EARLY ENVIRONMENTAL EVOLUTION OF VENUS; **Takafumi Matsui and Eiichi Tajika, Geophysical Institute, Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan**

Since Venus has an almost similar size and mass to those of Earth, an impact-induced steam atmosphere and magma ocean were probably formed on the surface of a growing Venus (1). However the present surface environment differs largely between Venus and Earth (2). Then the question is why. One of most probable answers is that the steam atmosphere did not condense into oceans for Venus (1). Recent more detail studies on the evolution of $H_2O - CO_2$ atmosphere, however, suggest that proto-ocean formation is also possible on Venus although the existence of ocean was temporary (3, 4). In this respect it is interesting to study a potential role of the CO_2 cycle mentioned in our previous papers (5) on the evolution of Venus.

Operation of the CO_2 cycle requires the existence of oceans and continents, and earth-like plate tectonics. We are not yet convinced that the Venusian plate tectonics are similar to that of Earth. However, judging from the amount of ^{40}Ar in the present Venusian atmosphere, degassing from the mantle should have been efficient in the past. Degassing from hot spot activity is also possible but it is probably less than that associated with crust production at the Earth-like mid ocean ridge, because the area of hot plumes on Venus is rather small (2). This suggests that the Earth-like plate tectonics may have been active in the past. The duration of the plate tectonics may be, however, no more than 2 billion years in order to explain the present abundance of ^{40}Ar in the atmosphere (Fig. 1).

It is also very uncertain whether or not granitic continents formed on Venus. If the existence of water is a necessary condition for the formation of granites as suggested by Campbell and Tayler (6), the formation of granitic continents was also possible on Venus when proto-oceans covered the surface. Therefore, we can apply our CO_2 cycle model to an early stage of evolution of Venus. Venusian proto-oceans, however, did not exist eternally, because a higher solar flux resulted in higher surface temperature, which caused the so-called "moist greenhouse effect". Photo dissociation of water vapor followed by a hydrogen escape to space would result in the loss of oceans within the time scale of 500 million years (7). Therefore we assumed the constant escape rate of water corresponding to the above estimate.

Weathering rate depends on the surface temperature. Therefore higher surface temperature suggests a higher consumption rate of CO_2 in the atmosphere by weathering. As shown in Fig. 2, the CO_2 partial pressure would be lesss than that of the present Earth as far as the continents appears on the oceans. However continents are expected to be eroded away in a short time scale if the growth rate is much smaller. Most of the surface carbon exist on the sea-floor as carbonate rock. In this respect we may consider that the CO_2 cycle did not play a major role in the evolution of surface environment on Venus. If we are able to find any evidence of heavy wethering and erosion related landscapes on Venus from the ongoing Magellan missions in the future, we could say that the above theoretical prospect is probable.

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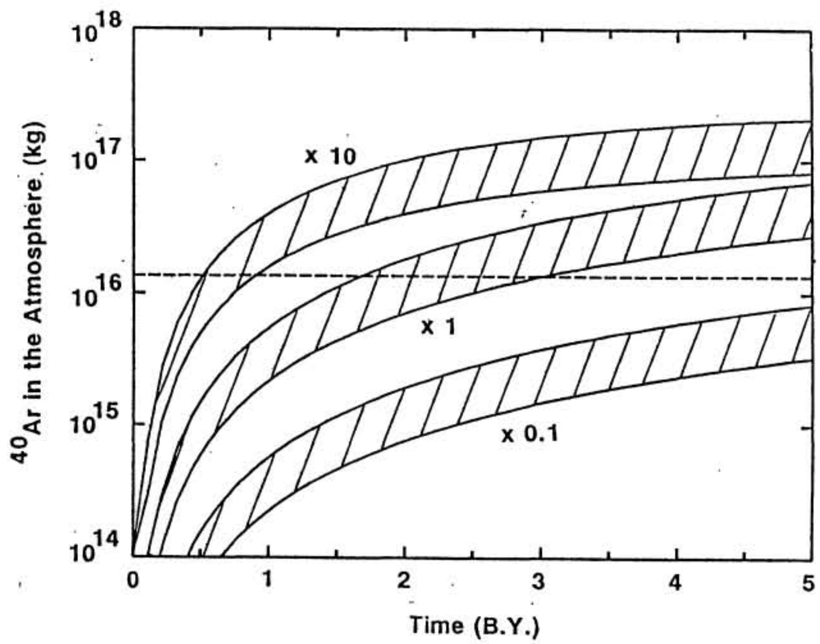

Fig. 1. Temporal variation of the amount of ^{40}Ar degassed from the interior by the midocean ridge type volcanism. The degassing rate is assumed to be one times, ten times, and one tenth of the present terrestrial value. Each shaded area represents the uncertainty of the estimate for the potassium abundance in the Earth.

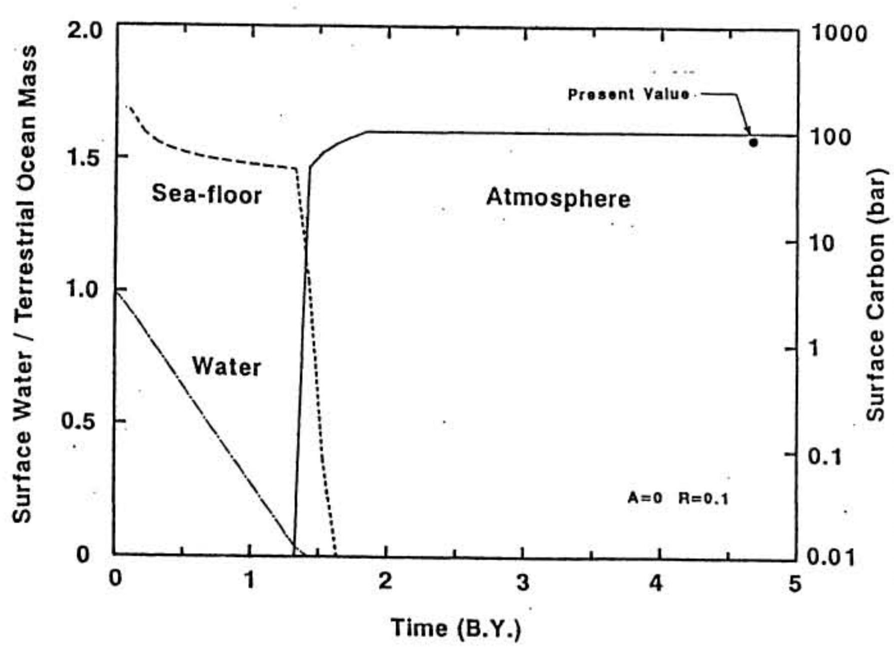

Fig. 2. Variation of carbon levels in venusian seafloor and atmosphere, and surface water on Venus. The escape rate of water is assumed to be constant. Degassing from mid-ocean ridges is assumed to be ceased at 2 billion years.

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