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Lava Flows Cooling: The initial hypothesis

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Many cooling models of lava have one precondition: an instantaneous-thick layer emplacement with a spatially uniform temperature, often as high as the effusion temperature. The cooling is then mostly controlled by conduction and is a function of the thermal parameters and dimensions of the lava flow (most important being thickness). However, many lavas, especially pahoehoe and compound lavas, are not directly emplaced with an established lava thickness but, rather, inflate from their core or result from piling-up of several layers, respectively. In both cases, this leads initially to thin fast-cooling lavas in which the final emplacement temperature may differ strongly from the initial temperature of the liquid lava feeding the flow.

Here we investigate both the behavior of inflating flows and superposition layering of lava. With a modified Peclet Number (Pe), where the velocity has been replaced by the inflation rate, we identify the conditions where lavas lose the most of their thermal energy before the final thickness is reached. For a given growth rate, inflating flows are hotter than those that grow through superposition. In the latter case, temperature depends not only with Pe, but also on the discrete lava-layer thickness. A clear quantification of the energy loss during these processes has been established and demonstrates the impact of each of them on the temperature of emplacement.

Apart from this simple point, our study raises the question of lava-flow morphology. The two processes described, despite having opposite thermal effects, may be coupled during a single eruptive event. When a lava reaches its emplacement temperature and stops, then the pressing material uphill starts to bifurcate, turn around or superpose the previously emplaced layer. Our Peclet number could be again modified to consider the traditional emplacement condition of a Graetz number of 300. Beyond this point, the inflating process turns into a superposing process and the conditions to maintain one or the other process are here discussed.