High-resolution mammal Biostratigraphy in the Middle Miocene continental record of Switzerland (Upper Freshwater Molasse, MN 4 - MN 9, 17 - 10 Ma) part I

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1. Introduction

The Upper Freshwater Molasse of Switzerland (OSM) comprises the youngest of four lithostratigraphic groups of the north alpine foredeep. With a maximum thickness of about 900m (plateau Molasse) these continental deposits cover the time interval of 17-10 Ma (MN 4 to MN 9 in European Mammal Units, see table 2, on the right). Due to the position in Central Europe and the presence of nearly all key-species of the European Middle Miocene reference localities, the very rich Swiss faunal succession plays an important role in intra-European correlation programmes.

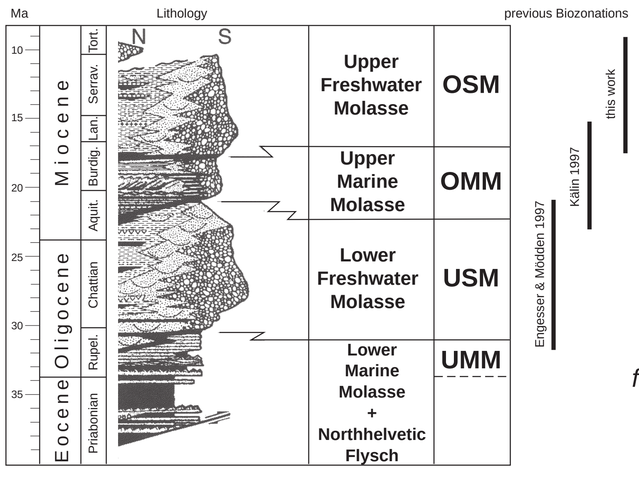

fig. 1: Generalized stratigraphic overview of the Swiss Molasse basin. Modified from Keller 1989.

2. Procedure

Intensive and systematic prospecting of micromammal sites from measured sections combined with a detailed litho-and magnetostratigraphic frame lead to substantial progress in the knowledge of the local faunal succession. Lithostratigraphic correlation within the most important sections, situated in the Hörnli alluvial fan, was facilitated by prominent marker beds such as the famous Hüllistein marker bed, and three main bentonite levels (Urdorf, Küsnacht and Leimbach). These dated intercalated volcanic ash layers (bentonites), together with an impact layer correlated with the Ries meteoric impact (Hofmann 1973), combined with high- resolution magnetostratigraphy carried out by the University of Berne (Schlunegger et al. 1996, Kempf et al. 1997) further constrained the temporal control of the faunal succession. Altogether, 11 highly fossiliferous sections were studied (see fig. 3), yielding more than 80 mammal sites, most of them very rich in material. The summerized faunal succession given in table 2 has been obtained by the correlation and combination of all these sections, using all available information.

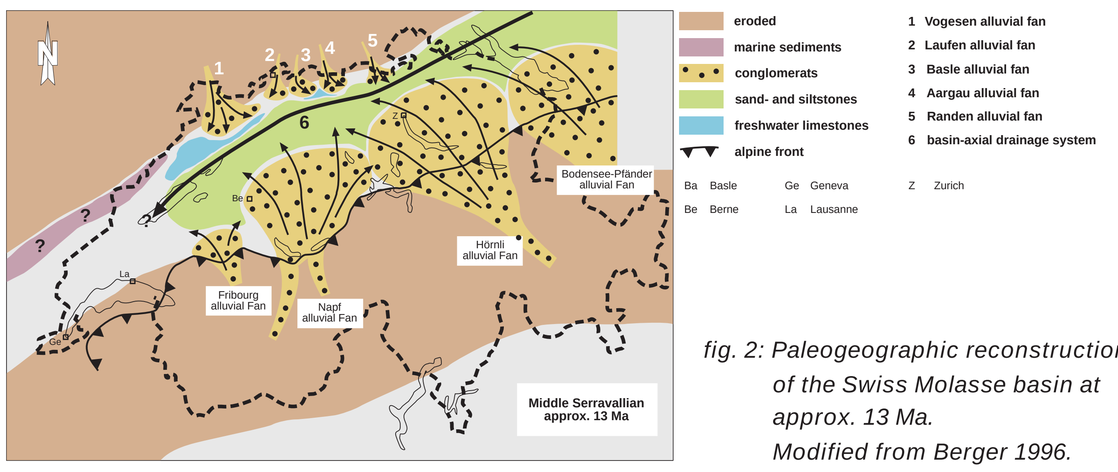

fig. 2: Paleogeographic reconstruction of the Swiss Molasse basin at approx. 13 Ma. Modified from Berger 1996.

3. Biostratigraphic results

Nearly all of the ”key”-species of the Central European MN-reference localities are recorded in the research area and thus enabled a reliable correlation to the MN-scheme.

Correlation to the European MN-units:

Swiss faunas containing *Ligerimys florancei* together with the first modern cricetids clearly indicate MN 4 age. Due to differences in the faunal composition it is not possible to calibrate accurately the position of the European reference locality **La Romieu** within the Swiss faunal succession. The numeric age of the Swiss MN 4(b) localities, derived from magnetostratigraphic data, is approx. 17. Ma. These ages correlate well with two isotopic data from the underlying marine sediments (data of Keller 1989). By the presence of the key-fossil *Megacricetodon lappi*, the European reference locality **Pont Levoy-Thenay** (MN 5) is correlated to the Swiss locality Aspitobel 520m. The latter locality is situated approx. 20 m above an equivalent of the Küsnacht bentonite, which is dated at 14.91 ± 0.09 Ma. The first representatives of *Megacricetodon lappi* (still smaller than the type-population) are recorded from Frohberg, a locality situated 20-30m below the Küsnacht bentonite. Therefore the key-fossil *Megacricetodon lappi* is restricted to a very short time interval (< 0.2 Ma) and represents a true bio-event. According to the MN-scheme in MEIN 1975 localities contemporaneous to Neudorf (Czech Republic) have to be considered as lowermost MN 6. Contemporaneous localities in Switzerland with the first *Anomalomys gaudryi* (Uzwil-Nutzenbuech, Chatzloch) are situated slightly above the ”Block-Horizont” (a boulder-horizon that corresponds to the Ries meteoric impact). According to Reichenbacher et al. 1998 the most probable age of the Ries meteoric event is approx. 14.9 Ma. This numeric age is confirmed by the position of the "Block-Horizont" in Eastern Switzerland (20-30m above the Küsnacht bentonite, 14.91 ± 0.09 Ma.). For these reasons, the MN 5/MN 6 ”boundary” is situated at approx 14.9 Ma. As a consequence, the biostratigraphic position of the European reference locality Pont Levoy-Thenay is at the very top of its MN-unit. The European reference locality **Sansan** (MN 6) is correlated by the presence of *Cricetodon sansaniensis*, *Eomuscardinus sansaniensis* and *Democricetodon* aff. *freisingensis* (formerly *D. gaillardi*) to the Swiss locality Niderwis. The magnetostratigraphic age of the latter locality is approx. 13.6 Ma. The magnetostratigraphic age of 15-15.2 Ma given for the reference locality Sansan (Sen 1996), derived from a very short section, has alreday been doubted by Heissig 1997.

The former reference locality of MN 7, **Steinheim**, is correlated by the presence of the key-fossils *Megacricetodon gregarius* and *Collimys transversus* to the swiss localities Helsighausen and Le Locle. Unfortunately, Helsighausen and Le Locle are not situated in an established section, but may be biostratigraphically correlated into the Schauenberg and Hörnli sections. Based on this correlation, the magnetostratigraphically derived age of the locality Helsighausen is approx. 13.4 Ma. *Megacricetodon gregarius* is restricted to a very short time interval (approx. 0.1 Ma) and represents a very useful bio-event ("*gregarius*-event" according to Heissig 1997).

The former reference locality of MN 8, **Anwil**, is correlated by the presence of *Deperetomys hagni* and *Keramidomys mohleri* to the localities Ottenberg 3 and Greuterschberg. The magnetostratigraphically derived age is 13-13.2 Ma.

The MN-unit 9 is represented in the Swiss Molasse basin by the presence of *Schizogalerix*, *Hispanomys* and *Microtocricetus molassicus* (Nebelberg TGL and Nebelbergweg localities). As recognized by Agusti et al. 1997, the position of the reference locality **Can Llobateres** is at the top of MN 9. Sediments of the age of Can Llobateres have not been preserved in the Swiss Molasse basin.

4. Magnetostratigraphic framework of the OSM in the Swiss Molasse basin

In the central and eastern Swiss Molasse basin a unique situation is provided by the terrestrial deposits of the Upper Freshwater Molasse (OSM, Burdigalian to Langhian). There, the frequent occurrence of stratigraphically indicative micro mammal remains allows, together with few radiometrically dated volcanic ash layers (bentonites), the development of a very reliable magnetostratigraphically constrained high-resolution temporal framework. Magnetostratigraphies were established within long (400 - > 1200 m) and continuous profiles that overlap temporally and correlate well based on either lithostratigraphic marker beds or regional biostratigraphic niveaux. The magneto-stratigraphic sections were calibrated individually but also within their regional context. For magnetostratigraphic purposes only fine-grained lithologies were used to analyse the palaeomagnetic properties of the individual profiles. Several tests were performed to examine the reliability of the magnetostratigraphic results. For details on the methodology see Schlunegger et al. 1996 and Kempf et al. 1997.

In the eastern Swiss Molasse basin the Zürich section includes a bentonite horizon that was radiometrically dated at 14.20 Ma (+/- 0.08) (Gubler et al., 1992). The resulting reversal pattern, which had been sampled very densely, fits perfectly in the GPTS. Moreover, the presence of at least three bentonite horizons, as well as the easy and reliable correlation of these layers into other sections provides a very robust database for magnetic correlation of the individual sections. In addition, a multitude of micro mammal faunas distributed throughout the investigated region allow a coherent biostratigraphic correlation with the present magnetostratigraphic sections. Even isotopic data give plausible results when considering the presented temporal correlations (data of Keller, 1989).

To conclude, our presented bio- and magnetostratigraphic correlations are based on several independent data sets and can therefore be considered very reliable.

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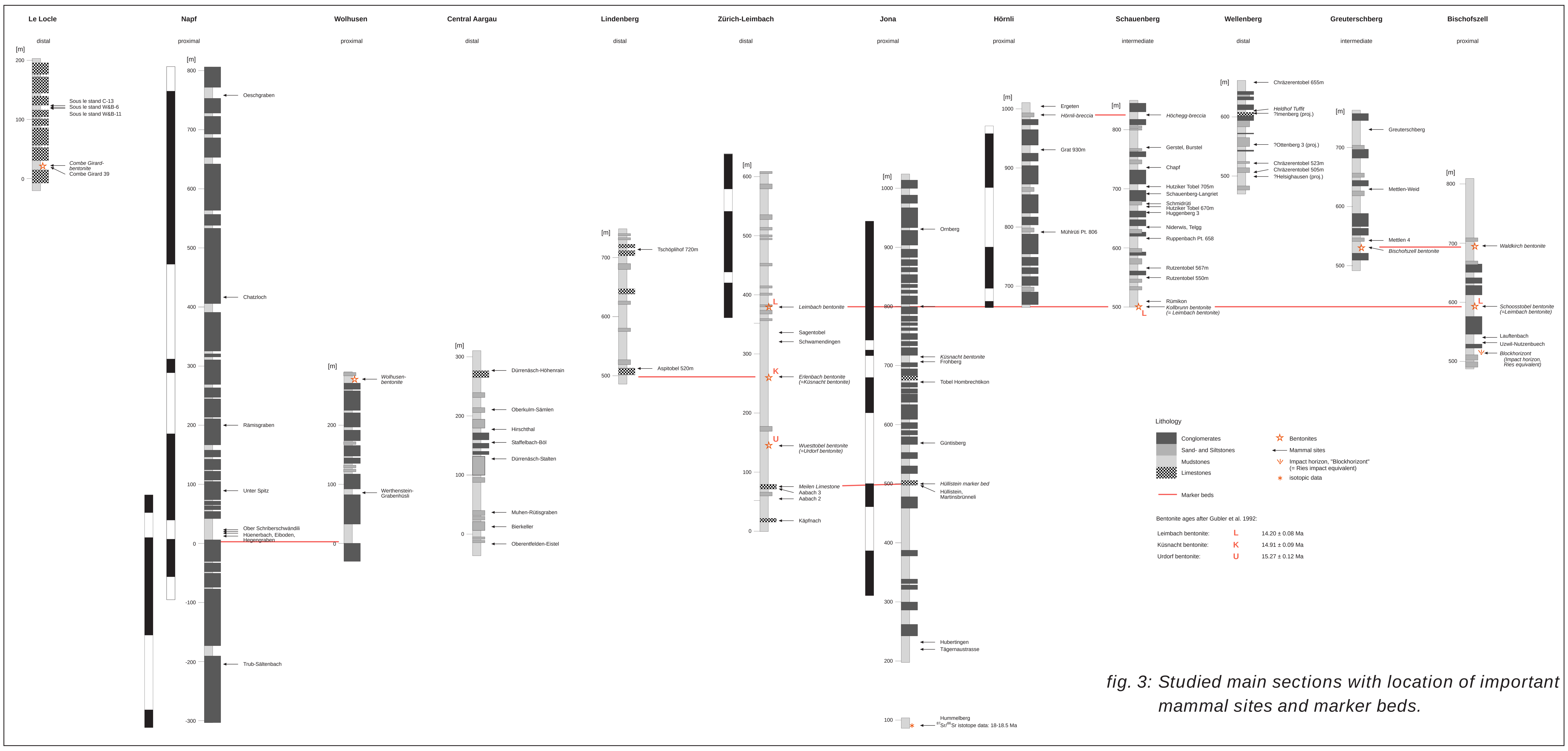

fig. 3: Studied main sections with location of important mammal sites and marker beds.

5. Calibration of MN-"boundaries"

Based on the biostratigraphic position of the European reference localities, it is possible to calibrate the MN-boundaries. It should be noted that the position of the reference localities Pont Levoy-Thenay, Sansan, and Anwil is extremly asymetric in their MN-units. Additionally, in the case of the reference localities Sansan, Steinheim, and Anwil, these three localities are situated very close together (< 0.7 Ma.).
With its lower "boundary" at 13.2 Ma (table 2) and its upper "boundary" at 11.1 Ma (Agusti et al. 1997), the MN-Unit 8 covers an extremely long time period (2.1 Ma). Faunas of middle and higher MN 8 age are (until today) very rare or even missing in Central Europe. The Swiss locality Chräzerentobel 655m, showing a very peculiar fauna may be a representative of a "middle MN 8"-unit.

The numeric ages of the MN-"boundaries", as derived from the Swiss faunal succession, are:

The MN 3/MN 4 "boundary" is situated between 18.2 Ma and 17.2 Ma
The MN 4/MN 5 "boundary" is situated between 16.8 Ma and 16.4 Ma
The MN 5/MN 6 "boundary" is situated at approx. 14.9 Ma
The MN 6/MN 7+8 "boundary" is situated at approx. 13.5 Ma
The MN 7/MN 8 "boundary" is situated at approx. 13.3 Ma

The numeric ages derived from the very rich Swiss faunal succession are in good agreement with data from Austria and Southern Germany, but differ considerably from the data published by the Spanish work group. In our opinion, the reason for these differences may be caused by:
i. a strong diachrony of bioevents between the Central European bioprovince and the Spanish bioprovince, or
ii. the lack of true small mammal key-fossils in the Spanish faunal succession (Spanish bioprovince). Additionally, the very asymetric position of the European reference localities within their MN-units severely hampers the recognition of the MN-boundaries in faunal successions poor in common taxa with the (Central European) reference localities.

6. Local high-resolution biozonation

In addition to the correlation to the European MN-scheme we were able to carry out the following local biozonation (see also tab. 2):
The European Mammal Unit MN 4 may be subdivided into 2 true biozones, the unit MN 5 into 3 biozones, and unit MN 6 into 4 biozones (see table 2). MN 7+8 is subdivided into a lowermost zone, which corresponds to the former MN 7 (Steinheim) and in one higher zone, which covers the lowermost MN 8. Some of the identified biozones are extremly short, e.g. the *Megacricetodon lappi* total range zone or the *Megacricetodon gregarius* total range (sub-) zone (<0.2 Ma), whereas some biozones have a long duration, e.g. the *Ligerimys florancei - Megacricetodon josti* n. sp. interval zone (approx. 1.5 Ma).

Until now, uppermost MN 8 faunas have not been discovered in Switzerland (neither elsewhere in Central Europe). The base of MN 9 may be defined by only one zone, but due to the scarcity of faunas of that time period in Switzerland, we refrained from establishing a zone. Due to later postmolassic erosional events, younger sediments are missing in the Swiss Molasse basin.

The bio- and chronostratigraphic results presented in this poster will be published in the near future.

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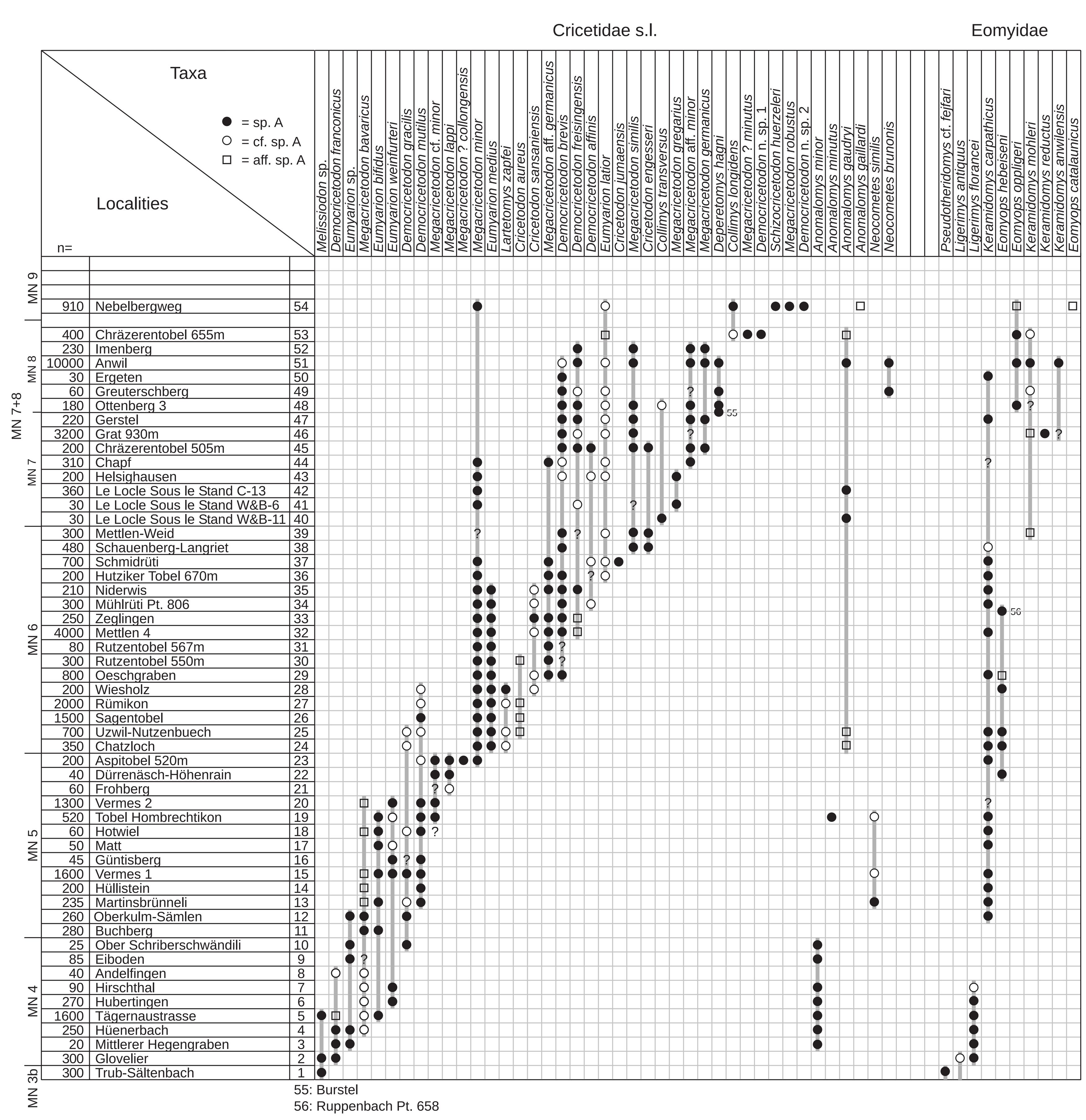

tab. 1: Range chart of selected rodent taxa of the Swiss Molasse basin.