

PRELIMINARY REPORT ON COLLECTION AND ANALYSIS OF
VOLCANIC GASES FROM SURTSEY

by

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Considerable effort has been exercised in connection with sampling and analysis of volcanic gases from Surtsey. Relatively little information is available on the chemistry of volcanic gases from Iceland and other parts of the Mid-Atlantic Ridge. On the other hand considerable information on volcanic gases from the Pacific area has been accumulated during the past few years, and it will be of major interest to compare the chemistry of volcanic gases from the Atlantic and Pacific areas.

Shortly after the Surtsey eruption changed over to a quiet outpouring of lava, attempts were made to collect escaping gases. During 1964 four such attempts were made on May 21st, August 19th, October 15th and November 25th. On each of these occasions different conditions of sampling were met with since conditions at the crater changed rapidly.

May 21st. Samples were taken from a lava fissure away from the main stream of lava. One meter below the surface the lava was still glowing, temperature measurements with an optical pyrometer indicated 840°C. Copper tubing was used to draw the gas into a dewer bottle, cooled in air, where water was condensed and from there the gas was pumped into the gas sampling tubes.

August 19th. On this sampling trip conditions were similar as during the first trip. Copper tubing proved, however, fully inadequate, because of drastical corrosion of tubes and too low melting point.

October 15th. Conditions at the crater had now changed in such a way, that the main bulk of lava escaped by closed channels after remaining for a short while in the open crater.

At a few places along the channel roof gases escaped. Sampling was performed at one such exit, a narrow opening where gases were emitted at high velocity. At 10 cm high torch like sodium coloured flame was formed as the gases burned with atmospheric oxygen.

Temperature measurements were attempted with thermocouples mounted on the end of an iron tube. This tube melted in the flame. Fortunately the copper tubing used for previous sampling attempts had now been replaced with a tube of stainless steel, which was lowered below the base of the flame. The gas instantly filled the sampling tubes and since pressure was considerably above atmospheric all along the sampling train, contamination was effectively prevented. Because of rapid reaction between sulphur dioxide and hydrogen sulphide under these conditions, the presence of H_2S was checked with lead acetate paper at the end of the stainless steel tube. The test was not indicative of any appreciable amount of H_2S , a faint brownish colour developed on the paper. In the condensate, however, considerable amount of elementary sulphur was precipitated resulting either from the reaction $2H_2S + SO_2 \rightleftharpoons 2H_2O + 3S$ or condensation of sulphur gas.

Because of the large amount of gas flowing through the sampling train, condensation of steam was probably not fully effective resulting in low steam to gas ratio.

November 25th. Conditions at the crater were similar as on the October trip. Samples were taken from an opening on the lava tunnel close to the crater wall. This opening was, however, 2-3 meter wide and a relatively quiet but large flame was developed. The stainless steel tube was lowered into this opening, and the gas drawn through the sampling train with an aspirator bottle.

Discussion.

With an exception of the gas sample of Oct. 15th all samples were heavily contaminated with air. This contamination results from convective air currents within the lava. On May 21st and August 19th reaction with the copper tubing resulted in low oxygen. No active volcanic gases were detected in those two samples except CO_2 .

As shown by the H/D analysis of the condensate from May 21st (Arnason, this report), the steam probably resulted from evaporation of sea water from the wet ash underlying the lava. During this early period of lavaproduction, large amounts of incrustations were formed on the lava surface, giving it a peculiar green colour. The principal component of these salts is apthitalit ($\text{K}_3\text{Na}(\text{SO}_4)_2$).

The gas samples of Oct. 15th are unique with regard to low, if any, atmospheric contamination. Maximal amount of air, which could have been introduced into this sample, is 1 percent if all nitrogen is considered atmospheric. Nitrogen and rare gases are however undoubtedly present in volcanic gases and a valuable upper limit for the concentration of these components in the gases from Surtsey is established with this analysis.

The Oct. 15th sample contains 3.4 percent CO in the non-condensable components and 45.9 percent CO_2 . In all other samples carbon is just found as CO_2 . Methan was not detected in any of the analysed samples. (Limit of detection of the analytical method is 0.01 percent CH_4).

Sulphur is present as SO_2 in all samples where sulphur was found. H_2S has not been detected in the gas samples, but strong smell of H_2S from the beginning period of lavaproduction has been reported. In the case of the Oct. 15th sample, H_2S , if present, was converted completely to elementary sulphur.

Equilibrium calculations by Heald, Naughton and Barnes (1962, 1963) show that at 1500°K and variable partial pressure of oxygen, there are regions where in each oxydation reduction couple, such as H₂S - SO₂ or H₂ - H₂O, the reduced or the oxydized gas is dominant. In the case of our Oct. 15th sample, the oxydized gas components are clearly dominant. The partial pressure of oxygen in a gassystem containing all sulphur as SO₂ is, according to Heald et alii, greater than 10⁻⁴ atm at 1500°K. The calculated equilibria given by these authors is found on the basis of a sample with atomic ratios, hydrogen : oxygen : carbon : sulphur - 275.5 : 142.2 : 2.680 : 1.000. The atomic ratios for our Oct. 15th sample are respectively 20.3 : 31.3 : 1.82 : 1.000, the difference between these two samples depending principally on higher water content in the sample from Hawaii. If we, however, use the calculated equilibrium curves of Heald et al., a minimum partial pressure of oxygen would be 10⁻⁹ atm if the detection limit for H₂S of our analytical method is 0.1 percent of the noncondensable components.

Based on the concentration of components in the Oct. 15th sample, the equilibrium temperature for this mixture can be calculated

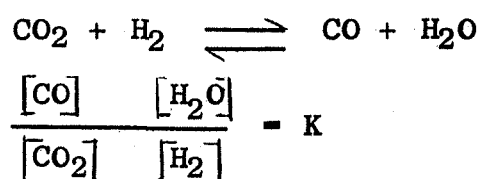


Fig. 1 shows the change in K with temperature according to values taken from Critical Tables and from Ellis (1957). For the Oct. 15th sample K = 1.30 indicating a temperature of 1190°K and 1157°K respectively (885 and 920°C).

This calculated equilibrium temperature is considerably below the measured temperature at the vent 1100 - 1200°C (Sigurgeirsson, this report), and 100° lower than the temperature

obtained by Arnason (this report) by means of isotope fractionation studies. These results are in accordance with the findings of Heald et al., which found an equilibrium composition of volcanic gases from Hawaii to correspond to a lower temperature than actually measured at the sampling site.

References

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TABLE I
Chemical analysis of volcanic gases.

	1.	2.	3.	4.	5.	6.
	21.5.64	19.8.64	15.10.64	25.11.64	25.11.64	
H ₂ O	62.83	11.74	80.00	76.94	76.94	18
O ₂	6.73	15.09	0.00	3.69	3.39	14
H ₂	0.00	0.00	4.56	0.00	0.00	0.022
CO ₂	0.07	0.44	9.18	0.99		0.37
SO ₂	0.00	0.00	5.40	0.90	2.05	0.057
CO	0.00	0.00	0.68	0.00	0.00	Tr.
CH ₄			0.00			
N ₂ +A	30.37	72.73	0.18	17.48	17.62	68
TOTAL	100.00	100.00	100.00	100.00	100.00	
TEMP. °C	840	840	1100	1100	1100	750

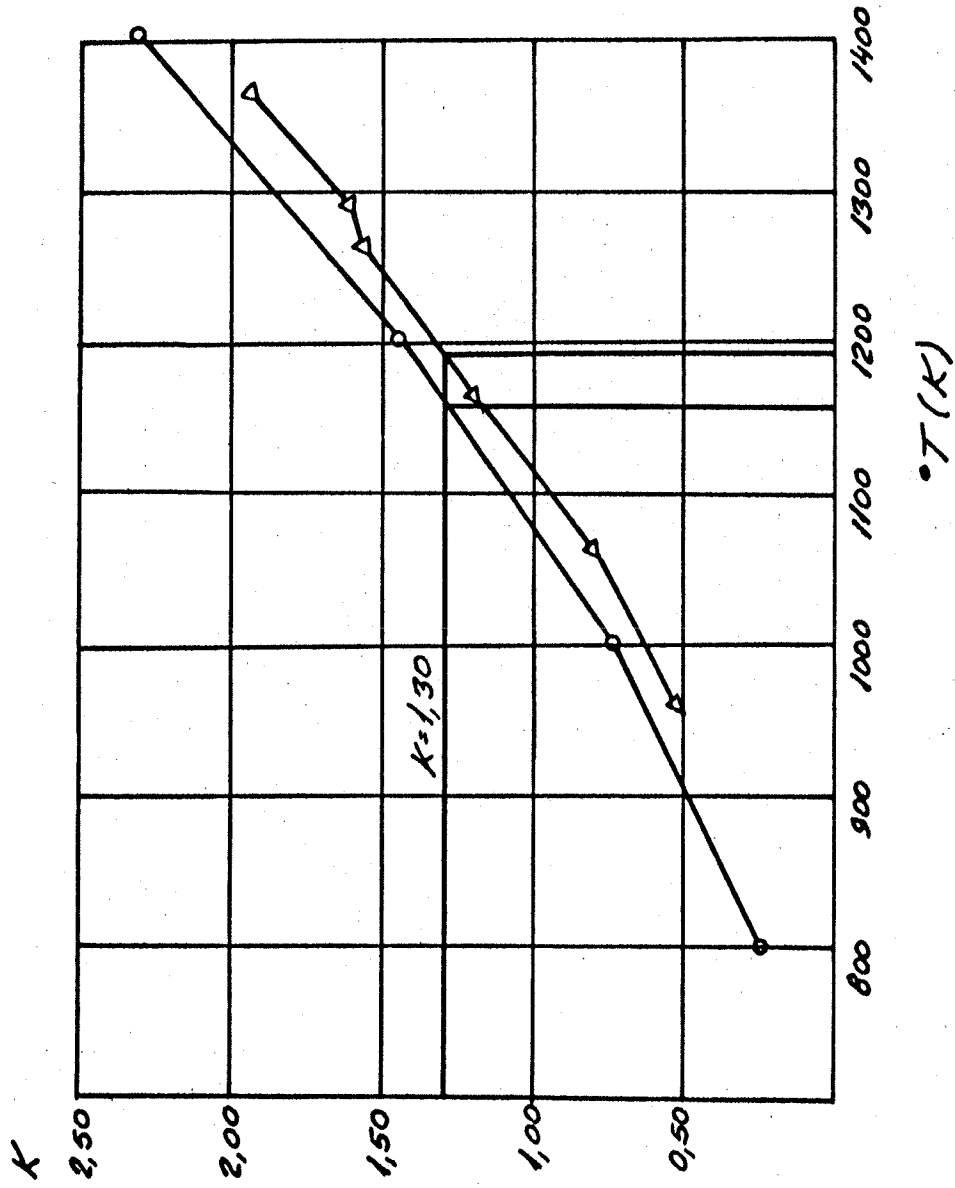
1-5. Surtsey.

6. Puu Puai, Hawaii 30.11.59 (KI-F) (HEALD, NAUGHTON, BARNES 1963).

H₂S : 0.12%

TABLE II
Chemical analysis of noncondensable component
of volcanic gases from Surtsey.

	21.5.64	19.8.64	15.10.64	25.11.64	25.11.64
O ₂	18.1	17.1	0.00	16.0	14.7
H ₂	0.00	0.00	22.8	0.00	0.00
CO ₂	0.2	0.5	45.9	4.3	8.9
SO ₂	0.0	0.0	27.0	3.9	
CO	0.0	0.0	3.4	0.0	0.0
CH ₄			0.00		
N ₂ +A	81.7	82.4	0.9	75.8	76.4
TOTAL	100.0	100.0	100.0	100.0	100.0



Ellis (1957)

Critical Tables



$K=1,30$

T (K)