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Tertiary sedimentation in the Swiss Molasse: an overview

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The up to 5 kms thick sequence of the Molasse Basin forms a typical clastic wedge representing the fill of the flexural foreland-depression created by the advancing Alpine thrust wedge. The sequence comprises two large coarsening and shallowing up cycles separated by the Burdigalian unconformity. These cycles consist of the Lower Marine Molasse (UMM) – Lower Freshwater Molasse (USM) and the Upper Marine Molasse (OMM) – Upper Freshwater Molasse (OSM) groups of Rupelian to Serravallian age. Clastic sedimentation prograded northwards in time as shown by the overlap and pinch-out of successively younger groups. The UMM (Rupelian) comprises a thick turbidite sequence at the base followed by storm deposits which are overlain by a regressive littoral series indicating a shoreline retreat from WSW to ENE parallel to the basin axis. Coastal sedimentation in the UMM basin which was a narrow funnel-shaped branch of the Paratethys was wave dominated without evidence of tidal activity.

The USM (Chattian-Aquitanian) is characterised by large conglomeratic alluvial fans at the Alpine thrust front which pass northwards into sandy to marly braid- and meanderplains with lakes at the distal edge. Localised sources of detritus from the area which is now the Jura occur along the northern basin margin. The presence of a gypsum series and of many beds with gypsum crystals indicate intermittent evaporative conditions in these lakes and high aridity. The compositional change from depositional systems dominated by sedimentary clasts and an apatite-zircon rich heavy mineral suite to systems with mainly igneous clasts and an epidote-rich heavy mineral assemblage at the early/late Chattian boundary is related to an increased rate of uplift in the Alps at c. 25 Ma. The lateral rivers drained into an axial fluvial system which flowed northeastwards reaching the coastline near Munich.

The base of the OMM (late Aquitanian-Burdigalian) is marked by a transgressive surface representing a regional unconformity. Flooding of the Molasse Basin initially occurred from the west and later also from the east linking the basin with both Tethys and Paratethys. Coarse-grained fan deltas, partly of Gilbert-type, were built-up by large rivers at the south coast. Farther offshore a basal wave-dominated sandstone succession, followed by a tide-dominated succession and finally a regressive unit were laid down (Lucerne Fm.). Following a second transgressive phase a succession of dark grey rhythmically bedded sandy marls with storm-derived sandstone beds was deposited offshore and in interdeltaic bays (St. Gallen Fm., "Helvetien"). Due to progradation of the fan deltas the regression which marks the begin of the OSM starts earlier in the proximal areas i.e. the facies limit OMM/OSM is clearly heterochronous. The transitional regressive facies corresponds to the "Süssbrackwasser Molasse" of the German Molasse Basin.

The OSM (late Burdigalian-Serravallian) represents the return of terrestrial sedimentation similar to the USM. Large alluvial fans developed at the Alpine thrust front with thicknesses measuring more than 1500 meters, often at the same position as the OMM

fan deltas. Smaller alluvial fans also formed at the northern basin margin. Both river systems drained into an axial river flowing towards the southwest, the reverse of the axial flow in the USM. The frequent occurrence of lacustrine limestone beds and lacustrine clastics suggest the former presence of numerous lakes on the alluvial plain. Several thin bentonite layers in the OSM of eastern Switzerland with ages from 15.4 to 14.4 Ma have been related to the volcanic activity in southern Germany. Despite the enormous progress achieved in the understanding of the sedimentary history of the Molasse Basin since the publication of the first palaeogeographic map by G. de Razumowsky in 1790, numerous questions concerning Molasse sedimentation and the depositional processes are still open. To mention but a few:

(i) The controversy of a possible link during the Rupelian of the Molasse Basin and the Rheingraben across the "Raurachian depression" (i.e. a connection of the Paratethys and the boreal seas) was reanimated by recent discoveries: paratethyan calcareous nannoplankton in the Rupelton of the Rheingraben and a nannoflora of Rupelian age in a karst fill in the Neuchâtel Jura Mountains.
(ii) Does the unconformity at the base of the Burdigalian really exist and if so, why is its duration beyond the resolution of biostratigraphic and paleomagnetic methods?
(iii) When did Molasse sedimentation end? What has happened since deposition of the last preserved Molasse sediments of Serravallian age (MN 9 = c. 11 Ma) and the Pleistocene glaciations i.e. during a time span of c. 10 Ma, equal to about a fourth of the Molasse period? Another puzzling discovery in this context is a micromammal fauna found in another karst fill in the Jura which reveals a Ruscinian (Pliocene) age!

The answers to these and other questions, and especially the construction of a much more detailed time framework will finally allow modelling of the depositional history of the Molasse Basin in relation to Alpine orogenic events with less ambiguities than at present.

The Tertiary strata of Molasse Basin and Rauracian Depression: Lithofacies development, subsidence and dynamic concept

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The main lithostratigraphic units of the Swiss Molasse Basin have been established a long time ago. These are from bottom to top: Lower Marine Molasse – Lower Freshwater Molasse – Upper Marine Molasse – Upper Freshwater Molasse. Along strike of the Molasse Basin, between lake Geneva and lake Constance, these groups show a more or less uniform character. On the contrary, the lithologies change dramatically