Formation theory of terrestrial planetary atmospheres: revisited.

Yutaka Abe[1]; Masahiro Ikoma[2]; Hidenori Genda[3]

[1] Earth Planetary Sci., Univ. Tokyo; [2] Interactive Research Center of Science, Tokyo Inst. Tech.; [3] Dep. of Earth and Planetary Sci., Tokyo Univ.

The formation and early evolution of the atmospheres of terrestrial planets are critically reviewed in the shed of recent planetary formation theory. There are three end-member possibilities of early atmospheres: a gravitationary captured solar composition atmosphere, a degassed atmosphere from planetesimals during accretion, and an atmosphere added at the last stage of accretion as a 'late veneer'. There real atmosphere should be a mixed one of these three atmospheres. First, we review the classical theory of the 'secondary atmosphere' (Brown, 1949, Suess, 1949) and clarify the constraints from the rare gas abundance. Them, we discuss the processes expected from the recent planetary formation theory. The recent planetary formation theory suggests the formation of protoplanets in a gas nebula followed by series of giant impacts among protoplanets. Thus, we have to consider the formation of a mixed atmosphere composed of gravitationally captured solar component and degassed component from planetesimals. Also, we have to consider the effect of giant impacts on the planetary atmosphere. We review some studies on these processes and propose a tentative new scenario of the atmosphere formation. The scenario suggests many future problems, such as the distribution of volatile components in the protoplanetary disk, contribution of icy planetesimals scatterd from Jupiter region, detailed properties of the mixed prooatmosphere, partition of volatiles into the planetary interior, the behavior of a hot rock-vapor atmosphere formed by giant impacts, the composition of early atmospheres, loss of planetary atmospheres (impact erosion, hydrodynamic escape, sputtering, etc.), comparative evolution study of atmospheres of Earth, Venus, and Mars, and variation of planetary atmospheres in extrasolar systems.