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Paleobiogeography of Early/Middle Miocene terrestrial gastropods in Central Europe: An approach using similarity indices

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ABSTRACT

Terrestrial gastropods are a common faunal element in continental Miocene fossil Lagerstätten of Europe. Although having lived during a time span that includes the Miocene Climatic Optimum and the devastating Ries/Steinheim meteorite impacts, the state of knowledge about their faunal composition and geographic distribution is surprisingly incomplete. The land snail faunas of 30 different Early and Middle Miocene deposits of Central Europe (European Mammal Neogene zones MN 4 to MN 8) were compared using statistical methods (cluster and NMDS analyses, using the Ochiai, Simpson and Kulczynski indices). This includes 300 different taxa identified so far. Most of the analyzed deposits were part of the Miocene Paratethys and are today located in France, SW Germany (Baden-Württemberg state), SE Germany (Bavaria state), Austria, Poland, and Hungary. Cluster analyses resulted in different clusters, the majority of which can be explained by their geographic situation and/or by their distribution in time (e.g., the consistently recovered Baden-Württemberg and Bavaria clusters and the Bakony Mountains cluster). The remaining clusters cannot be fully explained so far, but some possibilities are explored here. Our results reveal the power of a solid taxonomic framework as a basis for palaeobiogeographic studies. As such, more "basic" palaeontological studies are required to strengthen future analyses.

1. Introduction

Continental gastropods, especially those belonging to the Pulmonata, are a crucial faunal element in Miocene continental deposits. Despite their abundance in the European fossil record, however, only few attempts have been made to study them from a paleobiogeographical point of view. Esu (1999) broadly described the land snail faunal changes throughout the Neogene, but only in relation to climatic changes and in a more descriptive and qualitative manner. Stworzewicz (1993) also carried on a qualitative analysis, focusing only on the terrestrial gastropods of Poland. Finally, Harzhauser and Mandic (2008) analyzed the faunal diversity of freshwater gastropods of Neogene lake systems in Central and Southern Europe, describing also the interrelationships of these lakes.

Following a similar course as these previous authors, we aim to fill some gaps in the paleobiogeographical knowledge of terrestrial gastropods and present a study of the Miocene land snail fauna of Central Europe. We focus on deposits that are sufficiently known and studied. This means basically the Middle Miocene outcrops, in special the stratigraphic group known as the Upper Freshwater Molasse ("Obere Süßwassermolasse", in German; abbreviated OSM). This age is of particular importance, since the "Mid-Miocene Climatic Optimum" (ca. 17–15 Ma; European Mammal Neogene zone MN 5) was the last time interval favorable for thermophilous fauna and flora in Europe and a time of increased seasonality (Zachos et al., 2001; Böhme et al., 2011). We compare the land snail faunas of thirty distinct localities from the Middle Miocene of Poland, Hungary, Austria, Germany and France (Fig. 1), searching for similarities and differences. These localities were chosen according to their state of knowledge (and eventually the authors' ongoing works). After an overall statistical analysis clustering these localities in groups, we offer more detailed explanations of the localities and the relationship between them.

2. Material and methods

Information on each fossil deposit and its respective land snail fauna is widely scattered throughout the literature. Unfortunately, several of these localities were never systematically examined and species lists are rarely present; or, when present, not entirely reliable. Apart from some very recent works, the literature is mostly dated from the end of the 19th century or beginning of the 20th century (mainly Wenz, 1923), especially for the OSM.

Furthermore, for a locality to be chosen for the present analysis, it should count with at least eight different terrestrial gastropod species.

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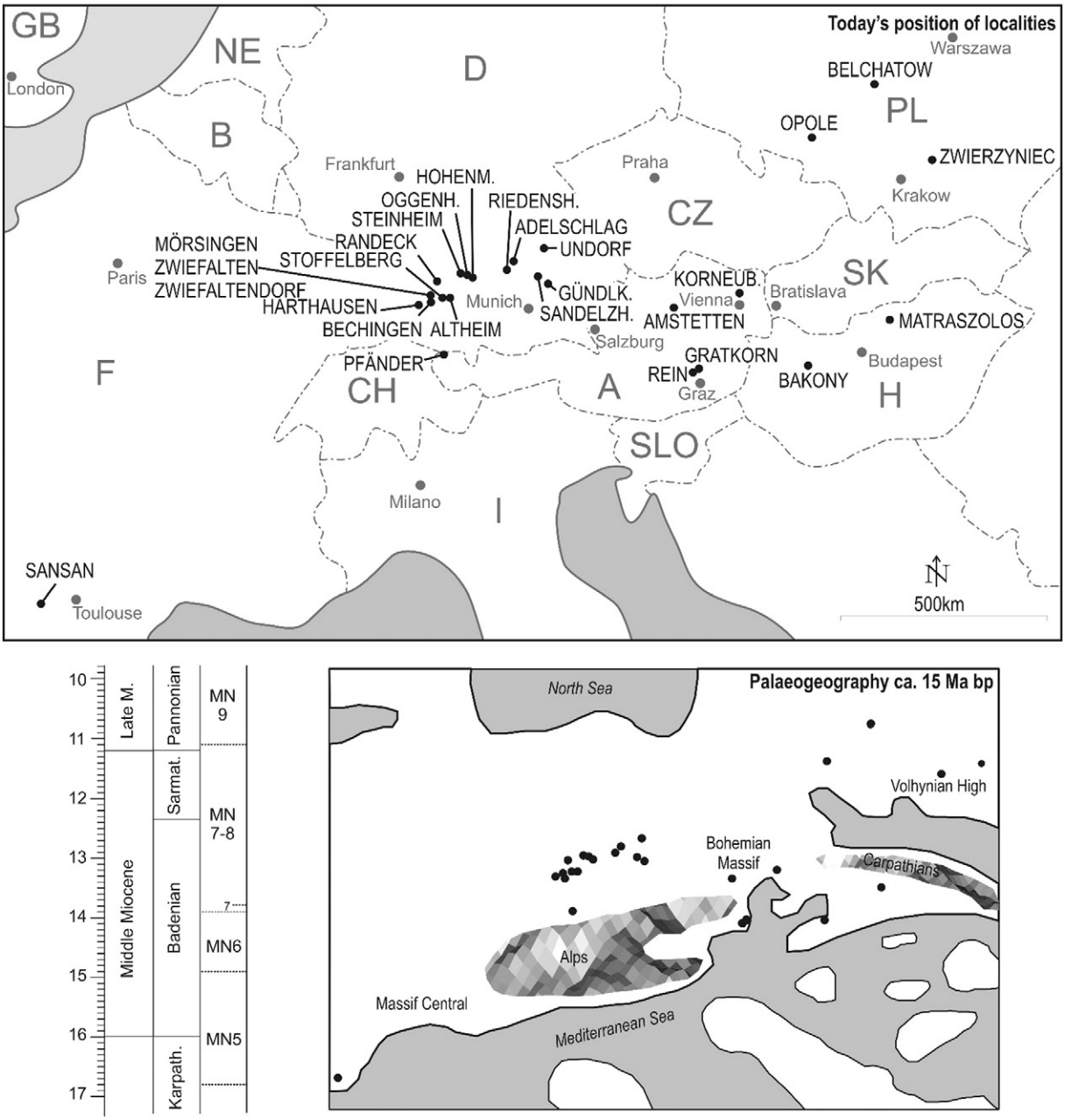

Fig. 1. Stratigraphy and localities. Mammal Neogene (MN) zones after Kälin and Kempf (2009). Map modified after Rasser and Harzhauser (2008).

This was deemed a good number for the biogeographical analysis and this choice implies that most known localities were left out, since they usually have just a few records of the most common species. There are two exceptions to this rule: Amstetten-Stubersheim and Harthausen auf der Scher, both in Germany (Fig. 1). Despite having only five species each, these localities were included because they are the best representatives in number of species of the Helicidenmergel stratigraphic unit (see below).

2.1. Taxonomy

The systematic classification used here follows the most recent works for each locality (as listed on Table 1), with eventual updates of posterior taxonomic works. On a few cases, literature data was complemented with material from the collection of the Staatliches Museum für Naturkunde Stuttgart (SMNS; Stuttgart, Germany).

The generic assignment of many species has changed often over the past century and sometimes there are concurrent distinct opinions about this matter. Conveniently, our statistical methodology only compares taxa at the species level, so distinct generic placements do not interfere.

2.2. Stratigraphy

Data on stratigraphy and age of the Middle Miocene localities used here were also acquired from the literature (Table 1). The age of the localities range from the European Mammal Neogene zones MN 4–5 to MN 7–8, spanning the entire Middle Miocene. During this period, two meteorite impacts have occurred in southern Germany, the so-called Ries impact (ca. 14.7 Ma) and the less-known Steinheim event (Buchner et al., 2013; Buchner and Schmieder, 2013).