Geophysical and Geological investigations of a major Miocene fault system within the city of Vienna: evidence for active tectonics

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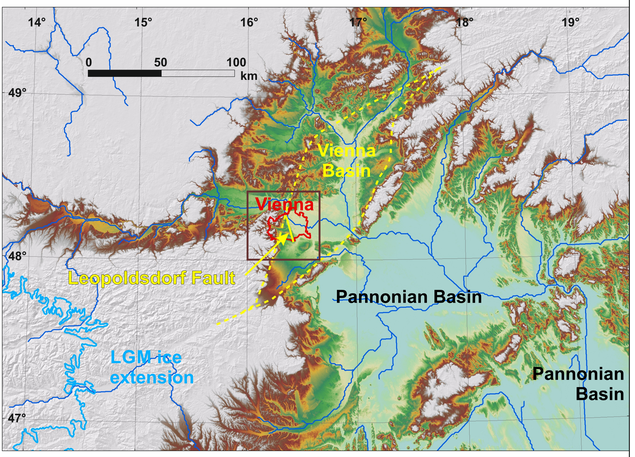
INTRODUCTION

The Vienna Basin is located at the transition between the Alps and the Carpathians, with a total length of c. 200 km and a maximum width of c. 55 km. Vienna city is situated at its western edge and is transversed by a set of major Miocene faults, part of the Leopoldsdorf Fault System. This normal fault system depicts the western sidewall of the Vienna Basin. Recent activity of such major sidewall fault systems delimiting the Miocene Vienna Basin remained unclear and not reliably constrained. To make statements on its Quaternary activity we focused on Pleistocene Danube Terraces in SE Vienna, crossing this fault system. These coarse-grained sediments sit on top of fine-grained marine sediments of the paratethys and are partly covered by loess-paleosol sequences, both generating a clear lithological contrast to the fluvial deposits. However, a lack of numerical age constraints and thick cover units of aeolian/colluvial sediments make stratigraphic correlations of terraces challenging. For a correlated at key sites we generated electrical resistivity measurments (ERT) and combined this information with drill log, seismic as well as high-res DEM data. Furthermore, we provided first age constraints from luminecence and cosmogenic nuclide dating.

Study area, Vienna and the Vienna Basin



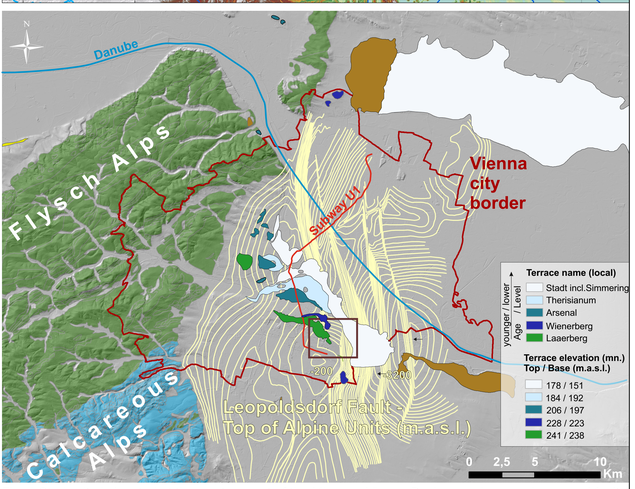
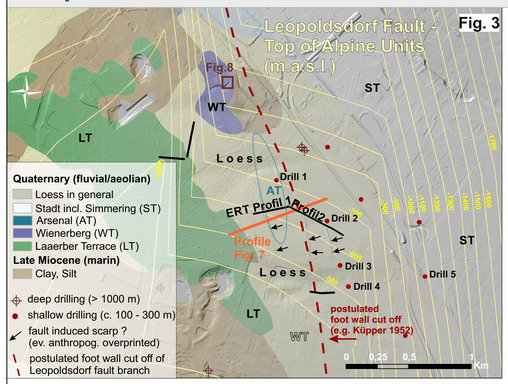
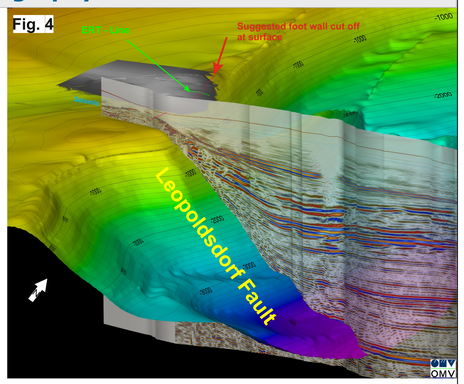


Fig. 1 Study site is located at the western part of the Miocene Vienna Basin covering a major normal fault system (Leopoldsdorf fault) transversing the entire city of Vienna. Pleistocene activity is focused at the eastern side at dominated by strike-slip movement (Vienna Basin Transfer fault). The recent activity of the major Miocene side wall (normal) faults remained unclear.
Fig. 2 Pleistocene Danube terrace distribution in the city of Vienna. Terraces in the E and SE parts of Vienna are crossing the Miocene Leopoldsdorf Fault System. Activity may result in normal faulting, tilting and to an increase accomodation space resulting in the thicking of strata. Sediment ages are poorly constrained and lack numerical data. Deposits are often difficult to access due to the position in the city and thick oess coverage.

Leopoldsdorf Fault and local terrace stratigraphy





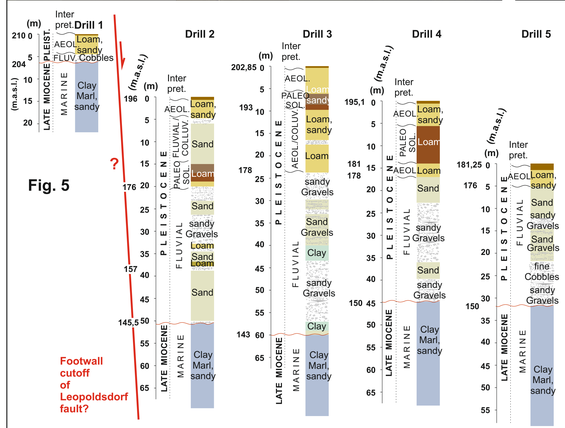
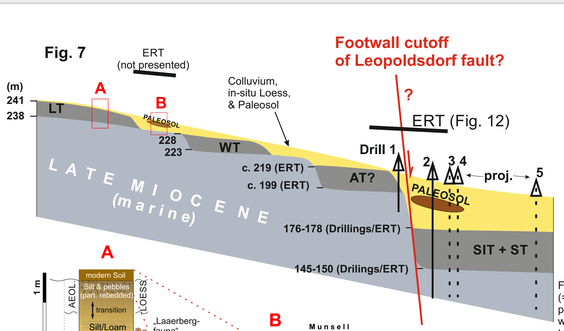


Fig. 3 Detailled overview of the study site. Terraces are partly buried on thick coverage of Loess and colluvium (slope wash).
ERT lines (black) are placed to cross the postulated footwall cut off of the Leopoldsdorf Fault System.

Fig. 4 Dimension of the Leopoldsdorf Fault system (after Wessely, 1979) offsetting Alpine units up to 4500 m. Seismic data shows the miocene mostly marin fill of the paratethys.
The postulated footwall cut off (Küpper, 1952) is shown in red, ERT lines in green.

Fig. 5 Driller's lithologic logs give a detailed insight into terrace deposits and cover units. Drillings situated near the terrace riser (between drill 1 and 2) show a thick colluvial coverage containg paleosol sequences.

Local terrace stratigraphy, and age constraints (OSL)



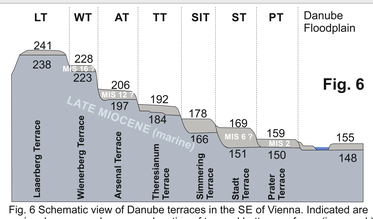


Fig. 6 Schematic view of Danube terraces in the SE of Vienna. Indicated are regional names and average elevation of top and bottom surfaces (in m a.s.l.). Suggsted timing of terrace formation is anotated in white (in MIS). The correlations to glacial maxima are however vague. Redrawn from WGM, 2014.

Fig. 7 Idealized profile showing the situation at the Laaerberg hill, SE Vienna (=study site). Locations of ERT profiles are shown as black lines (Fig. 12). For position of drillings see Fig. 5. Our new data show a part of the Arsenal Terrace which was not discovered before. Furthermore local data show that simmering terrace is thicker than generally supposed.

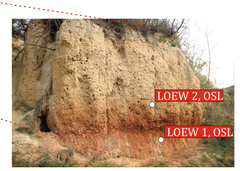
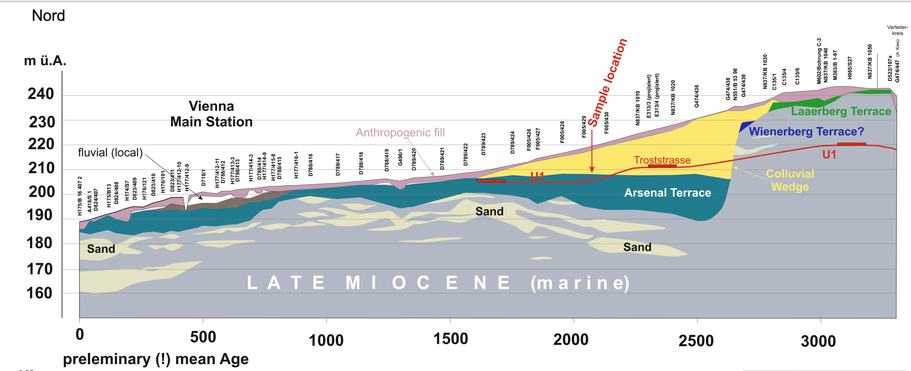


Fig. 8

Fig. 8 Profiles from the highest parts of Laaerberg hill: Laaerbergschotter (A) and sediments of the colluvial wedge on top of Miocene sediments (B). The famous loess paleosol sequence as orginally found in the outcrop „Löwygrube" has been redrawn from Küpper, 1952 and Fink and Majdan 1954. Fine material was not deposited/could almost not be preserved on top of the Laaerberg terrace. Sediments of the colluvial wedge (B) consisting of slope wash, in-situ loess and a thick paleosol layer have been dated for OSL.
Both Samples yielded minimum ages only, because of significant signal saturation effects. LOEW 1 was deposited at least prior to >162 ±13 ka (Min. age 2D0for LOEW 1) but mostlikely even prior to >258 ± 67 ka (Min. age max. De for LOEW 1). LOEW 2 yields >139 ±10 ka (Min. age 2D0for LOEW 1) and >189 ± 29 ka (Min. age max. De for LOEW 1) respectively.

Local terrace stratigraphy, and age constraints (^{10}Be/^{26}Al)



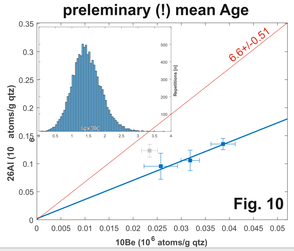
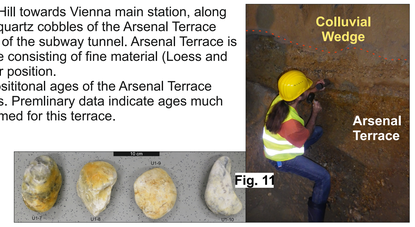


Fig. 9 Profile over the Laaerberg Hill towards Vienna main station, along the subway line U1. Sampling of quartz cobbles of the Arsenal Terrace was done during the construction of the subway tunnel. Arsenal Terrace is covered by a thick colluvial wedge consisting of fine material (Loess and redeposited Loess). See Fig. 2 for position.
Fig. 10 Derived prelimary (!) depositional ages of the Arsenal Terrace derived from cosmogenic nuclides. Premlinary data indicate ages much higher ages than previously assumed for this terrace.

Fig. 11 Sampling of the Arsenal Terrace (right) and sampled quartz cobbles (left).



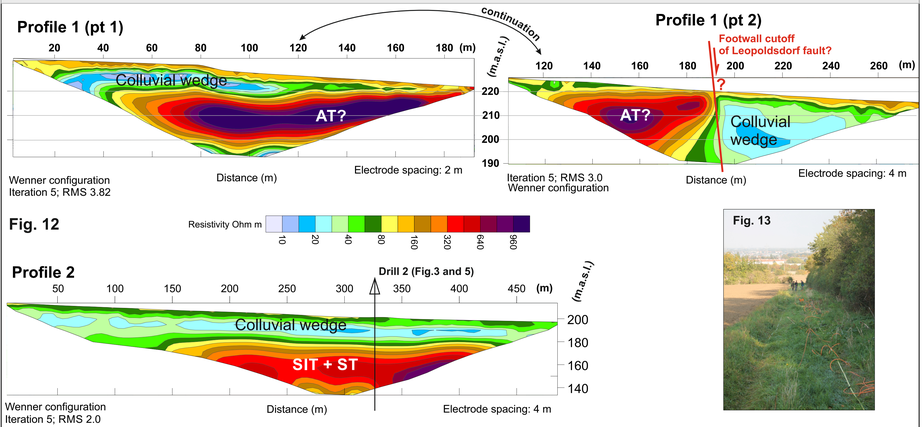


Fig. 12 ERT sections (Profile 1) over the clear step at TOP Late Miocene suggested to (partly) orginate from the activity of the Leopoldsdorf fault. Note that right profile is a continuation of the left (at c. 120 m) but has a lower resolution (Electrode spacing 4 m vs 2 m). The resistivity contrasts between sandy gravelly deposits (Arsenal Terrace) and the overlying fine sediments is striking. The underlying Late Miocene sediments with lower resistivity seem also to just have been reached at Profile 1 Pt 1 (at c. 195 m.a.s.l.). Profile 2 highlights the thick colluvial wedge on top of the Simmering/Stadt terrace. Also here, the Late Miocene might have been just reached (see also drilling 2, Fig. 5) at around 140 m.a.s.l. See Fig. 3 for profile locations and Fig. 7 for context.
Fig. 13 shows the configuration of the ERT down the Laaerberg hill (Profile 1, Pt. 1, 2 m Electrode spacing).

CONCLUSIONS

- Higher fluvial sequences along Danube in Vienna are much older than previsouly thought as suggested from cosmogenically derived ages of the Arsenal Terrace (Early Pleistocene). Consequently, higher terraces can also be constrained to have at least an Early Pleistocene age.
- Cosmogenically derived ages are consistent with minimum ages derived from luminescene ages (OSL).
- This indicates either a large chronological gap between the deposition of the older and the younger terraces (i.e. Stadt/Simmering, supposed to be MIS 6) or requires higher ages of the younger as well. In the former case the resuming activity of the Leopoldsdorf Fault system might be a very important factor to again provide accomodation space promoting preservation (i.e. at „Schwechat deep")
- ERT sections well highlight the fluvial deposits between fines relating to the Late Miocene (marine) and Pleistocene (Loess/slope wash, Paleosols) also showing a huge offset between the Arsenal and Simmering/Stadt Terrace. A so far undiscovered piece of the Arsenal Terrace in Vienna could be detected.
- The gap between the Arsenal and Stadt Terrace is exactly coinciding with the footwall cut off of the major Leopoldsdorf Fault system.
- Paleosol formation might be promoted during quiet periods of colluvial wegde formation.

References

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