EARLY EVOLUTION OF VENUS AND MARS. Takafumi Matsui, and Yutaka Abe, Geophysical Institute, Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.

We found recently that the surface temperature of an accreting earth reaches the melting temperature because the released impact energy is trapped by the blanketing effect of an impact-induced H_2O atmosphere (1,2). The H_2O content in an impact-induced atmosphere becomes almost constant after the surface temperature reaches the melting temperature (3). Irrespective of differences in the assumed H_2O content of the accreting material, the constant level of the H_2O content does not significantly depends on the initial H_2O content, and almost corresponds to the present amount of the ocean. Since, Venus and Mars, as well as the Earth, were probably formed by accretion of planetesimals, formation of an impact-induced atmosphere during accretion may play an important role in controlling the early thermal history and origin of the atmosphere and hydrosphere. In this paper we will study the early evolution of these two planets following the computational scheme developed by Abe and Matsui (3).

Figure 1 shows the surface temperature and evolution of an impact-induced H_2O atmosphere of the standard Venus model (accretion time = 50 m.y., initial H_2O content = 0.1%, degassing parameter = 0.2 and critical impact pressure = 228kb). When the surface of Venus is molten, the surface temperature is nearly constant and H_2O content in the atmosphere is also nearly constant. It is shown that the nearly constant level of H_2O content does not depend significantly on the initial H_2O content. The early evolution of Venus does not differ significantly from that of Earth (3), but present environmental conditions of these two planets are quite different. What is the difference in evolution of impact-induced H_2O atmospheres? Figure 2 shows the radiative equilibrium thermal structure of the H_2O atmosphere heated by only the solar radiation. Solar flux is assumed to be 0.7 times the present one. The numeral attached to each curve represents the ratio of the optical depth for infrared and solar radiation. Although it is difficult to estimate this ratio for the thick H_2O atmosphere considered in this study, we may estimate it to be about 50 based on the observation of the Venusian atmosphere. The most significant difference in the thermal structure (see the curve with the numeral 50) of the H_2O atmosphere between Venus and Earth is whether or not the temperature at the bottom of the atmosphere is higher than the critical temperature determined by the vapor pressure curve. The radiative equilibrium temperature at the bottom of the atmosphere is lower than the critical temperature for Earth but not for Venus, which means that H_2O can be liquid for Earth but not for Venus. This may be the reason Venus does not have a hydrosphere at present, since H_2O in the Venusian atmosphere is gradually dissipated by the photo dissociation from the upper atmosphere.

The Early evolution of Mars is rather complicated compared to Venus and Earth because the surface temperature does not exceed the melting temperature except for a rapid accretion model. Both early thermal history and H_2O content in the protoatmosphere and interior of Mars are shown to be dependent on initial conditions, specifically accretion time and initial water content of planetesimal. However, much H_2O is suggested to be contained in the surface layer for Mars compared to the present amount of the ocean on Earth, since initial water content of planetesimals in the Mars region is considered to be higher than that of the Earth region.

References

(1) Matsui, T. and Abe, Y. (1984) Lunar and Planetary Science XV, p.517-518. Lunar and Planetary Institute, Houston.
(2) Abe, Y. and Matsui, T. (1985) Proc. Lunar Planet. Sci. Conf. 15th, in J. Geophys. Res., 90, in press.
(3) Abe, Y. and Matsui, T. (1985) Lunar and Planetary Science XVI, this volume, Lunar and Planetary Institute, Houston.

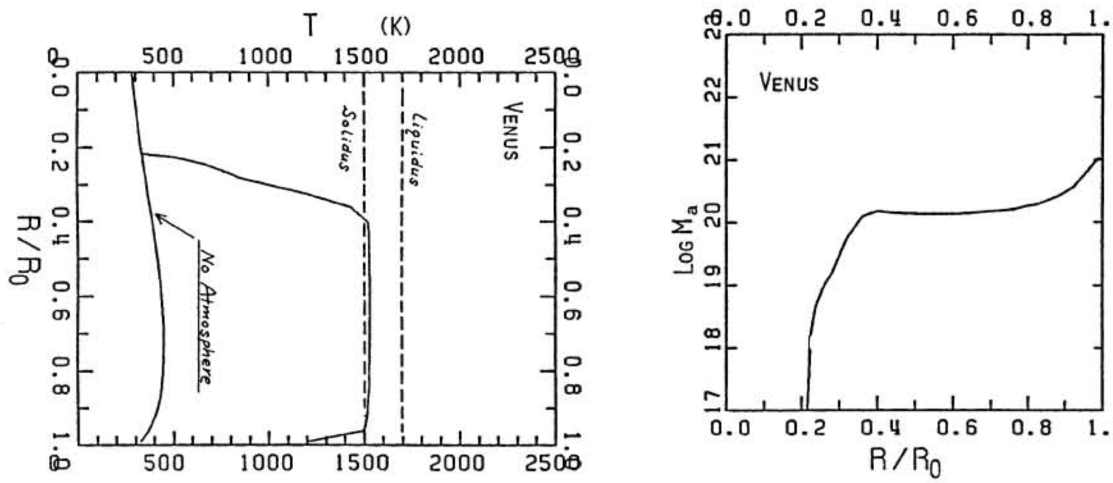

Figure 1. (a) Trace of the surface temperature and (b) evolution of an impact-induced H_2O atmosphere of the standard Venus model.

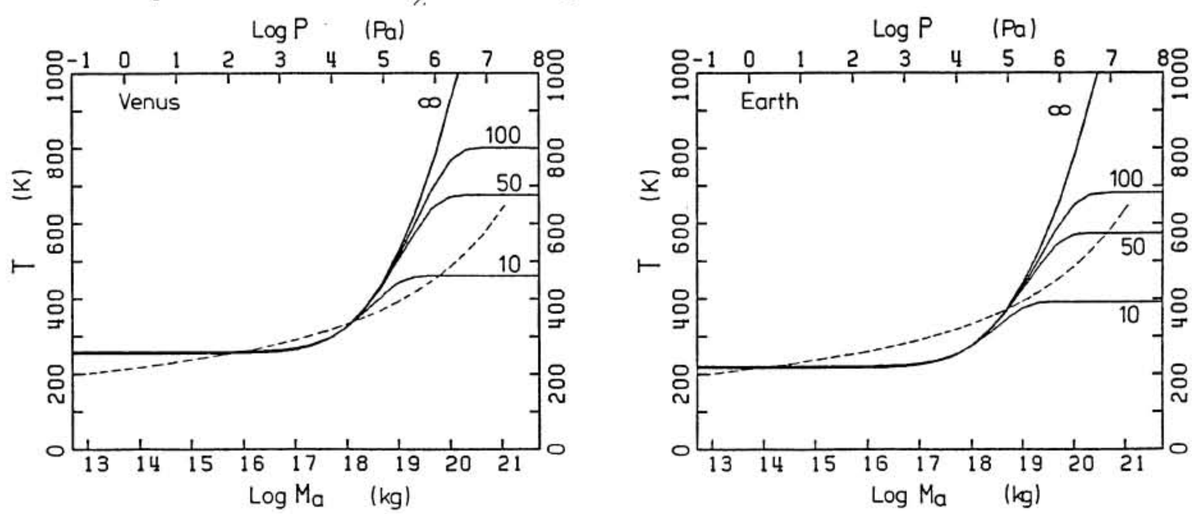

Figure 2. Radiative equilibrium thermal structures of the H_2O atmosphere for (a) Venus and (b) Earth heated by only the solar radiation. Solar flux is assumed to be 0.7 times the present one.