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PLANET TOPERS: Planets, Tracing the Transfer, Origin, Preservation, and Evolution of their ReservoirS

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Abstract

The PLANET TOPERS (Planets, Tracing the Transfer, Origin, Preservation, and Evolution of their ReservoirS) group is an Inter-university attraction pole (IAP) addressing the question of habitability in our Solar System. Based on the only known example of Earth, the concept refers to whether environmental conditions are available that could eventually support life, even if life does not currently exist. Life is believed to require liquid water, but important geodynamic processes affect the habitability conditions of a planet. The PLANET TOPERS group develops and closely integrates the geophysical, geological, and biological aspects of habitability with a particular focus on Earth neighboring planets, Mars and Venus.

1. The concept of habitability

Habitability is commonly understood as “the potential of an environment (past or present) to support life of any kind” (Steele et al., 2005). Based on the only known example of Earth, the concept refers to whether environmental conditions are available that could eventually support life, even if life does not currently exist (Javaux and Dehant, 2010). Life includes properties such as consuming nutrients and producing waste, the ability to reproduce and grow, pass on genetic information, evolve, and adapt to the varying conditions on a planet (Sagan, 1970). Terrestrial life requires liquid water. The common view, however, is that extraterrestrial life would probably be based on organic chemistry in a water solvent (Pace, 2001) although alternative biochemistries have been hypothesized. The stability of liquid water at the surface of a planet defines a habitable zone (HZ) around a star. In the Solar System, it stretches between Venus and Mars, but excludes these two planets. If the greenhouse effect is taken into account, the habitable zone may have included early Mars while the case for Venus is still debated.

The dynamic processes, e.g. internal dynamo, magnetic field, atmosphere, plate tectonics, mantle convection, volcanism, thermo-tectonic evolution, meteorite impacts, and erosion, modify the planetary surface, the possibility to have liquid water, the thermal state, the energy budget and the availability of nutrients. Shortly after formation (Hadean 4.4-4.0 Ga), evidence supports the presence of a liquid ocean and continental crust on Earth (Wilde et al., 2001), Earth may thus have been habitable very early on (Strasdeit, 2010). The origin of life is not understood yet but the oldest putative traces of life occur in the early Archaean (~3.5 Ga, see Figure 1).

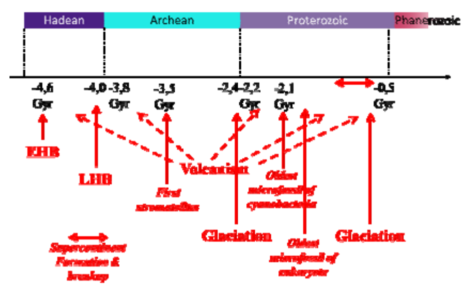

Figure 1: Earth’s history.

Studies of early Earth habitats documented in rock containing traces of fossil life provide information about environmental conditions suitable for life beyond Earth, as well as methodologies for their identification and analyses. The extreme values of environmental conditions in which life thrives today can also be used to characterize the “envelope” of the existence of life and the range of potential extraterrestrial habitats. The requirement of nutrients for biosynthesis, growth, and reproduction suggests that a tectonically active planet, with liquid water is required to replenish nutrients and sustain life (as currently known). These dynamic processes play a key role in the apparition and persistence of life. Mars is presently on the edge of the HZ, but may have been much more hospitable early in its history, as the examination of its surface suggests the existence of water very early on (about 4 Ga ago, see Figure 2) (Bibring et al., 2005; 2006). Since then, Mars lost most of its atmosphere, preventing the presence of liquid water at the surface. In comparison Earth is habitable at present and has been for at least 3.5 Ga.

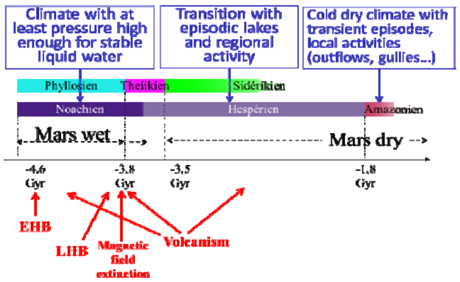

Figure 2: Mars' history, considering the major periods as described by Bibring et al. (2005; 2006).

2. Objectives and WPs

As explained above, we develop and closely integrate the geophysical, geological, and biological aspects of habitability in an interdisciplinary approach (see Figure 3) with a particular focus on Earth neighboring planets, Mars and Venus. We work in close collaboration with another group, the Helmholtz Alliance "Life and Planet Evolution", which has similar objectives. The dynamic processes, e.g. internal dynamo, magnetic field, atmosphere, plate tectonics, mantle convection, volcanism, thermo-tectonic evolution, meteorite impacts, and erosion, modify the planetary surface, the possibility to have liquid water, the thermal state, the energy budget and the availability of nutrients.
With the objective to better understand the habitability, we integrate these themes in the following work packages: (1) Internal geophysics and interaction with atmosphere; (2) Atmosphere and interaction with surface, hydrosphere, cryosphere, and space; (3) Identification of life tracers, and interactions with planetary evolution; (4) Accretion and evolution of planetary systems; and finally (5) Integration of information into Global System dynamics.

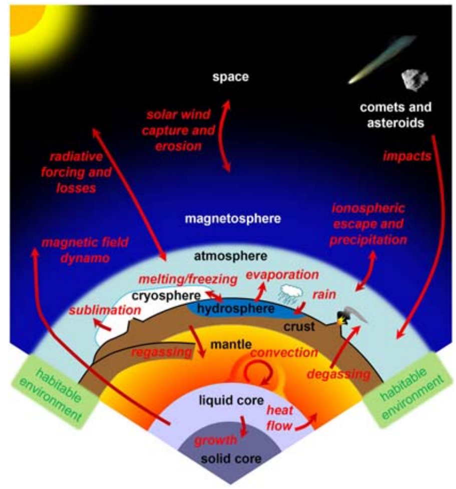

Figure 3: Sketch with all the interactions between the reservoirs as foreseen in this project.

3. Conclusion

By studying other planets, we seek to understand the processes that govern planetary evolution and discover the factors that have led to the unique evolution of Earth.

Acknowledgements

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