GEOSIGNATURES OF TERRESTRIAL EXOPLANETS. H. I. Hargitai[1], [1] NASA Ames Research Center / NPP (MS 239-20 Moffett Field, CA 94035, henrik.i.hargitai@nasa.gov).

Introduction: While bio- and technosignatures provide direct information about life, geosignatures [1] provide information about the potential niches life may occupy. These may be more easily detectable than biosignatures. To produce a potential geosignature database, potential types of geologies of planets should first be identified through modeling.

The geological surface: The surface relief is the interface between the planetary interior, the atmosphere and the cosmic environment. While considerable effort has been put into developing models of planetary interiors [2], planetary atmospheres, impact flux, and the chemical evolution of the surface [3], modeling the surface features at the interface of these modeled enviroments has not yet been attempted. Life occupies and adapts to the special conditions of these niches. The geological surface is the result of the interaction between the interior and exterior processes. Atmospheric processes are coupled to evolution of the interior [3], the parent star [4, 5], orbital parameters [6, 7], obliquity [8], planetary rotation [9, 10]. Material properties [11], and gravity are stable properties that fundamentally affect relief; available water [12, 13] and temperature [14] can change drastically over time. The landscape can include differing amounts of remnant and active landforms. These parameters may have numerouos combinations but the resulting landscapes can likely be grouped into a finite number of types.

Spectral signatures of exoplanetary geologies: With the direct multipixel imaging of a terrestrial exoplanet, we may be able to resolve large scale surface features and spectral signatures may reveal information about volcanic, hydrological or erosional processes that release, store and trap gases. These can be used as indicators of potentially habitable niche types. For example, plate tectonics that is characterized by active volcanism and also promotes erosion, may have specific spectral signature. Ocean planets [15] may also have an underwater geological surface whose specific spectral signatures may be identified. Coastal areas may contain biosignatures [16], and vary with the configuration and ratio of emerged continents.

Classification of planetary geological characters: A theoretical classification of different planetary geologies could be established based on a matrix of interior, atmosphereric and cosmic parameters that also change in time. This way, instead of the habitable-not habitable dichotomy, we could establish a refined classification of the potential geologies, and in turn, niches, defined by the intersection of planetary and stellar parameters, and the age of a system, many of which are known from observations.

Unmixing the planetary signals: The atmospheric composition results from degassing, erosion, burial, biological activity and stellar effects; the surface a mixture of liquids and land surfaces, which latter again is a mixture of various bedrocks, deposits and organisms. In these mixtures geosignatures may be stronger than biosignatures. The disk-integrated geo/biosignature ratio may change drastically. On present-day Earth, both in the atmosphere and on land biosignatures are dominating: the land is dominantly a biological surface spectrally, however, the water surface may not have strong biological component. Hadean Earth may have been also dominated by biosignatures [16].

Terrestrial analog: The evolving terrestrial surface could be classified into discrete types, with well-separable spectral signatures. For example, a Hadean planet [17], a Snowball planet [18, 19], a pre-vegetaion planet, a contemporary and future [20, 21] Earth all have a different set of niches which mixed together provide a single geosignature. Other planetary bodies could provide starting points for modeling geosignatures in variable parameters.

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