C. R. Palevol 15 (2016) 825–836

Contents lists available at ScienceDirect

Comptes Rendus Palevol

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General Palaeontology, Systematics and Evolution

Geopalaeontological setting, chronology and palaeoenvironmental evolution of the Baccinello-Cinigiano Basin continental successions (Late Miocene, Italy)

Cadre géo-paléontologique, chronologie et évolution des paléoenvironnements dans la succession continentale du bassin de Baccinello-Cinigiano (Miocène supérieur, Italie)

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ARTICLE INFO

Article history:
Received 12 March 2015
Accepted after revision 22 July 2015
Available online 9 October 2015

Handled by Lars vanden Hoek Ostende

Keywords:
Geological setting
Chronology
Palaeoenvironmental evolution
Oreopithecus faunas
Long continental succession
Late Miocene
Italyur
Italie

ABSTRACT

The Latest Miocene succession of the Baccinello-Cinigiano Basin in southern Tuscany (Italy) recorded a faunal turnover documenting the extinction of an older, insular, endemic faunal complex characterised by the extinct ape *Oreopithecus bambolii* and the setting of a new, continental, European faunal complex including the colobine monkey *Mesopithecus*. A similar turnover pattern (Late Miocene ape/Latest Miocene Cercopithecidae) is generally observed in Late Miocene continental successions of Eurasia, from Spain to central Europe, Southwest Europe, the near East, and Southwest Asia. Abundant literature reports that the Late Miocene Eurasian hominoid primate distribution closely tracks the climatic/environmental changes occurring during the 12–9 Ma interval, until their extinction in western Europe. In the primate record, the dispersion of Cercopithecidae and the contraction of hominids is interpreted as an event depicting a pattern of "continentalisation" in the Old World. The sedimentary succession of the Baccinello-Cinigiano basin, one of the longest continuous vertebrate-bearing continental successions in the Neogene Italian record, contributes to the debate on this hypothesis. This paper provides an overview of the main characteristics of the sedimentary succession, the chronological constraints (biochronology, radiometric datings, magnetostratigraphy), and the palaeoenvironmental evolution as derived from palaeobiological approaches and from the study of stable carbon and oxygen isotope contents along the entire sedimentary succession. The 2 myr geological history of the Baccinello Cinigiano Basin, which documents the evolutionary history of *Oreopithecus* and associated faunas, does not have a direct relation with the event of the Messinian Salinity Crisis. The evolutionary history of Baccinello-Cinigiano Basin and its palaeontological record have been mainly driven by the regional tectonism and palaeogeographic changes that affected the northern Tyrrhenian regions in Late Miocene (Latest Tortonian–Messinian) times.

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http://dx.doi.org/10.1016/j.crpv.2015.07.002
1631-0683/

Mots clés :
Mise en place géologique
Chronologie
Évolution paléoenvironnementale
Faunes à *Oreopithecus*
Longue succession continentale
Miocène supérieur
Italie

RÉSUMÉ

La succession du Miocène terminal du bassin Baccinello-Cinigiano dans le Sud de la Toscane (Italie) a enregistré un *turnover* faunique documentant un complexe faunique endémique insulaire antérieur, caractérisé par le grand singe éteint *Oreopithecus bambolii* et l'établissement d'un nouveau complexe faunique européen continental, incluant le singe colobine *Mesopithecus*. Un schéma similaire de *turnover* (grand singe du Miocène supérieur/Cercopithecidae du Miocène terminal) est généralement observé dans les successions continentales du Miocène supérieur, depuis l'Espagne jusqu'à l'Europe centrale, l'Europe du Sud-Ouest, le Proche-Orient et l'Asie du Sud-Ouest. Une abondante littérature rapporte que la répartition des primates hominoïdes eurasiens du Miocène supérieur suit les changements environnementaux et climatiques de l'intervalle 12–9 Ma, jusqu'à leur extinction en Europe de l'Ouest. Dans l'enregistrement des primates, la dispersion des Cercopithecidae et la contraction des hominidés constituent un évènement typique d'une continentalisation dans l'Ancien Monde. La succession sédimentaire du bassin de Baccinello-Cinigiano, l'une des plus longues successions continentales continues renfermant des vertébrés dans le registre néogène italien, contribue au débat à propos de cette hypothèse. L'article présente une vue d'ensemble sur les principales caractéristiques de la succession sédimentaire étudiée, les contraintes chronologiques (biochronologie, datations radiométriques, magnétostratigraphie) et l'évolution paléoenvironnementale d'après des approches paléobiologiques et l'étude des teneurs en isotopes stables du carbone et de l'oxygène le long de l'entière succession sédimentaire. L'histoire géologique du bassin Baccinello-Ciniglano sur 2 Ma, qui documente l'histoire évolutive d'*Oreopithecus* et des faunes associées, n'a pas de relation directe avec la crise de salinité messinienne. L'histoire évolutive du bassin et son registre paléontologique ont été principalement régis par la tectonique régionale et les changements paléogéographiques qui ont affecté les régions nord-tyrrhéniennes au cours du Miocène supérieur (Tortonien terminal et Messinien).

1. Introduction

The Latest Miocene continental record of the Italian peri-Tyrrhenian regions (Tuscany and Sardinia) documents the existence of a peculiar bioprovince characterised by the occurrence of vertebrate faunas with manifestly endemic features that differ from coeval mammal faunas, either from Europe or Africa: the so-called Tusco-Sardinian palaeobioprovince ("*Oreopithecus* Zone Faunas", or OZF in Bernor et al., 2001). The Latest Miocene faunal succession of the Tusco-Sardinian area has been known for a long time in the literature, and the geological setting, the evolutionary patterns of vertebrate records and their biogeographic significance have been exhaustively reported in a number of papers (e.g., Abbazzi et al., 2008b; Azzaroli et al., 1986; Benvenuti et al., 2001; Chesi et al., 2009; Delfino and Rook, 2008; Hürzeler and Engesser, 1976; Rook et al., 2011).

A celebrated taxon within these endemic faunal complexes is the endemic ape *Oreopithecus bambolii* (Gervais, 1872; Harrison and Rook, 1997; Hürzeler, 1951, 1958; Moyà-Solà and Köhler, 1997), whose fossils have been recovered since the nineteenth century from several mines exploiting lignite deposits in southern Tuscany (Fig. 1). Among these localities (Casteani, Montebamboli, Ribolla, etc.), the geology and palaeontology of the Baccinello area are the best known, thanks to the early research led by J. Hürzeler from the Basel Naturhistorisches Museum (De Terra, 1956; Gillet et al., 1965; Lorenz, 1968; Rook, 2012), who recovered abundant faunal remains from different stratigraphic levels. Since the 1990s, research conducted by the Vertebrate Palaeontology Research Group of the University of Florence (Fig. 2) has increased our knowledge of the palaeontology, geology and sedimentology of the area (Benvenuti et al., 1999a,b, 2001, 2015; Rook et al., 2000, 2011), allowing a better understanding of the sedimentary/environmental evolution of the Baccinello-Cinigiano Basin (henceforth referred to as the BC Basin).

2. Geological setting of the Baccinello-Cinigiano Basin

During the Late Miocene (Tortonian-Messinian), the topography of the Maremma region was influenced by concurrent regional tectonic processes: orogenic activity in the axial portion of the uplifting northern Apennines and the opening of the Tyrrhenian Sea (Boccaletti et al., 1990; Martini and Sagri, 1993; Martini et al., 2001). As a consequence, shallow basins, characterised by the deposition of fluviolacustrine sediments, started to form on the western side of the northern Apennine chain. The Late Serravallian-Early Tortonian Arenarie di Ponsano Formation, characterised by shallow marine sandstones deposited in small basins (Foresi et al., 1997), constrained the onset of emerged landscapes in the Tusco-Sardinian area to the mid-Late Tortonian. This terrestrial setting caused mammal immigrants from Europe to undergo progressive morphological change due to persisting interruption of the connections with the European mainland (Rook et al., 2006).

The BC Basin, a Late Neogene basin located 25 km east of Grosseto in southern Tuscany (Fig. 1), is one of the largest continental sedimentary basins of the region (Martini and Sagri, 1993; Marroni et al., 2015). It is filled with a minimum