

Combined thermodynamic and trace element modelling of garnet growth during subduction: Is coesite likely as an inclusion?

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Garnet in metamorphic rocks commonly exhibits compositional zoning of both major and trace elements. This zoning is a reflection of different growth and resorption stages along the followed P-T-t-path modified to variable degrees by diffusion-driven homogenisation.

In order to recreate the reaction history of selected natural eclogite facies rocks we have combined thermodynamic forward models, yielding detailed information on molar proportions and major element composition of stable phases along a pressure-temperature path, with a mass balance distribution of rare earth elements (REE) among the calculated stable phases during high pressure metamorphism. Our thermodynamic forward models reproduce the complex major element zoning patterns and growth zones in the natural garnets with garnet predicted during four different reaction stages: (1) chlorite breakdown, (2) epidote breakdown, (3) amphibole breakdown and (4) reduction in molar clinopyroxene at ultrahigh-pressure conditions. Mass-balance of the rare earth element distribution among the modelled stable phases yielded characteristic zoning patterns in garnet that closely resemble those in the natural samples and thus can be attributed to fractionation effects directly tied to specific garnet-forming reactions. The normalised rare earth element patterns in garnet exhibit distinct enrichment zones characteristic for the minerals involved in the garnet-forming reaction as well as local peaks that can be explained by fractionation effects and changes in the mineral assemblage due to mineral breakdown reactions. The applied forward-modelling approach has incorporated the changing effective bulk composition by fractionation effects and thus can better predict breaks in growth as recognised by step-like zoning profiles. In ultrahigh-pressure rocks such modelling allows assessment of the entrapment potential of coesite as inclusions in garnet and/or omphacite by predicting the amount of growth of these phases within the coesite stability field.

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