

“Distinguishing eustatic and epeirogenic controls on Lower-Middle Cambrian boundary successions in West Gondwana (Morocco and Iberia)”, by Ed Landing, Gerd Geyer and Wolfram Heldmaier, published in *Sedimentology* (2006), 53(4), 899–918 – discussion

As researchers working on the Cambrian of Gondwana, we welcome the contribution on the Moroccan Cambrian made by Landing, Geyer and Heldmaier (2006), who provide new data and stimulate constructive discussions, yet we think there are some issues to address.

The lithostratigraphical and biostratigraphical model for the Lower/Middle Cambrian boundary of north-western Gondwana (Morocco, Germany, Turkey, Sardinia and Spain) consists of uppermost Lower Cambrian (Upper Bilbilian; Liñán *et al.*, 1993b) siliciclastic, mixed or carbonate facies (with archaeocyathans and/or protolenid trilobites) followed by Middle Cambrian shales or carbonates with paradoxid trilobites (such as the earliest Middle Cambrian species *Acadoparadoxides mureroensis*) (Sdzuy *et al.*, 1999: figs 1 and 3). Thus the Daroca Formation (as well as the Daroca regression) and the lower part of the overlying Valdemiedes Formation in Spain are upper Lower Cambrian in age (Liñán *et al.*, 2002).

The main issue is that the authors follow the biostratigraphic scheme proposed by Geyer (1990) and place their Lower/Middle Cambrian boundary at the base of the *Hupeolenus* Zone; i.e. at a stratigraphic point below the classical Lower/Middle Cambrian boundary identified in the Mediterranean region since the Nineteenth Century. The latter boundary is validated by most authors working on the Cambrian of north-western Gondwana (Choubert, 1953: fig. 3; Hupé, 1960; Hutchinson, 1962; Sdzuy, 1971; Cowie *et al.*, 1972; Dean & Özgül, 1994; Loi *et al.*, 1995; Sdzuy *et al.*, 1999; Wotte *et al.*, 2004: fig. 2) and is currently under discussion by the International Subcommission on Cambrian Stratigraphy (ISCS). Actually, the international Cambrian correlation chart given by Geyer, Peng and Shergold (Geyer & Shergold, 2000) – which (with slight differences) is currently widely used (waiting until the ISCS completes its decisions on the subdivision of the Cambrian) – correlates the *Hupeolenus* Zone of Morocco with Lower Cambrian rocks of Spain, Baltica, Siberia, Kazakhstan, North and South

China, Australia, Laurentia and Western Avalonia.

Consequently, by proposing to place the Lower/Middle Cambrian boundary at the base of the *Hupeolenus* Zone, the authors date the Daroca Formation and the lower part of the overlying Valdemiedes Formation as Middle Cambrian in age. Nevertheless, the *Protolenus* FAD (First Appearance Datum) in Cadenas Ibéricas (a Lower Cambrian index) lies within the arkosic siliciclastics of the Daroca Formation. Moreover, the lower part of the Valdemiedes Formation yielded the Lower Cambrian trilobites *Protolenus dimarginatus*, *Protolenus jilocanus*, *Protolenus pisidianus*, *Protolenus termierelloides*, *Kingaspis campbelli*, *Hamatolenus (Hamatolenus) ibericus*, *Onaraspis altus* and *Alueva undulata*, well below the Valdemiedes event (Dies *et al.*, 2004). On the other hand, the co-existence of the last representatives of protolenids with *Acadoparadoxides mureroensis* in Turkey (Dean & Özgül, 1994) and Morocco (Geyer & Landing, 2004) reinforces the classic view of the Lower/Middle Cambrian boundary in the north-western margin of Gondwana, rather than rejecting it.

The latest Lower Cambrian Valdemiedes event is also a topic of controversy with the authors. The reference section for this ('rambla de Valdemiedes 2' section, near the village of Murero, Zaragoza province, NE Spain; Liñán & Gozalo, 1986) lies within the upper Valdemiedes Formation. At the reference section, Liñán *et al.* (1993a) noted changes in sediment mineralogy and trace fossil contents in the event beds, as well as the disappearance of numerous trilobite species and dwarfing of the brachiopod fauna. In this section, the Valdemiedes event is recorded in an expanded, monofacial succession (in a transgressive context), consisting of mudstones and siltstones, which (according to illite crystallinity values) did not surpass the anchizone. Thus, the cryptic unconformity at the Valdemiedes event in the Cadenas Ibéricas proposed by Landing *et al.* (2006) is poorly defined, if at all. Furthermore,

some authors used equivalent levels of the Valdemiedes Formation for studies on cyclostratigraphy, without finding any important sedimentary break (Álvarez *et al.*, 2000: figs 4 and 7). The Valdemiedes event has been identified in all Lower/Middle Cambrian localities of Cadenas Ibéricas (NE Spain). The palaeogeographic extent of the Valdemiedes event (and thus its probable significance as a geoevent) is a matter of further research, but its chronological position suggests this to be near to, or to coincide with, the widely accepted Lower/Middle Cambrian mass extinction (Liñán *et al.*, 2006).

Finally, we hope the opinions expressed herein can be useful for discussions on the Lower/Middle Cambrian transition in the north-western margin of Gondwana.

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