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原 著

Variation of the Chemical Composition of Water Emitted from the Prince of Wales Feathers and Waikorohihi Geysers During an Eruption of Each

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Abstract

In December, 1977 the authors collected 28 water samples from Prince of Wales Feathers Geyser and 17 water samples from Waikorohihi Geyser during an eruption of each and analyzed them.

As for Prince of Wales Feathers Geyser, the chloride and sulphate contents in the water were low at the start of eruption and increased with time. Then, they showed instantaneously distinct low values when the discharge of Prince of Wales Feathers increased corresponding to the drop in water level in the neighbouring geyser Te Horu and also when the neighbouring geyser Pohutu started erupting. At the latter stage of the eruption they decreased gradually with time until its eruption stopped.

As for Waikorohihi Geyser, the chloride and sulphate contents in the water were low at the start of eruption. Soon after the start, they increased distinctly for a short time and then decreased gradually with time until the eruption stopped.

As the maximum and minimum values of chloride and sulphate contents, P. of W. F. showed 606 and 585 mg/l Cl, and 112 and 81 mg/l SO₄; Waikorohihi showed 615 and 568 mg/l Cl, and 101 and 83 mg/l SO₄.

I) Introduction

On the North Island of New Zealand there were many geysers in the geothermal areas of the Taupo Volcanic Zone many years ago. However, some of them disappeared because of the construction of a dam for electric power or by boring to get more geothermal heat. Today it is well known that in Whakarewarewa four geysers Prince of Wales Feathers, Pohutu, Waikorohihi and Mahanga Geysers are still active and emit hot water periodically. E. F.

* Partly reported at the ACS/CSJ Chemical Congress held in Honolulu, Hawaii April 1-6, 1979.

Lloyd reported precisely the geology of Whakarewarewa Hot Springs in 1975¹⁾. Aikawa and Noguchi visited New Zealand and to inspect geysers in December, 1977. A map of the thermal regions of New Zealand and a map of Whakarewarewa Hot Springs are shown in figures 1 and 2. On December 3, 1977 the water emitted from the orifice of Prince of Wales Feathers Geyser was collected in 28 polyethylene bottles during an eruption. Also, on December 4, 1977 the water emitted from the Waikorohihi Geyser was collected in 17 polyethylene bottles during an eruption. Both geysers are alkaline showing 8.9 and 8.7 in pH respectively.

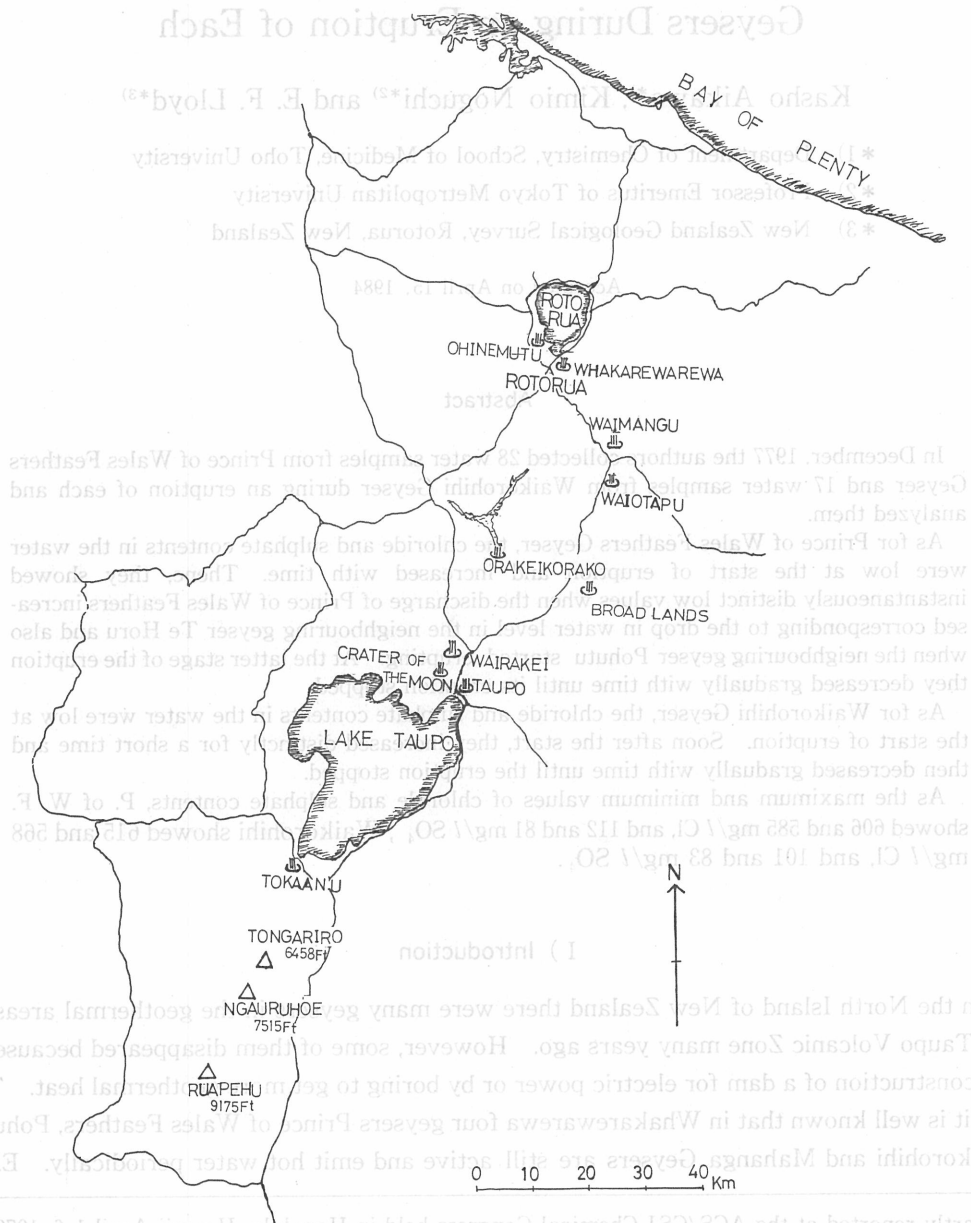


Fig. 1 A map of the thermal regions of New Zealand

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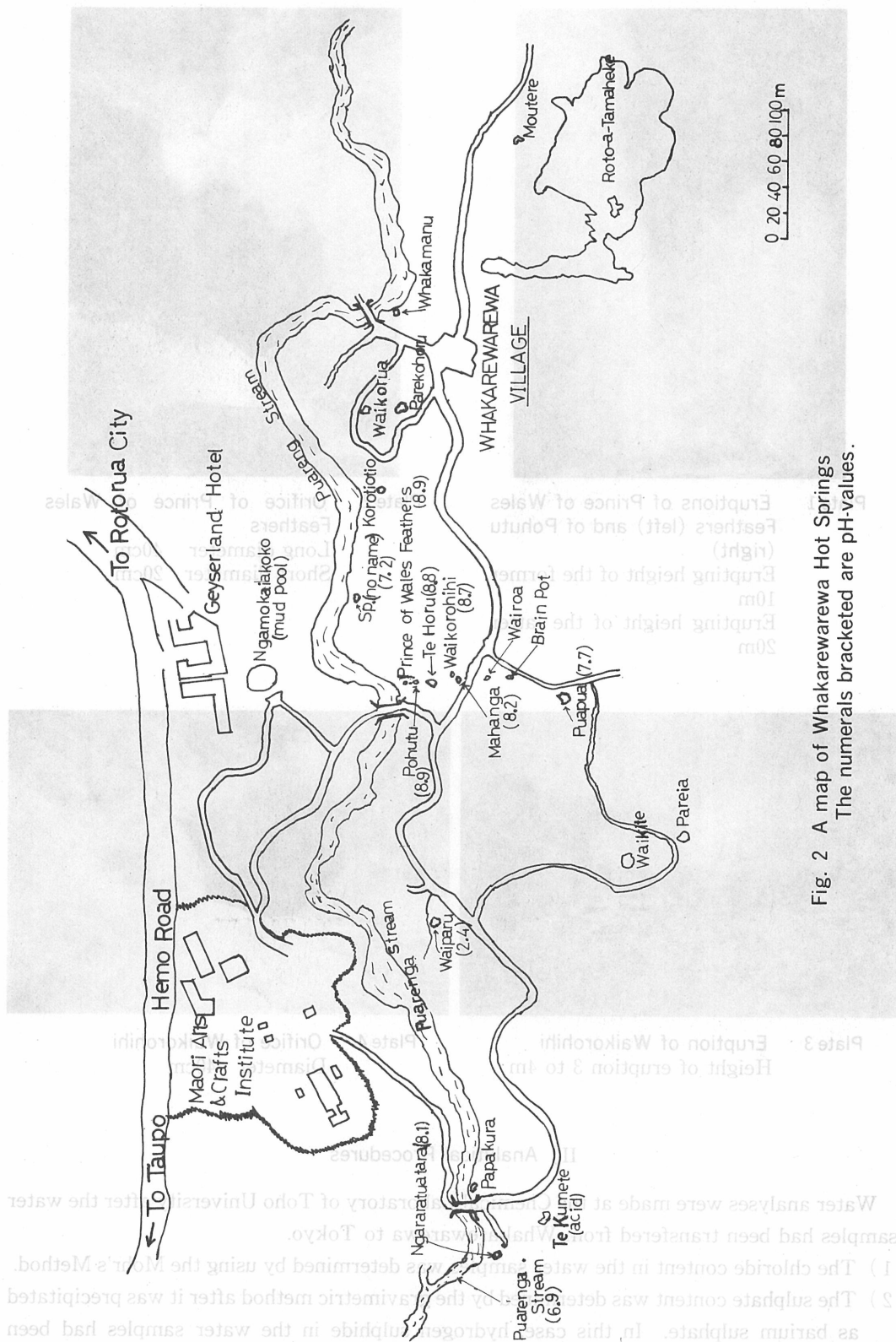


Fig. 2 A map of Whakarewarewa Hot Springs
The numerals bracketed are pH-values.

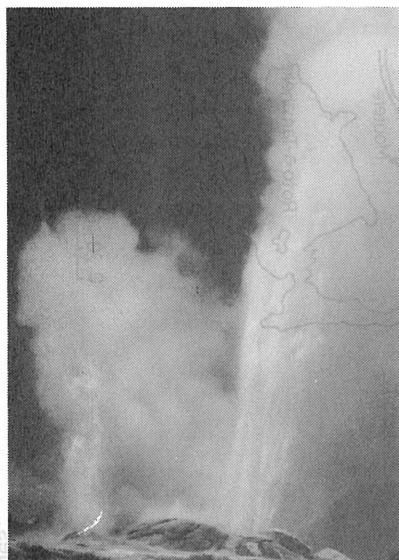


Plate 1 Eruptions of Prince of Wales Feathers (left) and of Pohutu (right)
Erupting height of the former 10m
Erupting height of the latter 20m



Plate 2 Orifice of Prince of Wales Feathers
Long diameter 40cm
Short diameter 20cm



Plate 3 Eruption of Waikorohihi
Height of eruption 3 to 4m

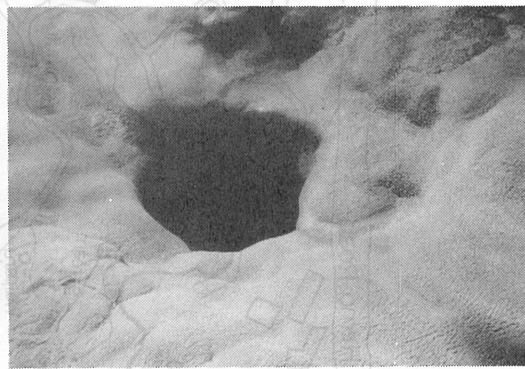


Plate 4 Orifice of Waikorohihi
Diameter 40cm

II) Analytical Procedures

Water analyses were made at the Chemical Laboratory of Toho University after the water samples had been transferred from Whakarewarewa to Tokyo.

- 1) The chloride content in the water samples was determined by using the Mohr's Method.
- 2) The sulphate content was determined by the gravimetric method after it was precipitated as barium sulphate. In this case, hydrogen sulphide in the water samples had been

oxidized completely to sulphate during transportation of the water samples from Whakarewarewa to Tokyo by ship.

III) The Results

The analytical results of the water samples from Prince of Wales Feathers Geyser are shown in table 1 and fig. 3. As shown in fig. 3, the contents of chloride and sulphate in the water emitted from Prince of Wales Feathers were found to be low at the beginning of the eruption. Then, their contents increased with time. When its discharge increased distinctly corresponding to the drop in the water level in the neighbouring geyser Te Horu, the chloride and sulphate contents in water decreased instantaneously and then increased distinctly. A similar phenomenon occurred in its chloride and sulphate contents when the eruption of the neighbouring, great geyser Pohutu started erupting. After that, their contents decreased gradually with time. At the end of the long eruption which continued for 77.5 minutes, the water emitted from P. of W. F. was found to be low in chloride and sulphate contents as in the beginning stage.

It is presumed that the water emitted from the orifice of Prince of Wales Feathers and Waikorohihi Geysers is a mixture of the thermal water rich in chloride and sulphate and the shallow ground water poor in them. At the beginning stage of the eruption of P. of W. F. the water relatively rich in shallow ground water was emitted. Then, the water richer in thermal water was emitted increasing with time. When its discharge increased distinctly corresponding to the drop in the water level in the neighbouring geyser Te Horu, the water richer in shallow ground water was emitted instantaneously and 1.4 minutes later the water richer in thermal water was emitted again.

A similar phenomenon occurred in the water emitted from the orifice of P. of W. F. when the nearby Pohutu Geyser started erupting. After that, the water richer in ground water was emitted with time until the eruption stopped. Anyway, both at the beginning and ending stages of the eruption the water richer in shallow ground water was emitted.

As for Waikorohihi Geyser, the analytical results are shown in table 2 and fig. 4. In this case, at the start of the eruption the contents of chloride and sulphate were low, but soon after that, they showed distinctly higher values for short time and then decreased gradually with time. At the end of the eruption they showed slightly higher value again. The above mentioned results can be explained as follows: At the start of the eruption the water relatively rich in shallow ground water flowed out from the orifice of Waikorohihi and soon after that, the water rich in thermal water was emitted high up in the air for a short time. Then, with time the water richer in ground water was emitted. At the end of the eruption the water slightly rich in thermal water was emitted instantaneously high again and then, the eruption stopped immediately.

The maximum and minimum values of the chloride and sulphate contents and the rate of change are shown in table 3.

As for the cause of periodic eruption of the geysers, it is presumed that periodic eruptions of the geysers are caused by the relatively lower temperature water, namely, the water relatively

Table 1. Variation of the chloride and sulphate contents in water emitted from Prince of Wales Feathers Geyser during its eruption Observed on Dec. 3, 1977

Sample number	Time since the eruption started (min)	Cl ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)
1)	0.2	590	90
2)	3.1	595	97
3)	10.0	595	108
	15.0		Waikorohiphi starts erupting
4)	17.3	600	112
	20.0		Discharge slightly increased
5)	27.2	597	104
6)	30.6	602	108
7)	30.9	602	93
8)	31.8	600	90
9)	32.8	606	105
10)	33.3	605	99
11)	34.6	600	96
12)	36.2	600	95
13)	42.0	591	85
14)	48.1	595	84
			Discharge of P. of W. F. increases
15)	48.4	596	85
16)	48.7	597	89
17)	49.1	596	86
	49.3		nearby Pohutu starts erupting
18)	49.7	586	82
19)	50.0	590	91
20)	50.2	590	90
21)	50.5	600	94
22)	51.1	603	99
23)	51.8	603	93
	55.5		Discharge of Pohutu decreases in height (commences splashing)
24)	56.7	598	89
25)	65.3	585	87
	66.0		Waikorohiphi stops erupting
	73.5		Pohutu stops erupting
26)	74.0	587	83
	74.2		Discharge of P. of W. F. decreases suddenly
27)	74.6	585	81
28)	77.6	586	87
			Eruption stopped

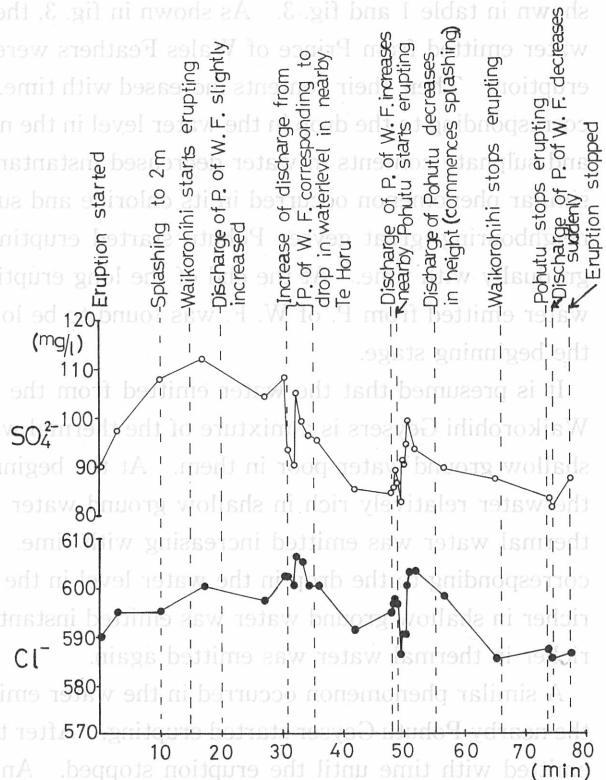


Fig. 3 Variation of the chloride and sulphate contents in the water emitted from Prince of Wales Feathers Geyser during its eruption

Observed on Dec. 3, 1977

Table 2 Variation of the chloride and sulphate contents in water emitted from Waikorohihi Geyser during its eruption Observed on Dec. 4, 1977

Sample number	Time since the eruption started (min)	Cl ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)
1)	0.0 Eruption started	588	87
2)	0.2	615	101
3)	0.4	598	93
4)	0.7	589	92
5)	2.0	589	89
6)	4.8	589	91
7)	9.7	585	90
8)	13.3	582	88
9)	16.4	582	87
	20.5 nearby Mahanga stars erupting		
10)	22.6	583	89
11)	31.9	583	88
	39.9 P. of W. F. becomes violent in eruption (erupts to 10m) Pohutu starts erupting		
12)	39.9	575	88
13)	46.2	575	87
	47.5 Pohutu stops erupting		
	52.8 P. of W. F. becomes violent in eruption		
	54.0 Pohutu starts erupting		
14)	55.3	570	85
15)	59.4	568	83
16)	59.8	570	88
17)	59.9 Eruption stopped	572	88
	Pohutu stopped erupting		

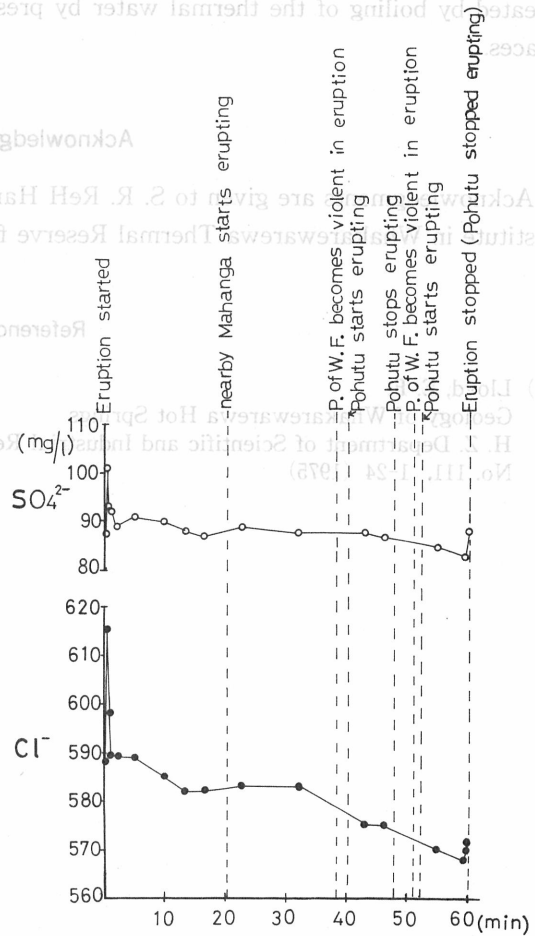


Fig. 4 Variation of the chloride and sulphate contents in the water emitted from Waikorohihi Geyser during its eruption.

Observed on Dec. 4, 1977

Table 3 The maximum and minimum values of chloride and sulphate contents and the rate of change

		Prince of Wales Feathers Waikorohihi			
		Cl	SO ₄	Cl	SO ₄
Maximum value	(mg/l)	606	112	615	101
Minimum value	(mg/l)	585	81	568	83
Difference	(mg/l)	21	31	47	18
Rate of change	(%)	3.5	27.7	7.6	17.8
Total number of samples collected		28	28	17	27

rich in ground water being heated in porous beds or in cavities under the ground with the mixture of thermal water and steam. In this case, it can be supposed that the steam was created by boiling of the thermal water by pressure decrease during its ascent from deep places.

Acknowledgments

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References

- Lloyd, E. F. Geology of Whakarewarewa Hot Springs H. Z. Department of Scientific and Industrial Research Information Series, No. 111, 1-24 (1975)

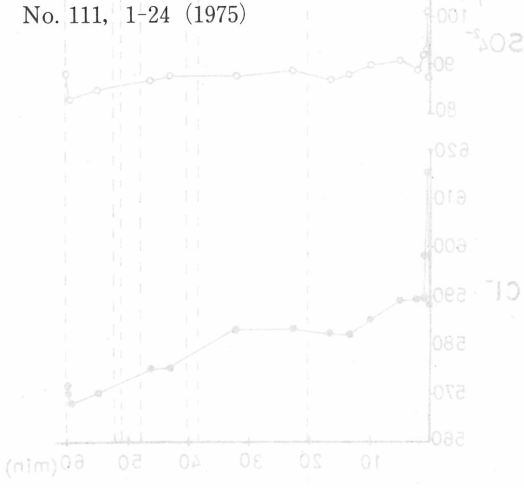


Fig. 4 Variation of the chloride and sulphate contents in the water emitted from Waiokohiri Geyser during its eruption. Observed on Dec. 4, 1977

Table 3 The maximum and minimum values of chloride and sulphate contents and the rate of change

Prince of Wales Feathers Waiokohiri	
	SO ₄ Cl
Maximum value (mg/l)	606 612
Minimum value (mg/l)	285 81
Difference (mg/l)	321 531
Rate of change (%)	37.7 7.6
Total number of samples collected	38 17

Sample number	Time since the eruption started (min)	Cl ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)
1	0.0	288	87
2	0.2	615	101
3	0.4	298	93
4	0.7	280	92
5	2.0	289	89
6	4.8	289	91
7	9.7	287	92
8	13.3	282	88
9	16.4	282	87
10	20.5	283	89
11	22.6	283	88
12	30.9	275	88
13	46.2	275	87
14	52.3	270	82
15	59.4	266	83
16	59.8	270	88
17	59.9	272	88

Observed on Dec. 4, 1977
 Geyser during its eruption
 Variation of the chloride and sulphate contents in the water emitted from the Prince of Wales Feathers and Waiokohiri Geysers During an Eruption of Each