

Dieter Uhl · Angela A. Bruch · Christopher Traiser  
Stefan Klotz

## Palaeoclimate estimates for the Middle Miocene Schrotzburg flora (S Germany): a multi-method approach

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**Abstract** We present a detailed palaeoclimate analysis of the Middle Miocene (uppermost Badenian–lowermost Sarmatian) Schrotzburg locality in S Germany, based on the fossil macro- and micro-flora, using four different methods for the estimation of palaeoclimate parameters: the coexistence approach (CA), leaf margin analysis (LMA), the Climate-Leaf Analysis Multivariate Program (CLAMP), as well as a recently developed multivariate leaf physiognomic approach based on an European calibration dataset (ELPA). Considering results of all methods used, the following palaeoclimate estimates seem to be most likely: mean annual temperature  $\sim 15\text{--}16^\circ\text{C}$  (MAT), coldest month mean temperature  $\sim 7^\circ\text{C}$  (CMMT), warmest month mean temperature between  $25$  and  $26^\circ\text{C}$ , and mean annual precipitation  $\sim 1,300$  mm, although CMMT values may have been colder as indicated by the disappearance of the crocodile *Diplocynodon* and the temperature thresholds derived from modern alligators. For most palaeoclimatic

parameters, estimates derived by CLAMP significantly differ from those derived by most other methods. With respect to the consistency of the results obtained by CA, LMA and ELPA, it is suggested that for the Schrotzburg locality CLAMP is probably less reliable than most other methods. A possible explanation may be attributed to the correlation between leaf physiognomy and climate as represented by the CLAMP calibration data set which is largely based on extant floras from N America and E Asia and which may be not suitable for application to the European Neogene. All physiognomic methods used here were affected by taphonomic biases. Especially the number of taxa had a great influence on the reliability of the palaeoclimate estimates. Both multivariate leaf physiognomic approaches are less influenced by such biases than the univariate LMA. In combination with previously published results from the European and Asian Neogene, our data suggest that during the Neogene in Eurasia CLAMP may produce temperature estimates, which are systematically too cold as compared to other evidence. This pattern, however, has to be further investigated using additional palaeofloras.

Dedicated to Prof. Dr. Harald Walther, Dresden, on the occasion of his 75th birthday.

D. Uhl (✉) · A. A. Bruch · C. Traiser · S. Klotz  
Institut für Geowissenschaften,  
Eberhard Karls Universität Tübingen,  
Sigwartstr. 10, 72076 Tübingen, Germany

D. Uhl  
Laboratory of Palaeobotany and Palynology,  
Department of Palaeoecology, Utrecht University,  
Budapestlaan 4, 3584 CD Utrecht, The Netherlands  
E-mail: dieter.uhl@gmx.de  
Tel.: +31-30-2532634  
Fax: +31-30-2535096

A. A. Bruch  
Senckenberg Research Institute and Natural History Museum,  
Senckenberganlage 25, 60325 Frankfurt, Germany

S. Klotz  
Laboratoire PaléoEnvironnements et PaléobioSphère (UMR  
5125), Université Cl.Bernard-Lyon 1,  
27-43 boulevard du 11 Novembre, 69622  
Villeurbanne Cedex, France

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### Introduction

Dealing with Global Change may become one of the major challenges for humankind in the 21st century (e.g. Steffen et al. 2004). A critical assessment of the possible impacts of Global Change must not only refer to the reliability of model predictions for the future, but also to information about past climate and environmental changes. In the terrestrial realm the reconstruction of past climatic and environmental conditions and changes is largely based on fossil plant remains. A large number of different methods have been developed to derive environmental data from these plants (e.g. Kershaw and