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CHEMICAL COMPOSITION OF WEATHERED AND UNWEATHERED STRATA OF THE MEADE PEAK PHOSPHATIC SHALE MEMBER OF THE PERMIAN PHOSPHORIA FORMATION
A. Measured Sections A and B, Central part of Rasmussen Ridge, Caribou County, Idaho

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or with the North American Stratigraphic Code. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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INTRODUCTION

Background

The U.S. Geological Survey (USGS) has studied the Permian Phosphoria Formation in southeastern Idaho and the Western U.S. Phosphate Field throughout much of the twentieth century. In response to a request by the U.S. Bureau of Land Management (BLM), a new series of resource and geoenvironmental studies was initiated by the USGS in 1998. Present studies consist of (1) integrated, multidisciplinary research directed toward resource and reserve estimations of phosphate in selected 7.5-minute quadrangles; (2) elemental residence, mineralogical and petrochemical characteristics; (3) mobilization and reaction pathways, transport, and disposition of potentially toxic elements associated with the occurrence, development, and use of phosphate; (4) geophysical signatures; and (5) improving the understanding of depositional origin. To carry out these studies, the USGS has formed cooperative research relationships with two Federal agencies, BLM and the U.S. Forest Service (USFS), which are responsible for land management and resource conservation on public lands; and with five private companies currently leasing or developing phosphate resources in southeastern Idaho. The companies are Agrium U.S. Inc. (Rasmussen Ridge mine), FMC Corporation (Dry Valley mine), Rhodia Inc. (Wooley Valley mine-inactive), J.R. Simplot Company (Smoky Canyon mine), and Solutia Inc. (Enoch Valley mine). Because raw data acquired during the project will require time to interpret, the data are released in open-file reports for prompt availability to other workers. The open-file reports associated with this series of resource and geoenvironmental studies are submitted to each of the Federal and industry cooperators for technical review; however, the USGS is solely responsible for the data contained in the reports.

Location and general geology

The location of the measured sections is shown in figure 1. The sections lie approximately 30 km northeast of Soda Springs, Idaho, in an area of southeastern Idaho that has had extensive phosphate mining over the past several decades and currently has four active phosphate mines. Service (1966) provides an evaluation of the western phosphate industry in Idaho and a brief description of the mining history, ore occurrence, and geology. More detailed discussion of the Phosphoria Formation in the Western Phosphate Field is given by McKelvey and others (1959). Cressman and Swanson (1964) discuss detailed stratigraphy and petrology of these same rock units in nearby southwestern Montana. Gulbrandsen and Krier (1980) discuss general aspects of the large and rich phosphorus resources in the Phosphoria Formation in the vicinity of the Soda Springs, Idaho. Gulbrandsen (1966, 1975, and 1979) summarized bulk chemical compositional data for various lithologies of the phosphatic intervals in the Phosphoria Formation. Oberlindacher (1990) mapped the geology of contiguous rocks, including the members of the Phosphoria Formation, directly to the south of the measured sections.

Correlation with Measured Sections

Stratigraphic sections of the Phosphoria Formation were measured and sampled by the USGS at the Enoch Valley mine in southeastern Idaho. Brief descriptions of the stratigraphic sections from which the samples discussed in this report have been taken are already published (Tysdal and others, 1999), although no thin section, X-ray, or analytical technique other than gamma spectrometry has been used to augment the field descriptions

ABSTRACT

This study reports bulk chemical composition of rocks collected from two exposed, measured stratigraphic sections at a phosphate mine in southeastern Idaho. The samples constitute a set of channel-sampled intervals across the entire thickness of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation at two locations exposed during mining. The samples characterize the lower phosphate ore, interlayered middle waste rock, and upper ore units of the member. The rocks from measured section A lie closer to the original, pre-mined ground surface than those of measured section B and, hence, are more oxidized and weathered than those of Section B.

of the rock units of that report. Informal bed names—introduced by Hale (1967, p. 152) and used generally throughout southeastern Idaho—are included in the Lithology or Description column of the data tables in this report. Informal bed names used only within a specific mine are not presented here. English units of measurement are used throughout this report to facilitate direct correspondence with units in the extensive historical literature on the Phosphoria and with current industry usage. Thicknesses and interval boundary footages listed here are true thickness of the strata at the sample site; these thicknesses are corrected for apparent thickening due to dip of the strata at the exposed sections at the mine benches.

The Phosphoria Formation in the vicinity of the measured sections consists of three members, which in ascending order are the Meade Peak Phosphatic Shale, Rex Chert, and the informally named cherty shale (McKelvey and others, 1959; Oberlindacher, 1990). The lithologic sections discussed here focus on the Meade Peak Phosphatic Shale Member. The Meade Peak unconformably overlies the Grandeur Tongue of the Permian Park City Formation, and the cherty shale member is overlain by the Triassic Dinwoody Formation. Both sections were measured on surfaces exposed by mining equipment. Section wpsA (western phosphate section A) was measured along a nearly vertical outcrop face; section wpsB was measured along a horizontal surface. Section wpsA is located about 500 ft north of section wpsB, is about 100 ft higher in elevation, and is much closer to the land surface that existed just prior to mining. Measuring a pair of sections close together, but at different depths below the original land surface, permits evaluation of important effects of weathering on rock geochemistry.

METHODS

Field Sampling

The samples within the measured sections that were obtained for geochemical and petrological analysis were taken as channeled samples across the entire thickness of the interval, as noted in the data tables. The choice of sampling intervals is intended to characterize strata of more or less uniform lithology and of a broad thickness that can be handled by typical mine equipment should the results of our analyses suggest that separate handling of such zones would be advantageous. Within these broad intervals, we have sampled finer-scale strata, sometimes as little as one foot thick, where we have noted a lithology different or distinctive from the broad interval as a whole.

Approximately 500g to 1 kg of rock were collected at each sample locality. Rock samples were scraped or chiseled in a consistent manner across each interval of uniform lithology in order to obtain a representative single sample of the entire interval. The bulk samples were shipped to the laboratories of the USGS in Denver, Colorado, for sample preparation.

Rock Sample Preparation

Rock samples were dried in air at ambient temperature. The coarse-fraction samples were disaggregated in a mechanical jaw crusher and a split was then ground in a ceramic plate grinder to <100 mesh (<0.15 mm). Splits of the latter material were provided to various collaborators and to the contract laboratory for analysis. All splits were obtained with a riffle splitter to ensure similarity with the whole sample. A set of splits for all samples was archived. Splits of about ~50 g were sent to the contract laboratory where they were prepared for analysis.

Analysis

Samples were analyzed for 40 major, minor, and trace elements using acid digestion in conjunction with inductively coupled plasma-atomic emission spectrometry (ICP-AES). For 40-element analysis, a split was dissolved using a low-temperature (<150°C) digestion with concentrated hydrochloric, hydrofluoric, nitric, and perchloric acids (Crock and others, 1983). The analytical contractor has modified this procedure to shorten the digestion time (P. Lamothe, USGS, oral communication). The acidic sample solution was taken to dryness and the residue was dissolved with 1 ml of aqua regia and then diluted to 10.0 g with 1% (volume/volume) nitric acid. This technique also provides analysis of Bi and Sn. However, an inconsistent bias in the Bi and Sn data exists presently for the analytical contractor (P. Lamothe, USGS, oral communication). Consequently, the concentration data for these two elements have been eliminated from the original analytical data set.

Another split of the sample was fused in lithium metaborate then analyzed by ICP-AES after dissolution. This technique provides a separate analysis of all major elements and a few trace elements. Most importantly, this is the only analytical technique of those used that measures Si in these siliceous, phosphatic shale samples. Si measurement is not possible using the 4-acid digestion technique because the Si is lost as a volatile fluoride compound during digestion. The fusion technique is used, instead, to provide analysis of this important component of the rocks. Although the Meade Peak Phosphatic Shale Member is known mostly for its phosphatic content, it also contains minor to modest amounts of siliceous components, which result from aluminosilicate minerals, quartz, or biogenic silica. Analysis of major elements using the fusion technique also provides a compositional check on the concentrations of these same elements as measured by acid digestion. The fusion technique is superior to acid digestion for analysis of resistant minerals, especially those containing Ti and Cr. Those elements were also measured using acid digestion in combination with ICP-AES analysis. However, because of superiority of the fusion technique, the analytical data for these two elements using acid digestion have been eliminated from the data set and only those for the fusion technique are reported.

Se analysis was done using hydride generation followed by atomic absorption (AA) spectroscopy. The hydride and AA technique also is used for the analysis of As and Sb. The hydride analytical technique is superior to other analytical techniques for analysis of Se and As. Consequently, the analytical data for Se by energy-dispersive x-ray fluorescence and for As using acid digestion ICP-AES have been eliminated from the data set and only those for the hydride technique are reported.

Te is measured using AA graphite furnace spectroscopy, and Tl is measured using ICP-Mass Spectrometry (ICP-MS). Total S and total C are measured using combustion in a LECO furnace followed by gas chromatographic measurement. For the other forms of carbon, carbonate carbon is measured as evolved CO_2 after acidification of the sample, and organic carbon is calculated as the difference between total and carbonate carbon. Crock and Lichte (1982) and Jackson and others (1988) discuss additional analytical methodology.

X-ray diffraction (XRD) was used to provide a semi-quantitative estimate of phosphate mineral abundance. In this case, the estimate is obtained from the relative peak heights of the 211 lattice-plane diffraction peak on the x-ray diffractogram. This technique measures only the phosphate associated with the mineral carbonate-fluorapatite, the common sedimentary form of apatite in these rocks. In theory, the relative peak height is directly proportional to the concentration of the carbonate-fluorapatite. This technique provides a minimum estimate of total phosphate because it is possible that small amounts of phosphate occur in other forms that are not detected by this method. For example, phosphate in organic compounds, amorphous forms, or in minerals other than carbonate-fluorapatite would be excluded from this x-ray analysis.

Each of the two sampled sections has been measured for equivalent uranium (eU) concentrations using a GAD-6 gamma spectrometer. This instrument measures gross gamma flux (including cosmic rays) and provides a quantitative measure of K, U, and Th. Determination of the abundance of these three elements occurs via detection and counting of a specific radionuclide surrogate for each element; each of these radionuclides has a distinctive energy peak in the total gamma ray spectrum. The reported total abundance of each of the three elements assumes normal crustal concentration of the measured nuclide with all collective isotopes for that element. In the case of the U measurement, secular equilibrium is assumed between the measured daughter decay nuclide and total U. When placed on the ground surface, the spectrometer integrates detection over a 2π (hemisphere) geometry. For typical crustal rocks and U concentrations, approximately 2 standard deviations of the total number of detected gamma rays are emitted from atoms within a hemisphere of approximately 1/2 m^3 volume. Proportionally higher detection weighting occurs for those gamma rays that are emitted closer to the detector and, therefore, which have a greater chance of passing through the detector.

Previous studies of the Phosphoria Formation have shown that the eU varies in direct proportion to total uranium and that total uranium varies in almost direct proportion to the phosphate content (McKelvey, 1956). For example, in an exhaustive study of nearly 1,000 phosphatic rocks from the Phosphoria Formation of southwestern Montana, U and eU differed by no more than 0.002 percent in a subset, and for the entire set the general ratio between eU and P_2O_5 was 0.3×10^{-3} (Swanson, 1970), with approximately 85 percent of the values contained within the range of 0.17×10^{-3} to 1×10^{-3}. Scatter in the U to P_2O_5 relationship results from syndepositional effects that affect U concentrations and (or) from post-depositional alteration, especially weathering, that might preferentially remove U but leave phosphate. For the phosphatic rocks of the Phosphoria Formation, the total gamma counts are dominated by decay of uranium and its various daughter products. The uranium is mostly located in the phosphate mineral lattice as a substitute for Ca; location of the decay (daughter) products is uncertain. Other radionuclides are minor: K_2O in the phosphorite is generally <1 percent, and Th concentrations are generally <25 parts per million (ppm) (Altschuler and others, 1958; Swanson, 1970; Herring, unpub. data). Concentrations of eU are given in ppm and are approximately equivalent to the total uranium concentration, also in ppm.

The measurements for eU were obtained on high-resolution, 1-foot (true-thickness) spacing across both of the sampled sections. These concentration data are graphed in the preliminary report on the stratigraphic descriptions of sections A and B (Tysdal and others, 1999). Measurements for the channel-sampled intervals reported here are averaged over the spacing that corresponds to each channel-sampled interval.

RESULTS

Analytical results of the rock analyses for the more-weathered stratigraphic section A and less-weathered section B (wpsA and wpsB) are listed in data tables 1 and 2, respectively. Interval base and top footages are specified relative to the stratigraphic base of the Meade Peak Phosphatic Shale Member, specifically from the base of the Fish-scale marker stratum, a bioclastic phosphorite unit, and these footage numbers increase upward through the sections. The concentration data in tables 1 and 2 are listed as reported by the contract laboratory and other collaborators. There has been no statistical manipulation of the data or consideration of qualified values. Qualified values of concentration result from detection of elements that are present but at concentrations less than their lower detection limits (LDL). They are listed in the data table with "<" preceding the LDL. No replacement values for these qualified concentrations, typically done with most traditional data summarization and analysis (Cohen, 1959), are included.

As a measure of analytical precision, the analytical sample set includes 11 replicated samples. These samples are identified in the remarks column of the data tables. As a measure of analytical accuracy, two phosphatic rock analytical standards accompanied the rock samples that were submitted to the contract laboratory. The reported analysis and best ongoing consensus values of these standards are given in table 3. The standards included as a part of the quality control monitoring of the contract laboratory also are included in table 3.

The samples were submitted to the contract laboratory in a randomized sequence. This eliminates systematic errors from sources such as, for example, instrumental drift. The abbreviations for analytical techniques in the column headings of tables A and B for analytical methodology are defined as follows:

XRD: X-ray diffraction
Hyd.: hydride generation
CVAA: cold vapor atomic absorption
FAA: flame atomic absorption
ICP-MS: inductively-coupled plasma spectrometry, mass spectrometry
ICP-16: inductively-coupled plasma spectrometry, fusion digestion
ICP-40: inductively-coupled plasma spectrometry, acid digestion

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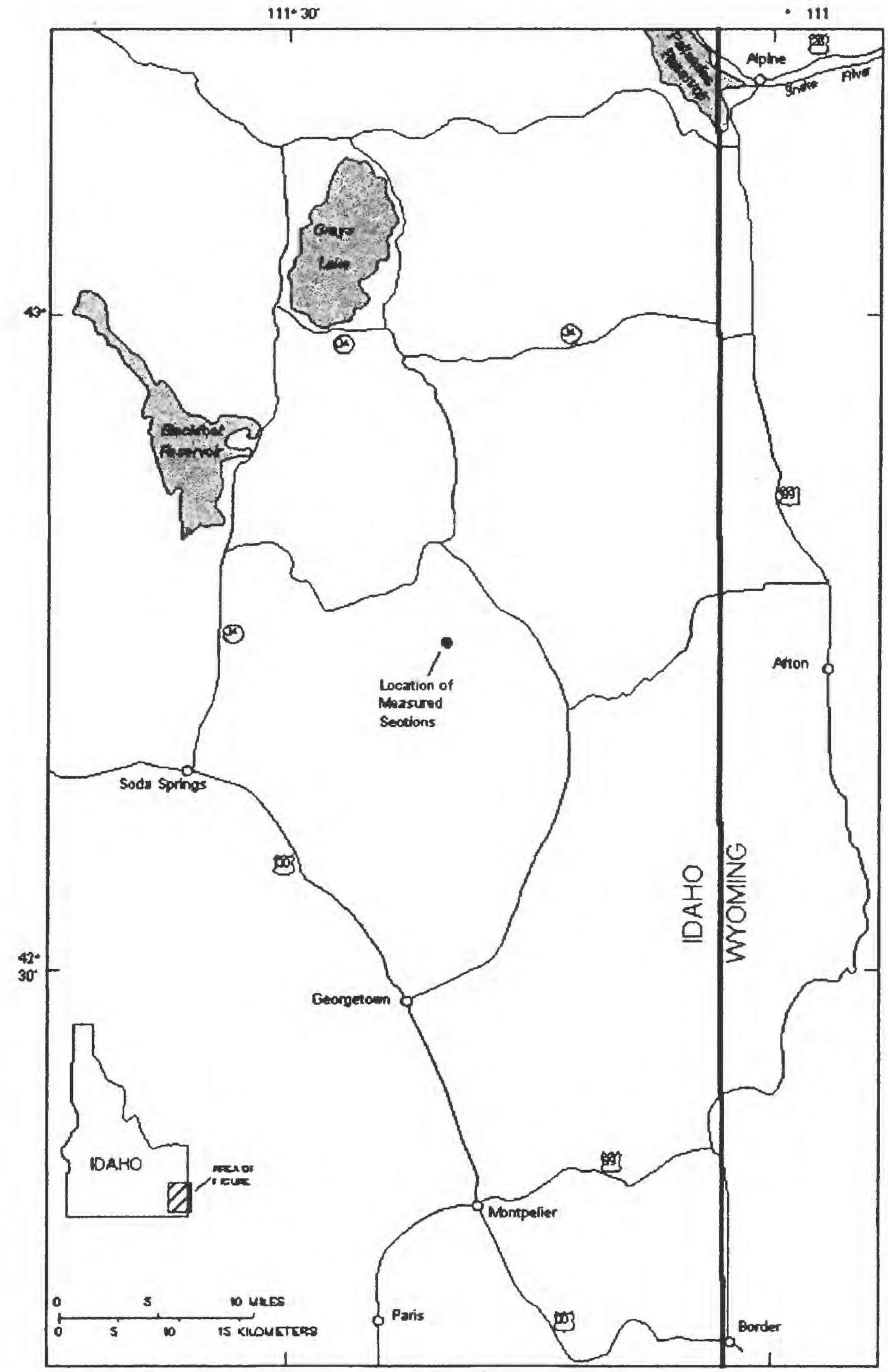

Figure 1. Index map of southeastern Idaho showing location of measured sections from which samples were collected.

Table 1. Analysis of samples from Measured Section A.

Field No.	Lab No.	Lithology or Description	Interval base, ft	Interval top, ft	Interval thickness, ft	Apatite relative peak height, XRD	Se, ppm, Hyd.	As, ppm, Hyd.	Hg, ppm, CVAA	Sb, ppm, Hyd.	Te, ppm, FAA	Tl, ppm, ICP-MS	C, %, Combustion
WPSA002C	C-122883	Lower Mudstone	0.3	4.3	4	22	10.3	82.6	0.36	22.7	0.2	9.3	0.91
WPSA006C	C-122905	Lower Phosphorite	4.3	7.3	3	127	7.9	15.4	0.36	12.5	<0.1	4.3	1.64
WPSA008C	C-122909	Lower Mudstone	7.3	8.7	1.4	153	6.7	26.3	0.37	19.1	0.2	3.1	1.49
WPSA008X	C-122882	duplicate of previous sample					5.7	28	0.24	21	0.1	2.6	1.49
WPSA015C	C-122907	Lower Phosphorite	8.7	21	12.3	115	11.9	6.2	0.37	7.3	0.3	4.7	2.45
WPSA022C	C-122900	Lower Mudstone	21	22.5	1.5	30	9.4	32.6	0.38	16.3	0.1	20	0.59
WPSA024C	C-122881	Lower Phosphorite	22.5	25	2.5	105	12.6	13.8	0.27	6.7	0.2	4.5	2.1
WPSA026C	C-122914	Lower Mudstone	25	27	2	53	61.6	33.7	0.42	19.1	0.3	7.7	1.72
WPSA030C	C-122884	Lower Phosphorite	27	34	7	157	16.3	19.5	0.45	9.7	<0.1	4.5	2.61
WPSA035C	C-122904	Lower Mudstone	34	36	2	103	27.2	25.1	0.53	7.8	<0.1	5.8	1.39
WPSA035X	C-122894	duplicate of previous sample					25.6	24.8	0.55	7.7	0.2	4.8	1.39
WPSA040C	C-122887	Lower Phosphorite	36	47.5	11.5	143	89.3	25.8	0.69	8	0.1	3	2.62
WPSA050C	C-122920	Middle Waste	47.5	55	7.5	95	185	44.6	0.97	6.8	0.2	1.8	3.96
WPSA057C	C-122890	Middle Waste	55	58	3	70	36.6	40.2	0.87	12.9	0.1	1.4	3.24
WPSA060C	C-122898	Middle Waste	58	62	4	87	84.1	23.8	1.05	5.7	0.1	1.3	8.95
WPSA062C	C-122892	Middle Waste carbonaceous	62	62.5	0.5	29	35.9	7.7	0.63	2.2	0.3	1.4	35
WPSA063C	C-122896	Middle Waste	62.5	65	2.5	86	64.8	20.2	0.85	5.9	0.4	1	8.13
WPSA070C	C-122918	Middle Waste	65	72	7	61	158	28.8	0.85	7.1	0.2	0.9	4.68
WPSA072C	C-122915	Middle Waste	72	73	1	68	160	42.4	0.69	8.6	0.3	0.7	2.13
WPSA080C	C-122916	Middle Waste	73	83	10	56	216	27.3	0.42	5.6	0.2	0.7	8.01
WPSA085C	C-122912	Middle Waste	83	86	3	19	43.2	41.8	0.22	11.8	0.2	1.7	3.59
WPSA085X	C-122899	duplicate of previous sample					45.1	39.4	0.57	12.6	0.2	1.5	3.52
WPSA087C	C-122906	Middle Waste	86	87	1	45	15	89.9	0.94	17.6	<0.1	1.6	1.79
WPSA096C	C-122888	sub-sample of next sample	95	96	1	115	16.9	107	0.57	13.1	<0.1	2.7	1.09
WPSA100C	C-122913	Middle Waste phosphatic	87	120	33	79	23.5	42.6	0.66	9.4	0.3	1.6	3.06
WPSA123C	C-122893	Middle Waste phosphatic	120	124	4	35	16.3	23.3	0.47	4.3	0.2	1.1	3.91
WPSA124C	C-122885	Middle Waste	124	125	1	35	3.1	29.6	0.92	5.6	<0.1	2.1	0.58
WPSA127C	C-122891	Middle Waste	125	129	4	47	10.7	26.7	0.4	3.7	0.2	1.3	3.56
WPSA127X	C-122911	duplicate of previous sample					10.3	26.9	0.37	3.8	0.1	1.2	3.63
WPSA129C	C-122908	Middle Waste	129	130	1	43	18	18	0.48	3.5	0.2	0.7	2.04
WPSA131C	C-122919	Middle Waste	130	132	2	15	81	26.6	0.69	6.4	0.2	2.6	1.72
WPSA131X	C-122903	duplicate of previous sample					76.6	27	0.7	6.6	<0.1	2.6	1.74
WPSA133C	C-122902	Middle Waste	132	133	1	69	19.1	25.3	0.5	4.2	<0.1	1.1	2.48
WPSA134C	C-122895	Middle Waste	133	134	1	76	12.3	15.5	0.48	3.2	<0.1	0.6	2.31
WPSA138C	C-122886	Middle Waste	134	143	9	67	11.8	25.2	0.63	6	<0.1	1.5	5.77
WPSA144C	C-122901	Middle Waste	143	145	2	25	31.1	24.2	0.62	10.8	<0.1	3.5	1.67
WPSA147C	C-122897	Upper Phosphorite	145	150.5	5.5	90	6.5	9.3	0.49	5.8	<0.1	3.6	3.1
WPSA147X	C-122910	duplicate of previous sample					6.6	9.3	0.53	5.7	<0.1	3.4	3.22
WPSA151C	C-123552	Upper Phosphorite	150.5	153	2.5	107	1.2	4.2	0.22	1.7	<0.1	1.8	1.34
WPSA153C	C-123555	Upper Mudstone	153	154	1	50	33.9	30.9	0.28	3.5	0.1	5.1	1.13
WPSA154C	C-123576	Upper Phosphorite	154	155.5	1.5	95	5.6	12.4	0.27	1.9	<0.1	1.7	1.19
WPSA154X	C-123580	duplicate of previous sample					5.6	11.3	0.27	2.7	<0.1	1.7	1.15
WPSA156C	C-123562	Upper Mudstone	155.5	156	0.5	36	2.6	30.4	0.3	5.8	0.1	7	0.51
WPSA158C	C-123579	Upper Phosphorite	156	159	3	85	1.4	4.3	0.32	2	<0.1	1.2	1.82
WPSA163C	C-123572	Upper Waste	159	164.5	5.5	20	15.3	21.8	0.25	2.2	<0.1	3	1.13

Table 1. Analysis of samples from Measured Section A.

Field No.	CO_2, %, Acidification	Carbonate C, %, Acidification	Organic C, %, difference	S, %, Combustion	Al, %, ICP-16	Ca, %, ICP-16	Fe, %, ICP-16	K, %, ICP-16	Mg, %, ICP-16	Na, %, ICP-16	P, %, ICP-16	Si, %, ICP-16	Ti, %, ICP-16	Ba, ppm, ICP-16	Cr, ppm, ICP-16	Mn, ppm, ICP-16
WPSA002C	0.21	0.06	0.85	0.15	5.38	3.42	4.02	2.43	0.37	0.11	1.6	27.9	0.4	289	789	670
WPSA006C	1.47	0.4	1.24	0.52	0.79	33.7	0.95	0.34	0.11	0.31	15.4	3.51	0.05	67	1050	106
WPSA008C	0.73	0.2	1.29	0.35	2.35	23	2.19	1.04	0.14	0.17	10.5	12.6	0.15	106	792	<100
WPSA008X	0.73	0.2	1.29	0.33	2.52	20.3	2	1.27	0.15	0.21	9.88	12.6	0.15	121	625	<100
WPSA015C	0.96	0.26	2.19	0.45	1.44	29	0.49	0.68	0.13	0.19	13.2	7.06	0.1	104	1000	<100
WPSA022C	0.24	0.07	0.52	0.08	6.14	7.6	2.32	2.72	0.13	0.66	3.63	25.5	0.4	189	454	656
WPSA024C	0.87	0.24	1.86	0.32	1.72	25.2	0.73	0.95	0.11	0.23	12.3	8	0.13	172	624	<100
WPSA026C	0.3	0.08	1.64	0.26	4.49	8.96	2.11	2.18	0.13	0.27	4.14	22	0.35	203	814	180
WPSA030C	1	0.27	2.34	0.37	1.44	27.4	0.65	0.82	0.13	0.16	13.2	6.78	0.1	138	958	<100
WPSA035C	0.71	0.19	1.2	0.2	3.45	22.1	1.48	1.45	0.19	0.12	10.2	12	0.17	112	992	362
WPSA035X	0.75	0.2	1.19	0.2	3.55	21.7	1.47	1.53	0.19	0.12	10.1	12.2	0.17	112	972	353
WPSA040C	0.78	0.21	2.41	0.4	2.21	22.5	1.09	1.08	0.15	0.2	10.7	10.9	0.15	166	1560	<100
WPSA050C	0.29	0.08	3.88	0.48	5.5	12.1	2.44	2.41	0.22	0.28	6.19	18.4	0.33	304	2920	<100
WPSA057C	0.43	0.12	3.12	0.41	4.97	13.6	2.34	2.05	0.18	0.28	6.53	17.2	0.31	224	1690	134
WPSA060C	0.24	0.07	8.88	0.94	5.52	9.7	2.46	2.14	0.34	0.13	5.22	15.5	0.32	308	3760	<100
WPSA062C	0.09	0.02	34.98	3.95	2.75	5.76	1.16	0.68	0.36	0.04	1.92	5.3	0.12	126	1560	<100
WPSA063C	0.45	0.12	8.01	0.91	4.53	13.6	2.04	1.52	0.25	0.12	6.82	13.4	0.24	239	3150	<100
WPSA070C	0.34	0.09	4.59	0.61	5.09	11	2.1	1.79	0.27	0.18	5.28	16.9	0.28	250	3600	<100
WPSA072C	0.23	0.06	2.07	0.26	4.99	6.77	2.69	1.58	0.11	0.57	3.34	22.6	0.37	205	1030	<100
WPSA080C	0.13	0.04	7.97	1.23	4.82	5.55	1.68	1.87	0.13	0.62	2.89	23	0.38	257	1310	<100
WPSA085C	0.04	0.01	3.58	0.41	6.39	2.26	2.65	2.58	0.26	0.3	1.34	25.3	0.44	312	1980	<100
WPSA085X	0.04	0.01	3.51	0.42	6.85	2.24	2.79	2.88	0.28	0.34	1.37	26.5	0.46	338	2020	<100
WPSA087C	0.21	0.06	1.73	0.19	7.78	4.22	3.96	2.4	0.19	0.09	2.49	21.4	0.35	191	1150	489
WPSA096C	0.66	0.18	0.91	0.35	1.48	24.4	4.04	0.51	0.08	0.29	12.8	7.86	0.12	112	1520	<100
WPSA100C	0.41	0.11	2.95	0.43	3.88	14.3	2.49	1.31	0.23	0.29	7.37	15.3	0.26	206	3090	<100
WPSA123C	0.22	0.06	3.85	0.46	4.39	9.37	1.64	1.71	0.2	0.45	4.89	22.4	0.35	287	1760	<100
WPSA124C	0.11	0.03	0.55	0.08	6.47	4.15	2.54	1.67	0.12	0.65	3.09	25.6	0.36	157	480	504
WPSA127C	0.19	0.05	3.51	0.38	3.75	8.47	1.64	1.44	0.14	0.48	4.35	24.6	0.27	226	1070	<100
WPSA127X	0.21	0.06	3.57	0.41	3.52	9.02	1.69	1.26	0.14	0.42	4.5	24.2	0.26	215	1110	<100
WPSA129C	0.35	0.1	1.94	0.29	3.16	14.6	1.36	1.2	0.09	0.41	7.02	19.9	0.27	194	666	<100
WPSA131C	0.06	0.02	1.7	0.19	5.87	1.61	2.25	1.66	0.05	1.01	1.44	28.7	0.46	240	528	1120
WPSA131X	0.07	0.02	1.72	0.18	5.97	1.64	2.24	1.69	0.05	1.04	1.47	28.8	0.46	235	512	1200
WPSA133C	0.47	0.13	2.35	0.36	2.92	17.8	1.65	1.13	0.12	0.48	8.66	16.4	0.24	197	950	<100
WPSA134C	0.85	0.23	2.08	0.36	1.43	27.5	1.01	0.53	0.09	0.33	13.1	8.59	0.1	148	802	<100
WPSA138C	0.35	0.1	5.67	0.64	4.21	11.2	1.85	1.74	0.27	0.4	5.55	18.4	0.29	258	1880	<100
WPSA144C	0.15	0.04	1.63	0.18	6.97	4.22	2.92	1.97	0.36	0.67	2.04	24.9	0.39	302	1040	145
WPSA147C	1.04	0.28	2.82	0.33	2.18	26.9	0.93	0.78	0.23	0.15	12.4	8.89	0.15	179	1740	<100
WPSA147X	1.03	0.28	2.94	0.34	2	27	0.87	0.68	0.21	0.14	12.3	8.32	0.14	152	1690	<100
WPSA151C	1.41	0.38	0.96	1.55	0.6	36.8	0.3	0.16	0.09	0.12	17	2.79	0.04	123	695	103
WPSA153C	0.41	0.11	1.02	0.12	3.87	12.8	1.96	1.08	0.21	0.46	6.17	22.9	0.35	255	765	490
WPSA154C	1.1	0.3	0.89	0.14	1.35	30.8	0.74	0.4	0.12	0.15	14.6	6.89	0.11	142	752	<100
WPSA154X	1.08	0.29	0.86	0.13	1.28	30.4	0.7	0.38	0.12	0.15	14.3	6.6	0.1	143	712	<100
WPSA156C	0.26	0.07	0.44	0.05	5.26	7.28	3.06	1.31	0.24	0.45	3.49	26.7	0.48	262	407	1220
WPSA158C	1.4	0.38	1.44	0.23	0.56	34.9	0.3	0.17	0.09	0.12	16	2.34	0.04	128	758	<100
WPSA163C	0.14	0.04	1.09	0.13	4.69	3.95	1.81	1.45	0.31	0.47	1.89	29.7	0.33	236	730	395

Table 1. Analysis of samples from Measured Section A.

Field No.	Nb, ppm, ICP-16	Sr, ppm, ICP-16	Y, ppm, ICP-16	Zr, ppm, ICP-16	Al, % ICP-40	Ca, % ICP 40	Fe, %, ICP 40	K, %, ICP-40	Mg, %, ICP-40	Na, %, ICP-40	P, %, ICP-40	Ag, ppm, ICP-40	Au, ppm, ICP-40	Ba, ppm, ICP-40	Be, ppm, ICP-40	Cd, ppm, ICP-40	Ce, ppm, ICP-40	Co, ppm, ICP-40
WPSA002C	10	139	63	393	5.36	3.595	4.27	2.31	0.345	0.11	1.53	<2	<8	275	<1	59	54	10
WPSA006C	<10	623	158	89	0.865	30.2	0.83	0.39	0.115	0.38	14.4	<2	<8	60	<1	158	18	<2
WPSA008C	<10	364	222	155	2.61	21.2	2.15	1.22	0.14	0.205	9.835	3	<8	97	<1	108	51	<2
WPSA008X	<10	391	226	151	2.57	20.3	1.96	1.22	0.135	0.205	9.505	4	<8	95	<1	105	47	<2
WPSA015C	<10	559	148	105	1.62	26.4	0.47	0.81	0.13	0.23	12.7	3	<8	91	<1	160	27	<2
WPSA022C	13	242	62	290	6.14	7.06	2.31	2.72	0.125	0.705	3.225	<2	<8	177	<1	90	59	6
WPSA024C	<10	807	94	144	1.78	25.1	0.77	0.94	0.1	0.23	12.4	<2	<8	146	<1	159	22	<2
WPSA026C	<10	273	97	282	5.06	8.67	2.25	2.61	0.135	0.335	3.785	5	8	226	<1	109	62	6
WPSA030C	<10	838	208	131	1.475	27	0.66	0.81	0.11	0.165	13.1	4	<8	108	<1	210	30	<2
WPSA035C	<10	681	242	135	3.735	20.5	1.45	1.63	0.185	0.135	9.445	8	<8	102	<1	130	44	<2
WPSA035X	<10	704	247	132	3.76	20.3	1.38	1.64	0.18	0.14	9.49	9	<8	100	<1	128	48	2
WPSA040C	<10	872	442	167	2.31	22.6	1.02	1.11	0.15	0.21	10.3	13	<8	157	<1	143	67	<2
WPSA050C	<10	521	164	157	5.55	10.6	2.35	2.51	0.205	0.315	5.465	8	<8	286	1	25	61	<2
WPSA057C	<10	612	145	194	5.04	13.2	2.44	2.06	0.175	0.3	6.26	6	<8	222	1	28	57	6
WPSA060C	<10	522	217	156	5.52	8.91	2.44	2.19	0.315	0.135	4.735	9	<8	295	1	21	62	<2
WPSA062C	<10	256	86	55	2.73	5.46	1.36	0.51	0.35	0.035	1.83	19	<8	103	<1	22	23	<2
WPSA063C	<10	846	197	125	4.645	12.6	2.11	1.6	0.23	0.14	6.345	9	<8	222	1	22	51	<2
WPSA070C	<10	1130	178	147	5.585	9.735	2.18	2.1	0.255	0.225	4.855	6	<8	260	1	14	59	<2
WPSA072C	<10	365	72	282	5.84	6.655	2.91	1.94	0.115	0.74	3.235	<2	<8	229	<1	13	69	<2
WPSA080C	<10	357	75	310	5.235	5.135	1.79	2.14	0.13	0.75	2.625	2	<8	279	1	9	58	<2
WPSA085C	<10	148	126	298	6.795	2.175	2.73	2.89	0.275	0.36	1.255	8	<8	356	1	33	82	<2
WPSA085X	<10	158	132	306	6.7	2.155	2.66	2.85	0.27	0.355	1.22	7	<8	346	1	32	80	<2
WPSA087C	<10	1060	80	145	8.29	4.12	4.05	2.39	0.2	0.1	2.345	6	<8	200	<1	53	59	12
WPSA096C	<10	1250	278	180	1.55	23.1	3.51	0.54	0.075	0.32	12	3	<8	98	<1	29	58	<2
WPSA100C	<10	948	298	196	4.295	13.2	2.59	1.57	0.235	0.36	6.95	6	<8	215	1	37	74	<2
WPSA123C	<10	360	228	313	4.535	8.84	1.72	1.79	0.195	0.495	4.5	6	<8	270	<1	19	71	<2
WPSA124C	<10	208	158	318	6.395	4.335	2.76	1.62	0.115	0.66	3.1	<2	<8	152	<1	11	73	12
WPSA127C	<10	327	165	236	3.795	8.355	1.73	1.45	0.135	0.51	4.385	6	<8	224	1	18	50	4
WPSA127X	<10	309	160	241	3.725	8.305	1.7	1.42	0.13	0.5	4.25	6	<8	215	1	19	56	<2
WPSA129C	<10	478	239	274	3.375	13.4	1.37	1.34	0.085	0.485	6.465	4	<8	185	1	16	72	<2
WPSA131C	10	438	32	419	6.035	1.66	2.27	1.79	0.045	1.165	1.425	<2	<8	254	<1	16	57	5
WPSA131X	12	447	32	413	6.055	1.525	2.29	1.8	0.045	1.165	1.345	<2	<8	250	<1	16	48	6
WPSA133C	<10	653	197	248	3.09	16.1	1.62	1.22	0.115	0.555	7.975	4	<8	187	<1	24	60	2
WPSA134C	<10	1010	325	103	1.54	25.8	0.82	0.58	0.08	0.375	12.3	5	<8	130	2	31	46	<2
WPSA138C	<10	562	198	211	4.195	11.1	1.96	1.69	0.255	0.41	5.365	7	<8	238	2	41	49	<2
WPSA144C	11	738	77	276	7.175	4.02	2.95	2.12	0.35	0.755	1.84	3	<8	303	1	50	63	4
WPSA147C	11	928	206	137	2.22	24.3	0.75	0.81	0.21	0.165	11.3	5	<8	154	<1	167	27	<2
WPSA147X	<10	865	194	135	2.215	24	0.85	0.81	0.21	0.165	11.5	5	<8	155	<1	170	29	<2
WPSA151C	<10	884	331	61	0.605	32.7	0.26	0.17	0.08	0.125	16.1	2	<8	76	<1	71	34	<2
WPSA153C	<10	287	210	380	3.825	11.1	1.81	1.12	0.195	0.455	5.555	6	<8	191	<1	28	59	3
WPSA154C	<10	691	351	139	1.305	28.8	0.28	0.42	0.11	0.16	13.4	4	<8	104	<1	42	40	<2
WPSA154X	<10	687	347	143	1.285	28.3	0.6	0.41	0.11	0.16	13.5	4	<8	96	<1	39	42	<2
WPSA156C	14	181	132	401	5.485	6.685	2.91	1.43	0.24	0.465	3.07	2	<8	234	<1	21	73	9
WPSA158C	15	882	188	42	0.57	33	0.28	0.19	0.09	0.13	15.7	<2	<8	86	<1	64	16	<2
WPSA163C	<10	136	109	301	4.815	3.945	1.86	1.6	0.32	0.495	1.895	<2	<8	230	1	22	61	9

Table 1. Analysis of samples from Measured Section A.

Field No.	Cu, ppm, ICP-40	Eu, ppm, ICP-40	Ga, ppm, ICP-40	Ho, ppm, ICP-40	La, ppm, ICP-40	Li, ppm, ICP-40	Mn, ppm, ICP-40	Mo, ppm, ICP-40	Nb, ppm, ICP-40	Nd, ppm, ICP-40	Ni, ppm, ICP-40	Pb, ppm, ICP-40	Sc, ppm, ICP-40	Sr, ppm, ICP-40	Ta, ppm, ICP-40	Th, ppm, ICP-40	U, ppm, ICP-40	V, ppm, ICP-40
WPSA002C	88	2	<4	<4	54	27	734	28	7	52	621	93	8	128	<40	10	<100	1340
WPSA006C	118	2	<4	<4	124	11	92	10	<4	46	128	46	<2	619	<40	<6	214	1710
WPSA008C	86	4	<4	<4	191	12	27	10	<4	80	273	18	3	365	<40	<6	<100	550
WPSA008X	88	3	<4	5	186	12	26	10	<4	80	262	16	2	362	<40	<6	<100	535
WPSA015C	91	<2	<4	<4	129	12	13	5	<4	50	82	15	3	570	<40	<6	125	874
WPSA022C	54	<2	<4	<4	56	13	517	11	<4	39	248	13	8	222	<40	12	<100	888
WPSA024C	78	<2	<4	<4	69	7	36	24	<4	26	71	11	2	750	<40	<6	151	1700
WPSA026C	97	2	<4	<4	80	13	155	59	<4	55	307	13	8	279	<40	7	<100	1370
WPSA030C	115	3	<4	5	163	11	37	8	<4	69	112	14	3	787	<40	<6	187	1580
WPSA035C	104	4	<4	5	199	15	315	10	<4	94	224	6	5	678	<40	<6	<100	656
WPSA035X	103	4	4	5	201	15	289	9	<4	94	220	6	4	671	<40	<6	<100	643
WPSA040C	176	7	<4	11	341	18	50	24	<4	186	153	15	4	844	<40	<6	114	1370
WPSA050C	162	4	8	<4	150	22	13	14	<4	95	152	10	12	475	<40	9	<100	238
WPSA057C	121	3	<4	4	132	17	119	42	<4	71	296	12	11	574	<40	8	<100	409
WPSA060C	157	4	11	6	180	35	6	15	<4	103	211	15	14	477	<40	7	<100	390
WPSA062C	45	<2	<4	<4	68	10	<4	5	<4	35	539	<4	5	217	<40	<6	<100	203
WPSA063C	155	3	<4	4	159	22	20	10	<4	78	205	13	11	784	<40	<6	<100	385
WPSA070C	155	3	9	<4	166	31	17	12	<4	101	233	9	13	1070	<40	<6	<100	276
WPSA072C	81	3	<4	<4	78	10	73	14	<4	53	174	10	10	387	<40	10	<100	247
WPSA080C	62	<2	6	<4	73	15	17	11	<4	52	105	9	9	356	<40	10	<100	225
WPSA085C	99	4	11	4	118	29	20	47	<4	94	339	14	16	151	<40	14	<100	672
WPSA085X	95	4	9	<4	114	28	19	44	<4	93	325	13	15	150	<40	14	<100	648
WPSA087C	116	2	<4	<4	96	13	414	12	5	65	798	8	13	1070	<40	12	<100	413
WPSA096C	99	6	<4	5	258	8	10	71	<4	164	45	12	<2	1140	<40	<6	<100	306
WPSA100C	175	7	9	7	298	26	58	31	<4	166	150	14	10	969	<40	10	<100	251
WPSA123C	129	4	12	4	154	21	11	20	<4	91	59	10	10	330	<40	10	<100	311
WPSA124C	57	3	<4	5	122	9	468	23	<4	74	389	6	11	199	<40	15	<100	257
WPSA127C	87	3	<4	5	113	15	82	23	<4	61	150	4	9	307	<40	9	<100	181
WPSA127X	87	3	<4	<4	109	14	73	23	<4	64	144	5	8	305	<40	6	<100	176
WPSA129C	70	5	5	6	164	8	10	7	<4	118	71	6	7	466	<40	8	<100	147
WPSA131C	64	<2	<4	<4	37	5	962	16	<4	31	254	5	9	434	<40	14	<100	398
WPSA131X	63	<2	<4	<4	35	5	981	16	4	26	253	7	10	436	<40	14	<100	397
WPSA133C	72	4	<4	6	135	9	32	14	<4	85	78	6	4	615	<40	<6	<100	176
WPSA134C	66	5	<4	6	217	7	14	7	<4	120	58	10	<2	971	<40	<6	<100	133
WPSA138C	175	3	8	5	120	26	18	11	<4	73	151	10	10	509	<40	8	<100	296
WPSA144C	87	2	5	<4	60	23	109	9	<4	43	244	9	11	709	<40	10	<100	516
WPSA147C	127	3	<4	4	121	18	23	8	<4	60	87	13	3	860	<40	<6	117	876
WPSA147X	126	3	<4	<4	123	17	25	7	<4	56	86	13	4	857	<40	<6	148	882
WPSA151C	36	3	<4	6	175	6	92	4	<4	86	32	10	3	789	<40	<6	154	305
WPSA153C	59	3	<4	5	119	13	371	8	<4	85	110	11	9	248	<40	6	<100	415
WPSA154C	53	4	<4	7	196	8	70	9	<4	108	44	11	<2	637	<40	<6	<100	255
WPSA154X	51	5	<4	7	193	8	86	8	<4	104	42	11	4	617	<40	<6	122	259
WPSA156C	45	2	<4	<4	85	17	984	13	<4	71	199	22	10	165	<40	11	<100	389
WPSA158C	48	<2	<4	<4	106	6	49	8	<4	43	45	7	2	802	<40	<6	129	408
WPSA163C	54	3	5	<4	76	24	385	27	<4	72	180	7	8	130	<40	8	<100	241

Table 1. Analysis of samples from Measured Section A.

Field No.	Y, ppm, ICP-40	Yb, ppm, ICP-40	Zn, ppm, ICP-40	eU, ppm, gamma spectrometry
WPSA002C	66	6	3000	74
WPSA006C	179	9	1320	152
WPSA008C	260	11	1530	154
WPSA008X	256	11	1460	
WPSA015C	174	8	982	112
WPSA022C	65	5	1910	79
WPSA024C	105	6	996	111
WPSA026C	108	7	1860	115
WPSA030C	237	11	1080	135
WPSA035C	278	13	1660	62
WPSA035X	280	13	1620	
WPSA040C	495	23	977	89
WPSA050C	175	9	537	62
WPSA057C	163	9	1240	54
WPSA060C	231	12	592	44
WPSA062C	89	5	532	46
WPSA063C	214	11	854	44
WPSA070C	202	10	944	44
WPSA072C	84	6	772	48
WPSA080C	78	5	291	56
WPSA085C	144	10	987	64
WPSA085X	141	10	933	
WPSA087C	96	7	4520	68
WPSA096C	310	12	324	65
WPSA100C	346	14	644	80
WPSA123C	247	13	199	53
WPSA124C	182	9	1160	51
WPSA127C	184	10	473	45
WPSA127X	182	10	462	
WPSA129C	274	14	342	50
WPSA131C	36	5	1310	35
WPSA131X	33	4	1320	
WPSA133C	220	11	429	58
WPSA134C	363	17	434	71
WPSA138C	217	12	807	59
WPSA144C	84	6	2070	67
WPSA147C	219	10	864	110
WPSA147X	223	11	868	
WPSA151C	346	17	491	145
WPSA153C	217	13	623	132
WPSA154C	365	18	404	95
WPSA154X	361	18	410	
WPSA156C	139	9	898	107
WPSA158C	197	9	460	107
WPSA163C	117	7	640	56

Table 2. Analysis of samples from Measured Section B.

Field No.	Lab No.	Lithology or Description	Interval base, ft.	Interval top, ft.	Interval thickness, ft.	Apatite, relative peak height, XRD	Se, ppm, Hyd.	As, ppm, Hyd.	Hg, ppm, CVAA	Sb, ppm, Hyd.	Te, ppm, FAA	Tl, ppm, ICP MS	C, %, Combustion
WPSB003C	C-123563	Lower Mudstone	0.3	5	4.7	11	4.2	101	0.08	6.5	<0.1	6.4	4.4
WPSB008C	C-123571	Lower Phosphorite	5	10	5	166	113	14.2	0.51	8	<0.1	8.5	2.99
WPSB018C	C-123577	Lower Phosphorite	10	24.5	14.5	16	78.1	15.4	0.43	4.3	<0.1	6.4	2.88
WPSB018X	C-123549	duplicate of previous sample					66.6	14.8	0.42	3.9	0.1	8.7	2.82
WPSB025C	C-123558	Lower Mudstone	24.5	25.5	1	78	10.3	15.3	0.14	3.3	<0.1	4.7	7.44
WPSB026C	C-123578	Lower Phosphorite	25.5	27	1.5	145	65.5	15.8	0.49	4.8	<0.1	7.2	3.15
WPSB027C	C-123587	Lower Mudstone	27	28	1	40	3.4	16.5	0.18	4.7	<0.1	6.3	9.06
WPSB033C	C-123585	Lower Phosphorite	28	37.5	9.5	190	30	15.5	0.29	7.6	<0.1	6.9	2.83
WPSB038C	C-123584	Lower Mudstone	37.5	40	2.5	27	19	24.8	0.1	3.9	<0.1	3	10.4
WPSB047C	C-123586	Lower Phosphorite	40	55	15	135	35.6	30.9	0.55	11.5	<0.1	5.9	6.32
WPSB059C	C-123567	Middle Waste	55	64	9	133	205	43.3	0.51	8	0.2	1.8	8.79
WPSB059X	C-123570	duplicate of previous sample					225	41.4	0.53	9.6	<0.1	1.7	8.98
WPSB065C	C-123560	Middle Waste	64	65.5	1.5	11	22.5	17.7	0.11	2.6	<0.1	<0.1	10.5
WPSB070C	C-123550	Middle Waste	65.5	75	9.5	95	229	41.4	0.74	8.1	0.1	0.9	10
WPSB080C	C-123561	Middle Waste	75	82.5	7.5	66	196	29.3	0.43	5.8	<0.1	1.2	7.73
WPSB084C	C-123569	Middle Waste	82.5	85	2.5	94	171	30	0.43	17	0.1	3.1	5.54
WPSB087C	C-123556	Middle Waste	85	90.5	5.5	98	188	17.7	0.55	8.8	0.1	1.8	11.8
WPSB091C	C-123551	Middle Waste, phosphatic	90.5	91.5	1	156	170	16	0.36	2.7	0.1	1.3	10.5
WPSB095C	C-123583	Middle Waste	91.5	97	5.5	45	78.3	31.8	0.46	4.6	<0.1	1.6	6.14
WPSB097C	C-123582	Middle Waste, phosphatic	97	98	1	171	24.9	18.4	0.37	4.5	<0.1	1	5.42
WPSB100C	C-123565	Middle Waste	98	105	7	68	45.4	23.7	0.36	2.1	<0.1	1.1	6.15
WPSB107C	C-123581	Middle Waste	105	108	3	23	9.6	41	0.38	5.4	<0.1	5.7	1.02
WPSB117C	C-123566	Middle Waste	108	129.5	21.5	63	135	29.6	0.57	4.9	0.1	2.4	11
WPSB131C	C-123564	Upper Phosphorite	129.5	132	2.5	140	1040	9.5	0.52	4.5	0.1	4.8	12.3
WPSB133C	C-123557	Upper Phosphorite	132	134	2	162	146	9.8	0.25	2.9	<0.1	3.3	3.1
WPSB133X	C-123554	duplicate of previous sample					148	9.3	0.25	2.7	<0.1	3.6	3.13
WPSB134C	C-123559	Upper Mudstone	134	135	1	75	286	29.9	0.28	4.7	<0.1	5.7	1.84
WPSB136C	C-123575	Upper Phosphorite	135	137	2	181	32.1	12.7	0.33	2.2	<0.1	1.6	1.65
WPSB136X	C-123573	duplicate of previous sample					31.9	13.8	0.35	3.1	<0.1	1.7	1.65
WPSB137C	C-123553	Upper Mudstone	137	137.5	0.5	17	129	47.5	0.23	3.5	0.1	3.8	0.74
WPSB139C	C-123568	Upper Phosphorite	137.5	140	2.5	170	6.6	6.7	0.27	1.6	<0.1	1.6	2.18
WPSB145C	C-123574	Upper Waste	140	151	11	24	35.8	26.7	0.24	1.8	<0.1	2.3	2.49

Table 2. Analysis of samples from Measured Section B.

Field No.	CO2, %, Acidification	Carbonate C, %, Acidification	Organic C, %, difference	S, %, Combustion	Al, %, ICP-16	Ca, %, ICP-16	Fe, %, ICP-16	K, %, ICP-16	Mg, %, ICP-16	Na, %, ICP-16	P, %, ICP-16	Si, %, ICP-16	Ti, %, ICP-16	Ba, ppm, ICP-16
WPSB003C	13.6	3.71	0.69	0.11	3.66	7.04	2.76	1.44	3.63	0.13	0.16	22.4	0.31	184
WPSB008C	1.82	0.5	2.49	0.77	0.53	32.1	0.33	0.25	0.17	0.39	14.5	2.79	0.04	84
WPSB018C	1.67	0.46	2.42	0.76	0.6	33.6	0.33	0.28	0.15	0.41	15.1	3	0.04	89
WPSB018X	1.68	0.46	2.36	0.74	0.56	32.6	0.32	0.27	0.14	0.4	14.6	2.76	0.04	92
WPSB025C	24.3	6.63	0.81	0.24	0.74	26.2	0.45	0.26	6.27	0.16	6.32	5.29	0.06	74
WPSB026C	2.82	0.77	2.38	0.63	1.24	29.7	0.49	0.59	0.55	0.35	13.3	5.82	0.08	123
WPSB027C	30.6	8.35	0.71	0.11	2.56	18.9	0.41	1.26	8.01	0.1	2.07	6.75	0.06	77
WPSB033C	1.74	0.47	2.36	0.4	0.99	31.4	0.51	0.53	0.23	0.22	14.5	5.01	0.07	118
WPSB038C	33.3	9.09	1.31	0.11	1.66	17.2	0.72	0.83	8.8	0.43	0.87	8.21	0.12	92
WPSB047C	3.85	1.05	5.27	0.7	1.71	23.7	0.82	0.86	0.92	0.29	10.1	9.37	0.12	150
WPSB059C	8.36	2.28	6.51	0.88	2.32	22.2	1.13	1.02	2.05	0.42	8.09	9.09	0.13	160
WPSB059X	8.47	2.31	6.67	0.87	2.31	20.5	1.06	1.02	2.01	0.42	7.71	8.9	0.13	152
WPSB065C	34.7	9.47	1.03	0.11	1.73	19.5	0.8	0.51	8.54	0.63	0.37	7.87	0.13	82
WPSB070C	1.26	0.34	9.66	1.05	4.36	12.1	1.86	1.74	0.33	0.47	5.02	15.9	0.26	243
WPSB080C	0.2	0.05	7.68	0.8	5.12	6.2	1.99	1.98	0.16	0.93	3.04	23.6	0.38	290
WPSB084C	3.3	0.9	4.64	0.62	3.57	15.9	1.38	1.4	0.65	0.46	6.6	14.6	0.22	183
WPSB087C	1	0.27	11.53	1.3	3.46	15.9	1.9	1.28	0.43	0.37	7.57	13.1	0.22	221
WPSB091C	0.55	0.15	10.35	1.24	2.3	20.4	1.12	0.93	0.15	0.4	9.78	10.6	0.17	183
WPSB095C	3.45	0.94	5.2	0.69	4.3	7.66	1.83	1.62	1	0.79	2.73	23	0.33	262
WPSB097C	0.8	0.22	5.2	0.74	1.35	27.4	0.8	0.48	0.12	0.35	12.6	7.3	0.1	153
WPSB100C	0.31	0.08	6.07	0.65	3.46	8.23	1.48	1.24	0.15	0.67	3.75	24	0.26	225
WPSB107C	0.13	0.04	0.98	0.13	4.87	3.1	2.15	1.48	0.05	1.39	1.44	26.1	0.39	229
WPSB117C	3.27	0.89	10.11	2.92	4.28	10.4	1.92	1.66	0.97	0.67	4.04	18.9	0.29	266
WPSB131C	1.24	0.34	11.96	1.15	0.96	28.3	0.45	0.35	0.16	0.14	12.7	4.06	0.07	122
WPSB133C	1.32	0.36	2.74	0.35	1.19	34.2	0.56	0.39	0.16	0.16	15.2	5.41	0.09	161
WPSB133X	1.32	0.36	2.77	0.35	1.17	33.4	0.55	0.38	0.17	0.16	15	5.17	0.08	154
WPSB134C	0.42	0.11	1.73	0.21	4.2	11.6	2.19	1.29	0.27	0.68	5.23	24	0.38	232
WPSB136C	1.33	0.36	1.29	0.22	0.78	33	0.52	0.23	0.1	0.16	15.1	4.5	0.06	129
WPSB136X	1.33	0.36	1.29	0.21	0.79	32.6	0.53	0.24	0.1	0.16	15.2	4.58	0.06	128
WPSB137C	0.12	0.03	0.71	0.08	6.1	2.69	2.86	1.36	0.25	2	1.27	31.9	0.5	261
WPSB139C	1.47	0.4	1.78	0.27	0.43	37	0.26	0.13	0.1	0.12	16.4	1.93	0.03	130
WPSB145C	0.19	0.05	2.44	0.33	4.67	2.15	1.95	1.54	0.34	0.66	0.96	31.1	0.36	261

Table 2. Analysis of samples from Measured Section B.

Field No.	Cr, ppm, ICP 16	Mn, ppm, ICP-16	Nb, ppm, ICP-16	Sr, ppm, ICP 16	Y, ppm, ICP-16	Zr, ppm, ICP 16	Al, % ICP-40	Ca, % ICP-40	Fe, %, ICP-40	K, %, ICP-40	Mg, %, ICP-40	Na, %, ICP-40	P, %, ICP-40	Ag, ppm, ICP-40	Au, ppm, ICP-40
WPSB003C	254	348	<10	66	25	303	3.89	6.635	2.77	1.68	3.835	0.13	0.15	<2	<8
WPSB008C	799	<100	<10	750	173	82	0.58	31.7	0.32	0.3	0.175	0.425	14.9	<2	<8
WPSB018C	918	<100	<10	825	167	79	0.61	30.9	0.31	0.31	0.145	0.42	14.6	<2	<8
WPSB018X	872	<100	<10	790	158	76	0.56	30	0.29	0.29	0.14	0.4	14.2	<2	<8
WPSB025C	254	151	<10	383	158	93	0.77	22.4	0.4	0.31	6.305	0.17	5.905	<2	<8
WPSB026C	1020	<100	<10	723	214	100	1.275	27.6	0.26	0.64	0.555	0.36	12.5	4	<8
WPSB027C	267	232	<10	217	58	56	2.725	18.6	0.4	1.46	8.425	0.12	2.045	<2	<8
WPSB033C	747	<100	<10	800	115	77	1.06	29.8	0.47	0.61	0.225	0.23	14.3	<2	<8
WPSB038C	176	175	<10	166	18	91	1.815	16.6	0.72	0.98	9.28	0.49	0.88	<2	<8
WPSB047C	1130	108	<10	830	259	140	1.725	21.5	0.75	0.92	0.915	0.3	9.345	4	<8
WPSB059C	1330	<100	<10	810	204	97	2.39	19.9	0.99	1.14	2.075	0.45	7.49	6	<8
WPSB059X	1230	<100	<10	806	203	86	2.44	19.3	1.03	1.15	2.1	0.48	7.525	6	<8
WPSB065C	206	253	<10	206	12	95	1.815	17.3	0.75	0.6	8.645	0.675	0.35	<2	<8
WPSB070C	2370	<100	<10	826	169	141	4.31	11.9	1.8	1.77	0.32	0.46	4.825	5	<8
WPSB080C	1380	<100	<10	468	102	298	5.305	5.81	1.9	2.12	0.155	0.94	2.85	3	<8
WPSB084C	1020	163	12	569	111	168	3.635	15.2	1.36	1.51	0.665	0.47	6.315	<2	<8
WPSB087C	3210	<100	<10	831	323	148	3.35	13.8	1.7	1.31	0.405	0.355	6.785	6	<8
WPSB091C	1240	<100	<10	743	419	158	2.275	18.7	0.71	0.95	0.14	0.4	8.95	6	<8
WPSB095C	1300	112	<10	273	118	294	4.495	7.665	1.83	1.77	1	0.825	2.69	4	<8
WPSB097C	1090	<100	<10	1150	435	112	1.355	25.5	0.57	0.53	0.11	0.365	11.7	4	<8
WPSB100C	1010	<100	<10	356	153	237	3.625	7.885	1.45	1.39	0.14	0.705	3.69	6	<8
WPSB107C	249	2570	11	301	46	352	5.56	3.595	2.4	1.78	0.045	1.58	1.565	<2	<8
WPSB117C	1570	122	<10	474	141	213	4.32	9.225	1.76	1.75	0.895	0.675	3.46	6	<8
WPSB131C	1160	<100	<10	734	112	71	0.99	25.8	0.42	0.38	0.145	0.15	12.4	<2	<8
WPSB133C	1000	<100	<10	918	314	106	1.16	28.1	0.47	0.4	0.145	0.16	13.5	2	<8
WPSB133X	967	<100	<10	924	312	104	1.175	29	0.49	0.41	0.145	0.16	13.9	2	<8
WPSB134C	828	<100	<10	304	199	385	3.995	10.1	1.91	1.27	0.24	0.655	4.635	5	<8
WPSB136C	807	<100	<10	875	339	88	0.84	30.9	0.51	0.28	0.1	0.18	14.8	3	<8
WPSB136X	758	<100	<10	861	336	88	0.835	29.9	0.5	0.28	0.1	0.18	14.7	4	<8
WPSB137C	451	<100	11	102	61	399	5.705	2.48	2.61	1.32	0.235	1.845	1.1	<2	<8
WPSB139C	732	110	<10	950	209	43	0.45	32.1	0.22	0.16	0.095	0.135	15.6	<2	<8
WPSB145C	574	<100	<10	94	70	324	4.72	2.095	1.93	1.64	0.34	0.66	0.875	<2	<8

Table 2. Analysis of samples from Measured Section B.

Field No.	Ba, ppm, ICP-40	Be, ppm, ICP-40	Cd, ppm, ICP-40	Ce, ppm, ICP-40	Co, ppm, ICP-40	Cu, ppm, ICP-40	Eu, ppm, ICP 40	Ga, ppm, ICP-40	Ho, ppm, ICP-40	La, ppm, ICP 40	Li, ppm, ICP 40	Mn, ppm, ICP-40	Mo, ppm, ICP-40	Nb, ppm, ICP-40	Nd, ppm, ICP-40
WPSB003C	169	<1	79	32	7	23	<2	<4	<4	18	20	339	20	<4	13
WPSB008C	55	<1	191	27	<2	138	<2	<4	<4	130	12	10	5	<4	54
WPSB018C	53	<1	137	19	<2	108	<2	<4	<4	118	10	9	6	<4	45
WPSB018X	52	<1	133	24	<2	105	<2	<4	<4	113	10	7	6	<4	43
WPSB025C	33	<1	183	33	<2	30	<2	<4	<4	119	5	126	4	<4	51
WPSB026C	77	<1	112	31	<2	92	2	<4	4	168	15	19	23	<4	64
WPSB027C	41	<1	235	22	<2	46	<2	<4	<4	42	8	210	10	<4	21
WPSB033C	76	<1	154	19	<2	78	<2	<4	<4	78	8	28	38	<4	32
WPSB038C	55	<1	121	28	<2	24	<2	<4	<4	15	3	165	22	<4	<9
WPSB047C	118	<1	162	46	4	128	3	<4	5	175	14	100	50	<4	88
WPSB059C	121	<1	50	42	<2	97	4	6	<4	166	13	57	22	<4	99
WPSB059X	122	<1	51	39	<2	99	4	13	<4	166	13	60	23	<4	102
WPSB065C	43	<1	11	16	<2	20	<2	<4	<4	10	3	221	9	<4	<9
WPSB070C	200	<1	15	54	<2	107	4	10	<4	147	26	16	33	<4	88
WPSB080C	262	1	6	78	<2	59	2	14	<4	91	19	7	15	<4	64
WPSB084C	158	<1	91	44	<2	73	2	<4	<4	94	13	138	29	<4	57
WPSB087C	161	<1	41	61	<2	159	6	13	7	249	33	18	15	<4	145
WPSB091C	130	1	21	76	<2	74	6	15	8	255	16	<4	15	<4	157
WPSB095C	220	<1	51	54	<2	80	2	9	<4	75	18	83	35	<4	44
WPSB097C	112	2	29	59	<2	98	6	<4	9	281	11	15	17	<4	164
WPSB100C	196	<1	18	47	<2	71	3	6	<4	99	16	27	30	<4	62
WPSB107C	226	<1	36	74	13	44	<2	<4	<4	42	6	2620	60	<4	43
WPSB117C	207	<1	64	45	4	111	2	4	<4	78	26	88	52	<4	47
WPSB131C	89	<1	126	10	<2	94	<2	<4	<4	61	14	17	25	<4	27
WPSB133C	103	<1	70	32	<2	50	3	<4	6	157	10	27	12	<4	77
WPSB133X	106	<1	71	30	<2	50	3	<4	6	161	10	28	12	<4	78
WPSB134C	185	<1	35	60	<2	67	4	4	6	113	16	26	32	<4	77
WPSB136C	90	<1	47	27	<2	48	4	<4	7	199	7	13	18	<4	105
WPSB136X	88	<1	47	39	<2	44	4	<4	7	199	7	13	17	<4	101
WPSB137C	210	<1	28	57	<2	34	<2	<4	<4	41	14	19	26	<4	40
WPSB139C	98	<1	48	18	<2	39	2	<4	<4	121	6	92	10	<4	55
WPSB145C	232	1	16	54	<2	40	<2	8	<4	45	23	47	18	<4	38

Table 2. Analysis of samples from Measured Section B.

Field No.	Ni, ppm, ICP-40	Pb, ppm, ICP-40	Sc, ppm, ICP-40	Sr, ppm, ICP-40	Ta, ppm, ICP-40	Th, ppm, ICP-40	U, ppm, ICP-40	V, ppm, ICP-40	Y, ppm, ICP-40	Yb, ppm, ICP-40	Zn, ppm, ICP-40	eU, ppm, gamma spectrometry
WPSB003C	679	4	6	60	<40	<6	<100	830	21	3	3480	16
WPSB008C	76	19	2	745	<40	<6	277	2200	194	9	1250	147
WPSB018C	63	15	2	728	<40	<6	226	2160	173	9	1110	135
WPSB018X	62	15	3	715	<40	<6	219	2060	166	8	1090	
WPSB025C	71	6	3	341	<40	<6	<100	793	162	7	730	75
WPSB026C	104	12	<2	638	<40	<6	<100	654	222	10	1250	53
WPSB027C	141	10	2	207	<40	<6	<100	862	60	3	1660	84
WPSB033C	152	12	3	754	<40	<6	163	1740	125	6	4090	94
WPSB038C	118	4	2	159	<40	<6	<100	669	19	1	1950	30
WPSB047C	255	14	3	723	<40	<6	130	1690	263	12	3040	77
WPSB059C	195	6	3	770	<40	<6	<100	508	221	10	884	38
WPSB059X	194	9	4	733	<40	<6	<100	511	221	10	887	
WPSB065C	61	<4	3	187	<40	<6	<100	166	11	1	320	13
WPSB070C	275	8	10	755	<40	<6	<100	308	180	9	1060	20
WPSB080C	114	9	11	433	<40	10	<100	259	106	7	284	14
WPSB084C	239	5	7	517	<40	<6	<100	879	119	7	1990	25
WPSB087C	167	10	6	714	<40	<6	<100	583	326	14	498	31
WPSB091C	83	11	<2	651	<40	<6	<100	294	438	21	271	30
WPSB095C	250	11	8	262	<40	8	<100	517	127	7	1310	25
WPSB097C	199	11	<2	1040	<40	<6	<100	219	452	18	877	21
WPSB100C	174	<4	8	340	<40	7	<100	227	172	9	804	21
WPSB107C	631	7	9	315	<40	9	<100	396	53	5	1770	15
WPSB117C	285	11	8	418	<40	<6	<100	403	144	8	1700	33
WPSB131C	113	12	3	671	<40	<6	169	2000	121	7	992	105
WPSB133C	103	11	3	784	<40	<6	115	630	312	15	844	114
WPSB133X	103	10	4	801	<40	<6	126	624	320	15	845	
WPSB134C	157	11	10	262	<40	<6	<100	656	205	12	1200	97
WPSB136C	66	10	6	810	<40	<6	142	356	361	17	585	80
WPSB136X	65	10	5	790	<40	<6	118	352	361	17	580	
WPSB137C	190	11	9	86	<40	11	<100	550	60	4	1360	85
WPSB139C	61	8	2	898	<40	<6	116	382	226	10	444	82
WPSB145C	198	9	8	86	<40	8	<100	169	70	5	878	26

Table 3. Analysis of Standard Reference Materials.

Standard Reference	Lab No.	As, ppm, Hyd.	Hg, ppm, CVAA	Sb, ppm, Hyd.	Se, ppm, Hyd.	Te, ppm, FAA	Tl, ppm, ICP-MS	Al, %, ICP-16	Ca, %, ICP-16	Fe, %, ICP-16	K, %, ICP 16	Mg, %, ICP-16	Na, %, ICP-16	P, %, ICP 16	Si, %, ICP-16	Ti, %, ICP-16	Ba, ppm, ICP-16	Cr, ppm, ICP-16	Mn, ppm, ICP-16	Nb, ppm, ICP-16	Sr, ppm, ICP-16	Y, ppm, ICP-16
Standard Reference SARL																						
analyzed as	C-122921	18.4			1.1	0.4	1.1															
analyzed as	C-122923	18.9			1	0.5	1.2															
analyzed as	C-123589	17.3	0.18		1.1	0.5	1.5	5.69	1.01	2.63	2.77	0.5	1.4	0.07	30.7	0.3	864	114	2140	37	142	53
analyzed as	C-123591	17.2	0.17		1.1	0.4	1.5	5.79	1.04	2.72	2.85	0.51	1.43	0.07	31.6	0.31	879	109	2150	42	143	56
Accepted Value		16.5	.155	5.1	0.9	0.6	1.4	5.79	1.06	2.67	2.98	0.55	1.53	0.09	33.56	0.25	879.2	110	2094	35	158	44
Standard Reference SARM																						
analyzed as	C-122922	36			0.4	0.8	2.8															
analyzed as	C-122924	36.4			0.4	0.8	2.8															
analyzed as	C-123590	40.4	0.1		0.4	0.9	2.9	6.12	0.53	3.15	2.81	0.45	1.12	0.06	31.3	0.35	759	103	5430	39	145	35
analyzed as	C-123592	36.8	0.1		0.4	0.8	2.9	6.09	0.54	3.21	2.79	0.46	1.11	0.07	31.2	0.36	782	177	5520	33	146	32
Accepted Value		37	0.117	5.6	0.33	0.68	2.8	6.09	0.58	3.22	2.92	0.5	1.19	.08	33.53	.35	764	101	5200	31	156	33
StdAFPC																						
	C-123588	7	0.12	1.4	1.2	<0.1	0.5	0.71	34.7	0.83	0.1	0.21	0.38	15.5	2.33	0.12	108	82	268	14	1010	160
	C-122889	6.4	0.12	1.8	1.6	<0.1	0.4	0.7	33.9	0.8	0.11	0.21	0.36	15	2.21	0.11	89	125	274	11	966	153
Accepted Value		7	0.13	3.4	1.4	0.1	0.5	0.67	32.9	0.79	0.12	0.19	0.39	14.6	2.39	0.13	61	61	265	11	983	157

Table 3. Analysis of Standard Reference Materials.

Standard Reference SARL	Zr, ppm, ICP-16	Al, % ICP-40	Ca, ppm, ICP-40	Fe, %, ICP-40	K, %, ICP 40	Mg, %, ICP-40	Na, %, ICP-40	P, %, ICP 40	Ag, ppm, ICP-40	Au, ppm, ICP-40	Ba, ppm, ICP-40	Be, ppm, ICP-40	Cd, ppm, ICP-40	Ce, ppm, ICP-40	Co, ppm, ICP-40	Cu, ppm, ICP-40	Eu, ppm, ICP-40	Ga, ppm, ICP-40	Ho, ppm, ICP-40	La, ppm, ICP-40	Li, ppm, ICP-40	Mn, ppm, ICP 40
analyzed as		5.8	1.03	2.66	3.05	0.515	1.505	0.075	<2	<8	918	4	3	152	6	347	<2	<4	<4	68	24	1960
analyzed as		5.9	1.045	2.77	3.04	0.515	1.565	0.075	<2	<8	923	4	3	149	6	339	<2	<4	<4	69	24	2000
analyzed as	363	6.0	1.035	2.62	3.11	0.54	1.73	0.075	<2	<8	913	4	3	168	5	337	<2	<4	<4	70	27	1950
analyzed as	380	6.0	1.045	2.61	3.09	0.515	1.815	0.07	<2	<8	879	4	3	162	6	308	<2	<4	<4	65	26	1960
Accepted Value	408	5.79	1.06	2.67	2.98	0.55	1.53	0.09	2.56	0.325	879.2	3.244	2.5	150.0	7.5	370	1.5	17	1.9	75	28	2094
Standard Reference SARM																						
analyzed as		6.2	0.555	3.21	3.1	0.475	1.205	0.07	<2	<8	831	3	6	105	10	313	<2	<4	<4	52	25	5070
analyzed as		6.0	0.53	3.09	2.99	0.46	1.15	0.07	<2	<8	818	3	6	108	10	305	<2	<4	<4	50	25	4970
analyzed as	344	6.1	0.54	3.02	3.05	0.48	1.175	0.07	2	<8	801	3	6	128	10	271	<2	<4	<4	53	28	4950
analyzed as	335	6.1	0.56	3.11	3.1	0.48	1.19	0.07	2	<8	797	3	6	122	9	275	<2	<4	<4	51	28	5040
Accepted Value	370	6.09	0.58	3.22	2.92	0.50	1.19	0.08	3.1	0.345	764	2.4	4.76	120	11	320	0.67	20	1.72	61	30	5200
StdAFPC																						
	251	0.66	33.1	0.78	0.11	0.195	0.41	15.2	<2	<8	68	2	12	129	4	17	3	<4	5	86	3	240
	249	0.66	33	0.53	0.12	0.195	0.41	15.1	<2	<8	73	2	11	120	3	16	4	<4	5	92	3	223
Accepted Value	255	0.61	30.8	0.56	0.1	0.201	0.37	16	< 2	<8	65	1.3	9.8	108	3	22	3.75	< 4	4.3	86.8	2.8	230

Table 3. Analysis of Standard Reference Materials.

	Mo, ppm, ICP-40	Nb, ppm, ICP-40	Nd, ppm, ICP-40	Ni, ppm, ICP-40	Pb, ppm, ICP-40	Sc, ppm, ICP-40	Sr, ppm, ICP-40	Ta, ppm, ICP-40	Th, ppm, ICP-40	U, ppm, ICP-40	V, ppm, ICP-40	Y, ppm, ICP-40	Yb, ppm, ICP-40	Zn, ppm, ICP-40	CO2, %, Acid	Crbnt. C, %, Acid	C, %, organic, difference	C, %, total, Comb.	S, %, total, Comb.
Standard Reference SARL																			
analyzed as	15	19	57	53	628	7	136	<40	26	<100	129	38	5	422					
analyzed as	15	25	56	53	630	7	138	<40	27	<100	129	38	5	432					
analyzed as	14	19	59	55	587	7	138	<40	26	<100	130	40	5	439	0.39	0.11	0.96	1.07	0.08
analyzed as	16	21	56	58	610	8	138	<40	23	<100	125	40	5	421	0.39	0.11	0.96	1.07	0.08
Accepted Value	13	35	66	52	578	7.8	158	2.8	19	5.2	140	44	4.6	420	0.40	0.11	0.86	0.97	0.07
Standard Reference SARM																			
analyzed as	16	20	38	46	1070	7	139	<40	23	<100	66	25	3	953					
analyzed as	14	21	37	44	1040	7	133	<40	23	<100	63	23	3	908					
analyzed as	15	28	39	43	1010	7	136	<40	24	<100	65	26	3	908	0.08	0.02	0.29	0.31	0.13
analyzed as	14	32	37	43	1020	7	138	<40	21	<100	65	24	3	927	0.09	0.02	0.28	0.3	0.12
Accepted Value	12	31	51	41	960	8.3	156	1.3	18	2.6	66	33	3.2	888	0.07	0.02	0.28	0.30	0.13
StdAFPC																			
	6	<4	68	15	14	5	933	<40	11	<100	76	170	11	111	3.37	0.92	0.28	1.2	0.34
	6	<4	66	13	15	<2	955	<40	9	103	78	174	11	111	3.36	0.92	0.31	1.23	0.31
Accepted Value	4	< 4	81	13	21	5	887	<40	10	173	71	157	11	91	3.33	0.91	0.2	1.11	0.37