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PRESENT STATUS OF THE OTAKE AND HATCHOBARU GEOTHERMAL POWER PLANTS(l)

ON THE OPERATING EXPERIENCE AND POWER PLANT CONSTRUCTION OF UNIT II

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ABSTRUCT

In 1949, the geothermal development of KEPCO initiated by surveys in the Otake, Kirishima and Unzen areas. After going through the basic exploration, the Otake Power Station of rated output 12.5MW, was constructed in 1967, and the Hatchobaru Power Station of rated output 55MW, the largest capacity of Geothermal Power Station in Japan, was completed in 1977. Both are operated with high capacity factors.

The development of Hatchobaru Unit II was begun by drilling of exploratory wells in 1981, was made sure by steam flow rate equivalent to 38MW by 6 wells. It is considered that long range operation is possible with the evaluation of the geothermal reservoir. After environmental influence was evaluated, the construction of 55MW Power Station was started in December 1987.

I. Role of geothermal power station in Kyushu Electric Power Company and the necessity of lower generating cost of geothermal power station.

KEPCO has been promoting the diversification of energy and most adequate composition of power sources (best mix) in which nuclear power station roles as base since the oil crisis in 1974.

As shown in Fig.1, power sources of KEPCO are composed by nuclear (20%) as base and by hydro (17%),gas thermal (23%) and oil fired thermal (34%) as weekly and daily cyclic lord adjustment.
The composition of power sources will be same for the future. High response and daily start/stop are required as the middle lord power stations such as thermal and hydro, however geothermal power station does not have such a function. Therefore lower generating cost is most important for geothermal power station, in addition creation of power demand and active promotion of multi purpose utilization of geothermal resource around power station are necessary to develop geothermal power stations.

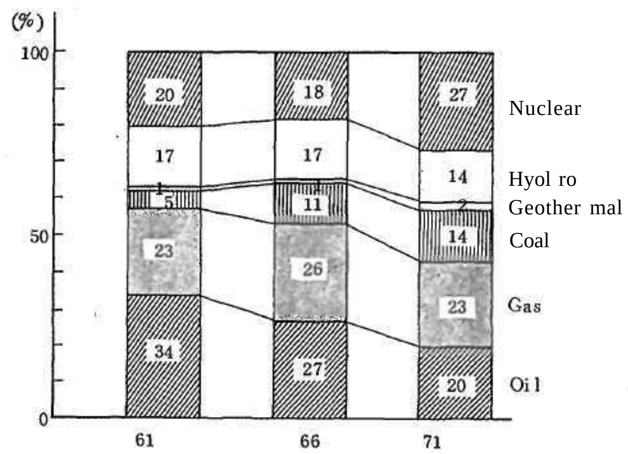

Fig. 1

Total Available Power by Energy Source

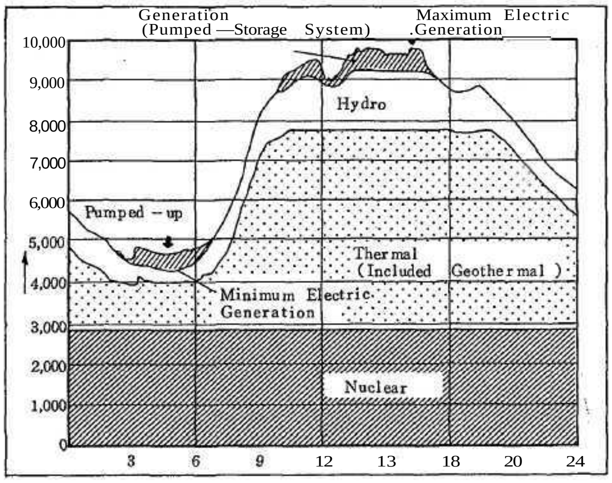

Fig.2 Example of Daily MW Demand

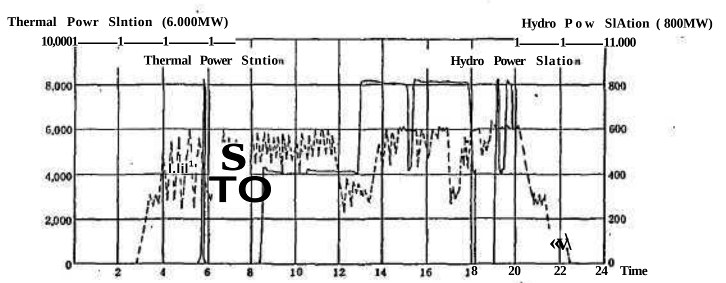

Fig- 3 Example of Daily MW Demand in Hydro and Thermal Power Station

II. Reservoir model and the conditions of production zone and reinjection zone of Otake and Hatchobaru geothermal fields

Geological strata of Otake and Hatchobaru fields are composed by Kujyu volcanic rocks (Quaternary), Hohi volcanic rocks (Quaternary), Usa group (Tertiary) and basement rocks (Pre-Tertiary) as shown in Fig. 4.

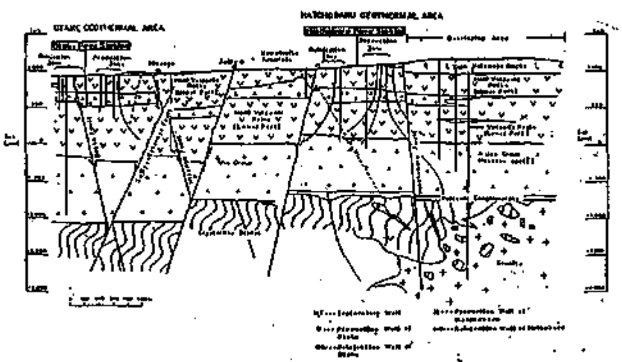

Fig. 4. Geologic Cton Scclion ol Olofcc-Hotchoboru Gtolhtlnjol Ate

Table 1 shows the list of production wells and reinjection wells of Otake and Hatchobaru power stations, and the list of exploratory wells of Hatchobaru power station Unit II.

Existing data, and new data (such as geophysical exploration data, geochemical survey data and well characteristics and etc) were reviewed to prepare "Resume for well drill planning" as shown in Table 2 in April 1987, in which reinjection wells are strongly recommended to be planned never to effect to the production wells.

The resume for well drill planning is very useful to develop the fault system reservoir at Otake and Hatchobaru geothermal fields.

1) Otake field

Developed production zones are distributed at comparatively shallow part(400 _ 500 m depth) surrounded by Otake fault, Yokoo fault and Hizenyu fault. The shallow reservoir is not directly controlled by the fault, but is formed in fractured zone sealed by Otake fault from the reinjection zone. A fault system reservoir was expected at the deep, but it is located at out of KEPCO's property, and therefore the exploration of the deep reservoir was abandoned because of the difficulty to get permission to enter the private land.

Replacing production well 0-22 was drilled in according to the abovementioned resume for well drill planning, was drilled deeper than the planned depth based on the fluid inclusion homogeneous temperature analysis of cuttings, was finally succeeded to produce steam which is equivalent to 6 MW from the depth of 1561 m.

Otake power station is continuously generating the rated output 12.5MW as shown in Fig.7 since the success of 0-22 drilling.

2) Hatchobaru field

Production wells and reinjection wells were drilled around the boundary of Hohi volcanic rocks and Usa group surrounded by Komatsuike fault and Komatsuike subfault as shown in Fig.6.

Exploratory wells(HT-12 15) for Hatchobaru Unit II were drilled in according to the abovementioned resume for well drill planning and to the new exploration data. Based on the new exploration data, NE-SW trending fault which is perpendicular to the Komatsuike subfault is expected as promissing reservoir, and exploratory well HT-12 17 were succeeded to produce steam from the NE-SW trending reservoir.
Based on the successes of these exploratory wells, Unit II is under construction.

		Jan '41 ~ Mar '87			Apr '87 ~			Total Rate of Success (%)
		Well Number	Success Well	Rate of Success(%)	Well Number	Success Well	Rate of Success (%)	
Hatchbaru	Production and Exploratory Well	30 (H-1 ~ 11-22 N HIT-5-l~HT-ll'')	23	77	4 (HT-14~15)	4	100	79
	Reinjection Well	25 (HR-l~HR-25)	18	72	2 (HTR-2, HR-26)	2	100	74
Otake	Production Well	14 (O-6~O-20)	10	71	1 (O-22)	1	100	73
	Reinjection Well	18 (OR-1~OR-18)	17	94	2 (OR-19, 20)	2	100	95
Total		87	68	78	9	y	100	80

Table 1. Results of Well Drilling

Table 2 Resume for Well Drill Planning

Item	Reason
A. The distance between the fault by Geological Survey and main lost circulation zone of each well	Geothermal reservoir locates in fracture zone by fault
B. The distance between clased controur part of 1 Hz apparent resistivity map by MT method and main lost circulation zone of each well	Ditto, apparent resistivity map in 1 Hz shows, resistivity map above 1,000m in depth. closed contour part shows change of electrical resistivity and a possibility of fault.
C. Depth change of electrical basement	Fracture zone locate in the layer
D. Resistivity rate of low resistivity zone around main lost circulation zone of each well	The degree of geothermal activity low resistivity by geothermal activity
E. Volume of low resistivity zone around main lost circulation zone of each well	The depth of bad permeability zone is estimated; low resistivity zone is correspond to acidic alterlation zone (bad permeability zone)

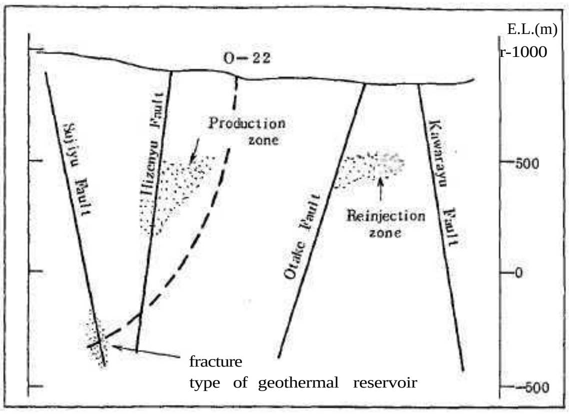

Fig. 5 Reservoir Model of Otake Field

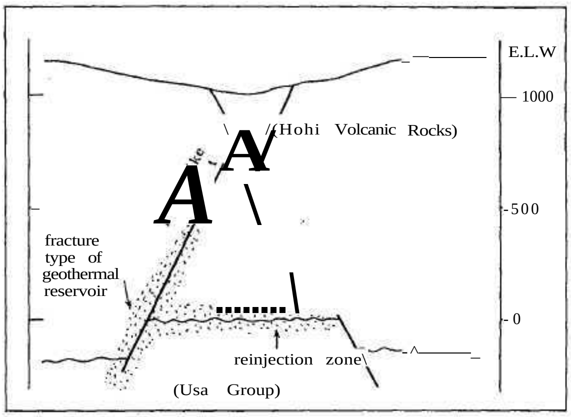

Fig. 6 Reservoir Model of Hatchobaru Field

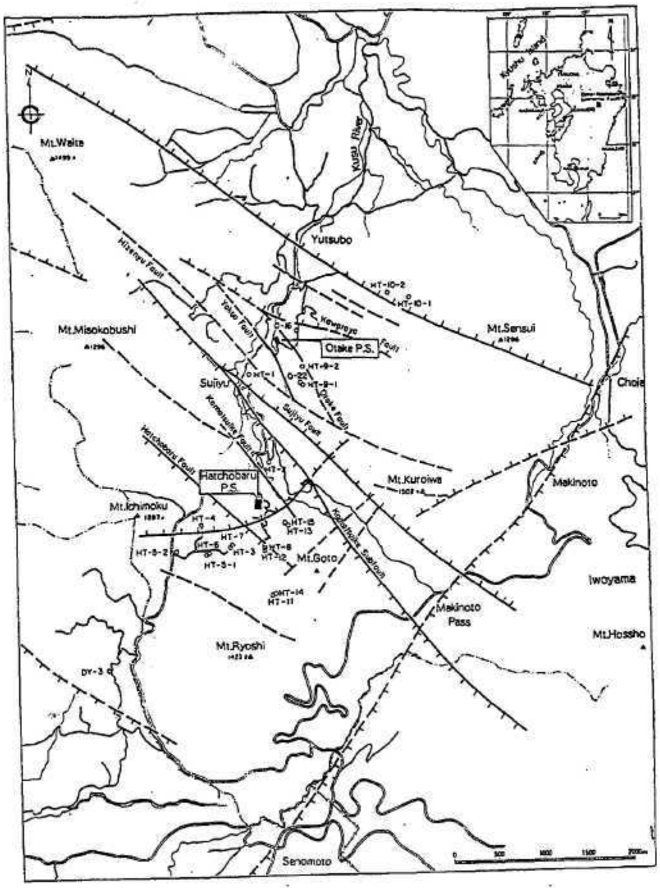

Fig. 7 Well location and faults in Otake and Hatchobaru

III. Power station operation conditions

1) Otake power station

Otake power station began commercial operation in 1967, using the separated steam and discharging the separated hot water to an adjacent river. However, to cope with the environmental regulation which came into effect in 1972 and restricts the arsenic concentration in the separated hot water, reinjection of separated hot water was started in 1973, and then generating output depended on the capacity of reinjection wells. Fortunately the power station could be continuously operated without serious problems. Generating output increased temporarily after drilled replacing production wells, however the total steam flow rate decreased gradually to the constant which is the total steam flow rate before drilling the replacing wells as shown in Fig.8. The power station is, however, generating the rated output continuously after drilled the replacing well 0-22.

Regarding maintenance conditions, several troubles such as the level control system for water tanks installed on separators, melting of brazed section in connection strips among generator rotor coil and short circuit between generator rotor coil, were occured, however these were not particular troubles for geothermal power stations. Countermeasures for corrosion and erosion of electrical equipments and cooling water system have been effective to operate power station without serious problems.

2) Hatchobaru power station

Hatchobaru power station was commenced the commercial operation in 1979 by the rated output 50MW, and its rated output was increased from 50MW to 55MW by considering the successes of production well drilling, the lower generating cost and the ability of main equipment of power station. The power station has been operated with very high capacity factor since the commencement as shown in Fig.8.

The power station was designed to generate 55MW at the minimum wet bulb temperature in winter and then to generate 51.5MW at 23 C wet bulb temperature in summer by the same steam flow rate. It is now under the examinations to decrease the generating cost by improvement the power station to generate 55MW in summer (by drilling necessary production wells) and to use the excess steam to generating 55MW for steam ejectors instead of motor driving blowers in winter.

Double flash system is very effective for power generating and its advantages are as follow.

(1) The ratio of steam-water of water dominated reservoir is usually changed after the commencement of power station. Double flash system can adjust the ratio of primary and secondary steam by changing the turbine inlet pressures, and then can maintain the generating output.

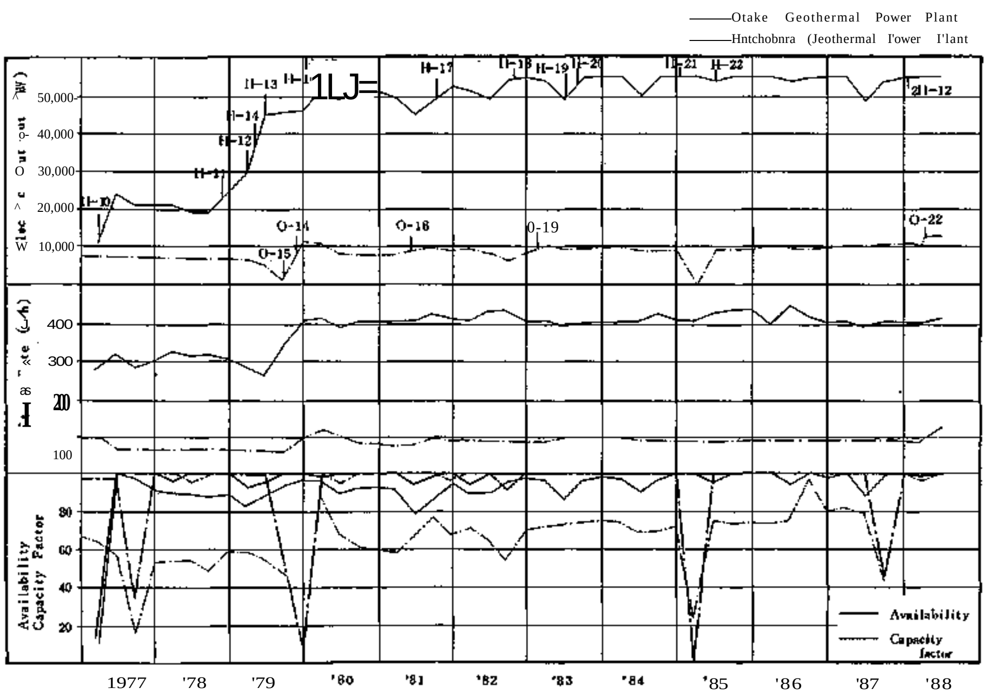

Fig. 8 Operation Condistions at Otake and Hatchobaru Geothermal Power Plants

(2) When production wells decrease the capacity and stop to produce primary steam at the power plant operating pressure, the wells can still be used to produce steam at lower wellhead pressure to utilize as secondary steam.

2. Developing plan of Hatchobaru Unit II

(1) Exploratory wells for Hatchobaru Unit II were drilled successfully, and the total steam flow from these wells is equivalent to 38MW.

Unit II was planned to construct as the adjoining place of Unit I and was designed as same as Unit I; namely two phase transmission system and double flash system. Specifications and layout are shown in Fig.9 and Fig.10 respectively.

(2) Environmental countermeasures and monitoring
Environmental regulation in Japan is most severe in the world, it regulates not only for geothermal development, but also for every industries.

Following items are required for environmental assessment to develop geothermal power station; namely air pollution (hydrogen sulfide), water pollution (water quality to discharge to river), noise and vibration pollutions, ground subsidence, induction of earthquake and influence to the adjacent hot springs. Environmental assessments have to be reported to local governments and Environmental Agency, and geothermal power station have to be operated to keep its environmental influences bellow the regulated values.

Table.*U* shows the monitoring items for environmental protection after the commencement of Unit II.

Table 3 Results of Well of Hatchobaru II

	Name of Well	D-illing Time	Dia XDepth (unX m)	Bore hole Temperaturi CO	Discharge Rate (T/H)		Equivaleut Electric Output
					Steam	Hot Wbtar	
Production Well	HT-5 - 1	56/12~ 57/5	216X3.0 0 0	284	Not dischanze		
	HT-6	57/4 ~ 57/6	216X2,500	286	dittio		
	HT-7	56^12~ 57/8	216X1,850	262	38	53	4,7 00
	HT-8	57/1 ~ 57/8	216X1,350	242	10	5	1,3 0 0
	HT-11	60/9 ~ 60/12	216X2,250	244	Not dischrged		-
	HT-12	60/3 ~60/5	216X1,50 0	278	63	54	9,0 0 0
	HT-13	61/8 ~ 60/12	216X1,503	272	52	153	9,0 0 0
	HT-14	61/ll~62/3	216X1,448	271	15	8	3,0 0 0
	HT-15	61/ll~62/S	216X1,290	261	17	186	11,0 00
Reinjection Well	HT-5- - 2	57/5 ~ 57/10	216X1,305	194			-

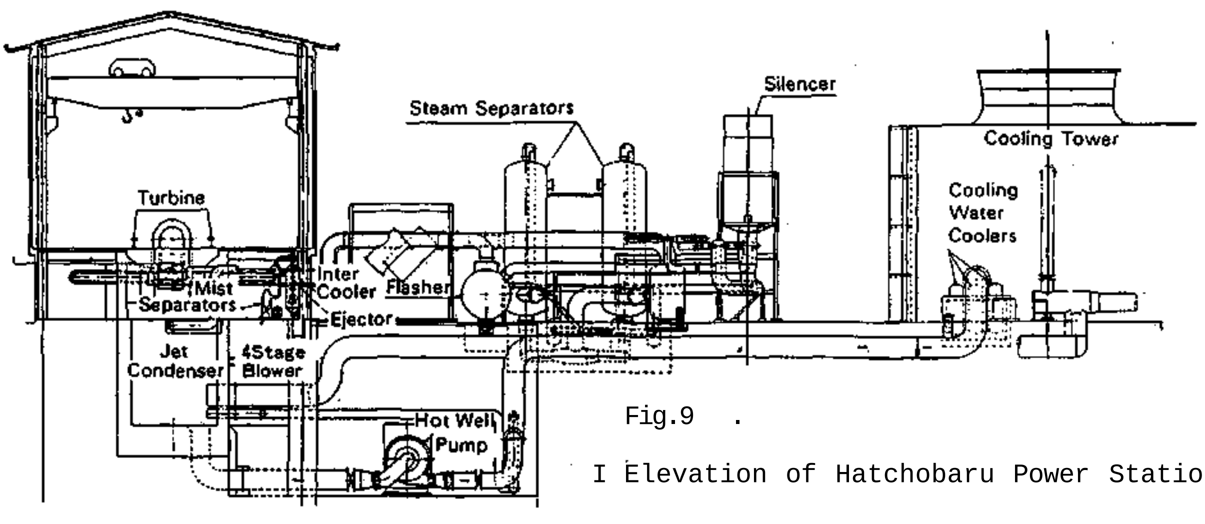

Fig.9 .

I Elevation of Hatchobaru Power Station

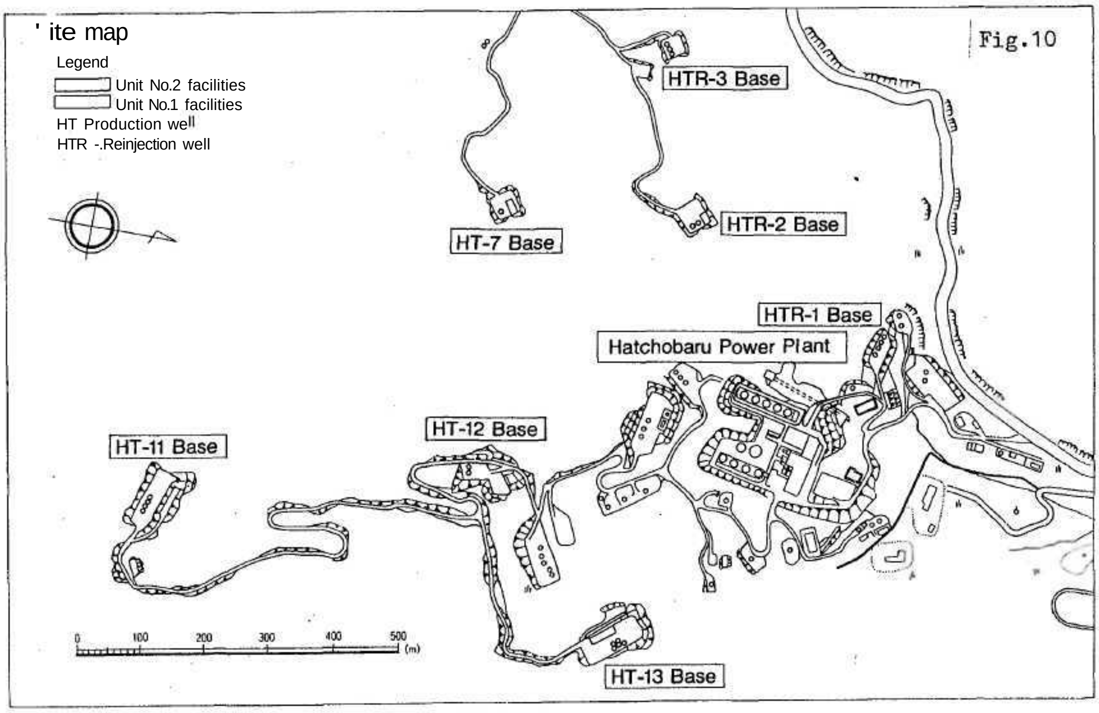

Table.A **List of environmental measuring items and sonitoring frequency**

Environmental measuring items				Frequency		Measuring points
Assessment by discharged fluid from product Hells	Water quality of river	Arsenic	As	4times/year	June September December March	5 points in watershed of Kusu river
		Chloride ion	ci-			
		Hydrogen ion concentration	PH			
	Arsenic concetration in river sediments		As	once/year	September	
	Reinjection wells	Injection rate per unit time		once/month	every month	Every injection wells
		Change of underground water level			September	Several observation wells
	Hydrogen sulfide gas concetration in air near the grand surface		H_2S	once/month	June September December Harch	6points power plant site and its vicinities
	Hydrogen ion concentration in surface soil		PH			
Survey of discharged fluid from product Hells	Flow rate of steal			4times/year	June December	Steam turbine inlet
	Flow rate of hotwater					Flashing tank outlet
	Chemical composition of hotwater	Arsenic	As			
		Chloride ion	cr			
		Hydrogen ion concentration	PH			
	Noncondensable gas	Gas ratio				Separator outlet
		Chemical composition of gas	CO 2			
			H_2S			
			N_2 otlie-rs			
Hoise measument				tHice/year	June December	9 points on boundary line of pawer plant
Survey of environmen-tal indicator	Vegitation survey of indicator plant			once/year	September	11 points in paHer plant site and one point in Mount Hitomeyama
	Observation of landscape					The hole vieH photograph
Hicro seismics				Continuous measurement	Continuous measurement	----------------

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