Imbibition with solidification in alumina feeding ATTILA KOVACS,
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— Liquid aluminium is produced from alumina by electrolysis in a Hall-Héroult cell.
The process by which the alumina is fed into the cell influences the overall behaviour
and efficiency of the cell. We develop a one-dimensional Stefan-type model for the
imbibition of molten cryolite into a cold porous lump of alumina. In the small
overheat limit, we analyse the small-time behaviour using the method of matched
asymptotic expansions and find there to be locally self-similar solutions that describe
analytically the competition between imbibition and freezing. Depending on the
balance between these effects, the problem may exhibit two self-similar solutions
(one being stable and the other unstable) or such a solution may cease to exist
(so that imbibition is not possible without the molten cryolite freezing first on the
exterior of the porous lump). Our asymptotic predictions are validated by direct
numerical simulations that are also used to investigate the late time behaviour. In
particular we predict the depth of imbibition before the cryolite freezes.

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