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ENDOGENOUS SYNTHESIS OF PREBIOTIC ORGANIC MOLECULES

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The necessary condition for the synthesis of organic compounds on the primitive earth is the presence of reducing conditions. This means an atmosphere of CH_4, CO, or CO_2 + H_2. The atmospheric nitrogen can be N_2 with a trace of NH_3, but NH_4^+ is needed in the ocean at least for amino acid synthesis. Many attempts have been made to use CO_2 + H_2O atmospheres for prebiotic synthesis, but these give at best extremely low yields of organic compounds, except in the presence of H_2. Even strong reducing agents such as FeS + H_2S or the mineral assemblages of the submarine vents fail to give significant yields of organic compounds with CO_2. There appears to be a high kinetic barrier to the non-biological reduction of CO_2 at low temperatures using geological reducing agents.

The most abundant source of energy for prebiotic synthesis is ultraviolet light followed by electric discharges, with electric discharges being more efficient, although it is not clear which was the important energy source. A reasonable rate of synthesis of amino acids from these sources under relatively reducing conditions is about 100 nmoles $cm^{-2}yr^{-1}$ of HCN, 10 nmoles $cm^{-2}yr^{-1}$ of amino acids or 0.10 moles cm^{-2} of amino acids in 10^7 yrs. This would give a concentration of 3×10^{-4} M in an ocean of the present size (300 liters cm^{-2}). The amino acids cannot accumulate over a longer period because the entire ocean passes through the 350°C submarine vents in 10^7 yrs, which decomposes all the organic compounds. Less reducing conditions such as CO or CO_2 atmospheres with only small amounts of H_2 give considerably less HCN and H_2CO with electric discharges. These compounds are central to prebiotic syntheses. Photochemical process would also make significant contributions. In an atmosphere of CO_2, N_2, and H_2O with no H_2, the production rates of HCN and H_2CO would be very low, 0.001 or less than that of a relatively reducing atmosphere. The concentration of organic compounds under these non-reducing conditions would be so low that there is doubt whether the concentration mechanism would be adequate for further steps toward the origin of life.

A number of workers have calculated the influx of comets and meteorites on the primitive earth as a source of organic compounds. Some of the amino acids from the meteorite proposed to have hit the earth

65 x 10^6 yrs ago have been detected at the Cretaceous/Tertiary boundary sediments.

The problem with proposing a large scale input of organic compounds from meteorites and comets is that they must survive passage through the atmosphere and the impact. There are some processes that would allow survival such as showers of centimeter to meter sized meteorites and various aerodynamic braking processes for larger objects. Even if all the input organic compounds survived, the amounts would be small relative to the earth based syntheses, except for the unfavorable case of a non-reducing atmosphere.

The earth based syntheses are continuous processes since much of the carbon from decomposed organic compounds can be recycled. The organic input from comets and meteorites is equivalent to a one time syntheses, and the destructive processes in the hydrothermal vents would remove these compounds on the average in 10^7 yrs or less. There are many other decomposition processes besides the vents for organic compounds. If it is assumed that the input rate was sufficient to overcome these destructive processes, then too much carbon and water, especially from comets, would have been added to the earth from comets and meteorites. We conclude that while some organic material was added to the earth from comets and meteorites the amount available from these sources at a given time was at best only a few percent of that from earth based syntheses under reducing conditions.