Possible formation of amino acids when molten lava comes in contact with water

by

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Introduction

During volcanic eruptions metallic carbides are exposed to the atmosphere and water where they react to form simple carbon compounds. These can be the first steps in further reactions towards amino acids and more complex organic compounds.

The experiment described was performed in order to test whether simple organic compounds might be synthesized from inorganic during the volcanic activities at Surtsey.

While the present experiment was being prepared, a group of scientists from National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California, U.S.A., visited Iceland on Oct. 4th, 1966. They were assisted in collecting samples of

a) dry and wet surface dust from Surtsey sand and a crater fumarole with temperatures ranging from 120°C to at least 150°C.

b) ash from the crater island "Syrtlingur" before and after it touched the surface of Surtsey.

These samples were analyzed by C. Ponnamperuma et. al. and are reported on in Surtsey Research Progress Report III (1967)

The water extract of the sample of "the Surtsey ash" contained 0.003 uM each of aspartic acid and alanine as well as 0.004 uM each of glycine and aerine. The HCl extract contained traces of glycine, serine and alanine. The freshly collected ash was found to contain 100 parts per million of organic matter and that from the fumaroles 50 parts per million. As stated by Ponnamperuma (1967) there were, however, a number of possible sources of

contamination, such as the sea water which constantly rushed into the crater, and organic matter in the air.

The following experiment described here, however, was carried out under aseptic measures where contamination with natural ocean water and air was prevented, and where the natural phenomena of contact between molten lava and water was directed under controlled conditions.

Methods

The experiment was performed as follows. Three different kinds of liquids were prepared:

1. Destillated water D.W.
2. Filtrated sea water S.W.
   This sea water was collected off the Reykjanes peninsula.
3. Artificial sea water A.S.W.
   This was prepared by dissolving in destillated water the various inorganic salts as listed in formula 1.

Liquid no. 1 was sterilized in an autoclave. Liquids nos. 2 and 3 were filtrated through Zeiss filters.

The solutions were stored in sterile containers in a cool storage. Three gallons of each sample were used in the experiment, but one gallon of each kept as a control.

Three new aluminium vessels of 20 liters capacity with lids were obtained. After thorough cleaning with destillated water they were sterilized in an autoclave for 45 minutes, then they were placed into sterile polyethylen bags and closed tightly. Three extra glass jars were also provided for and prepared as above, later to be filled with cinder.

In the course of experiment two ladles with long shafts were also used.

On Oct. 14th 1966 an expedition was made to Surtsey, the new volcanic island, where it was possible to get access to molten lava in an isolated opening approximately 500 m from the crater,

where the lava of 1100°C temperature flooded from the crater in subterraneous veins or closed tunnels from under the solidified surface of somewhat older lava. The solid lava surrounding the open spot was free of any vegetation as Surtsey was almost devoid of life and the atmosphere over the surface of Surtsey is furthermore very clean with quite a low bacterial count. This was tested on several occasions previously and during the summer 1966 (Fridriksson 1965, Fridriksson and Kolbeinsson 1965, and Kolbeinsson and Fridriksson 1967).

The liquids of each sample previously prepared as indicated in item 1, 2 and 3 had been carried to the island in nine gallon containers, three gallons of each sample. The aluminium vessels were then opened and each filled with one sample of liquid. Three gallons of liquid respectively being poured into each vessel. Then molten lava was scoped up with a ladle from the lava stream and poured into the vessels, an approximately six lbs. portion of lava into each vessel. When the molten lava came in contact with the liquid an explosive boiling occurred with steam being evolved for ca. 5 minutes. Then the solutions were again transferred from the aluminium vessels to the sterile 1 gallon glass containers, three containers for each solution.

The cinder from each lot was separated and transferred to three sterile glass jars The samples were transported to Reykjavik and stored in a cool storage.

On Febr. 4th 1967 liquid samples were drawn from the glass flasks under sterile conditions for bacteriological investigation. Liquid no. 2 and control turned out to be contaminated with a flagellated bacterium, but the remaining samples were sterile. The contamination of the liquid no. 2 is most likely due to failure in the filtration process.

Results and Analysis

a) Rock samples of each treatment (1, 2 and 3) were sent to Dr. C. Ponnamperuma of N.A.S.A., California. Two samples

of No. 1 and one sample of No. 2 and No. 3. Two of the containers broke during the transport and when the remaining two were tested, No. 1 and No. 2 were both contaminated.

b) A rock sample of treatment 1 (rock from distilled water) was shipped in the sterilized containers to Dr. Sidney W. Fox, Institute of Molecular Evolution, University of Main, Coral Gables, Florida, U.S.A. When this sample was tested for contamination, both before shipping from Iceland and in Florida, it proved to be free of organisms. It arrived in good condition and was tested for amino acids by analyses of the extract as well as of the crushed sample.

Amino acids were found present in both cases as indicated in attached list. On the whole the values were higher than in ash samples collected by Ponnamperuma et.al. except for the two sulfur-containing amino acids, methenine and cystine. The sample also contained a high NH_3 value 1.243 uM indicating a possible contribution from the geochemical environment.

All precautionary measures had been taken to prevent the samples ever coming in contact with any organic matter. Sample No. 1 was always kept in the clean sterile jar or distilled water. All implements used were washed thoroughly with distilled water and sterilized. And the test for contamination was performed in a sterilizing chamber at the Pathological Institute, Reykjavik. It would furthermore have to be considered highly unlikely that the sample of distilled water and cinder from Surtsey would serve as a favourable medium for growth if incidentally contaminated by bacteria.

As contamination must be regarded improbable it must be considered extremely likely that an amino acid synthesis did take place when molten basaltic lava of temperatures at 1100°C came in contact with the distilled water.

It should be accepted that abiogenesis does not necessarily have to be confined to the primordial conditions on primitive earth, but rather that it can take place wherever conditions may be similar to the conditions then present. Such conditions may be

produced during submarine volcanic activities. And these conditions may just have been present during the Surtsey eruption. There the basic compounds required for the synthesis were available in solution or gases whereas the energy necessary for bringing it about was available in forms of lightnings and temperatures of over 1100°C (Fridriksson 1966). Absence of oxygen is furthermore considered a necessity for the synthesis. It is regarded to have been almost, if not entirely, absent from the primitive atmosphere. In comparison analysis of volcanic gases from Surtsey as collected by Sigvaldason et.al. (1967) did similarly not show any free oxygen. Should these have been the conditions necessary for the primordial formation of life, the much similar conditions at Surtsey may have been providing conditions causing synthesis of primitive organic compounds.

Acknowledgements

I am indebted to Dr. Sidney W. Fox, Institute of Molecular Evolution, University of Main, Florida, U.S.A., for his kind assistance and criticism and to Mr. C.R. Windsor for analyzing the amino acids of the rock sample from Surtsey. This work has been sponsored by the Surtsey Research Society with a grant from the U.S. Atomic Energy Commission, Biology Branch, under contract No. AT(30-1)3549.

Formula [1] Artificial Sea Water

NaCl	18.014	g/l
$MgCl_2$	3.812	g/l
$MgSO_4$	1.752	g/l
$CaSO_4$	1.283	g/l
K_2SO_4	0.8163	g/l
$CaCO_3$	0.1221	g/l
KBr	0.1013	g/l
$SrSO_4$	0.0282	g/l
H_3BO_3	0.0277	g/l

ANALYSIS FOR AMINO ACIDS,

analyzed from a rock sample from Surtsey

Amino Acids	u Moles A	B
Lys	0.064	0.015
His	0.017	0.005
NH_3	0.694	1.243
Arg	0.048	0.010
Asp	0.096	0.037
Thr	0.055	0.010
Ser	0.056	0.027
Glu	0.082	0.068
Pro	0.037	0.033
Gly	0.136	0.150
Ala	0.136	0.027
Val	0.062	0.021
Met	0.014	
Ileu	0.045	0.018
Leu	0.073	0.026
Tyr	0.021	0.005
Phe	0.032	0.014

A - Extract of Surtsey Rock

B - Crushed Surtsey Rock