Gravel sequences at Seeland, Swiss Plateau west of Bern: Record of glacier advances during the Birrfeld glaciation

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Introduction

During the Quaternary, glaciers reached the Swiss foreland at least 15 times (Schlüchter, 2004). This is also the case for the Bernese Seeland, which was formed and affected by these glacial advances and which hosts thick glacial and fluvioglacial deposits. The gravel pits in Müntschemier and Finsterhennen provide outcrops of gravel and sand sequences (Fig. 1), recording glacier advances during the Birrfeld glaciation (105–25 ka). Schlüchter (2004) and Preusser et al. (2007) dated glaciofluvial deposits in the middle and lower part of the gravel pit Finsterhennen to the MIS 2 and MIS 4 (Fig. 4). In this study, the gravel pits in Müntschemier and Finsterhennen serve as basis to determine the provenance of the pebbles, the transport mechanism and the deposition environment. Furthermore, luminescence dating was applied on two samples from Müntschemier to compare the two gravel pits in terms of the depositional age.

Study site

The gravel pits in Müntschemier and Finsterhennen are situated on hills covered by till (Fig. 1) and clearly within the extent of the Last Glacial Maximum (LGM) glaciation (Fig. 2).

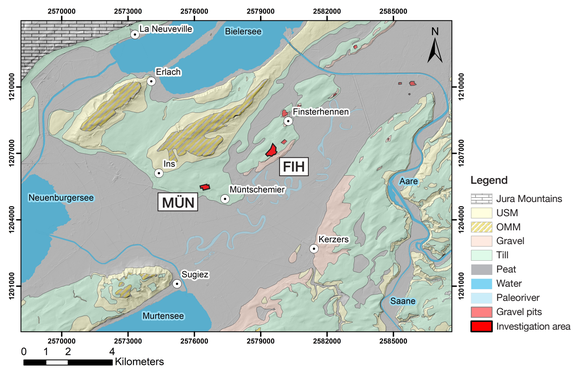


Fig. 1. Geological setting of the gravel pits in Müntschemier (MÜN) and Finsterhennen (FIH).

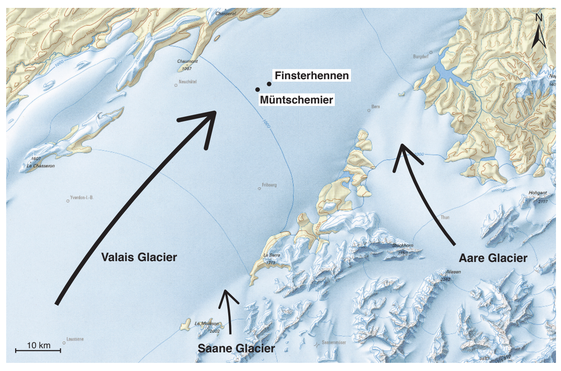


Fig. 2. Estimated ice extent during the LGM (24 ka). (https://map.geo.admin.ch, modified)

Methods

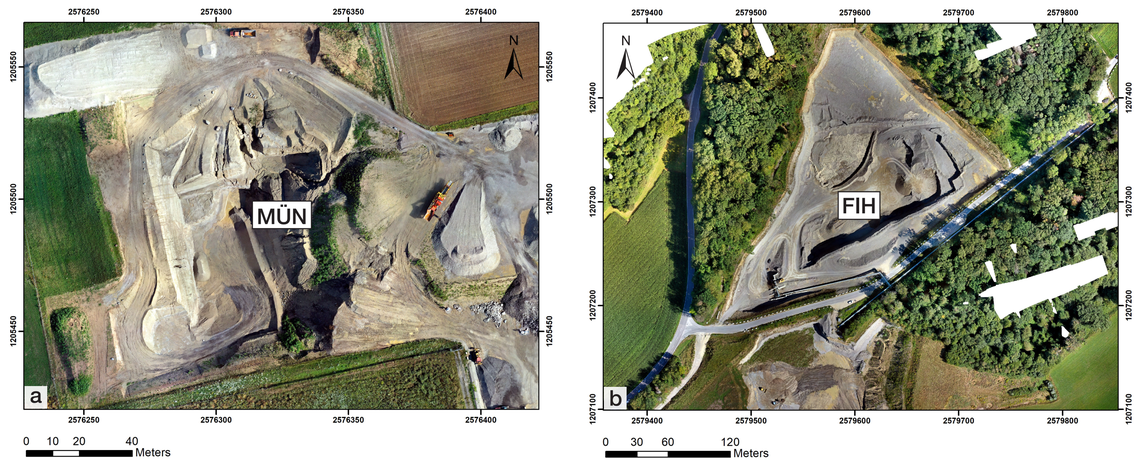
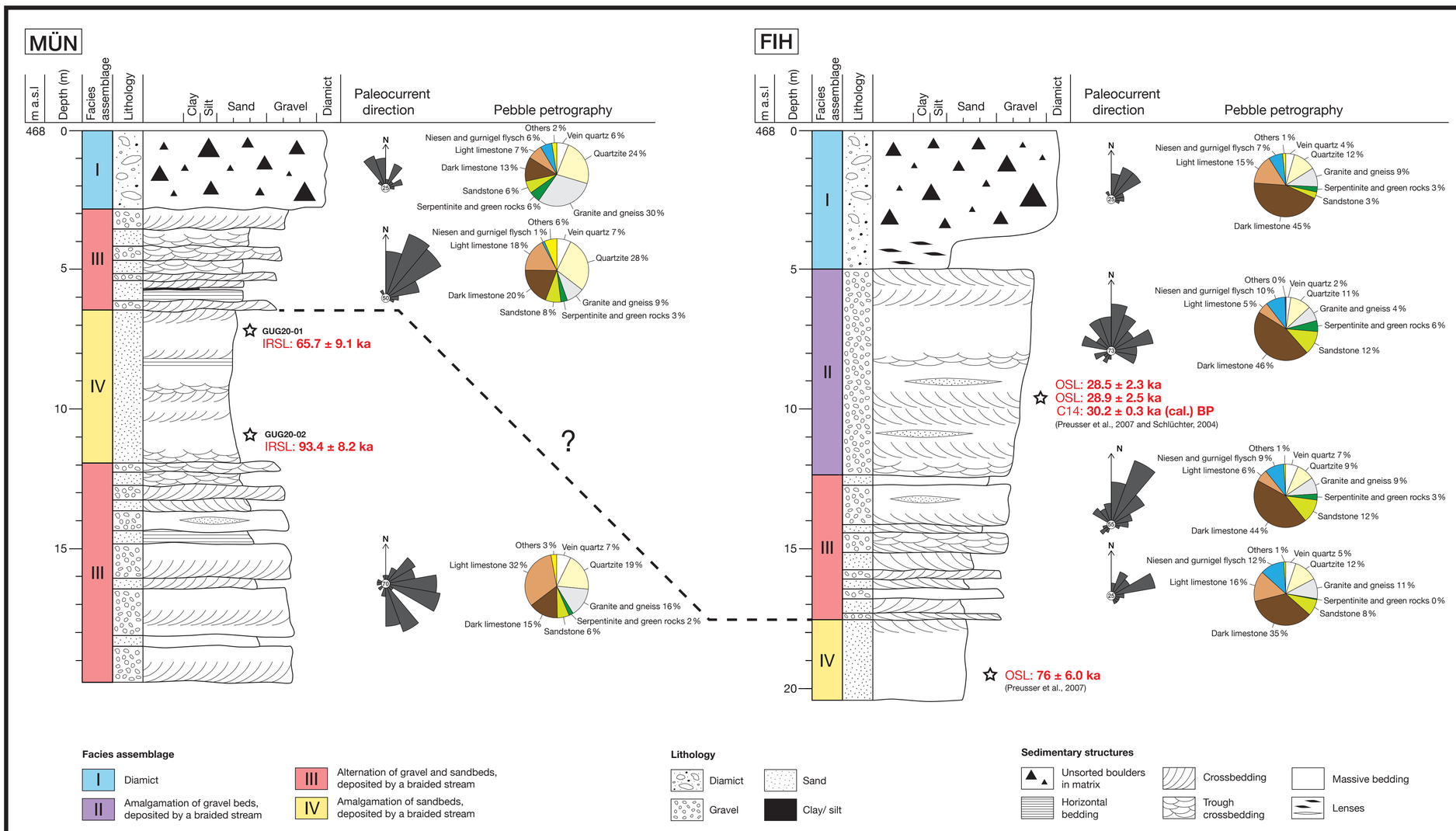


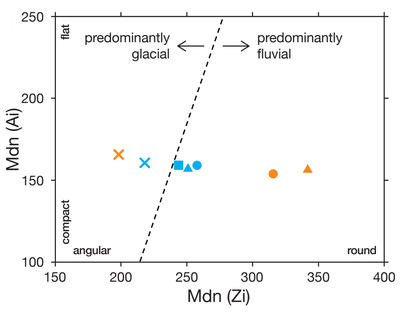
Fig. 3. Orthomosaic was generated in Agisoft Metashape Professional with images taken by the drone DJI Mavic Pro in (a) Müntschemier and (b) Finsterhennen.

Remote sensing was performed using a drone with an effort to gain an overview. (Fig. 3). ***Sedimentological logging*** in MÜN and FIN build the basis to reconstruct the sedimentary environment (Fig. 4). ***Paleocurrent direction*** analysis includes investigations of pebble fabrics and crossbeds (Fig. 4). Therefore, dip directions of a-axis (elongated pebbles), a-b-planes (flat pebbles) and crossbeds were measured. The ***pebble petrography*** contains information about the source area. Accordingly, 250 pebbles were collected and grouped into lithological classes (Fig. 4). Information on the ***pebble morphometry*** was gathered through measuring the length (L), the width (I), the thickness (E) and the smallest radius of curvature (2r) of 100 quartzite pebbles. The calculated roundness (Zi=2r/L*1000) and flattening index (Ai=(L+I)/2E*100) lead to an interpretation of the material transport mechanism and the depositional environment (Fig. 5). ***Infrared stimulated luminescence (IRSL) dating*** at 50 °C was applied on two samples in Müntschmier (GUG20-01 and GUG20-02) to obtain the sediment burial age.

Results



Pebble morphometry



Sections

- MÜN Diamict
- MÜN Upper gravel
- MÜN Lower gravel
- FIH Diamict
- FIH Upper gravel
- FIH Middle gravel
- FIH Lower gravel

Fig. 4. Sedimentological logs show the sedimentary record in Müntschemier (MÜN) and Finsterhennen (FIH) and the locations of the IRSL, paleocurrent direction analysis and pebble petrography investigations. IRSL: Samples GUG20-01 and GUG20-02. Paleoflow direction: Rose diagrams with paleoflow directions and amount of measurements. Pebble petroghraphy: Pie charts show the distribution of 250 pebbles, grouped into lithological classes.

Fig. 5. Pebble morphometry in MÜN and FIH. The sections Diamict, Upper gravel, Middle gravel and Lower gravel refer to the same locations as the paleocurrent direction and pebble petrography investigations in figure 4. Each section includes measurements of 100 quartzite pebbles. Modified after Schlüchter (1976).

Mdn (Zi) = Median of the roundness index
Mdn (Ai) = Median of the flattening index

Conclusion

Smaller grain sizes and sedimentary structures of the Müntschemier section indicate a distal braided river system which was possibly sourced by a glacier. In contrast, larger grains, sedimentary structures and the morphometry in the younger gravel layers in Finsterhennen point to a braided river system close to a glacier's snout. The occurence of serpentinite pebbles within the gravel and a dominant paleoflow towards northeast imply glacial advances of the Valais glacier during the Birrfeld glaciation, as testified by the IRSL ages. The correlation of the IRSL dates in Müntschemier with the OSL date from the lower part of the Finsterhennen section suggest a paleoslope of approx. 0.2° between Müntschemier and Finsterhennen. Further, the absence of the facies assemblage II in Müntschemier could be the consequence of erosion by the LGM glaciers. The different petrological composition of the diamict in Müntschemier and Finsterhennen shows either a local petrolocigal difference of the LGM-till (MIS 2) or the diamict in Müntschemier is interpreted as a till of an earlier MIS 4 glacier advance.

References
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