Stars to Planets: Experimental Determination of Exoplanet Mantle Solidi and Crust Compositions

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Interest in exoplanet studies has intensified over the last two decades with the discovery of ~4000 exoplanets. Investigation of these planets from outside our solar system primarily utilizes tools from the fields of astronomy and geophysics. However, understanding the surface (i.e., crust) compositions of these exoplanets, as well as the volcanic contribution to any atmosphere present, necessitates applying methods from the field of igneous petrology.

A host star composition can be used as a first order proxy to an exoplanet's composition [1, 2, 3] and may vary quite a bit relative to our star, particularly in Mg, Fe, Al, Ca, and Si [4], elements critical in rock-forming minerals. To determine the effect of this variation on exoplanet mantle solidi, we conducted piston-cylinder experiments over 1–2 GPa and 1100–1475°C on two non-Earth silicate exoplanet compositions. Our first exoplanet bulk composition explores the effect of a higher Mg/Si relative to Earth (1.42 vs. 1.06 [5]) and represents the high Mg end member of exoplanets [3]. Our second composition has an Mg/Si (0.93) similar to that of Earth, but a higher Ca/Al (1.81 vs. 1.07) to represent a system where clinopyroxene is favored to crystallize over garnet.

Our initial results indicate that while anhydrous exoplanet mantle melting curves may not diverge substantially from that of Earth, the exoplanet mantle phase proportions and melt compositions do deviate. Combined with exoplanetary mantle adiabats, these deviations result in variations in the exoplanets' extents of melting relative to Earth. Thus, we can predict differences in melt compositions—and thus crust compositions—of exoplanets with similar bulk compositions to those explored here.

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