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The origin of contractional structures in extensional gneiss domes

Wolfgang Franke
Institut für Geowissenschaften, Goethe-Universität, D-60438 Frankfurt, Germany

Rey et al. (2017) present a numerical model of melt intrusion into a pull-apart window driven by orogenic collapse and taken to support the tectonic model of Roger et al. (2015) for the Montagne Noire (southern France). While the numerical model represents a valuable addition to the subject in general, it is at variance with geological observations at local and regional scales.

In the Montagne Noire, the well-known coexistence of extension and contraction (grossly perpendicular to each other) has effected large-scale folds at deeper levels and flat fabrics in the upper crust, explained by Rey et al. by the advection of melt under a cover undergoing subhorizontal extension, with an abrupt change between these two regimes (see their figure 3B). In fact, the geological map reveals a gradual transition, which is better explained by a pull-apart in a transpressional regime (the "pinched pull-apart" of Franke et al., 2011). In this model (Fig. 1), the extensional detachment migrates up-section and toward the termination of the extensional window, while deeper levels are progressively shortened (see Mancktelow and Pavlis [1994] for an Alpine analogue).

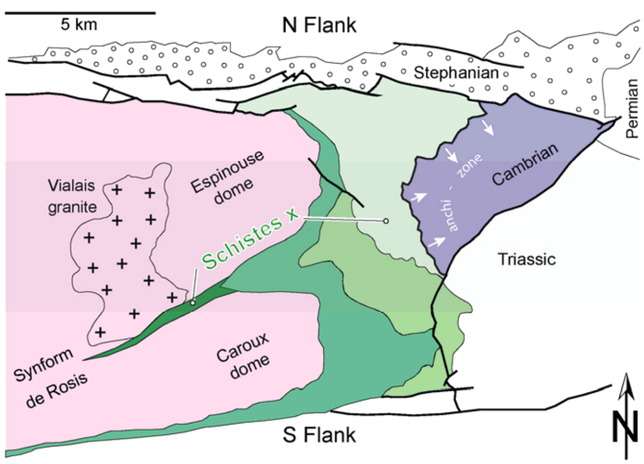

Figure 1. Geological map of the eastern termination of the Montagne Noire (southern France), to be read as a down-plunge projection of major antiforms and synforms whose amplitudes gradually decrease up-section and toward the east-northeast. Pink is gneisses, green shades are amphibolite to greenschist-grade schists, violet is Cambrian. (After Franke et al., 2011, their figure 2).

Derivation of the intruding masses from an orogenic root (Franke et al., 2003; Roger et al., 2015) can be ruled out for several reasons. While Roger et al. (2015) focus upon metamorphic events at ≤ 315 Ma, isotopic dating in the Montagne Noire reveals polyphase metamorphism which was active from the Viséan through to the Permian (>330–280 Ma; see Franke et al., 2011; Doublier et al., 2015). These ages prove that high-temperature/low pressure metamorphism started during ongoing foreland sedimentation and continued, in several phases, during and long after crustal thickening – a metamorphic record incompatible with the collapse model of Rey et al. (2017).

The same age range of polyphase metamorphism and granitoid magmatism (ca. 340–270 Ma) has also been reported from other metamorphic domes such as the Mouthoumet Massif south of the Montagne Noire (Kretschmer et al., 2015; Kretschmer, 2017, personal commun.) and from the Pyrenees (Denèle et al., 2014; Mezger and Gerdes, 2016; Schnaperelle, 2017). These domes cover large parts of the southern, Gondwanan foreland of the Variscides and partly are far away from areas of crustal stacking that could have "collapsed". Intrusion of melts and low-viscosity solids is sufficiently explained by the hydraulic gradient created in growing pull-apart windows.

The wide distribution of time-equivalent thermal pulses, including Carboniferous to Permian basalt extrusions in Scotland (Monaghan and Parrish, 2006), together with the mismatch, in space and time, between truly orogenic structures and hot "Variscan" domes require an an-orogenic heat source for these domes, such as a system of mantle plumes active at the western tip of the Tethys ocean. The extensive high-temperature regime from ca. 345 Ma onward has effectively weakened the lower crust and counter-acted crustal thickening in the Variscides (Franke (2014).

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