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GAS ANALYSES OF FUMAROLES FROM MT. HOOD, OREGON

Nancy L. Nehring[1], Harold A. Wollenberg[2], and David A. Johnston[1]

[1]U.S. Geological Survey, Menlo Park, California

[2]Lawrence Berkeley Laboratory, University of California

Berkeley, California

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INTRODUCTION

The eruptive activity of Mt. St. Helens beginning in March, 1980, coupled with earthquake activity on Mt. Hood in early July, has generated increased interest in the fumaroles near the summit of Mt. Hood. These fumaroles are associated with Crater Rock, a hornblende dacite plug, extruded 200 to 300 years ago (Crandell, 1980). A major eruption in about 1700 and lesser eruptions in 1805, 1859, and 1865 (Harris, 1976) were centered near Crater Rock. It is likely that future eruptions will occur in this area. Changes in the surficial characteristics of the fumaroles or changes in the composition of the gas emitted by the fumaroles could precede an eruption by a sufficient length of time to help predict the eruption.

In 1935, K. N. Phillips and G. R. Collins collected and analyzed the first samples of gases from the fumaroles (Phillips, 1936). F. D. Ayres and A. E. Creswell (1951) collected and analyzed gas samples from orifices they considered to be equivalent to those sampled by Phillips and Collins, and these (or orifices in the same area) were re-sampled in 1977 and 1978. Results of the early samplings and those of 1977 were summarized by Wollenberg and others (1979); the results of the 1978 sampling are presented here for the first time.

FUMAROLE LOCATIONS AND DESCRIPTIONS

Fumarolic activity on Mt. Hood is limited to the area around Crater Rock, on the south flank of the volcano, at about 3,000 meters elevation (Fig. 1). The fumaroles are roughly divided by location into four groups (Phillips and Collins, 1935):

(1) Crater Rock near the north ridge--No sublimates were present in 1935 or 1951. Temperatures for two vents were slightly below boiling, 71°C (160°F) and 86°C (187°F);

(2) Hot Rocks--the area west of Crater Rock, with several small but active vents. A temperature of 91°C (196°F), above boiling for the elevation, was measured in 1951;

(3) the Kitchen or Devil's Kitchen--the area just east of Crater Rock. This is a highly acid altered area with a crust of yellow, white, and greenish sublimates over muddy black ground. The fumaroles are 89°C (193°F), boiling temperature for the elevation;

(4) base of Steel Cliff--a fumarole issuing with considerable force from under a sulfur covered rock dominates the area. The temperature of this vent is also 89°C (193°F).

Approximate locations of the 1977 and 1978 samples are shown in figure 1. Because vents within the four groups are quite similar, it was impossible to resample exact locations, with the exception of the fumarole at the base of Steel Cliff. A sample from a fumarole on the ridge just west of Devil's Kitchen, in an area of little activity, was collected in 1978. (The Steel Cliff fumarole was not sampled in 1978 because of the danger of rock falls.)

METHODS

The methods for collection and analysis of the 1935 and 1951 samples are outlined by Ayres and Creswell (1951). Gases were bubbled through barium hydroxide solution which condensed the steam and absorbed the carbon dioxide and hydrogen sulfide. The remainder of each gas was collected in a glass bulb. The acid gases, carbon dioxide and total sulfur as hydrogen sulfide, were determined by absorption and titration, respectively. The remaining gas species were determined by the Orsat method.

The 1977 and 1978 samples were collected by inserting either stainless steel or teflon tubing into the vent and collecting gas into an evacuated bottle containing 4 N sodium hydroxide. A short piece of tygon tubing was used to connect the stainless steel or teflon tubing to the gas bottle. The acid gases, carbon dioxide and total sulfur as hydrogen sulfide, were determined by gravimetric methods on the sodium hydroxide solution. Other gas species were determined by gas chromatography.

GAS ANALYSES

Analyses for the major gas constituents are reported in Table 1. Analyses from Phillips (1936) and Ayres and Creswell (1951) are included for comparison with the 1977 and 1978 analyses. All analyses are presented on a dry weight basis because condensation of the water vapor occurs in the collection train and may run back into the fumarole if collecting is not done carefully and under ideal circumstances. The amount of water vapor is generally controlled by the temperature of the fumarole and changes in the water vapor content can be monitoried more accurately with a thermometer. Elimination of water vapor from the sum of gas species allows changes in the concentrations of other gases, which may accompany changes in the internal plumbing of the volcano, to be seen more readily. The 1977 gas analyses previously reported in Wollenberg and others (1979) have been revised in this report to show carbon dioxide values resulting from improvement in the method of analysis.

Semiquantitative hydrocarbon analyses in ppm (mole) were done for two of the 1978 samples.

Gas	Devil's Kitchen	Crater Rock
methane	55	3
ethene	0.14	0.07
ethane	trace	0
propene	0.12	0.06
propane	trace	trace
n-butane	0.27	0.69
1-penteneµ	0.12	0.16
n-pentane	trace	0.05

DISCUSSION

The gas compositions of the fumaroles on Mt. Hood appear to have been relatively constant over a forty-year timespan from 1935-1978. The only notable difference is a decrease in the methane concentrations between 1951 and 1977. At least three explanations for this decrease are possible (1) analytical problems, (2) organic matter covered by previous eruptions has been entirely decomposed, or (3) the gas source has changed. Analytical problems can probably be ruled out because there is excellent agreement in other geothermal systems between analyses done by the present method and analyses done by methods similar to those used in the early Mt. Hood work. Total decomposition of buried organic matter, possibly coupled with cooling of a magma body, may account for the decreased methane. A decrease in the methane of fumarole D, Steel Cliff, from 0.085 (1935) to 0.038 (1951) to <0.005 (1977) would support this argument. The ratio of methane to other hydrocarbon gases is low, suggesting a relatively large magmatic component in the Mt. Hood fumarole gases (Nehring and Truesdell, 1978). It is possible that the decrease in methane with time indicates a larger magmatic contribution to the gases and higher temperatures. However, because of the lack of data applicable to this problem, the significance of the decrease in methane is not known.

Changes in nitrogen and hydrogen sulfide are believed to be due to air contamination near the surface or during collection and not to represent significant changes in the gas composition. Hydrogen sulfide and oxygen react readily and will do so until one is consumed, leading to an inverse correlation of nitrogen and hydrogen sulfide.

Table 1. Analyses of the major constitutents (other than water vapor) of Mt. Hood fumarole gases--mole percent. n.d. indicates not determined.

Date	Temp °C(°F)	CO_2	Total S as H_2S	H_2	Inert gases[1] He	Ar	N_2	O_2	CH_4[2]
Base of Steel Cliff									
10/6/35	89(193)	86.9	2.92	0.25	0.11		8.99	0.85	0.085
5/15/51	89(193)	86.8	10.7	0.27	0.1		1.94	0.22	0.038
5/15/51	89(193)	86.9	10.5	0.24	0.2		2.04	0.25	0.033
7/21/77	91	91.5	4.02	0.51	0.00081	0.021	3.87	0	0
Devil's Kitchen									
10/6/35	89(193)	93.8	1.77	trace	0.05		4.21	0.13	n.d.
5/15/51	89(193)	89.9	4.11	3.87	0.3		0.17	0.16	0.040
5/15/51	89(193)	89.3	4.30	4.09	0.3		1.85	0.16	0.059
7/21/77	88	91.9	0.16	0.0062	0	0.081	5.61	1.26	0
10/4/78	--	94.4	3.90	1.22	0	0.0018	0.46	0	0
10/4/78	--	93.2	3.67	2.22	0	0.0027	0.87	0	0
Hot Rocks									
5/15/51	91(196)	90.9	2.26	4.02	as N_2		2.46	0.34	0.055
Crater Rock									
10/6/35	71(160)	0.69	0	0.58	as N_2		79.1	19.7	n.d.
5/15/51	86(187)	58.4	0	trace	0.44		32.9	8.32	0
7/21/77	90	96.7	1.23	1.22	0.025	0.0077	0.95	0.0082	0
10/4/78	--	92.7	3.69	2.76	0	0	0.89	0	0
10/4/78	--	93.3	2.63	3.21	0	trace	1.02	0	0
Ridge west of Devil's Kitchen									
10/4/78	--	6.3	0	0	0	0.084	70.5	17.0	0

1/ Inert gases reported as a group for 1935 and 1951 samples, the major components of which are Ar and He.

2/ Reported as "other combustibles as CH_4" in 1935 and 1951.

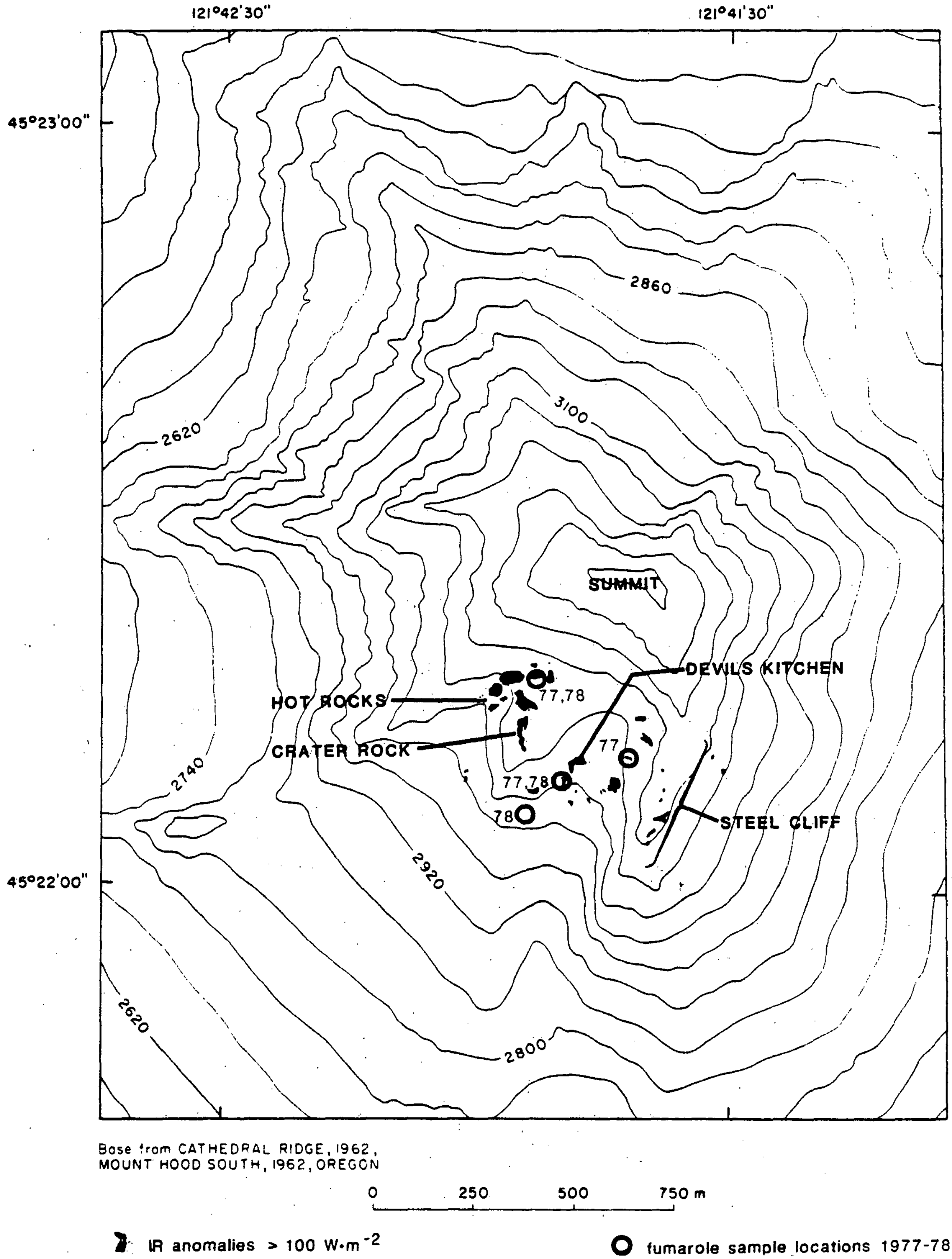

Figure 1. Map showing location of fumarole areas and 1977-78 sample locations. Base map and IR anomalies (Aug. 1977) used to depict extent of thermal area are from Friedman and others, 1981.

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