C. R. Geoscience 342 (2010) 175–177

Contents lists available at ScienceDirect

Comptes Rendus Geoscience

www.sciencedirect.com

Reply

Reply to the comment by Michard et al. on "Tectonic relationships of Southwest Iberia with the allochthons of Northwest Iberia and the Moroccan Variscides"

Réponse au commentaire sur Relations tectoniques du Sud-Ouest de l'Ibérie avec les allochtones du Nord-Ouest ibérique et le Maroc varisque par J.F. Simancas et al. [C. R. Geoscience 341 (2009) 103–113]

José Fernando Simancas [a,*], Antonio Azor [a], David Martínez-Poyatos [a], Abdelfatah Tahiri [b], Hassan El Hadi [c], Francisco González-Lodeiro [a], Andrés Pérez-Estaún [d], Ramón Carbonell [d]

[a] *Departamento de Geodinámica, Universidad de Granada, Campus de Fuentenueva s/n, 18071 Granada, Spain*
[b] *Institut scientifique, BP 703, Rabat-Agdal, Morocco*
[c] *Faculté des sciences Ben Msik-Sidi Othmane, BP 7955, Casablanca, Morocco*
[d] *Instituto de Ciencias de la Tierra Jaume Almera, CSIC, 08028 Barcelona, Spain*

ARTICLE INFO

Article history:
Received 11 September 2009
Accepted after revision 12 January 2010
Available online 6 March 2010

Michard et al. (2010) comment on some aspects of the Variscan geology of Morocco that were briefly accounted for in Simancas et al. (2009). In particular, they criticize our interpretation of the relationships between the Anti-Atlas and the Meseta domains, which we considered as being separated by a Late Carboniferous strike-slip shear zone. Based on the differences between these two geological domains, Michard et al. (2010) conclude that the corresponding crustal blocks would have been significantly separated in Early Palaeozoic times by an area of thin crust, later on telescoped during the Variscan orogeny by a major lithospheric continental shear zone. Fortunately, our general interpretation of this Palaeozoic boundary as an intracontinental shear zone is endorsed by Michard et al. (2010), who concentrate their contention on its relative importance and the timing when it started to be shaped. In the following short sections we explain our view.

1. Terminology

There has been important discussion on the age, slip and geometry of the fault set running roughly between the Mesetas and the Anti-Atlas, along the High Atlas (Houari and Hoepffner, 2003; Jacobshagen, 1992; Mattauer et al., 1972; Ouanaimi and Petit, 1992; Proust et al., 1977). Despite uncertainties due to discontinuous outcrop, we agree with the cartographic tracing and the terminological distinction made by Michard et al. (2010) in their Fig. 1, retaining the name South Atlasic Fault for the set of Alpine faults and renaming the shear zone between the Mesetas and the Anti-Atlas as South Meseta Fault Zone (SMFZ). This latter name is better than the previous one of Atlas Palaeozoic Transform (Piqué and Michard, 1989), which we avoided because of the plate-boundary significance usually given to the word Transform.

2. Interpretation of the South Meseta Fault Zone

The geological differences between the Mesetas and the Anti-Atlas domain are clear, as summarized by Michard et al. (2010) [see also (Hoepffner et al., 2005; Michard et al.,

DOI of original article: 10.1016/j.crte.2010.01.008
* Corresponding author.
E-mail address: simancas@ugr.es (J.F. Simancas).

doi:10.1016/j.crte.2010.01.007

2008; Piqué and Michard, 1989)]. However, in our view these differences not necessarily *"call for a basic role of the SMFZ as a major Variscan lithospheric discontinuity"*. Strong geological contrast may exist in orogens between neighboring crustal domains, without these domains having been far apart before orogenic telescoping. The Iberian Massif provides a good example concerning this issue. Thus, the strong geological contrast between the West Asturian-Leonese Zone (a very thick pile of Lower Palaeozoic metasediments, affected by recumbent folding, metamorphism and intruded to the west by Late Carboniferous granites) and the Cantabrian Zone [a comparatively thin and incomplete Cambrian to Early Carboniferous pre-orogenic sequence, subsequently affected by thin-skinned non-metamorphic deformation (Pérez Estaún et al., 1990; Pérez Estaún et al., 1991)] does not imply at all a very distant palaeogeographical position during the pre-orogenic evolution. Concerning the Mesetas/Anti-Atlas boundary, we give credit to the suggestion made by Ouanaimi and Petit, 1992 that the contrasting deformation in the Ouzellarh region might be explained by the presence of a stiff Precambrian basement with a thin Palaeozoic cover (promontory of the Anti-Atlas domain) in contact with a thicker Palaeozoic series (adjacent Meseta domain). Our view is that the contrasting features between the poorly-deformed Anti-Atlas and the more deformed, variably metamorphic Mesetas do not prove the major Variscan lithospheric discontinuity suggested by Michard et al. (2010) in their Fig. 2.

We believe that the significance attributed to the SMFZ must take into account the analysis of its different outcrops. The Tizi n'Test Fault to the west is the biggest continuous outcrop of the SMFZ (Fig. 1 in Michard et al., 2010), having been characterized as a dextral strike-slip fault with a displacement of approximately 50 km (Proust et al., 1977). In a previous work, Mattauer et al., 1972 had suggested a dextral displacement of nearly 200 km, but this figure is hardly compatible with the bend of the fault around the Ouzellarh Massif [(Ouanaimi and Petit, 1992), Fig. 1 in Michard et al., 2010]. Contrary to the narrow fault zone in the Tizi n'Test outcrop, the SMFZ in the eastern High Atlas appears as a wide shear zone [(Hoepffner et al., 2005; Michard et al., 2008), Fig. 1 in Michard et al., 2010]. At Tamlelt, Houari and Hoepffner, 2003 have featured the 60 km-wide shear zone as a *"dextral wrench dominated transpression"*. Despite the difficulties assessing such a wide strain-partitioned shear zone, the modeling made by (Houari and Hoepffner, 2003) has given a bulk shear strain of $\gamma = 1$, thus suggesting a strike-slip displacement of around 60 km.

Michard et al. (2010) indicate that the role of strike-slip tectonics along the SMFS must not be exaggerated to the detriment of compression, this latter proved by a number of thrust structures. However, all previous authors clearly conclude that dextral strike-slip kinematics is dominant, though non-exclusive (Houari and Hoepffner, 2003; Mattauer et al., 1972; Proust et al., 1977). On the other hand, Michard et al. (2010) suggest that *"the occurrence of the Ouzellarh salient limited necessarily the importance of strike-slip displacements"*. This geometrical constraint argues, in our view, against a major tectonic significance of the SMFZ.

3. Timing of the South Meseta Fault Zone

We have pointed out (Simancas et al., 2009) that the regional shortening direction inferred from the first-phase Devonian to Early Carboniferous folds in the Mesetas (Hoepffner et al., 2005) is not kinematically compatible with a dextral strike-slip displacement of the SMFZ. This is our main argument to sustain that this shear zone would have been originated later, contemporaneously with the Late Carboniferous regional deformation in the Mesetas.

4. Conclusion

We admit that the characterization of the boundary between the Mesetas and the Anti-Atlas is an open question and we do not reject the possibility of having wrongly minimized its tectonic meaning. The geological contrast between the Mesetas and the Anti-Atlas is certainly strong and sudden, but looking at the fault system that constitutes the boundary, we do not find pieces of evidence supporting the interpretation envisaged by Michard et al. (2010) as a long-lived major lithospheric tectonic contact. Instead, the SMFZ might be a Late Carboniferous, transpressional shear zone dominated by dextral strike-slip, with a displacement of less than or equal to 100 km and lesser shortening component.

Fortunately, Michard et al. (2010) support our view that the SMFZ must not be interpreted as a transform boundary linked to an orogenic suture, this being the real crucial point in our tectonic model (Simancas et al., 2009).

Acknowledgements

This research has been financed by the Agencia Española de Cooperación Internacional, the *Académie Hassan II des sciences et techniques*, and the Spanish Ministry of Science and Innovation through grants CGL2007-63101/BTE and TOPO-IBERIA CONSOLIDER-INGENIO CSD2006-00041.

References

Hoepffner, C., Soulaimani, A., Piqué, A., 2005. The Moroccan Hercynides. J. Afr. Earth Sci. 43, 144–165.

Houari, M.-R., Hoepffner, C., 2003. Late Carboniferous dextral wrench-dominated transpression along the North African craton margin (Eastern High-Atlas, Morocco). J. Afr. Earth Sci. 37, 11–24.

Jacobshagen, V., 1992. Major fracture zones of Morocco: the South Atlas and the Transalboran fault systems. Geol. Rundsch. 81, 185–197.

Mattauer, M., Proust, F., Tapponnier, P., 1972. Major strike-slip faults of Late Hercynian age in Morocco. Nature 237, 160–162.

Michard, A., Hoepffner, C., Soulaimani, A., Baidder, L., 2008. The Variscan Belt. In: Michard, A., Saddiqi, O., Chalouan, A., Frizon de Lamotte, D. (Eds.), Continental Evolution: the Geology of Morocco. Springer Verlag, pp. 65–131.

Michard, A., Ouanaimi, H., Hoepffner, C., Soulaimani, A., Baidder, L., 2010. Comment on "Tectonic relationships of Southwest Iberia with the allochthons of Northwest Iberia and the Moroccan Variscides" by J.F. Simancas et al. C. R. Geoscience 341 (2009), 103–113. C.R. Geoscience 342, 170–174.

Ouanaimi, H., Petit, J.P., 1992. La limite sud de la chaîne hercynienne dans le Haut Atlas marocain : reconstitution d'un saillant non-déformé. Bull. Soc. Geol. France 163, 63–72.

Pérez Estaún, A., Bastida, F., Martínez-Catalán, J.R., Gutiérrez Marco, J.C., Marcos, A., Pulgar, J.A., 1990. West Asturian-Leonese zone: Stratigraphy. In: Dallmeyer, R.D., Martínez García, E. (Eds.), Pre-Mesozoic Geology of Iberia. Springer Verlag, pp. 92–102.

Pérez Estaún, A., Martínez-Catalán, J.R., Bastida, F., 1991. Crustal thickening and deformation sequence in the footwall to the suture of the Variscan belt of northwest Spain. Tectonophysics 191, 243–253.

Piqué, A., Michard, A., 1989. Moroccan Hercynides, a synopsis The Paleozoic sedimentary and tectonic evolution at the northern margin of West Africa. Am. J. Sci. 289, 286–330.

Proust, F., Petit, J.P., Tapponnier, P., 1977. L'accident de Tizi n'Test et le rôle des décrochements dans la tectonique du Haut Atlas occidental (Maroc). Bull. Soc. Geol. France 19, 541–551.

Simancas, J.F., Azor, A., Martínez Poyatos, D.J., Tahiri, A., El Hadi, H., González Lodeiro, F., Pérez-Estaún, A., Carbonell, R., 2009. Tectonic relationships of Southwest Iberia with the allochthons of Northwest Iberia and the Moroccan Variscides. C. R. Geoscience 341, 103–113.