Plutonic-Squishy Lid: A New Global Tectonic Regime Generated by Intrusive Magmatism on Earth-Like Planets. D. L. Lourenço[1], A. B. Rozel[2], M. D. Ballmer[3], and P. J. Tackley[2], [1]Department of Earth and Planetary Science, University of California Berkeley, Berkeley, CA, USA (dlourenco@berkeley.edu), [2]Institute of Geophysics, Department of Earth Sciences, ETH Zurich, Zurich, Switzerland (antoine.rozel@erdw.ethz.ch; paul.tackley@erdw.ethz.ch), [3]Department of Earth Sciences, University College London, London, UK (m.ballmer@ucl.ac.uk)

Background: The thermal and chemical evolution of rocky planets is controlled by their surface tectonics and magmatic processes. On Earth, magmatism is dominated by plutonism/intrusion versus volcanism/extrusion [1]. On Venus this is also likely to be the case [2]. However, the role of plutonism on planetary tectonics and long-term evolution of rocky planets has not been systematically studied.

A new tectonic regime – "plutonic-squishy lid": In this study [3], we use numerical simulations to systematically investigate the effect of plutonism combined with eruptive volcanism. At low-to-intermediate intrusion efficiencies, results reproduce the three common tectonic/convective regimes as are usually obtained in simulations using a viscoplastic rheology: stagnant-lid (a one-plate planet), episodic (where the lithosphere is usually stagnant and sometimes overturns into the mantle), and mobile-lid (similar to plate tectonics). At high intrusion efficiencies, we observe a new additional regime called "plutonic-squishy lid." This regime is characterized by a set of small, strong plates separated by warm and weak regions generated by plutonism. Eclogitic drippings and lithospheric delaminations often occur close to these weak regions, which leads to significant surface velocities toward the focus of delamination, even if subduction is not active. The location of the plate boundaries is strongly time dependent and mainly occurs in regions of magma intrusion, leading to small, ephemeral plates. The plutonic-squishy-lid regime is also distinctive from other regimes because it generates a thin lithosphere, which results in high conductive heat fluxes and lower internal mantle temperatures when compared to a stagnant lid [4].

Possible applications – Archean Earth and Venus: The plutonic-squishy lid regime has the potential to be applicable to the Early Archean Earth as it combines elements of both protoplate tectonic and vertical tectonic models, and high intrusion efficiencies are required to form Earth's early continental crust [5]. Moreover, this regime also has the potential to be applicable to present-day Venus, agreeing well with observations of a globally fragmented and mobile lithosphere on Venus [6].

References: [1] Crisp J. A. (1984) *J. Volcanol. Geotherm. Res. 20(3-4)*, 177–211. [2] Gerya T. V. (2014) *EPSL, 391,* 183–192. [3] Lourenço D. L. et al. (2020) *Geochem. Geophys. Geosyst. 21*, e2019GC008756. [4] Lourenço D. L. et al. (2018) *Nat. Geosci. 11(5)*, 322-327. [5] Rozel A. B. et al. (2017) *Nature 545(7654)*, 332-335. [6] Byrne P. K. et al. (2021) *Proc. Natl. Acad. Sci. 118*, e2025919118.