TARGETING THE GEOLOGIC SIGNATURES OF EXOPLANETS: LESSONS LEARNED FROM SOLID BODIES IN THE SOLAR SYSTEM Y. Fujii[1], J. Kimura[1], J. Dohm[2], [1]Earth-Life Science Institute, 2-12-1 IE-1 Ookayama, Meguro-ku, Tokyo, 152-8550, Japan, [2]The University Museum, The University of Tokyo, Tokyo, Japan

Context: Detecting signs of biospheres on exoplanets is undoubtedly an important milestone in astronomy. While many studies focus on the biosignature molecules in the atmosphere through spectroscopy, exoplanetary surfaces would also comprise valuable information to optimize the identification of prime candidate life-containing exoplanets, or to conjecture the plausible form of life in the context of environment. For example, a prime candidate exoplanet might contain an ocean, a relatively thick atmosphere, and landmass, all interacting through hydrological cycling driven by the sun, at least for part of its evolutional history [1]. Also, in more general, the geology of Earth-size exoplanets is crucial for unfolding formational processes and evolutional histories in individual systems, which will contribute to the comprehensive planetology and assessment of the likelihood of habitable condition.

To explore the ability to characterize surface environments of terrestrial exoplanets with future direct imaging observations, disk-integrated spectra of the Earth (i.e. seen as a point source) have been studied at length as a primary test-bed. In addition to the spectroscopic features of atmospheric molecules, it has been shown that the major surface components, in particular ocean, continents and snow/ice, cause notable variation in the disk-integrated colors, which in turn allows us to infer the distributions of these components (e.g. [2-8]). In addition, seeking the samples of even wider variety anticipated for exoplanets, disk-integrated spectra of planets in the Solar System have also been studied (e.g. [9]-[11]), and spectral signatures of various terrestrial surfaces have been modeled ([12]).

Photometric Properties of Solid Bodies in the Solar System: Along this line, we surveyed the UV/visible/NIR color of solid planets and major moons in the Solar system (terrestrial planets, terrestrial moon, Galilean moons, etc.), taking into account both wavelength domain and time domain ([13]). We combine the observed colors of the bodies reported in the literature with the geological map information compiled through spacecraft data at local to global scales. We show that these essentially atmosphere-less bodies can produce 5-50% fractional peak-to-trough variation amplitude in 1 spin rotation, comparable to the Earth's variation, associated with various geological characteristics, including: large-scale heterogeneity of surface compositions such as resulting from volcanic activity, grain size distribution, and contaminations of ice. We also discuss that both the average colors and wavelength dependence of the variations are useful in diagnosing the surface characteristics of the bodies.

Implications for Exoplanets: There are several implications for future characterization of Earth-size exoplanets through direct imaging observations. Firstly, this early stage of investigation points out at least several geological processes to alter the colors of planetary surfaces regionally or globally, which exoplanets may also undergo. We discuss exogenic and endogenic conditions to make each feature, so as to characterize each target as a system. Secondly, if the time-domain observation becomes feasible, higher-order clues to the presence/absence or the kinds of geological activities on exoplanets would be available. The spin rotation period would also be measured for a variety of terrestrial exoplanets including those without oceans and continents; this then allows for phase-folding of the light curves, enabling the detection of localized features. We also examine the effects of possible atmospheres on surface colors as well as their influences on accurately observing surface characteristics.

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