Preliminary Comparative Study on Groundwater between the Fuji and the Hakone Areas

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(Abstract)

Chemical analyses of 23 groundwater samples revealed that groundwater quantities are obviously different between the Fuji and the Hakone areas, the former is unitary, the latter is various. The difference is related to geological and geochemical environment.

1. Introduction

Mt. Fuji and Mt. Hakone are both famous volcanoes, but there are significant differences in form, rock composition, and geological and geochemical environment between them. Is there any difference between the Fuji and the Hakone areas in groundwater quantity? This paper is a preliminary study on the quantity of groundwater based on the chemical analysis data from 11 samples of groundwater from the eastern foot of Mt. Fuji and 12 samples of groundwater from the Hakone area. This study has obtained meaningful results.

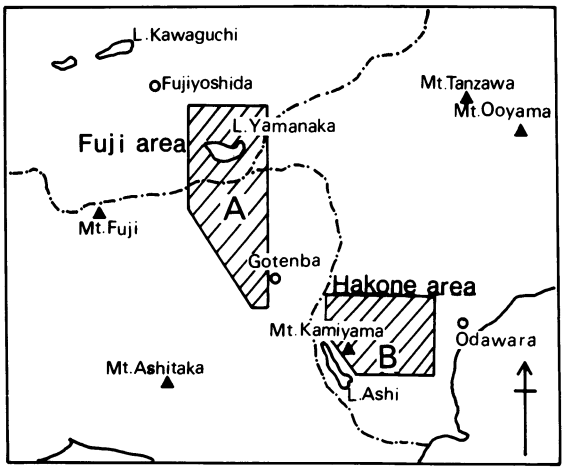

Fig. 1 Sketch map of the location of the sampling areas.

2. Chemical Composition of Groundwater

The Fuji area's 11 samples of groundwater were taken from the eastern foot of the volcano, as shown in part A, Figure 1. The Hakone area's 12 samples of groundwater were taken from the caldera of the Hakone volcano, as shown in part B, Figure 1. The names and

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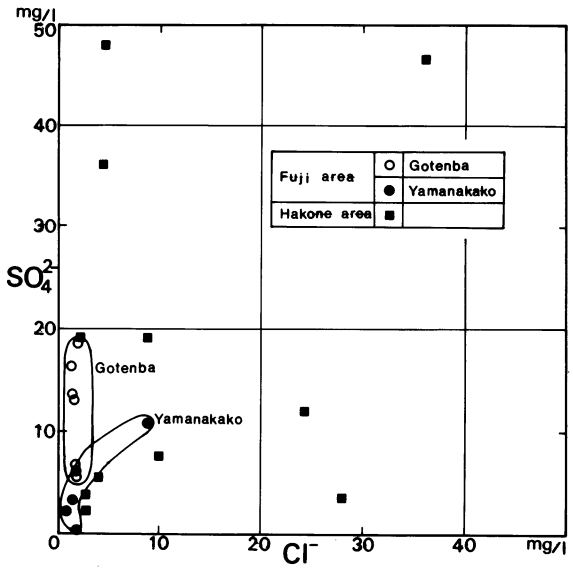


Fig.2 $Cl^- - SO_4^{2-}$ diagram of the Fuji and the Hakone groungwaters.

locations of sampling sites are listed in the tables.

The orifice temperatures of the groundwaters were within the range 10～20℃ except one sample (22.1℃). All the drinking water and the pH of the groundwater was 6 to 8. The groundwater outcrops in the Fuji area are shown in Photo 1～7.

The chemical composition of the groundwaters is listed in Table 1 and 2.

It shows:

(1) Cl^- content in the groundwater of the Hakone area is considerably higher than in the Fuji area;

(2) SO_4^{2-} content in the groundwater of the Hakone area is generally higher than in the Fuji area;

(3) H_2SiO_3 content in the groundwater of the Hakone area is lightly higher than in the Fuji area;

(4) But HCO_3^- content in the groundwater of the Fuji area is lightly higher than in the Hakone area;

(5) There is no large difference in major cations between the Hakone and the Fuji waters.

In the $Cl^- - SO_4^{2-}$ diagram (Fig. 2) and the major cations and anions diagrams (Fig. 3, 4, 5 and 6) the Hakone groundwater is highly scattered; but the Fuji groundwater is relatively concentrated. This indicates:

(1) In the Hakone area there are various groundwater systems which will provide more complex features.

(2) In the Fuji area where samples were collected, there is unitary groudwater system which may provide similar water composition.

Further study of the results shows the following:

Although the content of each chemical component in the groundwater is somewhat different in diffe-

Table 1 Chemical composition of groundwaters in the Fuji area.

Location	Temp. (℃)	pH	Residual (mg/ℓ)	Na^+ (mg/ℓ)	K^+ (mg/ℓ)	Ca^{2+} (mg/ℓ)	Mg^{2+} (mg/ℓ)	Cl^- (mg/ℓ)	SO_4^{2-} (mg/ℓ)	HCO_3^- (mg/ℓ)	NO_3^- (mg/ℓ)	H_2SiO_3 (mg/ℓ)	Rn (Pci/ℓ)	Note
Gumisawa No.1 well	12.5	8.1	120.2	10.2	1.60	16.8	3.85	1.83	18.9	75.8	0	27.9	23.2	*
Takane No.1 well	12.4	8.1	115.1	8.25	1.38	15.2	3.72	1.27	16.4	69.5	0	35.5	15.6	*
Takane No.3 well	12.5	7.5	107.3	7.80	1.41	13.9	3.70	1.35	12.8	69.5	2.18	33.8	25.1	*
Nakashimizu	13.4	7.2	104.7	6.60	1.64	13.1	2.75	1.74	5.65	63.2	3.67	46.9	36.7	*
Kamikobayashi	12.2	7.8	114.4	7.65	1.38	14.5	3.80	1.25	13.8	69.5	2.08	29.5	39.5	*
Subashiri-Yadamayama	11.5	7.8	91.6	6.85	1.23	12.0	2.06	1.68	6.16	56.9	2.06	39.7	17.6	*
Oshino	13.2	6.4	146.7	6.90	3.15	20.6	7.25	8.85	10.7	75.8	20.4	39.7	58.1	**
Oshino-Hakai	12.4	7.2	95.8	5.50	1.35	14.6	4.95	1.53	6.44	72.7	5.17	38.0	43.2	**
Azamigaoka No.1 well	10.3	7.4	63.5	4.30	1.10	9.67	2.90	0.88	2.05	51.8	2.53	15.5	39.9	**
Yamanakako-Yamanaka	12.7	7.7	97.1	5.85	2.40	18.8	7.00	1.74	0	112	0	27.6	68.5	**
Yamanakako-Hirano	10.4	7.2	81.2	4.25	1.15	11.3	3.85	1.34	3.28	60.0	3.80	48.8	34.8	**

* : Samples of Gotenba district. ** : Samples of Yamanakako district.

Table 2 Chemical composition of groundwaters in the Hakone area.

Location	Temp. (℃)	pH	Residual (mg/ℓ)	Na^+ (mg/ℓ)	K^+ (mg/ℓ)	Ca^{2+} (mg/ℓ)	Mg^{2+} (mg/ℓ)	Cl^- (mg/ℓ)	SO_4^{2-} (mg/ℓ)	HCO_3^- (mg/ℓ)	NO_3^- (mg/ℓ)	H_2SiO_3 (mg/ℓ)	Rn (Pci/ℓ)	Note
Tonosawa	15.0	7.0		12.2	0.93	10.7	2.61	9.73	7.89	56.5	3.07	52.2	67.6	
Ninotaira	18.5	6.3		10.2	2.39	16.4	5.22	8.84	19.2	68.4	10.3	62.7	87.4	
Miyagino	15.5	6.6		6.81	1.03	8.62	1.83	3.70	5.77	47.1	2.21	35.6	64.5	
Hakoneyumoto	19.2	7.5		45.2	0.79	5.98	0.06	23.9	12.3	84.8	6.51	44.3	100	
Sukumo	13.8	6.9		3.75	0.78	8.55	1.68	2.40	2.16	42.1	2.78	38.2	139	
Ōhiradai	16.9	7.1		9.13	1.31	15.8	3.84	27.8	3.75	49.6	3.83	58.6	261	
Gōra	19.3	6.6		11.8	3.67	32.7	6.57	35.9	46.7	44.0	5.38	75.5	58.3	
Fuezuka	17.1	6.4		8.55	1.13	19.7	7.13	4.63	48.4	42.1	1.61	59.4	64.6	
Kowakudani	22.1	7.0		12.4	2.56	24.5	10.0	4.22	36.5	102	2.06	88.4	89.5	
Sengokuhara	13.3	7.6		8.64	0.78	64.2	2.79	2.03	—	54.0	—	34.5	78.9	
Sengokuhara	13.5	7.4		4.32	0.45	12.8	2.53	2.52	4.17	60.3	—	46.8	58.9	
Motohakone	16.7	7.4		4.90	1.20	9.09	3.50	2.18	19.2	35.2	2.57	74.6	45.8	

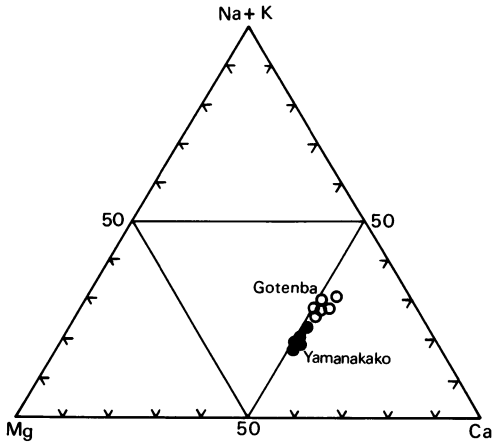


Fig.3 $Na^{+}+K^{+}-Mg^{2+}-Ca^{2+}$ diagram of the Fuji groundwaters.

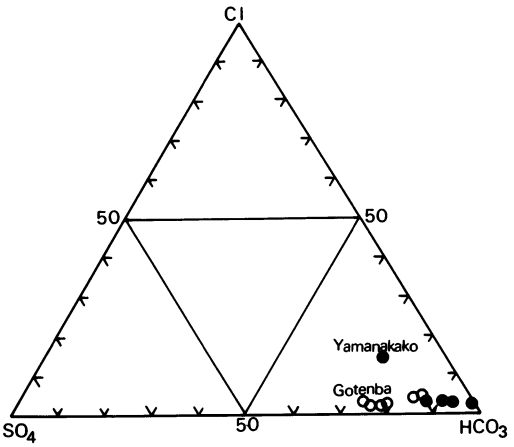


Fig.4 $Cl^{-}-SO_4^{2-}-HCO_3^{-}$ diagram of the Fuji groundwaters.

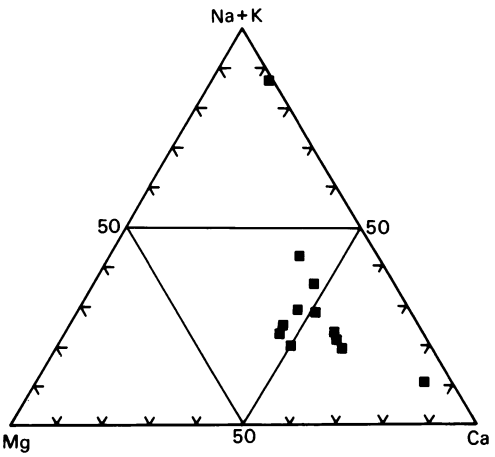


Fig.5 $Na^{+}+K^{+}-Mg^{2+}-Ca^{2+}$ diagram of the Hakone groundwaters.

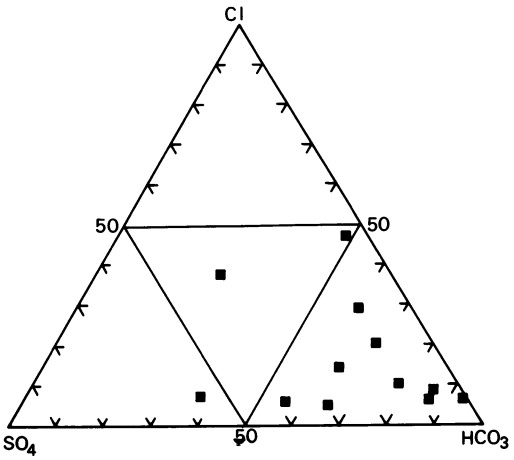


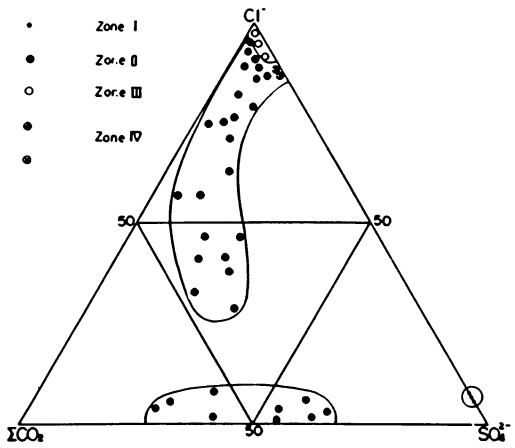
Fig.6 $Cl^{-}-SO_4^{2-}-HCO_3^{-}$ diagram of the Hakone groundwaters.

rent parts of the Fuji area, the distribution of cations and anions ratio is concentrated in certain limitted fields in Fig. 3 and Fig. 4.

3. Discussion

Many investigations have been made on volcanoes, and a wealth of data have been provided in geology and geochemistry on Mt. Fuji and Mt. Hakone (Tsuya et al., 1981, Oki, 1983). The compositional differences in groundwater between the Fuji and Hakone areas above mentioned have been controlled by the geological and geochemical environment.

In the Hakone caldera, a lot of hot springs and steaming grounds are found. Four types of thermal water have been recognized in this area (Fig. 7 and 8, Oki and Hirano, 1970). It is the underground thermal water with high NaCl content mixed with the groundwater from meteoric precipitation, that is important to note. It is very likely that the unusually high content of Cl^-, SO_4^{2-}, H_2SiO_3 in the Hakone groundwater is more or less influenced by the hydrothermal activity of the volcano.



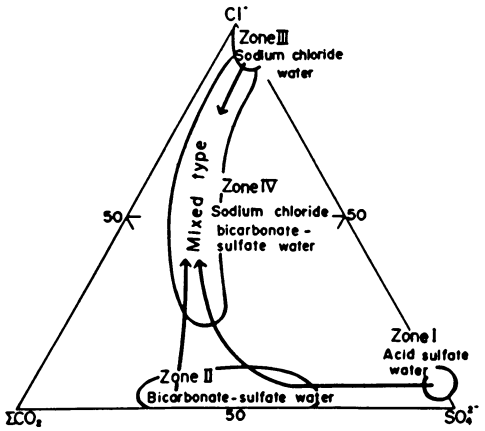


Fig.8 Cl^- — total CO_2 — SO_4^{2-} diagram and compositional trends of Hakone thermal waters (Oki and Hirano, 1970).

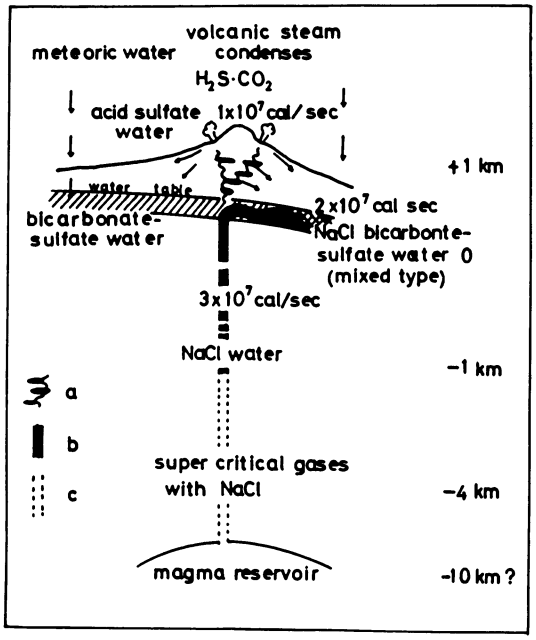


Fig.7 Genetic model of Hakone hydrothermal system (Oki and Hirano, 1970).
a:Repeated processes of vaporization and condensation of volcanic steam resulting in concentration of volatile components such as H_2S and CO_2.
b:Sodium chloride water (zone III).
c:Super critical gases (steam) with NaCl.

With regard to Mt. Fuji, it is the fact that the piezometric head of groundwater is so high, and the covering rock layer above so thick, which permits geothermal manifestation at shallow depth. Therefore, there is no hot springs outcrop or anomalous geothermal activity in the Fuji area (Fig. 9). For this reason, all groundwater of the Fuji volcano come directly from meteoric precipitation on the whole with the result that the chemistry of the Fuji groundwater is rather similar even in different location. where the Cl^-, SO_4^{2-} and H_2SiO_3 content in groundwater are all lower, a shallow cause of groundwater is indicated.

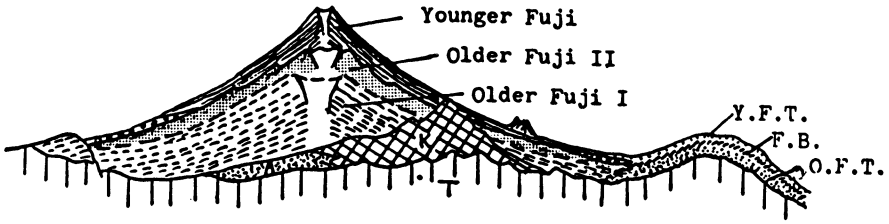


Fig. 9 Schematic cross section of the Fuji volcano (Tsuya et al., 1981).
K: Komitake volcano.
A: Ashitaka volcano.
T: Tertiary basement.

4. Acknowledgements

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Photo. 1 Groundwater site of Takane No. 3 well.

Photo. 2 Groundwater site of Takane No. 1 well.

Photo. 3 Groundwater site of Nakashimizu.

Photo. 4 Groundwater site of Subashiri-Yadamayama.

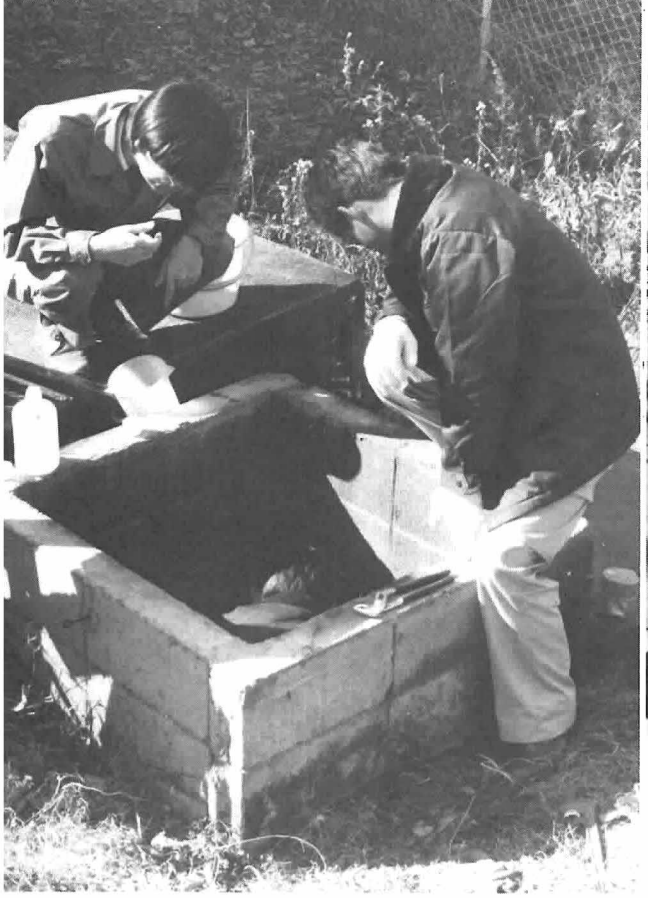

Photo. 5 Groundwater site of Azamigaoka No. 1 well.

Photo. 6 Groundwater site of Yamanakako-Yamanaka.

Photo. 7 Groundwater site of Yamanakako-Hirano.