**LPL COLLOQUIUM** Tuesday, November 16

**Toward Testable Theories of Terrestrial Planet Evolution to Enable Exoplanet Life Detection**

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Rocky planet evolution is sculpted by complex geophysical, geochemical, and astrophysical processes. Interpreting upcoming observations of terrestrial exoplanets will require an improved understanding of how these competing influences interact on long timescales. In particular, the interpretation of potential biosignature gases is contingent upon understanding the probable geochemical evolution of lifeless worlds. Here, I present a generalized model of rocky planet evolution that connects early magma ocean evolution to subsequent, temperate geochemical cycling. The thermal evolution of the interior, tectonic recycling of volatiles, surface climate, and atmospheric escape are explicitly coupled throughout this evolution. The model can reproduce the atmospheric evolution of a lifeless Earth; it consistently predicts an anoxic atmosphere and temperate surface conditions after 4.5 Gyrs of evolution. However, if initial volatile inventories are permitted to vary outside these “Earth-like” ranges, then dramatically different evolutionary trajectories are permitted, including scenarios whereby Earth-sized planets in the habitable zones of G-type stars accumulate oxygen rich atmospheres in the absence of life. The model also sheds light on the atmospheric evolution of Venus and Venus-like exoplanets; it can successfully recover modern Venus’s atmosphere composition and thermal state. Moreover, there is a clear dichotomy in the evolutionary scenarios that recover modern Venus conditions, one in which Venus was never habitable and perpetually in runaway greenhouse since formation, and another where Venus experienced ~1-2 Gyr of surface habitability. Upcoming observations of terrestrial exoplanets such as the Trappist-1 system, GJ 1132b, LHS 3844b, and LHS 1140b (many of which are highly irradiated Venus-analogs) will provide valuable opportunities to test and improve such generalized models. I will argue that an understanding of terrestrial planets—both solar system and extra solar—as a unified class of objects will be necessary to enable exoplanet life detection.