CLIMATE AND IMPACT: CLIMATIC CHANGE ON MARS CAUSED BY IMPACT BASIN FORMATION,

Takafumi Matsui, Eiichi Tajika, and Yutaka Abe, Geophysical Institute, Faculty of Science, Univ. of Tokyo, Bunkyo-ku, Tokyo 113, Japan.

It has been widely accepted that Mars had warmer climate in the past than the present (1). Recently Schultz and Britt (2) found that the channel density is different between the periods before and after Argyle basin formation. They pointed out an importance of climatic change caused by impact basin formation. In this paper we study evolution of such a transient atmosphere as produced by impact degassing of a single large basin formation.

A numerical procedure and model are summarized in Fig. 1 and 2. For simplicity, we assume volatile content in the surface layer of Mars similar to the present terrestrial volatile budget. We calculate the enthalpy change of the atmosphere-ground (basin floor) system due to radiative heat loss. Plane-parallel and radiative equilibrium grey atmosphere is assumed. Latent heat change by H_2O condensation is also taken into account. We assume the basin floor is molten just after its formation and so the initial surface temperatuer is 1500 K. The surface pressure of the transient impact-induced atmosphere is shown in Table 1. Since a hot transient atmosphere generated by impact degassing expands rapidly and covers the entire surface within several hours, a global averaged surface pressure is shown in this table. The surface pressure corresponding to the case that all H_2O degassed from the basin is distributed only above the basin is shown in the parenthesis.

Temporal variation of the surface temperature of model B is shown in Fig. 3. Broken lines indicate the transition tempaeratures of vapar-water and water-ice, respectively. As shown in this figure, wet-warm climate is expected to form and exist at least several years after the formation of 2000 km sized impact basin. This period extends to several thousand years for the higher surface pressure such as shown in the parenthesis. If we take into account the effect of the basin floor volcanism, the above characteristic time becomes also longer.

Although the charateristic cooling time is rather short, the above result suggests that climatic change caused by impact basin formation is possible. The amount of average precipitation on the entire surface is estimated to be 20000 to 50000 kg per square meter. However, since a strong low pressure system may be formed in the atmosphere above the basin, higher precipitation rate might be expected to occur around the basin. This prediction suggests higher channel density around the basin than the basin floor.

This calculation can be applied to the issue whether formation of an impact-induced steam atmosphere during accretion (3) is possible by stochastic large impacts. In Fig. 4 we compare the temporal variations of the surface temperature at various orbits. It is clearly shown that a steam atmosphere formation is possible for Venus and Earth.

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References
(1) Carr, M. (1986) The Surface of Mars. Yale Univ. Press, New Haven, Conn..
(2) Schultz, P.H. and Britt, D. (1986) Lunar and Planetary Science XVII, p.775-776, Lunar and Planetary Institue, Houston.
(3) Matsui, T. and Abe, Y. (1986) Nature 319, 303-305.

Table 1. Initial condition and result

Model	Radius(km)	Surface area(%)+	Initial surface pressure(bar)	Cooling time(year)* No greenhouse	Cooling time(year)* Greenhouse
A	500	0.5	0.21 (42)**	0.83	0.95
B	1000	2.2	0.83 (38)	4.3	75
C	3000	20.0	7.43 (37)	109	Te=569***

\+ Basin floor area over global surface area.
* Time required for cooling from initial temperature (1500K) to the solidification temperature.
** See the text.
*** Te is the equilibrium surface temperature satisfying the following condition: outgoing flux = incoming solar flux.

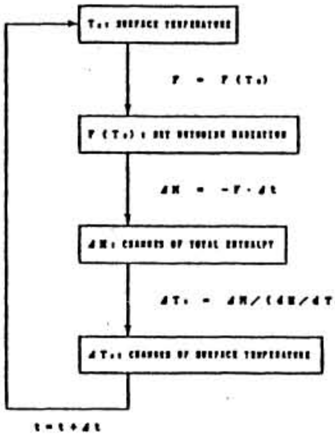

Figure 1. Flow chart of a numerical procedure.

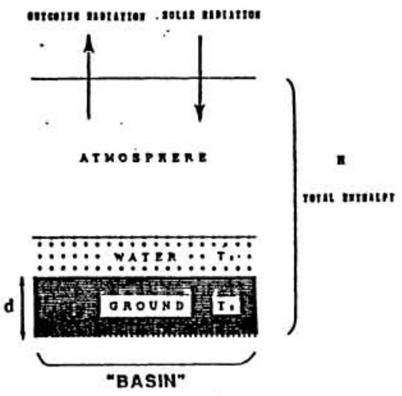

Figure 2. Model.

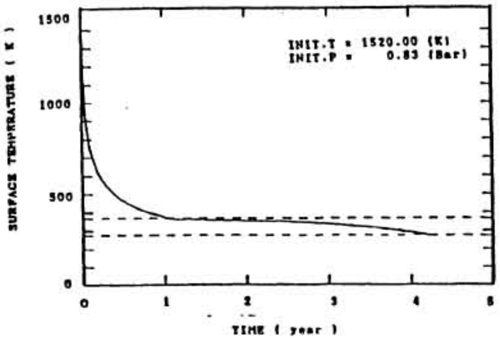

Figure 3. Temporal variation of the surface temperature.

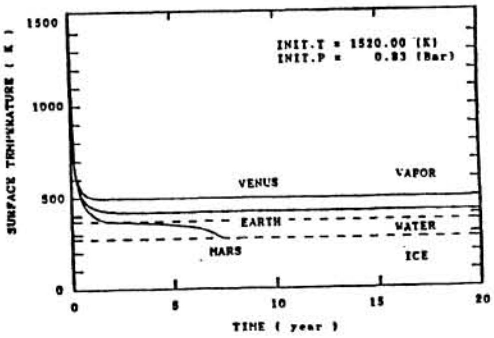

Figure 4. Temporal variation of the surface of temperature at various orbits.