Preliminary Magnetostratigraphy for the Jurassic–Cretaceous Transition in Porto da Calada, Portugal

Johanna Salminen, Jorge Dinis and Octávio Mateus

Abstract We present a stratigraphic log supporting a preliminary magnetostratigraphy of a Tithonian–Berriasian section in Porto da Calada (Portugal). Based on biostratigraphy and reversed and normal magnetostratigraphy, the location of the Tithonian–Berriasian boundary is tentatively located at ca. 52 m, not in disagreement with former proposals. Due to the occurrence of later remagnetization (diagenesis), the magnetostratigraphic definition of the Tithonian–Berriasian section at the Cabo Espichel (Portugal) location was not able to be established.

Keywords Lithostratigraphy · Magnetostratigraphy · Tithonian–Berriasian · Lusitanian Basin · Portugal

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Introduction

The Jurassic–Cretaceous boundary is still poorly understood and is the last system boundary without a GSSP. Furthermore, biostratigraphic correlations among palaeobiogeographical provinces are hampered by barriers to faunal exchange (e.g., Ogg et al. 2012). Dating by magnetostratigraphy coupled with regional correlations and biostratigraphy has been successfully used to make large-scale correlations. Earlier studies have placed the Tithonian–Berriasian boundary in various different positions, but currently the base of Chron M18r is assigned and is even a candidate as a correlation event marking the boundary (Ogg et al. 2012).

The onshore uppermost Jurassic to lowermost Cretaceous of the Lusitanian Basin (Western Portugal) has been the subject of numerous studies (Ramalho 1971; Rey 1972, 1993; Mateus 2006; Dinis et al. 2008; Myers et al. 2012). It includes several good exposures of the Jurassic–Cretaceous (J–K) transitions, for example, Porto da Calada, the Sintra–Cascais region, and Praia dos Lagosteiros–Cabo Espichel. Despite the favourable exposure, the exact position of the J–K boundary is poorly known, due to the lack of good biostratigraphic markers in a complex stratigraphy, which records important variations in a coastal landscape that was still under the influence of the late Oxfordian to early Kimmeridgian rifting.

Sampling and Methods

We collected 102 standard cores from the Porto da Calada section (lat 39.04°N, long 9.41°W), and 72 standard cores and four oriented block samples from the Cabo Espichel section (lat 38.42°N, long 9.22°W). A portable field drill was used and cores were oriented using both sun and magnetic compasses.

Palaeomagnetic measurements for magnetostratigraphy were conducted in the magnetically shielded room of the palaeomagnetic laboratory of the Department of Geology and Geophysics at Yale University, US. Samples were stepwise thermally demagnetized in a nitrogen atmosphere using an ASC Scientific model TD-48SC furnace. Remanent magnetization was measured using an automated sample-changing system attached to a 2G cryogenic magnetometer (Kirchvink et al. 2008). Sister specimens from the same cores were stepwise demagnetized using the alternating field (AF) method and a 2G cryogenic magnetometer in the Solid Earth Geophysics Laboratory at the University of Helsinki. Due to high-coercivity minerals in some of the samples, the thermal method was more effective.

Results of Magnetic Studies

The natural remanent magnetization (NRM) intensity for Porto da Calada samples was generally in the order of 10^{-3} A/m and magnetic susceptibility in the order of 10^{-4} SI, being typical for sedimentary rocks. NRM and susceptibility values depend on lithology, and limestone shows the lowest values (Fig. 1). The majority of the samples were totally cleaned during the thermal demagnetization and vectors decayed to origin, indicating that ChRM was successfully obtained and that no higher coercivity/unblocking temperature component was present. The colour of these fairly fine-grained samples was light or dark grey. Normal and reversed ChRM directions were obtained. Due to later diagenesis, a few samples of yellow and red colour did not reveal the original magnetization direction.

The Cabo Espichel samples had been totally remagnetized by post-formation processes and therefore did not reveal the original remanent magnetization direction.

Stratigraphy

At the Porto da Calada section, the Assenta member of the Lourinhã Formation is Tithonian in age. The Lourinhã Formation is Kimmeridgian–Tithonian in age, confidently biostratigraphically dated by numerous invertebrates and vertebrates (see Mateus 2006, and Ribeiro and Mateus 2012) and by strontium stable isotope curves (Schneider et al. 2009). The foraminifera, namely *Anchispirocyclina lusitanica* (Egger 1902), and ostracods of the 37–40 m limestone level (Fig. 1) (Rey 1972), are similar to the regional Tithonian assemblages (Ramalho 1971). Dinocysts of the 65–73 m interval are considered as representing the early to middle Berriasian boundary (Berthou and Leereveld 1990). The unconformity between the Porto da Calada and Vale de Lobos formations is dated by regional tectono–stratigraphic correlation as late Berriasian (Dinis et al. 2008). In this section, two dinosaurs were identified: axial and postcranial parts of Ankylosauria below the J–K boundary, and one tail spine of Stegosauridae above it, both chronologically consistent with the magnetostratigraphy.

Because the results from Cabo Espichel cannot be used for synsedimentary stratigraphic purposes, this outcrop is not discussed here.

Discussion and Conclusions

Based on the results for the Porto da Calada section, we correlate the reversed magnetozone at 33 m in the stratigraphic log with the M19r1 anomaly and the normal magnetozone between 35 and 51 m with M19n1 (Fig. 1). Following the

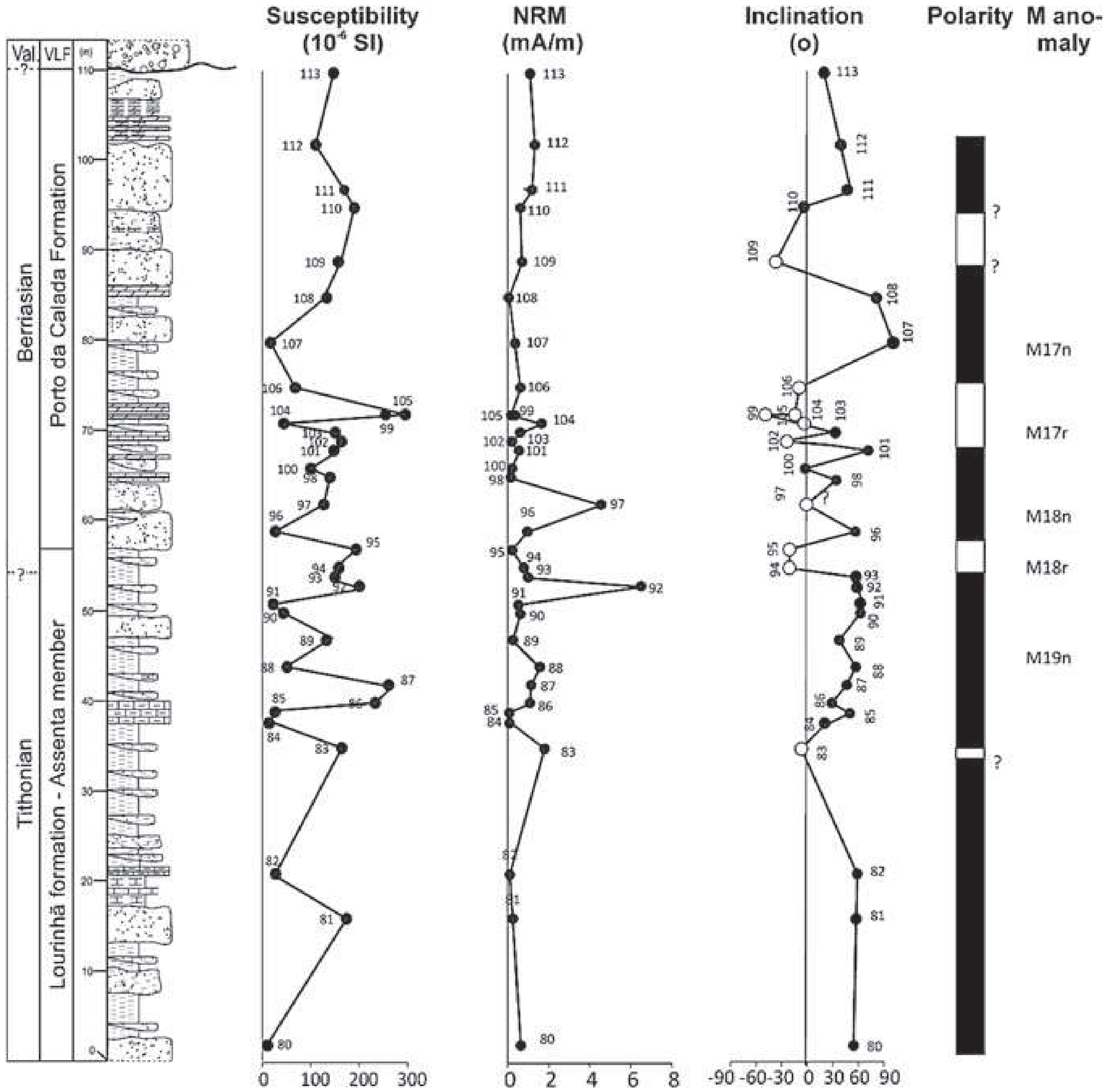

Fig. 1 Stratigraphy of the Porto da Calada section (Portugal): variation in magnetic susceptibility, intensity, inclination of ChRM, polarity column, and M-anomalies. *Black* (*white*) indicates *normal* (*reversed*) polarity

Ogg et al. (2012) scale, we place the J–K Tithonian–Berriasian boundary at the base of magnetozone M18r, at around 52 m of the log. This position is an improvement over previous proposals for this outcrop, namely that of Rey (1993), which tentatively located the J–K boundary at the base of the Porto da Calada Formation (at our 60 m) as a best fit between available biostratigraphy and regional correlations. However, it must be stressed that the proposed position of the J–K boundary is tentative, due to the scarcity of fossils and the uncertainties in their age significance in the studied succession.

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