

# **Prediction of volcanic eruption by measuring the chemical composition and amounts of gases.**

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Mt. Asama is located at the center part of Japan's main island and is well known as an active volcano which frequently emits andesitic bombs and lavas. The height of this mountain is about 2660 m above sea level. The studies of prediction of eruption of this mountain by measuring physical properties of volcanoes such as topographical change, volcanic tremor and earth current etc. have been done by geophysicists, especially by Dr. Minakami of Tokyo University and Mr. Sekiya of the Karuizawa Branch Station of Meteorological Observatory. Many excellent results were reported by these investigators.

Since it is clear that volcanic eruptions are caused by the increasing gaseous pressure, the study of volatile matters from magma reservoirs is very important. From a geochemical stand point, Noguchi, one of the authors, has precisely studied the variation of chemical composition of almost all spring waters and gases of Mt Asama and neighbouring area since 1933, and has found that the change of chemical composition of spring water and gases of Mt. Asama had almost no relationship with volcanic activity of the mountain except that inside the active crater. There are fumaroles at the inner wall of the second somma, Maekakeyama, emitting a steam and small quantity of carbon dioxide. The orifice temperature of these fumarole gases were about 44° C. The temperature and chemical composition of these fumarole gases were observed by Noguchi at 1:00 p. m. of July 22nd, 1936, that is, roughly 8 hours before the great eruption which occurred at 9:24 p. m. on the same day. The results of these observations showed that the values obtained were almost the same as when Mt. Asama was dormant.

As for the recent activity of Mt. Asama, on October 11th, 1958, volcanic ashes were emitted from the active crater for the first time after three years of dormancy. On the 19th, 27th, and 29th of October and 1st and 6th of November, ashes were again emitted and

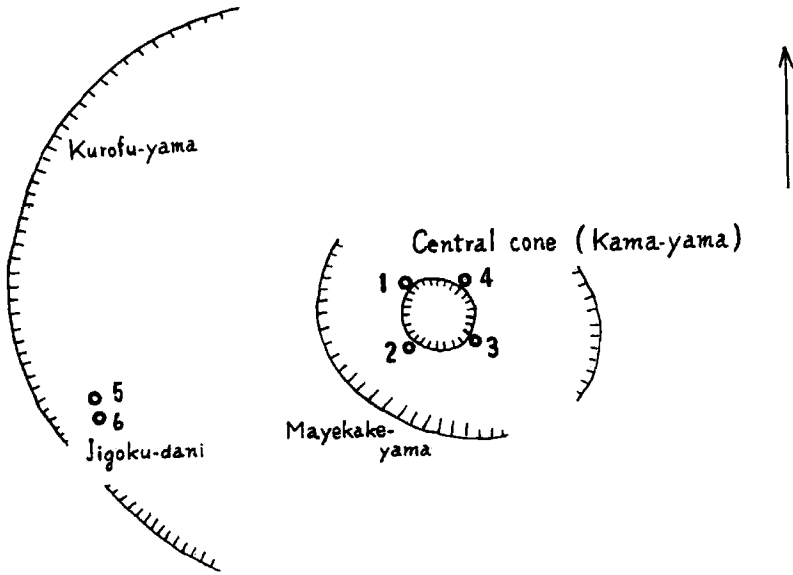


Fig. 1 - Crater of Mt. Asama. The numbers 1, 2, 3, 4, 5 and 6 indicate the positions where variations of gases were observed.

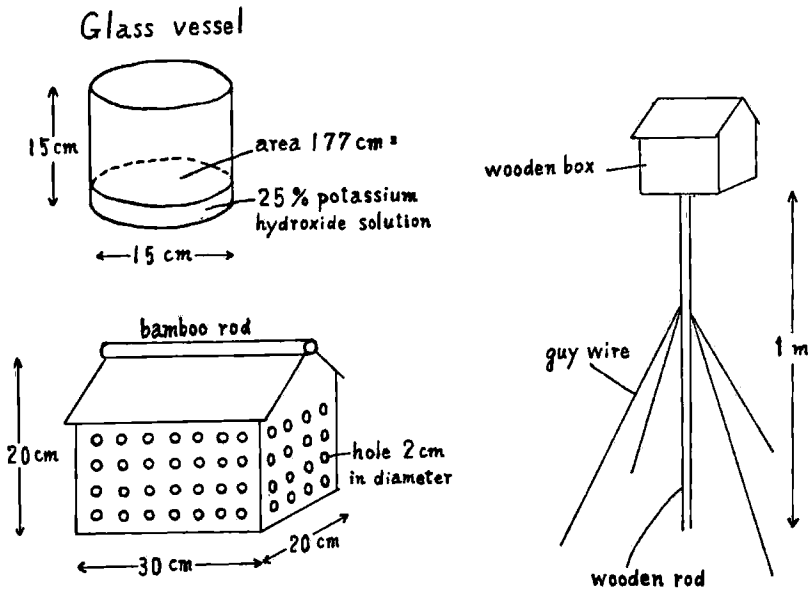


Fig. 2 - Glass vessel and wooden box.

at last a great eruption occurred at 10:50 p. m. on the 10th of November. The largest hole made by a bomb flying from the crater at the foot of Sekisonoyama, parasitic cone of Mt. Asama, was about 10 m in diameter, 4 m in depth, and 2800 m in distance from the crater. The bomb which flew the longest distance from the crater made a hole 3 m in diameter at the top of Koasamayama, about 3500 m distant from the crater. All glass windows of the residences

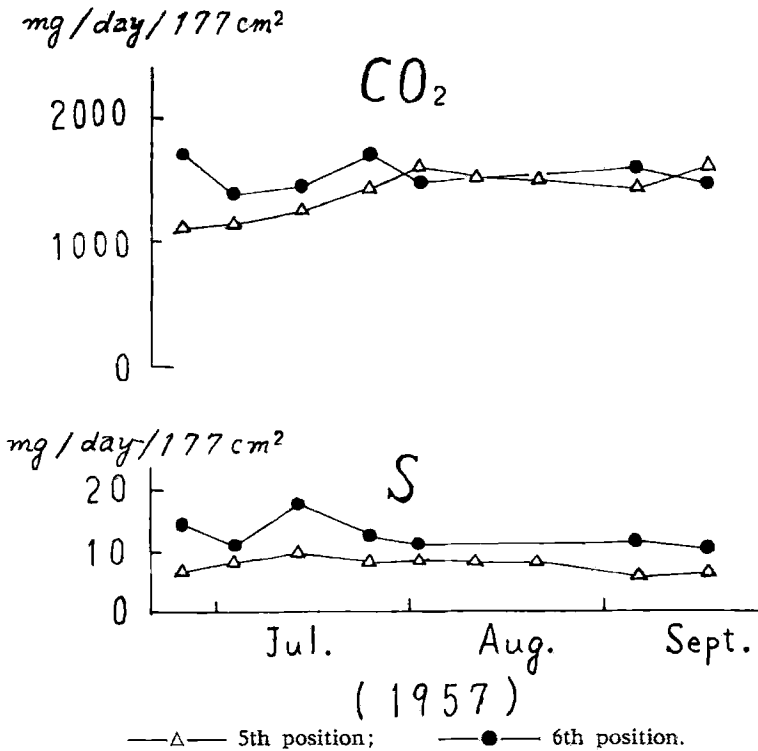


Fig. 3 - Variation of the amounts of carbon dioxide and sulphur compounds emitted at Jigokudani of Mt. Asama.

at Karuizawa, 12 km distant from the crater and which faced Mt. Asama, were destroyed by the blast from the explosion.

### 1. Method of Observation

To study the variation of volcanic gases the following equipment was used. A glass vessel, 15 cm in diameter and 15 cm in depth, containing 500 ml. of 25 % potassium hydroxide solution was placed

in a small wooden box. This box was 30 cm long, 20 cm wide, 20 cm high and contained many holes drilled 2 cm in diameter as shown in fig. 2. Six such boxes were constructed and placed at different locations one meter above the ground on wooden rod and supported by guy wires. The 1st, 2nd, 3rd and 4th pieces of this equipment were placed at the edge of the active crater, and 5th and 6th pieces

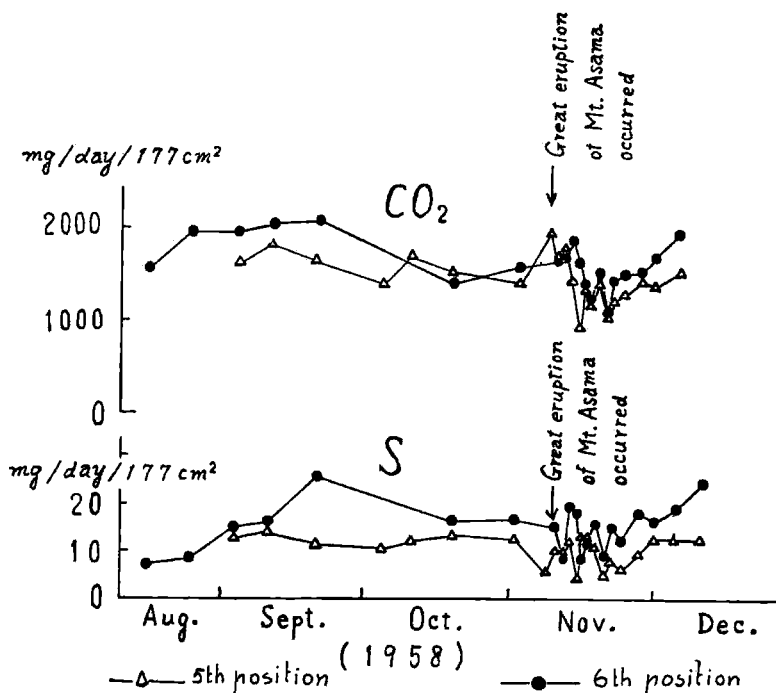


Fig. 4 - Variation of the amounts of carbon dioxide and sulphur compounds emitted at Jigokudani of Mt. Asama.

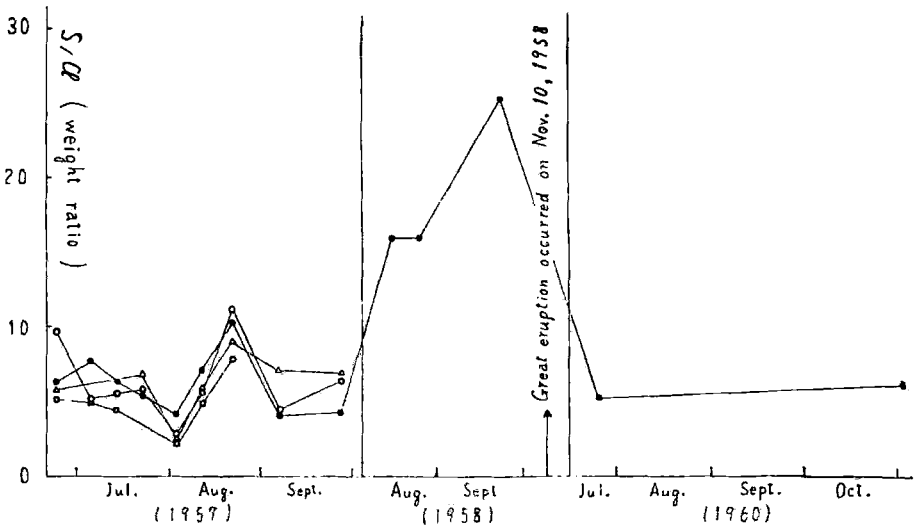
at a solfataric zone called as Jigokudani. The authors changed the potassium hydroxide solution about every 7 to 10 days and examined the quantity of chlorine and sulphur compound which were absorbed.

## 2. Analytical Procedure

### 1. Determination of chlorine.

10 ml of 25 % potassium hydroxide solution which absorbed acidic gases was poured into an Erlenmeyers flask. 20 ml of distilled

water and 0.5 ml of hydrogen peroxide solution were added to this solution. This mixed solution was slowly heated on the water bath until the oxygen bubbles disappear. The solution then was boiled on a piece of wire gauze for several minutes to destroy the hydrogen peroxide remaining in the solution. When the solution cooled, it was neutralized with nitric acid by using p-nitrophenol as an indicator, while stirring the solution adequately to expel free carbon dioxide.



—Δ— 1st position; —○— 2nd position; —□— 3rd position; —●— 4th position.  
 Fig. 5 - Variation of the ratio S/Cl observed at the edge of the crater of Mt. Asama.

After these processes were finished, the chlorine content was determined by silver nitrate using potassium chromate as an indicator.

## 2. Determination of sulphur.

A large part of the sulphur compounds emitted from the active crater of Mt. Asama are sulphur dioxide and hydrogen sulphide.

25 ml of 25 % potassium hydroxide solution which absorbed acidic gases, 25 ml of distilled water and 1 ml of 30 % hydrogen peroxide solution were mixed in Erlenmeyers flask. This solution at first was heated on the water bath and then boiled on a wire gauze as in the determination of chlorine. When the solution cooled, it was made acidic by adding 2 N hydrochloric acid, then 10 % barium

chloride solution was poured to this solution and the amount of precipitate of barium sulphate was determined gravimetrically.

### 3. Determination of carbon dioxide.

5 ml of the potassium hydroxide solution which absorbed acidic gases was poured into 25 ml of carbon dioxide free water, oxidized with hydrogen peroxide and titrated with 2 N-hydrochloric acid until

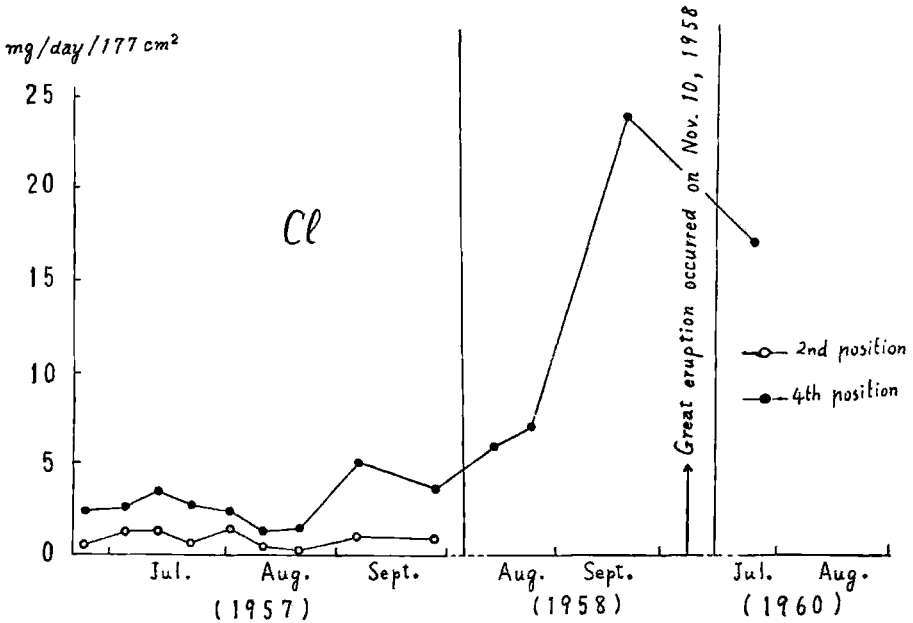


Fig. 6 - Variation of the amount of chlorine absorbed by potassium hydroxide solution per day at the edge of the crater of Mt. Asama.

the solution, first, was colorless of phenolphthalein and then acid to methyl orange. Carbon dioxide content was determined by the difference between these two titration values.

## 3. Results

### 1. Gases of Jigokudani.

Volcanic gases containing 78 % carbon dioxide and 0.5 % hydrogen sulphide, are emitted at a solfataric zone, called as Jigokudani, at the innerside of the 1st somma, Kurofuyama, 2000 m distant from the active crater.

The orifice temperature of these solfataras are almost same as that of the ordinary ground in this district (fig. 1).

The results obtained are shown in fig. 3 and 4. The amount of

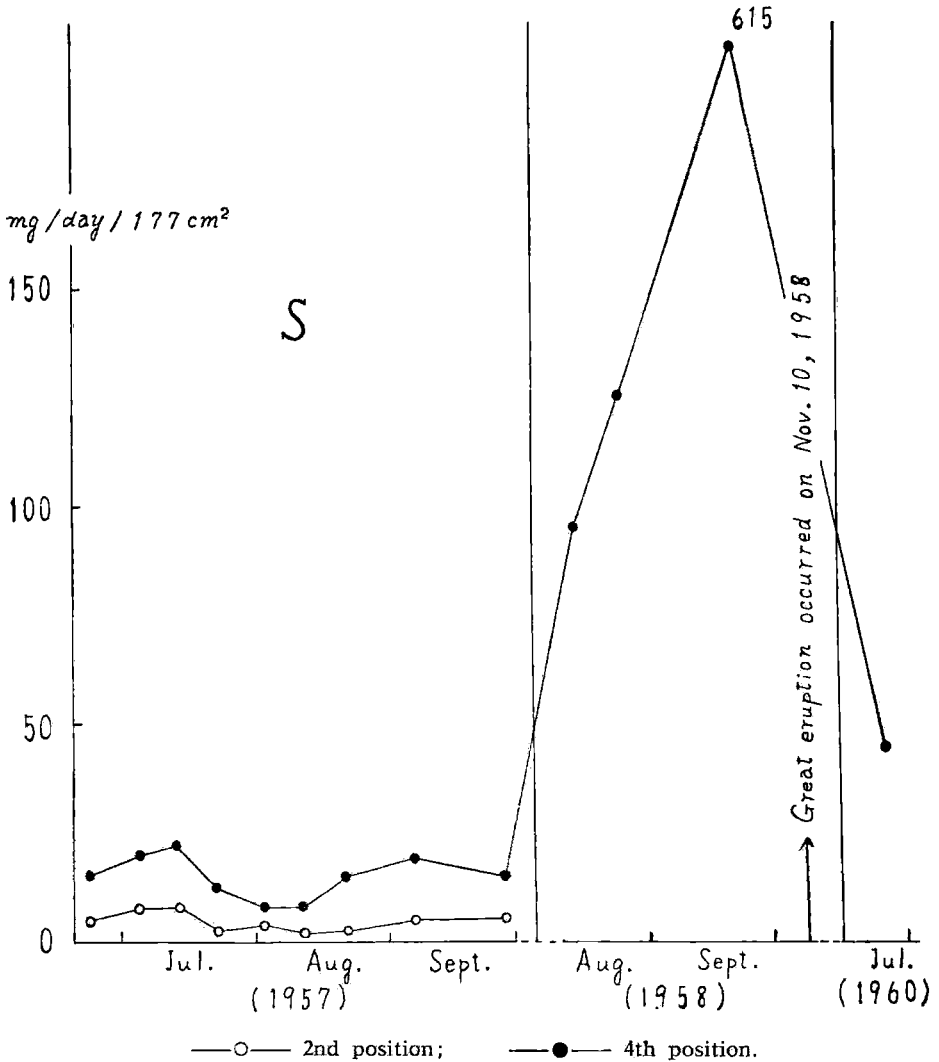


Fig. 7 - Variation of the amount of sulphur absorbed by potassium hydroxide solution per day at the edge of the crater of Mt. Asama.

sulphur compound and carbon dioxide in 1957, when Mt. Asama was dormant, were almost equal to that in 1958, when it was active. At

10:50 p. m. of the 10th of November, 1958, a great eruption of Mt. Asama occurred.

Immediately after this eruption, the amount of carbon dioxide and hydrogen sulphide slightly decreased. It will be reasonable to suppose that gas rising path was slightly and temporary closed on

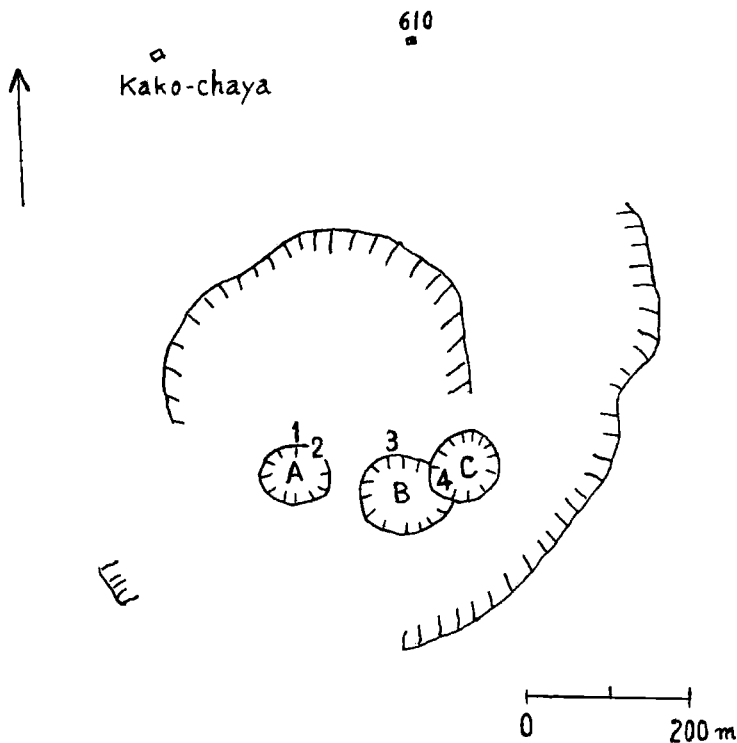


Fig. 8 - Crater of Mt. Mihara.

A: The vent created in January 1954.

B: The vent created in January 1956.

C: The vent created in October 1957.

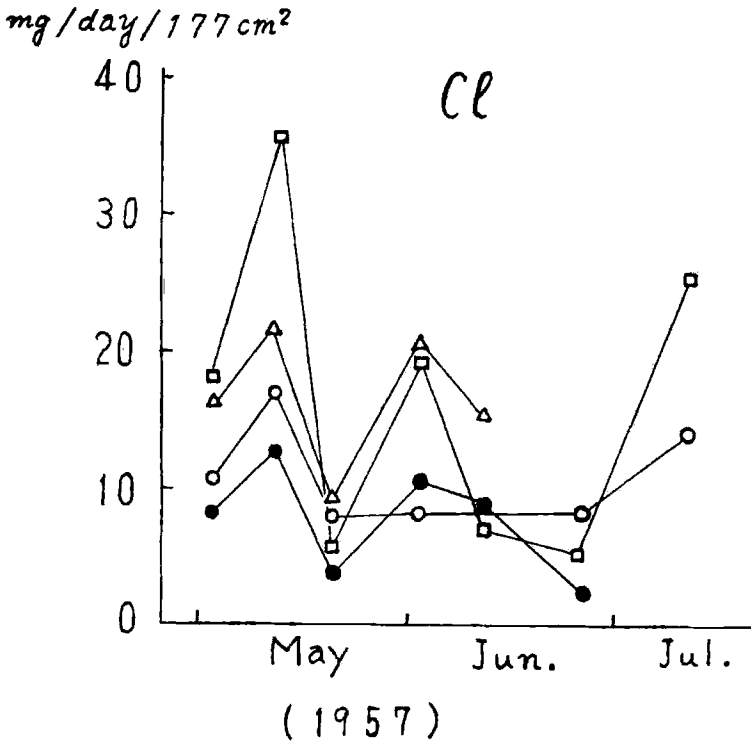
The numbers 1, 2, 3 and 4 indicate the positions where variation of gases were observed.

account of the earthquake caused by eruption. From these results, it is possible to conclude that there is no relation between the variation of chemical composition and amount of gas emitted from Jigokudani, and present activity of Asama.



2. Gas of active crater.

An enormous amount of volcanic gas containing steam, carbon dioxide, sulphur dioxide, hydrogen sulphide, hydrochloric acid, hydrofluoric acid, boric acid and ammonium chloride etc., are emitted from the active crater. The authors placed four boxes at the edge of active crater as shown in fig. 1 and observed the variation of

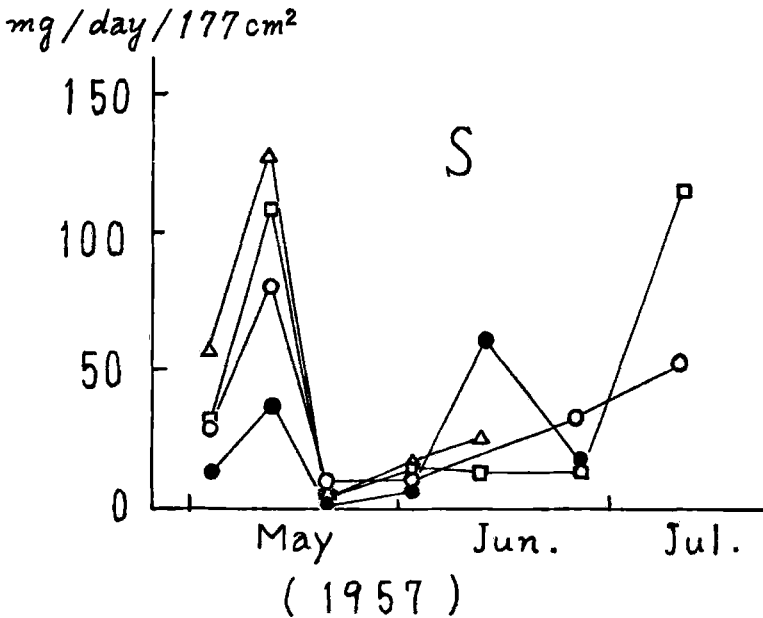


—○— 1st position; —●— 2nd position; —□— 3rd position; —△— 4th position.

Fig. 9 - Variation of the amount of chlorine absorbed by potassium hydroxide solution per day.

chemical composition and amount of gas in 1957, 1958 and 1960. In 1959 the authors could not take gas measurement at the top of the mountain on account of eruption. As shown in fig. 5, the ratio S/Cl which were observed at four points changed parallel to each other and remarkably increased when a great eruption was approaching. As shown in fig. 6, the amounts of chlorine observed at 2nd and 4th

position changed parallel to each other and remarkably increased when a great eruption was approaching. The potassium hydroxide solution placed at 1st and 3rd position, was disturbed by the curiosity of sightseers. But in this case it is possible to find only the ratio S/Cl in the solution. The variation of sulphur compounds observed at 2nd and 4th position are shown in fig. 7. The amounts of sulphur compounds observed at two points changed parallel to each other and increased when a great eruption was approaching. At the end of September, about one month before the great eruption, the amount of sulphur



—○— 1st position; —●— 2nd position; —□— 3rd position; —△— 4th position.  
Fig. 10 - Variation of the amount of sulphur absorbed by potassium hydroxide solution per day.

showed 615 mg/day/177 cm<sup>2</sup>, remarkably larger than 8-22 mg/day/177 cm<sup>2</sup> in 1957, when the mountain was dormant.

As for Mt. Mihara, the authors also placed four boxes at the edge of active vent created in 1956 and at the bottom of vent created in 1954 as shown in fig. 8 and observed the variation of chemical composition and amount of gases in 1957.

In this case the authors determined the variation of amount of sulphur compounds, hydrochloric acid and fluorine compounds.

As for the determination of fluorine, the potassium hydroxide solution which absorbed volcanic gases was treated with hydrogen peroxide in the same way as that in the determination of chlorine. After these processes were finished, silver sulphate, sea sand and sulphuric acid (or perchloric acid) were added to the solution. Fluorine content of distillate obtained from this solution by steam distillation was determined colorimetrically by the Al-hematoxylin method.

The results obtained are shown in fig. 9, 10, and 11. The amounts

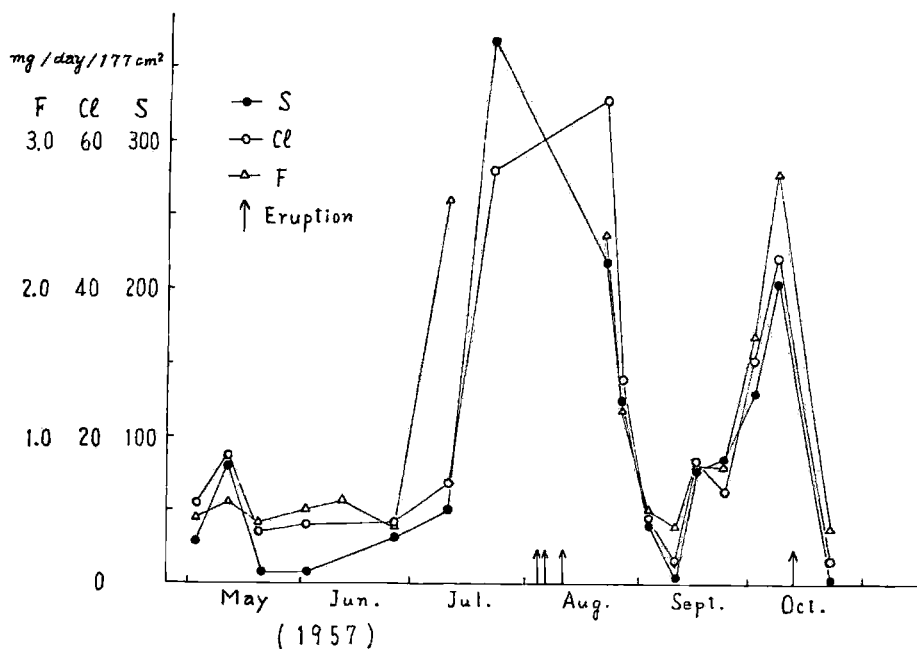


Fig. 11 - Variation of the amounts of fluorine, chlorine and sulphur absorbed by potassium hydroxide solution per day at the 1st position.

of chlorine and sulphur compounds observed at four points changed parallel to each other as shown in fig. 9 and 10.

April to early July, 1957, when the volcano was dormant, the amounts of fluorine, chlorine and sulphur compounds emitted from the volcano were small, that is, fluorine 0.35-0.55 mg/day/177 cm<sup>2</sup>, chlorine 7.6-16.7 mg/day/177 cm<sup>2</sup>, sulphur 9.0-81.1 mg/day/177 cm<sup>2</sup>. From the 17th to 30th of July, the gas amount showed a remarkably high value, that is, fluorine 2.6 mg/day/177 cm<sup>2</sup>, chlorine 56.2 mg/day/177 cm<sup>2</sup>, sulphur 369 mg/day/177 cm<sup>2</sup> and on August 5th and 6th

explosion occurred. In early October the gas again remarkably increased and the amount of gas absorbed by the potassium hydroxide solution from the 5th to 11th of October showed a very high value and on October 13th a large explosion occurred.

By measuring chemical composition and amount of gas emitted from an active volcano, it is possible to predict the time of an approaching eruption with some degree of accuracy.

### **Acknowledgment**

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