

ISOTOPES AND GASES IN A HAWAIIAN GEOTHERMAL SYSTEM: HGP-A

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Gases from the Hawaii Geothermal Project well-A (HGP-A) were sampled over the course of twelve months to determine their isotopic and chemical composition. Samples of steam and gas were collected and condensed at the well head through a twin cyclone steam/water separator during steam discharge of the well.

Gas separations were carried out on standard gas chromatographic columns with thermistor and mass spectrometric detection of the chromatogram peaks. Isotopic analyses were carried out on several individual components of the gas phase: CO₂ ($\delta^{13}\text{C}$), N₂, He, H₂O ($\delta^{18}\text{O}$).

Results. The results of the chemical analyses made for the geothermal gases sampled are summarized in Table 1. The most important aspect of the data presented here is that there appears to be a significant increase in the concentration of geothermal gases in the well output during each successive discharge of the well. Hydrogen and hydrogen sulfide appear to be increasing in concentration relative to the nitrogen and carbon dioxide fraction of the well gases. It is felt that these changes reflect the progressive maturation of the well toward a steady state composition of the geothermal fluids.

Helium analyses were also made on the well gases. It was found that the helium:nitrogen ratio in the well was at least six times the atmospheric concentration although analytical difficulties prevented an exact determination of the helium concentrations.

A summary of the isotopic analyses made on HGP-A gases is presented in Table 2. The carbon, nitrogen, and helium analyses were made on gases obtained during steam discharge while several oxygen analyses were made on downhole water samples.

The interpretation of the carbon isotope data is considerably complicated by the presence of ^{14}C at a concentration of 20% of modern carbon in the well gases, thus indicating that no less than 20% of the carbon dioxide in HGP-A is from atmospheric or biogenic sources. The origin, true age, and isotope composition of the biogenic fraction of the carbon in the well is presently unknown. Further testing of the well gases is presently planned in order to determine the relative contributions of the several possible sources of carbon in HGP-A.

The oxygen isotope data presented in Table 2 indicate only slight variations with depth in the well. This can be interpreted in one of two ways: either the water in the thermal reservoir (and the well bore) is very well mixed with depth, or one of the several possible fluid sources for HGP-A is providing nearly all the water in the well. It is presently felt that the latter possibility is the more likely.

The $\delta^{15}\text{N}$ values observed for HGP-A are richer in ^{15}N than any nitrogen ratios reported in the literature to date. Whether these values reflect the true isotopic composition of HGP-A nitrogen or whether they are an artifact of contamination is uncertain at present. Analyses by gas chromatography-mass spectrometry are presently underway to resolve this question.

The helium isotope ratios presented in Table 2 are seen to be quite high and are similar to values observed for helium in fumarole gases taken from the Kilauea summit. This is a very strong indication that there is a large component of magmatic gas in the geothermal well fluids. One can conclude from this that the heat source from which HGP-A taps its fluids is in close communication with the Kilauea volcanic system. It is believed that the inter-connection is laterally through the east rift zone rather than directly to the deep magma reservoir beneath Kilauea (R. Koyanagi, personal communication).

The conclusions which can be drawn from the above reported results are as follows: (1) There are at least 3, and possibly more, sources of geothermal fluids in HGP-A. The relative contributions of the fluids has been tentatively set at: ocean water, 10%; meteoric water, 65%; hydrothermal fluids, 25%. (2) The rift zone in which HGP-A is situated is in close contact with the Kilauea volcanic system. Thus it is possible that the exploitable lifetime of this heat source will be much longer than would be expected for an isolated geothermal system.

TABLE 1
SUMMARY OF GAS ANALYSES FOR HGP-A

Date/Type of Sample	Sampling Pressure (psi)	Temp. (°C)	Total Gas Content (mg/kg of discharge)	Composition (wt %)				Mole Ratio	
				CO ₂	H ₂ S	N ₂	H ₂	CO ₂ /H ₂ S	N ₂ /H ₂
29 Jan. 1977; Total Condensate from Cooled Cyclone Separator	50	30	991*	72	10	18	0.1	5.5	19.5
5 April 1977; Steam from Cyclone Separator	165	185	1604	59	20	21	0.5	2.3	3.0
9 May 1977; Steam from Cyclone Separator	167	188	1912	57	21	21	1	2.1	2.4
	40	188	2697	65	24	10	.4	2.1	1.8
19 July 1977; Steam from Cyclone Separator	25	180	1337	71	18	11	.5	3.0	1.6
Best estimate for total gas content of HGP-A	-	180	2100	60.3	21.7	17.3	.6	2.1	2.1

*The 29 Jan. 1977 values most closely reflect the composition of the HGP-A stack emissions.

TABLE 2
Isotope Analysis Results

Date Sampled	$\delta^{13}\text{C}$ ‰ vs PDB (CO ₂)	Comments
7-22-76	- 3.62	Carbon dioxide gas samples taken during steam discharge.
11-8-76	- 2.35	
11-16-76	- 3.28	
1-30-77	- 1.97	
2 - 77	- 2.29	
Mean	- 2.7	

Date Sampled	Depth Sampled	$\delta^{18}\text{O}$ (H ₂ O)
8-19-76	1000 ft	- 3.79
8-19-76	4300 ft	- 4.5
8-19-76	5800 ft	- 4.2
8-19-76	6300 ft	- 4.56
10-30-76	2270 ft	- 4.14
10-30-76	5800 ft	- 3.83
2-9-77	top / steam	- 5.58
2-9-77	top / steam	- 3.60

Date Sampled	$\delta^{15}\text{N}$ (N ₂)	Comments
5-8-77	+ 55.7	Nitrogen gas sampled during steam discharge-- all samples treated with CuO to remove CO and CH ₂ O.
5-8-77	+ 56.7	
7-19-77	+ 55.9	
7-19-77	+ 57.6	

Date Sampled	Depth Sampled	$\frac{^3\text{He}}{^4\text{He}}$
1-25-77	3500 ft	>> 8.25 x 10 ⁻⁶
1-25-77	5800 ft	8.25 x 10 ⁻⁶
2-9-77	top / steam	1.7 x 10 ⁻⁵
	Kilauea fumarole gas	2.0 x 10 ⁻⁵
	Atmospheric Air	1.4 x 10 ⁻⁶