

THE FORMATION OF AN IMPACT-GENERATED H<sub>2</sub>O ATMOSPHERE AND ITS IMPLICATIONS FOR THE EARLY THERMAL HISTORY OF THE EARTH.  
Takafumi Matsui and Yutaka Abe, Geophysical Institute, Faculty of Science, University of Tokyo.

Because the impact velocity of planetesimals exceeded probably some critical value, an impact-induced H<sub>2</sub>O atmosphere may have been formed on the Earth during its formation (Arrhenius et al., 1974; Benlow and Meadows, 1977; Jakosky and Ahrens, 1979; Lange and Ahrens, 1982). The evolution of such an impact-generated atmosphere was studied by Jakosky and Ahrens (1979) and Lange and Ahrens (1982). Because they calculated the surface temperature using basically the accretion model of Weidenschilling (1976) who calculated the thermal evolution of the Earth resulting from accretion of particulate matters, their studies are incomplete to understand the evolution of such an atmosphere. As is well-known, H<sub>2</sub>O gas absorbs most of the infrared radiation. Therefore, once an H<sub>2</sub>O atmosphere was formed, the surface temperature increased due to the blanketing effect of the H<sub>2</sub>O atmosphere.

Considering the impact energy distribution at the surface as calculated by Kaula (1979) and the impact degassing process as proposed by Lange and Ahrens (1982), and assuming the atmospheric structure radiatively equilibrated, we can calculate the thermal regime of the Earth during its formation. For simplicity the mass of the impacting planetesimal is assumed to be constant (10<sup>15</sup> kg). The absorption coefficient of the H<sub>2</sub>O gas is also assumed to be constant (0.001 m<sup>2</sup>/kg), so that the optical depth is a function of the amount of H<sub>2</sub>O atmosphere generated. The initial temperature profiles of two simple models with accretion time of 5x10<sup>6</sup> years are shown in Fig. 1. The dotted lines are temperature profiles without the H<sub>2</sub>O atmosphere and the solid lines are for the H<sub>2</sub>O atmosphere. As is shown in these figures, the surface temperature increases rapidly once the impact dehydration initiates. The numerals attached to the solid lines indicate the H<sub>2</sub>O content. The total amount of H<sub>2</sub>O of the Earth is more than ~10<sup>21</sup> kg and hence the H<sub>2</sub>O content should be larger than 0.01%. The difference in density of planetesimals causes the difference in peak pressure generated and hence the density controls the radius over which the impact dehydration initiates.

One of the most important implications for the internal constitution is that the Earth cannot retain significant amount of H<sub>2</sub>O within the mantle. In addition, dissociation of H<sub>2</sub>O into H and O, and the escape of H from the exosphere may produce a large amount of free oxygen, which is possibly consumed at the surface by the oxidization of Fe. Therefore, the oxidation state of the mantle may have been established during the accretion stage. Although we have not so far taken into account the hydration reaction, that is, a sort of serpentinization process which is one of the most important sinks of the generated H<sub>2</sub>O atmosphere, this may not significantly influence the above results, because such a hydration reactions will occur only at the uppermost layer.

#### References

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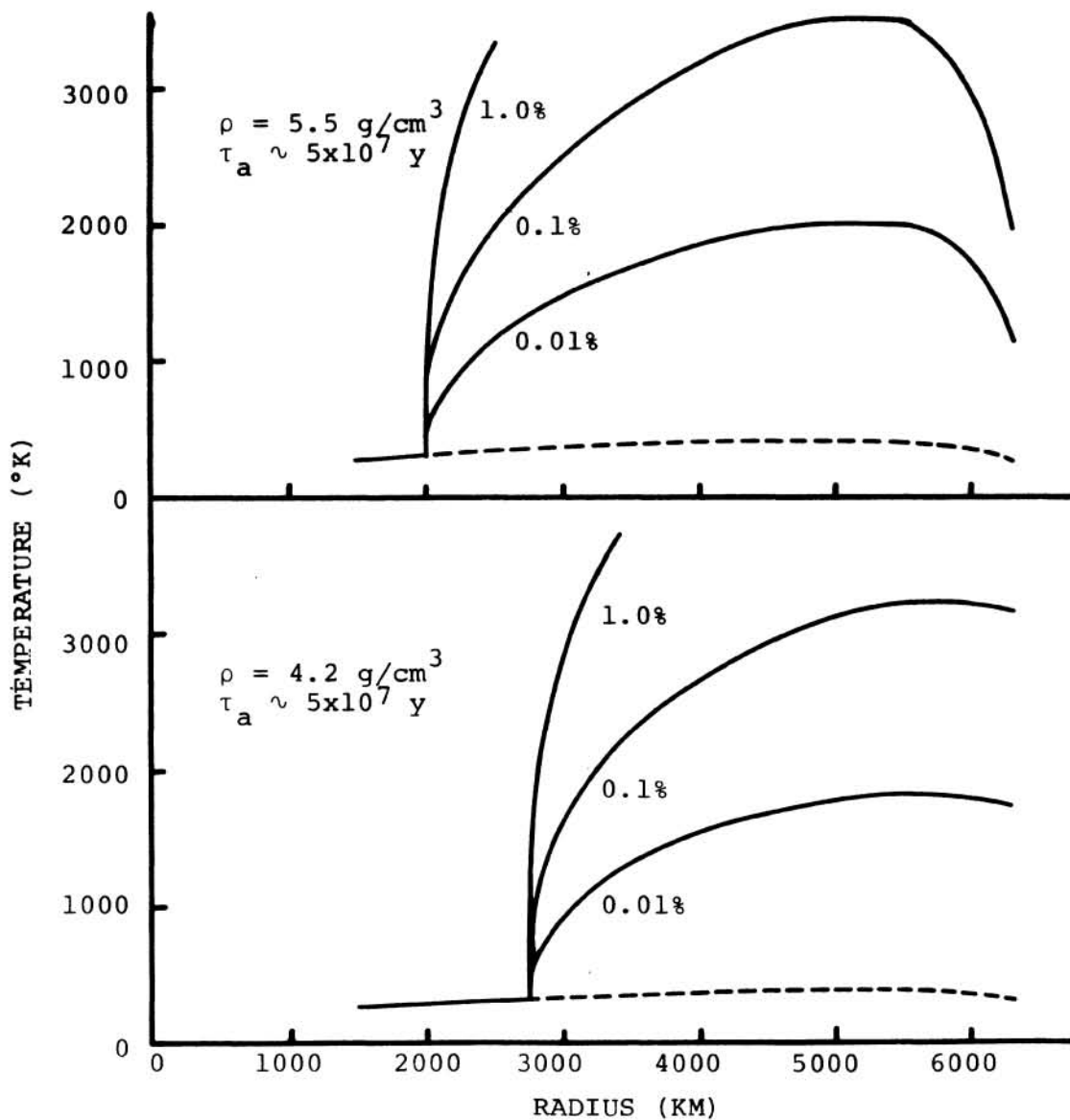
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Fig. 1. Early thermal profiles for the Earth