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ACID AND CONDENSABLE CONSTITUENTS IN FUMAROLIC GASES OF USU (JAPAN) AND MOUNT ST. HELENS (U.S.A.)

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ABSTRACT. — A short trip to volcanoes Usu and Mount St. Helens gave the opportunity of collecting samples from the fumaroles inside the active craters, by means of extremely simple and light operating devices. The magmatic gases, at temperatures of 512 and 540° C respectively, have been both absorbed in alkaline solution and condensed at about 70° C.

The analytical results for most of major constituents and several minor species are given.

The similar chemical picture displayed by the investigated manifestations seems to be ascribed to the similar type of volcanism and probably also to the similar stage of activity.

With reference to the latter point, no information can obviously arise from a single observation, while a systematic periodical survey of the compositional trend of the fumarolic gases can give an idea of the possible evolution of the magmatic activity.

The comparison of the present results with the available information from previous investigations seems to point out a declining magmatic activity, but the lack of a more considerable set of data prevents any further serious consideration.

RIASSUNTO. — Una breve visita ai vulcani Usu e Mount S. Helens ha dato l'opportunità di raccogliere campioni dalle fumarole ubicate all'interno dei crateri attivi, per mezzo di apparecchiature assai semplici e leggere. I gas magmatici, a temperature di 512 e 540° C rispettivamente, sono stati sia assorbiti in soluzione alcalina sia condensati a circa 70° C.

Sono riportati i risultati analitici per la maggior parte dei costituenti fondamentali e per diverse specie minori.

Il quadro chimico simile per le due manifestazioni studiate sembra da attribuire allo stesso tipo di vulcanismo e probabilmente anche al simile stadio di attività.

Una osservazione singola non può fornire molte informazioni, ma il controllo sistematico della composizione della emissione gassosa può dare un'idea dell'evoluzione dell'attività.

Il confronto dei risultati ottenuti con quelli disponibili relativi ad osservazioni precedenti sembra indicare un declino nell'attività magmatica, ma la mancanza di una serie di osservazioni più consistente impedisce ogni ulteriore seria considerazione.

The volcano Usu is located in the island of Hokkaido, northern Japan, at the margin of the Toya caldera; it remained in a dormant state during thousands of years and started again its activity in 1663. After the first rhyolitic pumice eruption, at intervals of 30-50 years dacitic magma extrusions occurred, with occasional « nuée ardente » phenomena. The lava dome Showa-Shinzan was produced in 1943-45, then a new cycle began in august 1977 with pumice emissions, phreatic and phreatomagmatic eruptions (NIIDA et al., 1980). At present a strong persistent fumarolic activity can be observed.

Mount St. Helens, in the Cascade Range, western United States, erupted with violence on May 18, 1980, after a repose of 123 years. The initial lateral blast, which is responsible for the total destruction of a vast area, was followed by the extrusion of a dacitic dome; since then at intervals new domes grew up, along with explosive phenomena of varying intensity (CHRISTIANSEN and PETERSON, 1981).

In summer 1981 a short trip to these volcanoes gave the opportunity of investigating the fumaroles inside the active craters.

The fumarole « I » was considered at Usu (MATSUO, oral communication), while at

TABLE 1

Chemical composition of the sample collected at the «I» fumarole of Usu volcano, on 29 august 1981

Temperature 512 °C

Constituent	weight %	volume %	volume % dry gases
H_2O	94.3	97.5	
CO_2	4.70	1.98	80.9
H_2S	0.50	0.27	11.1
SO_2	0.16	0.05	1.9
HCl	0.25	0.13	5.1
HF	0.02	0.02	0.6
B	0.0022	0.0037	0.15
Br	0.0017	0.0004	0.02
NH_4	0.00023	0.00020	0.01
Zn	0.0000042		
Cd	0.0000080		
Pb	0.0000062		
Cu	0.0000012		

Mount St. Helens the attention was paid to the gases escaping from a crack at the base of the central dome.

The magmatic gases, conveyed through a titanium tube, have been both condensed and absorbed in KOH solution, following the procedure suggested by PICCARDI (1980).

Since the operator was alone in the field, it was not possible to carry out a complete set of samplings, and non condensable gases have been neglected.

TABLE 2

Chemical composition of the sample collected from a crack inside of the crater of Mount St. Helens, on 16 september 1981

Temperature 540 °C

Constituent	weight %	volume %	volume % dry gases
H_2O	92.0	96.5	
CO_2	7.0	3.0	85.7
H_2S	0.43	0.24	6.8
SO_2	0.23	0.07	2.0
HCl	0.26	0.13	3.7
HF	0.047	0.04	1.1
B	0.0067	0.012	0.33
Br	0.0036	0.0008	0.02
NH_4	0.0003	0.0003	0.008
Zn	0.0000051		
Cd	0.0000037		
Pb	0.0000580		
Cu	0.0000005		

It has been possible, however, to obtain correct information about all the important components of gaseous emissions, among which hydrogen only remained out of consideration.

The analytical results provided by the procedures described in MARTINI et al. (1981) for major constituents and in PICCARDI et al. (1979) for heavy metals, are reported in tables 1 and 2.

On the basis of single analyses it is possible to receive only a general idea on the compositional characters of the investigated manifestations, which are located on the opposite sides of Pacific Ocean, but nonetheless the remarkable similarity in the chemical picture seems to allow some further consideration.

TABLE 3

Variation in time of specific molar ratios and temperature at « I » fumarole of Usu volcano; data for Mount St. Helens are reported for comparison

	USU		MT. ST.HELENS
	1979	1981	1981
SO_2+H_2S / CO_2	0.33	0.16	0.10
SO_2+H_2S /HCl	6.30	2.46	2.38
HF / HCl	0.39	0.15	0.03
Temp. °C	607	512	540

By the comparison of the present data for Usu with previous results (MATSUO, 1980) we can observe along with a lowering in temperature of about 100° C a significant decrease in sulphur species, while substantially constant values are displayed by the high concentrations of water and the low contents in carbon dioxide. This appears better defined if we take into account the ratios which are normally considered as indicators of evolution in fumarolic activity (MUELLER, 1970; GIGGENBACH, 1975; MENYAILOV, 1975).

By the table 3 it is easy to verify that a decrease in the values of those ratios occurred at the same time of a fading down of the apparent magmatic activity, so that the only evident differences arising from

this comparison provide an empirical indication of a declining magmatic stage.

It is not possible to derive any information of this kind for Mount St. Helens, because the data available for comparison (CASADEVALL and GREENLAND, 1981; EVANS et al., 1981) pertain to samples collected in the first months after the eruption of May 18, for which the differences in the field and laboratory procedures can represent a difficulty for a correct crosscheck.

The strong similarity in the chemical composition of the gaseous emissions of Usu and Mount St. Helens, however, can be explained by the similarity in the type of volcanism and of magma composition, but could also be considered a hint of a similarity in magmatic stage. That is, comparable evolution of volcanic activity could produce similar ratios of chemical constituents in the gaseous phases at a given magmatic stage.

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