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Structural pattern and ascent model in the Central Extremadura batholith, Hercynian belt, Spain: Reply

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I ACKNOWLEDGE with thanks the interest my colleagues at Salamanca have taken in my paper (Castro 1986). I think the criticisms of Martínez-Catalán & Diez-Balda and this response may contribute to a better comprehension of the ascent model proposed for the Central Extremadura batholith (CEB). This model is based mainly on the compatibility between the structures appearing in the individual plutons and the structures in the metasedimentary host rocks. In the model the ascent conduits for granite emplacement are extensional fractures developed at 45° from an E–W oriented, dextral shear zone *acting from depth*. Both the maximum extension and the maximum shortening are perfectly compatible with the E–W shear regime, but the compatibility is more complex than suggested by Martínez-Catalán & Diez-Balda in their Discussion. Some confusion has clearly arisen from my paper and there are a number of points I shall make in answer to the criticisms.

Firstly, it is necessary to distinguish between the geometrical elements associated with a deep, E–W shear zone (e.g. maximum extension) and the elements associated with the effects of this shear zone in the shallow levels of the crust. In the epizonal levels, the shear zone deformed previously folded metasediments with a schistosity. Extensional fractures were developed and used by the granitoid magmas as ascent conduits. These fractures were rotated in a dextral sense and changed from being zones of extension to zones of compression when they reached the N–S position (Castro 1986, fig. 16).

The criticisms by Martínez-Catalán & Diez-Balda mainly concern two points: (1) incompatibility of the fabric attitude of the deformed plutons, ranging from N10°E (e.g. Montanchez, fig. 2) to N30°E (e.g. Alijares, fig. 5) with the E–W dextral shear zone; and (2) the antithetic, N–S sinistral shear zones which only appear on one margin of certain plutons (e.g. Plasenzuela, Montanchez and Santa-Cruz). They suggest an alternative interpretation in which the plutons could have been deformed prior to rotation in a dextral shear zone which could "in no case" produce an E–W orientation.

In answer, the transverse shortening deduced from the internal structure of the Montanchez (figs. 2 and 3) and Alijares (fig. 5) plutons is a local situation induced by the closure of the fractures (ascent conduits). This shortening is locally the maximum shortening, but not directly related to the E–W dextral shear zone. The direction of maximum infinitesimal shortening at depth will be N135° (at 45° from the shear direction) as noted by Martínez-Catalán & Diez-Balda but at the upper levels this shortening is resolved in a direction perpendicular to the fractures as these are planes of strong rheological discontinuity (to become the contact between the host rocks and unconsolidated pluton). At no point of my paper did I state that the transverse shortening of the pluton was the maximum finite shortening associated with the E–W dextral shear zone. The transverse shortening is only a local situation.

Regarding the criticism of my fig. 16, I note that zones 1 and 2 are drawn on the ellipse. Zone 2 (in black), indicates the critical field of fractures which have been rotated in a dextral sense. In this field, from N–S to N30°E, the fractures are zones across which there is incremental compression, and a transverse shortening appears locally perpendicular to the fracture.

Martínez-Catalán & Diez-Balda also discuss the interpretation proposed for the antithetic shear zones. The fact that these shear zones (N–S sinistral, see Castro, figs. 2, 4, 5 and 10) appear only on one of the two margins of certain plutons (e.g. Plasenzuela and Santa-Cruz) could be due to a non-uniform cooling of the pluton during emplacement. Only the consolidated border is deformed, while the opposite one acted passively. The criticism on the interpretation of the antithetic shears seems irrelevant: the same point could be made to invalidate the alternative interpretation regarding the development of the sinistral shear zones of a NW–SE trend before the rotation of the plutons. I noted in my paper that these shear zones do not continue longitudinally into the metasedimentary host rocks.

Finally, I must comment on the alternative interpretation proposed by Martínez-Catalán & Diez-Balda. All the Hercynian plutonism postdates the first deformation phase in the Iberian chain. In the Central Extremadura area there are all kinds of evidence for this. (i) All plutons clearly cut the D_1 structures (e.g. S_1). (ii) The contact metamorphism is postkinematic to the first deformation phase (D_1). (iii) The contact metamorphism is deformed by the shear zones (sinistral) when they appear in the contact of a pluton. (iv) The S_1 schistosity is also deformed by the shear zones (N–S sinistral) in the proximities of certain plutons which exhibit antithetic shears. Consequently, the interpretation in the Discussion that "... the earlier plutons were emplaced at the end of the first deformation phase." is inconsistent with the field data reported by myself and by others geologists working in the Hercynian belt.

Martínez-Catalán & Diez-Balda also discuss the orientation of the dextral shear zone. I deduced an E–W orientation (approximately) from the arrangement of the non-rotated plutons (NW–SE). These late plutons could be slightly rotated, and an orientation ranging from N70°E to 100° may be plausible for the trend of the dextral shear zone. I proposed the approximated E–W orientation, in order to simplify the model. In no case can the orientation of this major shear zone be greater than the trend of the regional schistosity (S_1, 120–130°). These structures cannot be rotated in a dextral sense if the shear direction is parallel to the structures or greater (135–170°) as suggested in the Discussion.

I consider the structural evidence to be strong in support of the hypothesis that the plutons of the CEB were emplaced along extensional fractures in relation to a major shear zone in the second deformation phase. Extensional fracturing and dyke propagation are effective mechanisms for magma ascent, and the only mechanisms that can act in the brittle crust (see references in Castro 1986, 1987). Examples of granite emplacement related to extensional fracturing have been reported by other authors as noted in my paper.

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