Thermal history and emplacement mechanisms of Theo's Flow lava: a proxy for Martian lava flows

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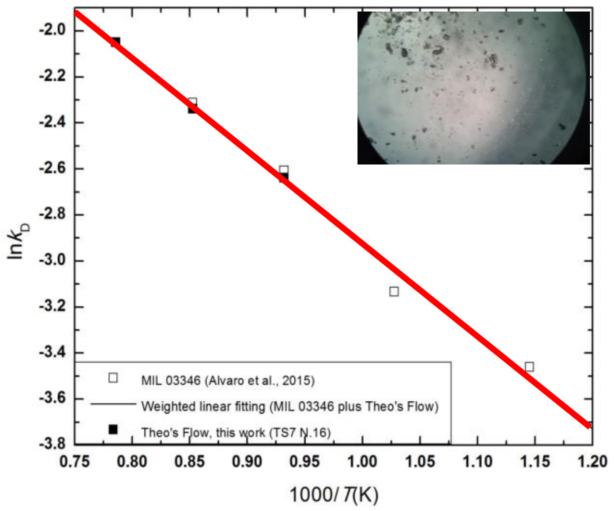
Introduction

Terrestrial analogues are often investigated to get insights into the geological processes occurring on other planetary bodies. The pyroxenitic layer of the 120m-thick magmatic pile Theo's Flow (Archean Abitibi greenstone belt Ontario, Canada), due to its petrological similarities, has been regarded as a possible terrestrial analogue of Martian nakhlites (e.g. Lentz et al. 1999, 2011). However, its origin and cooling history and, as a consequence those of nakhlites, have been a matter of vigorous debate. **Did this lava flow originate from a single magmatic event similar to those supposed to occur on Mars or do the different units derive from multiple episodes of lava emplacement?**

Methods

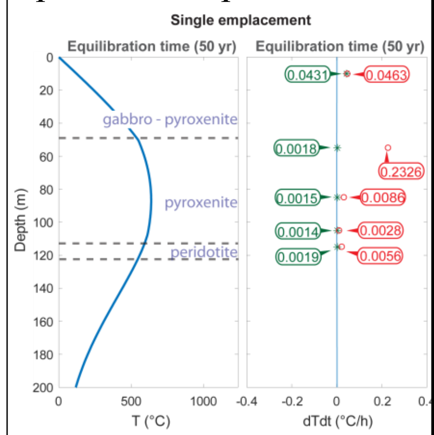
To answer this question, we calculated the closure temperature and the cooling history for six augite crystals from Theo's Flow lava sampled at four different stratigraphic depths. These results were then coupled with (i) the low viscosity data by Vetere et al. (2019) on the same composition and (ii) the results from the finite difference method in order to test the possible emplacement mechanisms for Theo's Flow.

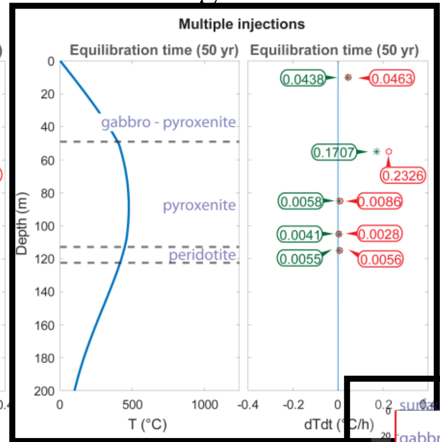


$\ln k_D$ = -4040(±180)/$T(K)$+1.12(±0.17) (R^2=0.988) (Murri et al. 2016)

Results & Conclusions

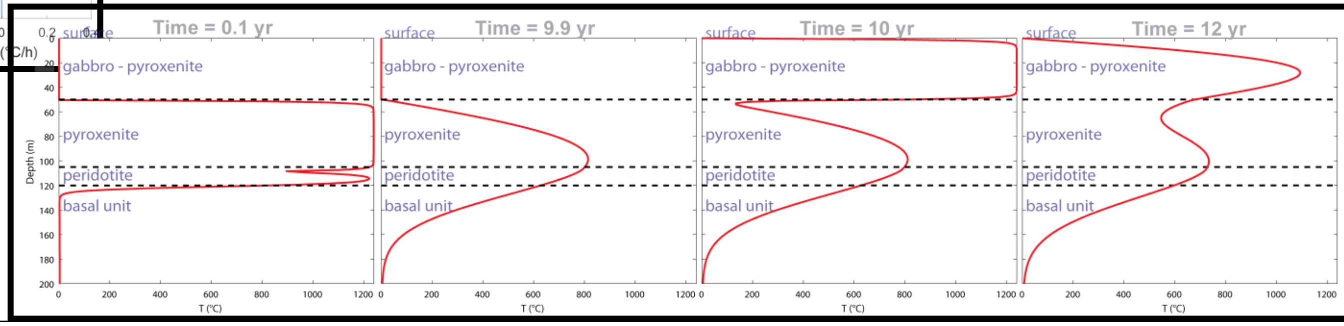
The combination of geothermometric constraints on augite single crystals and numerical simulations in the framework of a multi-methodological approach, allowed us to demonstrate that Theo's Flow has been formed by **multiple magma emplacements** that occurred at different times (Murri et al. 2019). This result supports the idea that lava flows with compositions similar to the Theo's Flow pyroxenite observed on Mars could be the result of a process where low viscosity lavas are emplaced during multiple eruptions. This has profound implications for understanding the multiscale mechanisms of lava flow emplacement on Earth and other Terrestrial bodies.





Units	Gabbro-Pyrox.	Top Pyrox.	Middle Pyrox.	Low Pyrox.	Peridotite
T_C (°C)	749	791	706.5	622	645
CR (°C/h)*	0.0463	0.2326	0.0086	0.0028	0.0056
CR (°C/h)†	0.0438	0.1707	0.0058	0.0041	0.0055
CR (°C/h)‡	0.0431	0.0018	0.0015	0.0014	0.0019

Table 1. * cooling rates estimated by using the model from Ganguly 1982, † cooling rates from the modeled scenario with multiple injections and those from a unique magma emplacement ‡



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