https://doi.org/10.1130/G54962Y.1

Melting the myth: Prograde garnet dissolves during early crustal melting

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As discussed by Duan and Zhang (2026), our study (Tesser et al., 2026) documented substantial melt-assisted dissolution of early-formed subsolidus garnet during the onset of partial melting, including >40% net garnet volume loss and disruption of preexisting prograde chemical zoning. This interpretation was based on μ-CT-derived three-dimensional (3-D) reconstructions across a well-constrained subsolidus–suprasolidus transition, combined with high-resolution compositional mapping of centrally sectioned garnet porphyroblasts. Duan and Zhang present melt inclusion (MI) petrography and trace-element zoning from Himalayan migmatites that they interpret as evidence for continuous peritectic garnet growth during anatexis and use these observations to argue against the broader applicability of our model. We welcome the opportunity to clarify the scope of our work before discussing the implications of their data.

First, we clarify that our study does not oppose peritectic garnet growth during crustal melting. Rather, it documents a distinct interval during suprasolidus conditions (ca. 650–770 ºC) in which preexisting subsolidus garnet undergoes significant dissolution and chemical re-equilibration. This behavior does not require complete consumption of all subsolidus garnet prior to renewed growth and is consistent with the survival of large relic garnet domains, such as in our figure 3E (Tesser et al., 2026). Crystal size distribution data further show a pronounced reduction of small garnet size classes at the onset of melting (fig. 2G in Tesser et al., 2026), consistent with removal of smaller crystals and survival of larger garnet populations. Subsequent overgrowth or recrystallization on these surviving crystals plausibly explains why MI may occur near garnet rims or mantles in migmatites (Duan and Zhang, 2026).

Second, we note that garnet-hosted MI do not uniquely require monotonic peritectic garnet growth. Inclusion entrapment and preservation can occur during growth, resorption–regrowth cycles, and dissolution-precipitation processes, all of which are observed in melting experiments (e.g., Asimus et al., 2024). In such cases, MI may record local interface conditions during replacement or overgrowth on surviving domains rather than exclusively continuous growth over pristine subsolidus crystals.

Third, a key difference between the two datasets lies in the types of constraints on garnet evolution available. Our study is based on a progressive metapelitic sequence with broadly comparable bulk compositions, allowing systematic evaluation of changes in garnet volume and trace-element distributions across the subsolidus–suprasolidus transition. Our model is further constrained by targeted analysis of centrally sectioned porphyroblasts. Note that even carefully centered garnet sections preserve only very small HREE-Y–rich nuclei (e.g., fig. 3D in Tesser et al., 2026), such that minor off-sectioning may entirely miss the chemical core. In contrast, Duan and Zhang primarily present observations from isolated migmatitic samples without documenting garnet distributions across the solidus. While their dataset provides valuable insight into chemical zoning and MI distributions, it does not explicitly constrain the temporal evolution of garnet through the melting interval. As a result, their interpretation necessarily relies on inferring processes from static snapshots rather than from observed progression through comparable metamorphic conditions. This distinction is particularly important because garnet zoning and MI distributions are inherently 3-D features and may be strongly affected by sectioning geometry. Without population- or sequence-based constraints, multiple evolutionary pathways can reproduce similar apparent zoning geometries.

Fourth, the evidence used by Duan and Zhang (2026) to infer preserved subsolidus growth and undisturbed peritectic overgrowth is derived from different garnets. The bell-shaped Mn spot profile presented in their Fig. 1A is interpreted as evidence of a preserved prograde garnet core, whereas the high-resolution elemental maps shown in their Fig. 1F exhibit comparatively diffuse Mn zoning. This distinction is important because the evidence for a preserved prograde core and heavy rare earth element (HREE) and yttrium (Y) enrichment within garnet mantles is not documented in the same crystal. If the mapped garnet indeed represents uninterrupted subsolidus-to-suprasolidus growth, the absence of concentric, bell-shaped HREE-Y zoning remains difficult to reconcile with the Rayleigh fractionation pattern expected for prograde garnet growth from a homogeneous bulk reservoir. Furthermore, Duan & Zhang interpret the HREE-Y–, Zr–, Sc–, and Cr–enriched garnet mantle as a product of peritectic garnet growth during biotite dehydration melting. In their model, Sc and Cr are supplied by biotite consumption, whereas Zr and HREE-Y are liberated through accessory phase dissolution and subsequently incorporated into the growing garnet annulus. Although this interpretation is plausible, generating the broad HREE-Y–rich annulus would require a substantial trace-element flux from accessory phases that typically occur in very low modal abundances in metapelites. Consequently, the proposed mechanism warrants further mass-balance evaluation. Moreover, because accessory phases that host HREE-Y (e.g. zircon, xenotime, monazite and apatite) also contain Zr, P, and light- to middle-rare earth element (L-MREE) as major structural constituents, extensive dissolution sufficient to generate the observed broad HREE-Y–rich annulus might also be expected to produce coupled enrichments in these elements within garnet, which were not reported in the high-resolution maps.

Alternatively, the enriched garnet mantles coinciding with MI-rich domains and absence of a preserved HREE-Y–rich core are consistent with reactive trace-element redistribution associated with subsolidus garnet dissolution during early crustal melting (Tesser et al., 2026). The absence of a preserved HREE-Y–rich core may reflect off-sectioning or, more plausibly, extensive modification of the original subsolidus nucleus by melt-assisted dissolution. Given the strong partitioning of HREE-Y into garnet relative to coexisting melt, progressive dissolution of smaller HREE-Y–rich subsolidus garnets may dynamically redistribute these elements into surviving larger garnet crystals, where they may be incorporated into recrystallized domains or subsequent peritectic overgrowths. In this scenario, MI trapped within garnet mantles may record either localized peritectic overgrowth or melt-assisted dissolution-precipitation replacement.

Our study therefore does not oppose peritectic garnet growth and volume increase in migmatites but rather highlights that partial dissolution of subsolidus garnet near the solidus can generate complex trace-element patterns that require careful interpretation.

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