The Northeast Alentejo Neoproterozoic-Lower Cambrian succession (Portugal): Implications for regional correlations in the Ossa-Morena Zone (Iberian Massif)

La sucesión Finiproterozoica-Cambrica Inferior del Nordeste Alentejano (Portugal): Implicaciones en las correlaciones regionales de la Zona de Ossa-Morena (Macizo Ibérico).

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ABSTRACT

The Neoproterozoic-Lower Cambrian succession of the Northeast Alentejo (Portugal) is revised from a stratigraphic perspective in order to propose regional correlations with similar Ossa-Morena Zone domains in Spain. This revision now allows a better characterization of one of the most illustrative Neoproterozoic-Lower Cambrian stratigraphic sections of the Iberian Massif. The Serie Negra Group that is represented in Portugal by the Mosteiros Formation and Besteiros Amphibolites can be correlated with the Tentudia Formation and probably to part of the Montemolin Succession. The Neoproterozoic?– Cambrian transition unit known as the Volcano-Sedimentary Complexes of Nave de Grou-Azeiteiros and Freixo-Segóvia in Portugal are correlationable with the Malcocinado Formation widely distributed within the Ossa Morena Zone in Spain. The uppermost units, attributed to the Lower Cambrian and recognized as the Detritic-Carbonate Complexes of Ouguela and Assumar in the Northeast Alentejo can be correlated with the terrigenous Torreárboles Formation and the carbonate Alconera Formation described in Spain. In the context of the orogenic cycles in Iberia, the concept of Cadomian basement should be enlarged to the Cambrian period.

Key Words: *Neoproterozoic – Lower Cambrian succession, Ouguela stratigraphic section, Assumar stratigraphic section, Northeast Alentejo, Ossa-Morena Zone.*

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Introduction

The Ossa-Morena Zone (OMZ) Lower Cambrian succession in the Northeast Alentejo weredescribed as siliciclastic and carbonate sequences overlying the Neoproterozoic Serie Negra succession (Gonçalves, 1969-70, 1971; Gonçalves and Peinador Fernandes, 1973; Gonçalves *et al.*, 1975, 1978). The Lower Cambrian age was applied to the Northeast Alentejo sequences through stratigraphic correlations (Gonçalves, 1971) with similar chronostratigraphic sequences defined in Elvas (Delgado, 1904; Teixeira, 1952) and in Spain (Vegas, 1970). Although results of biochronology were available since the early 1970´s from the Spanish OMZ sector (Liñan, 1978; Liñan and Gonzalo, 1986; Liñan and Quesada, 1990; Liñan *et al.*, 1993), no paleontological research was developed in Portugal for the Lower Cambrian formations.

The Neoproterozoic strata of the OMZ was interpreted as a sequence which include two main units from bottom to top (Arriola *et al.*, 1984; Eguiluz, 1987; Eguiluz and Abalos, 1992; Quesada, 1990):

1) The Serie Negra (Carvalhosa, 1965) includes an upper monotonous shale and greywacke suite with interlayered black cherts, carbonates, felsic tuffs and metabasites (Tentudia Formation, Eguiluz, 1987) and a lower amphibolite-rich succession (Montemolin Succession, Eguiluz, 1987); Ion-microprobe U-Pb dating of detrital zircons from the upper part of the Serie Negra revealed an uppermost Vendian age (Neoproterozoic) for the deposition of this succession (metagreywakes deposition, 564±30 Ma, U/Pb on zircon, Schäfer *et al.*, 1993); Reported 40Ar/39Ar mineral ages indicate Cadomian tectonothermal activity (black quartzite metamorphism, 550±10 Ma, 40Ar/39Ar on amphibole, Blatrix and Burg, 1981) and;

2) The Malcocinado Formation (Fricke, 1941) correlated with the Bodonal-Cala Complex, Jabugo Series (Bard, 1969), S. Jeronimo Formation (Liñan, 1978), represents volcanic suites with tuffs, reworked tuffs, rhyolites, basites and polygenic conglomerate layers with pebbles of the underlying Serie Negra;

Volcanoclastic rocks from S. Jerónimo Formation, considered as Neoproterozoic based on palynological and ichnofaunal data (Liñan and Palácios, 1983), are overlain unconformably by the Lower Paleozoic siliciclastic and carbonatic sequences (Torrearboles and Alconera Formations respectively, Liñan, 1978) dated paleontologically as Lower Cambrian (Liñan *et al.*, 1993).

Recent available SHRIMP-dates from this volcanic suites (Malcocinado Formation and correlated units) indicates a maximum deposition age of 522±8 Ma for reworked tuffs and 514±9 Ma for porphyritic rhyolites protolith age (U/Pb on

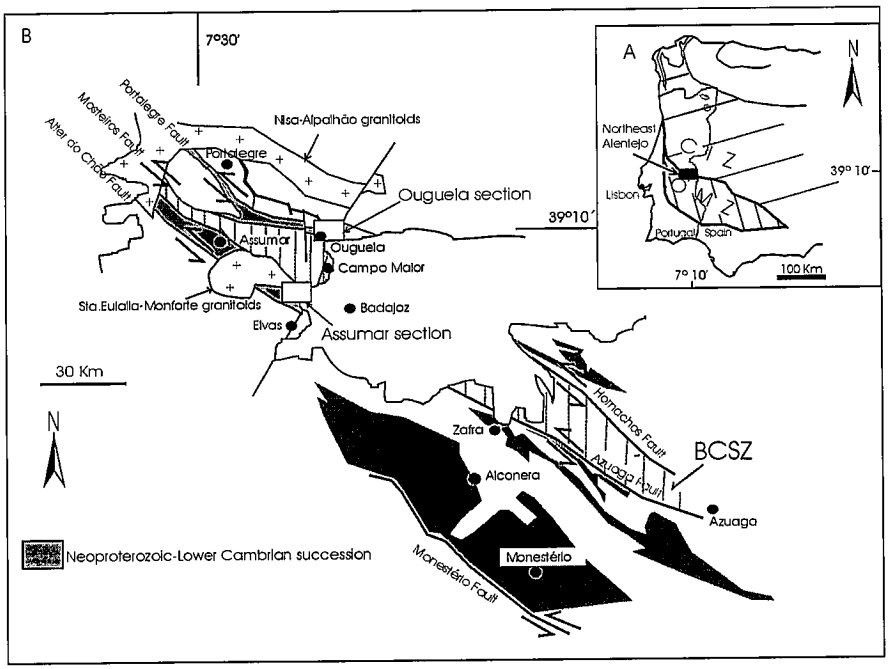

Figure 1.- A – **Geological sketch of the Northeast Alentejo located at the Ossa-Morena (OMZ) / Central Iberian (CIZ) boundary. B – Schematic geological map of the OMZ showing the distribution of the Neoproterozoic-Lower Cambrian successions and the localization of the Ouguela and Assumar section which are separated by the Badajoz-Cordoba shear zone (BCSZ).**

Figura 1.- A – Esbozo geológico de la localización del Nordeste Alentejano en la frontera entre las zonas de Ossa-Morena (OMZ) y Centro-Ibérica (CIZ). B – Mapa geológico esquemático con la distribución de la sucesión Finiproterozoica-Cámbrica Inferior de la Zona de Ossa-Morena y localización de los sectores de Ouguela y de Assumar separadas por la zona de cisalla de Badajoz-Córdoba (BCSZ).

zircon, Ordoñes-Casado, 1998), suggesting a Middle to Upper Cambrian age what is clearly in conflict with the paleontological data.

In Portugal, the Serie Negra was attributed to Neoproterozoic on the basis of acritarch content (Gonçalves and Palácios, 1984) and the isotopic geochemistry (Sm/Nd/Pb) data point to a 550-600 Ma age for deposition event (Beetsma, 1995). Lower Cambrian sequences were considered to be mainly unfossiliferous. The only described fossiliferous horizons with trilobites (Delgado, 1904; Teixeira, 1952) are from the Elvas stratigraphic section included in the Vila Boim Formation (Gonçalves, 1978; Oliveira *et al.*, 1991).

In the Northeast Alentejo region two-major Neoproterozoic-Lower Cambrian areas are present, which are separated by a blastomylonitic belt (the Badajoz-Cordoba shear zone, BCSZ (s.l.); e.g. Burg *et al.*, 1981; Abalos and Eguiluz, 1992; Azor *et al.*, 1994; Pereira and Silva, 2001). The main objective of this paper is to revise the previous works using a new interpretation within the context of a plausible geodynamic model for the OMZ evolution. Following this purpose two local stratigraphic sections on both side of the BCSZ are described herein.

The Ouguela Stratigraphic Section: Neoproterozoic-Lower Cambrian succession at north of the BCSZ

For more than sixty kilometres, from Crato to Ouguela, the Mosteiros Formation (Gonçalves and V.Oliveira, 1986) included in the Serie Negra Group (SNG) mainly consist of slates and greywackes with intercalations of basic and felsic volcanic and / or volcaniclastic rocks, black cherts and minor carbonates.

In the vicinity of Arronches and Ouguela this previously deformed and metamorphosed under low-grade conditions Neoproterozoic succession is unconformably overlian by the Volcanic-Sedimentary Complex (VSC) of Nave de Grou-Azeiteiros and / or by Lower Cambrian platform sedimentary sequences included on the Detritic-Carbonate Complex (DCC) of Ouguela (Pereira, 1999).

The Neoproterozoic-Lower Cambrian magmatism (VSC Nave de Grou-Azeiteiros) is made up of a series of felsic and intermediate metatuffs with intercalated ryolites and dacites. This complex lies unconformably over the SNG and is overlain by siliciclastic materials of the typical Lower Cambrian OMZ platform sequences (Fig.2; Marmeleiros and Abrilongo river cross-sections, at North of Ouguela).

Sedimentary structures such as interbedded, cross-stratified and channelled sandstones, intraformational conglomeratic horizons together with siltstones at the top with parallel lamination and sumpled beds, suggest that the lower detritic part of the DCC of Ouguela was deposited in shallow subtidal and intertidal conditions probably influenced by prograding coastline environments. Shallow platform depositional environment is also proposed for the upper carbonate sequence of the DCC of Ouguela where relics of echinoderms were described (Pereira, 1999).

3. The Assumar Stratigraphic Section: Neoproterozoic-Lower Cambrian succession at south of the BCSZ

The Assumar stratigraphic section (fig.2) has been described in a narrow band at the northern border of the Megastructure of Assumar (Pereira and Silva, 1999) along more than sixty kilometres. The band is parallel to the BCSZ and is cut by a later Carboniferous granitoid (Monforte-Santa Eulália massif).

This stratigraphic section is well documented and preserved at North of Alter do Chão and to SE, in an enlarged syncline, at south of Campo Maior. It includes two unconformities (Pereira, 1999): one between the SNG and the VSC of Freixo-Segóvia and a second at the base of the DCC of Assumar (Fig.2. Segóvia and Freixo cross-sections, at South of Campo Maior).

The Freixo-Segóvia VSC appears to rest unconformably over the SNG composed of several kilometers thick metasediments and volcanics (Mosteiros Formation) with abundant amphibolites (Besteiros Amphibolites. Pereira and Silva, 1998). It is made of acid-intermediate pyroclastic rocks, acid lavas and polygenic conglomerates deformed and metamorphosed in very low to low metamorphic conditions, contrasting with the biotite-rich schists, amphibolites, paragneisses and intercalations of black metacherts and carbonates from the Neoproterozoic deformed rocks where amphibolitic metamorphic facies prevails.

At the top of the succession siliciclastic and carbonate platform facies develop and unconformably overlie the SNG and / or the Freixo-Segóvia VSC. The DCC of Assumar is made of a basal detrital series with sandstones, arkoses and slates evolving to upper carbonate rocks with interbedded limestones and shales, and dolostones (Pereira, 1999).

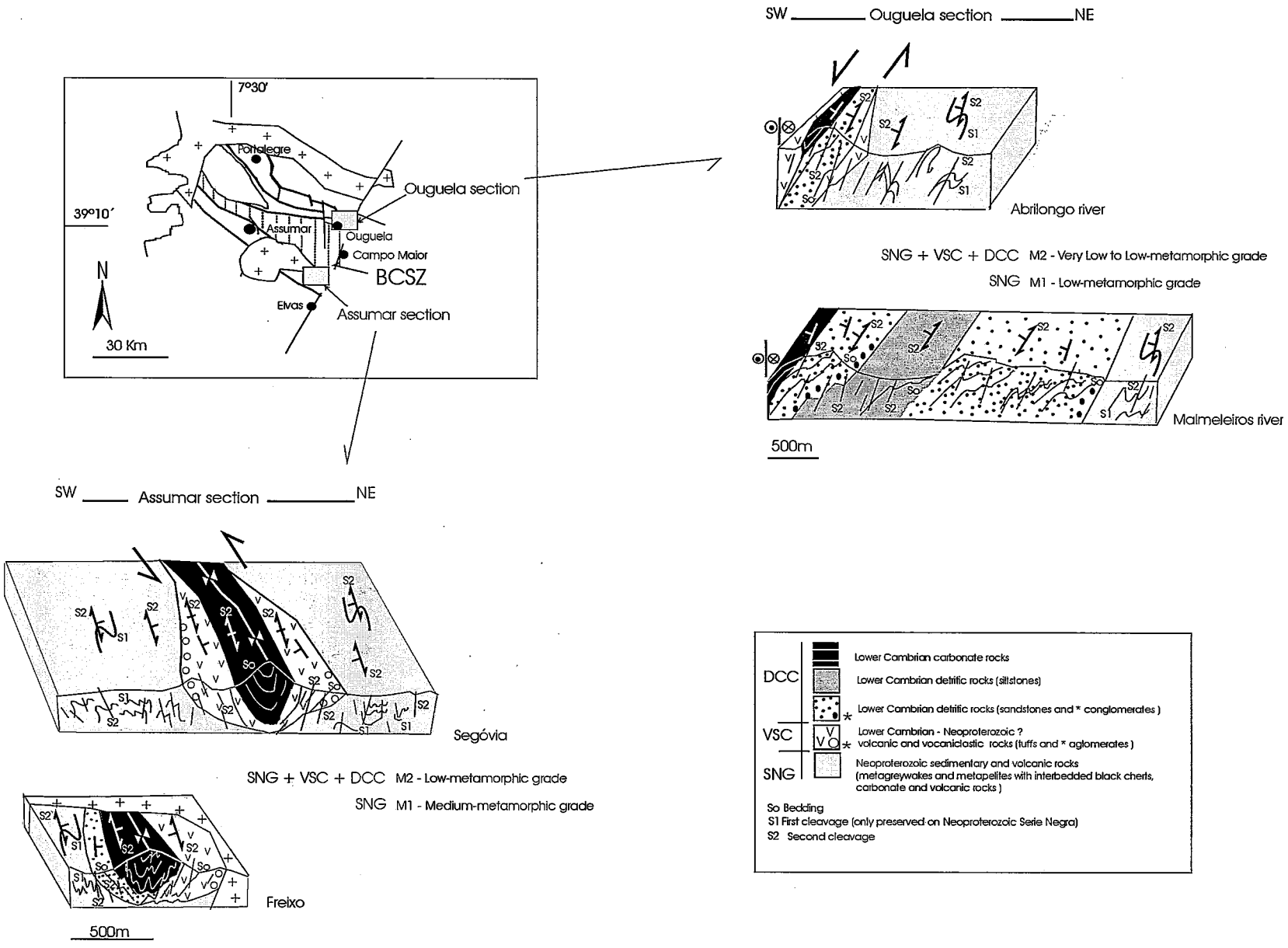

Figure 2.- **Neoproterozoic-Lower Cambrian successions of the Northeast Alentejo. Schematic cross-sections representing the Ouguela section (at North of the BCSZ) and the Assumar section (At South of the BCSZ) Neoproterozoic-Lower Cambrian stratigraphy.**

Figura 2.- Sucesión Finiproterozoica-Cámbrica Inferior del Nordeste Alentejano. Cortes geológicos esquemáticos a representar la estratigrafía Finiproterozoica-Cambrica Inferior del sector de Ouguela (al Norte de la BCSZ) y del sector de Assumar (al Sur de la BCSZ).

The sedimentary features are similar to those described for the Ouguela stratigraphic section but no fossils were found yet.

Discussion: regional correlations

The unconformity between the Serie Negra Group and the overlying volcanic-sedimentary complexes has been considered the ending of the Cadomian orogen-related processes and the beginning of Variscan cycle. To the basal conglomerate facies included in the VSC of Assumar (Lower Cambrian of Assumar, Gonçalves, 1971) was assigned a fundamental stratigraphic value to define the first stage of anorogenic Lower Paleozoic events.

This concept must be reinterpreted due to recent radiometric data from Spain (SHRIMP, U/Pb on zircons, Ordoñes-Casado, 1998), which indicate similar ages for this Cambrian magmatism (522-514 Ma) and anatetic domes generation on the SNG (510-530 Ma) considered to result from Cadomian metamorphism (Eguiluz *et al.*, 2000). Considering these facts the concept of Cadomian basement need to be enlarged to the Cambrian period.

Despite several disagreements between some recent geochronological data and paleontological established charts an attempt to clarify the Precambrian-Cambrian boundary and associated Cadomian geodynamic events must be done. A transcurrent regime is regarded as a probable cause for thickness and facies development between different Neoproterozoic? – Lower Cambrian volcanic series and Lower Cambrian sedimentary platform pull-apart basins of the OMZ as first stages of the Paleozoic tectonics.

The correlation of the Northeast Alentejo succession with comparable sectors of the OMZ domains in Spain proposed here pretends to be a contribution to the characterization of one of the most illustrative Neoproterozoic-Lower Cambrian stratigraphic sections of the Iberian Massif: 1) The Serie Negra Group which is represented in Portugal by the Mosteiros Formation and Besteiros Amphibolites can be correlated with the Tentudia Formation and probably to part of the Montemolin Succession. 2) The Neoproterozoic? – Lower Cambrian transition unit known as the VSC of Nave de Grou-Azeiteiros and Freixo-Segóvia in Portugal are correlationable with the Malcocinado Formation widely distributed within the OMZ in Spain; 3) The upper most units attributed to the Lower Cambrian recognized as the DCC of Ouguela and Assumar in the Northeast Alentejo can be correlated with the terrigenous Torreárboles Formation and the carbonate Alconera Formation described in Spain (Fig.1).

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