| Ber. Inst. Erdwiss. K.-F.-Univ. Graz | ISSN 1608-8166 | Band 9 | Graz 2004 |
| --- | --- | --- | --- |

# THE WINGEOL LAMINATION TOOL: A NEW SOFTWARE FOR RAPID, SEMI-AUTOMATED ANALYSIS OF LAMINATED PALEOCLIMATE ARCHIVES

Michael MEYER[1], Robert FABER[2] & Christoph SPÖTL[1]

[1] Institut für Geologie und Paläontologie, LFU Innsbruck
[2] TerraMath, Phorusgasse 8, 1040 Wien

Lamination is a widespread growth phenomenon in many geological and biological materials. Examples of macroscopic lamination include tree rings, varved lake sediments, ice cores and reef corals. The origin and growth mechanism of lamination, although complex in detail and different for each environment, is generally driven by processes on subannual to multiannual time scales.

Laminated sediments of annual origin (annually laminated or annually banded sediments) are currently top priority in paleoclimate research as they are recognized as very high-resolution archives of environmental change that can be validated using instrumental data for the most recent period of the last 200 years. In certain areas, laminated sedimentary sequences provide continuous millennial-scale records, e.g., the marine late glacial sediments in the Cariaco basin (Hughen et al., 2004) or Holocene speleothems from Oman (Fleitmann et al., 2004).

In many cases examination of annually laminated successions requires microscopic techniques and the process of lamina counting and thickness measurement remains a tedious task. Various software is in use for counting tree rings (Varem-Sanders & Campbell, 1996; Conner et al. 2000) but it is not versatile enough for convenient use on sediment cores or petrographic thin sections. Algorithms for automated lamina recognition on surfaces of sediment cores (Schaaf & Thurow, 1994) and petrographic thin sections (Zolitschka, 1996) only work for regularly layered sediments. The lamina counting tool recently presented by Frankus et al. (2002) assists manual counting but is impracticable for more complex or curved laminae.

We developed a C++ based software tool (WinGeol Lamination Tool) that is capable of semi-automatically detecting and measuring laminae also in sediments showing large internal growth variability. Individual digital images of thin sections or sediment surfaces are imported and stitched together. The total file size may exceed several hundred megabytes thus enabling rapid processing of long laminated sequences. A full set of functions for image enhancement is implemented to optimize subsequent lamination analysis. The operator draws a profile line perpendicular to the layer boundaries and defines data-, no-data- and link-segments along this profile line in order to maintain control over laminated and nonlaminated features. The lamination tool computes a grayscale or RGB profile along the profile line and a buffer zone can be determined to include pixel values laterally adjacent to the profile. It is thus possible to grasp even noisy or faint laminae. The algorithm for automated lamina detection uses the grayscale or RGB profile as computation basis. Specific parameters, set by the operator, allow adjustment of this algorithm to detect different types of lamination. Each single lamina boundary suggested by the detection algorithm can be evaluated and readjusted by the operator in order to distinguish between annual and subannual layering where necessary. The number and thickness of detected laminae and the grayscale or RGB profile can be exported as an ASCII file for subsequent visualisation and interpretation using common statistical software packages.

The WinGeol Lamination Tool provides an important step to efficiently and quantitatively examine lamination in a variety of layered archives down to the micron scale.

## References

CONNER, S.W., SCHOWENGERDT, R.A., MUNRO, M., AND HUGHES M. K. (2000): Engineering design of an image acquisation and analysis system for dendrochronology. Opt. Eng., 39, 453-463.

FLEITMANN, D., BURNS, S.J., NEFF, U., MUDELSEE, M., MANGINI, A. & MATTER, A. (2004): Palaeoclimatic interpretation of high-resolution oxygen isotope profiles derived from annually laminated speleothems from southern Oman. Quat. Sci. Rev., 23, 935-945.

FRANCUS, P., KEIMING, F., AND BESONEN, M. (2002): An algorithm to aid varve counting and measurement from thin-sections. J. Paleolimnol., 28, 283-286.

HUGHEN, K., LEHMAN, S., SOUTHON, J., OVERPECK, J., MARCHAL, O., HERRING, C. & TURNBULL, J. (2004): $^{14}C$ activity and global carbon cycle changes over the past 50,000 years. Science, 303, 202-207.

SCHAAF, M. AND THUROW, J. (1994): A fast and easy method to derive highest-resolution time-series datasets from drillcores and rock samples. Sedim. Geol., 94, 1-10.

VAREM-SANDERS, T.M.L. and CAMPBELL I. D. (1996): Dendroscan a tree-ring width and density measurement system. Special Report, 10. UBC Press, Vancouver, 131 pp.

ZOLITSCHKA, B. (1996): High resolution lacustrine sediments and their potential for paleoclimatic reconstruction. In: NATO ASI Series - Climatic variations and forcing mechanisms of the last 2000 years, ed. by D.P. Jones, et al, pp. 444-478. Springer.