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6. Stratigraphy in Switzerland - new data and developments

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6. Stratigraphy in Switzerland - new data and developments

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Comité Suisse de Stratigraphie – Schweizerisches Komitee für Stratigraphie (SCNAT)

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6.1

Tracing the extent and formation of the Oxfordian limestone-marl successions of the Effingen Member

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The Effingen Member consists of an up to 240 m thick intercalation of limestones and marls in northeastern Switzerland. Individual limestone beds are mostly bundled in 3 - 12 m thick successions which are surrounded by calcareous marl successions. The sediments were deposited in an epicontinental sea during the lower to middle Oxfordian (Late Jurassic) in about 2 Myr with a depositional centre between Brugg and Olten (''Argovian'' realm, Wetzel et al. 2003). Towards the west the epicontinental basin was limited by a carbonate reef and platform (''Celtic'' realm), which prograded to the southeast during the Oxfordian. Previous studies have focused mostly on the correlation of basinal and shallow marine sediments or individual limestone-marl successions using outcrops.

In this study, facies, extent and stratigraphic correlation of the limestone and calcareous marl successions within the Effingen Member are studied using morphological mapping, geophysical borehole analysis, macro- and microfacies analysis and seismic facies analysis. Whereas it is was postulated that the most characteristic of the limestone successions, referred to as Gerstenhübel Beds, can be followed on a large scale (Gygi & Persoz 1986), the extent of the other successions was not known so far. Our study shows that the limestone successions can form morphological elements in the field that can be followed over up to 500 m based on high resolution LiDAR mapping. Clay mineral content records derived from geophysical logging represent a powerful tool to correlate boreholes on a previously unprecedented resolution. Based on this analysis certain limestone successions especially in the upper Effingen Member can be followed over at least 20 km, which is consistent with seismic facies analysis. The Gerstenhübel Beds can also be followed over several kilometers but towards the west they seem to thin and change their characteristics. Limestone successions consist mostly of micrite which is presumably transported from the northwestern platform or from local shallow marine swells in the east. A detailed analysis of the clay mineral content suggests a diachronous transition of the top of the Effingen Member to the overlying more calcareous sediments from the central Argovian basin both towards east and west. It is postulated that the intercalation of limestone and calcareous marl successions was forced by climate cycles in combination with sea level changes in a differentially subsiding basin.

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6.2

Die Rolle der Biostratigraphie für die Korrelation lithostratigraphischer Einheiten

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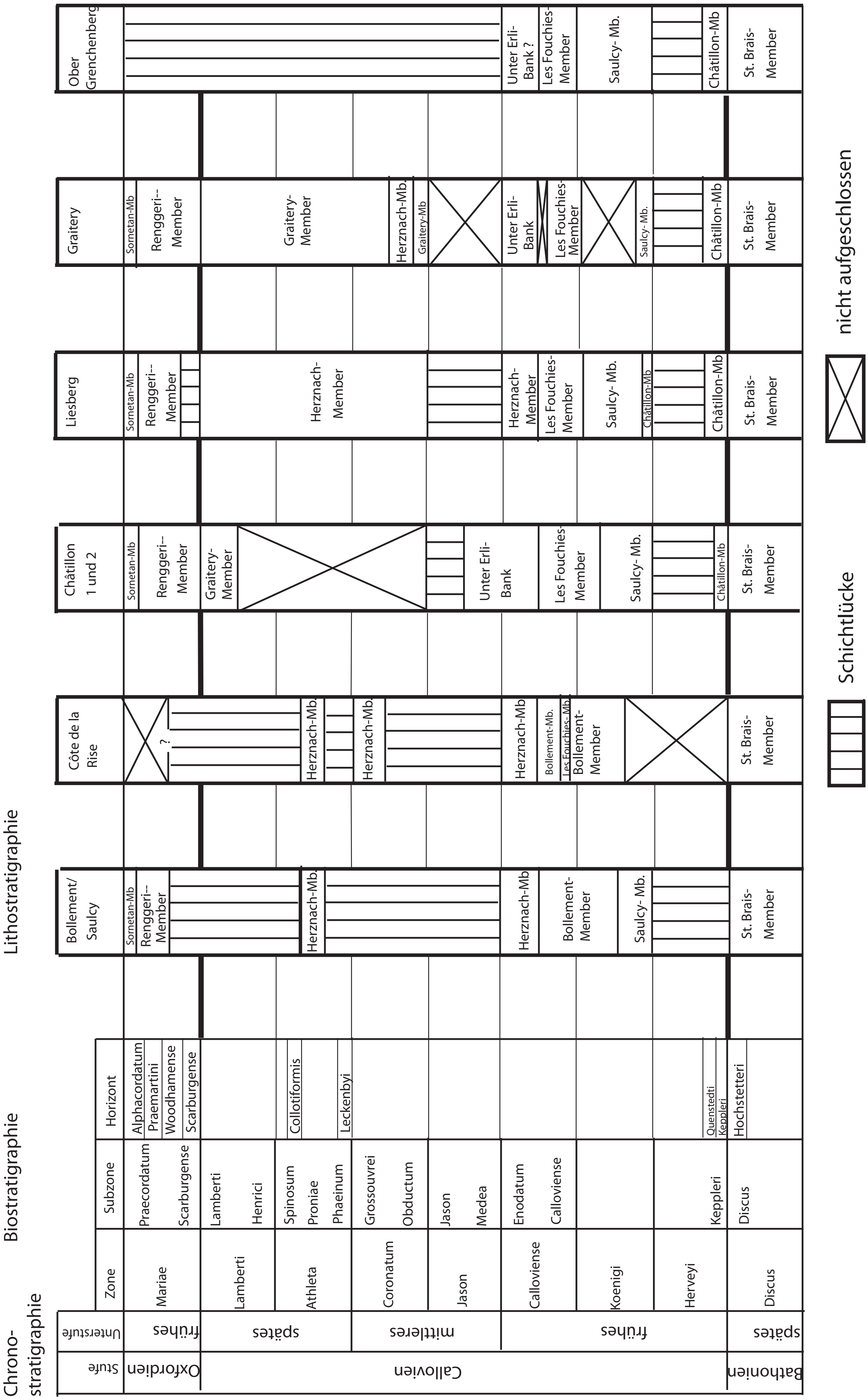
Die Definition lithostratigraphischer sedimentärer Gesteinskörper basiert auf rein lithologischen Kriterien wie Fazies, Ablagerungsraum, Sedimentstrukturen, Partikel, Porosität, Farbe, u.s.w., wobei Unter- und Obergrenze generell nicht isochron sein müssen.

Wird aber die räumliche Entwicklung eines solchen Sedimentkörpers in der Zeit betrachtet, ist es am einfachsten die Biostratigraphie zu verwenden. Neben der zeitlichen Abgrenzung des Gesteinskörpers können so gleichzeitig auch Schichtlücken und deren Dauer ermittelt werden.

Zur biostratigrapohischen Datierung können unterschiedlichste Organismengruppen herangezogen werden. Für die Jura-Zeit erreicht man mittels Ammoniten die beste zeitliche Auflösung. Die zeitliche Auflösung ist aber abhängig vom Ablagerungsraum und von der Sedimentationsgeschwindigkeit.

Wie Figur 1 zeigt, ist die biostratigraphische Auflösung in der koenigi-Zone relativ schlecht: Dies kann damit erklärt werden, dass während dieser Periode die Karbonatplattform vorrückt und der Lebensraum deshalb immer seichter wird. Solche Bedingungen sind für Ammoniten ungünstig. Gleichzeitig wird hier im Callovien die grösste Sedimentmenge abgelagert.
Die beste zeitliche Auflösung weist das Renggeri-Member auf: Hier beträgt die Meerestiefe deutlich mehr als 50 Meter, was zu diversen Ammonitenfaunen führt. Eine gleichzeitig hohe Sedimentationsrate erlaubt eine gute Abgrenzung der sich in der Zeit folgenden Ammonitenpopulationen.



Figur 1. Chronostratigraphische Einordnung der lithologischen Einheiten im späten Bathonien, Callovien und frühen Oxfordien im zentralen Nordwestschweizer Jura.

6.3
Neugliederung der Trias in der Nordschweiz – ein Arbeitsbericht

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Arbeitsgruppe „Jura-Ost“ des Schweizerischen Komitees für Stratigraphie SKS

Die Arbeitsgruppe „Jura Ost“ des Schweizerischen Komitees für Stratigraphie SKS (Burkhalter & Heckendorn 2009) hat im Herbst 2012 vorgeschlagen, die Trias des Ostjura aufgrund von Literaturdaten entsprechend den Vorgaben von Remane et al. (2005) neu zu gliedern (Jordan 2012). Der Vorschlag wurde vom Komitee wohlwollend aufgenommen und wird von der Schweizerischen Landesgeologie im Rahmen von Harmos unterstützt.

Im Vordergrund stehen dabei die Ansprache in Gelände und Bohrungen sowie die Kartierbarkeit. Entsprechend ergeben sich insgesamt sechs Formationen. Um die Korrelation mit den bis anhin verwendeten stratigraphischen Einheiten zu erleichtern, werden 18 Member bezeichnet.

Für verschiedene Formationen finden sich auf Schweizer Boden keine Typusprofile, die den Anforderungen von Remane et al. (2005) entsprechen. So wird hier jeweils eine Kombination von Typlokalität (namengebende Örtlichkeit mit rudimentären Aufschlüssen) und Paratypusprofil (vollständiges Referenzprofil in Bohrung) vorgeschlagen.

Eine Übernahme der in Deutschland verwendeten Formationen mitsamt ihrer Typusprofile wurde geprüft und verworfen. Die im Zentrum des Germanischen Beckens oft mehrere Dutzend Meter mächtige Formationen keilen in der hier betrachteten Randzone so stark aus, dass sie, um der Anforderung der Kartierbarkeit zu genügen, zusammengefasst werden müssen. Ferner entspricht die randliche Ausprägung in einigen Fällen kaum mehr der im Beckeninnern vorherrschenden Fazies.

Die vorgeschlagene Gliederung ist rein lithofaziell. Jüngere Untersuchungen im Germanischen Becken haben gezeigt, dass die Formationsgrenzen oft diachron sind (z.B. Franz et al. 2013). Wie weit dies auch in der Nordschweiz nachweisbar ist, bleibt abzuklären. Die vorgeschlagene Gliederung ist so ausgelegt, dass sie durch zukünftige Erkenntnisse zwar verfeinert und präzisiert aber wohl kaum in Frage gestellt werden kann.

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6.4

Stratigraphic scaling and correlations – mind the gaps !

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For the harmonisation of the legend of the Geological Atlas of Switzerland 1:25'000, a revised lithostratigraphic scheme is under development [Morard et al. 2012]. The present contribution is a first personal reflection about some fundamental options for the graphical presentation of the results of this project, to be further discussed by the stratigraphic community.

From field logging to basin analysis and further correlations, different kinds of stratigraphic representations are used. These mainly differ in the choice of the parameter used as vertical scale, whereas the horizontal axis usually represents lateral variation:

(a) In a first step, individual profiles are measured and drawn proportionally to their original thickness. The identification of marker beds is the most basic (though not always straightforward and univocal) method to correlate one profile to the next.

(b) In order to consistently "map" the stratigraphic succession in a given region, a first lithostratigraphic synthesis is established as a working legend. Observed discontinuities at formation boundaries can be integrated at this point.

(c) With some chance, a relative age can already be assessed in the field, e.g. based on fossil finds. Careful analysis may later provide a more detailed relative datation (stage, biozone, isotopic event, ...). This step is nowadays often simultaneous to – if not preceded by – the next one.

(d) Ultimately an interpretation in terms of absolute ages and durations can be tentatively proposed. This involves critical assumptions concerning both the specific case under study and the reference chart used.

As can readily be seen from the virtual example illustrated in Fig.1a–d, each scaling technique has its own strengths and limitations. The most problematical pitfalls concern the (non-)representation of hiatuses and diachronism, as well as the pervasive distortion of either spatial proportions or time (or both). All these shortcomings ultimately result from the non-linear and fragmentary nature of the stratigraphic record.

For our harmonisation project, a compromise has to be found between scientific correctness (spatial pattern and temporal succession), ease of reading (deliberate symbolism vs. pseudo-realism), but also stability relative to future age revisions. In this respect, and keeping in mind that the project is aimed at the elaboration of a legend for field geological mapping, the representation scheme should primarily highlight the geometrical relationships of the elemental lithostratigraphic units – i.e. formations, including the nature of their contacts. Our challenge is thus to try and develop a "scaling method" somewhat intermediate between Fig. 1b and 1c.

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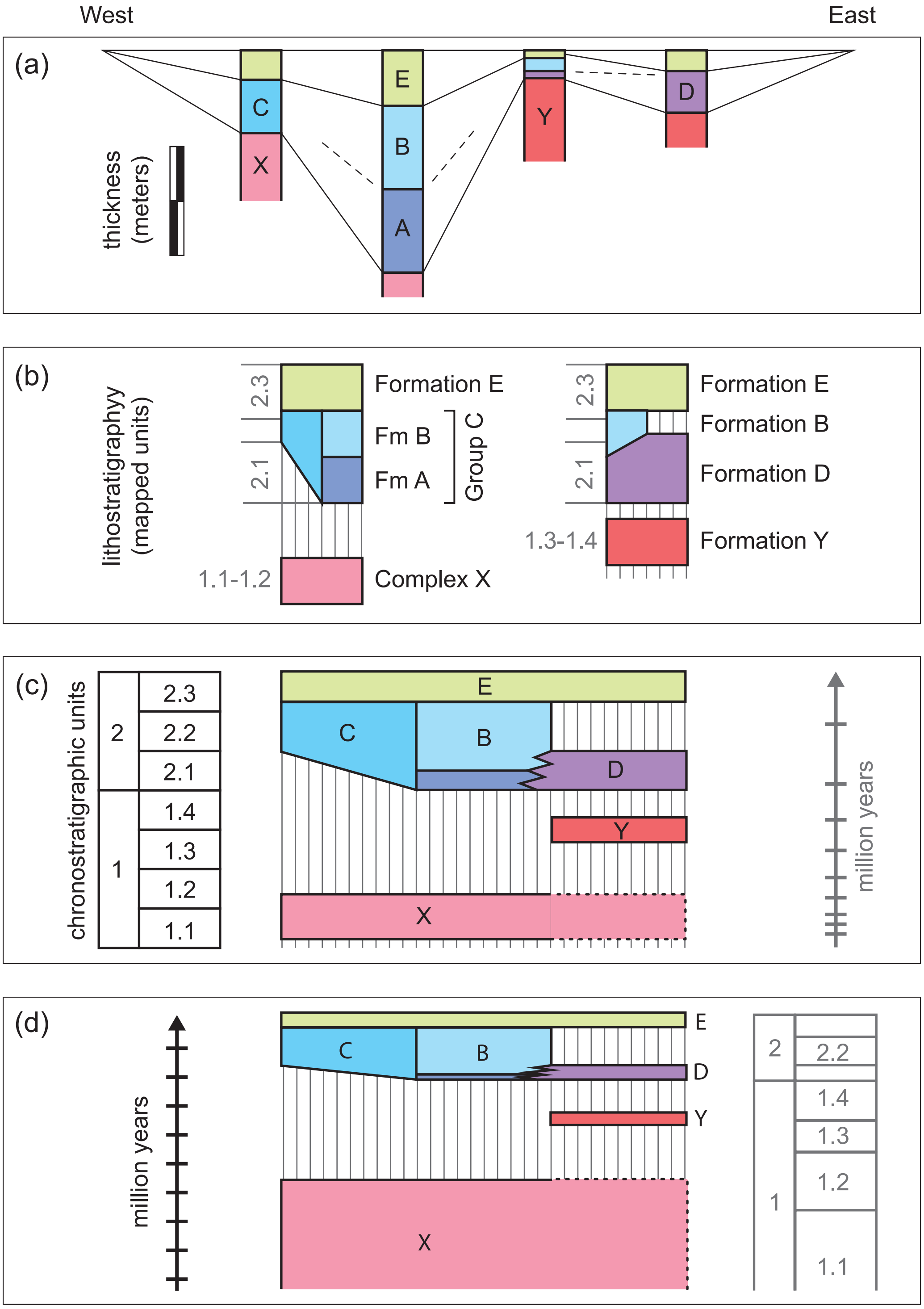

Figure 1. Alternative representation schemes with differing vertical stratigraphic scaling for a simple virtual geological situation (discussion in the text).

6.5

Chrono- and Biostratigraphy of the Opalinus Clay of the Mont Terri Rock Laboratory, Canton Jura, Switzerland

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Since the existence of the Mont Terri Project, for the first time, the Opalinus Clay has been subjected to a macropaleontological study. Ammonites were extracted from bedrock from a number of small exposures and a drill core at the Mont Terri Rock Laboratory. In addition, ammonites were obtained from excavated material of a particular stretch of drifting.

From the faunal spectrum, it was possible to make a biostratigraphical subdivision of the basal strata of the Opalinus Clay. *Pleydellia aalensis* s.l., *P. fluitans, P. subcompta*?, *P. leura* and *P. costula* were found in the >10-meter-thick basal strata of the Opalinus Clay. The stratigraphical occurrence of these ammonites is evidence that a significant part of the Opalinus Clay of the Mont Terri Rock Laboratory belongs most certainly to the latest Toarcian (aalensis Subzone, Aalensis Zone). Furthermore, there is evidence in the exposed section that the Late Toarcian ammonite fauna was succeeded without significant facies change by an Early Aalenian faunal assemblage that included *Leioceras opalinum*. These macropaleontological and lithological facts corroborate our micropaleontological data set.

The basal strata of the Opalinus Clay of the Mont Terri Rock Laboratory are lithofacially significantly different from the deposits of the same age of the Tabular Jura and the eastern Folded Jura, which appear in a mostly phosphoritic marly facies (= Gross Wolf Member after Reisdorf et al. 2011, "Jurensis-Schichten" *sensu* Jordan 1983, "Jurensismergel" *sensu* Müller 1984). When considering the facies and the thickness relationships of the latest Toarcian in the Mont Terri area, however, there exists a strong affinity with the strata south of Freiburg i.Br., Germany (cf. for example Etter 1990; Geologisches Landesamt Baden-Württemberg 1996; Wetzel & Allia 2003).

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P 6.1

Lithostratigraphy in the Prealps: proposed units in the area of Château-d'Oex

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The edition of map sheet 144 Châteaux-d'Oex (Plancherel & Dall'Agnolo in prep.) of the Geological Atlas of Switzerland 1:25000 showed the necessity of proposing several lithostratigraphic units for formal definition. Many of them are derived from established names and are officialised by using the term of «Formation» or «Member» instead of «Couches» and will not be discussed here. Other units are new or replace informal names. A novelty is that melanges are treated and described like formations (or groups).

In the Préalpes médianes, the Formation des Erpilles (Carnian) is proposed as formal substitute for the «formation bré-chique» (Baud 1972). The best profile is found at the rock face close to Erpilles.

The Combe du Pissot Formation, of early Toarcian age is proposed following the classic profile described by Jeannet (1913) in the Tinière valley. This formation consists of bituminous shales (Couches du Creux de l'Ours) and glauconitic marls (Couches des Chevalets) as a lateral facies variation.

Within the Staldengraben Formation (Septfontaine 1983) of middle Jurassic age the Soladier, Verdy, Vanil Carré and Col de Lys Members are proposed as replacement of the subunits A, B, C, D.
The Torrent de Lessoc Formation (Oxfordian) is proposed to replace the «calcaires noduleux». A good profile is described by Weiss (1949) in the gorges de Mury near Lessoc.

The «Calcaires massifs» (Kimmeridgian-early Berriasian) are now formally subdivided into two formations. These are the medium to thick bedded limestone of the Moléson Formation and the massif limestone of the Dorfflüe Formation. Very comprehensive descriptions can be found in Heinz & Isenschmid (1988).
The Sciernes d'Albeuve Formation (Berriasian-Barremian) replaces the «calcaires plaquetés formation» (Spicher 1966). Excellent profile descriptions can be found in Boller (1963).
The Cuvigne-Derrey Formation stands for the so called «Flysch des Préalpes médianes» described by Favre (1952).
The Coulaytes Melange (late Eocene-early Oligocene) is proposed as a formal unit representing the «Flysch à lentilles de Couches Rouges» (Badoux 1962) on top of the Préalpes médianes.

A similar but not identical unit is called Melange des Mattes and represents the «Flysch à lentilles de Couches Rouges» on top of the Breccia nappe.

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P 6.2

New lithostratigraphic formations of the middle penninic Klippen nappe (late Triassic – early Jurassic)

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In the course of editing a new map sheet of the Geological Atlas of Switzerland 1:25'000 (map sheet Alpnach; Funk et al. in prep.) the formal definition of four lithostratigraphic units is proposed. The investigated units are part of the middle penninic Klippen nappe and are of late Triassic (Rhaetian) to early Jurassic (Hettangian – Pliensbachian) age. The proposed formations are based on stratigraphic profiles that were originally described in great detail by Christ (1920) in the Stanserhorn region.

Late Triassic
1. Lückengraben-Formation, Rhaetian: Christ (1920, p. 9 ff.) describes a detailed profile in the Lückengraben near Wiesenberg on the southern flank of the Stanserhorn (Swiss coordinates: 670.110/197.725). The profile is composed of ca. 45 m micritic, sparitic, dolomitic and sandy limestone beds with occasional marl intervals.

Early Jurassic
2. Horngraben-Formation, Hettangian: The Jurassic profiles were originally described by Christ (1920, p. 19 ff.) at the locality «Brandgraben», which is today named «Horngraben» (667.875/197.175) southwest of the Stanserhorn summit. The profile of the Horngraben-Formation is composed of ca. 70 m micritic, sparitic, oolithic and sandy limestone beds.

3. Brand-Formation, Sinemurian: A ca. 37.5 m thick profile follows up-section of the Horngraben-Formation. The profile consists of dark gray sparitic limestone beds (echinoid-breccia) and a siliceous micritic limestone at the top of this unit.

4. Obflue-Formation, Pliensbachian: The profile follows on top of the Brand-Formation in the Horngraben and is composed of ca. 27 m gray siliceous micritic limestone beds interbedded with thin layers of brown marl.

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P 6.3

The Middle Triassic (Anisian) marine transgression in central Switzerland, comparisons with the Jura Mountain and the Brescian Prealps

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During the basal Triassic, a shallow sea flooded the crystalline basement in central Switzerland. The knowledge on this transgression, i.e., stratigraphic allocation, depositional environment and paleogeographic setting, has been refined by numerous geologists since the end of the 18th century (e.g., Brunnschweiler, 1948; Widmer, 1949). Still, chronology, dynamics and direction(s) of this transgression remain unclear. First efforts based on palynological data (Gisler et al., 2007) indicated a marine transgression direction from the Tethys towards the Jura Mountains at lowermost Anisian time.

This study focuses on different stratigraphic sections in central Switzerland, i.e., Scheidnössli, Limmernsee, Val Punteglias, Obersand, Schwandi and Hüfihütte, where lack of vegetation, well-exposed rocks and little tectonic deformation allowed detailed logging. The first sediments deposited on the weathered crystalline basement consist of conglomerats and sandstones. Numerous sedimentary structures such as ripple marks or channels can be observed in this siliciclastic unit.

Following-up section, the clastic beds become thinner and dolomite layers appear randomly until they dominate. In the uppermost 20 m of the sequence, dolomite beds become massive and show a well-developed stacking pattern. The tops of the Triassic sections are erosive surfaces followed by black shales of Lias to Dogger in age. The thickness of these sedimentary deposits vary from one section to another with an West to east decreasing trend. The Val Punteglias section is the thickest (54 m), and the Schwandi section the thinnest (9 m).

Facies and microfacies determinations, sedimentary structure analyses as well as stable isotope analyses ($\delta^{13}C$, $\delta^{18}O$) have been carried out. Preliminary results show that the sedimentary record displays several depositional sequences implying that high-frequency relative sea-level fluctuations were superimposed onto the general transgressive trend. These observations allow to correlate the six locations and to give indications about the depositional system and paleotopography.

This data have been compared with a borehole from the Jura mountains (Weiach) and with two well-documented sections of the Brescian Prealps (Northern Italy) i.e. Dosso Alto and Bagolino (Brack & Rieber, 1986; Brack et al., 2005) where isotopic analyses have been carried out. This allows getting a better understanding on the Alpine realm at middle Triassic times.

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