EXOPLEX: A CODE FOR CALCULATING THE MINERALOGY AND MASS-RADIUS RELATIONSHIPS FOR ROCKY PLANETS A. M. Lorenzo[1], S.J. Desch[1], C. Unterborn[1], S.H. Shim[1], K. Byeongkwan[1], [1]Arizona State University School of Earth and Space Exploration, email: Alejandro.Lorenzo@asu.edu.

Introduction: The field of exoplanets has moved from one of discovery to one of characterization. In the aftermath of surveys by Kepler and CoRoT, thousands of exoplanets of various mass, radius, and orbital parameters have been discovered, many are rocky and Earth-like in size and mass. The search for life in the universe will begin with observations of these planets. Characterization of Earth-like planets is the next phase of exoplanet studies, but it is still in its infancy. In many cases, we don't know much more about a planet than its mass, radius, and insolation. In the lack of further information, and in the absence of a clear definition of the community, "Earth-like" has become synonymous with a 1 Earth-mass, 1 Earth-radius planet. But the search for life will demand more than this. Detectability of life is possible if a planet's abiotic geochemical cycles are observably different from its biogeochemical cycles with life. Assessing detectability requires characterization of not just mass and radius, but a planet's internal composition, and the manifestation of this geochemistry on its surface.

As is well understood, mass and radius alone allow too many degenerate solutions to constrain planetary composition beyond "rock", "ice", "metal", and "atmosphere". It is vital to supplement these studies with stellar elemental compositions. In parallel with observational efforts, better modeling tools are needed. To that end, we have developed the ExoPlex code, which is a planetary mass-radius and mineralogy code. For a given bulk planetary composition, we calculate the mineralogy as a function of depth in the planet and derive M-R relations. The mineralogy as a function of depth allows assessments of mantle rheology, vigor of mantle convection, and other factors important to geoscience.

Methods: Our model is for rocky bodies differentiated into a core, mantle and water layer. Inputs of relative elemental abundances of Mg-Si-Fe-S-O-Al-Ca are used to set the core mass fraction. We use techniques similar to [1,2,3] where we assume planets to be spherically symmetric, so our model varies only along the radial direction.

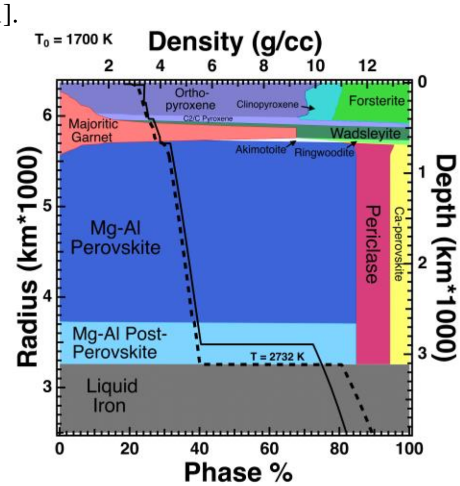
From the surface, we integrate the equation of hydrostatic equilibrium and calculate along a compositionally self-consistent adiabatic temperature gradient. Temperature and pressure fields are then used to find density using the appropriate equation of state for each region. Temperature and pressure profiles are then updated iteratively until the fractional change in density of every layer is $< 10^{-6}$.

Mantle mineralogy is found using the Gibbs free energy minimization code, PerpleX [4]. Thermoelastic parameters for the resultant phase assemblages are calculated from the formulation of [5,6].

Alloys of Fe with S, Si, and O are considered for model cores in addition to pure Fe. In core conditions, light elements effectively reduce the molar weight of Fe for the equation of state with no significant impact on compressibility [7].

Our water layer consists of liquid water and ices Ih, VI, and VII. We use melting curves from [9] to find the state within the water phase diagram.

Results: A figure from ExoPlex illustrating the mantle phase diagram of a planet with solar composition appears below [10]. The solid line is the density calculations from ExoPlex and the dotted is from the PREM [11].



Discussion: ExoPlex is available now at: https://github.com/CaymanUnterborn/ExoPlex. Initial studies looking at the effects of stellar bulk composition on planetary structure are forthcoming and scheduled for release Fall 2017.

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