Geophysical Research Abstracts
Vol. 17, EGU2015-3266, 2015
EGU General Assembly 2015

Exhumation of high-pressure rocks in a Variscan migmatite dome (Montagne Noire, France)

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The Variscan orogen contains numerous domal structures composed mostly of migmatitic gneiss and granite, with lesser amounts of mafic rock. In the Montagne Noire (MN) migmatite dome of the southern Massif Central (France), some mafic rocks record eclogite facies metamorphism that contrasts with the low-pressure/high-temperature (LP/HT) conditions recorded by host gneiss. To understand the relationship of eclogite to migmatite/gneiss evolution, we determined P-T-time conditions of eclogite and gneiss and evaluated the location of HP rocks within the dome in the context of dome dynamics.

Migmatite and granite in the dome commonly contain sillimanite and/or cordierite, and the schist carapace also contains index minerals of LP/HT metamorphism (andalusite, cordierite, sillimanite). There is sparse evidence, however, for earlier HP conditions: relict kyanite in schist and gneiss. The age of this metamorphism is not known but the LP/HT metamorphism and migmatite/granite crystallization was ∼315-300 Ma (monazite, zircon U-Pb).

Most MN eclogites have been significantly retrogressed. We focused our study on a relatively fresh eclogite (Terme de Fourcaric locality) containing omphacite (Jd36) + zoned pyrope–rich garnet (up to prp50 at the rim) + rutile + zircon. P-T conditions determined from a pseudosection and from Zr-in-rutile and grt-cpx thermometry indicates T = 700-800 C at P ∼ 1.5 GPa. U-Pb dating of zircon by LA-ICP-MS reveals core ages of ∼360 Ma and rim ages of ∼315 Ma. The zircon core age is similar to results obtained by Faure et al. (2014) for eclogite from the same general locality using a Sm-Nd grt-cpx-whole rock isochron (interpreted as age of eclogite metamorphism). The rim age is similar to their U-Pb zircon and rutile results that they interpreted as the age of "hydrothermal" metamorphism. The interpretation of Faure is consistent with regional geologic age information, although the lack of retrogression in the Fourcaric eclogite and the high prp content of garnet rims presents a challenge for ascribing the zircon rim age to hydrothermal alteration.

Of the 5 reported eclogite localities in the MN, 4 are located near a high-strain zone along the long axis of the dome and one is located in a shear zone at the SSW margin of the gneissic core. 2D and 3D numerical models show that migmatite domes may form in response to extension of the upper crust, as the partially molten deep crust ascends along a steep, axial high strain zone and then flows into subdomes flanking this zone, forming a double dome such as the MN. This mode of dome formation is an efficient mechanism for rapid exhumation of deep crust. Migmatite dome rocks equilibrate at LP/HT, but eclogite inclusion in migmatite preserve their deep origin, track exhumation, and inform the internal dynamics of domes. Domes like the MN demonstrate that the opportunistic low-viscosity deep crust flows readily to fill gaps created by extensional/ transtensional domains in the collapsing late-Variscan orogen.