Partially differentiated planetesimals may retain primitive crusts

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Summary:

– Partial silicate melts of CV and CM chondrite material were too dense to ascend through the primitive crusts of their parent bodies.

– CV and CM parent planetesimals may have retained a primitive crust while undergoing internal differentiation

1. Chondritic parent bodies may have undergone interior melting and differentiation

Chondrites are sedimentary aggregates of primitive dust and rock particles from the solar nebula. Many, especially carbonaceous chondrites, have experienced little to no metamorphic heating [1].

At the same time, paleomagnetic [2], petrographic, and isotopic [3] evidence suggests that some chondritic planetesimals may have preserved a nearly unheated primitive crust underlain by a molten interior. **The preservation of such a primitive crust requires that deep melts did not ascend buoyantly through the crust onto the surface. We therefore calculate expected densities of chondritic melts to evaluate the likelihood of ascent and eruption on the parent bodies of several meteorite classes.**

2. Source regions of planetesimal melts were likely dry

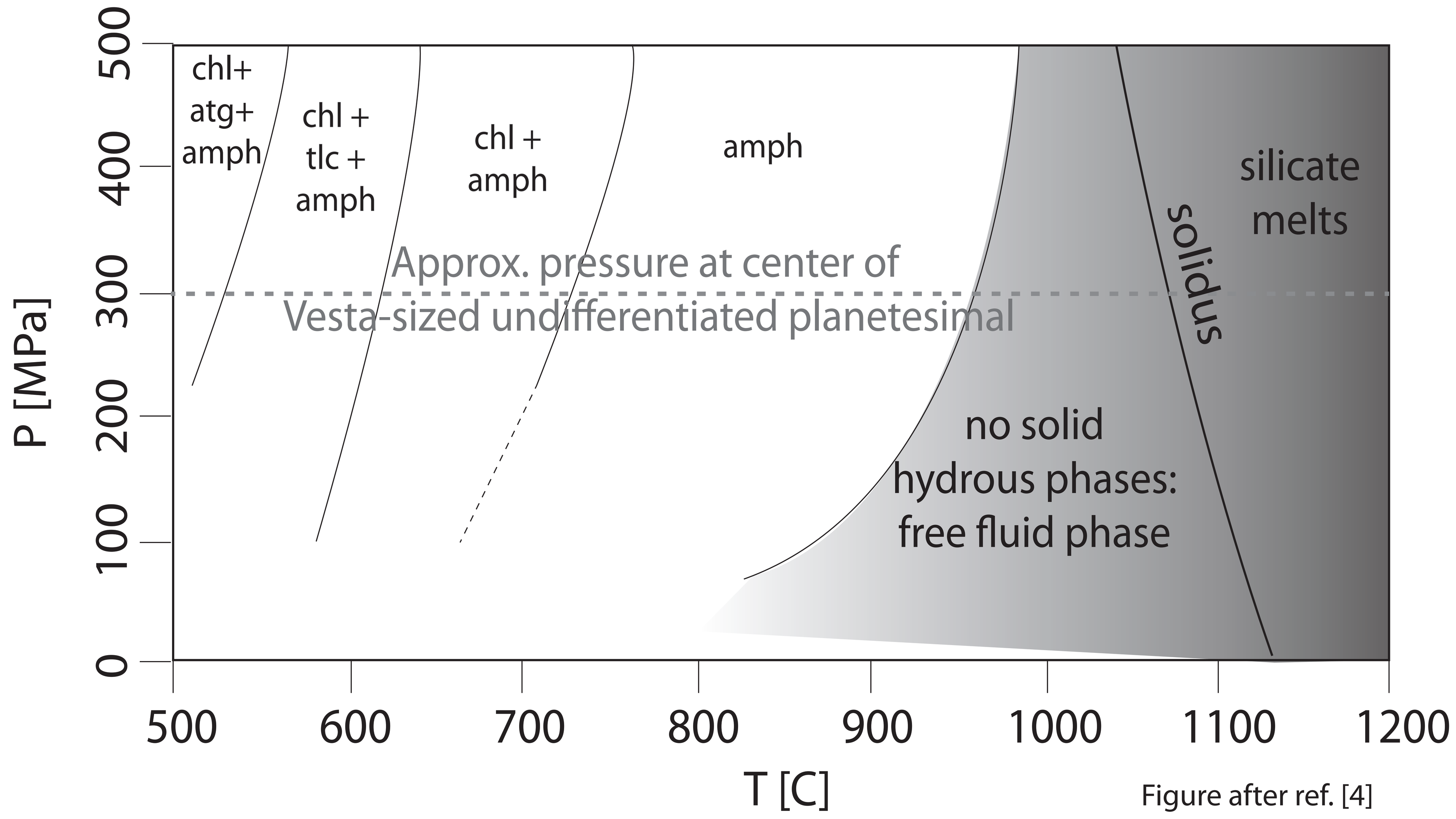
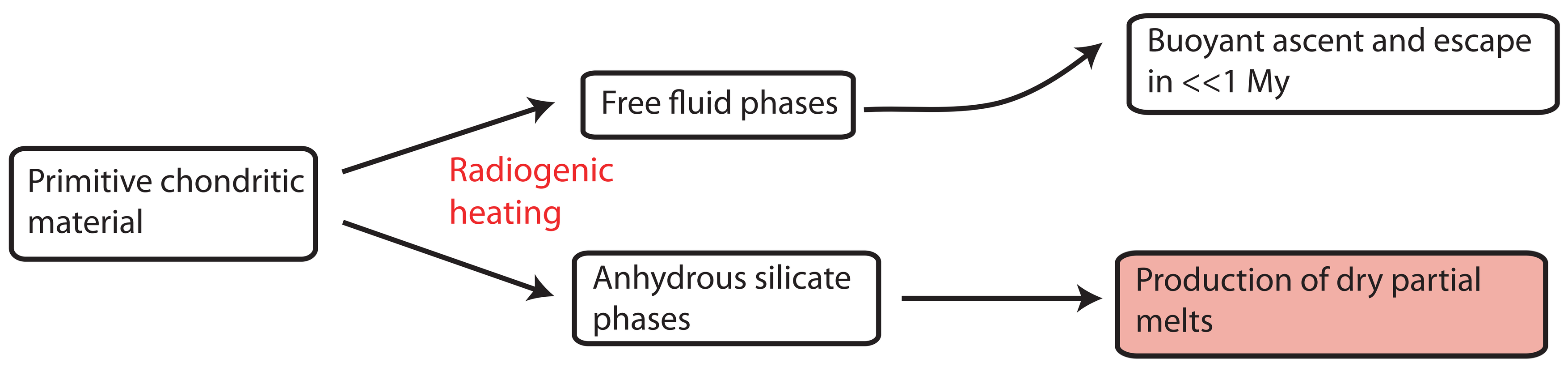


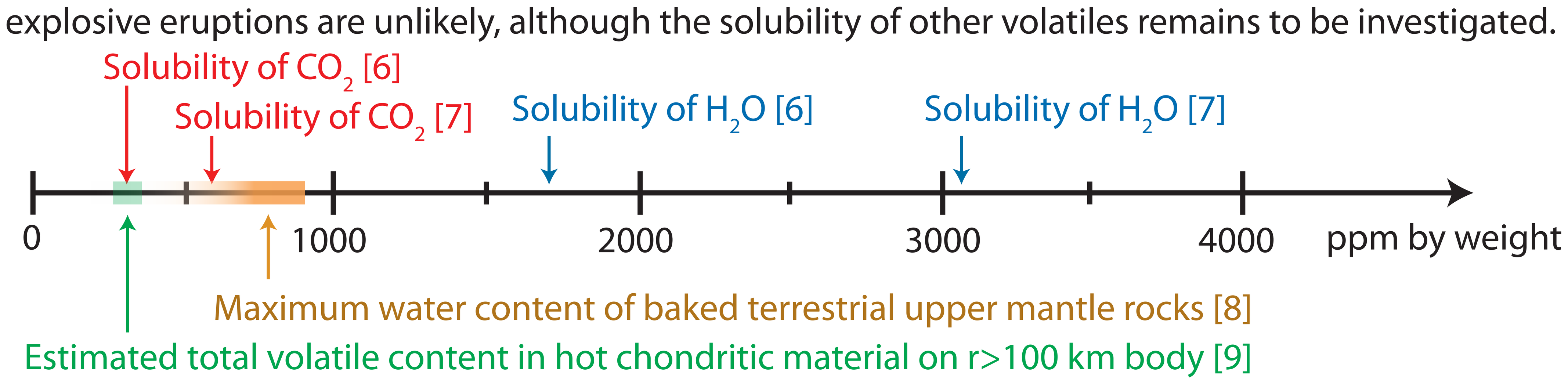
Figure after ref. [4]

Due to the low internal pressure of planetesimals, there are no hydrous silicate phases stable immediately below solidus temperatures [4].

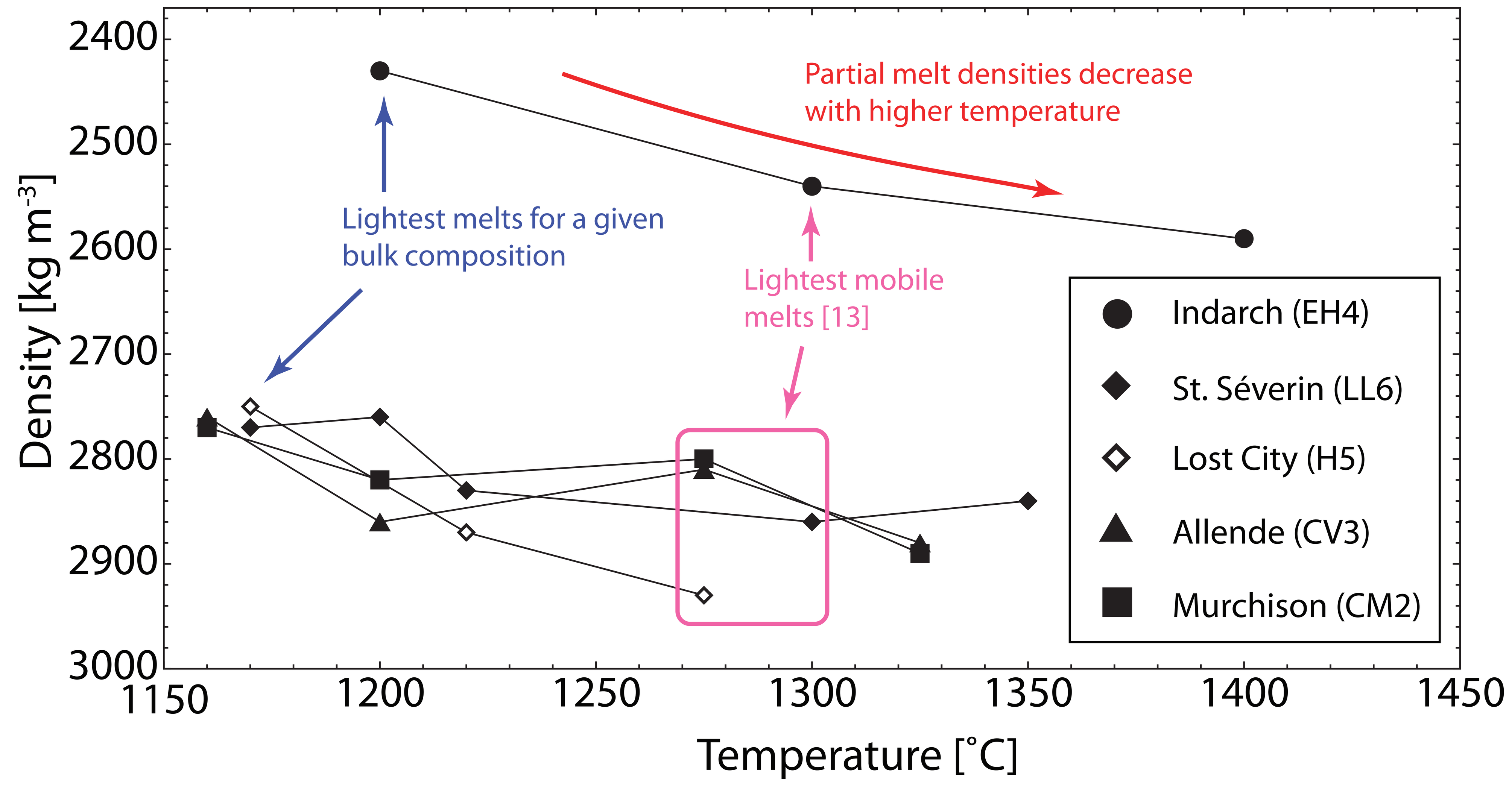
Therefore, unlike in terrestrial subduction zones, the precursor materials to planetesimal melts do not release water upon melting and the resulting melts are expected to be dry.



In planetesimals with diameter >120 km, free fluids are expected to ascend rapidly through the porous chondritic crust [5]. The amount of water and CO_2 remaining in the rock is likely lower than their solubility in silicate melts at ~50 bar (10 km depth on Vesta-sized body). Bubble formation and explosive eruptions are unlikely, although the solubility of other volatiles remains to be investigated.



3. Even the least dense melts of CV and CM chondrites are denser than the porous crust



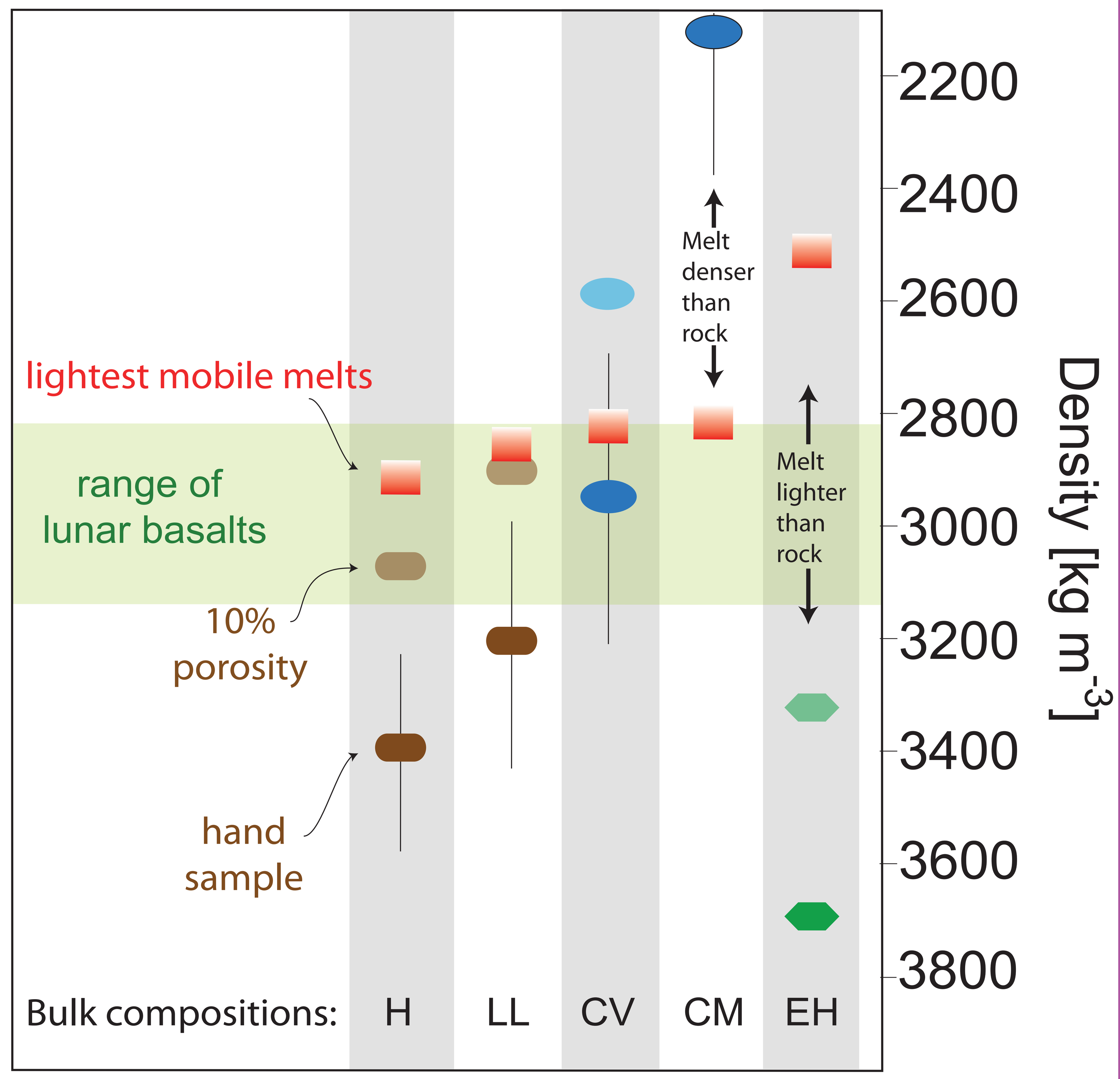
We calculate the expected densities of partial melts [10] with experimentally determined compositions for ordinary [11], CV [12], CM [12], and enstatite chondrites [13].

We compare the density of the chondritic crust to the densities of the lightest melts able to migrate.

Adopting 10% as the crustal macroporosity, melts of CV and CM chondrites are heavier than the surrounding rock and would not ascend to the surface.

In contrast, the FeO-poor partial melts of enstatite chondrites are expected to ascend readily.

The CV and CM parent bodies therefore are expected to retain a chondritic crust even during internal melting, consistent with paleomagnetic results [2].



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