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# Climatic control on vegetation and sedimentary dynamics during the Miocene (Burdigalian to Langhian) in northeastern Tunisia

*Dynamique végétale et sédimentaire et impact du climat au cours du Miocène (Burdigalien–Langhien) en Tunisie Nord-orientale*

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## Abstract

Palynological and sedimentological analyses were performed on Miocene sediments of North-East Tunisia in order to detect the changes in depositional environments, including those linked to eustasy, along with changes in vegetation and climate. The specific integration of palynological (pollen and dinocysts) and sedimentological (including facies analysis) data indicate that shallow marine settings persisted until the early Burdigalian–Langhian, and that open marine environments developed progressively in the late Langhian. Since the early Serravallian, deltaic environments developed under a fluctuating, but predominantly warm climate. The palynological data support a subtropical climate during the Burdigalian, with tropical conditions prevailing at the Langhian–Serravallian transition. The observed high frequency values of megathermic and mega-mesothermic pollen taxa represent the vegetation response to the Miocene climatic optimum (MCO).

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**Keywords:** Palynology; Palaeoecology; Miocene climatic optimum; Sedimentology; Mediterranean

## Résumé

Une analyse sédimentologique et palynologique a été effectuée sur les sédiments du Miocène inférieur à moyen du Nord-Est de la Tunisie dans le but de conclure sur la nature et l'évolution de l'environnement de dépôt et la signature eustatique, d'une part, et sur la dynamique de la végétation et du climat, d'autre part. L'interprétation des zones polliniques, des associations des faciès et du découpage séquentiel reflètent un milieu marin peu profond au Burdigalien–Langhien inférieur évoluant vers un milieu franchement marin au Langhien supérieur puis deltaïque à la base du Serravallien, sous le contrôle d'un climat fluctuant mais généralement chaud. En effet, l'évolution des groupes écologiques prédéfinis reflète un climat subtropical au Burdigalien à tropical au passage Langhien–Serravallien. Le maximum de fréquence des taxons mégathermes et méga-mesothermes est une réponse de la végétation à l'optimum climatique du Miocène (MCO).

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**Mots clés :** Palynologie ; Paléocécologie ; Optimum climatique du Miocène ; Sédimentologie ; Méditerranée

## 1. Introduction

In northeastern Tunisia, palynological studies are limited to basins of clay deposits rich in organic matter (lignites

and plant-bearing clays), belonging to fluvial to deltaic sediments of Serravallian–Tortonian age (Planderova et al., 1969; Planderova, 1971; Demacq et al., 1974; Van Campo, 1978, 1979; Tayech, 1984; Méon and Tayech, 1986; Suc and Bessais, 1990; Gaaloul-Announ, 1995; Mannai-Tayech, 2006b; Ben Moktar and Mannai-Tayech, 2011, 2014; Ben Moktar, 2013). These deposits are unfortunately poor in biostratigraphic markers, consequently, they are not well dated.

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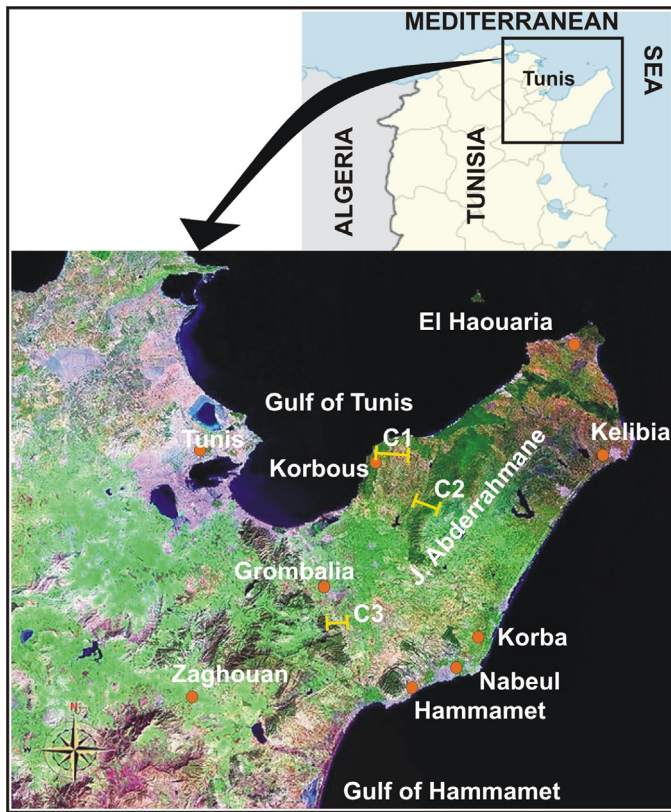


Fig. 1. Location of the study area and location of sections (C1: Douala section; C2: Oued Sidi Hamouda section; C3: Grombalia section).

In contrast, the lower and middle Miocene marine is well dated by the planktonic foraminifera (Hooyberghs, 1973, 1977; De Meuter and Symons, 1973; Ben Ismaïl-Latrache, 1981). But palynological studies are rare. In this work, a combined sedimentological and palynological approach was carried out for these marine deposits of northern Tunisia. Besides the detailed lithological description and identification of facies associations, a systematic inventory of the paleoflora was used to construct pollen diagrams. This correlation of facies associations and pollen zones improves our knowledge of paleoenvironmental conditions, allowing the restoration of prior depositional and climatic settings.

## 2. Geological setting

The North-East region of Tunisia is situated on the southern Tethyan margin. It constitutes, along with Sicily, the pelagian platform and therefore the transition zone that separates the basins of the western Mediterranean from those of the eastern Mediterranean (Bédier et al., 1996; Mannai-Tayech, 2009). The sector, which is the focus of our study, is bordered to the north and east by the Mediterranean Sea, to the west by the line between Tunis and Zaghouan and to the south by the Nabhana Oued and Draa Souatir anticline (Fig. 1). During the Neogene, this region witnessed a succession of extensional and compression events, which resulted in the formation of microbasins filled by deposits characterized by a sharp lateral facies variation

from north to south and east to western Tunisia (Mannai-Tayech, 2006a). The lower to middle Miocene identified in these microbasins corresponds to the following formations:

- the formation “A” defined by Hooyberghs (1973), which is characterized by sporadic outcrops of pecten-containing, coarse sandstones and clays with benthic and planktonic microfossils, is of Burdigalian age;
- the Oued Hammam Formation, which was dated Burdigalian–lower Langhian (Hooyberghs, 1973, 1977; De Meuter and Symons, 1973), was defined by clay marls rich in microplankton [*Globigerinoides altiapertura*/*Globigerinoides trilobus trilobus* (biozone N7 of Blow) and *Globigerinoides sicanus*/*Praeorbulina glomerata* (biozone N8 of Blow)];
- the Aïn Grab Formation, which was dated middle to upper Langhian thanks to the presence of *Obulina suturalis* (Hooyberghs, 1977; Ben Ismaïl-Latrache, 1981), contains a fossiliferous carbonate facies rich in benthic bivalves, echinoderms, bryozoans and polyps, in addition to planktonic microfossils;
- the Mahmoud Formation corresponds to clays and marls with a planktonic fauna that includes the *Orbulina suturalis* and *Orbulina universa* biozone (N9 zone of Blow, 1969), which is upper Langhian in age (Hooyberghs, 1977; Ben Ismaïl-Latrache, 1981).

The entire group is capped by a thick detrital series of the Saouaf Formation, which is of Serravallian-Tortonian age (Mannai-Tayech, 2006a, 2009).

## 3. Materials and methods

### 3.1. Approach of the sedimentological study

The area, which is the focus of this study, has already been the subject of numerous sedimentological and sequence stratigraphic studies (Blondel, 1991; Mannai-Tayech et al., 1992; Ben Salem, 1992; Boujamaoui, 2000; Mannai-Tayech, 1996, 2006a, 2009; El Euch-El Koundi, 2007). The approach taken in this study is primarily based on a detailed description of lithofacies, faunal content and sedimentary features, plus a careful observation of the depositional organization and structure. We have identified facies associations and depositional sequences defined in the basin. This study is based on cuttings from Douala, Oued Sidi Hamouda (Takelsa Basin) and Grombalia (Grombalia Basin) (Figs. 1 and 2). They are relatively the most comprehensive and cover, from a stratigraphic point of view, the early to middle Miocene. The detailed description and photography of the lithological units, along with the sedimentary features and fossils allow us to determine the facies associations, and, therefore, to reconstruct the depositional environments.

### 3.2. Chemical processing and differentiated groups

Twenty-six samples were systematically subjected to mechanical and chemical processing to extract the organic phase

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