THE EFFECT OF OBLIQUITY AND SURFACE CONDITION ON THE FREEZING CONDITION OF A PLANET: HABITABILITY AND PALEO-MARS ENVIRONMENT

Yutaka Abe[1], Ayako Abe-Ouchi[2]

[1] Earth Planetary Sci., Univ. Tokyo, [2] CCSR, Univ. Tokyo

To discuss habitability on extrasolar planets we investigated the water circulation and the condition for the occurrence of a completely frozen state (a 'snow-ball' state) with a general circulation model for both a land planet case (a wet planet without fixed ocean) and an aqua planet (a planet entirely covered by an ocean). We particularly concerned about the effect of obliquity, because a chaotic change of planetary obliquity is suggeted from dynamics. Since availability of liquid water is a necessary condition for life, water circulation is an important comtrolling factor of habitability. The complete freezing gives severe restrictions on the types of life, even though it may not sterilize the planet. Effects of obliquity and the surface condition are also important issues for understanding the environment of paleo-Mars, which likely experienced active hydrological cycle and large obliquity change. In addition, it has good chance to fall in a frozen state owing to the faint radiation of the young Sun and the large orbital radius.

The results are summarized as follows. 1. A land planet shows stronger resistance to the com-plete freezing than an aqua planet. 2. Both land and aqua planets in an oblique regime show stronger resis-tance to the complete freezing than those in an upright regime. However, the dependence on the obliquity is not clear within the upright regime. 3. On a land planet in an oblique regime, low latitude area is more suscep-tible to freezing than the mid latitude area. Thus, there is a good chance of low-latitude-only freezing (freezing of low latitude without freezing the entire planet) of a land planet. 4. On an aqua planet with high obliquity, low latitude freezing occurs at lower solar constant than on a land planet with high obliquity. The range of the solar constant that yields low-latitude-only freezing is much narrower on an aqua planet than that on a land planet. Thus, low-latitude-only freezing is unlikely on an aqua planet.

Implications for the paleo-Mars: 1. In order to keep a wet ground at the low latitude area of paleo-Mars, the planet must be in the oblique regime, or with oceans. Under such conditions, however, the low latitude is relatively easily covered by permanent snow. Thus, it is more difficult to keep unfrozen wet surface on low latitude than to keep Mars from the completely frozen state under the condition of the present obliquity. 2. If the obliquity changed significantly while Martian water cycle was active and the average temperature was de-creasing steadily, there must have been a period while only the low latitude area is covered by permanent snow. It is an interesting question whether we can find such evidence from geological records.

Implication for the Habitability on a Planet: 1. A water rich aqua planet may not be the best place for life, and a land planet with some water may be better than an aqua planet, because an aqua planet easily falls in a completely frozen state. 2. It is a difficult question whether high obliquity or low obliquity planet is prefer-able. A high obliquity planet is resistive to the complete freezing, but experiences severe seasonal change. The calmest climate is found on 45 obliquity aqua planet.