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Eocene to Oligocene dinoflagellate cysts from the Tattofte section, western External Rif, northwestern Morocco: Biostratigraphy, paleoenvironments and paleoclimate

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ABSTRACT

The palynological analysis of the Eocene–Oligocene succession from the Tattofte section in the western External Rif (northwestern Morocco) reveals the presence of well-preserved and diverse assemblage, rich in dinoflagellate cysts (dinocysts). Qualitative analyses, especially of the dinocysts, differentiate the individual stages of the deposits, while quantitative analyses permit paleoenvironmental and paleoclimatic interpretations. We assign the lower part of the Tattofte section to the Middle Eocene (Lutetian and Bartonian) and its upper part to the Upper Oligocene (Chattian), and define a hiatus spanning the Late Eocene (Priabonian) and Early Oligocene (Rupelian). The dinocyst marker events used for the biostratigraphic interpretations include the first and last occurrences of marker species, such as *Batiacasphaera compta*, *Castellodinium compactum*, *Cerebrocysta bartonensis*, *Distatodinium biffii*, *Distatodinium paradoxum*, *Distatodinium ellipticum*, *Enneadocysta arcuata*, *Homotryblium floripes*, *Hystrichokolpoma bullatum*, *Impagidinium velorum*, *Lentinia serrata*, *Pentadinium imaginatum*, *Rhombodinium spinula*, *Saturnodinium perforatum* and *Ynezidinium brevisulcatum*, as well as the *Chiropteridium* spp. acmes. And we equate the Chattian with the dinocyst *Distatodinium biffii* Zone of Brinkhuis et al. (1992).

Changes in the relative abundances of selected dinocyst groups, spores and pollen lead to the distinction, from oldest to youngest, of four marine environments: 1) marginal marine to coastal inner neritic under relatively warm-water during the Middle Eocene; 2) outer neritic to oceanic during a transgressive regime in the early Chattian; 3) fluctuating restricted to open marine in the middle Chattian; and 4) shallow coastal to open marine due to sea-level fall at the top of the section in the latest Chattian, suggested by the *Chiropteridium* spp. acmes.

The acmes of selected thermophilic dinocyst taxa, such as *Polysphaeridium* spp. and *Homotryblium* spp. suggest warm water marine conditions, which may be related to the Middle Eocene climatic optimum (MECO) and Late Oligocene warming.

1. Introduction

The stratigraphy of the western External Rif Chain (northern Morocco), where the Tattofte section is located (Fig. 1), is unknown due to the structural complexity of this Alpine chain and the lithological similarities, especially of the marl deposits. Multidisciplinary biostratigraphic studies are required to refine the age of the deposits and to establish correlations. However, the scarcity or absence of calcareous micro-, meso- and macrofossils, which may be due to their dissolution at the carbonate compensation depth (CCD) or from tectonic activity and metamorphism in several regions of the Rif, such as the region of Arbaa Ayacha (Guédé et al., 2014), hampers biostratigraphic dating of the deposits. Thus the focus on biostratigraphic studies has switched to palynomorphs — primarily dinocysts, spores and pollen — which seem to show much more promise. The utility of this group has been demonstrated in several papers published on assemblages of the External Rif. Slimani et al. (2008, 2010, 2012, 2016), Slimani and Toufiq (2013), Guédé et al. (2014), Guédé (2016) and Chekar et al. (2016) have undertaken detailed palynological studies, especially of the dinocysts, on the Paleocene and the Eocene throughout the Rif Chain, but the

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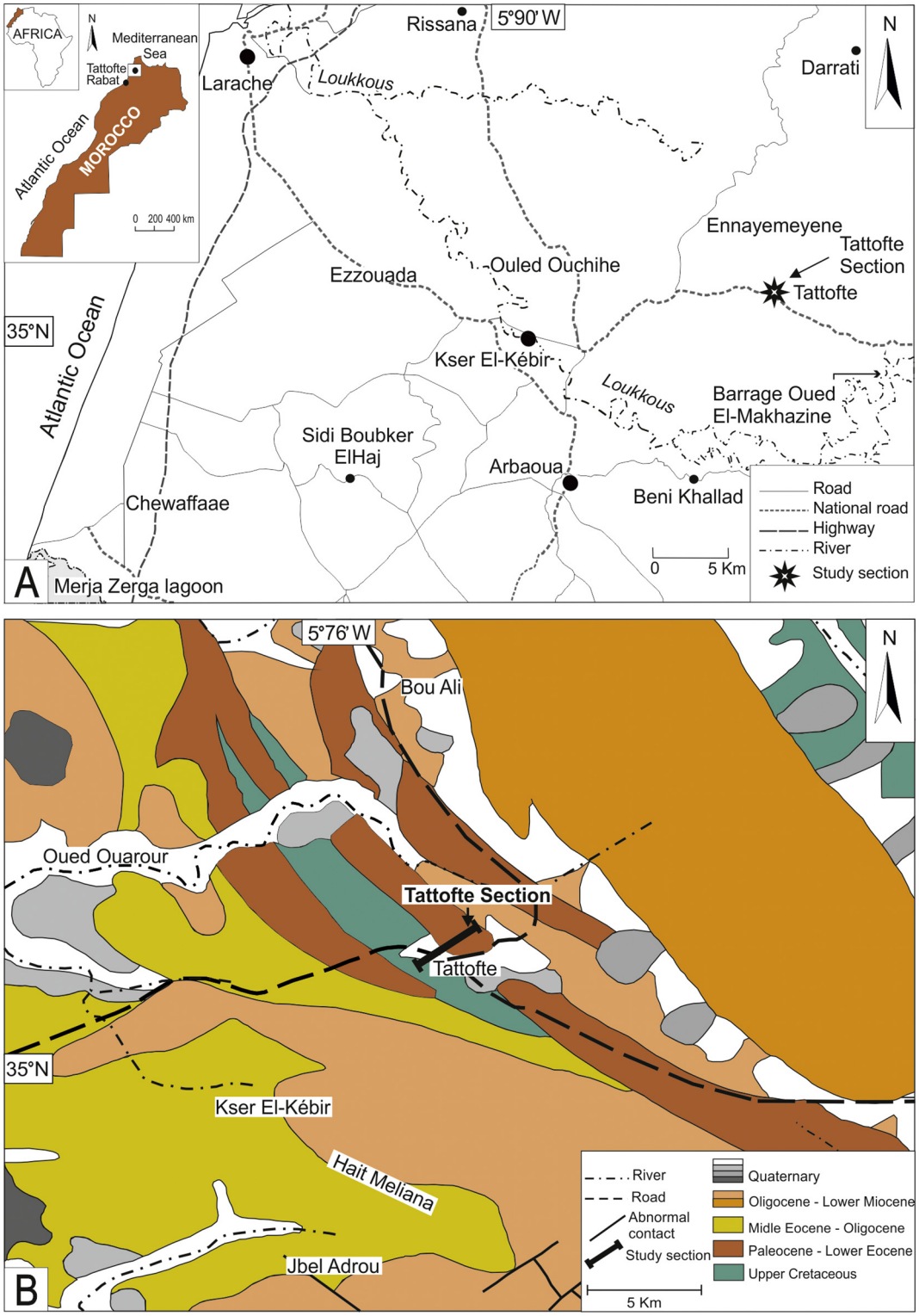

Fig. 1. Location map (A) and geological setting (B) of the Tattofte section, western External Rif, northwestern Morocco. B is adapted from the geological map of Rif 1:500,000 (Suter, 1980a).

Oligocene has been neglected. Palynological studies of marly successions of the Upper Cretaceous to Lower Eocene at Arba Ayacha (40 km NE of the study area) and Tangier (80 km NE of the study area) have provided age control and refinement (Guédé et al., 2014; Slimani et al., 2016; Chekar et al., 2016). The identification of the Paleocene in the uppermost part of the interval formerly assigned to the Late Cretaceous by Suter (1980a) and the determination of the Cretaceous–Paleogene and Paleocene–Eocene boundaries, are among the most important results of the studies in the Arbaa Ayacha region. Furthermore, the detailed palynological analyses in the Tangier region confirmed the Middle Eocene–Oligocene age previously assigned to the Ibn Batouta section in the geological map of Tanger-Al Manzla (1:50,000) and allowed a paleoenvironmental and palaeoclimatic reconstruction of the interval (Chekar et al., 2016).