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SOIL SAMPLES SO-1, SO-2, SO-3 AND SO-4 — CERTIFIED REFERENCE MATERIALS

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by

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J.A. McKeague² and H. Kodama³

SYNOPSIS

Through the cooperation of the Canada Centre for Mineral and Energy Technology (CANMET) and the Land Resource Research Institute of Agriculture Canada, four soil samples have been prepared as compositional reference materials: a clayey soil, a sandy podzolic B horizon with a high organic content, a calcareous till, and a chernozemic A horizon. All have a wide range of compositions. Bulk samples of 180 to 280 kg of each were dried, ground to minus 74 μm , blended, tested for homogeneity and bottled in 200-g units.

Thirty-six laboratories participated in the certification program by providing analytical results for 1 to 25 constituents for each of two bottles of each sample. Based on statistical analyses of the data, the four reference samples were certified for Al, Fe, Mn, K, Zn, Cu, Cr and Pb, and one or more were certified for Si, Na, Mg, Ca, P, Ti, Hg, Ni, Sr and V. Preliminary data were obtained for another 47 elements.

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ECHANTILLONS DE SOL SO-1, SO-2, SO-3 et SO-4 -

MATERIAUX DE REFERENCE CERTIFIES

par

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SOMMAIRE

Quatre échantillons de sol ont été préparés en tant que matériaux de référence certifiés - un sol argileux, un horizon B podsolique sablonneux ayant une haute teneur de matières organiques, un argile à blocs calcaire et un horizon A chernozémique - en vertu de la coopération entre le Centre canadien de la technologie des minéraux et de l'énergie (CANMET) et l'Institut de recherche sur les terres d'Agriculture Canada. Les échantillons ont tous une grande variété de compositions. Les échantillons en vrac de 180 à 280 kg chacun ont été asséchés, broyés à $-74 \mu\text{m}$, mélangés, soumis à des essais d'homogénéité et embouteillés en contenants de 200 g.

Trente-six laboratoires ont participé au programme de certification en fournissant des résultats d'analyse pour 1 à 25 composantes de chacune des deux bouteilles d'échantillons. Selon les résultats du traitement statistique des données, les quatre échantillons de référence ont été certifiés pour Al, Fe, Mn, K, Zn, Cu, Cr et Pb. Un ou plus ont été certifiés pour Si, Na, Mg, Ca, P, Ti, Hg, Ni, Sr et V. Des données préliminaires ont été obtenues pour 47 autres éléments.

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INTRODUCTION

This report describes the preparation, characterization and certification of four soil samples — SO-1, SO-2, SO-3 and SO-4 — for use as certified reference materials. The work is another facet of the Canadian Certified Reference Materials Project (CCRMP) to certify materials that have potential value in conventional analytical and earth science laboratories. Because there is a demand for reference soils, a cooperative program was conducted by CANMET and Agriculture Canada to make such materials available to analysts involved in agriculture, forestry and environmental studies, particularly those associated with mining and metallurgical operations. Reference materials certified previously by CCRMP are described in a catalogue available from CANMET (1).

The recommended values for the certified elements are given in Table 1; methodological, statistical and other analytical information is presented in Tables 2 to 5.

ORIGIN AND PREPARATION OF SAMPLES

The four samples were selected to represent major kinds of soil materials and to include a wide range of properties. Bulk samples were taken by soil scientists in different areas of Canada and sent to CANMET in Ottawa for processing. Information on the samples follows.

SO-1: Origin - 23 km northwest of Hull, Quebec at 45° 30' 50" N, 75° 58' 40" W. The sample is somewhat weathered Champlain Sea clay from a depth of 35 to 75 cm below surface in an upland position. In pedological terms, the sample is of the C horizon of Rideau clay, a Regosolic soil. It contains about 80% clay (<2 µm) of mixed mineralogy.

SO-2: Origin - Montmorency Forest about 47° 20' N, 71° 9' W, 72 km north of Quebec City. The sample, supplied by C.R. DeKimpe, is of the B horizon of a Ferro-Humic Podzol developed in sandy till. The organic matter content is approximately 10%. Sampling depth was 10 to 30 cm.

SO-3: Origin - Near Guelph, Ontario at 43° 33' N, 80° 19' W. The sample, supplied by R. Protz, is of the calcareous till parent material of the Guelph series, a Gray Brown Luvisol. The sample has an appreciable content of both calcite and dolomite.

SO-4: Origin - Northeast of Saskatoon, Saskatchewan at 53° 2' N, 106° 42' W. The sample, supplied by H.B. Stonehouse, is of the A horizon of a Black Chernozemic soil developed in silty glacial lacustrine deposits.

At the CANMET laboratories each soil sample was dried in 70-kg batches at 120°C for 17 h. Stones and gravel fragments were removed and each batch was ball milled until the soil passed a 74 µm sieve. The batches of each soil were combined and each sample was tumbled in one lot in a rotating conical mixer for 8 h. The four soil samples were then bottled in 200-g units with each bottle bearing a number that permitted random sampling of the lot. The number of 200-g units obtained for SO-1 was 792, SO-2, 1193, SO-3, 1097, and SO-4, 990. Particle size analyses for the four materials are given in Table 6.

Six bottles were selected, according to a random bottle-number scheme, from the stocks of each of the four soil samples to assess their homogeneity by an energy dispersive X-ray fluorescence technique. For each soil, counting data for silicon, potassium, calcium and titanium were subjected to an analysis of variance. Although some bottle-to-bottle differences were detected, they were considered to be minor in relation to the anticipated between-laboratory standard deviations in the interlaboratory certification program. This assumption was borne out by the analytical results which indicated no abnormality in homogeneity (Table 5).

INTERLABORATORY CERTIFICATION PROGRAM

The laboratories participating in the program are listed alphabetically in Appendix A. Each of these was arbitrarily assigned a code number so that analytical results could be recorded while preserving the anonymity of the laboratory. The code number bears no relation to the alphabetical order of the laboratory.

The participating laboratories received two randomly selected bottles of each of the four soil samples. They were requested to determine as many elements as possible by methods of their choice and to report the results on the basis of overnight drying at 105°C. Where the laboratory provided data for an element or elements by more than one method, each set of data was treated statistically as if it originated in a separate laboratory.

STATISTICAL TREATMENT OF ANALYTICAL RESULTS

Detection of outliers

Cochran's test was used to identify data sets with abnormally high coefficients of variation (2) (Table 5). These sets were then examined individually by Dixon's test to determine if the high variance was caused by one or more values that were remote from the mean of the set (2). Such values were excluded and the coefficients of variation were recalculated. Sets continuing to have abnormally high cv's were not used for further computations.

Data sets whose means differed by more than twice the overall standard deviation from the grand mean were also excluded from calculations of recommended values and other statistics. Because of the unusually high within- and between-laboratory variations in this program, the tests could not be applied rigidly, i.e., some subjectivity was required in identifying outliers. All outliers are identified in Tables 5(a) and (b).

Estimation of consensus values and 95% confidence limits

A one-way analysis of variance technique was used to calculate the consensus values (means) and their variance. The analytical data were assumed to fit the following model (3):

$$x_{ij} = \mu + y_i + e_{ij}$$

where:

x_{ij} = the j^{th} result reported in set i ;

μ = the true value that is estimated by the overall mean $\bar{x}_{..}$;

y_i = the discrepancy between the mean of the results from set i ($\bar{x}_{i.}$) and μ ; and

e_{ij} = the discrepancy between x_{ij} and $\bar{x}_{i.}$

It is assumed in this analysis that both y_i and e_{ij} are normally distributed with means of zero and variances of ω^2 and σ^2 , respectively. The significance of ω^2 can be detected by comparing the ratio of "between-set" mean squares to "within-set" mean squares with the F statistic at the 95% confidence level and with the appropriate degrees of freedom. The magnitude of ω^2 and σ^2 can be estimated from the ANOVA table.

The consensus value in the above model can be estimated by the overall mean $\bar{x}_{..}$, thus:

$$\bar{x}_{..} = \frac{\sum_i^k \sum_j^{n_i} x_{ij}}{\sum_i^k n_i}$$

Analysis of variance and expected mean squares for the one-way classification

Source of variance	Sums of squares	Degrees of freedom	Mean squares	E [Mean squares]
Between-sets	$\sum_i^k n_i (\bar{x}_{i.} - \bar{x}_{..})^2$	$k-1$	S_2^2	$\sigma^2 + \frac{1}{k-1} \left(\sum_i^k n_i - \frac{\sum_i^k n_i^2}{k} \right) \omega^2$
Within-sets	$\sum_i^k \sum_j^{n_i} (x_{ij} - \bar{x}_{i.})^2$	$\sum_i^k n_i - k$	S_1^2	σ^2
Total	$\sum_i^k \sum_j^{n_i} (x_{ij} - \bar{x}_{..})^2$	$\sum_i^k n_i - 1$		

with the variance of the overall mean being given by:

$$V[\bar{x}..] = \frac{\sum_{i=1}^k n_i^2}{\left(\sum_{i=1}^k n_i\right)^2} \omega^2 + \frac{\sigma^2}{\sum_{i=1}^k n_i}$$

The 95% confidence limits for the overall mean are then given by:

$$\bar{x}.. \pm \left[t_{0.975, (k-1)} \cdot \sqrt{V[\bar{x}..]} \right]$$

where:

n_i = the number of results reported in set i ;

k = the number of sets.

The above values and other statistics computed from the one-way ANOVA are presented in Table 1.

Certification factor

The certification factor is a measure for evaluating the quality of reference materials issued by the CCRMP (4). It is computed from the following expression:

$$CF = 200 \left[t_{0.975, (k-1)} \cdot \sqrt{V[\bar{x}..]} \right] / \bar{x}.. / \bar{cv}$$

where \bar{cv} is the average of the within-set coefficients of variation and is given by:

$$\bar{cv} = \sum_{i=1}^k cv_i / k$$

The critical value of CF is 4. If a selected constituent has a CF greater than 4, the reference material is considered to be of unacceptable quality with respect to that constituent.

The certification factors for the four reference soils are given in Table 1 with the consensus values which are boxed in for easy identification. The latter are accepted as recommended values if their certification factor is less than 4. An exception is calcium in soil sample S0-3 for which the spread is much higher than expected for its level of concentration. The assignment of a recommended value was considered to be unjustified. For completeness, Table 1 also gives information in italics for some elements that were not certified (i.e., $CF > 4$).

Discussion of analytical methods

A methodological classification of elements with relatively abundant analytical data is given in Table 3. Only the methods used by three or more laboratories, or by two laboratories that submitted at least 10 results are listed. Some results close to the overall mean for the corresponding element were obtained by all the analytical methods used. Those by emission spectroscopy (ES), however, generally yielded the highest spread, i.e., the 95% confidence interval expressed as a percentage of the mean. This is partly due to the small number of laboratories using this method. That the results by atomic absorption are in better agreement with the recommended means, especially for the elements at the $\mu\text{g/g}$ level, is a consequence of their being the most predominant.

From the data in Table 5 it is evident that the capability of the analyst is the most important factor in determining the reliability of results as both good and poor data were generated by all methods.

Moisture and loss on ignition (LOI)

Contributing analysts were requested to dry their subsamples overnight at 105°C prior to analysis. It was assumed, therefore, that the majority of the moisture results given in Tables 5(a) and (b) were obtained after a drying period of 16 to 18 h. Experiments performed at CANNMET after completion of the interlaboratory program showed that, for all four soil samples, moisture values do not vary significantly with drying periods ranging from 16 to 20 h. Thus, the vague instruction to dry "overnight" did not introduce uncertainty in the certified values in Table 1.

Loss on ignition (LOI) results were volunteered by a number of contributors. Although, their experimental parameters were not usually defined, it is assumed that a temperature of approximately 1000°C was used. It is evident, however, that the results were obtained on samples that were dried overnight at 105°C . Again, experiments at CANNMET showed that for all four soils, there was no significant difference in LOI values for samples whose heating times at 1000°C varied from one to three hours. Moreover, LOI values at 900°C were only marginally lower than those at 1000°C .

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Table 1

Recommended values and other statistical parameters for SO-1 to SO-4 (outliers excluded)

[based on samples dried at 105°C for 16 h (overnight)]

Element	N n		\bar{x}	95% CL		Spread		$\bar{c}\bar{v}$	CF	N n		\bar{x}	95% CL		Spread		$\bar{c}\bar{v}$	CF
	SO-1	SO-2		low	high	%	%			low	high		%	%				
			(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)	(wt %)
Al	21	161	9.38	9.21	9.55	4	1.9	2.0		21	161	8.07	7.89	8.25	5	3.0	1.5	
Ca	20	149	1.80	1.73	1.87	8	4.2	1.9		21	151	1.96	1.86	2.05	10	4.0	2.5	
Fe	29	229	6.00	5.87	6.13	4	2.7	1.5		30	235	5.56	5.40	5.71	6	2.6	2.2	
K	22	156	2.68	2.61	2.76	5	2.3	2.3		21	150	2.45	2.41	2.49	3	2.3	1.4	
Mg	22	164	2.31	2.21	2.42	9	3.1	2.8		22	161	0.54	0.51	0.57	13	4.8	2.6	
Mn	32	253	0.089	0.087	0.092	5	3.7	1.4		29	229	0.072	0.070	0.074	6	3.0	1.9	
Na	19	136	(1.90)	--	--	(13)	(2)	(5.9)		18	131	(1.74)	--	--	(14)	(2)	(5.5)	
P	9	69	0.062	0.053	0.072	31	9.1	3.4		9	81	(0.30)	--	--	(17)	(3)	(6.0)	
Si	13	94	25.72	25.50	25.93	2	0.7	2.5		12	93	24.99	24.77	25.22	2	0.7	2.8	
Ti	17	139	0.53	0.51	0.54	7	4.1	1.6		18	137	0.86	0.84	0.88	5	4.0	1.2	
			($\mu\text{g/g}$)	($\mu\text{g/g}$)	($\mu\text{g/g}$)							($\mu\text{g/g}$)	($\mu\text{g/g}$)	($\mu\text{g/g}$)				
Cr	22	178	160	145	175	18	5.5	3.4		25	207	16	14	18	27	13.5	2.0	
Cu	27	223	61	59	64	8	3.3	2.3		23	206	7	6	8	26	12.9	2.0	
Hg	10	82	0.022	0.019	0.025	29	9.3	3.1		12	94	0.082	0.073	0.091	23	6.9	3.3	
Ni	29	250	94	87	100	13	5.1	2.6		23	193	(12)	--	--	(66)	(14)	(4.7)	
Pb	24	194	21	17	24	36	13.8	2.6		24	193	21	17	24	34	13.0	2.6	
Sr	13	104	(300)	--	--	(34)	(6)	(5.6)		13	104	340	290	390	29	7.8	3.7	
V	13	96	139	131	147	12	8.6	1.4		11	86	64	54	75	33	10.5	3.2	
Zn	27	221	146	141	151	6	3.7	1.7		24	203	124	119	129	8	2.7	3.0	
			($\mu\text{g/g}$)	($\mu\text{g/g}$)	($\mu\text{g/g}$)							($\mu\text{g/g}$)	($\mu\text{g/g}$)	($\mu\text{g/g}$)				
			(wt %)	(wt %)	(wt %)							(wt %)	(wt %)	(wt %)				
Al	21	164	3.05	2.94	3.15	7	4.8	1.5		21	159	5.46	5.31	5.60	5	1.8	2.9	
Ca	21	154	(14.8)	--	--	(8)	(3)	(2.5)		21	151	1.11	1.06	1.16	9	3.1	2.9	
Fe	27	214	1.51	1.45	1.56	7	4.2	1.7		26	203	2.37	2.30	2.43	6	2.2	2.5	
K	21	139	1.16	1.12	1.21	7	2.8	2.6		20	144	1.73	1.71	1.76	3	2.4	1.3	
Mg	19	135	(5.11)	--	--	(9)	(2)	(4.3)		22	164	0.56	0.52	0.60	14	5.8	2.4	
Mn	30	230	0.052	0.051	0.054	7	3.2	2.1		32	253	0.060	0.058	0.062	6	4.5	1.4	
Na	18	128	0.74	0.70	0.77	10	3.3	3.1		18	123	(0.97)	--	--	(15)	(2)	(9.0)	
P	8	67	(0.046)	--	--	(21)	(5)	(4.2)		9	72	0.090	0.084	0.097	15	7.8	1.9	
Si	12	87	15.86	15.67	16.05	2	0.7	3.4		11	83	(32.0)	--	--	(2)	(0.4)	(4.2)	
Ti	15	111	(0.19)	--	--	(14)	(3)	(4.9)		18	133	0.34	0.32	0.36	11	4.8	2.3	
			($\mu\text{g/g}$)	($\mu\text{g/g}$)	($\mu\text{g/g}$)							($\mu\text{g/g}$)	($\mu\text{g/g}$)	($\mu\text{g/g}$)				
Cr	23	196	26	23	29	24	12.7	1.9		25	214	61	55	66	19	9.4	2.1	
Cu	23	192	17	16	18	14	6.2	2.3		24	216	22	21	23	8	6.9	1.1	
Hg	10	83	0.017	0.011	0.024	71	24.0	3.0		12	100	(0.033)	--	--	(53)	(8)	(6.9)	
Ni	24	213	16	13	19	37	12.8	2.9		26	230	26	23	29	20	8.4	2.4	
Pb	21	162	14	11	17	47	14.2	3.3		24	193	16	13	19	34	14.5	2.3	
Sr	11	93	217	188	246	27	7.7	3.5		12	103	170	152	188	21	5.8	3.6	
V	12	88	(44)	--	--	(54)	(11)	(4.9)		11	82	90	79	101	24	7.0	3.5	
Zn	25	215	52	50	55	9	5.8	1.5		26	218	94	91	97	6	3.5	1.8	

N = number of sets; n = number of results; \bar{x} = overall mean (recommended value); CL = confidence limits; Spread = 95% confidence interval as percentage of mean; cv = average within-lab coefficient of variation; CF = certification factor (see page 3).

Note: Entries in italics are for elements which were not certified; they are given only to complete the record and are for information purposes only.

Table 2

Analytical results for carbon, nitrogen, LOI[†] and moisture*
(outliers excluded)

Constituent	SO-1					SO-2				
	N	n	\bar{x} (wt %)	Spread %	\overline{cv} %	N	n	\bar{x} (wt %)	Spread %	\overline{cv} %
Carbon	5	36	0.25	18	4.6	6	38	4.8	6	0.8
Nitrogen	5	27	0.04	104	16.1	5	30	0.22	56	4.7
LOI	6	39	4.4	14	2.9	7	41	11.5	8	1.1
Moisture (105°)	4	16	4.1	65	2.4	4	24	3.3	42	5.0
	SO-3					SO-4				
Carbon	4	31	6.6	7	0.6	6	38	4.4	8	1.0
Nitrogen	3	22	0.02	172	23.1	5	30	0.4	45	2.3
LOI	8	42	25.3	1	0.4	7	40	10.4	4	1.3
Moisture (105°)	4	16	0.4	72	10.6	4	16	3.1	73	6.0

N = number of sets; n = number of results; \bar{x} = overall mean; Spread = 95% confidence interval as percentage of mean; \overline{cv} = average within-lab coefficient of variation; LOI = loss on ignition (some lab to lab variation in conditions of determination)

* The reference soils are not certified for these constituents. These statistics are presented for information only.

† Based on samples dried at 105°C for 16 h (overnight); a temperature of ~1000°C is assumed.

Table 3

Methodological classification for elements with relatively abundant analytical data (outliers excluded)

Method	SO-1				SO-2				SO-3				SO-4			
	N (n)	\bar{x}	Spread %	\bar{cv} %	N (n)	\bar{x}	Spread %	\bar{cv} %	N (n)	\bar{x}	Spread %	\bar{cv} %	N (n)	\bar{x}	Spread %	\bar{cv} %
<u>Aluminum</u>		(wt %)				(wt %)				(wt %)				(wt %)		
AA	9 (78)	9.43	8	2.5	10 (86)	8.12	9	5.0	9 (84)	3.03	14	7.0	9 (82)	5.43	10	2.4
XRF	6 (52)	9.36	4	1.4	5 (44)	8.04	7	1.2	6 (49)	3.02	12	4.6	6 (46)	5.42	10	1.6
<u>Barium</u>																
AA	2 (20)	0.08	--	3.1	3 (26)	0.09	32	8.0	3 (26)	0.03	151	22.5	2 (20)	0.07	--	3.0
XRF	2 (12)	0.09	--	1.5	2 (12)	0.11	--	1.1	2 (12)	0.02	--	3.6	2 (12)	0.08	--	1.6
ES	3 (22)	0.10	119	5.0	3 (22)	0.11	112	4.9	3 (22)	0.03	177	8.4	3 (22)	0.08	98	4.1
NAA	3 (25)	0.09	39	5.5	2 (20)	0.10	--	5.2	2 (20)	0.03	--	5.6	2 (20)	0.08	--	2.6
<u>Calcium</u>																
AA	9 (70)	1.73	12	5.4	10 (81)	1.86	14	5.7	9 (75)	14.3	14	5.2	11 (89)	1.09	13	2.9
XRF	6 (53)	1.81	14	2.2	6 (50)	2.01	13	2.5	5 (44)	15.3	19	0.8	6 (46)	1.13	24	2.0
ES	3 (14)	1.97	60	2.5	3 (14)	2.13	48	2.2	3 (14)	14.8	22	3.7	3 (14)	1.15	37	3.1
<u>Iron</u>																
AA	11 (90)	5.95	8	4.5	12 (99)	5.50	10	3.6	12 (99)	1.46	12	5.1	10 (86)	2.29	9	2.5
XRF	6 (53)	6.11	10	1.1	6 (46)	5.62	15	2.4	6 (46)	1.52	23	4.3	6 (46)	2.43	14	2.3
ES	3 (14)	6.33	20	3.5	3 (13)	6.21	26	2.5	2 (12)	1.65	--	5.2	3 (14)	2.67	34	2.3
COLOR	4 (32)	5.77	13	1.9	4 (32)	5.33	13	1.4	4 (32)	1.56	21	1.4	4 (32)	2.32	5	0.9
NAA	3 (25)	5.89	9	1.5	2 (20)	5.32	--	2.6	2 (20)	1.55	--	4.0	2 (20)	2.40	--	3.0
TITR	2 (15)	6.32	--	0.7	3 (25)	5.78	29	0.8	--	--	--	--	--	--	--	--
<u>Magnesium</u>																
AA	12 (93)	2.26	12	2.6	13 (99)	0.54	16	4.2	11 (84)	4.99	11	2.4	13 (98)	0.56	14	4.0
XRF	5 (50)	2.35	24	5.4	4 (36)	0.58	36	5.8	4 (40)	5.33	30	1.5	4 (40)	0.62	41	8.1
ES	3 (14)	2.50	41	2.5	3 (14)	0.54	39	4.1	--	--	--	--	3 (14)	0.55	39	10.6
<u>Manganese</u>																
AA	18 (152)	0.088	7	3.1	16 (138)	0.070	7	3.0	18 (145)	0.052	8	2.2	18 (152)	0.059	7	3.0
XRF	5 (38)	0.094	15	2.8	5 (34)	0.076	19	3.5	5 (39)	0.054	33	5.5	5 (39)	0.062	26	7.4
ES	3 (14)	0.098	47	4.7	3 (14)	0.076	34	4.3	--	--	--	--	3 (14)	0.060	63	8.2
COLOR	2 (20)	0.088	--	5.9	2 (19)	0.075	--	1.2	2 (19)	0.052	--	5.8	2 (20)	0.066	--	4.1
NAA	3 (24)	0.089	26	2.1	3 (24)	0.073	35	2.5	3 (23)	0.055	32	3.0	3 (24)	0.061	30	2.4
<u>Phosphorus</u>																
XRF	2 (20)	0.065	--	6.7	2 (20)	0.32	--	2.3	2 (20)	0.052	--	6.3	2 (20)	0.090	--	4.5
COLOR	5 (37)	0.064	45	2.0	6 (51)	0.30	27	1.6	4 (32)	0.045	37	0.4	5 (37)	0.092	34	3.5
<u>Potassium</u>																
AA	11 (75)	2.63	4	2.7	10 (73)	2.42	4	2.2	11 (75)	1.17	12	2.8	9 (70)	1.73	6	1.4
XRF	6 (54)	2.71	8	1.2	6 (49)	2.48	5	2.0	6 (46)	1.12	12	2.9	6 (46)	1.72	7	2.9
ES	3 (13)	2.96	69	3.3	3 (14)	2.50	17	3.4	--	--	--	--	3 (14)	1.78	15	4.0
<u>Silicon</u>																
XRF	6 (53)	25.80	3	0.9	5 (44)	24.98	4	0.8	5 (38)	15.90	5	0.9	5 (44)	32.11	4	0.5
GRAV	3 (17)	25.51	6	0.3	3 (17)	24.79	7	0.3	3 (17)	15.90	5	0.4	3 (17)	31.78	3	0.4
<u>Sodium</u>																
AA	13 (97)	1.88	18	1.5	13 (97)	1.75	16	2.2	12 (86)	0.73	16	2.6	13 (97)	0.96	20	1.5
NAA	3 (25)	2.01	15	2.0	2 (20)	1.84	--	2.0	2 (20)	0.74	--	3.2	2 (20)	1.00	--	2.4
<u>Titanium</u>																
AA	4 (36)	0.55	17	7.1	4 (36)	0.86	13	6.2	3 (25)	0.19	34	3.2	4 (36)	0.32	40	9.6
XRF	6 (54)	0.53	13	2.4	6 (50)	0.88	11	2.1	6 (47)	0.19	31	1.8	6 (46)	0.35	16	3.5
ES	3 (14)	0.54	20	6.2	3 (14)	0.85	16	4.0	--	--	--	--	3 (14)	0.39	64	2.7
COLOR	3 (25)	0.52	10	1.5	4 (27)	0.85	20	2.3	3 (25)	0.21	37	3.4	4 (27)	0.34	17	2.6

(see legend next page)

(continued)

Table 3 (continued)

Methodological classification for elements with relatively abundant analytical data (outliers excluded)

Method	SO-1				SO-2				SO-3				SO-4			
	N (n)	\bar{x}	Spread %	\overline{CV} %	N (n)	\bar{x}	Spread %	\overline{CV} %	N (n)	\bar{x}	Spread %	\overline{CV} %	N (n)	\bar{x}	Spread %	\overline{CV} %
<u>Chromium</u>		($\mu\text{g/g}$)				($\mu\text{g/g}$)				($\mu\text{g/g}$)				($\mu\text{g/g}$)		
AA	13(114)	158	28	6.1	17(153)	16	28	11.6	16(145)	27	30	15.2	16(150)	57	24	8.9
XRF	3(17)	174	22	2.1	3(17)	22	182	19.5	--	--	--	--	3(17)	70	13	4.0
ES	3(22)	171	32	8.2	2(12)	11	--	15.8	2(19)	21	--	10.9	3(22)	75	146	8.7
NAA	2(20)	152	--	2.2	2(20)	11	--	9.5	2(20)	23	--	4.5	2(20)	64	--	4.9
<u>Cobalt</u>																
AA	13(125)	33	32	4.7	14(134)	14	76	7.3	14(134)	13	71	7.5	16(154)	16	54	6.8
NAA	3(25)	31	75	2.7	2(20)	8	--	2.9	2(20)	6	--	5.1	2(20)	11	--	4.0
<u>Copper</u>																
AA	20(174)	61	8	2.7	19(171)	7	25	10.9	19(165)	17	13	6.4	19(171)	21	9	5.3
XRF	3(22)	64	65	3.7	--	--	--	--	2(12)	20	--	1.9	--	--	--	--
ES	3(22)	66	55	5.3	2(20)	7	--	28.5	--	--	--	--	2(20)	23	--	9.2
<u>Lead</u>																
AA	19(162)	22	39	11.7	19(162)	21	41	11.9	16(131)	14	60	13.4	19(161)	17	37	12.8
XRF	3(17)	16	95	17.9	3(17)	21	35	16.4	3(17)	14	21	8.3	3(17)	13	67	18.1
<u>Mercury</u>																
AA	10(82)	0.022	29	9.3	12(94)	0.082	23	6.9	10(83)	0.017	71	24.0	11(90)	0.031	57	7.0
<u>Nickel</u>																
AA	21(197)	94	14	4.6	17(154)	13	73	10.0	18(167)	17	42	12.2	20(183)	27	24	7.4
XRF	4(27)	85	78	4.3	2(12)	10	--	7.8	3(21)	13	271	14.4	3(22)	24	157	4.6
ES	3(21)	107	106	6.1	3(22)	7	869	41.2	2(20)	9	--	16.3	2(20)	21	--	10.2
<u>Strontium</u>																
AA	5(46)	240	74	11.2	5(46)	290	48	11.0	4(36)	210	50	5.9	5(46)	170	46	7.4
XRF	4(32)	310	46	0.9	4(32)	370	87	7.1	3(30)	190	12	13.0	2(20)	150	--	3.5
ES	3(21)	390	68	2.2	3(21)	400	58	3.5	3(22)	260	43	3.0	3(22)	190	54	2.4
<u>Vanadium</u>																
AA	4(38)	148	29	12.3	3(30)	72	103	17.8	3(30)	55	182	24.7	3(29)	99	113	8.7
XRF	3(14)	136	74	1.8	2(12)	74	--	3.3	3(14)	29	175	6.7	3(14)	94	79	2.7
ES	2(12)	125	--	16.1	2(12)	51	--	8.8	2(12)	61	--	5.2	2(12)	82	--	10.4
COLOR	2(17)	132	--	3.4	2(17)	57	--	4.8	2(17)	30	--	4.6	2(17)	80	--	3.7
<u>Zinc</u>																
AA	19(159)	145	8	3.5	17(146)	127	10	2.8	18(163)	53	10	5.3	18(156)	94	8	3.4
XRF	4(27)	140	28	2.1	4(27)	114	27	1.6	4(27)	48	14	5.2	4(27)	93	24	2.1
ES	2(20)	155	--	5.3	2(20)	115	--	4.9	--	--	--	--	2(20)	99	--	3.5

Legend: AA = atomic absorption; XRF = X-ray fluorescence; ES = emission spectroscopy; COLOR = colorimetry(absorptiometry); NAA = neutron activation analysis; TITR = titrimetry.

N (n) = number of sets (number of results); \bar{x} = overall mean of sets; Spread = 95% confidence interval as percentage of mean; \overline{CV} = average within-lab coefficient of variation.

Table 4

Mean and precision of sets of results for elements not certified (outliers excluded)^a

Element	SO-1				SO-2				SO-3				SO-4			
	N	n	\bar{x} ($\mu\text{g/g}$)	s	N	n	\bar{x} ($\mu\text{g/g}$)	s	N	n	\bar{x} ($\mu\text{g/g}$)	s	N	n	\bar{x} ($\mu\text{g/g}$)	s
As	5	33	1.9	0.3	5	33	1.2	0.2	5	35	2.6	0.1	6	42	7.1	0.7
B	4	35	20	4	3	25	2.7	0.3	5	44	22	7	4	39	43	10
^b Ba	11	84	900	100	11	85	1010	160	11	85	280	70	10	79	780	90
Be	2	14	0.6	--	2	15	1.2	--	1	5	0.4	--	2	15	1.7	--
Bi	1	5	0.5	--	1	5	0.1	--	1	5	0.1	--	1	5	0.1	--
Cd	6	32	0.15	0.09	6	29	0.18	0.14	6	31	0.14	0.08	6	34	0.42	0.12
Ce	4	29	103	7	3	25	112	17	3	25	34	3	3	24	54	5
Cl	1	3	150	--	1	4	84	--	1	5	210	--	1	5	30	--
Co	20	169	33	7	20	172	13	8	18	169	12	8	22	193	15	6
Cs	3	24	5.0	0.2	2	15	0.4	--	2	15	1.2	--	3	25	3.1	0.3
Dy	1	5	5	--	1	5	11	--	1	5	3	--	1	5	4	--
Er	1	5	2.4	--	1	5	4.8	--	1	5	1.8	--	1	5	2.2	--
Eu	4	30	1.7	0.2	3	25	3.7	0.6	3	25	0.8	0.2	3	25	1.0	0.1
F	2	15	700	--	2	15	500	--	2	15	300	--	2	15	300	--
Ga	4	24	28	5	4	22	26	4	4	25	10	4	4	24	13	4
Gd	1	5	6	--	1	5	11	--	1	5	3	--	1	5	4	--
Ge	1	5	1	--	1	5	1.5	--	1	5	1	--	1	5	1.5	--
Hf	4	30	2.6	0.4	3	25	19	3	3	25	4.7	0.5	3	25	8	2
Ho	1	5	1	--	1	5	2	--	1	5	0.5	--	1	5	1	--
I	1	3	12	--	1	5	17	--	1	5	1	--	1	5	3	--
In	1	5	0.1	--	1	5	0.3	--	1	5	0.1	--	1	5	0.1	--
La	5	40	56	2	4	35	48	2	3	25	17	1	4	34	31	3
Li	5	33	40	14	5	32	9	2	4	30	9	3	4	30	18	5
Lu	3	25	0.3	0.02	2	20	0.5	--	2	20	0.2	--	2	20	0.4	--
Mo	4	30	2	1	5	41	2	1	3	19	2	1	4	29	1	1
Nb	1	5	12	--	1	5	27	--	1	5	6	--	1	5	13	--
Nd	3	20	47	2	2	15	57	--	2	15	18	--	2	15	27	--
Pr	1	5	13	--	1	5	15	--	1	5	5	--	1	5	8	--
Rb	10	61	144	20	10	61	81	7	10	61	41	11	10	61	75	19

Legend - see next page

(continued)

Table 4 (continued)

Element	SO-1				SO-2				SO-3				SO-4			
	N	n	\bar{x} ($\mu\text{g/g}$)	s	N	n	\bar{x} ($\mu\text{g/g}$)	s	N	n	\bar{x} ($\mu\text{g/g}$)	s	N	n	\bar{x} ($\mu\text{g/g}$)	s
S	3	17	100	23	3	17	340	100	3	17	150	34	3	17	440	200
Sb	2	15	0.2	--	1	5	0.1	--	2	15	0.3	--	2	15	0.7	--
Sc	5	31	19	2	3	21	11	1	3	25	6	2	4	26	10	2
Se	1	10	0.1	--	2	20	0.3	--	1	10	0.05	--	2	20	0.4	--
Sm	4	30	8.2	0.3	3	25	12	2	3	25	3.5	0.3	3	25	4.9	0.2
Sn	2	15	3	--	1	5	3	--	1	5	1	--	2	15	3	--
Ta	2	10	0.6	--	1	5	1	--	1	5	0.5	--	1	5	0.5	--
Tb	3	20	0.9	0.1	2	15	1.8	--	2	15	0.5	--	2	15	0.6	--
Th	4	30	12	1	3	24	3.7	0.5	3	24	3.9	0.4	3	25	8.7	0.7
Tl	1	5	0.9	--	1	5	0.7	--	1	5	0.3	--	1	5	0.4	--
Tm	1	5	0.4	--	1	5	0.8	--	1	5	0.3	--	1	5	0.4	--
U	4	30	1.6	0.1	2	15	1.2	--	3	25	1.1	0.3	3	25	2.3	0.3
W	1	5	0.7	--	1	5	0.4	--	1	5	0.6	--	1	5	1	--
Y	5	37	24	2	6	38	40	5	5	27	17	2	6	38	23	3
Yb	3	20	2.4	0.2	2	15	4	--	2	15	1.6	--	2	15	2.3	--
Zr	6	44	81	13	7	53	790	70	7	53	150	30	7	54	310	60

N = number of sets; n = number of results; \bar{x} = overall mean; s = standard deviation of means of sets.

^a Approximately 90% of the results were obtained by physical methods of analysis such as emission, X-ray fluorescence, and spark-source mass spectroscopy and neutron activation analysis; the remainder were by atomic absorption and colorimetric methods.

^b Although the certification factors for barium in SO-2 and SO-3 are less than 4, the precision of their means is substantially less than expected at their levels of concentration, therefore, they are not assigned as recommended values.

Table 5(a)†

Analytical results for reference soil samples SO-1 and SO-2

REFERENCE SOIL SO-1											REFERENCE SOIL SO-2										
ALUMINUM (WT%)											ALUMINUM (WT%)										
LAB- 6 (AA)	9.67	9.44	9.45	9.44	9.46	9.45	9.43	9.44	9.43	9.46	LAB- 6 (AA)	8.43	8.42	8.41	8.41	8.42	8.42	8.41	8.41	8.39	8.43
LAB-21 (AA)	8.80	8.62	8.88	9.25	9.20	9.00	8.73	8.80	9.50	9.38	LAB-21 (AA)	7.60	7.23	7.71	7.75	8.00	7.50	7.60	7.70	7.65	8.00
LAB-21 (AA)	9.41	9.50	9.25	9.53	9.33	9.50	9.25	9.50	9.25	9.40	LAB-21 (AA)	8.50	8.25	8.30	8.30	8.30	8.50	8.40	8.25	8.30	8.25
LAB-27 (AA)	9.76	9.29	9.44	10.24							LAB-27 (AA)	9.32	6.69	8.82	7.70						
LAB-27 (AA)	9.24	9.24	9.24	9.30	9.33	9.26	9.22	9.28	9.33	9.30	LAB-27 (AA)	7.93	7.95	7.95	8.01	7.89	7.95	7.94	7.89	7.94	7.94
LAB-28 (AA)	9.42	9.52	9.47	9.21	9.21	9.15	8.89	8.83	8.83	8.99	*LAB-28 (AA)	8.36	7.61	8.57	8.41	8.68	8.31	8.46	8.68	8.89	8.68
LAB-40 (AA)	10.50	9.90	10.20	10.60	10.40	10.20	9.80	9.80	9.60	10.00	LAB-40 (AA)	8.50	8.10	8.30	9.00	8.80	8.80	8.30	9.00	8.90	8.60
LAB-40 (AA)	10.00	10.80	10.40	11.00							LAB-40 (AA)	9.10	9.00	8.80	8.50						
*LAB-43 (AA)	10.85	9.45	8.92	8.50	9.55	7.00	5.45	4.39	4.90	3.12	LAB-43 (AA)	9.98	8.08	7.90	7.50	7.44	8.67	5.07	6.56	6.82	5.14
LAB-46 (AA)	9.21	9.00	9.21	9.21	9.21	9.10	9.16	8.89	8.79	8.94	*LAB-46 (AA)	7.78	7.78	7.99	7.67	7.83	7.73	7.46	7.78	7.78	7.73
LAB- 8 (XRF)	9.59	9.45	9.58	9.62	9.58	9.75	9.52	9.88	9.73	9.45	LAB- 8 (XRF)	8.19	8.41	8.23	8.32	7.88	8.27	8.05	8.44	8.36	8.63
LAB- 9 (XRF)	9.54	9.56	9.52	9.41	9.73	9.54	9.45	9.48	9.50	9.49	LAB- 9 (XRF)	8.28	8.23	8.23	8.18	8.21	8.17	8.27	8.36	8.24	8.15
LAB-14 (XRF)	9.24	9.11	9.13	9.38							LAB-14 (XRF)	7.95	8.01	7.99	8.00						
LAB-15 (XRF)	9.00	9.34	9.28	9.16	9.18	9.24	9.43	9.33	9.14	9.37	LAB-15 (XRF)	7.92	8.06	7.98	7.69	7.83	7.59	8.14	7.83	7.86	7.94
LAB-28 (XRF)	9.57	9.15	9.10	9.05	8.73	9.31	8.99	9.31			LAB-29 (XRF)	7.86	7.79	7.80	7.75	7.77	7.85	7.84	7.78	7.80	7.84
LAB-29 (XRF)	9.25	9.34	9.35	9.21	9.27	9.34	9.34	9.20	9.28	9.26	LAB-22 (ES)	7.66	7.51								
LAB-22 (ES)	8.63	8.62									LAB-24 (ES)	8.36	8.47								
LAB-24 (ES)	9.43	9.71									LAB- 9 (COLOR)	8.26	8.24	8.21	8.15	8.17	8.28	8.18	8.15	8.12	8.21
LAB- 9 (COLOR)	9.48	9.46	9.41	9.46	9.31	9.46	9.49	9.48	9.46	9.32	LAB-55 (NAA)	7.66	7.73	8.00	7.69	7.65	8.05	7.81	7.71	8.19	7.81
LAB-55 (NAA)	9.38	9.50	9.47	9.19	9.38	8.72	8.78	9.08	8.77	8.77	LAB-50 (TITR)	7.95	7.92	7.96	7.88	7.79					
LAB-50 (TITR)	9.28	9.28	9.28	9.34	9.37						LAB-29 (GRAV)	8.01	8.01								
LAB-29 (GRAV)	10.09	9.87																			
ARSENIC (UG/G)											ARSENIC (UG/G)										
LAB-20 (AA)	2.3	1.7	2.0	2.0							LAB-20 (AA)	1.4	1.0	1.1	1.3						
*LAB- 9 (XRF)	5.0	5.0	3.0	6.0	3.0	6.0	6.0	3.0	4.0	5.0	*LAB- 9 (XRF)	3.0	2.0	2.0	2.0	3.0	3.0	3.0	2.0	1.0	1.0
LAB-11 (COLOR)	1.8	1.4	1.6	1.7							LAB-11 (COLOR)	1.2	1.0	.6	.7						
LAB-35 (COLOR)	1.9	2.1	2.1	2.1	2.1	2.0	2.1	2.1	2.2	2.1	LAB-35 (COLOR)	1.1	1.1	1.2	1.1	1.2	1.1	1.0	1.2	1.2	1.0
LAB-49 (COLOR)	1.9	2.1	2.1	2.1	2.0	2.1	2.2	2.3	2.6	2.4	LAB-49 (COLOR)	1.2	1.3	1.4	1.1	1.3	1.1	1.3	1.1	1.2	1.2
LAB-41 (SSMS)	2.0	2.8	2.6	1.9	1.9						LAB-41 (SSMS)	1.8	1.3	1.0	1.4	1.4					
BARIUM (UG/G)											BARIUM (UG/G)										
*LAB-43 (AA)	598	538	655	366	642	250					LAB-43 (AA)	1059	988	827	775	776	630				
LAB-44 (AA)	789	848	844	848	815	771	788	790	814	818	LAB-44 (AA)	877	881	883	917	896	918	878	879	878	888
LAB-50 (AA)	805	800	825	875	850	805	830	825	840	850	LAB-50 (AA)	990	960	1000	950	920	905	940	990	950	1000
LAB- 8 (XRF)	843	829	842	838	809	879	807	806	813	856	LAB- 8 (XRF)	1009	1023	1038	1035	1033	998	1034	1074	1058	1028
LAB-28 (XRF)	1000	1000									LAB-28 (XRF)	1250	1250								
LAB-22 (ES)	929	912	903	871	936	871	888	877	891	899	LAB-22 (ES)	1013	1014	993	994	978	953	941	994	985	936
LAB-24 (ES)	796	786									LAB-24 (ES)	901	897								
LAB-45 (ES)	1104	1187	963	1146	1210	1462	1357	1314	1230	1151	LAB-45 (ES)	1292	1044	1132	1423	1418	1249	1235	1441	1317	1528
LAB- 4 (NAA)	839	836	822	801	830	793	786	776	772	853	LAB- 4 (NAA)	892	868	875	875	822	853	832	807	811	903
LAB-33 (NAA)	810	820	880	820	950						LAB-55 (NAA)	1011	1035	1180	1144	1196	1162	1076	1126	1036	1030
LAB-55 (NAA)	921	928	813	895	917	918	912	978	1001	994	LAB-41 (SSMS)	1100	930	1100	1100	1200					
LAB-41 (SSMS)	990	1100	820	860	960																
BORON (UG/G)											BORON (UG/G)										
LAB-45 (ES)	22	16	18	21	28	30	29	30	28	24	LAB-19 (COLOR)	3.0	3.0	3.0	4.0	3.0	3.0	3.0	4.0	3.0	3.0
LAB-19 (COLOR)	14	13	14	16	16	14	13	14	15	17	LAB-49 (COLOR)	2.5	2.3	2.2	2.5	2.8	2.8	2.2	2.0	2.0	2.9
LAB-49 (COLOR)	18	20	20	20	20	19	20	21	20	20	LAB-41 (SSMS)	2.2	3.3	1.0	2.6	3.8					
LAB-41 (SSMS)	23	17	23	15	20																
CADMIUM (UG/G)											CADMIUM (UG/G)										
LAB- 6 (AA)	.190	.120	.120	.170	.230	.210	.120	.240	.160	.170	LAB- 6 (AA)	.160	.160	.190	.150	.150	.190	.190	.190	.180	.160
LAB-11 (AA)	.028	.043	.028	.028							LAB-11 (AA)	.011	.016								
LAB-11 (AA)	.269	.302	.294	.252	.259	.280	.271				LAB-11 (AA)	.173	.182	.185	.165	.168	.185				
LAB-21 (AA)	.080	.075									LAB-21 (AA)	.035	.040								
LAB-30 (AA)	.120	.140	.130	.120							LAB-30 (AA)	.090	.080	.090	.080						
*LAB-46 (AA)	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	*LAB-46 (AA)	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
LAB-41 (SSMS)	.100	.090	.090	.090	.060						LAB-41 (SSMS)	.400	.400	.200	.500	.500					

† See legend and note at end of Table 5(b) on p. 30.

REFERENCE SOIL SO-1

TITANIUM (WT%)										
LAB-21 (AA)	.61	.59	.62	.50	.51	.62	.61	.59	.64	.52
LAB-21 (AA)	.55	.50	.60	.52	.51	.55	.60	.51	.52	.55
LAB-28 (AA)	.51	.58	.54	.54	.48	.54	.54	.48	.48	.48
LAB-43 (AA)	.52	.60	.52	.55	.51	.55				
LAB- 8 (XRF)	.59	.59	.57	.58	.57	.55	.57	.59	.58	.58
LAB- 9 (XRF)	.51	.51	.50	.51	.52	.51	.50	.49	.51	.51
LAB-14 (XRF)	.47	.50	.49	.50						
LAB-15 (XRF)	.53	.51	.52	.52	.50	.52	.52	.53	.52	
LAB-28 (XRF)	.54	.62	.54	.54	.54	.48	.54	.54	.54	.54
LAB-29 (XRF)	.50	.50	.50	.50	.50	.50	.50	.50	.50	
LAB-22 (ES)	.53	.51								
LAB-24 (ES)	.50	.55								
LAB-45 (ES)	.57	.55	.44	.61	.55	.57	.61	.57	.50	.54
LAB- 9 (COLOR)	.51	.51	.53	.52	.53	.51	.52	.51	.52	.51
LAB-27 (COLOR)	.52	.52	.51	.52	.50	.51	.52	.51	.51	.52
* LAB-29 (COLOR)	.70	.80								
LAB-50 (COLOR)	.53	.53	.53	.55	.54					
LAB-55 (NAA)	.48	.49	.46	.47	.47	.45	.44	.48	.44	.43

URANIUM (UG/G)										
LAB- 4 (NAA)	1.4	1.4	1.3	1.3	1.5	1.5	1.3	1.4	1.4	1.3
LAB-33 (NAA)	1.7	1.5	1.4	1.7	1.8					
LAB-55 (NAA)	2.1	2.0	1.6	2.0	2.1	1.8	1.5	1.7	.9	1.1
LAB-41 (SSMS)	1.3	2.2	1.6	1.8	1.8					

VANADIUM (UG/G)										
LAB-29 (AA)	155	156	164	151	147	145	144	160	154	
LAB-42 (AA)	120	170	150	130	180	160	190	190	170	
* LAB-43 (AA)	230	155	163	113	140	74	123	129	129	138
LAB-50 (AA)	140	133	148	138	175	170	148	138	148	150
LAB- 8 (XRF)	114	132	131	138	132	133	127	137	129	125
LAB-14 (XRF)	142	142								
LAB-28 (XRF)	160	160								
LAB-24 (ES)	148	132								
LAB-45 (ES)	103	104	78	127	107	155	155	169	100	121
LAB-38 (COLOR)	137	138	140	135	137	135	134	132	135	133
	131	135								
LAB-50 (COLOR)	130	134	120	122	121					
LAB-55 (NAA)	124	135	135	145	135	124	145	145	145	135
LAB-41 (SSMS)	130	160	150	130	120					

YTTRIUM (UG/G)										
LAB- 9 (XRF)	24	22	23	22	26	22	25	22	22	23
LAB-14 (XRF)	22	22								
LAB-22 (ES)	24	26	25	25	28	26	26	27	27	26
LAB-45 (ES)	24	24	24	23	29	25	22	23	21	19
LAB-41 (SSMS)	22	30	23	24	24					

REFERENCE SOIL SO-2

TITANIUM (WT%)												
LAB-21 (AA)	.92	.92	.85	.75	.71	.95	.91	.92	.78	.73		
LAB-21 (AA)	.86	.90	.90	.82	.80	.88	.89	.90	.83	.80		
LAB-28 (AA)	.90	.84	.84	.84	.84	.78	.78	.84	.84	.84		
LAB-43 (AA)	.89	.95	.89	.98	.87	.95						
LAB- 8 (XRF)	.95	.95	.95	.97	.99	.96	.96	.95	.93	.95		
LAB- 9 (XRF)	.87	.86	.85	.85	.86	.86	.87	.87	.86	.85		
LAB-14 (XRF)	.83	.83	.82	.82								
LAB-15 (XRF)	.83	.87	.86	.86	.93	.88	.89	.77	.87	.91		
LAB-28 (XRF)	.90	.90	.84	.84	.90	.90						
LAB-29 (XRF)	.86	.87	.87	.89	.88	.87	.87	.87	.87	.87		
LAB-22 (ES)	.85	.83										
LAB-24 (ES)	.89	.92										
LAB-45 (ES)	.82	.75	.81	.81	.85	.90	.96	.83	.93	.78		
LAB- 9 (COLOR)	.81	.82	.80	.82	.82	.80	.80	.82	.80	.81		
LAB-27 (COLOR)	.85	.83	.85	.87	.84	.85	.84	.85	.87	.89		
LAB-29 (COLOR)	.98	.92										
LAB-50 (COLOR)	.86	.88	.87	.89	.89							
LAB-55 (NAA)	.67	.73	.81	.70	.72	.97	.92	.92	.97	.80		

URANIUM (UG/G)												
LAB- 4 (NAA)	1.0	1.0	1.0	.8	1.1	1.2	1.1	1.1	1.2	1.4		
LAB-41 (SSMS)	1.0	1.2	1.2	1.7	1.2							

VANADIUM (UG/G)												
LAB-29 (AA)	72	67	67	57	57	54	51	51	61	61		
LAB-42 (AA)	110	130	110	58	68	96	69	100	59	88		
LAB-43 (AA)	78	69	82	69	69	74	57	51	62	69		
LAB- 8 (XRF)	84	80	82	82	73	85	84	82	77	84		
LAB-14 (XRF)	34	35										
* LAB-28 (XRF)	160	160										
LAB-24 (ES)	80	75										
LAB-45 (ES)	45	45	39	51	48	52	47	56	41	37		
LAB-38 (COLOR)	62	59	57	61	58	59	59	58	60	56		
	58	59										
LAB-50 (COLOR)	51	49	55	57	57							
LAB-55 (NAA)	53	48	52	57	48	56	65	59	59	68		
LAB-41 (SSMS)	81	57	60	76	60							

YTTRIUM (UG/G)												
LAB- 9 (XRF)	36	38	38	38	36	37	38	40	38	38		
LAB-14 (XRF)	39	35										
LAB-22 (ES)	40	41	39	38	42	43	43	43	40	43		
LAB-45 (ES)	33	36	35	33	37	33	40	32	43	46		
LAB-41 (SSMS)	46	56	43	58	39							

See legend and note on p 30

REFERENCE SOIL SO-1

	ZINC (UG/G)									
LAB- 5 (AA)	106	108	106	105	107	100	100	102	99	99
LAB- 6 (AA)	134	130	135	135	135	135	132	134	134	135
*LAB-11 (AA)	144	120	137	141	142	147	141	137		
LAB-19 (AA)	152	148	163	157	159	165	154	171	162	159
LAB-20 (AA)	140	145								
LAB-21 (AA)	140	130	140	145	130	140	130	135	145	160
LAB-27 (AA)	163	165	174	160						
LAB-30 (AA)	124	124	124	124						
LAB-35 (AA)	145	147	143	146	145	147	145	147	149	146
LAB-39 (AA)	144	141	142	138	136	142	144	143	142	137
LAB-40 (AA)	126	155	158	163	160	138	176	150	156	160
LAB-40 (AA)	149	157	156	152						
*LAB-41 (AA)	194	213	159	194	196	205	213	173	208	196
LAB-42 (AA)	130	130	130	130	120	120	130	120	120	120
*LAB-43 (AA)	136	131	145	141	130	65	124	131	138	125
LAB-44 (AA)	132	160	173	140	153	157	147	187	152	161
LAB-45 (AA)	157	157	160	155	157	159	157	155	156	157
LAB-46 (AA)	149	142	142	143	142	133	140	140	141	137
LAB-47 (AA)	150	151	154	152	150	152	150	149	153	150
LAB-50 (AA)	143	136	148	138	149	138	128	132	140	
LAB-52 (AA)	146	151	147	146	144	144	145	146	145	144
LAB- 8 (XRF)	126	140	130	125	123	132	130	125	131	129
LAB- 9 (XRF)	144	144	140	143	140	144	144	143	144	143
LAB-14 (XRF)	157	153								
LAB-19 (XRF)	151	153	146	149	151					
LAB-22 (ES)	155	156	156	155	154	150	157	152	153	153
LAB-45 (ES)	135	165	170	156	157	184	160	149	145	142
LAB- 4 (NAA)	171	170	167	168	165	161	164	155	160	161
LAB-41 (SSMS)	160	170	130	140	160					

	ZIRCONIUM (UG/G)									
LAB- 8 (XRF)	76	79	74	78	72	74	79	74	69	62
LAB- 9 (XRF)	60	62	61	77	69	63	76	65	69	60
LAB-22 (ES)	95	101	93	97	97	97	98	94	96	97
LAB-36 (ES)	70	110	130	120	75	80	80	90		
*LAB-45 (ES)	162	201	109	147	202	222	159	274	164	108
LAB-41 (SSMS)	77	97	84	82	71					

	LOI (WT%)									
LAB- 9	4.09	4.04								
*LAB-14	5.56	5.59								
LAB-15	4.20	4.83	4.45	4.34	4.62	4.38	4.89	4.53	4.20	4.59
*LAB-22	8.20	8.26								
LAB-24	4.41	4.14								
LAB-27	4.58	4.47	4.45	4.49	4.50	4.55	4.49	4.51	4.47	4.55
LAB-29	4.29	4.09	3.90	4.23	4.32	4.30	3.98	4.26	3.91	4.36
LAB-50	4.91	4.85	4.85	4.72	4.93					

	MOISTURE (WT%)									
LAB-22	3.30	3.22								
LAB-24	3.78	3.75								
LAB-29	4.36	4.68	4.78	4.71	4.31	4.30	4.76	4.27	4.72	4.21
LAB-55	3.66	3.55								

REFERENCE SOIL SO-2

	ZINC (UG/G)									
*LAB- 5 (AA)	89	85	87	87	90	85	89	89	88	89
LAB- 6 (AA)	110	110	112	110	112	112	110	112	112	110
*LAB-11 (AA)	95	89	94	96	97	98				
LAB-19 (AA)	151	139	143	147	144	163	129	141	144	140
LAB-20 (AA)	123	118								
*LAB-21 (AA)	125	120	125	130	130	125	120	125	130	150
LAB-27 (AA)	143	163	147	139						
*LAB-30 (AA)	63	61	61	63						
LAB-35 (AA)	120	121	118	121	124	123	124	123	125	125
LAB-39 (AA)	117	110	116	115	115	115	115	115	113	113
*LAB-40 (AA)	115	148	140	141	136	140	135	133	137	142
LAB-40 (AA)	144	142	144	136						
LAB-42 (AA)	110	110	110	110	110	110	100	110	110	110
*LAB-43 (AA)	124	120	158	124	122	137	127	124	123	118
LAB-44 (AA)	125	124	127	133	130	134	121	127	127	122
LAB-45 (AA)	137	137	140	142	140	137	138	140	141	138
LAB-46 (AA)	124	123	123	124	122	128	125	125	124	123
LAB-47 (AA)	134	138	133	140	140	136	133	134	134	137
LAB-50 (AA)	125	116	122	119	127	130	119	126	125	124
LAB-52 (AA)	130	130	134	131	130	130	130	129	130	131
LAB- 8 (XRF)	109	102	109	101	108	109	113	111	108	103
LAB- 9 (XRF)	110	113	112	110	112	113	114	113	114	113
LAB-14 (XRF)	119	121								
LAB-19 (XRF)	127	127	127	127	127					
LAB-22 (ES)	121	117	120	116	121	119	116	118	118	120
LAB-45 (ES)	101	103	102	107	124	112	111	109	127	117
LAB- 4 (NAA)	126	129	129	129	126	130	130	125	127	126
*LAB-41 (SSMS)	170	83	130	87	88					

	ZIRCONIUM (UG/G)									
LAB- 8 (XRF)	682	722	689	689	699	715	670	702	671	675
LAB- 9 (XRF)	716	698	738	707	712	727	738	727	728	729
LAB-22 (ES)	864	850	843	823	868	843	827	841	849	819
LAB-36 (ES)	900	700	700	900	750	620	1000			
LAB-45 (ES)	698	840	966	702	1053	680	1028	864	612	1149
LAB-41 (SSMS)	730	600	1000	650	1100					

	LOI (WT%)									
LAB- 9	11.10	11.06								
LAB-14	12.58	12.53								
LAB-15	11.71	11.00	11.42	11.17	11.73	12.01	12.38	11.78	11.70	11.77
*LAB-22	14.36	14.17								
LAB-24	11.47	11.52								
LAB-27	11.26	11.18	11.18	11.20	11.25	11.47	11.35	11.30	11.45	11.46
LAB-29	11.29	11.06	10.98	10.83	10.94	11.34	11.37	11.34	10.70	11.41
LAB-50	12.04	12.08	12.01	12.13	12.12					

	MOISTURE (WT%)									
*LAB-22	2.33	2.08								
LAB-24	2.62	2.55								
LAB-29	3.42	3.78	3.76	4.27	3.83	3.30	3.41	3.19	4.00	3.13
LAB-38	3.21	3.15	3.21	3.08	3.11	3.29	3.28	3.12	3.17	3.20
LAB-55	3.12	3.38								

REFERENCE SOIL S0-3

PHOSPHORUS (WT%)										
LAB-43 (AA)	.037	.038	.037	.035	.043	.050	.046	.041	.040	.039
LAB- 8 (XRF)	.046	.049	.046	.049	.049	.049	.049	.049	.046	.049
LAB- 9 (XRF)	.050	.050	.050	.050	.050	.060	.060	.060	.060	.060
LAB- 9 (COLOR)	.050	.050	.050	.050	.050	.050	.050	.050	.050	.050
LAB-14 (COLOR)	.040	.040								
* LAB-27 (COLOR)	.090	.070	.110	.110						
* LAB-27 (COLOR)	.070	.070								
* LAB-29 (COLOR)	.017	.022								
LAB-38 (COLOR)	.047	.047	.046	.046	.046	.047	.047	.047	.046	.046
LAB-42 (COLOR)	.041	.040	.040	.040	.040	.042	.041	.041	.041	.040
* LAB-50 (COLOR)	.070	.060	.060	.060	.060					
LAB-41 (SSMS)	.042	.047	.049	.047	.034					

POTASSIUM (WT%)										
LAB- 6 (AA)	1.03	1.05	1.00	1.05	1.05	1.02	1.05	1.05	1.05	1.06
LAB- 9 (AA)	1.29	1.31	1.29	1.34	1.35	1.33	1.32	1.31	1.34	1.34
LAB-20 (AA)	1.12	1.12								
LAB-21 (AA)	1.15	1.10	1.15	1.13	1.15	1.13	1.13	1.15	1.15	1.15
LAB-27 (AA)	1.16	1.17	1.15	1.21	1.21	1.17	1.19	1.18	1.21	1.21
LAB-28 (AA)	1.20	1.20	1.10	1.10	1.20	1.00	1.10	1.10	1.00	1.10
LAB-29 (AA)	1.37	1.38								
LAB-40 (AA)	1.17	1.24	1.17	1.20	1.20	1.16	1.10	1.11	1.20	1.16
LAB-40 (AA)	1.35	1.19	1.23	1.20						
LAB-43 (AA)	1.20	1.31								
LAB-50 (AA)	1.15	1.15	1.15	1.17	1.14					
LAB-27 (FLAME)	1.22	1.23	1.15	1.20						
LAB- 8 (XRF)	1.18	1.20	1.18	1.18	1.18	1.20	1.21	1.21	1.17	1.18
LAB- 9 (XRF)	1.07	1.07	1.10	1.09	1.10	1.10	1.10	1.09	1.12	1.04
LAB-14 (XRF)	1.11	1.10	1.10	1.09						
LAB-15 (XRF)	1.20	1.15	1.23	1.18	1.24	1.18	1.11	1.15	1.12	1.16
LAB-28 (XRF)	1.10	1.00								
LAB-29 (XRF)	1.03	1.05	1.14	1.05	1.10	1.05	1.04	1.05	1.07	1.06
LAB-22 (ES)	1.20	1.24								
LAB-24 (ES)	1.12	1.11								
* LAB-45 (ES)	1.21	.85	1.12	1.39	1.47	1.50	1.18	1.11	1.36	1.40
LAB- 4 (NAA)	1.25	1.31	1.27	1.29	1.24	1.16	1.26	1.36	1.26	1.20

RUBIDIUM (UG/G)										
LAB- 8 (XRF)	43	43	39	34	49	47	35	36	32	34
LAB- 9 (XRF)	37	34	41	38	37	35	35	36	35	38
LAB-14 (XRF)	35	37								
LAB-28 (XRF)	70	70								
LAB-22 (ES)	40	36	39	37	38	37	39	40	39	38
LAB-45 (ES)	41	47	42	47	45	41	43	40	40	46
LAB- 4 (NAA)	41	42	40	42	43	39	41	43	39	42
LAB-41 (SSMS)	45	49	54	40	52					

SCANDIUM (UG/G)										
LAB- 4 (NAA)	4.9	5.0	5.0	5.1	5.0	4.9	4.9	5.0	4.8	4.9
LAB-55 (NAA)	5.5	5.6	5.5	5.5	5.9	6.0	5.6	6.1	6.2	6.2
LAB-41 (SSMS)	7.6	6.0	8.4	13.0	8.0					

REFERENCE SOIL S0-4

PHOSPHORUS (WT%)												
LAB-43 (AA)	.084	.087	.086	.094	.087	.087	.087	.087	.087	.075	.098	
LAB- 8 (XRF)	.086	.086	.082	.086	.090	.090	.082	.090	.086	.086		
LAB- 9 (XRF)	.090	.090	.090	.090	.100	.100	.090	.100	.100	.090		
LAB- 9 (COLOR)	.100	.100	.100	.100	.090	.090						
LAB-14 (COLOR)	.070	.080										
* LAB-27 (COLOR)	.120	.120	.140	.110								
* LAB-29 (COLOR)	.031	.026										
LAB-38 (COLOR)	.094	.096	.095	.095	.093	.094	.094	.095	.097	.096		
LAB-42 (COLOR)	.079	.081	.080	.080	.082	.081	.079	.081	.081	.081		
LAB-50 (COLOR)	.110	.110	.110	.110								
LAB-41 (SSMS)	.140	.077	.088	.066	.061							

POTASSIUM (WT%)												
LAB- 6 (AA)	1.74	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75
* LAB- 9 (AA)	1.83	1.81	1.83	1.83	1.83	1.80	1.81	1.82	1.75	1.81		
LAB-20 (AA)	1.69	1.69										
LAB-21 (AA)	1.78	1.78	1.80	1.80	1.78	1.78	1.80	1.78	1.80	1.80		
LAB-27 (AA)	1.69	1.75	1.70	1.73	1.72	1.70	1.75	1.69	1.74	1.73		
LAB-28 (AA)	1.60	1.60	1.60	1.70	1.70	1.70	1.60	1.70	1.60	1.70		
* LAB-29 (AA)	1.94	1.93										
LAB-40 (AA)	1.75	1.68	1.70	1.70	1.73	1.70	1.74	1.68	1.65	1.66		
LAB-40 (AA)	1.87	1.74	1.80	1.72								
* LAB-43 (AA)	1.60	2.14										
LAB-50 (AA)	1.69	1.70	1.69	1.69	1.71							
LAB-27 (FLAME)	1.74	1.72	1.71	1.74								
LAB- 8 (XRF)	1.74	1.78	1.80	1.82	1.86	1.83	1.81	1.82	1.79	1.79		
LAB- 9 (XRF)	1.73	1.73	1.72	1.72	1.72	1.60	1.63	1.50	1.73	1.59		
LAB-14 (XRF)	1.69	1.69	1.69	1.70								
LAB-15 (XRF)	1.74	1.72	1.82	1.73	1.92	1.79	1.59	1.72	1.66	1.69		
LAB-28 (XRF)	1.60	1.70										
LAB-29 (XRF)	1.71	1.74	1.70	1.72	1.73	1.71	1.72	1.73	1.71	1.69		
LAB-22 (ES)	1.77	1.70										
LAB-24 (ES)	1.75	1.70										
LAB-45 (ES)	1.67	1.96	2.00	1.84	1.70	1.67	1.92	1.79	1.73	1.68		
LAB- 4 (NAA)	1.62	1.68	1.85	1.59	1.78	1.59	1.72	1.85	1.71	1.66		

RUBIDIUM (UG/G)												
LAB- 8 (XRF)	76	71	74	65	73	72	70	75	76	67		
LAB- 9 (XRF)	68	69	67	68	69	70	70	68	68	68		
LAB-14 (XRF)	62	67										
LAB-28 (XRF)	120	120										
LAB-22 (ES)	82	81	82	86	84	81	79	80	81	79		
LAB-45 (ES)	55	56	64	63	59	65	63	62	62	61		
LAB- 4 (NAA)	78	79	80	80	75	75	78	80	75	78		
LAB-41 (SSMS)	130	78	97	79	72							

SCANDIUM (UG/G)												
LAB- 4 (NAA)	8.0	8.1	8.2	8.2	8.2	8.1	8.1	8.1	8.1	8.1	8.1	8.1
LAB-55 (NAA)	10.2	10.2	9.3	9.2	9.3	9.1	9.2	9.6	9.3	9.4		
LAB-41 (SSMS)	18.0	14.0	11.0	10.0	10.0							

REFERENCE SOIL S0-3

TITANIUM (WT%)										
* LAB-21 (AA)	.31	.31	.30	.25	.26	.31	.30	.30	.25	.25
LAB-21 (AA)	.20	.20	.22	.20	.20	.20	.21	.20	.21	.20
* LAB-28 (AA)	.18	.18	.18	.18	.18	.18	.18	.18	.24	.18
LAB-43 (AA)	.20	.19	.19	.20	.20	.17				
LAB- 8 (XRF)	.15	.15	.15	.15	.15	.15	.15	.14	.14	.15
LAB- 9 (XRF)	.21	.21	.22	.21	.21	.21	.21	.21	.21	.21
LAB-14 (XRF)	.18	.18	.18	.19						
LAB-15 (XRF)	.20	.21	.21	.20	.22	.20	.20	.20	.20	.21
* LAB-28 (XRF)	.18	.18	.12	.18						
LAB-29 (XRF)	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18
LAB-22 (ES)	.19	.18								
LAB-24 (ES)	.24	.24								
* LAB-45 (ES)	.31	.33	.29	.41	.31	.36	.32	.35	.31	.31
LAB- 9 (COLOR)	.23	.23	.23	.23	.23	.23	.21	.22	.23	.23
LAB-27 (COLOR)	.20	.21	.22	.21	.22	.19	.21	.21	.21	.20
* LAB-29 (COLOR)	.31	.37								
LAB-50 (COLOR)	.20	.20	.20	.19	.19					
LAB-55 (NAA)	.16	.20	.18	.19	.17	.18	.20	.19	.17	.16

URANIUM (UG/G)										
LAB- 4 (NAA)	.7	.7	.8	.8	.7	.8	.8	.7	.8	
LAB-55 (NAA)	1.3	.9	1.1	1.5	1.1	1.1	1.5	1.2	1.1	1.4
LAB-41 (SSMS)	1.0	1.4	1.4	1.6	1.4					

VANADIUM (UG/G)										
LAB-29 (AA)	48	50	46	38	35	33	40	33	45	50
LAB-42 (AA)	98	78	97	73	67	68	69	87	56	84
LAB-43 (AA)	48	47	61	34	43	40	30	29	28	85
LAB- 8 (XRF)	28	26	23	32	25	20	30	23	20	27
LAB-14 (XRF)	32	34								
LAB-28 (XRF)	40	40								
LAB-24 (ES)	55	56								
LAB-45 (ES)	67	58	59	66	68	49	61	66	64	63
LAB-38 (COLOR)	28	30	29	27	27	28	32	31	32	30
	31	31								
LAB-50 (COLOR)	31	33	32	31	33					
LAB-55 (NAA)	34	38	38	38	38	36	36	38	40	34
LAB-41 (SSMS)	44	40	43	49	32					

YTTORIUM (UG/G)										
LAB- 9 (XRF)	15	14	13	14	14	15	15	17	15	15
LAB-14 (XRF)	12	14								
LAB-22 (ES)	17	17	14	16	18	18	16	16	17	15
* LAB-45 (ES)	48	30	41	36	50	55	31	51	53	29
LAB-41 (SSMS)	19	16	21	20	21					

REFERENCE SOIL S0-4

TITANIUM (WT%)												
LAB-21 (AA)	.37	.38	.38	.34	.32	.38	.34	.38	.32	.33		
LAB-21 (AA)	.33	.33	.35	.35	.33	.35	.32	.33	.33	.34	.33	
LAB-28 (AA)	.30	.24	.30	.30	.30	.24	.30	.24	.30	.24	.30	
LAB-43 (AA)	.37	.28	.26	.29	.27	.24						
LAB- 8 (XRF)	.38	.37	.36	.38	.38	.38	.38	.38	.38	.38	.37	
LAB- 9 (XRF)	.34	.34	.34	.34	.35	.34	.34	.34	.34	.34	.34	
LAB-14 (XRF)	.32	.33	.33	.33								
LAB-15 (XRF)	.35	.35	.34	.35	.35	.35	.35	.35	.34	.35	.35	
LAB-28 (XRF)	.30	.24										
LAB-29 (XRF)	.34	.34	.34	.34	.34	.34	.34	.34	.34	.34	.34	
LAB-22 (ES)	.35	.34										
LAB-24 (ES)	.35	.35										
LAB-45 (ES)	.43	.39	.38	.41	.43	.42	.40	.41	.44	.36		
LAB- 9 (COLOR)	.32	.32	.33	.32	.33	.33	.33	.33	.33	.32	.33	
LAB-27 (COLOR)	.35	.35	.33	.33	.33	.35	.34	.35	.33	.34		
LAB-29 (COLOR)	.39	.37										
LAB-50 (COLOR)	.33	.34	.33	.35	.34							
LAB-55 (NAA)	.37	.30	.31	.30	.34	.31	.30	.32	.29	.29		

URANIUM (UG/G)												
LAB- 4 (NAA)	1.7	2.0	1.9	1.8	2.0	2.0	2.0	1.9	2.3	2.3		
LAB-55 (NAA)	2.9	2.8	2.8	2.1	2.2	2.9	2.4	2.5	2.6	2.1		
LAB-41 (SSMS)	2.6	1.9	2.3	3.2	3.0							

VANADIUM (UG/G)												
LAB-29 (AA)	82	85	82	72	74	78	82	77	83	83		
LAB-42 (AA)	120	110	150	120	130	130	110	130	120	110		
* LAB-43 (AA)	106	95	107	84	100	93	84	81	88	45		
LAB- 8 (XRF)	85	103	97	90	80	92	95	99	94	94		
LAB-14 (XRF)	80	81										
LAB-28 (XRF)	110	110										
LAB-24 (ES)	82	90										
LAB-45 (ES)	75	77	75	103	72	79	68	96	76	92		
LAB-38 (COLOR)	82	82	83	82	84	83	77	80	73	78		
	74	74										
LAB-50 (COLOR)	82	80	81	85	82							
LAB-55 (NAA)	76	72	70	76	75	101	101	99	97	92		
* LAB-41 (SSMS)	180	100	120	79	68							

YTTORIUM (UG/G)												
LAB- 9 (XRF)	22	22	18	19	23	20	23	20	20	20		
LAB-14 (XRF)	19	20										
LAB-22 (ES)	22	24	23	22	25	27	22	25	22	24		
LAB-45 (ES)	26	24	23	22	21	22	18	22	24	22		
LAB-41 (SSMS)	34	21	32	30	21							

See legend and note on p 30

REFERENCE SOIL S0-3

	ZINC (UG/G)									
LAB- 5 (AA)	45	44	47	48	48	54	46	54	48	51
LAB- 6 (AA)	52	52	52	52	52	52	54	54	54	52
LAB-11 (AA)	60	56	55	51	53	53	55	54		
LAB-19 (AA)	55	58	60	55	54	56	56	59	67	55
LAB-20 (AA)	42	39								
LAB-21 (AA)	55	50	55	50	50	55	50	55	55	50
* LAB-27 (AA)	70	73	80	72						
LAB-30 (AA)	49	48	49	49						
LAB-35 (AA)	52	51	52	51	52	50	50	51	48	51
LAB-39 (AA)	49	49	49	51	50	51	50	48	49	50
LAB-40 (AA)	58	71	64	67	71	50	72	64	70	70
* LAB-40 (AA)	77	68	67	68						
LAB-42 (AA)	49	49	44	46	47	49	59	39	48	
LAB-43 (AA)	58	56	50	53	53	51	47	53	46	45
LAB-44 (AA)	52	53	50	46	50	49	48	47	49	47
LAB-45 (AA)	71	53	59	57	63	60	56	57	58	62
LAB-46 (AA)	48	48	48	48	42	50	46	45	46	47
LAB-47 (AA)	57	61	61	58	58	54	57	59	55	59
LAB-50 (AA)	58	57	61	60	62	56	53	60	54	53
LAB-52 (AA)	55	54	54	54	54	52	52	52	52	52
LAB- 8 (XRF)	54	51	40	45	46	48	50	44	45	49
LAB- 9 (XRF)	46	50	46	46	48	47	46	44	48	46
LAB-14 (XRF)	50	48								
LAB-19 (XRF)	55	48	52	49	53					
LAB-22 (ES)	42	43	45	45	44	44	45	43	44	40
* LAB-45 (ES)	70	43	51	82	45	45	56	36	34	14
LAB- 4 (NAA)	51	58	54	53	56	58	56	53	55	59
LAB-41 (SSMS)	53	77	59	52	46					

	ZIRCONIUM (UG/G)									
LAB- 8 (XRF)	136	143	137	149	144	157	140	147	149	163
LAB- 9 (XRF)	148	139	146	142	161	145	143	148	152	160
LAB-22 (ES)	177	177	185	190	177	176	168	177	185	181
LAB-36 (ES)	160	160	145	130	130	100	120			
LAB-45 (ES)	156	100	72	115	78	76	93	159	115	86
LAB-41 (SSMS)	170	180	120	200	160					

	LOI (WT%)									
LAB- 9	25.22	25.22								
LAB-14	25.47	25.50								
* LAB-15	26.28	25.64	25.31	25.11	25.45	25.34	25.55	25.37	25.20	25.44
LAB-22	25.56	25.64								
LAB-24	25.20	25.09								
LAB-27	25.08	25.10	25.00	25.08	25.37	25.10	25.31	25.30	25.23	25.25
LAB-29	25.38	25.26	25.06	25.48	25.30	25.31	25.35	25.25	25.21	25.27
LAB-50	25.62	25.64	25.62	25.34	25.37					

	MOISTURE (WT%)									
LAB-22	.28	.31								
LAB-24	.34	.33								
LAB-29	.37	.52	.38	.46	.36	.33	.53	.39	.46	.32
LAB-55	.26	.32								

REFERENCE SOIL S0-4

	ZINC (UG/G)									
* LAB- 5 (AA)	70	65	68	68	69	69	65	68	67	68
LAB- 6 (AA)	96	84	84	84	84	84	82	84	84	84
LAB-11 (AA)	97	95	91	105	98	99	93			
LAB-19 (AA)	105	96	99	100	99	104	112	100	99	101
LAB-20 (AA)	88	92								
LAB-21 (AA)	95	90	90	95	95	95	90	95	95	95
LAB-27 (AA)	107	105	106	109						
LAB-30 (AA)	84	83	82	82						
LAB-35 (AA)	93	94	95	93	92	95	95	97	97	94
LAB-39 (AA)	93	93	93	89	90	93	94	92	89	89
LAB-40 (AA)	92	114	98	110	112	90	111	107	114	110
* LAB-40 (AA)	114	110	112	116						
LAB-42 (AA)	79	94	80	80	80	80	87	79	80	79
* LAB-43 (AA)	91	90	94	89	91	93	88	84	111	84
LAB-44 (AA)	93	94	91	91	99	93	90	93	90	105
LAB-45 (AA)	102	99	103	104	100	99	99	103	104	102
LAB-46 (AA)	91	92	90	90	92	93	93	94	93	93
LAB-47 (AA)	101	104	100	104	100	97	97	104	102	102
LAB-50 (AA)	90	83	89	88	89	83	77	86	83	83
LAB-52 (AA)	98	98	98	97	96	97	97	98	97	97
LAB- 8 (XRF)	87	84	85	88	84	87	90	90	95	91
LAB- 9 (XRF)	91	90	90	91	92	93	92	93	91	92
LAB-14 (XRF)	94	97								
LAB-19 (XRF)	101	103	104	103	102					
LAB-22 (ES)	98	100	101	101	98	98	97	99	100	99
LAB-45 (ES)	96	93	96	96	96	98	113	95	97	100
LAB- 4 (NAA)	90	94	94	95	90	91	96	93	93	92
LAB-41 (SSMS)	78	85	100	78	85					

	ZIRCONIUM (UG/G)									
LAB- 8 (XRF)	254	256	263	251	250	274	268	261	278	268
LAB- 9 (XRF)	274	288	272	273	267	268	278	276	262	281
LAB-22 (ES)	322	327	326	334	327	316	323	321	318	327
LAB-36 (ES)	270	200	250	280	300	250	170	250		
LAB-45 (ES)	333	446	336	346	326	412	356	378	592	317
LAB-41 (SSMS)	260	250	410	390	500					

	LOI (WT%)									
LAB- 9	10.19	10.18								
LAB-14	10.63	10.67								
LAB-15	10.91	10.74	10.21	10.43	10.65	10.57	10.39	10.33	10.36	
* LAB-22	13.18	13.09								
LAB-24	10.28	10.84								
LAB-27	10.39	10.47	10.45	10.47	10.56	10.35	10.40	10.35	10.38	10.40
LAB-29	10.28	9.98	10.18	10.27	10.18	10.25	10.14	10.25	10.06	10.52
LAB-50	10.86	10.78	10.81	10.77	10.67					

	MOISTURE (WT%)									
LAB-22	2.41	2.41								
LAB-24	2.66	2.16								
LAB-29	3.58	3.51	3.26	3.38	3.24	3.08	3.57	3.32	3.52	3.01
LAB-55	2.82	2.95								

Legend: AA - atomic absorption; FLAME - flame emission; XRF - X-ray fluorescence; ES - emission spectroscopy; COLOR - colorimetry (absorptiometry); NAA - neutron activation analysis; TITR - titrimetry; GRAV - gravimetry; SSMS - spark source mass spectrometry; COMB - combustion; GC - gas chromatography.

* - Indicates set in which one or more values are gross outliers and were not used in computations.

NOTE: This table does not give the raw data for certain elements, such as most rare earths, for which there is insufficient data for certification or for useful comparisons to be made among methods. For such elements, however, overall means are given in Table 4.

Table 6
Particle size analysis (wet screen)

Size of fraction (μm)	SO-1	SO-2	SO-3	SO-4
	wt %			
+74	6.7	0.1	-	0.2
-74 +55	1.2	0.6	0.1	3.4
-55 +46	2.9	7.8	7.4	10.8
-46 +37	1.1	7.0	4.6	7.2
-37	88.1	84.5	87.9	78.4

APPENDIX A

Participating Laboratories

- Alberta Institute of Pedology, University of Alberta, Edmonton, Alberta.
- Alberta Research Council, Edmonton, Alberta.
- Bondar-Clegg and Company Limited, Ottawa, Ontario.
- Canada Centre for Mineral and Energy Technology, Mineral Sciences Laboratories, Department of Energy, Mines and Resources, Ottawa, Ontario (three independent analysts).
- Centre de Recherche Petrographiques et Geochimiques, Centre National de la Recherche Scientifique, Vandoeuvre-les-Nancy, France.
- Chemistry and Biology Research Institute, Agriculture Canada, Ottawa, Ontario.
- Commonwealth Scientific and Industrial Research Organization, Division of Mineral Chemistry, Port Melbourne, Victoria, Australia.
- Department of Mines, Australia, South Launceston, Tasmania, Australia.
- European Economic Community Research Laboratories, Ispra, Italy.
- Geological Survey of Czechoslovakia, Prague, Czechoslovakia.
- Geological Survey of Israel, Geochemistry Department, Jerusalem, Israel.
- Geological Survey of Japan, Kawasaki, Japan.
- Geological Survey of Norway, Chemistry Division, Trondheim, Norway.
- Imperial College of Science and Technology, Department of Geology, London, England.
- Inco Limited, Analytical Services, Process Technology, Copper Cliff, Ontario.
- Inco Limited, Geological Research, Field Exploration, Copper Cliff, Ontario.
- Institute for Geological Sciences, London, England.
- Kansas State University, Department of Geology, Manhattan, Kansas.
- Kyoto University, Faculty of Agriculture, Kyoto, Japan.
- Land Resource Research Institute, Agriculture Canada, Ottawa, Ontario.
- Macaulay Institute for Soil Research, Aberdeen Scotland.
- Manitoba Department of Mines, Resources and Environmental Management, Geological Surveys Branch, Winnipeg, Manitoba.
- Ministry of Natural Resources, Mineral Research Branch, Toronto, Ontario.
- National Institute of Agricultural Sciences, Department of Soils and Fertilizers, Tokyo, Japan.
- National Research Council, Physical and Chemical Science Laboratories, Ottawa, Ontario.
- Norges Landbrukshøgskole, Ås, Norway.
- Ontario Ministry of Environment, Laboratories Branch, Rexdale, Ontario.
- Rijksuniversiteit, Laboratorium voor Analytische en Agrochemie, Gent, Belgium.
- Rijksuniversiteit, Laboratorium voor Fysische Aandrijfskunde en Bodemkunde, Gent, Belgium.
- Rothamsted Experimental Station, Pedology Department, Harpenden, Herts., England.
- Royal Tropical Institute, Tropical Soils Division, Department of Agricultural Research, Amsterdam, Netherlands.
- The Hebrew University of Jerusalem, The Levi Eshkol School of Agriculture, Rehovot, Israel.
- University of Oslo, Institute for Geology, Oslo, Norway.
- University of Wisconsin, Department of Soil Science, Madison, Wisconsin, U.S.A.
- University of Wisconsin, Nuclear Reactor Laboratory, Madison, Wisconsin, U.S.A.
- Water Quality Branch, Department of Fisheries and the Environment, Burlington, Ontario (two independent analysts).