Biostratigraphic dating of palaeolake deposits from an overdeepening in the Swiss Northern Alpine Foreland by numerical assessments of vegetation composition and the role of species dynamics

Patrick Schläfli [1, 2, 3], Erika Gobet [2], Willy Tinner [2, 3], Jacqueline van Leeuwen [2], Elisa Vescovi [2], Guilhem Douillet [1], Michael Schwenk [1], Dimitri Bandou [1] & Fritz Schlunegger [1]

[1] Institute of Geological Sciences, University of Bern, Switzerland (patrick.schlaefli@geo.unibe.ch)
[2] Institute of Plant Sciences, University of Bern, Switzerland
[3] Oeschger Centre for Climate Change Research, University of Bern, Switzerland

the aim

Biostratigraphic dating of Quaternary palaeolake deposits from a novel drill core from the SW margin of overdeepened lake Thun, Switzerland.

These palaeolake deposits contain interglacial pollen assemblages. Were they deposited during MIS 5e (last interglacial) or during MIS 7a (penultimate interglacial)?

the approach

We use two numerical methods to compare fossil pollen assemblages of the novel drill core (see left) with two dated reference archives from MIS 5e and from MIS 7a.
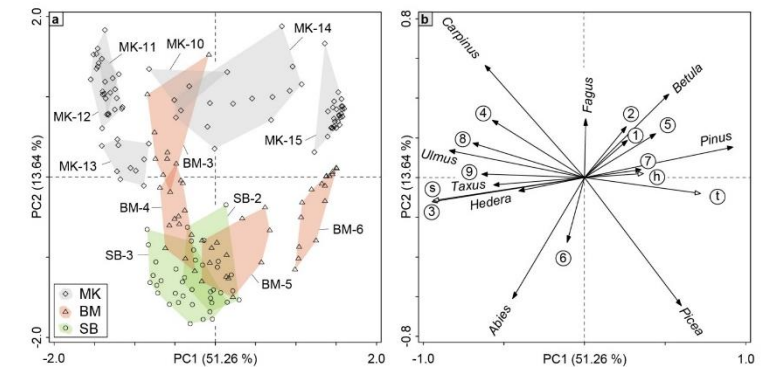
Principal component analysis (PCA)

Distance analysis (distantia)
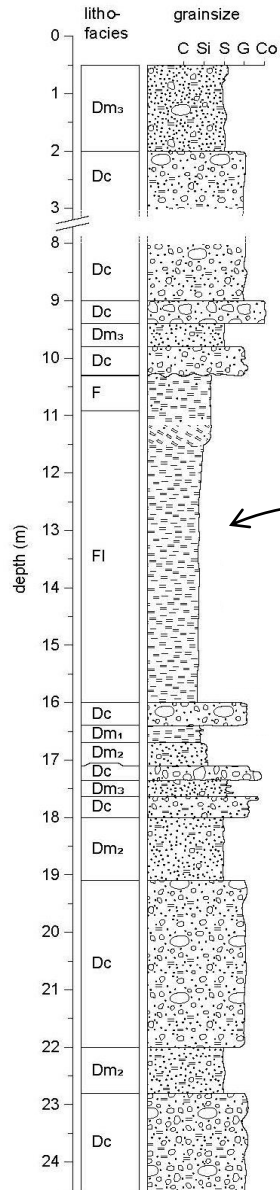
Lithofacies
F   Fines
Fl   Fines, laminated
Dc   Clast-supported diamict
Dm   Matrix-supported diamict
          Indices 1: clast poor
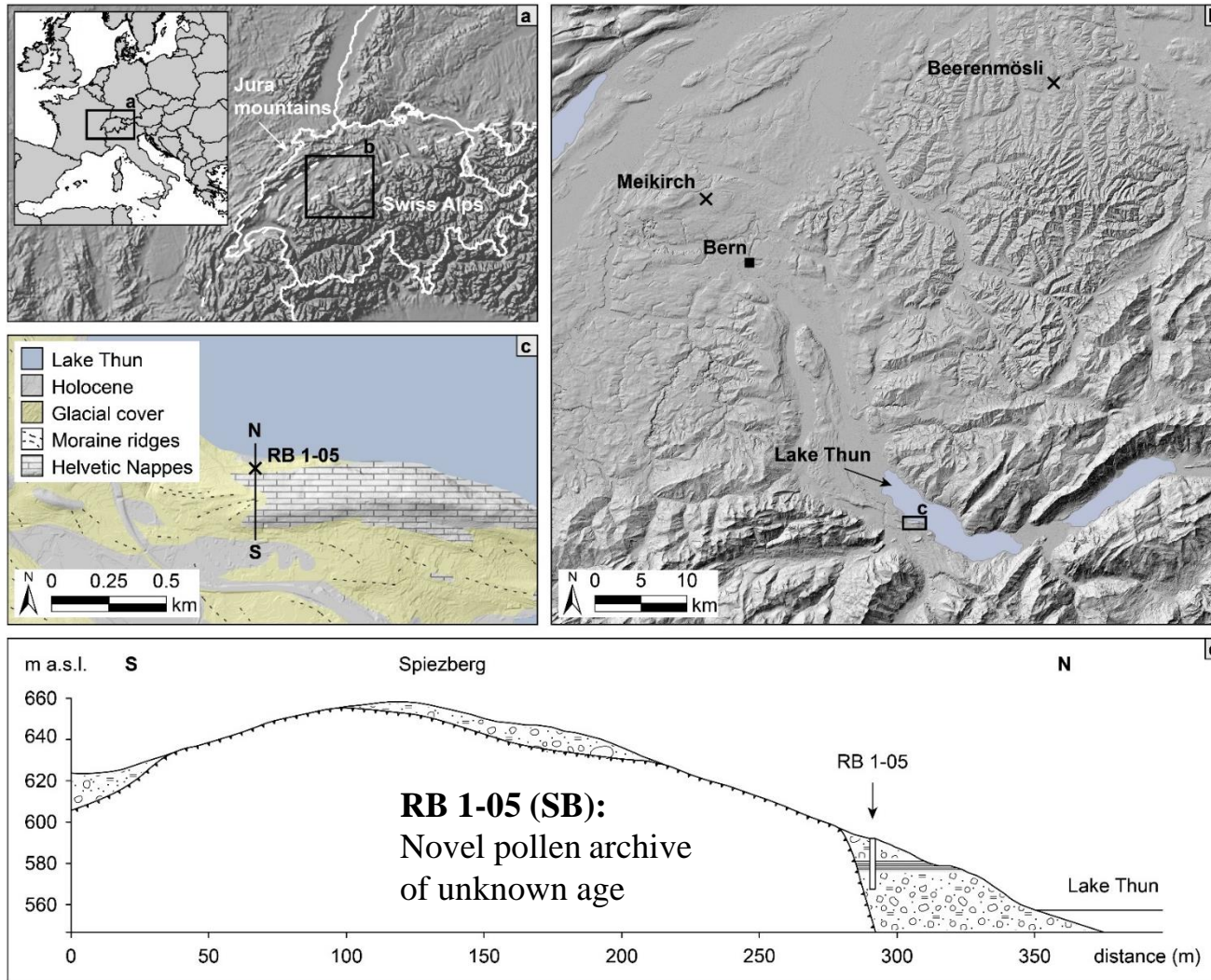   2: intermediate
                     3: clast rich
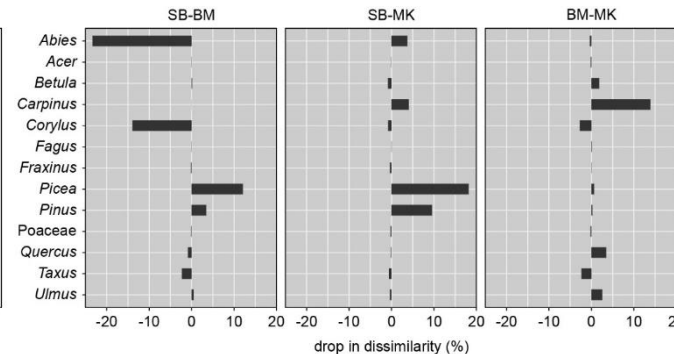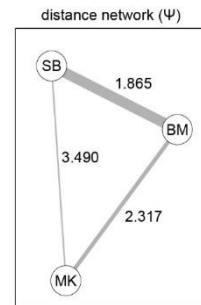
on the next slide →

See the study area and the two reference archives

Reference pollen archives to compare our pollen assemblages with:

Beerenmösli (BM): MIS 5e

Meikirch (MK): MIS 7a

Modified after Lisiecki & Raymo (2005)

on the next slide →

See what pollen assemblages we found in the novel archive RB 1-05

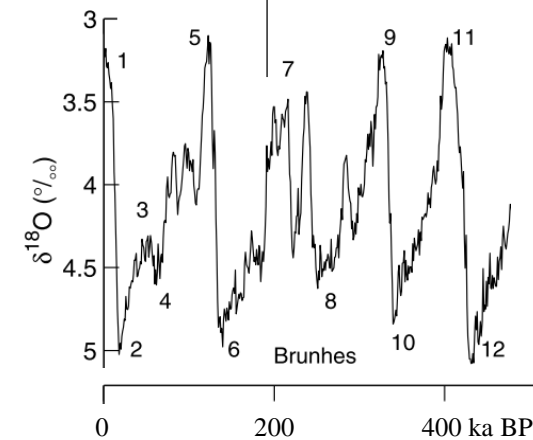**RB 1-05 (SB):**
Novel pollen archive of unknown age

For reference pollen archives see Wegmüller (1992), Welten (1982) and Preusser et al. (2005);
Acknowledgements to Peter Zwahlen for discovery of novel archive and mapping in the Spiezberg area
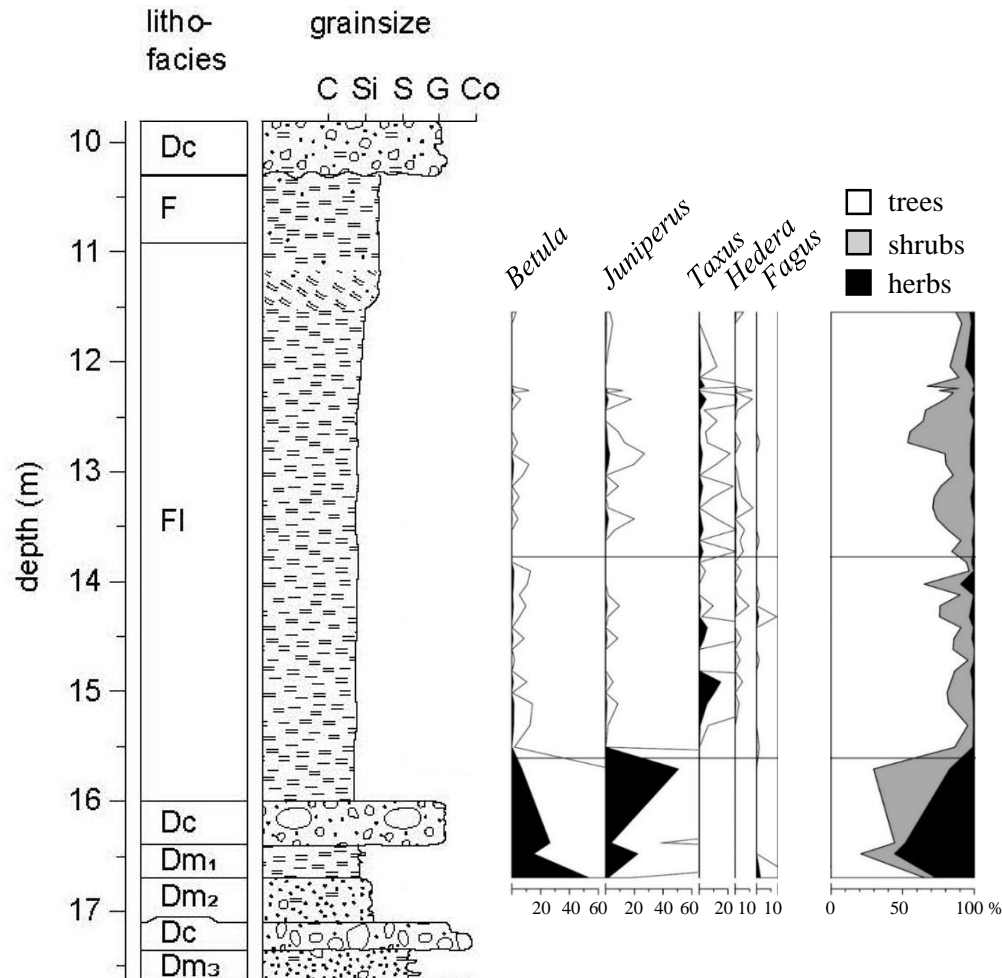
Legend on 2nd slide

We found three significant local pollen assemblage zones (LPAZ) in the palaeolake deposits from drill core RB 1-05.

Method: Optimal partitioning and the broken stick model.

SB-2 and SB-3

Closed forest vegetation (> 90 % trees and shrubs) and thermophilous taxa *Hedera* and *Taxus* indicate full interglacial conditions.
Low abundances of *Fagus* (< 2 %) already point towards MIS 5e age of deposits.
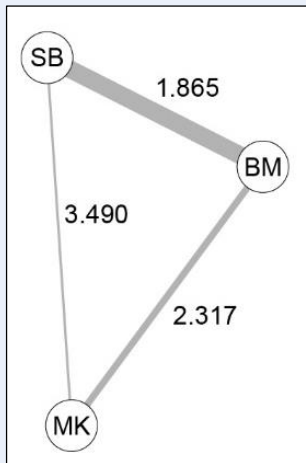
SB-1

Open vegetation (up to 50 % herbs) with pioneer taxon *Betula* and *Juniperus* indicate late glacial conditions.

on the next slide →

See the results of the 1st numerical comparison with the two reference archives

1st approach: Distance analysis (distantia)

Total distances (Euclidean) between the three archives:

SB: novel archive
BM: MIS 5e reference
MK: MIS 7a reference

Pollen assemblages of the novel archive resemble more the assemblages of MIS 5e reference.

The **drop in dissimilarity** is a measure of how much a pollen taxon contributes to similarity (negative values) or dissimilarity (positive values) in the pairwise comparison of the pollen archives:
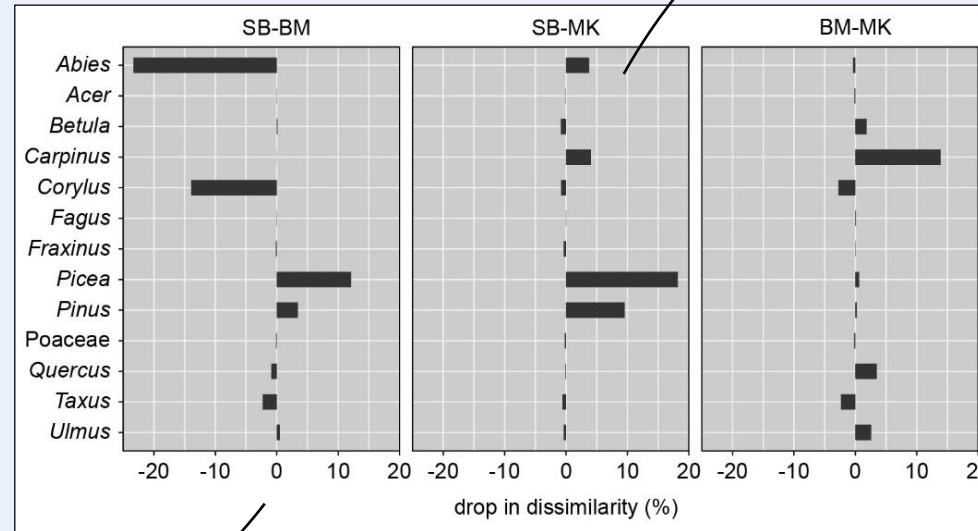
No taxon contributes more than 1 % to similarity between novel archive (SB) and MIS 7a reference (MK)
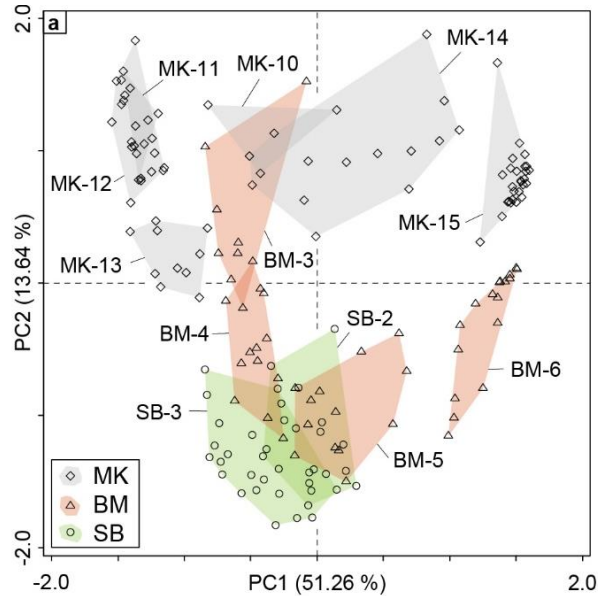

Main difference between MIS 5e (BM) and MIS 7a (MK) references is *Carpinus*, which was less dominant during MIS 5e.

Corylus and *Abies* account for more than 30 % of similarity between novel archive (SB) and MIS 5e reference (BM).

on the next slide →

See the results of the 2nd comparison, the PCA

Benito & Birks (2020); Birks & Gordon (1974)

2nd approach: Principal component analysis (PCA)

a. Sample scores of all three pollen archives. Pollen samples are grouped according to the assemblage zone they belong to. Zones of novel archive (SB, green) plot closer to zones of MIS 5e reference (BM, red) than to zones of MIS 7a reference (MK, grey), assuming an MIS 5e age of palaeolake deposits.
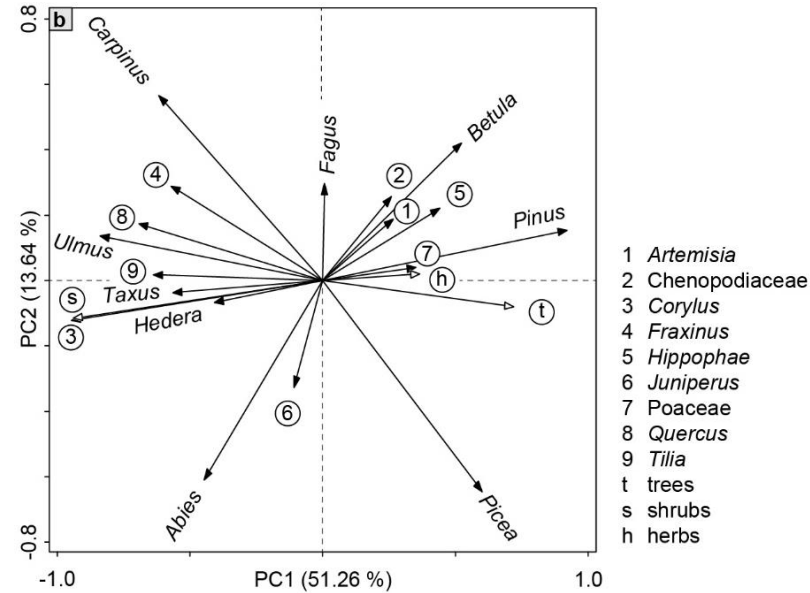
b. Species scores indicate that PC1 represents a climate gradient from temperate (left) to boreal vegetation (right). PC2 is mainly explained by *Fagus-Abies-* dynamics, probably driven by competition for light.

What to learn from the PCA?

Archives of interglacials MIS 5e and MIS 7a are indistinguishable on climate-driven PC1, assuming high resilience of vegetation to climate variability in time.

PC2 (*Fagus-Abies*-dynamics) explains most of inter-archive variance and allows to distinguish between MIS 5e and MIS 7a pollen assemblages.

To the conclusions →

Conclusions

I
Palaeolake deposits of RB 1-05 were probably deposited during MIS 5e.

II
Both numerical methods (distantia, PCA) are suitable for pollen biostratigraphic dating of the sedimentary infill of overdeepenings.

III
PCA captures high resilience of vegetation to Quaternary climate variability (PC1).

IV
Species dynamics of *Fagus* and *Abies* (competition for light) and *Carpinus* account for differences between MIS 5e and MIS 7a vegetation composition.

Some references on the last slide →

References

Benito, B.M., Birks, H.J.B., 2020. distantia: an open-source toolset to quantify dissimilarity between multivariate ecological time-series. Ecography 43, 1–8.

Gordon, A.D., Birks, H.J.B., 1974. Numerical methods in Quaternary palaeoecology: II. Comparison of pollen diagrams. New Phytologist 73(1), 221–249.

Lisiecki, L.E., Raymo, M.E., 2005. A Pliocene-Pleistocene stack of 57 globally distributed benthic $\delta^{18}O$ records. Paleoceanography 20.

Preusser, F., Drescher-Schneider, R., Fiebig, M., Schlüchter, C., 2005. Re-interpretation of the Meikirch pollen record, Swiss Alpine Foreland, and implications for Middle Pleistocene chronostratigraphy. Journal of Quaternary Science: Published for the Quaternary Research Association 20(6), 607–620.

Wegmüller, S., 1992. Vegetationsgeschichtliche und stratigraphische Untersuchungen an Schieferkohlen des nördlichen Alpenvorlandes. Denkschriften der Schweizerischen Akademie der Naturwissenschaften 102. Birkhäuser, Basel, Berlin.

Welten, M., 1982. Pollenanalytische Untersuchungen im Jüngeren Quartär des nördlichen Alpenvorlandes der Schweiz. Beiträge zur geologischen Karte der Schweiz. Stämpfli + Cie AG, Bern.