

Deciphering climatic and environmental signals from varved sediments by applying process-related studies

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The workshop was hosted by the Maarmuseum in Manderscheid in the Eifel region, and was an opportunity for stimulating discussions amongst scientists active in analyzing annually laminated (varved) lacustrine and marine sediments for climatic and environmental reconstruction. Supporting funds were obtained from the German Science Foundation and PAGES. The Maarmuseum's director Martin Koziol provided invaluable logistical support.

A diverse range of high-resolution archives from five continents and the marine realm was discussed. Forty-one scientists from 16 countries, including 16 early career scientists, represented a wide range of research fields including climate modelers, geophysicists, and biologists. This cross-disciplinary communication between data and model specialists was essential to understand relationships between climatic and environmental changes.

The workshop focused on deciphering climatic and environmental signals contained in varved sediments by applying complementary process-related studies. We learned from other scientific disciplines about alternative techniques

for proxy development, calibration and validation. Additional foci were advances in studying varved records, identification of challenging new coring sites, and managing data.

The first session was devoted to the reconstruction of hydro-climatic events. In his keynote lecture Scott Lamoureux (Canada) presented long-term process studies at varved Arctic lake sites to demonstrate complex links between climatic forcing and sedimentological responses.

The second session's focus was directed toward calibration of biological proxies. The keynote given by Andy Lotter (The Netherlands) highlighted the potential of biota-based transfer functions that provide enough temporal resolution to study the resilience and recovery time of ecosystems after external and internal disturbances.

Learning from other communities in terms of calibration and validation was the topic of the third session with three keynotes. Joel Guiot (France) presented the evolution of climate reconstruction methods from statistical techniques to complex model inversions and emphasized the need for high temporal resolution data as provided by varved records. The

second keynote by Dominik Fleitmann (Switzerland) about speleothems directed the attention to annual growth bands of stalagmites and their paleoclimatic significance. Finally, keynote speaker Tom Swetnam (USA) linked dendrochronology with varved records pointing out the challenges obtained by combining both archives. Complemented by moderated poster and wrap-up sessions, the workshop was characterized by lively scientific discussions. Compiled abstracts of all talks and posters are available online (Zolitschka 2012).

The first product emerging from the VWG – a multi-authored article in *Quaternary Science Reviews* – relates to the worldwide distribution of varved records and the fidelity of their chronologies (Ojala et al. 2012). Discussions resulted in the plan to produce a second publication stressing the need for the development of best practice examples for varve counting applied to different varve types, including error estimations and corroboration by radiometric dating techniques and automated image analyzing methods for comparison. A different product of the VWG is the growing on-line varve image library (preliminary version at: www.geopolar.uni-bremen.de/varves) to help researchers in the evaluation of laminated sediments. It shows annotated examples of the overall macroscopic appearance, internal structure and composition of varves.

Another highlight of the 3rd workshop of the VWG was the one-day field trip to the iconic maar lakes (Fig. 1) of the West Eifel Volcanic Field boasting Central Europe's longest varve chronology – 23,220 calendar years BP at Lake Holzmaar.

References

- Ojala AEK et al. (2012) *Quaternary Science Reviews* 43: 45–60
Zolitschka B (Ed) (2012) *3rd PAGES Varves Working Group Workshop – Program and Abstracts*, Terra Nostra 1, 113 pp



Figure 1: Lakes like Meerfelder Maar are important archives for climatic and environmental reconstructions since the Late-Glacial. The record of this site extends back into the Weichselian and provides a potential target for a future integrated lake deep drilling project. Most of the Holocene and Late Glacial sediments are annually laminated (varved). As an example the microphotography (inset) shows minerogenic varves of Younger Dryas age (courtesy A. Brauer).