Publié dans Eclogae Geologicae Helvetiae 85, n° 3, 695-699, 1992
qui doit être utilisé pour toute référence à ce travail

Tectonic evolution and vertical movement in Western Switzerland

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ABSTRACT

Using a few facts (drainage pattern, well data, evolution of clay minerals) and some estimations, a reconstruction of the Tertiary sediment pile is proposed. It is used to describe the regional uplift since the top of the Upper Freshwater Molasse and the erosion in a profile La Chaux-de-Fonds Courtion. Despite the important erosion in the Molasse Basin, it is very difficult to have an idea of its timing and destination of the erosion product.

RÉSUMÉ

En utilisant quelques données (drainage vosgiens et molassique à l'époque de l'OSM, forage de Courtion et l'évolution des associations minérales) on propose la reconstruction du prisme sédimentaire tertiaire dans un profil La Chaux-de-Fonds Courtion. Ces données permettent de dessiner le soulèvement régional ainsi que l'érosion du même secteur. Cette dernière bien que très importante, près de 2 km dans le bassin molassique, ne peut être datée et on ignore où a été dirigé ce matériel détritique.

In Western Switzerland the timing of Tertiary deposits and later periods of erosion are badly constrained. In the Jura, owing to lack of good exposure and fossils, stratigraphical correlations are especially difficult. The situation is worse in the Molasse Basin, where deep erosion has preserved only the Oligocene sediments. Some speculation is necessary when dealing with the history of the Miocene-Quaternary evolution.

During the upper Middle Miocene, pebbles coming from the Vosges accumulated in the youngest fluvial deposits of the Delemont Basin. At the same time, chalk was precipitated into a lake which was fed only by local rivers in the region of Le Locle (Weidmann, personnel communication). Dealing with such a situation one has to admit that the rivers coming from the Vosges had to pass through the present Jura in order to join the main drainage of the Molasse Basin (flowing SW to the "Proto-Rhone") (Bürgisser 1981). At that time, the region of Le Locle was probably only a few tens of meters above sea level (Hantke 1980) and it could therefore have had its drainage driven directly westward to the Bresse or southward to the Molasse Basin. This lake in its short period of existence (a few hundred thousand years at the most) filled the bottom of a newly formed syncline and can therefore be associated with the first development of the Jura folding. Over 200 m of sediments were deposited in this lake which was

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probably never deep (repeated lignite horizons) and changed shape as folding proceeded. Subsequently these sediments have been folded and they are now in a vertical or overturned position on both sides of the syncline. Unfortunately, the time span of folding is unknown. Underneath these lake concordant deposits of conglomerates of up to 40 m of "Helvetian" Gompholites (Favre 1910) attests by their pebbles, local erosion of the surrounding Cretaceous and upper Jurassic. A Middle Miocene relief was probably caused by cliffs due to faults or the first development of folding.

During the late Quaternary, several large piedmont glaciers successively occupied the Molasse Basin. Their disappearance could have induced subsidence and isostatic recovery similar to that of lake Bonneville (Crittenden 1963). The difference in crustal structure can probably explain the absence of such movements in Switzerland (Schaer 1981).

Relative to the Molasse Basin, the rather high elevation of the first internal chain of the western Jura is marked by young morphological features. The slight erosion of the Cretaceous and Jurassic limestone and unequilibrated river profiles speak for young development.

Recent earthquakes and high horizontal stresses measured in a tunnel, are evidence that the region is still tectonically active. However, the repetition of precise levelling suggests a relative stability of the Jura region in comparison with the Molasse Basin (Schaer et al. 1990).

Despite the difficulty of following the sedimentary and structural evolution of western Switzerland during and after the Miocene we have attempted to show in a cartoon some of the main facts and suppositions that can be illustrated (Fig. 1). They are presented in a profile running from Courtion in the Molasse Basin passing through Neuchâtel and heading up to La Chaux-de-Fonds in the Jura.

In Fig. 1 A a view of the Tertiary sediments before the Jura folding is shown. In order to unravel the effects of the folding, the present distance from La Chaux-de-Fonds to Neuchâtel has been increased by six kilometers. The Courtion and Tschugg well data with their nearby Upper Marine Molasse have been used to show the thickness of the Lower Freshwater Molasse (USM). As these sediments do not exist near La Chaux-de-Fonds, their pinching out must be located south of that city. In our drawing the inflection point at Tschugg has probably no real significance.

The proposed thickness of 600 m of the Upper Marine Molasse (OMM) at the Courtion well site is extrapolated from data collected further to the SE (Rutsch 1967). The Upper Marine Molasse and brackish "Helvetian" present in La Chaux-de-Fonds have a total thickness of no more than a few tens of meters. A straight line has been drawn between these two points.

The Upper Freshwater Molasse is totally absent from western Switzerland. It is therefore extremely difficult to make any accurate suggestions concerning the thickness and the extension of these deposits. At Courtion, Monnier (1984) using clay mineral evolution suggests that erosion has removed some 1200 meters of sediments with reference to the Küsnacht well. There, one can estimate that erosion has taken away a minimum of 500 meters (200 meters above the highest preserved regional level which is 300 meters above the top of the well (Pavoni 1957). We suggest therefore, that at Courtion the thickness of Upper Freshwater Molasse was at least 1100 m placing the top of the Tertiary pile 2400 m above the present land surface.

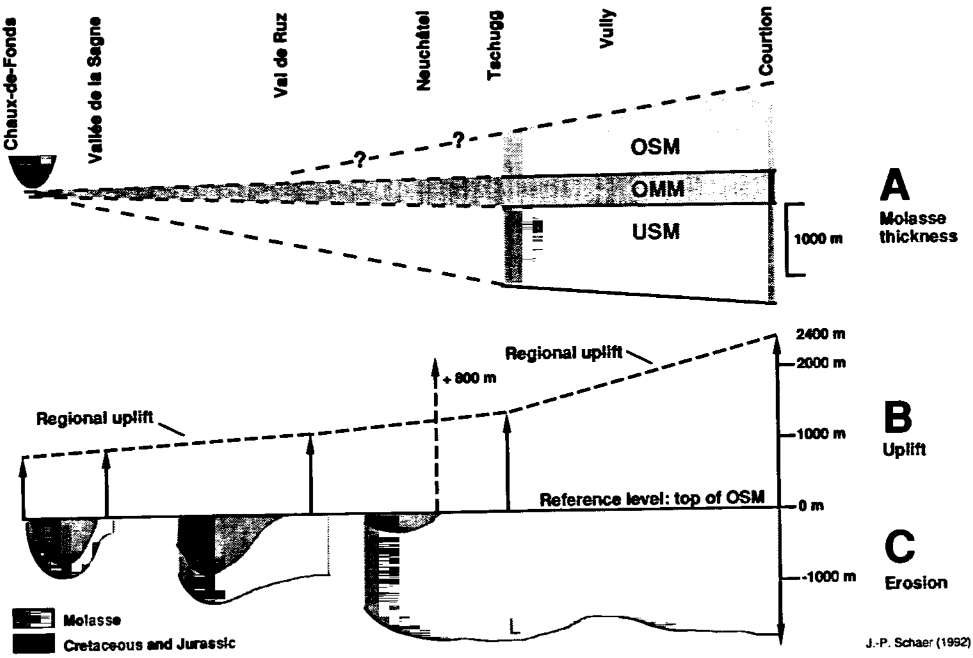

Fig. 1. Cartoon of the sedimentary and morphological evolution of the Jura Molasse Basin evolution during the Tertiary and Quarternary time. A: Molasse thickness. OSM = Upper Freshwater Molasse, OMM = Upper Marine Molasse, USM = Lower Freshwater Molasse. The lake sediments of Le Locle and La Chaux-de-Fonds are above and outside the main drainage of the OSM. B: Uplift relative to the proposed top of the OSM. C. Erosion: light grey Molasse, (L position of lake Neuchâtel) darker grey Cretaceous and Jurassic sediments.

We mentioned that the Upper Freshwater Molasse drainage system never reached La Chaux-de-Fonds. We suggest the pinching out of these sediments took place near the Val-de-Ruz. From there, a straight line has been drawn up to Courtion to illustrate the possible top of the Upper Freshwater Molasse. Despite its uncertainty, especially in the Jura. It has been taken as a reference line, which at the time was close to sea level (B in fig. 1). The altitude of localities situated in synclines or in flat lying environment of the Molasse Basin has been used to draw the regional uplift since the top of the Upper Freshwater Formation. Neuchâtel shows a higher uplift in comparison to the latter localities. This situation is connected to its position on the southern limb of the first Jura anticline where the extra rise has been produced by thrusting.

Our suggested uplifts are slightly different from those presented by Laubscher (1974) but are of the same order of magnitude. The main discrepancy is shown by the position of the maximum rise. We place it at Courtion whereas Laubscher located it at the level of the first Jura anticline. There our total uplift (regional + local thrust induced uplift) would bring the top of the Upper Freshwater Molasse to an altitude of about 2500 m which is not so different from Laubscher's suggestion.

Having drawn the uplift and the presumed thickness of the entire Molasse pile, the erosion along our profile is easy to deduce as shwon in Fig. 1 C. It is more than two km between Courtion and Neuchâtel. In the Jura two erosion components have been distinguished: that of the Molasse in light grey and that of the Jurassic plus Cretaceous formations in darker grey. As we enter the Jura, the total erosion thickness decreases but the importance of the Jurassic and Cretaceous component remains high up to La Chaux-de-Fonds and further N (not shown in the profile). The slight erosion of the Cretaceous and Jurassic limestones of the first Jura anticline could be linked to its thick and long lasting protection by Molasse sediments.

In this short review some important questions have not been considered. When did erosion take place? Where did the material disappear to? We assume that with a high uplift in the Swiss Molasse Basin, its drainage would have persisted for some time. At first, in the uplifted part of the alluvial plain, sedimentation could have been replaced by erosion whose products could have been sent to the Bas Dauphiné marine Basin or even further south. Mixed with other alpine sediments, their identification will be extremely difficult. During the Tortonien, a general tendency of continentalisation took place along the "Rhone gutter". This prevented the deposition of sediments which are not in direct connection with alpine rivers. Only a very restricted part of the sediment left there could have a Swiss Molasse origin. During the Pleistocene, the Dombes region, North of Lyon, received some coarse sediments which transited through the Jura which was already formed or in formation. Some of these could well have been Molassic but their volume is small when compared with the missing volume of the Molasse Basin. The search for eroded Molasse sediments along the Rhine river is even more difficult, almost impossible as they have also been mixed with similar materials of alpine origin.

It is admitted that the morphology of the Swiss Molasse Basin has been produced by glacial action. No precise data exist to estimate the volume of erosion during the successive glacier invasions.

The search for facts to unravel the story of the western Swiss Molasse Basin shows certain similarities with that of a good detective story. We are lost in the middle with too many questions, ready to suspect the most obvious actors.

Acknowledgements

I am very greateful for the critical comments and discussions provided by M. Burkhard and M. Weidmann.

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