The Neoproterozoic-Cambrian Transition in Central Spain with a Discussion of Terminal Ediacaran Stratigraphy

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Introduction

A thick (>2 km) succession of terminal Neoproterozoic (Ediacaran) - Cambrian siliciclastics and minor carbonates crop out over a wide area of central Spain. The importance of this area to studies of the Ediacaran - Cambrian transition was first documented by Brasier et al. (1979) and has been further corroborated by new palaeontological finds (Palacios 1989; Vidal et al., 1994a; Vidal et al. 1999; Palacios, et al., 2002). The outcrops cover a wide area, involve modest structural complications, and their investigation remains at a preliminary stage. Here we summarize the current knowledge and attempt to put the succession into a broader context of Ediacaran stratigraphy.

The succession represents a general shallowing upward from turbiditic to shallow-water and near-shore deposits. Deposition took place on an immature passive margin, in part in grabens or semi-grabens, and records the terminal stages of the Cadomian Orogeny (Vidal, et al., 1999; Palacios, et al., 2002). The lithostratigraphical nomenclature has for long been in a state of flux; here we use the scheme of Vidal et al.(1994a) and Palacios & Vidal (1996). The basal Domo Extremeño Group consists of a thick succession of immature, turbiditic sandstones. Simple trace fossils occur low in the Domo Extremeño Group (Vidal, et al., 1994b) suggesting that these strata are no older than about 560 Ma. The only other palaeontological data consist of acritarchs such as Palaeogomphosphaera (Palacios, 1989) and, towards the top, more diverse trace fossils. Of particular interest is the occurrence of trace fossils showing angular junctions and traces preserved on lower bedding planes as
rows of discontinuous segments or pods (Palacios, 1989; Vidal, et al., 1994a). These appear to represent surface expressions of three-dimensional burrow systems comparable to *Treptichnus*. In the area of the Ibor Anticline the Domo Extremeño Group is succeeded by the Ibor Group with a thin basal unit, which includes platform carbonates. Further to the east, in the Valdeleacasa Anticline, the lower part of the Rio Huso Group largely consists of mudstones with scattered dolomitic sandstones and olistostromic levels in places developed as a megabreccia (Fuentes Olistostrome). Finds of the skeletal fossil *Cloudina*, including *Cloudina hartmannae*, in storm influenced platform carbonates of the Ibor Group (Palacios 1989, Vidal et al.1994a) suggest a latest Ediacaran age. Garcia Hidalgo (1993) reported trace fossils, including *Hormosiroidea*, at a stratigraphical position immediately above *Cloudina*-bearing units in the Ibor Anticline. In more eastern areas *Cloudina* is found also in olistostromic units. Higher in the succession are mudstones containing carbonaceous discoidal fossils that have been compared to *Chuaria* and *Beltanelliformis* (*Beltanelloides*), as well as Phanerozoic-aspect trace fossils (Brazier, et al., 1979; Vidal, et al., 1994a; Gamez, Vintaned and Linan ,1996). The middle part of the Ibor and Rio Huso Groups consists of black micro-laminated shales that in places are phosphatic, and which has yielded *Sabellidites* (Vidal, et al., 1994a) in the Ibor Anticline. Both groups are terminated by green shales, sandstones and minor limestones. The higher strata of the Ibor and Rio Huso groups contain early Cambrian skeletal fossils, including trilobites and the mollusc *Anabarella*, as well as age-diagnostic acritarchs (Vidal, et al., 1999, Palacios, et al., 2002). Notable is also the presence of abundant carbonaceous filaments.

**Discussion**

The current palaeontological data suggest that strata of the Domo Extremeño and Ibor/Rio Huso groups encompass the Ediacaran to Cambrian transition. The occurrence of *Cloudina* suggests that, as a starting point, the central Iberian succession should be compared with other *Cloudina* bearing regions. A terminal Ediacaran age is currently accepted for *Cloudina* in Namibia, South China, Oman, western USA and probably Brazil. Recent radiometric dates in Namibia and Oman confirm that *Cloudina* ranges close to the currently accepted age for base of the Cambrian. It has been suggested that a Nama Assemblage contains the youngest of three Ediacaran Assemblages (Gehling and Narbonne,
2002; Waggoner, 2003), characterized by the mineralized and agglutinated taxa *Cloudina*, *Namacalathus* and *Archaeichnium* and a low diversity of Ediacara-type fossils including *Swartpuntia* and *Emietta*. Geographic and palaeoenvironmental factors must also be considered in addition to the still relatively scant information (cf. Waggoner, 2003; Grazhdankin, 2004), but this scheme nevertheless forms a useful starting point for discussion.

At present, comparison of the central Iberian succession to the Nama Assemblage is based on the occurrence of *Cloudina hartmannae*. The *Cloudina*-bearing intervals in central Spain are currently under investigation in the search for a higher diversity of skeletal fossils. Nonmineralized Ediacara-type fossils are so far unknown from central Spain, with *Beltanelliformis* the only possible exception. An interesting similarity between Namibia and central Spain is, however, the occurrence of three-dimensional burrow systems, which consist of numerous interconnected parts and, therefore, can be considered moderately complex traces. Trace fossils in the Urusis Formation of Namibia have been identified as *Treptichnus* sp. (Jensen, *et al.*, 2000). This occurrence is constrained between 548 and 545 Ma and widely accepted to represent a pre-Cambrian age. The presence of treptichnid-type trace fossils may, therefore, be added as a further characteristic of the Nama assemblage. The stratigraphic context of the central Iberian *Cloudina* is consistent with a latest Ediacaran age, and provides support for a latest Ediacaran trace fossil zone containing the first treptichnid-type trace fossils (Jensen, 2003), occurring in close association to *Cloudina*.

The Ediacaran-Cambrian boundary is in many areas of the world located in close stratigraphic proximity to a major unconformity of possible eustatic origin (e.g., Pyle, *et al.*, 2004). The Ediacaran-Cambrian boundary as defined on trace fossils is located at or somewhat below this unconformity. The Proterozoic-Cambrian boundary in Spain is widely represented by a period of non-deposition and erosion (e.g. Valladeres, *et al.*, 2002). Valladeres, *et al.* (2000) identified a level correlative to the Fuentes olistostrome to represent a regional sequence boundary. However, Vidal, *et al.* (1994a) interpreted this interval to be largely explicable by instability in the carbonate platform. An important task for further studies is renewed examination of the evidence for and against a break in sedimentation at this level.
References


