24	24	28
71	49	55	16	29	26
62	118	51	19	30	21
46	151	46	25	29	17
8	74	51	14	35	16
5	48	52	10	38	14
60	44	41	20	39	2
44	90	44	13	43	1
103	38	45	8	47	-2
57	82	37	20	43	-6

*Number of results for those components for which ten or more were received. See text for explanation how these figures were derived and applied.

TABLE 10A - LABORATORY RATINGS - MINOR CONTRIBUTORS

Lab. No.	*No. of Results	Per Cent Good	Per Cent Fair	Per Cent Poor	Rating
33	6	100	0	0	100
64	2	100	0	0	100
6	15	93	7	0	93
49	26	81	15	4	77
78	3	67	33	0	67
108	26	69	19	12	57
56	27	63	30	7	56
112	9	78	0	22	56
111	17	64	24	12	52
14	21	71	10	19	52
24	20	55	25	20	35
107	4	50	25	25	25
54	13	54	15	31	23
109	13	46	31	23	23
10	28	39	43	18	21
1	17	42	29	29	13
101	23	48	9	43	5
47	18	44	17	39	5
105	18	44	12	44	0
74	14	29	42	29	0
102	8	50	0	50	0
70	2	0	100	0	0
110	4	25	0	75	-50

*See footnotes to Table 9A.

Table 12A - Recommended Values - "Complete Analysis" (Per cent, Dry Basis)

	SY-2	SY-3	MRG-1
SiO_2	60.09A	59.68A	39.24A
Al_2O_3	12.15A	11.80B	8.56A
Fe_2O_3	2.35B	2.48B	8.23B
FeO	3.55B	3.56B	8.60A
MgO	2.69A	2.64A	13.51A
CaO	8.00A	8.26A	14.72B
Na_2O	4.35A	4.15A	0.71A
K_2O	4.51A	4.24A	0.18B
H_2O+	0.46B	0.47B	0.99B
CO_2	0.46?	0.40B	1.01B
C	0.03?	0.03?	0.03?
TiO_2	0.15A	0.15B	3.75B
P_2O_5	0.44A	0.54A	0.07A
F	0.50B	0.70A	0.02B
S	0.01B	0.05B	0.06B
MnO	0.32A	0.33A	0.17A
Others*	0.41?	1.13?	0.31?
Σ	100.47?	100.61?	100.16?
Less O/F, S, Cl	0.22?	0.32?	0.04?
Σ (corrected)	100.25?	100.29?	100.12?
Fe_2O_3TR**	6.29A	6.47B	17.80A
Fe_2O_3TC***	6.29B	6.44B	17.79B

*See Table 5A for individual elements

**Total iron, expressed as ferric oxide, reported as such

***Total iron, expressed as ferric oxide, calculated from derived values for FeO and Fe_2O_3.

See text for explanation of other symbols.

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