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CERTIFICATE OF ANALYSIS FOR

Lateritic Soil Lithogeochem

CERTIFIED REFERENCE MATERIAL

OREAS 45f

Table 1. Certified Values, SDs, 95% Confidence and Tolerance Limits for OREAS 45f.

Constituent	Certified Value	SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Pb Fire Assay						
Au, Gold (ppb)	19.3	1.7	18.6	19.9	18.3*	20.2*
Pd, Palladium (ppb)	56.6	4.0	55.0	58.2	55.3	57.9
Pt, Platinum (ppb)	38.1	2.5	37.1	39.0	36.3	39.9
Aqua Regia Digestion (sample weights 10-50g)						
Au, Gold (ppb)	18.0	1.6	17.3	18.8	17.1*	19.0*
Borate Fusion XRF						
Al_2O_3, Aluminium(III) oxide (wt.%)	20.49	0.169	20.40	20.57	20.38	20.60
BaO, Barium oxide (ppm)	264	46	205	323	239	289
CaO, Calcium oxide (wt.%)	0.137	0.006	0.135	0.140	0.134	0.141
Cr_2O_3, Chromium(III) oxide (ppm)	705	47	687	723	659	751
Cu, Copper (ppm)	356	9	347	365	345	366
Fe_2O_3, Iron(III) oxide (wt.%)	22.26	0.304	22.12	22.40	22.14	22.39
K_2O, Potassium oxide (wt.%)	0.283	0.005	0.281	0.285	0.280	0.287
MgO, Magnesium oxide (wt.%)	0.420	0.011	0.415	0.425	0.410	0.430
MnO, Manganese oxide (wt.%)	0.031	0.002	0.030	0.031	0.029	0.033
Na_2O, Sodium oxide (wt.%)	0.090	0.013	0.084	0.096	0.084	0.096
Ni, Nickel (ppm)	289	24	270	309	264	315

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

*Gold Tolerance Limits for typical 30g fire assay charge weight and 25g aqua regia sample weight are determined from 20 x 85mg INAA results and the Sampling Constant (Ingamells & Switzer, 1973).
Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Borate Fusion XRF continued						
P_2O_5, Phosphorus(V) oxide (wt.%)	0.071	0.004	0.069	0.074	0.069	0.073
S, Sulphur (wt.%)	0.032	0.002	0.030	0.033	0.029	0.034
SiO_2, Silicon dioxide (wt.%)	43.59	0.252	43.47	43.71	43.41	43.77
Sr, Strontium (ppm)	28.6	6.9	21.7	35.5	IND	IND
TiO_2, Titanium dioxide (wt.%)	1.99	0.018	1.98	2.00	1.98	2.01
V_2O_5, Vanadium(V) oxide (ppm)	454	59	399	509	430	478
Zr, Zirconium (ppm)	260	19	240	280	252	268
Thermogravimetry						
LOI^{1000}, Loss on ignition @1000°C (wt.%)	10.27	0.322	10.12	10.42	10.19	10.35
Borate / Peroxide Fusion ICP						
Al, Aluminium (wt.%)	10.41	0.212	10.32	10.50	10.25	10.57
Ba, Barium (ppm)	210	10	206	215	204	217
Be, Beryllium (ppm)	1.03	0.15	0.86	1.20	IND	IND
Bi, Bismuth (ppm)	0.20	0.04	0.17	0.23	IND	IND
Ca, Calcium (wt.%)	0.102	0.015	0.093	0.112	0.093	0.112
Ce, Cerium (ppm)	29.4	1.58	28.2	30.6	27.9	30.9
Co, Cobalt (ppm)	49.0	3.02	47.1	51.0	46.8	51.3
Cr, Chromium (ppm)	476	23	462	489	459	492
Cs, Cesium (ppm)	3.66	0.244	3.53	3.79	3.46	3.86
Cu, Copper (ppm)	362	15	354	369	347	376
Dy, Dysprosium (ppm)	2.88	0.193	2.73	3.03	2.66	3.10
Er, Erbium (ppm)	1.65	0.17	1.53	1.77	1.55	1.75
Eu, Europium (ppm)	0.62	0.07	0.57	0.67	0.58	0.67
Fe, Iron (wt.%)	15.16	0.353	15.00	15.32	14.95	15.36
Ga, Gallium (ppm)	26.2	2.46	24.6	27.8	24.7	27.6
Gd, Gadolinium (ppm)	2.57	0.26	2.36	2.78	2.33	2.81
Hf, Hafnium (ppm)	6.97	0.79	5.95	7.99	6.39	7.54
Ho, Holmium (ppm)	0.56	0.06	0.51	0.61	0.52	0.60
K, Potassium (wt.%)	0.228	0.020	0.217	0.239	0.215	0.242
La, Lanthanum (ppm)	15.7	1.6	14.5	16.9	14.7	16.7
Li, Lithium (ppm)	20.4	1.39	19.1	21.7	18.5	22.4
Lu, Lutetium (ppm)	0.26	0.04	0.23	0.29	0.23	0.28
Mg, Magnesium (wt.%)	0.242	0.011	0.236	0.247	0.234	0.249
Mn, Manganese (wt.%)	0.024	0.002	0.022	0.025	0.022	0.025
Na, Sodium (wt.%)	0.070	0.007	0.061	0.078	IND	IND
Nb, Niobium (ppm)	23.7	2.04	22.6	24.9	22.6	24.8
Nd, Neodymium (ppm)	13.0	0.90	12.1	13.8	12.3	13.6
Ni, Nickel (ppm)	268	23	256	281	256	281
P, Phosphorus (wt.%)	0.030	0.004	0.027	0.032	0.025	0.035

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Borate / Peroxide Fusion ICP continued						
Pr, Praseodymium (ppm)	3.44	0.221	3.26	3.63	3.14	3.75
Rb, Rubidium (ppm)	31.6	2.02	30.2	32.9	30.5	32.6
Sb, Antimony (ppm)	0.63	0.14	0.53	0.73	IND	IND
Sc, Scandium (ppm)	35.8	2.02	33.7	37.8	33.7	37.9
Si, Silicon (wt.%)	19.72	0.598	19.44	20.00	19.44	19.99
Sm, Samarium (ppm)	2.60	0.160	2.48	2.72	2.46	2.74
Sn, Tin (ppm)	3.37	0.67	2.81	3.93	IND	IND
Sr, Strontium (ppm)	26.9	4.2	23.6	30.1	24.6	29.1
Ta, Tantalum (ppm)	1.56	0.144	1.46	1.65	1.40	1.71
Tb, Terbium (ppm)	0.41	0.040	0.38	0.44	0.38	0.44
Th, Thorium (ppm)	9.99	0.794	9.51	10.47	9.57	10.41
Ti, Titanium (wt.%)	1.14	0.041	1.13	1.16	1.12	1.17
Tm, Thulium (ppm)	0.26	0.04	0.23	0.29	0.24	0.28
U, Uranium (ppm)	2.32	0.191	2.21	2.43	2.18	2.45
V, Vanadium (ppm)	261	7	257	266	254	269
Y, Yttrium (ppm)	14.7	1.46	13.9	15.6	14.1	15.3
Yb, Ytterbium (ppm)	1.79	0.168	1.69	1.89	1.69	1.90
Zn, Zinc (ppm)	34.3	5.2	30.6	38.1	30.9	37.8
Zr, Zirconium (ppm)	261	20	243	279	246	276
4-Acid Digestion						
Al, Aluminium (wt.%)	10.16	0.451	10.00	10.32	9.93	10.39
As, Arsenic (ppm)	9.67	0.842	9.42	9.91	8.97	10.37
Ba, Barium (ppm)	206	9	203	210	202	211
Be, Beryllium (ppm)	1.20	0.15	1.16	1.25	1.13	1.28
Bi, Bismuth (ppm)	0.21	0.017	0.20	0.22	0.20	0.23
Ca, Calcium (wt.%)	0.096	0.007	0.093	0.099	0.093	0.098
Ce, Cerium (ppm)	28.8	2.40	27.9	29.8	27.8	29.9
Co, Cobalt (ppm)	44.5	2.32	43.7	45.4	43.5	45.6
Cr, Chromium (ppm)	417	35	405	430	403	431
Cs, Cesium (ppm)	3.65	0.248	3.56	3.74	3.50	3.80
Cu, Copper (ppm)	363	16	357	368	355	370
Dy, Dysprosium (ppm)	2.23	0.132	2.14	2.32	2.10	2.35
Er, Erbium (ppm)	1.33	0.090	1.28	1.38	1.28	1.39
Eu, Europium (ppm)	0.63	0.07	0.59	0.68	0.60	0.67
Fe, Iron (wt.%)	14.65	0.561	14.43	14.87	14.41	14.89
Ga, Gallium (ppm)	26.7	1.24	26.3	27.2	25.8	27.7
Gd, Gadolinium (ppm)	2.31	0.27	2.13	2.49	2.19	2.42
Hf, Hafnium (ppm)	4.64	0.435	4.48	4.80	4.45	4.82
Ho, Holmium (ppm)	0.45	0.05	0.41	0.48	0.42	0.47
In, Indium (ppm)	0.11	0.010	0.10	0.11	0.09	0.12
K, Potassium (wt.%)	0.224	0.009	0.221	0.228	0.218	0.231

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
4-Acid Digestion continued						
La, Lanthanum (ppm)	15.7	1.43	15.2	16.2	15.1	16.3
Li, Lithium (ppm)	20.4	1.18	20.0	20.9	19.3	21.6
Lu, Lutetium (ppm)	0.19	0.03	0.17	0.20	0.18	0.20
Mg, Magnesium (wt.%)	0.229	0.015	0.224	0.235	0.223	0.235
Mn, Manganese (wt.%)	0.022	0.001	0.022	0.023	0.022	0.023
Mo, Molybdenum (ppm)	2.27	0.219	2.19	2.35	2.17	2.37
Na, Sodium (wt.%)	0.063	0.004	0.060	0.065	0.061	0.064
Nb, Niobium (ppm)	23.1	1.54	22.5	23.8	22.3	24.0
Nd, Neodymium (ppm)	12.3	0.93	11.7	12.8	11.9	12.7
Ni, Nickel (ppm)	256	16	251	262	250	263
P, Phosphorus (wt.%)	0.030	0.002	0.029	0.030	0.028	0.031
Pb, Lead (ppm)	14.7	1.18	14.3	15.2	14.2	15.3
Pr, Praseodymium (ppm)	3.43	0.277	3.23	3.63	3.28	3.58
Rb, Rubidium (ppm)	31.2	1.94	30.5	32.0	30.2	32.3
S, Sulphur (wt.%)	0.029	0.002	0.029	0.030	0.028	0.030
Sb, Antimony (ppm)	0.64	0.062	0.61	0.66	0.59	0.68
Sc, Scandium (ppm)	36.3	2.27	35.4	37.1	35.0	37.6
Se, Selenium (ppm)	2.26	0.38	2.07	2.45	2.06	2.46
Sm, Samarium (ppm)	2.49	0.146	2.40	2.57	2.35	2.62
Sn, Tin (ppm)	2.85	0.165	2.80	2.91	2.68	3.02
Sr, Strontium (ppm)	25.1	1.22	24.7	25.5	24.2	26.0
Ta, Tantalum (ppm)	1.66	0.25	1.56	1.75	1.58	1.73
Tb, Terbium (ppm)	0.37	0.024	0.36	0.38	0.35	0.39
Th, Thorium (ppm)	9.99	0.894	9.65	10.33	9.60	10.38
Ti, Titanium (wt.%)	1.08	0.040	1.06	1.09	1.05	1.10
Tl, Thallium (ppm)	0.20	0.017	0.19	0.21	0.19	0.21
Tm, Thulium (ppm)	0.20	0.03	0.18	0.22	0.18	0.22
U, Uranium (ppm)	2.09	0.150	2.03	2.14	2.02	2.16
V, Vanadium (ppm)	253	8	250	255	247	258
W, Tungsten (ppm)	1.27	0.14	1.22	1.32	1.21	1.33
Y, Yttrium (ppm)	10.9	1.2	10.4	11.4	10.4	11.4
Yb, Ytterbium (ppm)	1.25	0.14	1.18	1.32	1.20	1.29
Zn, Zinc (ppm)	35.3	2.26	34.4	36.2	33.8	36.7
Zr, Zirconium (ppm)	172	11	168	176	166	178
Aqua Regia Digestion (sample weights 0.15-50g)						
Al, Aluminium (wt.%)	4.81	0.62	4.53	5.08	4.68	4.93
Ba, Barium (ppm)	158	7	155	161	154	162
Be, Beryllium (ppm)	0.98	0.090	0.95	1.02	0.94	1.03
Bi, Bismuth (ppm)	0.17	0.014	0.16	0.17	0.16	0.18
Ca, Calcium (wt.%)	0.075	0.006	0.073	0.077	0.074	0.077
Ce, Cerium (ppm)	22.3	2.3	21.4	23.2	21.6	23.1

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Aqua Regia Digestion (sample weights 0.15-50g) continued						
Co, Cobalt (ppm)	39.2	3.44	37.9	40.5	38.2	40.3
Cr, Chromium (ppm)	341	25	332	351	333	349
Cs, Cesium (ppm)	1.88	0.27	1.75	2.00	1.78	1.97
Cu, Copper (ppm)	336	16	330	342	327	345
Dy, Dysprosium (ppm)	1.49	0.113	1.41	1.57	1.43	1.55
Er, Erbium (ppm)	0.78	0.063	0.74	0.83	0.75	0.82
Eu, Europium (ppm)	0.49	0.06	0.45	0.54	0.47	0.52
Fe, Iron (wt.%)	13.69	0.560	13.48	13.90	13.40	13.97
Ga, Gallium (ppm)	20.3	1.91	19.5	21.1	19.6	21.1
Gd, Gadolinium (ppm)	1.70	0.159	1.58	1.82	1.63	1.78
Ge, Germanium (ppm)	0.12	0.02	0.10	0.13	0.11	0.13
Hf, Hafnium (ppm)	0.93	0.17	0.85	1.01	0.88	0.98
Hg, Mercury (ppm)	0.031	0.005	0.028	0.033	0.025	0.037
Ho, Holmium (ppm)	0.28	0.022	0.26	0.30	0.27	0.29
In, Indium (ppm)	0.087	0.006	0.085	0.090	0.083	0.091
K, Potassium (wt.%)	0.082	0.014	0.076	0.088	0.079	0.085
La, Lanthanum (ppm)	10.7	0.75	10.4	11.1	10.4	11.1
Lu, Lutetium (ppm)	0.097	0.007	0.093	0.101	0.089	0.105
Mg, Magnesium (wt.%)	0.152	0.021	0.144	0.160	0.147	0.158
Mn, Manganese (wt.%)	0.015	0.002	0.014	0.015	0.014	0.015
Mo, Molybdenum (ppm)	1.19	0.23	1.10	1.29	1.13	1.26
Na, Sodium (wt.%)	0.032	0.004	0.030	0.034	0.031	0.033
Nd, Neodymium (ppm)	10.1	1.0	9.3	10.8	9.7	10.5
Ni, Nickel (ppm)	192	14	186	198	186	198
P, Phosphorus (wt.%)	0.022	0.001	0.022	0.023	0.021	0.023
Pb, Lead (ppm)	12.4	0.60	12.2	12.6	12.0	12.7
Pd, Palladium (ppb)	39.9	2.3	39.2	40.6	35.5	44.4
Pr, Praseodymium (ppm)	2.63	0.37	2.34	2.92	2.54	2.73
Pt, Platinum (ppb)	36.7	2.0	35.5	37.8	33.3	40.0
Rb, Rubidium (ppm)	14.4	1.08	13.9	14.9	13.8	14.9
S, Sulphur (wt.%)	0.027	0.004	0.025	0.028	0.026	0.027
Sc, Scandium (ppm)	31.4	2.26	30.6	32.3	30.3	32.5
Sm, Samarium (ppm)	1.91	0.25	1.72	2.10	1.81	2.01
Sn, Tin (ppm)	1.97	0.21	1.87	2.06	1.88	2.05
Sr, Strontium (ppm)	13.2	1.11	12.7	13.6	12.7	13.7
Tb, Terbium (ppm)	0.25	0.014	0.24	0.26	0.23	0.26
Th, Thorium (ppm)	7.67	0.661	7.40	7.94	7.47	7.87
Ti, Titanium (wt.%)	0.097	0.020	0.088	0.107	0.093	0.102
Tl, Thallium (ppm)	0.12	0.01	0.11	0.12	0.11	0.12
Tm, Thulium (ppm)	0.11	0.008	0.10	0.12	IND	IND
U, Uranium (ppm)	1.09	0.091	1.05	1.12	1.06	1.12

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 1 continued.

Constituent	Certified Value	SD	95% Confidence Limits		95% Tolerance Limits	
			Low	High	Low	High
Aqua Regia Digestion (sample weights 0.15-50g) continued						
V, Vanadium (ppm)	217	11	213	221	213	221
Y, Yttrium (ppm)	6.74	0.336	6.61	6.87	6.45	7.03
Yb, Ytterbium (ppm)	0.69	0.045	0.67	0.71	0.67	0.71
Zn, Zinc (ppm)	22.2	3.7	20.7	23.7	21.3	23.1
Zr, Zirconium (ppm)	30.0	4.3	28.1	31.9	28.2	31.9
Infrared Combustion						
C, Carbon (wt.%)	0.318	0.021	0.310	0.327	0.308	0.328

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

INTRODUCTION

OREAS reference materials are intended to provide a low cost method of evaluating and improving the quality of analysis of geological samples. To the geologist they provide a means of implementing quality control in analytical data sets generated in exploration from the grass roots level through to prospect evaluation, and in grade control at mining operations. To the analyst they provide an effective means of calibrating analytical equipment, assessing new techniques and routinely monitoring in-house procedures.

SOURCE MATERIALS

OREAS 45f was prepared from a blend of mineralised ferruginous soil, barren mature soil and minor additions of gold and nickel ores. The ferruginous soil was developed over a Ni-Cu-PGE mineralised contact between gabbro and pyroxenite in a layered mafic intrusive from the Southern Murchison region of Western Australia. It contains anomalous precious and base metal values (Au, PGE's, Cu and Ni). The barren soil was taken from a layer of mature soil developed in situ over early Tertiary tholeiitic basalt in outer eastern Melbourne, Victoria, Australia.

COMMINUTION AND HOMOGENISATION PROCEDURES

The materials constituting OREAS 45f were prepared in the following manner:

- Drying to constant mass at 105°C;
- Milling of barren material to >98% minus 75 microns;
- Milling of mineralised ferruginous soil and ore materials to 100% minus 35 microns;
- Preliminary homogenisation and check assaying of source materials;
- Pre-equilibration of material to typical laboratory atmosphere (~3.95% H_2O: 20 degrees Celsius, 60% humidity);
- Final homogenisation by blending the source materials in specific ratios to achieve target grades;
- Packaging in 10g and 60g units in laminated foil pouches and 500g units in plastic wide-mouth jars.

ANALYTICAL PROGRAM

Thirty-three commercial analytical laboratories participated in the program to certify the analytes reported in Table 1. The following methods were employed:

- Gold by 25-50g fire assay with ICP-OES and/or ICP-MS (23 laboratories) and AAS (6 laboratories) finish;
- Instrumental neutron activation analysis for Au on 20 x 85mg subsamples to confirm homogeneity (1 laboratory);
- Gold by 10-50g aqua regia digestion with ICP-OES and/or ICP-MS finish (15 laboratories), AAS finish (4 laboratories);
- Lithium borate fusion followed by X-ray fluorescence (up to 21 laboratories);
- Thermogravimetry: Moisture at 105°C (15 laboratories oven dried and 12 laboratories used a thermogravimetric analyser). LOI at 1000°C (19 laboratories used a thermogravimetric analyser and 6 laboratories used conventional muffle furnace);
- Lithium borate fusion (7 laboratories) or sodium peroxide fusion (11 laboratories) followed by full elemental suites ICP-OES and/or ICP-MS finish;
- Four acid digestion followed by full elemental suites ICP-OES and/or ICP-MS finish (up to 31 laboratories depending on the element);
- Aqua regia digestion using 0.15 to 50g sample weights followed by full elemental suites ICP-OES and/or ICP-MS finish (up to 30 laboratories depending on the element);
- Total C and S by infra-red combustion furnace (27 laboratories);
- Gold and Platinum Group Elements (PGE's) by 25g nickel sulphide (NiS) collection fire assay with ICP-MS finish (1 laboratory).

It is important to note that in the analytical industry there is no standardisation of the aqua regia digestion process. Aqua regia is a partial empirical digest and differences in recoveries for various analytes are commonplace. These are caused by variations in the digest conditions which can include the ratio of nitric to hydrochloric acids, acid strength, temperatures, leach times and secondary digestions. Recoveries for sulphide-hosted base metal sulphides approach total values, however, other analytes, in particular the lithophile elements, show greater sensitivity to method parameters. This can result in lack of consensus in an inter-laboratory certification program for these elements.

The approach applied here is to report certified values in those instances where reasonable agreement exists amongst a majority of participating laboratories. The results of specific laboratories may differ significantly from the certified values, but will, nonetheless, be valid and reproducible in the context of the specifics of the aqua regia method in use. Users of this reference material should, therefore, be mindful of this limitation when applying the certified values in a quality control program.

For the round robin program twenty 1.5kg test units were taken at predetermined intervals during the bagging stage, immediately following homogenisation and are considered representative of the entire prepared batch. The six samples received by each laboratory were obtained by taking two 120g scoop splits from each of three separate 1.5kg test units. This format enabled nested ANOVA treatment of the results to evaluate homogeneity, i.e. to ascertain whether between-unit variance is greater than within-unit variance.

Table 1 presents the 179 certified values together with their associated 1SD's, 95% confidence and tolerance limits and Table 2 below shows 63 indicative values. Gold homogeneity has been evaluated and confirmed by instrumental neutron activation analysis (INAA) on twenty ~85 milligram sample portions (see Table 3) and by a nested ANOVA program (see '**nested ANOVA**' section). Table 4 provides performance gate intervals for the certified values of each method group based on their pooled 1SD's. Tabulated results of all elements (including Au INAA analyses) together with uncorrected means, medians, standard deviations, relative standard deviations and percent deviation of lab means from the corrected mean of means (PDM[3]) are presented in the detailed certification data for this CRM (**OREAS 45f DataPack-1.0.180813_142352.xlsx**).

Table 2. Indicative Values for OREAS 45f.

Constituent	Unit	Value	Constituent	Unit	Value	Constituent	Unit	Value
NiS Fire Assay								
Au	ppb	*17.7*	Pd	ppb	*56.0*	Rh	ppb	*3.32*
Ir	ppb	*1.45*	Pt	ppb	*36.6*	Ru	ppb	*3.31*
Borate Fusion XRF								
As	ppm	*9.40*	F	ppm	*1430*	Zn	ppm	*29.4*
Cl	ppm	*192*	Rb	ppm	*35.6*			
Co	ppm	*39.1*	Sn	ppm	*< 10*			
Thermogravimetry								
H_2O	wt.%	*3.95*						
Borate / Peroxide Fusion ICP								
Ag	ppm	*< 1*	Ir	ppb	*< 15*	S	wt.%	*0.034*
As	ppm	*9.49*	Mo	ppm	*2.15*	Se	ppm	*< 20*
B	ppm	*< 20*	Pb	ppm	*14.9*	Te	ppm	*< 1*
Cd	ppm	*< 0.2*	Pt	ppb	*< 50*	Tl	ppm	*< 0.5*
Ge	ppm	*2.25*	Re	ppm	*< 0.01*	W	ppm	*1.37*
I	ppm	*15.8*	Rh	ppb	*< 30*			
In	ppm	*< 0.2*	Ru	ppb	*< 30*			
4-Acid Digestion								
Ag	ppm	*0.088*	I	ppm	*14.3*	Rh	ppb	*< 5*
B	ppm	*9.47*	Ir	ppb	*< 300*	Ru	ppb	*< 10*
Cd	ppm	*0.024*	Pd	ppb	*59.3*	Te	ppm	*0.080*
Ge	ppm	*0.28*	Pt	ppb	*41.5*			
Hg	ppm	*0.033*	Re	ppm	*< 0.002*			
Aqua Regia Digestion (sample weights 0.15-50g)								
Ag	ppm	*0.057*	Li	ppm	*9.19*	Se	ppm	*0.58*
As	ppm	*2.70*	Nb	ppm	*0.17*	Ta	ppm	*< 0.01*
B	ppm	*< 10*	Re	ppm	*< 0.001*	Te	ppm	*0.032*
Cd	ppm	*0.011*	Rh	ppb	*< 10*	W	ppm	*0.006*
I	ppm	*15.8*	Ru	ppb	*< 10*			
Ir	ppb	*7.22*	Sb	ppm	*0.24*			
Infrared Combustion								
S	wt.%	*0.025*						

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.

Note: the number of significant figures reported is not a reflection of the level of certainty of stated values. They are instead an artefact of ORE's in-house CRM-specific LIMS.

STATISTICAL ANALYSIS

Certified Values, Confidence Limits, Standard Deviations and Tolerance Limits (Table 1) have been determined for each analyte following removal of individual, laboratory dataset (batch) and 3SD outliers (single iteration).

For individual outliers within a laboratory batch the z-score test is used in combination with a second method that determines the per cent deviation of the individual value from the batch median. Outliers in general are selected on the basis of z-scores > 2.5 and with per cent deviations (i) > 3 and (ii) more than three times the average absolute per cent deviation for the batch. In certain instances statistician's prerogative has been employed in discriminating outliers.

Each laboratory data set mean is tested for outlying status based on z-score discrimination and rejected if > 2.5. After individual and laboratory data set (batch) outliers have been eliminated a non-iterative 3 standard deviation filter is applied, with those values lying outside this window also relegated to outlying status.

Certified Values are the means of accepted laboratory means after outlier filtering. The INAA data (see Table 3) is omitted from determination of the certified value for Au and is used solely for the calculation of Tolerance Limits and homogeneity evaluation of OREAS 45f.

95% Confidence Limits are inversely proportional to the number of participating laboratories and inter-laboratory agreement. It is a measure of the reliability of the certified value. A 95% confidence interval indicates a 95% probability that the true value of the analyte under consideration lies between the upper and lower limits. *95% Confidence Limits should not be used as control limits for laboratory performance.*

Indicative (uncertified) values (Table 2) are present where the number of laboratories reporting a particular analyte is insufficient (< 5) to support certification or where inter-laboratory consensus is poor.

Standard Deviation values (1SDs) are reported in Table 1 and provide an indication of a level of performance that might reasonably be expected from a laboratory being monitored by this CRM in a QA/QC program. The SD's take into account errors attributable to measurement uncertainty and CRM variability. For an effective CRM the contribution of the latter should be negligible in comparison to measurement errors. The SD values thus include all sources of measurement uncertainty: between-lab variance, within-run variance (precision errors) and CRM variability. OREAS prepared reference materials have a level of homogeneity such that the observed variance from repeated analysis has its origin almost exclusively in the analytical process rather than the reference material itself.

The SD for each analyte's certified value is calculated from the same filtered data set used to determine the certified value, i.e. after removal of any individual, lab dataset (batch) and 3SD outliers (single iteration). These outliers can only be removed after the absolute homogeneity of the CRM has been independently established, i.e. the outliers must be confidently deemed to be analytical rather than arising from inhomogeneity of the CRM. **The standard deviation is then calculated for each analyte from the pooled accepted analyses generated from the certification program.**

In the application of SD's in monitoring performance it is important to note that not all laboratories function at the same level of proficiency and that different methods in use at a particular laboratory have differing levels of precision. Each laboratory has its own inherent SD (for a specific concentration level and analyte-method pair) based on the analytical process and this SD is not directly related to the round robin program.

The majority of data generated in the round robin program was produced by a selection of world class laboratories. The SD's thus generated are more constrained than those that would be produced across a randomly selected group of laboratories. To produce more generally achievable SD's the 'pooled' SD's provided in this report include inter-lab bias. This 'one size fits all' approach may require revision at the discretion of the QC manager concerned following careful scrutiny of QC control charts.

Table 4 shows **Performance Gates** calculated for two and three standard deviations. As a guide these intervals may be regarded as warning or rejection for multiple 2SD outliers, or rejection for individual 3SD outliers in QC monitoring, although their precise application should be at the discretion of the QC manager concerned. A second method utilises a 5% window calculated directly from the certified value. Standard deviation is also shown in relative percent for one, two and three relative standard deviations (1RSD, 2RSD and 3RSD) to facilitate an appreciation of the magnitude of these numbers and a comparison with the 5% window. Caution should be exercised when concentration levels approach lower limits of detection of the analytical methods employed as performance gates calculated from standard deviations tend to be excessively wide whereas those determined by the 5% method are too narrow. One approach used at commercial laboratories is to set the acceptance criteria at twice the detection level (DL) ± 10%.

i.e. Certified Value ± 10% ± 2DL (adapted from Govett, 1983)

Tolerance Limits (ISO Guide 3207) were determined using an analysis of precision errors method and are considered a conservative estimate of true homogeneity. The meaning of tolerance limits may be illustrated for copper (Cu) by 4-acid digestion, where 99% of the time ($1-\alpha=0.99$) at least 95% of subsamples ($\rho=0.95$) will have concentrations lying between 355 and 370 ppm. Put more precisely, this means that if the same number of subsamples were taken and analysed in the same manner repeatedly, 99% of the tolerance intervals so constructed would cover at least 95% of the total population, and 1% of the tolerance intervals would cover less than 95% of the total population (ISO Guide 35). *Please note that tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.*

For gold the tolerance has been determined by INAA using the reduced analytical subsample method which utilises the known relationship between standard deviation and analytical subsample weight (Ingamells and Switzer, 1973). In this approach the sample aliquot is substantially reduced to a point where most of the variability in replicate assays should be due to inhomogeneity of the reference material and measurement error becomes negligible. In this instance a subsample weight of 85 milligrams was employed and the 1RSD of 1.53% calculated for a 30g fire assay or aqua regia sample (28.67% at 85mg weights) confirms the high level of gold homogeneity in OREAS 45f. Given the low concentration level of gold (19.3ppb) and that those laboratories mostly reported to the nearest ppb, this level of homogeneity is more than sufficient for its intended purpose.

Please note that these RSD's and tolerance limits pertain to the homogeneity of the CRM only and should not be used as control limits for laboratory performance.

Table 3 below shows the INAA data determined on 20 x 85mg subsamples of OREAS 45f. An equivalent scaled version of the results is also provided to demonstrate an appreciation of what this data means if 30g fire assay determinations were undertaken without the normal measurement error associated with this methodology.

Table 3. Neutron Activation Analysis of Au (in ppb) on 20 x 85mg subsamples showing the equivalent results scaled to a 30g sample mass typical of fire assay determination.

Replicate No	Au 85mg actual	Au 30g equivalent*
1	34.3	20.1
2	22.6	19.9
3	14.8	20.3
4	16.2	20.3
5	21.1	19.8
6	13.7	20.0
7	27.3	20.0
8	18.4	20.2
9	19.8	20.1
10	17.2	20.9
11	24.6	20.8
12	18.2	20.4
13	16.5	19.9
14	17.9	20.0
15	32.4	20.5
16	15.7	19.9
17	15.0	19.8
18	23.0	19.9
19	19.7	20.0
20	14.4	19.8
Mean	20.1	20.1
Median	18.3	20.0
Std Dev.	5.8	0.31
Rel.Std.Dev.	**28.67%**	**1.53%**

*Results calculated for a 30g equivalent sample mass using the formula: $x^{30g\ Eq} = \frac{(x^{INAA}) - RSD@30g}{RSD@85mg} + \bar{X}$

where $x^{30g\ Eq}$ = equivalent result calculated for a 30g sample mass
(x^{INAA}) = raw INAA result at 85mg
$\bar{X}$ = mean of 85mg INAA results

The homogeneity of OREAS 45f has also been evaluated in a **nested ANOVA** of the round robin program. Each of the thirty-three round robin laboratories received six samples per CRM and these samples were made up of paired samples from three different, non-adjacent sampling intervals. The purpose of the ANOVA evaluation is to test that no statistically significant difference exists in the variance between-units to that of the variance within-units. This allows an assessment of homogeneity across the entire prepared batch of OREAS 45f. The test was performed using the following parameters:

- Null Hypothesis, H_0: Between-unit variance is no greater than within-unit variance (reject H_0 if *p*-value < 0.05);
- Alternative Hypothesis, H_1: Between-unit variance is greater than within-unit variance.

P-values are a measure of probability where values less than 0.05 indicate a greater than 95% probability that the observed differences in within-unit and between-unit variances are real. The datasets were filtered for both individual and laboratory data set (batch) outliers prior to the calculation of *p*-values. This process derived no significant *p*-values across the entire 179 certified values except for Gd by fusion with ICP. For this isolated case the 'significant' *p*-value is most likely due to random statistical probability given the high number of analytes considered for this ANOVA test. As there is no other supporting evidence to suspect greater between-unit variance compared with within-unit variance the null hypothesis is retained.

It is important to note that ANOVA is not an absolute measure of homogeneity. Rather, it establishes whether or not the analytes are distributed in a similar manner throughout the packaging run of OREAS 45f and whether the variance between two subsamples from the same unit is statistically distinguishable to the variance from two subsamples taken from any two separate units. A reference material therefore, can possess poor absolute homogeneity yet still pass a relative homogeneity test if the within-unit heterogeneity is large and similar across all units. Based on the statistical analysis of the results of the inter-laboratory certification program it can be concluded that OREAS 45f is fit-for-purpose as a certified reference material (see 'Intended Use' below).

Table 4. Pooled-Lab Performance Gates for OREAS 45f.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Pb Fire Assay											
Au, ppb	19.3	1.7	15.8	22.7	14.1	24.4	8.93%	17.85%	26.78%	18.3	20.2
Pd, ppb	56.6	4.0	48.6	64.6	44.6	68.5	7.06%	14.12%	21.19%	53.7	59.4
Pt, ppb	38.1	2.5	33.1	43.1	30.6	45.6	6.55%	13.09%	19.64%	36.2	40.0
Aqua Regia Digestion (sample weights 10-50g)											
Au, ppb	18.0	1.6	14.8	21.3	13.2	22.9	9.01%	18.01%	27.02%	17.1	18.9
Borate Fusion XRF											
Al_2O_3, wt.%	20.49	0.169	20.15	20.82	19.98	20.99	0.83%	1.65%	2.48%	19.46	21.51
BaO, ppm	264	46	172	356	126	402	17.40%	34.80%	52.20%	251	277
CaO, wt.%	0.137	0.006	0.126	0.149	0.120	0.155	4.19%	8.37%	12.56%	0.131	0.144
Cr_2O_3, ppm	705	47	610	800	563	847	6.71%	13.42%	20.12%	670	740
Cu, ppm	356	9	337	375	327	384	2.65%	5.29%	7.94%	338	373
Fe_2O_3, wt.%	22.26	0.304	21.66	22.87	21.35	23.17	1.36%	2.73%	4.09%	21.15	23.38
K_2O, wt.%	0.283	0.005	0.273	0.293	0.268	0.298	1.79%	3.58%	5.36%	0.269	0.297
MgO, wt.%	0.420	0.011	0.399	0.441	0.388	0.452	2.53%	5.07%	7.60%	0.399	0.441
MnO, wt.%	0.031	0.002	0.028	0.034	0.026	0.036	5.37%	10.74%	16.11%	0.029	0.032
Na_2O, wt.%	0.090	0.013	0.063	0.117	0.050	0.130	14.80%	29.61%	44.41%	0.085	0.094
Ni, ppm	289	24	241	338	217	362	8.37%	16.74%	25.10%	275	304
P_2O_5, wt.%	0.071	0.004	0.064	0.079	0.060	0.082	5.11%	10.23%	15.34%	0.068	0.075
S, wt.%	0.032	0.002	0.028	0.035	0.026	0.037	5.76%	11.52%	17.28%	0.030	0.033
SiO_2, wt.%	43.59	0.252	43.09	44.09	42.83	44.34	0.58%	1.15%	1.73%	41.41	45.77
Sr, ppm	28.6	6.9	14.8	42.4	8.0	49.3	24.06%	48.11%	72.17%	27.2	30.0
TiO_2, wt.%	1.99	0.018	1.96	2.03	1.94	2.05	0.88%	1.76%	2.64%	1.89	2.09
V_2O_5, ppm	454	59	337	572	278	631	12.94%	25.88%	38.82%	432	477
Zr, ppm	260	19	222	299	203	318	7.37%	14.74%	22.12%	247	273

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 4 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Thermogravimetry											
LOI^{1000}, wt.%	10.27	0.322	9.63	10.91	9.30	11.24	3.14%	6.27%	9.41%	9.76	10.78
Borate / Peroxide Fusion ICP											
Al, wt.%	10.41	0.212	9.99	10.83	9.77	11.05	2.04%	4.07%	6.11%	9.89	10.93
Ba, ppm	210	10	191	230	182	239	4.54%	9.07%	13.61%	200	221
Be, ppm	1.03	0.15	0.73	1.34	0.58	1.49	14.77%	29.53%	44.30%	0.98	1.08
Bi, ppm	0.20	0.04	0.12	0.28	0.08	0.32	19.89%	39.78%	59.66%	0.19	0.21
Ca, wt.%	0.102	0.015	0.073	0.132	0.059	0.146	14.20%	28.40%	42.59%	0.097	0.108
Ce, ppm	29.4	1.58	26.2	32.6	24.6	34.1	5.39%	10.78%	16.17%	27.9	30.9
Co, ppm	49.0	3.02	43.0	55.1	40.0	58.1	6.17%	12.33%	18.50%	46.6	51.5
Cr, ppm	476	23	431	521	408	543	4.74%	9.47%	14.21%	452	499
Cs, ppm	3.66	0.244	3.17	4.15	2.93	4.39	6.67%	13.34%	20.01%	3.48	3.84
Cu, ppm	362	15	332	391	317	406	4.12%	8.24%	12.36%	343	380
Dy, ppm	2.88	0.193	2.49	3.27	2.30	3.46	6.72%	13.44%	20.16%	2.74	3.02
Er, ppm	1.65	0.17	1.30	2.00	1.13	2.17	10.58%	21.15%	31.73%	1.57	1.73
Eu, ppm	0.62	0.07	0.49	0.76	0.42	0.83	10.96%	21.91%	32.87%	0.59	0.65
Fe, wt.%	15.16	0.353	14.45	15.86	14.10	16.22	2.33%	4.66%	6.99%	14.40	15.91
Ga, ppm	26.2	2.46	21.3	31.1	18.8	33.5	9.38%	18.77%	28.15%	24.9	27.5
Gd, ppm	2.57	0.26	2.05	3.10	1.79	3.36	10.13%	20.26%	30.39%	2.44	2.70
Hf, ppm	6.97	0.79	5.40	8.54	4.61	9.33	11.28%	22.56%	33.85%	6.62	7.32
Ho, ppm	0.56	0.06	0.44	0.68	0.38	0.74	10.66%	21.31%	31.97%	0.53	0.59
K, wt.%	0.228	0.020	0.188	0.268	0.168	0.289	8.81%	17.61%	26.42%	0.217	0.240
La, ppm	15.7	1.6	12.4	19.0	10.7	20.6	10.51%	21.01%	31.52%	14.9	16.5
Li, ppm	20.4	1.39	17.6	23.2	16.3	24.6	6.82%	13.65%	20.47%	19.4	21.5
Lu, ppm	0.26	0.04	0.19	0.33	0.15	0.36	13.65%	27.30%	40.95%	0.25	0.27
Mg, wt.%	0.242	0.011	0.219	0.264	0.208	0.275	4.63%	9.26%	13.90%	0.230	0.254
Mn, wt.%	0.024	0.002	0.020	0.027	0.018	0.029	7.91%	15.82%	23.73%	0.022	0.025
Na, wt.%	0.070	0.007	0.055	0.084	0.048	0.092	10.56%	21.12%	31.68%	0.066	0.073
Nb, ppm	23.7	2.04	19.7	27.8	17.6	29.8	8.59%	17.19%	25.78%	22.5	24.9
Nd, ppm	13.0	0.90	11.2	14.7	10.3	15.6	6.92%	13.83%	20.75%	12.3	13.6
Ni, ppm	268	23	223	314	201	336	8.39%	16.79%	25.18%	255	282
P, wt.%	0.030	0.004	0.021	0.039	0.017	0.043	14.74%	29.48%	44.23%	0.028	0.031
Pr, ppm	3.44	0.221	3.00	3.88	2.78	4.11	6.43%	12.86%	19.29%	3.27	3.61
Rb, ppm	31.6	2.02	27.5	35.6	25.5	37.6	6.42%	12.83%	19.25%	30.0	33.1
Sb, ppm	0.63	0.14	0.34	0.91	0.20	1.06	22.61%	45.21%	67.82%	0.60	0.66
Sc, ppm	35.8	2.02	31.8	39.8	29.7	41.9	5.64%	11.28%	16.92%	34.0	37.6
Si, wt.%	19.72	0.598	18.52	20.91	17.92	21.51	3.03%	6.07%	9.10%	18.73	20.70
Sm, ppm	2.60	0.160	2.28	2.92	2.12	3.08	6.17%	12.33%	18.50%	2.47	2.73
Sn, ppm	3.37	0.67	2.03	4.71	1.35	5.38	19.93%	39.85%	59.78%	3.20	3.54
Sr, ppm	26.9	4.2	18.4	35.3	14.2	39.5	15.67%	31.34%	47.02%	25.5	28.2
Ta, ppm	1.56	0.144	1.27	1.84	1.12	1.99	9.28%	18.56%	27.84%	1.48	1.63
Tb, ppm	0.41	0.040	0.33	0.49	0.29	0.53	9.89%	19.78%	29.67%	0.39	0.43
Th, ppm	9.99	0.794	8.40	11.58	7.61	12.37	7.94%	15.89%	23.83%	9.49	10.49

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 4 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Borate / Peroxide Fusion ICP continued											
Ti, wt.%	1.14	0.041	1.06	1.23	1.02	1.27	3.62%	7.25%	10.87%	1.09	1.20
Tm, ppm	0.26	0.04	0.19	0.34	0.15	0.37	14.14%	28.29%	42.43%	0.25	0.27
U, ppm	2.32	0.191	1.94	2.70	1.75	2.89	8.23%	16.46%	24.69%	2.20	2.43
V, ppm	261	7	247	276	240	283	2.80%	5.59%	8.39%	248	275
Y, ppm	14.7	1.46	11.8	17.6	10.3	19.1	9.90%	19.81%	29.71%	14.0	15.4
Yb, ppm	1.79	0.168	1.46	2.13	1.29	2.30	9.37%	18.74%	28.10%	1.70	1.88
Zn, ppm	34.3	5.2	23.9	44.8	18.7	50.0	15.18%	30.36%	45.55%	32.6	36.1
Zr, ppm	261	20	221	302	201	322	7.75%	15.50%	23.24%	248	274
4-Acid Digestion											
Al, wt.%	10.16	0.451	9.26	11.06	8.81	11.51	4.44%	8.89%	13.33%	9.65	10.67
As, ppm	9.67	0.842	7.98	11.35	7.14	12.19	8.71%	17.43%	26.14%	9.18	10.15
Ba, ppm	206	9	188	225	179	234	4.44%	8.89%	13.33%	196	217
Be, ppm	1.20	0.15	0.91	1.50	0.76	1.65	12.24%	24.48%	36.71%	1.14	1.26
Bi, ppm	0.21	0.017	0.18	0.25	0.16	0.26	7.78%	15.56%	23.34%	0.20	0.22
Ca, wt.%	0.096	0.007	0.081	0.111	0.074	0.118	7.72%	15.45%	23.17%	0.091	0.101
Ce, ppm	28.8	2.40	24.0	33.6	21.6	36.0	8.33%	16.65%	24.98%	27.4	30.3
Co, ppm	44.5	2.32	39.9	49.2	37.6	51.5	5.20%	10.40%	15.60%	42.3	46.8
Cr, ppm	417	35	348	486	314	521	8.28%	16.56%	24.84%	396	438
Cs, ppm	3.65	0.248	3.15	4.14	2.91	4.39	6.79%	13.57%	20.36%	3.47	3.83
Cu, ppm	363	16	331	394	316	409	4.30%	8.60%	12.90%	344	381
Dy, ppm	2.23	0.132	1.96	2.49	1.83	2.62	5.91%	11.83%	17.74%	2.11	2.34
Er, ppm	1.33	0.090	1.15	1.51	1.06	1.60	6.77%	13.54%	20.31%	1.27	1.40
Eu, ppm	0.63	0.07	0.48	0.78	0.41	0.86	11.79%	23.58%	35.37%	0.60	0.67
Fe, wt.%	14.65	0.561	13.53	15.77	12.97	16.33	3.83%	7.66%	11.49%	13.92	15.38
Ga, ppm	26.7	1.24	24.3	29.2	23.0	30.5	4.62%	9.25%	13.87%	25.4	28.1
Gd, ppm	2.31	0.27	1.77	2.84	1.51	3.11	11.55%	23.11%	34.66%	2.19	2.42
Hf, ppm	4.64	0.435	3.77	5.51	3.33	5.94	9.37%	18.74%	28.11%	4.41	4.87
Ho, ppm	0.45	0.05	0.34	0.55	0.29	0.60	11.59%	23.17%	34.76%	0.42	0.47
In, ppm	0.11	0.010	0.09	0.13	0.08	0.14	9.45%	18.91%	28.36%	0.10	0.11
K, wt.%	0.224	0.009	0.206	0.242	0.198	0.251	3.99%	7.97%	11.96%	0.213	0.236
La, ppm	15.7	1.43	12.9	18.6	11.4	20.0	9.08%	18.15%	27.23%	14.9	16.5
Li, ppm	20.4	1.18	18.1	22.8	16.9	24.0	5.78%	11.56%	17.33%	19.4	21.5
Lu, ppm	0.19	0.03	0.13	0.24	0.10	0.27	14.97%	29.94%	44.92%	0.18	0.20
Mg, wt.%	0.229	0.015	0.199	0.259	0.184	0.274	6.54%	13.07%	19.61%	0.218	0.241
Mn, wt.%	0.022	0.001	0.019	0.025	0.018	0.026	6.21%	12.43%	18.64%	0.021	0.023
Mo, ppm	2.27	0.219	1.83	2.71	1.61	2.93	9.66%	19.32%	28.98%	2.16	2.38
Na, wt.%	0.063	0.004	0.054	0.071	0.050	0.075	6.66%	13.32%	19.98%	0.059	0.066
Nb, ppm	23.1	1.54	20.1	26.2	18.5	27.8	6.63%	13.27%	19.90%	22.0	24.3
Nd, ppm	12.3	0.93	10.4	14.1	9.5	15.0	7.59%	15.19%	22.78%	11.6	12.9
Ni, ppm	256	16	225	288	210	303	6.10%	12.19%	18.29%	244	269
P, wt.%	0.030	0.002	0.026	0.033	0.024	0.035	6.25%	12.50%	18.76%	0.028	0.031

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 4 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
4-Acid Digestion continued											
Pb, ppm	14.7	1.18	12.4	17.1	11.2	18.2	8.00%	16.00%	23.99%	14.0	15.5
Pr, ppm	3.43	0.277	2.88	3.98	2.60	4.26	8.07%	16.14%	24.21%	3.26	3.60
Rb, ppm	31.2	1.94	27.4	35.1	25.4	37.1	6.21%	12.43%	18.64%	29.7	32.8
S, wt.%	0.029	0.002	0.026	0.033	0.024	0.034	6.01%	12.01%	18.02%	0.028	0.031
Sb, ppm	0.64	0.062	0.51	0.76	0.45	0.82	9.68%	19.36%	29.05%	0.60	0.67
Sc, ppm	36.3	2.27	31.7	40.8	29.5	43.1	6.26%	12.52%	18.77%	34.5	38.1
Se, ppm	2.26	0.38	1.51	3.02	1.13	3.39	16.66%	33.31%	49.97%	2.15	2.38
Sm, ppm	2.49	0.146	2.20	2.78	2.05	2.92	5.86%	11.72%	17.58%	2.36	2.61
Sn, ppm	2.85	0.165	2.52	3.18	2.36	3.35	5.79%	11.59%	17.38%	2.71	2.99
Sr, ppm	25.1	1.22	22.7	27.5	21.4	28.8	4.86%	9.72%	14.58%	23.8	26.4
Ta, ppm	1.66	0.25	1.16	2.15	0.91	2.40	15.04%	30.09%	45.13%	1.57	1.74
Tb, ppm	0.37	0.024	0.32	0.42	0.30	0.44	6.35%	12.71%	19.06%	0.35	0.39
Th, ppm	9.99	0.894	8.20	11.78	7.31	12.67	8.94%	17.89%	26.83%	9.49	10.49
Ti, wt.%	1.08	0.040	1.00	1.16	0.96	1.20	3.70%	7.40%	11.10%	1.02	1.13
Tl, ppm	0.20	0.017	0.17	0.23	0.15	0.25	8.20%	16.40%	24.60%	0.19	0.21
Tm, ppm	0.20	0.03	0.14	0.26	0.11	0.29	14.71%	29.42%	44.14%	0.19	0.21
U, ppm	2.09	0.150	1.79	2.39	1.64	2.54	7.20%	14.41%	21.61%	1.98	2.19
V, ppm	253	8	236	269	227	278	3.32%	6.64%	9.96%	240	265
W, ppm	1.27	0.14	0.98	1.55	0.84	1.70	11.20%	22.40%	33.60%	1.21	1.33
Y, ppm	10.9	1.2	8.4	13.4	7.2	14.6	11.36%	22.73%	34.09%	10.4	11.4
Yb, ppm	1.25	0.14	0.97	1.52	0.83	1.66	11.09%	22.18%	33.28%	1.19	1.31
Zn, ppm	35.3	2.26	30.7	39.8	28.5	42.0	6.41%	12.82%	19.23%	33.5	37.0
Zr, ppm	172	11	149	194	138	206	6.54%	13.07%	19.61%	163	181
Aqua Regia Digestion (sample weights 0.15-50g)											
Al, wt.%	4.81	0.62	3.56	6.05	2.94	6.68	12.97%	25.95%	38.92%	4.57	5.05
Ba, ppm	158	7	145	171	138	178	4.14%	8.28%	12.41%	150	166
Be, ppm	0.98	0.090	0.80	1.16	0.71	1.25	9.20%	18.40%	27.60%	0.93	1.03
Bi, ppm	0.17	0.014	0.14	0.20	0.13	0.21	8.32%	16.64%	24.95%	0.16	0.18
Ca, wt.%	0.075	0.006	0.062	0.088	0.056	0.094	8.53%	17.06%	25.58%	0.071	0.079
Ce, ppm	22.3	2.3	17.8	26.8	15.5	29.1	10.10%	20.21%	30.31%	21.2	23.4
Co, ppm	39.2	3.44	32.4	46.1	28.9	49.6	8.77%	17.53%	26.30%	37.3	41.2
Cr, ppm	341	25	290	392	265	417	7.44%	14.88%	22.32%	324	358
Cs, ppm	1.88	0.27	1.34	2.41	1.08	2.67	14.17%	28.35%	42.52%	1.78	1.97
Cu, ppm	336	16	303	368	287	385	4.83%	9.67%	14.50%	319	353
Dy, ppm	1.49	0.113	1.26	1.72	1.15	1.83	7.61%	15.21%	22.82%	1.42	1.57
Er, ppm	0.78	0.063	0.66	0.91	0.59	0.97	8.08%	16.15%	24.23%	0.74	0.82
Eu, ppm	0.49	0.06	0.37	0.61	0.31	0.67	12.33%	24.65%	36.98%	0.47	0.52
Fe, wt.%	13.69	0.560	12.57	14.81	12.01	15.37	4.09%	8.18%	12.26%	13.00	14.37
Ga, ppm	20.3	1.91	16.5	24.2	14.6	26.1	9.42%	18.83%	28.25%	19.3	21.3
Gd, ppm	1.70	0.159	1.38	2.02	1.22	2.18	9.35%	18.70%	28.05%	1.62	1.79
Ge, ppm	0.12	0.02	0.08	0.15	0.07	0.17	14.63%	29.26%	43.88%	0.11	0.12

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

Table 4 continued.

Constituent	Certified Value	Absolute Standard Deviations					Relative Standard Deviations			5% window	
		1SD	2SD Low	2SD High	3SD Low	3SD High	1RSD	2RSD	3RSD	Low	High
Aqua Regia Digestion (sample weights 0.15-50g) continued											
Hf, ppm	0.93	0.17	0.60	1.26	0.43	1.42	17.85%	35.70%	53.55%	0.88	0.97
Hg, ppm	0.031	0.005	0.021	0.041	0.016	0.046	16.29%	32.58%	48.87%	0.029	0.032
Ho, ppm	0.28	0.022	0.23	0.32	0.21	0.34	7.99%	15.97%	23.96%	0.26	0.29
In, ppm	0.087	0.006	0.074	0.100	0.068	0.106	7.36%	14.71%	22.07%	0.083	0.092
K, wt.%	0.082	0.014	0.054	0.110	0.040	0.124	17.18%	34.35%	51.53%	0.078	0.086
La, ppm	10.7	0.75	9.2	12.2	8.5	13.0	6.97%	13.95%	20.92%	10.2	11.3
Lu, ppm	0.097	0.007	0.083	0.111	0.077	0.118	7.04%	14.07%	21.11%	0.092	0.102
Mg, wt.%	0.152	0.021	0.110	0.194	0.089	0.215	13.76%	27.52%	41.29%	0.144	0.160
Mn, wt.%	0.015	0.002	0.011	0.018	0.010	0.020	11.17%	22.35%	33.52%	0.014	0.015
Mo, ppm	1.19	0.23	0.74	1.65	0.51	1.87	18.97%	37.93%	56.90%	1.13	1.25
Na, wt.%	0.032	0.004	0.025	0.040	0.021	0.044	11.62%	23.24%	34.86%	0.031	0.034
Nd, ppm	10.1	1.0	8.0	12.1	7.0	13.1	10.05%	20.11%	30.16%	9.6	10.6
Ni, ppm	192	14	165	219	151	233	7.13%	14.26%	21.39%	182	201
P, wt.%	0.022	0.001	0.019	0.025	0.018	0.026	6.44%	12.88%	19.32%	0.021	0.023
Pb, ppm	12.4	0.60	11.2	13.6	10.6	14.2	4.84%	9.68%	14.52%	11.8	13.0
Pd, ppb	39.9	2.3	35.4	44.4	33.1	46.7	5.67%	11.34%	17.01%	37.9	41.9
Pr, ppm	2.63	0.37	1.90	3.37	1.53	3.73	13.92%	27.84%	41.75%	2.50	2.76
Pt, ppb	36.7	2.0	32.6	40.7	30.6	42.7	5.49%	10.98%	16.47%	34.8	38.5
Rb, ppm	14.4	1.08	12.2	16.5	11.1	17.6	7.49%	14.99%	22.48%	13.7	15.1
S, wt.%	0.027	0.004	0.018	0.035	0.014	0.039	15.30%	30.60%	45.90%	0.025	0.028
Sc, ppm	31.4	2.26	26.9	35.9	24.6	38.2	7.19%	14.38%	21.56%	29.8	33.0
Sm, ppm	1.91	0.25	1.42	2.40	1.17	2.64	12.84%	25.67%	38.51%	1.81	2.00
Sn, ppm	1.97	0.21	1.55	2.38	1.35	2.58	10.50%	20.99%	31.49%	1.87	2.06
Sr, ppm	13.2	1.11	10.9	15.4	9.8	16.5	8.45%	16.90%	25.34%	12.5	13.8
Tb, ppm	0.25	0.014	0.22	0.28	0.20	0.29	5.83%	11.65%	17.48%	0.24	0.26
Th, ppm	7.67	0.661	6.35	8.99	5.69	9.65	8.62%	17.24%	25.86%	7.29	8.05
Ti, wt.%	0.097	0.020	0.057	0.137	0.038	0.157	20.49%	40.99%	61.48%	0.093	0.102
Tl, ppm	0.12	0.01	0.09	0.14	0.08	0.15	10.48%	20.96%	31.44%	0.11	0.12
Tm, ppm	0.11	0.008	0.09	0.12	0.08	0.13	7.59%	15.17%	22.76%	0.10	0.11
U, ppm	1.09	0.091	0.91	1.27	0.82	1.36	8.34%	16.69%	25.03%	1.03	1.14
V, ppm	217	11	196	238	186	249	4.84%	9.68%	14.52%	206	228
Y, ppm	6.74	0.336	6.07	7.41	5.74	7.75	4.98%	9.95%	14.93%	6.41	7.08
Yb, ppm	0.69	0.045	0.60	0.78	0.55	0.82	6.56%	13.12%	19.67%	0.65	0.72
Zn, ppm	22.2	3.7	14.9	29.5	11.2	33.2	16.50%	32.99%	49.49%	21.1	23.3
Zr, ppm	30.0	4.3	21.5	38.6	17.2	42.9	14.23%	28.46%	42.69%	28.5	31.5
Infrared Combustion											
C, wt.%	0.318	0.021	0.277	0.360	0.256	0.381	6.50%	13.00%	19.50%	0.303	0.334

SI unit equivalents: ppm, parts per million ≡ mg/kg ≡ µg/g ≡ 0.0001 wt.% ≡ 1000 ppb, parts per billion.
Note: intervals may appear asymmetric due to rounding.

PARTICIPATING LABORATORIES

1. AGAT Laboratories, Mississauga, Ontario, Canada
2. Alex Stewart International, Mendoza, Argentina
3. ALS, Brisbane, QLD, Australia
4. ALS, Johannesburg, South Africa
5. ALS, Lima, Peru
6. ALS, Loughrea, Galway, Ireland
7. ALS, Perth, WA, Australia
8. ALS, Vancouver, BC, Canada
9. American Assay Laboratories, Sparks, Nevada, USA
10. ANSTO, Lucas Heights, NSW, Australia
11. Bureau Veritas Commodities Canada Ltd, Vancouver, BC, Canada
12. Bureau Veritas Geoanalytical, Adelaide, SA, Australia
13. Bureau Veritas Geoanalytical, Perth, WA, Australia
14. Inspectorate (BV), Lima, Peru
15. Intertek Genalysis, Perth, WA, Australia
16. Intertek Testing Services, Townsville, QLD, Australia
17. Intertek Testing Services Philippines, Cupang, Muntinlupa, Philippines
18. MinAnalytical Services, Perth, WA, Australia
19. Nagrom, Perth, WA, Australia
20. Ontario Geological Survey, Sudbury, Ontario, Canada
21. PT Geoservices Ltd, Cikarang, Jakarta Raya, Indonesia
22. PT Intertek Utama Services, Jakarta Timur, DKI Jakarta, Indonesia
23. PT SGS Indo Assay Laboratories, Jakarta, Indonesia
24. SGS, Randfontein, Gauteng, South Africa
25. SGS Australia Mineral Services, Perth, WA, Australia
26. SGS Canada Inc., Vancouver, BC, Canada
27. SGS del Peru, Lima, Peru
28. SGS Geosol Laboratorios Ltda, Vespasiano, Minas Gerais, Brazil
29. SGS Lakefield Research Ltd, Lakefield, Ontario, Canada
30. SGS Mineral Services, Townsville, QLD, Australia
31. Shiva Analyticals Ltd, Bangalore North, Karnataka, India
32. UIS Analytical Services, Centurion , South Africa
33. Zarazma Mineral Studies Company, Tehran, Iran

PREPARER AND SUPPLIER

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It is packaged in in 10g and 60g units in laminated foil pouches and 500g units in plastic wide-mouth jars.

METROLOGICAL TRACEABILITY

The analytical samples were selected in a manner to represent the entire batch of prepared CRM. This 'representivity' was maintained in each submitted laboratory sample batch and ensures the user that the data is traceable from sample selection through to the analytical results that underlie the consensus values. Each analytical data set has been validated by its assayer through the inclusion of internal reference materials and QC checks during analysis.

The laboratories were chosen on the basis of their competence (from past performance in inter-laboratory programs undertaken by ORE Pty Ltd) for a particular analytical method, analyte or analyte suite, and sample matrix. Most of these laboratories have and maintain ISO 17025 accreditation. The certified values presented in this report are calculated from the means of accepted data following robust statistical treatment as detailed in this report.

Guide ISO/TR 16476:2016, section 5.3.1 describes metrological traceability in reference materials as it pertains to the transformation of the measurand. In this section it states, *"Although the determination of the property value itself can be made traceable to appropriate units through, for example, calibration of the measurement equipment used, steps like the transformation of the sample from one physical (chemical) state to another cannot. Such transformations may only be compared with a reference (when available), or among themselves. For some transformations, reference methods have been defined and may be used in certification projects to evaluate the uncertainty associated with such a transformation. In other cases,* ***only a comparison among different laboratories using the same method is possible. In this case, certification takes place on the basis of agreement among independent measurement results*** *(see ISO Guide 35:2006, Clause 10)."*

COMMUTABILITY

The measurements of the results that underlie the certified values contained in this report were undertaken by methods involving pre-treatment (digestion/fusion) of the sample. This served to reduce the sample to a simple and well understood form permitting calibration using simple solutions of the CRM. Due to these methods being well understood and highly effective, commutability is not an issue for this CRM. All OREAS CRMs are sourced from natural ore minerals meaning they will display similar behaviour as routine 'field' samples in the relevant measurement process. Care should be taken to ensure 'matrix matching' as close as practically achievable. The matrix and mineralisation style of the CRM is described in the 'Source Material' section and users should select appropriate CRMs matching these attributes to their field samples.

INTENDED USE

OREAS 45f is intended to cover all activities needed to produce a measurement result. This includes extraction, possible separation steps and the actual measurement process (the signal producing step). OREAS 45f may be used to calibrate the entire procedure by producing a pure substance CRM transformed into a calibration solution.

OREAS 45f is intended for the following uses:

- For the monitoring of laboratory performance in the analysis of analytes reported in Table 1 in geological samples;
- For the verification of analytical methods for analytes reported in Table 1;
- For the calibration of instruments used in the determination of the concentration of analytes reported in Table 1.

STABILITY AND STORAGE INSTRUCTIONS

OREAS 45f contains negligible reactive sulphide (S = 0.03 wt.%) and in its unopened state and under normal conditions of storage it has a shelf life beyond ten years. Its stability will be monitored at regular intervals and purchasers will be notified if any changes are observed. OREAS 45f is moderately hygroscopic and has been pre-equilibrated to a normal laboratory atmosphere (20 degrees Celsius, 60% humidity). This pre-equilibration yielded a moisture level of ~3.95% and facilitates ease of use by reducing the potential change in moisture content upon exposure of the CRM to different laboratory atmospheres. If the CRM is exposed and left to equilibrate in extremely dry or humid laboratory atmospheres a significant change in hygroscopic moisture is likely. Care should be taken in these circumstances to limit exposure of the CRM prior to assay.

INSTRUCTIONS FOR CORRECT USE

The certified values for OREAS 45f refer to the concentration levels in its packaged state. There is no need for drying prior to weighing and analysis.

HANDLING INSTRUCTIONS

Fine powders pose a risk to eyes and lungs and therefore standard precautions such as the use of safety glasses and dust masks are advised.

LEGAL NOTICE

Ore Research & Exploration Pty Ltd has prepared and statistically evaluated the property values of this reference material to the best of its ability. The Purchaser by receipt hereof releases and indemnifies Ore Research & Exploration Pty Ltd from and against all liability and costs arising from the use of this material and information.

DOCUMENT HISTORY

Revision No	Date	Changes applied
1	4th September, 2018	Corrected Table 1 method group title (for Borate Fusion XRF).
0	13th August, 2018	First publication.

QMS ACCREDITED

ORE Pty Ltd is accredited to ISO 9001:2015 by Lloyd's Register Quality Assurance Ltd for its quality management system including development, manufacturing, certification and supply of CRMs.

CERTIFYING OFFICER

3rd September, 2018

Craig Hamlyn (B.Sc. Hons - Geology), Technical Manager - ORE P/L

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