Variation in Stellar Mg/Si and its Implication for Mineralogy and Convection. M.D. Pagano[1], S-H. Shim[1], S.-Desch[1], P.A. Young[1], [1]School of Earth and Space Exploration, Arizona State University, Tempe, AZ 85287 (mpagano@asu.edu, SHDShim@asu.edu, Steven.Desch@asu.edu, patrick.young.1@asu.edu)

Introduction: The advent of high-spectral-resolution spectroscopy applied to more and more nearby stars has revolutionized our ideas about stellar elemental abundances [1]. We now recognize that each star has its own "fingerprint" of unique elemental abundances that span a wide range of abundance ratios. This implies a considerable range of chemical compositions this implies for any exoplanets they host, a range currently unexplored in models of planet interiors. The wide range of stellar compositions and the high frequency of Earth-like exoplanets mean that exoplanets must exist with previously unimagined compositions. Exoplanets that are nominally Earth-like, with just moderate variations in key rock-forming elements, may be very common, and yet may behave geophysically quite differently from Earth. Here we consider the effect of Mg/Si ratio on convection and tectonics.

Stellar Variation: We determined the elemental abundances for 458 sun-like stars (FGK), and used these abundances to obtain Mg/Si ratios for each star. This Mg/Si ratio, which is an absolute ratio, is unnormalized to the sun and therefore can be compared to the Earth and solar Mg/Si value. The Mg/Si parameter space ranges from below 1, where pyroxene would dominate, to close to 2, where olivine would dominate. The mean Mg/Si ratio in our sample was 1.22, which is higher than solar, 1.05 [2]. There are a handful of stars with Mg/Si < 1, and a few stars (including tau Ceti) that approach Mg/Si $= 2$, but none higher.

Planetary Mineralogy: We explore the exotic parameter space of high Mg/Si, or magnesium-rich stars. There are no absolute cut-offs, but we explore those stars that have Mg/Si ratios approaching 2, with the assumption that stars with excess Mg will lead to planets with the same enhancement. As a planet's Mg/Si approaches 2, we reach an area where olivine, $(Mg,Fe)_2SiO_4$ will dominate with diminishing pyroxene, $(Mg,Fe)(Al,Si)O_3$ as opposed to Earth where these two are almost in equal proportions [3]. More importantly, the Mg-rich mantle could contain ferropericlase, (Mg,Fe)O, at shallow depths, as opposed to the Earth where it only exists in the lower mantle. If the Mg-rich terrestrial exoplanets have surface volcanism through (partial) melting of the deep mantle similar to Earth, such as some hot spots and mid oceanic ridges, the high Mg/Si ratio will result in very different magnitude of melting and composition of melts. Mantle melting processes are believed to be responsible for the formation of the crust on Earth.

The increased amount of ferropericlase may have a profound impact on mantle dynamics. For the lower mantle, an increase in ferropericlase expected from the elevated Mg/Si ratio, could decrease the viscosity of the lower mantle by two orders of magnitude [4]. The severe decrease in mantle viscosity should result in more vigorous convection, potentially affecting surface tectonics.

Other Implications: As well as stellar abundances impact on planetary tectonics and mineralogy, these abundances can also have impacts on the habitability of planets through alteration of the time a planet spends in its star's habitable zone (mostly through variations in O abundance [5]), and planetary atmospheres. Vigorous convection, as with high Mg/Si planets, is likely to lead to more effective mixing of interiors with the surface, possibly leading to a less oxidized surface. More rapid equilibration of planet surfaces with their relatively reducing interiors could shift outgassing of carbon to be richer in CH_4 as opposed to CO_2.

References: [1] Fischer & Valenti (2005) *ApJ, 622,* 1102. [2]Asplund et al. (2009) Annual Reviews of Astronomy and Astrophysics, 47, 481:522 [3] McDonough, W. F., & Sun.(1995), Chemical Geology, 120, 223 [4] Ammann, M. W., Brodholt, J. P., Dobson, D. P. (2011), E&PSL, 302, 393 [5] Young, Liebst, & Pagano (2012) *ApJL, 755,* 31.