EXOPLEX: A CODE FOR CALCULATING THE INTERNAL STRUCTURE, MINERALOGY AND MASS-RADIUS RELATIONSHIPS FOR EXOPLANETS. A. M. Lorenzo[1], S. J. Desch[1] and S.-H. Shim[1] , [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287. (alejandro.lorenzo@asu.edu)

Introduction: Exoplanet observations have been trickling in with increasing accuracy for the past few decades [1,2]. In addition to this, we are learning more about their host stars though the use of large catalogs of reliable data for host star abundances [5]. We present a code for combining the two to model the interior structure and mineralogy of terrestrial exoplanets.

Methods: We employ a technique similar to [3,4,6,7] by integrating the equation of hydrostatic equilibrium. Thus we assume spherical symmetry. Likewise, our model represents planets which are differentiated where they have a core, mantle and an overlying water layer. The initial model is of a planet with a solid iron core and pure bridgmanite mantle ($MgSiO_3$). We then split each region into concentric shells with fixed mass. To find the pressure in each shell, we calculate the gravitational acceleration and use the initial density values of iron or bridgmanite to find the pressure using the equation of hydrostatic equilibrium. The temperature gradient, we assume is adiabatic. Our temperature model is derived from Maxwell's thermodynamic relations which use compositionally dependent emissivity and specific heat capacity to calculate temperature in a region.

With the temperature and pressure at each zone, we can find the resultant mineralogy. We use a Gibbs free energy minimization scheme, $\mathcal{G}(T, P, k_i)$ [8].Where k_i is species i in a minlticomponent system. In this case, for the mantle we allow minerals within the MgO-SiO2-FeO regime and Fe-O2-Si-S2 for the core. These combine to form various minerals based on input stoichiometry and the Gibbs free energy formulation of [8]. We utilize the perplex package for making these calculations [9] which yield the bulk moduli and density of each shell using the appropriate equations of state.

With the new density we recalculate the volume of each shell using its known mass. Over several iterations the subsequent density change relaxes and the formulation is complete.

Because equations of state are sensitive to experimental measurements, the mass limit of each planet is about 3 $M_{\oplus}$ or when the mantle pressure exceeds 200 Gpa [8]. Beyond the stability of post-perovskite.

Results: Planet radii have shown to be relatively invariant to a reasonable range of abundance inputs for terrestrial type planets composed mostly of silicates and an Fe core [3,4,6,7]. Indeed, our model shows a similar outcome. However, we show that internal structure is highly variant across the range of abundances seen in stars.

Our model allows for input of light elements in the Fe core. Typical exoplanet models do not include this option. In this presentation, we explore the outcomes of light alloying elements in the cores of terrestrial planets. We find that adding this extra parameter does change overall radius slightly which can have an observable impact when combined with mantle volume variations due to stoichiometric inputs. More importantly this does have implications when considering planets stripped mostly of their mantles through impacts. With a large amount of alloy elements, a mostly core planet can be mistaken for a terrestrial planet with a differentiated mantle and core. Previous consideration of this problem has led some groups to believe that there is a maximum amount of mantle stripping [10] however we argue that cores alloyed with light elements must also be considered when looking at abnormally dense planets.

Conclusions: We find that over the range of plausible elemental abundances for host stars, a wide variety of terrestrial planet structures and compositions can be created. Understanding exoplanets does require this tie to observed abundances. While overall radii are invariant to input abundances the internal structure of a planet is sensitive to this input. In turn the geophysical evolution of a planet may rely on structure. For example, the existence of an internal dynamo.

We also explored the effects of having a core with light alloying elements. These alloys do raise the volume of the core slightly and may have implications on the existence of liquid phases in an outer core.

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