showed low cytotoxicity to alveolar macrophages, which are an important part of the lungs' natural clearance mechanism. Since in vitro cytotoxicity and fibrogenicity of minerals appear to be correlated, it seems unlikely that the ash is highly fibrogenic.

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18 June 1980

Composition of the Mount St. Helens Ashfall in the Moscow-Pullman Area on 18 May 1980

Abstract. *Mineralogical and chemical analyses of the ashfall from Mount St. Helens on 18 May 1980 indicate that there were two distinct ashes. The early dark ash is composed principally of plagioclase and lithic fragments of plagioclase and glass with titanium-rich magnetite and some basaltic hornblende and orthopyroxene. The later pale ash, four-fifths by weight of the whole fallout, is 80 percent glass with plagioclase as the principal crystalline phase. Quartz and potassium feldspar are rare to absent in both ashes. Chemical analyses of nine ash fractions and of the glass in each type emphasize the differences between the two ash types and their chemical homogeneity.*

Moscow, Idaho, and Pullman, Washington, straddle the Idaho-Washington border about 400 km east-northeast of Mount St. Helens. Three explosions were heard in Pullman at 9:03 a.m. (P.D.T.) on Sunday, 18 May 1980, some 31 minutes after the eruption of Mount St. Helens is reported to have occurred.

Table 1. Percentages (by weight) of the major oxides in Mount St. Helens ash, 18 May 1980; column A, average of three XRF analyses of dark ash (samples HVA-1, HVA-2, and MSHA-1) (see Fig. 1); column B, average of two XRF analyses of mixed dark and pale ash (samples HVA-3 and MSHA-2); column C, average of four XRF analyses of pale ash (samples HVA-4, HVA-5, MSHA-3, and MSHA-4); column D, partial microprobe analysis of glass particles in the dark ash; and column E, microprobe analysis of the colorless glass particles in the pale ash (0.1 percent chlorine and no lead or sulfur were detected in this glass); N.A., not analyzed; N.D., not detected. Parentheses in column C indicate standard deviations.

Oxide	A	B	C	D	E
SiO_2	64.21	66.98	68.20 (0.19)	76.15	72.20
Al_2O_3	17.20	16.41	16.15 (0.10)	13.50	15.40
TiO_2	0.70	0.59	0.53 (0.01)	N.A.	0.45
Fe_2O_3*	2.21	1.84	1.66 (0.03)	1.43†	2.51†
FeO*	2.53	2.11	1.90 (0.03)		
MnO	0.07	0.06	0.05 (0.005)	N.A.	0.04
CaO	5.07	4.12	3.70 (0.04)	1.22	2.48
MgO	1.85	1.41	1.22 (0.03)	N.A.	0.98
K_2O	1.52	1.75	1.85 (0.02)	3.02	1.99
Na_2O	4.47	4.59	4.57 (0.09)	4.05	3.88
P_2O_5	0.19	0.17	0.15 (0.00)	N.A.	N.D.

*Total iron assigned as 44 percent Fe_2O_3 and 56 percent FeO. †Total iron shown as FeO.

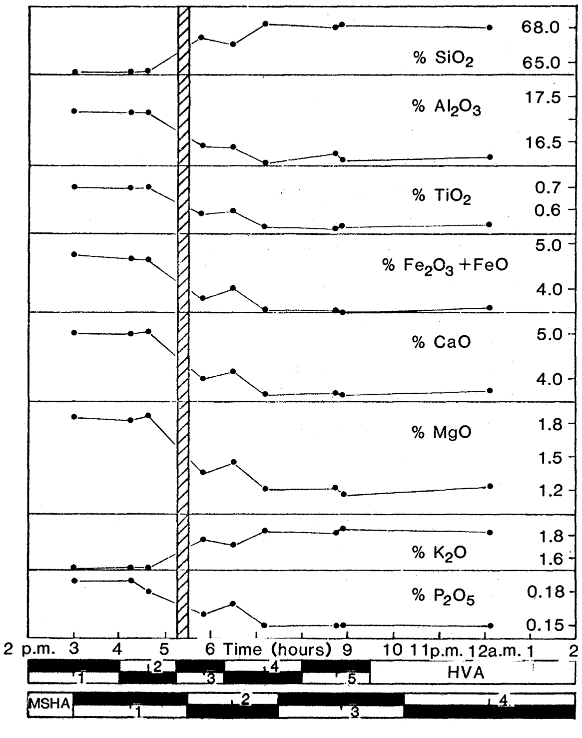

Fig. 1. Change in the oxide percentages of major elements in the ash plotted against time on 18 May 1980. The period over which samples were collected is shown at the base of the figure. HVA samples were collected 5 km north of Pullman (SW¼, SE¼, section 18, T15N, R45E); MSHA samples were collected on the Washington State University campus (SW¼, NE½, section 5, T14N, R45E). The ruled vertical zone indicates the period of abrupt change in the color and composition of the ash.

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The ashfall, which was preceded by a massive dark cloud, began about 2:00 p.m. and continued until about 2:00 a.m. the next morning. The mass/area ratio of the ash that fell on Moscow was 2.29 kg/m^2, and that of the ash that fell on Pullman was 2.14 kg/m^2. The ash samples from Moscow that we examined were untreated, whereas ash samples from Pullman were dried at 100°C before being analyzed. Because of settling, measurements of ash thickness differ, depending on when they were made. Initial thicknesses have ranged from about 1.00 cm in Moscow to over 1.25 cm just north of Pullman. Although precise values are not yet available, the initial thickness increased northward to a maximum of about 7.00 cm along an east-northeast axis about halfway between Pullman and Spokane, Washington.

The first ash to fall was visibly darker than the later ash, and observers noted that the change occurred abruptly between 5:15 and 5:30 p.m. (Fig. 1). The mass of the pale ash is between two and four times that of the dark ash. The two ashes have similar particle sizes, with most particles ranging between 10 and 100 μm. But smaller fragments are present; air pollution data (*1*) indicate significant quantities of particles between 0.1 and 1.0 μm in the air up to a week after the main ashfall.

The dark ash is composed predominantly of plagioclase crystals (strongly zoned around 50 mole percent anorthite), glass which varies from colorless to dark brown and which usually includes abundant microlites and composite lithic fragments of plagioclase and glass. Crystals of titanium-rich magnetite make up 5 to 10 percent (by volume), and crystals of basaltic hornblende form about 1 percent by volume. Occasional crystals of orthopyroxene are present.

The pale ash is composed of about 80 percent clear glass, typically vesicular with ragged outlines and largely free of microlites. Plagioclase is the principal crystalline phase in this ash as well, but smaller crystals of iron oxide and hornblende are present. Neither quartz nor potassium feldspar have been observed under the optical microscope, but quartz or cristobalite and possibly very small grains of biotite have been detected with the electron microprobe.

Nine ash samples have been analyzed for major elements by x-ray fluorescence (XRF) methods (*2*). The exact location and accumulation period of each sample is recorded with the chemical composition in Fig. 1. The analyses are strongly bimodal. The first three samples collected (dark ash) have virtually identical compositions (Table 1, column A); the next two samples were collected over the period of abrupt change, and they are mixtures of the two ash types (Table 1, column B); the last four samples collected (pale ash) are virtually identical, and their average composition is recorded in Table 1, column C, together with the "standard deviation" of the four measurements for each oxide. Columns D and E of Table 1 give the compositions of the glass in the dark and pale ashes, respectively, analyzed on an electron microprobe (*3*).

The bimodal nature of the ash implies two separate source materials, probably associated with separate explosions. This conclusion is strengthened by the quite distinct glass compositions in the two ashes. The dark ash in bulk appears to represent silicic andesite, with abundant plagioclase both as phenocrysts and as groundmass, and may be derived from a part of the old volcanic cone dispersed in the first explosion. The pale ash in bulk has the composition of rhyodacite and may represent new magma. If so, it was mainly liquid when it erupted explosively with only minor amounts of crystalline plagioclase and possibly iron oxide and hornblende.

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Gravitropism in Plant Stems May Require Ethylene

Abstract. *Two inhibitors of ethylene synthesis in plants (cobaltous ion and aminoethoxyvinylglycine) and two inhibitors of ethylene action (silver ion and carbon dioxide) significantly delay the gravitropic response (upward bending) of mature dicot stems laid on their sides. This evidence suggests that ethylene may be required in the gravitropic response of shoots.*

Our evidence that ethylene plays a role in stem gravitropism (an upward bending of stems laid on their sides) could lead to resolution of some of the objections presently being raised against the Cholodny-Went theory, a model of gravitropic mechanism formulated in 1926 (*1*). Statoliths (now thought to be amyloplasts, each containing two or more starch grains) fall toward the bottom of gravity-sensitive cells called statocytes; this is gravity perception. According to the model, this settling leads to a redistribution of the plant growth hormone auxin (indole-3-acetic acid) toward the bottom of the statocytes and ultimately toward the cells on the lower side of a stem turned on its side, causing increased growth of these lower cells and thus an upward bending of the stem; this is the expression of the perceived gravity stimulus (*2*). Other plant-stem growth hormones, the gibberellins, have also been implicated (*3*), and it has been recognized that stems will bend even when leaves or apical meristems, or both, have been removed (*4*).

In 1976, Digby and Firn (*5*) reviewed several papers on plant gravitropism and concluded that the Cholodny-Went model did not adequately agree with the facts. For one thing, evidence seems to suggest that stem bending occurs before sufficient time has elapsed for movement and action of auxin, and gibberellins require even more time than auxins to induce cell elongation (*6*). They also concluded that too little auxin accumulates on the lower side to cause the observed unequal growth. The observed differences in the concentration of auxins and gibberellins on the upper and lower sides of gravitropically responding stems could be consequences of the bending rather than its cause.

There are a few hints in the literature that ethylene might be required in gravitropism. It has long been known, for example, that relatively high concentrations of ethylene can redirect the gravitropic response of shoots so that they grow horizontally rather than vertically (*7*). Chadwick and Burg (*8*) reported that ethylene, produced by treatment with low concentrations of indole-3-acetic acid, was responsible for inhibition of root growth and proposed that ethylene was essential for gravitropic curvature in roots. They showed that CO_2, a widely used inhibitor of ethylene action in plants (*9*), retarded gravitropic response of pea and lima bean roots but not pea

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