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The Strong Influence of Magmatic Heat Transport on Terrestrial Planetary Evolution

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On Io, "heat pipe" volcanism is thought to be the major mode of heat loss from the interior. This mechanism can also, however, be important on larger terrestrial planets, particularly at early times, and this is the topic of this presentation.

Firstly, we consider planets with stagnant lids. In models of early Mars, Keller and Tackley [2009] found that magmatism has a dramatic buffering effect on early mantle temperature, causing cases with differing initial temperatures to converge to the same value that is much lower than obtained without magmatism, an effect subsequently termed the "thermostat effect" in the martian evolution models of Ogawa and Yanagisawa [2011]. This effect becomes more important with increasing planet size. In numerical models of Venus [Armann and Tackey, 2008], it was found that heat pipe magmatism is the dominant heat loss mechanism over most of the planet's evolution, if there are no episodic lithospheric overturn events interrupting the stagnant lid mode.

Secondly, we consider planets with plate tectonics. On present-day Earth, mid-ocean ridge magmatism contributes around 10% of the total heat transport. Early parameterized models of Davies [1990] predicted that magmatism can be important for Earth's heat loss, but it has largely been ignored by the Earth mantle modelling community, with a few exceptions. Xie and Tackley [2004] found magmatic heat transport to be the most important heat loss mechanism at early times in thermo-chemical convection models representing Earth. Here we present new models of the thermo-chemical and magmatic evolution of Earth-like planets [Nakagawa and Tackley, 2012], also finding that magmatism is an important heat loss mechanism throughout much of the planet's history.

In a broader context, the importance of magmatic heat loss for both stagnant lid and plate tectonics planets together with its increasing importance with planet size, leads to the prediction that on super-Earths it will be even more important.

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