

The Höwenegg fossil turtle assemblage (Late Miocene, South Germany): preliminary results on taxonomic composition and diversity

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Introduction

During the Late Cenozoic (Tertiary, Quaternary) the Western Palearctic region experienced a number of climatic changes (e.g., Ice Ages), geotectonic changes (e.g., final rise of the Alps; extension and formation of sedimentary basins) as well as more complex events (e.g., Messinian salinity crisis; changes in sea level; Middle Miocene climatic Optimum). These events had a significant impact on the evolution of flora and fauna in this region during those periods. Ectothermic reptiles, such as turtles, are more susceptible to these changes and can be used as palaeoecological indicators. Also, and mainly due to the presence of their carapace, turtles have an excellent fossil record which provides the ability of exporting considerable inferences. Nevertheless, compared to other vertebrate groups (e.g., mammals), the turtle fossils have been rarely studied elaborately.

Particularly in Europe, the fossil record of the turtles is mostly complete, from the Tertiary to the Present (e.g., Lapparent de Broin 2001; Danilov, 2005). Therefore, the study of fossilized turtles can provide insights regarding the effect of climate and environmental changes on the evolution, diversity, and anatomy of the turtles.

Objective and study area

Herein, we present some preliminary results of the doctoral study of the first author. The purpose of this study is to contribute and strengthen the knowledge of classification, evolution, taphonomy and palaeoecology of the Neogene of the western Palearctic, focused on the study of the rich and diverse fossilized turtle's record of the Höwenegg region, Germany.

Höwenegg is a locality found 2.5 Km from Immendingen, which is part of the Hegau, a volcanic area in Southern Germany. Höwenegg locality is noteworthy for its Late Miocene fauna (MN9) with well-preserved and almost complete skeletons of vertebrates, invertebrates and plant fossils. Höwenegg fossils belong to the Vallesian stage, and more specifically to the MN9 biozone (Munk *et al.*, 2007; Giersch *et al.*, 2010; Wolf *et al.*, 2012).

The most important vertebrate findings are the mammals (*Miotragocerus pannoniae*, *Hippotherium primigenium*, *Aceratherium incisivum*), a big amount of fishes, as well as a remarkable number of turtle samples (Bernor *et al.*, 1997; Giersch *et al.*, 2010; Schleich 1985). The taxonomy and diversity of the chelonian assemblage is one of the primary objectives of this study.

Methodology

- Preparation, conservation and cataloguing of the fossilized skeletal material will be carried out primarily at the Department of Geology of the University of Patras, Greece, as well as in several Natural History Museums and Collections of Germany (Karlsruhe, Mainz, Freiburg and Darmstadt) where the skeletal material is stored.
- Taxonomic analysis. For the taxonomic determination of Höwenegg's turtle fauna standard anatomical and paleontological techniques will be used.
- Phylogenetic analysis. Cladistic analyses will be carried out and the most comprehensive taxa will be analyzed in a phylogenetic context.
- Taphonomic study. The taphonomic study concerns the collection and analysis of various quantitative and qualitative data, as well as their final connection to the taphonomic history of the skeletal material.
- Diversity. Study the diversity of fossilized turtles both locally (α -) and regionally (β - and γ -diversity).
 Palaeoecological analysis. Palaeoecological inferences will be made through the study of skeletal anatomy, sedimentology, and palaeohistology.

Results

The preliminary study of the Höwenegg's turtle fauna reveals the presence of several cryptodiran clades of turtles. Most of them appear to be represented by a single taxon (Pan-Trionychidae, Pan-Chelydridae, Emydidae, Geoemydidae), whereas tortoises (Testudinidae) are apparently represented by a small and a medium-to-large taxon. Our preliminary assessment, therefore, identifies up to six different turtle species surviving in Höwenegg during the Late Miocene. These clades were quite diverse in Central Europe during the Neogene, and Höwenegg appears to be one of the most diverse localities of that period. The preservation of the fossils in many cases is fairly good. The majority of the specimens correspond to partial shell and isolated shell fragments, whereas limb elements are few. Of particular highlight of the Höwenegg assemblage is a partial skeleton of a chelydrid taxon, preserving skull, shell and associated limb bones.

Starting with Höwenegg, the results of this thesis will be compared and correlated with those of other coeval localities in detail, as well as with other adjacent regions from Central (e.g., Switzerland, Austria) and South Europe (e.g., Italy, Greece) with available data. The study of fossilized turtles from Höwenegg, combined with other local and European localities where fossilized turtles have been found, will make a significant contribution to the knowledge of the diversity and evolution of turtles in Central and Northern Europe during the Neogene. Finally, particular emphasis will be given on the comparison of the occurrence and diversity of the various turtle clades between Central and Southern Europe. Information from rich and diverse places with detailed geological / stratigraphic and faunal backgrounds, such as Höwenegg, could contribute significantly to the assessment of the origin and evolution of the Neogene European turtles. The results of this study will contribute also to the interpretation of the evolutionary and palaeoecological model at a regional and continental level.

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