

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

X-Ray Spectrometric Major-Element Analyses of Tephra
Samples from the May 18, 1980 Eruption of Mt. St. Helens--
Samples collected from Washington, Idaho,
and Montana.

By

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Trade names used in this paper are for
descriptive purposes only and do not
constitute endorsement by the U.S. Geological Survey.

Introduction

During the May 18, 1980 explosive eruption of Mt. St. Helens, a plume of tephra rose to more than 15 km above sea level. As winds blew the cloud to the East, a layer of ash was deposited over much of Washington, Idaho, and Montana. The ash was thickest in the vicinity of Mt. St. Helens with a secondary thickening as much as 8 cms centered around Ritzville, Adams Co., Washington.

Geologic interest and concern about the possible effects the ash might have on people, water resources, agriculture, livestock, and the regional economy are prompting a great deal of scientific research. To achieve the timely dissemination of chemical data, a series of open-file reports will act as a repository for periodic releases, of chemical analyses from U.S. Geological Survey Laboratories.

Sample Collection

Twenty-eight samples of volcanic ash were collected along the extent of the fall. Various people, mostly from the U.S. Geological Survey, collected samples from their field areas and forwarded them to the laboratory for analysis so as to determine what effect the constituents of the ash might have on the water resources of their respective regions. As the samples arrived and were organized, efforts were made, (by calling people and asking them to collect specific samples,) to "fill the gaps" in the sampling array.

Table 1 gives the sample localities, date of collection, affiliation of the collector, and--where known--the name of the collector. Those samples that were wetted by rain are marked with an asterisk. Most of the samples listed in table 1 are grab samples which were collected during the chaos of the fall. The principal goal of the first study was to get samples immediately--preferably samples that had not yet been wetted by rain--because a study of the availability of various constituents to ground water, plants, and other biologic systems was of prime importance. At least one additional study currently in progress has been organized to include samples of various stratigraphic horizons in the fallen material. Without the early, rapid collection of grab samples, however, none of the availability studies would have been possible.

Table 1.--NEAR HERE

Table 1.--Collection data for Mt. St. Helens Volcanic Ash Samples

[Asterisk (*) indicates samples wetted by rain]

No.	Sample Locality	Collection date	Source
1.	North Fork Ahtanum Creek, Tampico, Wash.	5/19/80	U.S. Geological Survey
2.	North Fork Ahtanum Creek, Tampico, Wash.	5/22/80	U.S. Geological Survey
3.	South Fork Ahtanum Creek, Tampico, Wash.	5/19/80	U.S. Geological Survey.
4.	South Fork Ahtanum Creek, Tampico, Wash.	5/22/80	U.S. Geological Survey.
5.	Toppenish Creek, Fort Simco, Wash.	5/20/80	U.S. Geological Survey.
6.	North Fork Simcoe Creek, White Swan, Wash.	5/20/80	U.S. Geological Survey.
7.	Tieton, Wash.	5/19/80	R. Kroget.
8.	*Yakima River, Union Gap, Wash.	5/22/80	U.S. Geological Survey.
9.	*Sunnyside, Wash.	5/28/80	U.S. Geological Survey.
10.	Richland, Wash.	5/19/80	W. Silker, Battelle Northwest Laboratories
11.	Royal City, Wash.	5/21/80	U.S. Geological Survey.
12.	Moses Lake, Wash.	5/21/80	B. Hewitt, Water & Power Resources, Columbia Basin Project.

13. Cheney, Wash.	5/19/80	U.S. Geological Survey.
14. Spokane, Wash.	5/20/80	U.S. Geological Survey.
15. Spokane II, Wash.	5/21/80	U.S. Geological Survey.
16. Moscow, Idaho	5/21/80	S. Wood, University of Idaho.
17. Palouse River, Potlatch, Idaho	5/21/80	U.S. Geological Survey.
18. Lapwai Creek, Lapwai, Idaho	5/21/80	U.S. Geological Survey.
19. *Bloom Creek, Bovill, Idaho	5/22/80	U.S. Geological Survey.
20. Clearwater River, Spalding, Idaho	5/21/80	U.S. Geological Survey.
21. Potlatch River, Kendrick, Idaho	5/21/80	U.S. Geological Survey.
22. *Lafour Creek, Cataldo, Idaho	5/23/80	U.S. Geological Survey
23. *East Fork Big Creek, Calder, Idaho	5/23/80	U.S. Geological Survey.
24. *Boulder, Creek, Mullan, Idaho	5/22/80	U.S. Geological Survey.
25. Potomac Valley, near Missoula, Mont.	5/19/80	R. B. Curry, University of Montana

26. Kalispell, Mont.	5/19/80	U.S. Geological Survey.
27. Helena, Mont.	5/19/80	U.S. Geological Survey.
28. Missoula, Mont.	5/19/80	S. Luthy, University of Montana.

[Readers are reminded that the ash was still falling while many of the samples were collected. Collection dates therefore carry some stratigraphic significance.]

Chemical Analysis

Sample Preparation

Because of the fine-grained nature of the ash samples, further comminution did not seem to be necessary and could only have contaminated the samples. A few samples that had been wetted with rain were air dried.

The 0.8-gram portions of the "as-received" samples were weighed into ignited, tared, platinum-gold (95:5) crucibles. The samples were then ignited for 20 minutes in a muffle furnace at 925°C, cooled in a desiccator and reweighed. The weight loss is reported as loss on ignition (LOI), in percent (table 4).

In order to eliminate particle-size effects and to decrease matrix effects, samples were presented to the X-ray spectrometer as a lithium tetraborate glass-disc fusion product. An 8-gram charge of lithium tetraborate was added to each crucible and mixed with the ignited sample. Four drops of concentrated hydrobromic acid were added to the contents of each crucible to serve as a nonwetting agent; this addition prevents the finished disc from sticking to the mold. Seven crucibles with sample, and seven empty molds (Taggart and Wahlberg, 1979) were loaded into an automatic fluxer (Taggart and Wahlberg, 1980) which was then placed in a muffle furnace at 1120°C for 17 minutes. During this time the tilting action of the fluxer homogenizes the molten sample-flux mixture. After the mixing phase of the fusion is completed the crucibles are inverted, thus pouring the fused mixture into the molds. The fluxer is then removed from the muffle furnace and cooled to near room temperature. The hardened glass discs are removed from the molds, labeled, and stored in individual plastic boxes--all without touching the analytical surface of the disc.

X-ray Fluorescence Analysis

The sample discs are analyzed with a Phillips PW1600 wavelength-dispersive simultaneous X-ray spectrometer. The samples are loaded into the instrument, care being taken to avoid touching the analytical surface of the glass disc. Each sample is irradiated by a rhodium target end-window tube operating at 35 kilovolts and 60 milliamps. The spectrometer chamber is kept under a vacuum of less than 0.2 mm of mercury. Table 2 shows the instrument parameters for each element.

Table 2.--NEAR HERE

Each sample is counted for 100 seconds. Because of the superior stability of the PW 1600, use of what is variously known as an updater, monitor pellet, or drift pellet is unnecessary. Experience has shown that the "drift" of the instrument over an 8-hour period is commonly less than the counting statistics of many of the channels involved in "updating" with a monitor pellet. To substantiate that drift has not occurred, a test pellet of known composition is recounted every tenth sample. In the event that drift has occurred since the last time the test pellet was measured, the results for the intervening unknowns are discarded. Surprisingly, samples usually can be run for an 8-hour shift with less than the acceptable cutoff of 0.5 percent drift (1 percent drift for Na due largely to poor counting statistics). When drift does occur, or after a period when the instrument has not been used, the slope of the calibration curves are restandardized and recalculated rather than just "updating" to a single monitor pellet.

Table 2.--Instrument parameters

Element	Line	Crystal	Detector-gas	Window
Na	K _α	semifocused TLAP-----	Flowcounter w. P10--	1 μm polypropylene
Mg	K _α	semifocused TLAP-----	Flowcounter w. P10--	1 μm polypropylene
Al	K _α	semifocused PE-----	Flowcounter w. P10--	1 μm polypropylene
Si	K _α	semifocused PE-----	Flowcounter w. P10--	1 μm polypropylene
P	K _α	semifocused GE-----	Flowcounter w. P10--	1 μm polypropylene
K	K _α	semifocused PE-----	Flowcounter w. P10--	1 μm polypropylene
Ca	K _α	semifocused LiF 200-----	Sealed argon-----	50 μm Beryllium
Ti	K _α	semifocused LiF 200-----	Sealed argon-----	50 μm Beryllium
Mn	K _α	semifocused LiF 200-----	Sealed argon-----	50 μm Beryllium
Fe	K _α	semifocused LiF 200-----	Sealed argon-----	50 μm Beryllium

TLAP----- Thallium hydrogen phthalate;
 PE----- Pentaerythritol tetrakis (hydroxymethyl) methane;
 GE----- Germanium (111);
 LiF----- Lithium Fluoride.
 P10 gas----- 90 percent argon + 10 percent methane.

The instrument is controlled and all calculations are carried out with a dedicated Digital Equipment Corporation (DEC) PDP 11/04 computer. Because of the computer automation of the instrument, a restandardization routine takes only 12 minutes longer than updating (unattended "machine" time), and generally yields better results.

To diminish the effects of blank contribution, flux is homogenized in 15-pound batches by rolling in a large carboy. Batches are numbered and glass blanks are prepared from each batch. Utilizing the DEC PDP 11/04, recalibration of the intercept of the calibration curves with glass blanks eliminates relatively small blank contributions in less than 15 minutes.

Interelement matrix effects are corrected with de Jongh's matrix model (de Jongh, 1973). Alpha influence coefficients for the de Jongh model are calculated from fundamental parameters utilizing the program ALPHAS on an IBM 360/75 computer. Alphas suitable for a 1:10 sample to lithium tetraborate dilution of geologic materials were determined by Lobeek (1976). Extensive tests were conducted to determine the relationship between theoretically determined alphas and experimentally observed interelement effects. Seven elements were selected with a range of characteristic X-ray energies. In all cases the theoretically determined influence coefficients were valid for all of these elements. In addition, the difficulty encountered with count rates on the sodium channel pointed out the advantages of using theoretical alphas.

The method has been tested on international geologic standards from agencies around the world. Table 3 shows the results obtained on a variety of

Table 3.--NEAR HERE

igneous materials on a one sample disc--one analysis basis. Blind duplicates submitted by various investigators indicate high precision.

Table 4 presents the results determined on the Mt. St. Helens ash samples.

Table 4.--NEAR HERE

Table 3.--Analyses of seven igneous rock standards (expressed in percent)

	SiO ₂	Al ₂ O ₃	¹ Fe ₂ O ₃ * MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO
Andesite AGV-1	XRF---- 59.9 Abbey-- 59.72	17.2 17.22	6.88 6.84	5.11 5.00	4.25 4.31	2.99 2.93	1.08 1.05	0.52 0.50	0.08 0.10
Dunite DTS-1	XRF---- 40.6 Abbey-- 40.68	0.18 0.29	49.8 49.83	0.11 0.13	<0.2 0.01	<0.05 0.00	<0.02 0.01	<0.05 0.00	0.11 0.11
Granite G-2	XRF---- 69.9 Abbey-- 69.19	15.6 15.35	2.73 2.67	1.98 1.98	3.94 4.06	4.54 4.52	0.49 0.50	0.13 0.14	0.02 0.04
Grandodiorite GSP-1	XRF---- 67.2 ABBey-- 67.31	15.2 15.19	4.32 4.33	2.04 2.02	2.61 2.80	5.51 5.53	0.66 0.66	0.29 0.28	0.02 0.04
Basalt BRN	XRF---- 38.4 ABBey-- 38.39	10.2 10.25	13.0 12.9	14.0 13.87	2.91 3.07	1.38 1.41	2.70 2.61	1.10 1.05	0.18 0.20
Granite GSN	XRF---- 66.4 Abbey-- 65.98	15.0 14.71	3.73 3.75	2.55 2.51	3.61 3.78	4.69 4.64	0.67 0.68	0.28 0.28	0.04 0.06
Lujavarite NIM-SARM-3-L	XRF---- 52.1 ABBey-- 52.45	13.6 13.59	9.97 9.96	3.18 3.24	8.23 8.30	5.38 5.46	0.48 0.49	0.05 0.06	0.74 0.76

¹Total Fe as Fe₂O₃

Table 4.--Analyses of tephra samples from Mt. St. Helens
 [Values expressed in percent; LOI, loss on ignition;
 Analysts, J. E. Taggart and J. S. Wahlberg]

Sample No.	1	2	3	4	5	6	7
SiO ₂	58.6	59.0	59.3	59.5	61.1	59.7	59.9
Al ₂ O ₃	18.5	18.6	18.7	18.5	17.4	18.7	18.0
Total Fe as FeO	5.75	5.75	5.42	5.27	5.31	5.10	5.62
MgO	3.58	3.56	3.31	3.13	2.87	2.99	3.22
CaO	6.68	6.72	6.59	6.47	5.81	6.53	6.22
Na ₂ O	4.29	4.31	4.31	4.32	4.33	4.40	4.29
K ₂ O	0.86	0.88	0.91	0.95	1.22	0.95	1.01
TiO ₂	0.79	0.80	0.75	0.73	0.82	0.73	0.79
P ₂ O ₅	0.17	0.17	0.16	0.16	0.18	0.15	0.16
MnO	0.10	0.10	0.09	0.09	0.09	0.09	0.09
LOI	0.28	0.39	0.40	0.52	0.76	0.35	0.44
Total	99.60	100.28	99.94	99.64	99.89	99.69	99.74

Sample No.	8	9	10	11	12	13	14
SiO ₂	59.8	59.5	60.5	64.0	64.8	66.2	65.8
Al ₂ O ₃	17.8	17.7	17.4	16.6	16.5	16.2	16.2
Total Fe as FeO	5.86	6.08	5.31	4.66	4.52	3.61	3.56
MgO	3.31	3.32	2.64	1.99	1.84	1.39	1.44
CaO	6.18	6.28	5.72	4.72	4.61	4.18	4.17
Na ₂ O	4.26	4.28	4.34	4.47	4.51	4.69	4.62
K ₂ O	1.02	1.07	1.23	1.44	1.48	1.63	1.63
TiO ₂	0.83	0.97	0.86	0.73	0.72	0.56	0.56
P ₂ O ₅	0.18	0.18	0.18	0.15	0.16	0.16	0.15
MnO	0.10	0.10	0.08	0.07	0.06	0.05	0.05
LOI	0.46	0.30	0.55	0.54	0.52	0.75	0.69
Total	99.80	99.78	98.81	99.37	99.72	99.42	98.87

Sample No.	15	16	17	18	19	20	21
SiO ₂		66.8	67.4	66.5	66.7	65.9	65.3
Al ₂ O ₃		16.0	16.0	15.9	16.2	16.1	16.3
Total Fe as FeO		3.31	3.28	3.36	3.42	3.50	3.64
MgO		1.30	1.24	1.32	1.35	1.43	1.57
CaO		3.93	3.84	3.95	4.05	4.14	4.37
Na ₂ O		4.62	4.68	4.61	4.67	4.57	4.60
K ₂ O		1.69	1.72	1.70	1.67	1.64	1.60
TiO ₂		0.54	0.53	0.54	0.56	0.58	0.59
P ₂ O ₅		0.14	0.14	0.15	0.15	0.16	0.16
MnO		0.05	0.05	0.05	0.05	0.05	0.05
LOI		0.59	0.56	1.04	0.61	0.82	0.80
Total		98.97	99.44	99.12	99.43	98.89	98.98

Sample No.	22	23	24	25	26	27	28
SiO ₂	67.4	67.2	67.4	65.6	65.5	65.2	63.7
Al ₂ O ₃	15.9	16.0	16.0	16.1	16.0	16.4	16.8
Total Fe as FeO	3.23	3.28	3.21	3.51	3.55	3.64	4.02
MgO	1.20	1.26	1.22	1.49	1.48	1.59	1.87
CaO	3.84	3.90	3.86	4.22	4.23	4.48	4.95
Na ₂ O	4.63	4.72	4.74	4.55	4.44	4.46	4.48
K ₂ O	1.71	1.71	1.72	1.62	1.62	1.60	1.49
TiO ₂	0.52	0.52	0.51	0.56	0.57	0.58	0.65
P ₂ O ₅	0.15	0.14	0.14	0.16	0.17	0.16	0.18
MnO	0.05	0.05	0.05	0.05	0.05	0.05	0.06
LOI	0.54	0.69	0.60	0.88	1.09	0.95	0.88
Total	99.17	99.47	99.45	98.74	98.70	99.11	99.08

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