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Eclogite inclusions in migmatite domes as recorders of deep-crust exhumation mechanism, magnitude, and rate

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Fragments of refractory material such as mafic rocks occur in quartzofeldspathic gneiss and migmatite in domal structures that form when the upper crust extends, driving rapid upward flow of the ductile lower crust. The Montagne Noire, French Massif Central, is an example of an eclogite-bearing migmatite 'double dome' characterized by a vertical high-strain zone (HSZ) and flanking subdomes. Two eclogite localities preserve garnet and omphacite: one in the HSZ and one at the SW margin of the dome. Zircon U-Pb and trace-element data for the HSZ eclogite show that high-pressure metamorphism occurred during the same orogenic event as migmatite dome formation, so the P-T-t-deformation records of eclogites in different structural sites can be used to understand deep crust exhumation in the context of dome dynamics. Numerical models predict that material in the HSZ ascends directly from the deep crust. Material in the subdomes may come from the deep crust or from more intermediate crustal levels; in some cases, dome-margin rocks follow a transport path with an earlier vertical component to the top of the dome, followed by flow into the footwall of an extensional shear zone below the shallow crust. In the Montagne Noire dome, eclogite in the HSZ contains garnet with rutile inclusion-bearing, pyrope-rich rims (up to 50 mol%) and omphacite with up to 36 mol% jadeite. Retrogression is characterized by amphibolite + plagioclase symplectite that has preferentially consumed cpx; texturally late biotite also occurs. The lower-pyrope cores of garnet contain abundant quartz inclusions and record prograde amphibolite facies metamorphism. Peak P-T conditions were 1.4 GPa at ∼725°C, and eclogite metamorphism was closely related to host migmatite at ∼315 Ma. Exhumation was rapid, from the deep crust (>40 km) to shallow emplacement of the dome at <10 km depth. Dome-margin eclogite occurs along the tectonized contact between migmatite/gneiss and the schist carapace of the dome. Garnets display similar textures to the HSZ eclogite garnets (rutile-bearing rims around quartz-bearing cores). However, garnet is lower in pyrope (max = 33 mol%) and omphacite is lower in jadeite content (max = 29%) relative to the HSZ eclogite. Retrogressed dome-margin eclogite displays symplectitic textures but is also extensively overprinted by Na-Ca and Ca amphibole and abundant biotite, culminating in some rocks in the complete destruction of cpx; in these rocks, which are garnet amphibolites, evidence for former eclogite conditions is in inclusions/zoning. These petrologic observations are consistent with different paths and residence times of eclogite in migmatite in the two different sites. Microstructural and geochronologic/geochemical analyses are ongoing for the dome-margin eclogite for comparison of the P-T-t-d history with eclogite from the HSZ eclogite.