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# Annotated index of lithostratigraphic units currently used in the Upper Jurassic of northern Switzerland

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*Keywords:* Lithostratigraphic units, type localities, Upper Jurassic, northern Switzerland

*Vorwort des Redaktors*

*Wegen ihrer grossen Bedeutung für das Verständnis der Stratigraphie des Schweizer Juras wurde die vorliegende Zusammenstellung von R. Gygi in die Eclogae aufgenommen, obwohl es sich nicht um eine wissenschaftliche Originalarbeit im üblichen Sinne handelt. Es sollte aber berücksichtigt werden, dass die hier vom Autor vorgeschlagene lithostratigraphische Nomenklatur ein persönlicher Vorschlag ist, der mit dieser Veröffentlichung nicht zur "offiziellen" Nomenklatur der Schweizerischen Geologischen Gesellschaft wird. Seit die Schweizerische Stratigraphische Kommission zu existieren aufgehört hat, gibt es (schon seit längerer Zeit) keine Instanz, die auf diesem Gebiet regulierend wirken könnte. Auf lange Sicht kann aber auf eine derartige Regulierung nicht verzichtet werden, und der vorliegende Beitrag wird sicher die Diskussion über das beste Verfahren zur Erreichung einer allgemein anerkannten lithostratigraphischen Nomenklatur der Schweiz neu beleben.*

*J. Remane*

*Preface by the editor*

*Despite the fact that the annotated index of lithostratigraphic units by R. Gygi is not an original scientific publication in the current sense, it was included in the present issue of the Eclogae because of its great importance for the understanding of the stratigraphy of the Jura Mountains. On the other hand it should be taken into account that this index is a personal classification proposed by an individual author and not the "official" lithostratigraphic nomenclature of the Swiss Geological Society. As the Swiss Stratigraphic Commission has ceased to exist (quite a number of years ago) there is no authority which might establish a formal lithostratigraphic nomenclature. In the long run, such an authority is, however, urgently needed. The present contribution will certainly animate the discussion about the best way to arrive at a generally agreed lithostratigraphic nomenclature of Switzerland.*

*J. Remane*

ABSTRACT

This paper gives an overview of the names in alphabetic order and the type localities or reference sections of 50 lithostratigraphic units that were studied by the author in his detailed paper about the Late Jurassic in northern Switzerland (Gygi 2000b). 29 of these names were published after 1961, the date of publication of the Lexique stratigraphique international, Europe, fascicule 7a: Jura et fossé du Rhin, by Waibel & Burri. Each unit is briefly characterized by its lithology, thickness, biochronological age and the geographical range.

ZUSAMMENFASSUNG

Die vorliegende Arbeit gibt einen Überblick über die Namen in alphabetischer Reihenfolge und die Typlokalitäten beziehungsweise Referenzprofile der lithostratigraphischen Einheiten, welche der Autor in seiner detaillierten Arbeit über den Späten Jura der Nordschweiz untersucht hat (Gygi 2000b). 29 dieser Namen wurden nach 1961 publiziert, dem Erscheinungsdatum des Lexique stratigraphique international, Europe, fascicule 7a: Jura et fossé du Rhin, von Waibel & Burri. Jede Einheit wird kurz charakterisiert durch die Lithologie, Mächtigkeit, das biochronologische Alter und die geographische Verbreitung.

RESUME

Cette note donne une vue d'ensemble par ordre alphabétique des noms des unités lithostratigraphiques qui ont été étudiées par l'auteur dans son travail détaillé sur le Jurasssique supérieur de la Suisse septentrionale (Gygi 2000b). Parmi ces noms, 29 ont été publiés après 1961, année de publication du Lexique stratigraphique international, Europe, fascicule 7a: Jura et fossé du Rhin, par Waibel & Burri. Chaque unité est caractérisée brièvement par sa lithologie, son épaisseur, son âge biochronologique et sa répartition géographique.

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## 1. Introduction

Only 16 of the lithostratigraphic names that are used here are mentioned in the Lexique stratigraphique international, Europe, fascicule 7a: Jura et fossé du Rhin, by Waibel & Burri (1961). 29 names, the majority, were published after 1961 and are dispersed in the literature. The type localities of many lithostratigraphic units have often not been specified or were indicated vaguely. It is the purpose of this paper to give exact type localities or reference sections of all the lithostratigraphical units that were studied by the author since 1962. As far as possible natural outcrops, which will probably also be accessible in the future, were selected as type localities or reference sections. Sections measured by the author are preceded by RG and are all listed in table 1 by Gygi (2000b). Locality names and coordinates were read from the National Map of Switzerland (Landeskarte, abbreviated with LK) at the scale of 1:25.000. The name and number of the map sheets cited here refer to the LK maps at the scale of 1:25.000.

## 2. Lithostratigraphic units with type localities and reference sections

### 2.1 **Baden Member** (Moesch 1867)

Member of an unnamed formation

The Baden Member was named by Moesch (1867, p. 178) Badenerschichten. The name is derived from the city of Baden, Canton Aargau, northern Switzerland. Moesch did not specify a type locality. There is at present no complete outcrop of the member at Baden. The lower part of the member was measured at Baden by Gygi (1969, p. 17, section RG 47), coordinates 664.930/258.100 (LK 1070 Baden). The member consists there of thin beds of glauconitic and marly micritic limestone with siliceous sponges. Intercalated are beds of glauconitic marl. The most abundant macrofossils are siliceous sponges and ammonites. A complete natural outcrop of the member was in 1961 100 m west of the ruin of Besserstein at Villigen, Canton Aargau, coordinates 658.100/264.010 (LK 1070 Baden) along a footpath. Slight cleaning with a pickaxe would be necessary in order to see the section today. The member has there a total thickness of 1.80 m and consists of two parts. Below is a micritic, marly limestone with glauconite, siliceous sponges and abundant ammonites. This massive bed is 1 m thick and is ovelain by 0.8 m of brownish gray marl without glauconite and macrofossils. This outcrop is in the upper part of section RG 62 in Gygi (1969, Pl. 17) that is designated here as the reference section of the Baden Member. The member could be biochronologically dated in the large quarry of Mellikon, Canton Aargau (section RG 70 in Gygi 1969, Pl. 17, beds 120–125). The ammonite *Sutneria platynota* (Reinecke) occurs at the base of the member and *Idoceras balderum* (Oppel) at the top of bed 124 and in the lowermost Wettingen Member above. The biochronological age of the Baden Member thus ranges from the beginning of the Platynota Chron to the early Divisum Chron (see Gygi 2000b, Fig. 40, refigured as Fig. 2 in this paper).

The typical condensed and glauconitic facies with siliceous sponges of the Baden Member occurs in the area between the Rhine river in the north, the western part of Mt. Lägeren east of Baden in the east and Mt. Chestenberg near Möriken, Canton Aargau, in the west. The member grades to the northeast in the Klettgau valley into the Schwarzbach Formation and to the west (from west of Aarau) into the Reuchenette Formation.

### 2.2 **Balsthal Formation** (Gygi 1969)

Synonymy: Gygi (2000b, p. 61)

The Balsthal Formation was named by Gygi (1969, p. 83). The name refers to the village of Balsthal, Canton Solothurn. The type locality is section RG 9 of Gygi (1969) which is equivalent to the revised section RG 438 in Gygi (2000b, Pl. 44) in the gorge of the Steinebach creek north of Balsthal, west of Mt. Holzflue (see Fig. 4 in Gygi 1969). The coordinates are 619.370/241.350, LK 1107 Balsthal. The lithology of the Balsthal Formation is mostly a carbonate oolite, locally with varying admixtures of oncoids. The mean thickness of the Balsthal Formation is about 70 m. The formation locally includes coral bioherms in the platform interior (Gygi & Persoz 1986, Pl. 1A, see also Gygi 2000b, p. 63). Ammonites are very rare (Gygi 1995, Fig. 2 and 20).

The upper boundary of the Balsthal Formation is mappable in a large part of northwestern Switzerland. Earlier mapping geologists interpreted it to be the boundary between their "Séquanien" and "Kimméridgien" that meant lithostratigraphical units. This boundary is well visible on the cover and in text-figure 38 of the book by Gygi (2000b). To the east, the boundary can be traced to Mt. Rüttelhorn, 2 km northwest of the village of Farnern, Canton Bern, LK 1107 Balsthal. In section RG 440 in the gully east of the summit of Mt. Rüttelhorn, which is on the territory of the village Rumisberg BE, this boundary is conspicuous (Pl. 43 in Gygi 2000b, between beds no. 14 and 15). About 3 m above the boundary is a stromatolite at the base of bed 20. Gygi (2000b, plate 43) interpreted the stromatolite to be sequence boundary K 1 of Gygi et al. (1998), in analogy to section RG 307 near Péry (Gygi 2000b, Pl. 22).

About 7 km to the east-northeast of Mt. Rüttelhorn is the western cliff of Chluser Roggen below point 702. This is section RG 450 which is figured in Gygi (2000b, text-fig. 37) and is located at Balsthal at coordinates 619.710/239.380, LK 1107 Balsthal. Bed no. 7 of the section, which is 12 m below the top of the cliff, is a breccia 0.6 m thick that weathers back as a conspicuous notch. The components of the breccia are saccharoidal, entirely dedolomitized limestone fragments with some fine-grained, angular detrital quartz (thin-section Gy 7433). The notch formed by the breccia is clearly visible as an uneven line in Gygi (2000b, Fig. 37). The breccia is interpreted to be a palaeosol labelled with "Pal" in the figure. The palaeosol has a relief of more than

1 m at this locality and was also found in the road tunnel in Steinebach gorge north of Balsthal (section RG 438, Pl. 44 in Gygi 2000b). This is bed 52 of the section and is probably eqivalent to sequence boundary K 1 of Gygi et al. (1998).

The mappable boundary between the massive upper Balsthal Formation and the well-bedded lower Reuchenette Formation that is conspicuous in northwestern Switzerland cannot be discerned in the type section RG 438 of the Balsthal Formation at Balsthal. To conclude of section RG 440 east of Mt. Rüttelhorn, the formation boundary in section RG 438 at Balsthal must be below sequence boundary K 1. According to Gygi & Persoz (1986, table 2 and Pl. 1), the boundary between the Balsthal and Reuchenette Formations coincides in northwestern Switzerland with the boundary between the Planula and the Platynota Zones. This is confirmed by the ammonite J 30530 *Lithacosphinctes evolutus* (Quenstedt) in the Museum of Natural History Basel that was found by B. Martin and P. Tschumi ca. 3.5 m below the palaeosol in section RG 439 (unpublished) on the western bank of Dünnern river at Innere Klus, 1 km southwest of Balsthal. F. Atrops (Lyon) identified a cast of the specimen and assigned it to the earliest Platynota Chron. The ammonite is figured in Gygi (1995, Fig. 19). It is because of the ammonite J 30530 that Gygi (2000b, Pl. 44) drew the boundary between the Balsthal and Reuchenette Formations arbitrarily at the top of bed 49 of section RG 438. This is inappropriate, because this boundary is based on biostratigraphy instead of lithostratigraphy and is not mappable. Therefore it is proposed here that the palaeosol be the upper boundary of the Balsthal Formation in the area around Balsthal even though the palaeosol is younger than the mappable formation boundary in northwestern Switzerland.

Gygi (2000b, p. 60) separated the Günsberg Formation from the Balsthal Formation. The two formations so defined cannot be separated satisfactorily in the southernmost range of the Jura mountains between Mt. Hasenmatt and Mt. Weissenstein. But the Balsthal Formation as defined by Gygi (2000b) becomes the time equivalent of the Villigen Formation in Canton Aargau. The Villigen Formation could be dated biochronologically with ammonites (Gygi & Persoz 1986, Pl. 1) as the later part of the Bimammatum Chron and the Planula Chron. The age of the Balsthal Formation could be established only by correlation with clay minerals (Gygi & Persoz 1986, plate 1A) and sequence stratigraphy (Gygi et al., 1998) with the Villigen Formation. The geographical range of the Balsthal Formation is from Olten, Canton Solothurn, in the east to beyond Péry, Canton Bern, in the west. The boundary of the Balsthal Formation with the Courgenay Formation in the northwest is transitional and is drawn where the ooid content of the rock drops to zero near St-Ursanne, Canton Jura (Fig. 1).

### 2.3 **Banné Member** (Marcou 1848)
Member of the Reuchenette Formation

This member was first distinguished by Marcou (1848, p. 104) and called: "Marnes (= marl) kimméridiennes ou du Banné". On page 105 he also wrote about "Calcaires (= limestones) kimméridiens ou du Banné" overlying his Marnes du Banné. The term Calcaires du Banné was fortunately ignored by subsequent authors and can be rated to be forgotten. Later the Banné Member as it is known today was called Pterocera marl by several mapping geologlists as for instance Schneider (1960, p. 10). The Banné Member is named after the hill called Le Banné 1 km south of Porrentruy, Canton Jura, LK 1085 St-Ursanne. A thin veneer of the lowest part of the Banné Member covers the almost flat top of the hill, and bivalves and gastropods that are characteristic of the member can be collected there from the fields.

No outcrop of the member exists at this time on Le Banné hill that is to be considered as type locality. A large and complete outcrop of the member is at present in the quarry at the locality called L'Alombre aux Vaches 2 km southwest of Courgenay, Canton Jura, LK 1085 St-Ursanne. This is the unpublished section RG 341 at coordinates 574.800/248.200 that is here designated as the reference section of the member. The unit is there a yellowish marl with a thickness of 5.2 m. The marl is relatively rich in carbonate in the middle. It contains in the lower part a profusion of bivalves and numerous gastropods and brachiopods. The member could be dated biochronologically at this locality by the ammonite *Aspidoceras* cf. *acanthicum* (Oppel) MNHB J 30714 found by A. and H. Zbinden and figured by Gygi (1995, Fig. 17/4). The age of the member is the Acanthicum Chron. The Banné Member occurs around Porrentruy and to the south to Glovelier, Canton Jura. Further south the member grades into unfossiliferous limestone of the Reuchenette Formation.

### 2.4 **Bärschwil Formation** (Gygi & Marchand 1993)
Synonymy: Gygi (2000b, p. 52)

Gygi & Marchand (1993, page 998) combined the marly units Renggeri Member, Terrain à chailles Member (now Sornetan Member, see Gygi 2000b) and Liesberg Member in the Bärschwil Formation. The name refers to the village of Bärschwil, Canton Solothurn, LK 1087 Passwang. The type locality is the unnamed landslide 300 m west of the farm Vögeli at Bärschwil on LK 1086 Delémont that was called Fringeli by older authors. This is section RG 399 at coordinates 601.490/246.780 that is represented as plate 34 in Gygi (2000b).

The lower boundary of the formation is transitional and is drawn where the iron ooid content of the underlying Herznach Formation (Gygi 2000b, p. 51) drops to zero. The Renggeri Member, the lowermost member of the Bärschwil Formation, is a homogenous gray marl-clay about 55 m thick. The Sornetan Member in the middle is a gray marl with ellipsoidal carbonate nodules, ammonites and bivalves, about 45 m thick. The overlying Liesberg Member is a gray marl with irregularly formed carbonate concretions and very abundant, mainly platy hermatypic corals and a thickness of 10–25 m. The upper boundary of the formation is as well a transition. It is defined to be where the overlying limestones of the St-Ursanne For-

mation begin to form a cliff, ridge or steep slope. The lower boundary of the Bärschwil Formation is within the Scarburgense Subzone of the Mariae Zone and the upper boundary within the Antecedens Subzone of the Transversarium Zone. The boundaries are dated with ammonites (Gygi 1990a, 1995). The geographic range of the Formation is in northwestern Switzerland (Gygi 1990c, Fig. 2–4). The formation has a thickness of more than 100 m in northwestern Switzerland and thins out to decimeters or even centimeters in the southeast (Gygi & Persoz 1986, table 1).

2.5 **Birmenstorf Member** (Moesch 1863)
Member of the Wildegg Formation

The name Birmenstorf Member was first plublished by Moesch (1863, p. 160). He named it "Birmensdorferschichten" after the village that was then named Birmensdorf, Canton Aargau. The name of this village is today spelled Birmenstorf (LK 1070 Baden) in order to distinguish it from Birmensdorf, Canton Zürich, only 18 km to the southeast. The type locality of the member is the vineyard called Nettel northeast of Birmenstorf that was mapped by Gygi (1977, Fig. 2). Apparently there was never an outcrop of the Birmenstorf Member at or near the type locality. Gygi (1969, p. 64) therefore proposed the natural outcrop of section RG 60 in the Eisengraben cleft north of Neumatt near Gansingen, Canton Aargau (LK 1069 Frick) to be the reference section of the Birmenstorf Member. The coordinates of section RG 60 are 651.560/264.080.

The Birmenstorf Member is a succession of micritic limestones, marly limestones and marl (Gygi 2000a, Fig. 2). Siliceous sponges are very abundant and are associated with ammonites. The mean thickness of the member is about 5 m. The base is defined by a condensed bed with a thickness of less than 10 cm that often contains chamositic iron ooids. This is a regional marker bed. The upper boundary of the member is difficult to define (Gygi 1969, p. 66). The age of the Birmenstorf Member is by definition of the Transversarium Zone by Oppel & Waagen (1866) the Transversarium Chron as it was redefined by Gygi (2000a). The age of the member was established biochronologically with a rich assemblage of ammonites (Gygi 1977, Gygi & Marchand 1982). The Birmenstorf Member can be followed from Mt. Weissenstein north of Solothurn to the east of Baden, Canton Aargau, and to Dangstetten in southern Germany northeast of Zurzach (Gygi 1990c, Fig. 5). The member is the basinal time equivalent of the upper Sornetan Member, the Liesberg Member and of the St-Ursanne Formation (Gygi & Persoz 1986, table 2). The Birmenstorf Member grades to the northeast into the Mumienmergel Bed, the Mumienkalk Bed and into a thin, glauconitic marl at the base of the Effingen Member in the Klettgau valley and the Randen hills in Canton Schaffhausen (Gygi 2000b, Fig. 40).

2.6 **Buix Member** (Gygi 2000b). Previously "Kreide von St. Ursanne". Member of the St-Ursanne Formation
Synonymy: Gygi (2000b, p. 56)

The Buix Member was renamed by Gygi (2000b, p. 56). It is named after the village of Buix north of Porrentruy in Canton Jura (LK 1065 Bonfol) where it crops out in the quarry of Les Creppes (unpublished section RG 347) where it is easily accessible. However, the base of the member is not visible in that quarry. A complete outcrop of the member is in the quarry of the former lime works near the railway station of St-Ursanne, Canton Jura. This section has been studied in detail by Pümpin (1965, Pl. 1, section 2). Gygi (2000b, p. 56) proposed beds 8–10 in Pümpin's section to be the reference section of the Buix Member. A schematic version of this section was later published by Gygi (1982, Fig. 4). This is section RG 336 at coordinates 579.200/246.370, LK 1085, St-Ursanne.

The Buix Member is a massive, yellowish-white to pure white, more or less porous and friable limestone which was compared with chalk by Ziegler (1962). Coral bioherms occur in this unit near Leymen, France, Flüh, Canton Solothurn, and Delémont, St-Ursanne and Buix, Canton Jura. Locally, the limestone was slightly dolomitic, but the euhedral dolomite crystals have been dissolved and left empty pores as in the unpublished section RG 344, beds 3 and 8 near Courtemaîche, Canton Jura. In this case, the rock weathers in perpendicular rods as was observed by Liniger (1970, p. 7). Large chert nodules occur in the upper Buix Member in the sections RG 343 and 344 at Courtemaîche. The mean thickness of the member is about 35 m. The age was established biochronologically with ammonites by Gygi (1995, Fig. 2) that were found by V. Pümpin at St-Ursanne near the boundary between the Antecedens and the Luciaeformis Subzones in the Transversarium Zone. The Buix Member occurs in the Ajoie region in the northern part of Canton Jura and near Liesberg, Canton Baselland. It is the lagoonal facies of the upper St-Ursanne Formation (Fig. 1).

2.7 **Bure Member** (Gygi 1995). Previously "Humeralis-Mergel"). Member of the Vellerat Formation
Synonymy: Gygi (2000b, page 59)

The Bure Member was renamed by Gygi (1995, p. 11 and Fig. 2). The name is derived from the village of Bure northwest of Porrentruy in Canton Jura (LK 1064 Montbéliard). Outcrops of this marly member are always artificial and temporary. A complete section of the member was provided by the exploration well BUR 2 for the Transjurane superhighway. The well was measured and published by Gygi (2000b, Pl. 16) as section RG 454 at coordinates 567.649/254.670, LK 1065 Bonfol. This is the type section.

The Bure Member is mainly a soft grey marl, but in some places like the type locality there are thin intercalations of limestone. The thickness is almost exactly 10 m at the type locality. The member contains neither ammonites (Gygi 1995,

Fig. 2) nor dinoflagellates (Ghasemi et al., 1999). It could only be dated by correlations with clay minerals (Gygi & Persoz 1986, Pl. 1A, correlation I) and sequence stratigraphy (Gygi et al. 1998, Fig. 2, sequence boundary O 7 ). The geographical range of the Bure Member externds over the northern Canton Jura (Ajoie region) and adjacent southern Alsace (France), see Fischer (1965, p. 19 and 58/59) and to the south to Glovelier, Canton Jura. Further south and to the east the member grades into the Oolithe rousse Member and ultimately into the Crenularis Member that can be dated with ammonites at the Bimammatum Subchron.

2.8 **Courgenay Formation** (Gygi 1995). Previously: "Humeralis-Kalke"
Synonymy: Gygi (2000b, p. 60)

Gygi (1995, p. 12) proposed the Courgenay Formation for the lagoonal limestones between the marly Vellerat Formation below and the Reuchenette Formation above. The name refers to the village of Courgenay in the southern Ajoie region of Canton Jura. The type section is RG 350 along the road called Chemin Paulin (name not indicated on the map) 4 km southwest of the village at coordinates 573.790/247.100, LK 1085 St-Ursanne. The section is represented as plate 19 in Gygi (2000b).

The Courgenay Formation has two members. The La May Member below is a well-bedded micritic limestone with a thickness of 31 m in the section RG 350 at Chemin Paulin. Above follows the Porrentruy Member, an almost pure white, massive micritic limestone which is 13 m thick in the reference section that is RG 350. No ammonites were found to date in the Courgenay Formation. It is only with clay minerals that it can be shown that the Porrentruy Member is coeval with the Letzi Member in Canton Aargau (correlation K by Gygi & Persoz 1986, Pl. 1A). The Letzi Member can be dated with ammonites as earliest Kimmeridgian. The Courgenay Formation grades distally, between St-Ursanne and Glovelier, Canton Jura, into the oolitic Balsthal Formation that includes the "Court Formation" of Bolliger & Burri (1970, p. 73). Gygi (2000b, p. 61) showed that the Court Formation is a junior synonym of the Balsthal Formation and is therefore a superfluous term.

2.9 **Crenularis Member** (Moesch 1863). Member of the Villigen Formation

Moesch (1863, p. 157) named the Crenularis Member (Crenularisschichten) that became well-known because of the geological maps by Mühlberg. The name is derived from the echinoid *Hemicidaris crenularis* (Lamarck) that rarely occurs in the member. Moesch (1863 and 1867) did not indicate a type locality. Gygi (1969, p. 69) declared his section RG 62 along the road from Villigen to Mt. Geissberg, Canton Aargau, to be the type locality of the member. The road there crosses the well-exposed Crenularis Member at the elevation of about 510 m at coordinates 657.890/264.040, LK 1070 Baden. This section is however unfavorable as a type section, because the outcrops along the road are discontinuous. The continuous section RG 62 was assembled from five partial sections that were measured on both sides of the short valley through which the road runs. The locations of the partial sections are indicated in Gygi (1969, p. 61–62). A good and complete outcrop of the typical Crenularis Member is at present accessible in the upper part of the large quarry west of Gabenchopf 2 km westnorthwest of Villigen (LK 1070 Baden). This quarry can serve as reference section.

The Crenularis Member is a biomicritic limestone with uneven bedding planes and a knobby weathering. According to Gygi (1969, Pl. 19), the mean thickness of the member is 3 m. It contains siliceous sponges and abundant bivalves, mainly of the genus *Pholadomya*. Ammonites are rather rare, but the mineral glauconite is always present. The member is dated biochronologically by the ammonite *Epipeltoceras* cf. *bimammatum* (Quenstedt) J 31726 in the Museum of Natural History Basel that was found by Moesch and figured by Gygi (2000b, Pl. 10, Fig. 5). The ammonite is from bed 31 in the unpublished section RG 36 of Fahr quarry at Auenstein, Canton Aargau, LK 1089 Aarau. It documents the early Bimammatum Subchron. The Crenularis Member can be followed from Oftringen, Canton Aargau in the west to east of Burghorn on Mt. Lägeren east of Baden, Canton Aargau (Gygi 1969, p. 70). In the tabular Jura of Canton Aargau it extends to Baldingen. The thickness of the member greatly increases to 17 m near Mellikon, Canton Aargau (Gygi 1969, Pl. 17 and 19) because of the growth of sponge bioherms. This is an atypical local facies which is transitional to the Hornbuck Member in the Klettgau valley. In the proximal direction (to the west), the Crenularis Member can be traced into the lowermost Olten Member of Gygi (1969) that was also called Crenularis Member by Moesch (1867, p. 150).

2.10 **Delémont Member** (Gygi 2000b)
Member of the St-Ursanne Formation
Synonymy: Gygi (2000b, p. 55)

The Delémont Member of the lower St-Ursanne Formation was renamed by Gygi (2000b, p. 55). The name refers to Delémont, the capital of Canton Jura (LK 1086 Delémont), where the member crops out along the road northwest of Vorbourg chapel in section RG 366 (see plate 23 in Gygi, 2000b, beds 1–9). Gygi (2000b, p. 56) selected as reference section of the member RG 306, beds 107–110, in the quarry of Chestel at Liesberg, Canton Baselland, at coordinates 599.690/249.570, LK 1086 Delémont.

The Delémont Member forms a 4–8 km wide belt within the lower St-Ursanne Formation. This belt runs from Ocourt on the Doubs river to St-Ursanne, Canton Jura, Delémont, and Liesberg, Dittingen and Blauen in Canton Baselland. The member is made up mainly by carbonate oolite and is 24 m thick in the reference section. There are hermatypic corals and oncoids at the base. Northeast of St-Ursanne the oncoids be-

come so concentrated that they form an oncolite. This local facies was called Caquerelle pisolite by Ziegler (1962, p. 18). This must be distinguished from the Couches de la Caquerelle of Rollier (1892, p. 282), a synonym of the Buix Member (see above). The Caquerelle oncolite was figured by Pümpin (1965, Fig. 6 and 7). At present the oncolite is well exposed in the unpublished section RG 338 at the locality Côte du Frêne near Asuel, Canton Jura, LK 1085 St-Ursanne, at coordinates 581.950/247.990 along a forest road 400 m southwest of Les Malettes. The Delémont Member grades to the northwest and to the southeast into biomicritic limestone with hermatypic corals and coral bioherms, the Grellingen Member. No ammonites were found in the Delémont Member. There are ammonites of the early Antecedens Subchron in the upper Sornetan Member below and ammonites from the boundary between the Antecedens and Luciaeformis Subchron in the Buix Member above (Gygi, 1995, Fig. 2). The age of the Delémont Member can therefore be assigned to the Antecedens Subchron.

2.11 **Effingen Member** (Moesch 1857)
Member of the Wildegg Formation

The Effingen Member (Effingerschichten) was named by Moesch (1857, p. 55). The name refers to the village of Effingen, Canton Aargau, LK 1069 Frick. Moesch (1867, p. 143) wrote that the best outcrops of the member were on the hill called Ruge north of Effingen. This hill is then the type locality of the Effingen Member although there are no outcrops at present. A reference section must then be found. A complete section of the Effingen Member was published by Gygi (1969, Pl. 17, section RG 37) at coordinates 653.900/252.400 in the quarry of Jakobsberg, 1 km east of Auenstein, Canton Aargau, LK 1089 Aarau. At that time, the lower part of the Effingen Member was only known from a borehole drilled on Gerstenhübel hill (not indicated in LK 1089 Aarau) in the township of Veltheim east of Jakobsberg quarry. This part of the section is now well exposed in a road cut between the quarries of Jakobsberg (township of Auenstein) and Unteregg (township of Veltheim, Canton Aargau). This is section RG 226 that was published by Gygi (1973, Fig. 3). The upper part of section RG 226 and section RG 37 are now the reference sections of the Effingen Member.

The Effingen Member is mostly a blue-gray marl with intercalated successions of marly limestones or pure limestones, respectively. The thickest limestone succession is that of the Gerstenhübel Beds (see below) in the lower Effingen Member. In the upper part of the Effingen Member there are often thin layers of sandy limestone or dolomite that are partly small turbidites (Gygi 1969, Pl. 4, Fig. 12) and partly tempestites (Gygi 1986, Fig. 7). The greatest thickness of the Effingen Member is about 260 m near Riniken, Canton Aargau (Gygi 1990c, Fig. 6). Ammonites are rare, but the age of the member could be established to be of the Bifurcatus Chron by *Larcheria* cf. *schilli* (Oppel) J 23539 and by *Dichotomoceras* cf. *bifurcatus* (Quenstedt) J 23543. The *Euaspidoceras hypselum* (Oppel) J 27259 from the upper Effingen Member indicates that sedimentation of the Effingen Member ended in the early Bimammatum Chron. All these ammonites were figured by Gygi (2000b) and are kept in the Museum of Natural History Basel. The Effingen Member can be followed (with different names) from the French Jura through Switzerland to the Swabian Alb in southern Germany.

2.12 **Geissberg Member** (Moesch 1867)
Member of the Villigen Formation

The Geissberg lithostratigraphical unit (Geissbergschichten) was named by Moesch (1857, p. 57) and then encompassed all the limestone members included in the Villigen Formation *sensu* Gygi & Persoz (1986, p. 407) between the Effingen Member below and the Baden Member above. Moesch (1867, p. 145) restricted the unit to the rank of what is today a member and conceived it as the thickly bedded micritic limestones between the marly Effingen Member below and the glauconitic Crenularis Member above. According to Moesch (1857, p. 57), the cliff above the southern slope at the western end of Mt. Geissberg west of Villigen, Canton Aargau, must be considered to be the type locality of what is at present the Geissberg Member. This cliff is now called Chamerenfelsen and is located at coordinates 655.000/264.400, LK 1069 Frick.

The thickness of the Geissberg Member at Mt. Geissberg near Villigen in the large quarry on the north slope of Mt. Geissberg, west of Gabenchopf near Villigen, is between 15 and 20 m. This quarry (coordinates ca. 656.650/265.050, LK 1070 Baden) is now considered to be the reference section of the Geissberg Member. An entire section of the member is also in the natural outcrop of the gully south of the part of the village Villigen called Ob Chilen. This is section RG 63 that is schematically represented in Gygi (1969, Pl. 19). The great thickness of the Geissberg Member near Baden (Gygi 1969, Pl. 19) is exceptional. The macrofossils of the Geissberg Member are mostly bivalves, but large ammonites of the genus *Lithacosphinctes* occur too (Mühlberg, 1908, p. 43). The Geissberg Member is delimited in the west by the Olten Member. In the northeast it grades into the lower Hornbuck Member (Fig. 1).

2.13 **Gerstenhübel Beds** (Gygi 1969). Thick limestone succession within the Effingen Member of the Wildegg Formation

The Gerstenhübel Beds (Gerstenhübel-Schicht) were named by Gygi (1969, p. 66). The type locality is the hill called Gerstenhübel (coordinates 654.100/252.500) 2 km south-southeast of Veltheim, Canton Aargau, LK 1089, Aarau, where the unit was quarried for some time. The names Veltheim and Gerstenhübel are not indicated on the map LK 1089, Aarau. The Gerstenhübel Beds are the succession no. 37 in section RG 37 of Gygi (1969, Pl. 17). This is the type section.

The Gerstenhübel Beds are a well-bedded succession of

micritic limestone layers (Gygi 2000b, Fig. 8). The individual layers are 10–30 cm thick. One of these layers is a submarine debris flow deposit at the type locality. This and the occurrence of coccoliths in the type section (Gygi 1969, Fig. 1) are an indication that the Gerstenhübel Beds were laid down in relatively deep water. The Gerstenhübel Beds are 13.4 m thick in the type section (Gygi 1973, Fig. 3). There, the lower boundary is transitional and is drawn where the marly intercalations between the limestone layers become less than a few centimeters thick. J. Haller and R. Trümpy found an *Amoeboceras* cf. *serratum* (Sowerby) in the Gerstenhübel Beds in the quarry of Steinacher 600 m north of Mönthal, Canton Aargau, LK 1069 Frick. This specimen was first figured by Atrops et al. (1993, Pl. 1, Fig. 6) and was refigured by Gygi (2000b, Pl. 8, Fig. 4). Its age is probably the late Bifurcatus Chron. The Gerstenhübel Beds are a unit mappable at the scale of 1:25.000 in Canton Aargau between Erlinsbach and Brunegg and to Mt. Geissberg near Villigen. To conclude of mineral stratigraphy (Gygi & Persoz 1986, Pl. 1A), its time equivalent in the shallow water facies might be a thin but prominent oolitic intercalation in the middle of the Röschenz Member (Fig. 1). The correlation of the Gerstenhübel Beds east of Brunegg and Villigen is uncertain. The Gerstenhübel Beds are a morphologically prominent, mappable limestone intercalation in the mostly marly Effingen Member.

2.14 **Glaukonitsandmergel Bed** (Zeiss 1955). Marker Bed of an unnamed formation

The Glaukonitsandmergel Bed was named by Zeiss (1955, p. 257). The author stated that the type area of the bed was the region of Blumberg, southern Germany (LK 1011 Beggingen). A type locality was not indicated by Zeiss, but it is probable that he measured the thickness of 2.4 m given in his figure 30 in the opencut iron mine at the south slope of Stoberg hill west of Kuristobel (see caption to figure 31 in Zeiss 1955). This pit was later filled up. The closest natural outcrop of the Glaukonitsandmergel Bed is now on the western slope of Mt. Eichberg, 2 km northwest of Blumberg in a landslide called Bleiche at coordinates 680.230/300.430. The unit is there 2.25 m thick. These are beds 22–26 of section RG 87 in Gygi (1969, Pl. 16). It is proposed here to designate section RG 87 at Achdorf, southern Germany, as type section of the Glaukonitsandmergel Bed.

The bed is at the locality Bleiche a dark gray marl-clay with mica and quartz sand mainly in the lower half and much glauconite in the upper part. Zeiss (1955) dated the unit with cardioceratid ammonites at the late Mariae and Cordatum Chrons. Further south, in Canton Schaffhausen, the unit is only 10–15 cm thick in several sections as figured by Gygi (1977, Pl. 11) and there represents only the Cordatum Subchron that was documented by cardioceratids as figured by Gygi & Marchand (1982). The Glaukonitsandmergel Bed was found as far to the southwest as the NAGRA borehole near Weiach, Canton Zürich (Matter et al. 1988, p. 44). Further to the southwest the bed grades into the Schellenbrücke Bed (Gygi 1977, p. 454).

2.15 **Grellingen Member** (Gygi 2000b)
Member of the St-Ursanne Formation

The Grellingen Member was named by Gygi (2000b, p. 55) after the village of Grellingen, Canton Baselland, LK 1067 Arlesheim. Gygi did not indicate a type locality. The best, easily accessible natural outcrop is along the footpath that circumvents the small waterfall of an unnamed creek above Eigenhollen at coordinates 613.000/253.700 on the territory of the village of Duggingen, Canton Baselland, LK 1087 Passwang. The Grellingen Member there forms a vertical cliff with an overhang at the base. This is proposed to be the type locality.

The Grellingen Member is normally a massive limestone forming cliffs and has a biomicritic or bioarenitic matrix with hermatypic corals. It is a coral biostrome. Coral bioherms are uncommon, but they do occur (Gygi 2000b). The average thickness of the member is about 30 m. The lower boundary with the marly Liesberg Member is at many localities transitional. The upper boundary with the oolitic Tiergarten Member or the porous, chalk-like Buix Member, respectively, is well-defined. No ammonites have yet been found in the Grellingen Member. Ammonites of the Antecedens Subchron occur below in the Sornetan Member (Duong 1974, Pl. 3, Fig. 1, refigured by Gygi 1995, Fig. 25) and above in the Buix Member (Gygi 1995, Fig. 14). The age of the Grellingen Member is thus a fraction of the Antecedens Subchron. The Grellingen Member forms the lower part of the St-Ursanne Formation everywhere in northwestern Switzerland where the formation occurs, except for a relatively narrow strip where the lower St-Ursanne Formation is oolitic/oncolitic (Delémont Member). The correlation of the Grellingen Member can be read from figure 1.

2.16 **Günsberg Formation** (Gygi 2000b). Previously Günsberg Member (Gygi & Persoz 1986)
Synonymy: Gygi (2000b, p. 59)

Gygi (1969, p. 83) named the beds no. 128–189 in section RG 14 at Günsberg, Canton Solothurn, Günsberg Member and regarded the member to be a part of the Balsthal Formation. He designated section RG 14 in the landslide called Gschlief to be the type section of the member (coordinates 609.500/235.550, LK 1107 Balsthal). This happens to be near the lateral transition of the member into the upper Effingen Member (Gygi & Persoz 1986, p. 402). Gygi & Persoz (1986) revised the Günsberg Member by excluding the Steinebach Member from it, but they again considered the revised Günsberg Member to be part of the Balsthal Formation, because the Günsberg Member cannot easily be separated from the Balsthal Formation in the southernmost Jura fold between Mt. Hasenmatt and Mt. Weissenstein in Canton Solothurn.

Nevertheless, Gygi (2000b, p. 60) advocated to exclude the Günsberg Member from the Balsthal Formation and to give it

the rank of a formation on its own. The reason was that the Günsberg Formation as defined this way encompasses the narrow carbonate platform between the lagoonal Vorbourg and Röschenz Members in the proximal direction and the basinal Effingen Member in the distal direction (Fig. 1). The bulk of the Günsberg Formation is a carbonate oolite with coral bioherms at the base and at the distal margin. No subdivision into members is recommended, because coral bioherms and coral biostromes (like the biostrome of the "Moutier Korallenkalk" of Bolliger & Burri 1970 in section RG 381 published by Gygi 2000b, plate 28, in the Gorges de Court near Moutier, Canton Bern, LK 1106 Moutier) can also occur within the formation.

The best section of the Günsberg Formation is at the present time in the quarry of La Charuque south of Péry, Canton Bern, LK 1126 Büren a. A. This is section RG 307 in Gygi (2000b, Pl. 22). There is some uncertainty in this section about the delimitation of the Günsberg Formation at the top. Gygi & Persoz (1986, Fig. 10, section "Reuchenette") assigned the limestone succession with oncoids of beds no. 197–202 in section RG 307 to the Hauptmumienbank Member because of the erosion-resistant, pure limestone lithology and the elevated kaolinite content.

Gygi et al. (1998, Fig. 6A) regarded the oolite with inclined bedding of beds no. 193–195 in the Péry section RG 307 to be the Steinebach Member which is the distal time equivalent of the Hauptmumienbank Member. The reason was that there is a paraconformity with a hummocky limonite crust at the top of the oolitic bed 195, whereas no such paraconformity can be discerned at the top of the oncolitic bed 202 above. Gygi et al. (1998, Fig. 6A) interpreted the paraconformity at the top of bed 195 as sequence boundary O 7 which is normally situated at the top of their Hauptmumienbank/Steinebach/Geissberg Members (Fig. 2 and 3).

The paraconformity at the top of bed 195 of section RG 307 at Péry probably *is* a sequence boundary, but not O 7 as believed by Gygi et al. (1998). The paraconformity above bed 195 at Péry is rather the time equivalent of the erosion surface on top of sand waves of the uppermost Röschenz Member in section RG 441 beside the cantonal road 1.7 km east of Liesberg, Canton Baselland, LK 1086 Delémont, coordinates 600.950/250.440, as figured by Gygi & Persoz (1987, Fig. 2A, in the middle of the figure). This erosion surface was interpreted to be a maximum flooding surface by Gygi et al. (1998, p. 538).

The problem cannot be resolved, because there are no ammonites, neither in the upper Günsberg Formation nor in the Hauptmumienbank Member. But the inclined bedding of the calcarenites below both the erosion surface in section RG 441 near Liesberg and the paraconformity in section RG 307 near Péry is an indication that the calcarenites were deposited during a small transgression and that they are of the same age. "Sequence boundary O 7" of Gygi et al. (1998) at Péry and the erosion surface at Liesberg would then be indeed a sequence boundary older than O 7 that was not recognized by Gygi et al. (1998) or Gygi (2000b, Fig. 40). The small and apparently rapid transgression mentioned above occurred during the Hypselum Subchron (Gygi 1986, Fig. 4) and provided for the increase of water depth above the marginal marine sediments on the platform. This probably eustatic sea level rise caused open marine facies with hermatypic corals and calcarenites to retrograde far into the platform interior (Gygi & Persoz 1986, p. 411 and Pl. 1A).

The Günsberg Formation could be biochronologically dated with ammonites (Gygi 1995, Fig. 2, 11 and 17/2). Its sedimentation began in the Bifurcatus Chron and ended in the Hypselum Subchron. The Günsberg Formation occurs on a relatively narrow strip 8-15 km wide that runs from Péry to Hochwald in Canton Solothurn (south-southeast of Basel). The age and the correlation of this heterochronous formation are represented in figure 2.

In conclusion, it is most likely that the pure, erosion-resistant limestone succession of beds 197–202 in section RG 307 at Péry is a marginal facies of the Hauptmumienbank Member, as Gygi & Persoz (1986, Fig. 10 "Reuchenette") have indicated. This has to be born in mind when looking at figure 1 that is refigured without changes from Gygi 2000b).

### 2.17 **Hauptmumienbank Member** (Ziegler 1956)

Member of the Vellerat Formation

Synonymy: Gygi (2000b, p. 59)

The name "Hauptmumienbank" was introduced by Ziegler (1956, p. 42). It means main mummy bed. Steinmann (1880, p. 152) called an oncoid a mummy when the core is a recognizeable macrofossil. Gygi & Persoz (1986, p. 400) used the term Hauptmumienbank Member for the whole limestone succession between the marls and marly limestones of the Röschenz Member (Gygi 1995, p. 11) below and the Bure Member (Gygi 1995, p. 11) or Oolithe rousse Member above. Ziegler (1956) did not designate a type section. The best section accessible to the public is now section RG 366 near Vorbourg chapel at Delémont, LK 1086 Delémont. The Hauptmumienbank Member there crops out along the road at coordinates 593.830/247.580. This is section RG 366 in Gygi (2000b, Pl. 23). Beds no. 67–73 of the succession at this locality can be regarded as type section of the Hauptmumienbank Member.

The member in section RG 366 at Delémont is underlain by the marly Röschenz Member and overlain by the Oolithe rousse Member. The thickness of the Hauptmumienbank Member is normally only a few meters, but it may grow to more than 10 m where it grades laterally into the Steinebach Member as in section RG 381 in Court gorge at Moutier BE (Pl. 28 in Gygi 2000b). The beds 39–41 with hermatypic corals of this section ("Moutier Korallenkalk" of Bolliger & Burri 1970, Pl. 16, section 4) must maybe also be assigned to the Hauptmumienbank Member, because they rest on a paraconformity that is possibly a sequence boundary which was not discerned by Gygi et al. (1998) (see Günsberg Member above). The oncoid content is normally greatest near the top of the member. There are no ammonites to date the Hauptmumienbank Member biochronologically. Gygi & Persoz (1986, Pl.

1A) indicated with clay minerals that the oolitic Steinebach Member and the basinal Geissberg Member are time equivalents of the Hauptmumienbank Member. Gygi (1995, Fig. 23) could prove with an ammonite from the upper Geissberg Member at Olten that these three members belong to the later part of the Hypselum Subchron (Gygi 1995, Fig. 2). The great geographic range of the Hauptmumienbank Member can be read from Ziegler (1956, Fig. 12) and Gygi (1990c, Fig. 7).

2.18 **Herznach Formation** (Gygi 2000b)
Synonymy: Gygi (2000b, p. 51)

The name Herznach Formation was proposed by Gygi (2000b, p. 51). The type locality is in the galleries of the now closed iron mine near the village of Herznach, Canton Aargau, LK 1069 Frick. The excellent and detailed section published by Jeannet (1951, Fig. 2) can serve as type section even though it is no more accessible. The Herznach Formation begins in this section with bed A5 and ends with bed F3. Bed F3 is the equivalent of bed 8 in section RG 209 in the Herznach iron mine as published by Gygi (1977, Pl. 11, section 1).

The Herznach Formation is a succession of iron oolites of varying age and has a thickness of 3.4 m in the old part of the iron mine below Hübstel hill at Herznach. 2.4 m of this thickness are made up by the iron oolitic orebody. The thickness of the orebody increases southwest of Wölflinswil, a village 4 km to the west of Herznach, to 6.2 m (Fehlmann & Rickenbach 1962, Pl. 2). The Herznach Formation is therefore a unit which is mappable at the scale of 1:25.000 (see Fehlmann & Rickenbach 1962, Pl. 1). The age of the formation is documented with ammonites to be from the latest part of the early Callovian (Enodatum Subchron, Jeannet 1951) to the Cordatum Subchron of the Cordatum Chron (Gygi & Marchand 1982). The Herznach Formation is several meters thick only in the region of Herznach. To the east it pinches out completely at Veltheim, Canton Aargau, in section RG 226 in Mangold & Gygi (1997, Fig. 2) where a thin iron oolite of the middle Bathonian is overlain by the Birmenstorf Member of the Transversarium Chron, middle Oxfordian. Only in Canton Schaffhausen the formation thickens again and there grows to a thickness of more than 2 m (Fehlmann & Rickenbach 1962, Fig. 12). Iron ore of this formation was mined at Blumberg nearby in southern Germany during World War 2. In northwestern Switzerland the formation is usually only a few decimeters thick and forms a marker bed between the Dalle nacrée Member below and the Renggeri Member above. It has been mined for iron at Erzberg east of Schelten Pass in Canton Solothurn (Fehlmann & Rickenbach 1962, p. 44).

2.19 **Holzflue Member** (Gygi 1969)
Member of the Balsthal Formation
Synonymy: Gygi (2000b, p. 63)

The name Holzflue Member (Holzflue-Schichten) was proposed by Gygi (1969, p. 86) and refers to Mt. Holzflue north of Balsthal, Canton Solothurn, LK 1107 Balsthal. The type section is RG 9 in Gygi (1969, Pl. 18) or the revised section RG 438 on plate 44 in Gygi (2000b), respectively, that was measured at the same locality in the Steinebach gorge. Holzflue Member is a necessary name for the distal part of the Balsthal Formation. In the proximal part, the Laufen Member (Gygi 1995, p. 13) below and the Verena Member above can be distinguished above the Steinebach and Hauptmumienbank Members. At Balsthal and further to the east towards Olten this is impossible as is indicated in figure 1.

The Holzflue Member is 70 m thick at the type locality. Most of it is oolite, but there is a micritic intercalation in the type section: the middle part of bed 44 of section RG 438. The oolite in the upper part of the Holzflue Member is somewhat friable and weathers back as a hollow at Mt. Holzflue and north of the road tunnel in Steinebach gorge. The rock becomes a pure white, porous and very friable oolitic grainstone in the upper part of the quarry of Mösliloch at the western slope of Vorberg west of the village of Egerkingen, Canton Solothurn, LK 1108 Murgenthal. This is the upper part of bed no. 57 in the unpublished section RG 448. In one of the former quarries at the locality called Loch at Wangen, Canton Solothurn (west of Olten, LK 1088 Hauenstein), the rock of the Holzflue Member is a porous, white micrite (Gygi 1969, Pl. 19). This is the type locality of the Wangen Member as conceived by Moesch (1867, p. 165).

The age of the Holzflue Member could only be established with clay minerals. The member belongs to the later part of the Bimammatum Chron and to the Planula Chron. The upper Holzflue Member at Mt. Holzflue cannot be distinguished from the Verena Member at St. Verena chapel, the type locality of the Verena Member (see below). The eastern boundary of the Holzflue Member is marked by the Olten Member, a limestone with hermatypic corals. There is a transition between the upper Holzflue Member and the upper Letzi Member at Olten (Gygi 1969, Pl. 19). The colour of the Holzflue Member is lighter than that of the oolitic Steinebach Member below that has a brownish tinge. But near Balsthal the uppermost Steinebach Member is an almost white friable oolite that weathers back. This was already noted by Delhaes & Gerth (1912, p. 18).

2.20 **Hornbuck Member** (Würtenberger & Würtenberger 1866). Member of the Villigen Formation

The name Hornbuck Member (Hornbuck-Schichten) was introduced by Würtenberger & Würtenberger (1866, p. 25). It refers to the hill called Hornbuck north of Riedern am Sand that belongs to the township of Erzingen in the Unterklettgau valley, southern Germany. Würtenberger & Würtenberger did not designate a type section, and Gygi (1969, Pl. 19) was not in a position to give a complete section of the member in the Klettgau valley or the Randen hills. The best outcrop of the member is section RG 76 along a forest road on the north slope of Hornbuck hill at coordinates 675.850/276.220 at the elevation of 500 m, LK 1051 Eglisau. This section can be desig-

nated as type locality of the Hornbuck Member even though the base of the member is not exposed there.

The Hornbuck Member is a succession of somewhat marly limestone beds with marl intercalations. Where the limestone beds contain many siliceous sponges, their carbonate content and the thickness increase, so that the beds can merge in small sponge bioherms (Gygi 1969, Fig. 2 and Pl. 19). Siliceous sponges and ammonites are the dominant macrofossils. The thickness of the member is about 10 m. The base is where siliceous sponges appear and the limestone beds become relatively pure above the underlying marly Effingen Member. The top is where the marly interbeds become very thin and sponges disappear. The member is dated with an *Epipeltoceras bimammatum* (Quenstedt) that was found at the type locality of the member and was figured by Gygi (2000b, Pl. 10, Fig. 4) at the Bimammatum Subchron. The member grades north of the Rhine river into the Crenularis Member and probably into the Geissberg Member.

2.21 **Knollen Bed** (Moesch 1863). Marker bed within the Villigen Formation

Moesch (1863, p. 163) discerned this excellent marker bed (Knollenbank) between the Wangen Member below and the Letzi Member of Canton Aargau above for the first time. He did not designate a type locality. The best outcrop of the marker bed is west of Villigen, Canton Aargau, LK 1070 Baden, in section RG 62 at the locality Schrannechopf that is not mentioned on the map. The road that leads from Villigen to Mt. Geissberg cuts across the almost horizontal Knollen Bed (Knollenschicht of Moesch 1867, p. 169) at the bend of the road at coordinates 657.700/264.070 at an elevation of 525 m. The outcrop was figured by Gygi et al. (1998, Fig. 12). The photograph shows the upper part of bed 58 of section RG 62 and bed 59. The uppermost 10 cm of bed 58 is made up of corroded limestone nodules several centimeters across that are embedded in a marly glauconitic matrix. In the uppermost 20 cm of bed 58 and in the overlying bed 59 there are limonite nodules (primarily iron sulfide) with a diameter of up to several centimeters. Bed 59 has a slight content of fine-grained glauconite. The nodular upper part of bed 58 and bed 59 with many pectinid bivalves with a limonitic crust are the Knollen Bed with a total thickness of 30 cm. Section RG 62 (Pl. 17 in Gygi 1969) is the type section.

The Knollen Bed is normally only a few decimeters thick and contains some fine-grained glauconite. Where it includes many siliceous sponges, its thickness can increase to form low sponge bioherms. Bioherms were found in the large quarry of Mellikon in Canton Aargau, north of the ruin of Küssaburg as well as near Immendingen and Möhringen in southern Germany (Gygi 1969, Pl. 19). It is probable that Schweigert & Callomon (1997, p. 27) found *Amoeboceras bauhini* (Oppel) in the Knollen Bed in the quarry on Mt. Plettenberg 7 km southwest of Balingen, southern Germany and that the Knollen Bed is at the base of the Kimmeridgian Stage. The Knollen Bed can be traced from Schönenwerd in Canton Solothurn (west of Aarau) through Canton Aargau, the Klettgau, Randen in Canton Schaffhausen as far as the area near Balingen in southern Germany over a distance of 120 km (Gygi 1969, p. 57). The base of the Knollen Bed is sequence boundary O 8 of Gygi et al. (1998).

2.22 **Küssaburg Member** (Würtenberger & Würtenberger 1866). Member of the Villigen Formation

Würtenberger & Würtenberger (1866, p. 30) introduced the name Küssaburg Member (Küssaburg-Schichten) for a succession of bedded, micritic limestones between the Hornbuck Member below and the Wangental Member above. The name is derived from the ruin of Küssaburg southeast of the village of Bechtersbohl in the lower Klettgau valley (southern Germany), LK 1050 Zurzach. There are only insignificant outcrops of the member below the Küssaburg ruin, but a continuous section could be measured in 1962 in the gully called Steiggraben 2 km southwest of the village of Geisslingen in the German lower Klettgau valley. This is section RG 74 at coordinates 670.550/273.020 which is less than 2 km east of Küssaburg ruin. The section is represented in Gygi (1991, Fig. 4) and can serve as type section of the Küssaburg Member.

The thickness of the Küssaburg Member in the Steiggraben gully is 32.5 m. Below is the glauconitic Crenularis Member with a sponge bioherm at the base. The top of the Küssaburg Member in the type section RG 74 is marked by the glauconitic bed 46 that belongs to the Knollen Bed. Ammonites are rare in the Küssaburg Member. Gygi & Persoz (1986, table 3 and Pl. 1) mentioned *Taramelliceras (Metahaploceras) litocerum* (Oppel) of the Hauffianum Subchron. Gygi (1969, p. 98 and Fig. 5) claimed to have found fragments of *Subnebrodites* in the Küssaburg Member. This is based on an error. There is a transition between the Küssaburg Member and the coeval Wangen Member of Canton Aargau. The boundary in figure 1 is drawn arbitrarily along the Rhine river that is the boundary between Switzerland and Germany north of Mellikon in Canton Aargau.

2.23 **La May Member** (Gygi 1995). Previously "Humeralis-Kalke". Member of the Courgenay Formation
Synonymy: Gygi (2000b, p. 61)

The La May Member was named by Gygi (1995, p. 12). The name refers to the small valley called La May 2.5 km northeast of St-Ursanne in Canton Jura, LK 1085 St-Ursanne, where part of the member crops out at coordinates ca. 580.750/247.500 in the unpublished section RG 337. Below is the marl of the Bure Member which is covered, and above is a good outcrop of the massive Porrentruy Member. The only complete section of the La May Member was provided by the exploration well for the Transjurane superhighway near La Coperie farm 2 km east of St-Ursanne. This is section RG 443 which is represented as plate 20 in Gygi (2000b).

The limestone of the La May Member is mostly micritic,

well-cemented and well-bedded. Rounded lithoclasts of micrite grow to a diameter of 10 mm and are not rare. Macrofossils are *Cycloserpula socialis* (Goldfuss) and the bivalve *Pholadomya*. The thickness of the member is about 30 m in the borehole near La Coperie that Gygi (2000b, p. 61) proposed to be the type section for lack of a complete outcrop at the surface. No ammonites have been found in the La May Member to date. The clay mineral stratigraphy by Gygi & Persoz (1986, Pl. 1A) indicates that the age of the La May Member ranges from the Hauffianum Subchron of the Bimammatum Chron to the lower Planula Chron (Gygi, 1995, Fig. 2). The La May Member occurs only in Canton Jura. The boundaries of the member with the Laufen and Verena Members are transitional.

2.24 **Laufen Member** (Gygi 1995)
Member of the Balsthal Formation
Synonymy: Gygi (2000b, p. 62)

The name Laufen Member was proposed by Gygi (1995, p. 13). It is derived from the small medieval city of Laufen in Canton Baselland, LK 1087 Passwang. The upper part of the member is currently being quarried as a well-known building stone in the small valley of Schachlete north of Laufen, on the territory of the village of Dittingen (unpublished section RG 457 at coordinates 604.530/253.070).

Complete sections of the member close to Laufen are above the cantonal road east of the former cement works at Liesberg (figured by Gygi 2000b, Fig. 35) and in the limestone quarry of the former Liesberg cement works (Gygi 2000b, Pl. 32). Gygi (2000b, p. 62) proposed that beds no. 27–48 in this quarry be the type section of the Laufen Member. The member is 16 m thick in this section and is made up of bedded micritic limestone with oncoids near the base. The lithology of the Laufen Member is very variable. Micrite, pelmicrite, oncolite, oolite, oolitic oncolite, dolomitic oncolite or even coral limestone can occur. The Laufen Member is very fossiliferous in some places (Gygi 2000b, Fig. 19). Ostreid bivalves and ribbed brachiopods *(Septaliphoria)* are common. One ammonite has been found in the upper part of the member in the quarry Schmidlin in the Schachlete valley near Dittingen, Canton Baselland, by J. Jermann. Gygi (1995, Fig. 20) figured this *Lithacosphinctes*, but he could not identify it. It is only by means of mineral stratigraphy (Gygi & Persoz 1986) and sequence stratigraphy (Gygi et al. 1998) that the member can be dated at the Bimammatum and Hauffianum Subchrons of the Bimammatum Chron. The Laufen Member occurs in northwestern Switzerland. It grades laterally into the Oolithe rousse and into the lower La May Members in the proximal direction. The boundary to the lower Holzflue Member in the distal direction is also a transition.

2.25 **Letzi Member** (Moesch 1863)
Member of the Villigen Formation

According to Moesch (1863, p. 164/165), Escher von der Linth originally proposed the name Letzi Member (Letzischichten). The name refers to the hill called Letzi 2.5 km northeast of the village of Effingen, Canton Aargau, LK 1069 Frick. A small quarry was opened in the Letzi Member 100 m east of the now demolished farm Letzi in the 19th century in order to provide for lithographic limestone (coordinates 652.040/262.200) which is the type locality. The outcrop does not exist any more.

The Letzi Member is a well-bedded, pure micritic limestone with a mean thickness of about 20 m (Gygi 1969, pl 17). Macrofossils are uncommon, but some bivalves *(Pholadomya)* and ammonites were found. The Letzi Member is underlain by the glauconitic Knollen Bed and overlain by the glauconitic Baden Member. The upper part of the Letzi Member could be dated with a *Subnebrodites laxevolutus* (Fontannes) in the large quarry at Mellikon, Canton Aargau (Gygi 2000b, Pl. 11, Fig. 4) at the Planula Chron of the early Kimmeridgian. *Sutneria galar* (Oppel) J 32809 occurs in the uppermost two meters of the Letzi Member (bed 114, Gygi 1969, Pl. 17, section RG 70). Thanks to the Knollen Bed marker, the Letzi Member can be exactly correlated lithostratigraphically with the Wangental Member in Canton Schaffhausen. Gygi (1969, Pl. 16, section RG 82) found *Subnebrodites schroederi* (Wegele) J 31714 in bed 134 of the section directly above the base of the Wangental Member. The specimen is figured in Gygi (2000b, Pl. 13, Fig. 4). Consequently, the age of the Letzi Member is the Planula Chron. A good reference section of the member are beds 63–119 of section RG 70 at Mellikon, Canton Aargau, which is figured by Gygi (1969, Pl. 17).

2.26 **Liesberg Member** (Rollier 1888)
Member of the Bärschwil Formation
Synonymy: Gygi (2000b, page 54)

The name Liesberg Member (Couches de Liesberg) goes back to Rollier (1888, p. 71). It is derived from the village of Liesberg, Canton Baselland, LK 1086 Delémont, where there is a good section of the member in the clay pit of Hinter Chestel near Liesbergmüli. This is section RG 306 that is represented as plate 31 in Gygi (2000b). Gygi (2000b, p. 54) designated beds no. 99–106 of section RG 306 to be the type section of the Liesberg Member.

The Liesberg Member is 25 m thick in the type section. The average thickness of the member is only about half as much. The matrix is a blue-gray marl that includes irregularly shaped nodules of calcium carbonate. The nodules can be partly chertified. As much as 30% of the rock volume are hermatypic corals that are mainly discoidal near the base and increasingly ellipsoidal (like bread loafs) towards the top. The corals are accompanied by a profusion of brachiopods, bivalves and echinoderms. Many of the macrofossils are partly chertified. The Liesberg Member occurs only in northwestern Switzerland. The distal boundary of the member is below the coral bioherms at the platform margin of the St-Ursanne Formation (Fig. 1). The base of the member is usually clear-cut and is drawn where the first hermatypic corals appear. The upper boundary can be transitional as in the landslide west of Vögeli

farm at Bärschwil, Canton Solothurn, LK 1087 Passwang. This outcrop is the "Fringeli" of older authors and is represented as plate 34 in Gygi (2000b). Angela Coe found a large perisphinctid ammonite 2 m below the top of the member in the type section at Liesberg. Unfortunately, the specimen could not be identified. Nevertheless, it can be said that the Liesberg Member represents only a fraction of the Antecedens Subchron of the Transversarium Chron, because ammonites of the Antecedens Subchron have been figured from the Sornetan Member below (Duong 1974, Pl. 3, Fig. 1 and Gygi 1995, Fig. 25): *Gregoryceras romani* (de Grossouvre) and from the upper St-Ursanne Formation above (Gygi 1995, Fig. 14): *Perisphinctes (Dichotomosphinctes) dobrogensis* Simionescu.

2.27 **Mumienkalk Bed** (Gygi 1977). Marker bed near the base of the Wildegg Formation

Gygi (1977, p. 455) named a characteristic, glauconitic limestone bed near the base of the Upper Jurassic in Canton Schaffhausen Mumienkalk Bed. Bed 14 of section RG 81b at Gächlingen, Canton Schaffhausen, LK 1031 Neunkirch, can be designated to be the type of the Mumienkalk Bed. The type locality is the excavation RG 81b alongside a forest road southwest of Räckolterenbuck hill at coordinates 680.980/287.240 at the elevation of 750 m. The type section is figured in Gygi (1977, Pl. 11, section 6).

The Mumienkalk Bed is 15–25 cm thick at the type locality and could be divided into a lower and an upper half in the larger part of the excavation. It never crops out naturally. The macrofauna of the bed is dominated by ammonites, but parts of siliceous sponges are also common. The perisphinctid ammonites of this bed will published at a later date. The palaeoenvironment of the Mumienkalk was discussed in detail by Gygi et al. (1979, p. 941/949). The ammonites of the bed indicate that it is condensed (Gygi 2000a, Fig. 3). The bed includes ammonites of both the Antecedens and Luciaeformis Subchrons of the Transversarium Chron. The Mumienkalk Bed grades in the Unterklettgau valley into the upper part of the condensed bed at the base of the Birmenstorf Member of Canton Aargau (Gygi 2000a, Fig. 2). North of Canton Schaffhausen, the bed was recorded in the opencut iron mine of Blumberg, southern Germany (Gygi 1977, Pl. 11, section 9, bed 3).

2.28 **Mumienmergel Bed** (Gygi 1977). Marker bed at the base of the Wildegg Formation

The Mumienmergel Bed was named by Gygi (1977, p. 455). It is a gray marl with a violet tinge and a thickness of 10 cm. It contains little fine-grained glauconite and oncoids of varying size. The small oncoids are more or less spherical. Oncoids with a diameter greater than 3–4 cm tend to be flattened. Large oncoids have a diameter of as much as 25 cm and resemble a cow-pat. Their core is usually an ammonite (Gygi 1992, Fig. 36). These oncoids are then mummies which gave the bed the name. The type locality of the bed is the excavation RG 81b alongside a forest road southwest of Räckolterenbuck hill at Gächlingen, Canton Schaffhausen, LK 1031 Neunkirch, at coordinates 680.980/287.240 at the elevation of 750 m. The section is figured in Gygi (1977, Pl. 11, section 6). The Mumienmergel Bed is bed 13 of section RG 81b.

The macrofauna of the Mumienmergel Bed is dominated by ammonites. The ammonites are commonly thickly encrusted with ferriferous calcium carbonate which includes abundant glauconite pellets. According to the ammonites, the bed is condensed. It contains ammonites of both the Densiplicatum and the Antecedens Subchrons of the Transversarium Chron (Gygi 2000a, Fig. 3). The bed grades in the Unterklettgau valley into the lower part of the condensed bed at the base of the Birmenstorf Member of Canton Aargau (Gygi 2000a, Fig. 2). To the north, the bed continues beyond the Swiss/German border.

2.29 **Olten Member** (Gygi 1969)
Member of the Balsthal Formation
Synonymy: Gygi (2000b, p. 64)

The Olten Member ("Oltener Korallenkalk") was named by Gygi (1969, p. 94). The name is derived from the city of Olten, LK 1088 Hauenstein, where the member forms a cliff on the northwestern slope of Hardflue hill above the railway goods yard of Olten (unpublished section RG 22, coordinates 635.550/244.980). Gygi (1969) did not designate a type locality. A complete section of the member is in the limestone quarry of the former cement works on the north slope of Mt. Born 2.5 km southwest of Olten that was measured by Gygi (1969, Pl. 18, section RG 21, coordinates 633.900/242.280). This quarry can serve as type locality. Beds 29–36 of section RG 21 are assigned to the Olten Member.

The thickness of the Olten Member is 26 m in the type section. The lower part of the member is thick-bedded, whereas the upper part is massive. The matrix of the limestone is pure micrite below with varying admixtures of fine-grained biogenic detritus in the upper part. Chert nodules occur in the middle. 10–20% of the rock volume are mostly dish-shaped coral colonies of the genera *Dimorphoseris* and *Stylina* as well as undifferentiated microsolenids (Gygi 2000b, Fig. 12). The base of the member is where the first hermatypic corals appear, and the top where corals disappear. The geometry of the member is progradational (Gygi & Persoz 1986, Pl. 1A). The most proximal individual patch reefs appear in the distal time equivalent of the Steinebach Member in the gorge 1 km northwest of Wangen near Olten. At the time of maximum development the coral limestone belt must have grown to a width of 3–4 km and may have been a bank reef. Gygi (1969, p. 95) pointed out that the reef front and the fore-reef ramp must have had a very subdued relief. Growth of the coral bank ceased during deposition of the upper Holzflue Member and the upper Letzi Member.

2.30 **Oolithe Rousse Member** (Rollier 1888)
Member of the Vellerat Formation
Synonymy: Gygi (2000b, p. 59)

The unit called Oolithe rousse was first discerned and named by Rollier (1888, p. 63). No type locality was designated by this author, but he stated that the member was quarried at La Chaux-de-Fonds, Canton Neuchâtel, and in the Franches Montagnes, Canton Jura. In the area studied by Gygi (2000b), the best outcrop of the member is in the Gorges du Pichoux at Sornetan, Canton Bern, LK 1105 Bellelay, at coordinates 584.020/236.810. These are beds no. 108–111 of section RG 315 in plate 21 of Gygi (2000b). Section RG 315 can serve as type section of the Oolithe Rousse Member.

The thickness of the Oolithe Rousse Member can be, according to Ziegler (1956, p. 8), as much as 8 m, and is 6.4 m in the type section. It is a thinly bedded, sometimes marly, carbonate oolite. When it is a grainstone, it can be locally cross-bedded. If it is a wackestone under the handlens, the matrix is often made up of dedolomitized rhombs. Both rhombs and ooids have a limonitc coating that gives the rock its characteristic red-brown colour. Unweathered oolite is blue-gray (see Gygi & Persoz 1986, p. 413). Gygi & Persoz (1986, Pl. 1A) proved with their correlation I that the Oolithe Rousse Member has the same age as the Crenularis Member of Canton Aargau. The Crenularis Member is dated with ammonites at the Bimammatum Subchron of the Bimammatum Chron. The Oolithe Rousse Member occurs in a broad strip between La Chaux-de-Fonds, Canton Neuchâtel, and Liesberg, Canton Baselland (see palaeogeographical map in Ziegler 1956, Fig. 12).

2.31 **Pichoux Formation** (Greppin 1870)
Synonymy: Gygi (2000b, p. 57)

The Pichoux Formation was named by Greppin (1870, p. 80) "Calcaires du Pichoux". The term went unnoticed by subsequent stratigraphers until 100 years later, when Bolliger & Burri (1970, p. 71) reintroduced the name without knowledge of Greppin (1870). Bolliger & Burri (1970) stated that the Gorges du Pichoux at Sornetan, Canton Bern, LK 1105 Bellelay, were the type locality. This is where sections RG 314 and 315 have been measured later which are described in Gygi (2000b, p. 32/33). The middle and upper parts of the Pichoux Formation are easily accessible along the road through the Gorges du Pichoux at coordinates 584.080/237.100.

The proximal Pichoux Formation is more than 50 m thick. The proximal time equivalent is the St-Ursanne Formation (Gygi & Persoz 1986, Pl. 1A, correlations A, B and C). Towards the basin the formation thins out and grades into the Birmenstorf Member of Canton Aargau, as was presumed by Bolliger & Burri (1970, p. 71). The formation consists of well-bedded micritic limestones. There is a marly intercalation which is probably the time equivalent of the boundary between the Grellingen and Tiergarten Members of the St-Ursanne Formation (Gygi & Persoz 1986, Pl. 1A, correlation B, Gygi 2000b, Fig. 39, see this paper, Fig. 1). The Pichoux Formation can contain siliceous sponges and ammonites as well as bivalves. Wholly fossilized sponges were found only directly above the base of the formation. Further up there are only sponge spicula (Gygi 2000b, Fig. 11). The figured ammonites of the formation are of the middle and late Transversarium Chron (Gygi 1990a, Pl. 5, Fig. 4, and Gygi 1995, Fig. 8). The wedge of the Pichoux Formation can be followed from Canton Neuchâtel to Canton Baselland in the region of Gempen.

2.32 **Porrentruy Member** (Gygi 1995)
Member of the Courgenay Formation
Synonymy: Gygi (2000b, p. 60)

The Porrentruy Member ("Porrentruy-Schichten") was proposed by Gygi (1995, p. 12). The name is derived from the small city of Porrentruy, Canton Jura, LK 1085 St-Ursanne, where the upper part of the member crops out in a quarry on the eastern slope of Le Banné hill west of La Rasse, 1 km south of Porrentruy. This is bed 88 at the base of section RG 340 which is represented as plate 17 in Gygi (2000b). A complete section of the Porrentruy Member is along the forest road called Chemin Paulin 4 km southwest of Courgenay, Canton Jura, LK 1085 St-Ursanne, at coordinates 573.920/247.400. This is section RG 350 which is published as plate 19 in Gygi (2000b). Bed 79 of this section is the reference section of the member.

The thickness of the Porrentruy Member is 12.7 m in the reference section. There, the member is a massive, grayish- to yellowish-white, pure micritic limestone. This is traversed by thickly-spaced, curved joints. The unit forms a low ridge around which there is a slight bend of the road. Near Porrentruy in section RG 340 and elsewhere the rock is porous and almost pure white. No ammonites were found as yet in this member. It is only by means of the mineral stratigraphic correlation K that Gygi & Persoz (1986, Pl. 1A) could indicate that the age of the Porrentruy Member is the Planula Chron. The Porrentruy Member can be followed from near St-Ursanne (unpublished section RG 337 at La May, bed 40) through the Ajoie to at least as far as Montbéliard in adjacent France, where the member is called "Calcaires crayeux à *Cardium*" (Chauve et al. 1985, p. 14).

2.33 **Renggeri Member** (Choffat 1878)
Member of the Bärschwil Formation
Synonymy: Gygi (2000b, p. 52)

The name Renggeri Member (Couches à *Ammonites renggeri*) has been introduced into the geological literature by Choffat (1878, p. 35). It is nowadays a commonly used name and can still be used, even though it refers to the fossil *Creniceras renggeri* (Oppel), an ammonite. This taxon occurs in the lowermost part of the Renggeri Member (Gygi 1990a, Fig. 3). Choffat did not designate a type locality of this thick marl-clay that nowhere crops out naturally with the exception of some small

outcrops in creek beds. At the present time there is only one locality where the member crops out cleanly from base to top. This is section RG 280 in the Andil clay pit 500 m southwest of the village of Liesberg, Canton Baselland, LK 1086 Delémont, which is represented as plate 30 in Gygi (2000b). Local people call the site "Ampthil". Section RG 280 is the reference section of the Renggeri Member.

In the reference section, the Renggeri Member is 60 m thick. It is a homogenous, blue-gray marl-clay which includes abundant, small ammonites in the lowermost 3 meters. The ammonites are casts of iron sulfide (pyrite, marcasite, or a mixture of the two minerals). Based on ammonites, Gygi (1990a and 1995) could assign the Renggeri Member to the Mariae and to the earlier part of the Cordatum Chron. The member occurs in the whole of northwestern Switzerland and in a large part of adjacent France. To the southeast it thins out to zero (Gygi & Persoz, 1986, Pl. 1A). Thin lenses of time-equivalent iron oolite reappear only in Canton Aargau as for instance in sections RG 60 and 210 near Gansingen. Ammonites from these lenses were figured by Gygi & Marchand (1982, Pl. 2).

### 2.34 **Reuchenette Formation** (Thalmann 1966)
Synonymy: Gygi (2000b, p. 65)

The Reuchenette Formation was named by Thalmann (1966, p. 32). Reuchenette is the name of a group of houses at the southern end of the village of Péry, Canton Bern, LK 1126 Büren a. A. The type section as figured by Thalmann (1966, Fig. 5) was measured to the south of Reuchenette on both sides of the valley.

The Reuchenette Formation is a thick succession of carbonate platform sediments ranging from shallow subtidal to intertidal facies. This term replaces the "Kimméridgien" of earlier authors which was meant in the lithostratigraphical sense. Mouchet (1995, 1998) made a detailed study of the formation that he again called "Kimméridgien". Gygi (2000b) dealt only with the lower part of the Reuchenette Formation and discussed the lower boundary. The boundary between the massive upper Balsthal Formation below and the well-bedded lower Reuchenette Formation above is conspicuous in a large part of northwestern Switzerland (Gygi 2000b, cover of the book and figure 38, see also plate 22). Some authors have distinguished members in the Reuchenette Formation, but these members cannot be correlated over greater distances.

According to Thalmann (1966, Fig. 5), the thickness of the Reuchenette Formation is 160 m in the type section. The ammonite species *Gravesia polypleura* Hahn = *Gravesia gravesiana* (d'Orbigny) *in* Hantzpergue (1989) was found ca. 15 m above the top of the formation (Mouchet, 1995, p. 9), it is thus probable that the upper boundary of the Reuchenette Formation is close to the Kimmeridgian-Tithonian stage boundary in the type region of the formation. The thickness of the Reuchenette Formation seems to diminish in the distal direction (towards the east), as the ammonite *Aulacostephanus (Aulacostephanus) autissiodorensis* (Cotteau) seems to occur in the thin-bedded micritic limestone above the Solothurn turtle limestone in the Bargetzi quarry at Solothurn (Gygi, 1995, Fig. 24). This ammonite documents the uppermost part of the Kimmeridgian Stage *sensu gallico* (Mouterde et al. 1971). The thin-bedded limestone in which the ammonite was probably found begins only 47 m above the base of the Reuchenette Formation at Oberdorf in the quarry north of Wäberhüsli 5 km northwest of Solothurn. This quarry is represented as plate 41 in Gygi (2000b, section RG 433). Buxtorf et al. (1908, p. 59) assigned the unit in which the ammonite was found to his "Portlandkalke".

Thalmann (1966, p. 89) followed Buxtorf et al. (1908) and defined the Solothurn turtle limestone to be the uppermost member of his Reuchenette Formation. The reason was the occurrence of what he called *Exogyra praevirgula* in the thinly bedded limestones above the turtle limestone. This ostreid bivalve is now called, according to Enay & Boullier (1981, p. 742), *Nanogyra striata* (Smith). Gygi (1995, Fig. 26) proved with a figured ammonite that the Virgula Member at Alle near Porrentruy belongs to the Eudoxus Zone of the Kimmeridgian Stage. It is likely that the Reuchenette Formation at the type locality is more or less time-equivalent with the Kimmeridgian Stage *sensu gallico* (Mouterde et al. 1971). Therefore the question arises whether Thalmann's formation boundary at Solothurn is correct. The ammonite as figured by Gygi (1995) suggests that the upper boundary of the Reuchenette Formation near Solothurn should be placed at least as high as the top of the thin-bedded limestones above the turtle limestone. This is why Gygi (2000b, Pl. 41, section RG 433) did not indicate an upper boundary of the Reuchenette Formation near Solothurn. It can be observed in the quarry northwest of Wäberhüsli at Oberdorf northwest of Solothurn (Gygi 2000b, Pl. 41), that the thin-bedded micritic "Portlandkalke" of Buxtorf et al. (1908) are only a thin intercalation in thick-bedded limestones. Provided that the thin-bedded micrite and the limestones above near Solothurn are assigned to the Twannbach Formation (Häfeli 1966, p. 574), the Reuchenette Formation would be only 46 m thick near Solothurn (Gygi 2000b, Pl. 41) as compared with 130 m as presumed by Thalmann (1966, p. 89).

The platform margin and therefore the distal boundary of the Reuchenette Formation *sensu stricto* is at Balsthal, Canton Solothurn, LK 1107 Balsthal. It is marked by small coral bioherms in the cliff below the castle Alt Falkenstein at coordinates 619.050/239.570. The bioherms are indicated in plate 1B by Gygi & Persoz (1986). They can be discerned from a distance looking north from the industrial yard of Klus south of the Dünnern river at Balsthal. Beyond these bioherms is a carbonate ramp facies that extends east to Schönenwerd, Canton Solothurn, LK 1089 Aarau (Gygi & Persoz 1986, Pl. 1B). There are many bivalves and some ammonites in these limestones near Olten (Gygi 1986, Fig. 6B) which indicate relatively shallow water. Gygi (2000b, p. 65) assigned the ramp facies provisionally to the Reuchenette Formation, because the basinal Baden and Wettingen Members cannot be differentiated

between Balsthal and Schönenwerd. He did not want to introduce a new name for these ramp limestones that have never been studied in detail except for a quarry near Olten (Gygi 1969, Pl. 18, section 21).

2.35 **Röschenz Member** (Gygi 1995). Previously "Natica-Schichten". Member of the Vellerat Formation
Synonymy: Gygi (2000b, p. 58)

The Röschenz Member was renamed by Gygi (1995, p. 11). The name is derived from the village of Röschenz, Canton Baselland, LK 1087 Passwang. It replaces the obsolete name Natica-Schichten, because gastropods of the genus *Natica* do not occur in the member. The type section of the member is along the road which leads from Röschenz westward down to Müli (LK 1086 Delémont). This section, RG 402, could be measured in August 1983 when the road was repaired. It is represented as plate 33 in Gygi (2000b).

The thickness of the Röschenz Member is 33 m in the type section. The mean thickness is 35 m. The member is a succession of limestones of shallow water to intertidal facies and marl. Stromatolites are quite common. Fine-grained detrital quartz is abundant mainly in the marls. Gastropods of the genus *Neritoma* (previously called "*Natica*") are uncommon. Nerineid gastropods as well as bivalves are the dominant macrofossils. Ammonites have not been recorded to date. The lower boundary of the Röschenz Member above the Vorbourg and proximal Günsberg Members is often a transition as in the type section RG 402. The upper boundary with the Hauptmumienbank Member is well-defined. An indication of the age of the Röschenz Member is given by the ammonite *Perisphinctes (Perisphinctes) panthieri* Enay that P. Bitterli has found at the transition Röschenz Member – Günsberg Formation at Seewen, Canton Solothurn. The specimen is figured in Gygi (1995, Fig. 11 and 17/1) and documents the Bifurcatus Chron. The mineral stratigraphic correlation H of Gygi & Persoz (1986, plate 1A) proves that the uppermost part of the Röschenz Member belongs to the early Bimammatum Chron. The geographical range of the Röschenz Member is indicated on the palaeogeographical map of figure 6 in Gygi (1990c).

2.36 **Schellenbrücke Bed** (Gygi 1977). Marker bed at the top of the Herznach Formation

The name of this bed was proposed by Gygi (1977, p. 454) and refers to an old bridge called Schellenbrücke (bridge built by convicts) at coordinates 646.450/252.750, 1 km northeast of the village of Küttigen, Canton Aargau, LK 1089 Aarau. The bed crops out beside the cantonal road 100 m north of the bridge and is bed no. 3 in section RG 32 on plate 17 in Gygi (1969). This is the type locality.

The Schellenbrücke Bed is only 5–10 cm thick at the type locality. It is a ferriferous, iron oolitic limestone with abundant ammonites of the Cordatum Subchron of the Cordatum Chron. The bed is the uppermost unit of the Herznach Formation. Its upper boundary is in most places a crust of chamosite or limonite with a shining, mammillate surface (Gygi 1992, Fig. 30). The Schellenbrücke Bed is discontinuous. It does not occur south of Veltheim, Canton Aargau, as Gygi (1969) thought (section RG 37a, Gygi 1969, Pl. 2, Fig. 4, "eisenoolithischer Kalk der unteren Oxford-Stufe"). This assumption was based on a drill core only. Mangold & Gygi (1997) demonstrated with ammonites that in section RG 226 that was later measured in the new road cut south of Veltheim, the iron oolite below the Birmenstorf Member is of Bathonian age. Neither does the Schellenbrücke Bed occur at Oberehrendingen, Canton Aargau, LK 1070 Baden, in the old marl quarry of Hinterstein 1 km southeast of the village (section RG 51a, bed 0, see Gygi 1969, Pl. 3, Fig. 8). Mangold & Gygi (1997, Fig. 5/4) proved with an ammonite that the iron oolite of section RG 51b, bed 2 (which corresponds to bed 0 in section 51a) at the same locality is of Bathonian age. The Schellenbrücke Bed passes in the Unterklettgau valley (southern Germany) into the Glaukonitsandmergel Bed.

2.37 **Schwarzbach Formation**
(Würtenberger & Würtenberger 1866)

This formation was named by Würtenberger & Würtenberger (1866, p. 37) Schwarzbach-Schichten after the Schwarzbach creek that has its source northwest of Rafz, Canton Zürich, LK 1051 Eglisau. The creek then runs west and empties into the Kothbach 1 km southeast of Oberlauchringen in the German Unterklettgau valley, LK 1050 Zurzach. The unit was ranked as a member by Gygi et al. (1989, Fig. 2). It is now considered to be a formation in southern Germany under another name by Schweigert (1995, Fig. 1). The type locality of the Schwarzbach Formation is at the eastern end of the small ravine of the Schwarzbach north of Bühl, a village 1.5 km south-southwest of Dettighofen, LK 1051 Eglisau (Würtenberger & Würtenberger 1866, p. 19). There are only small and partial natural outcrops of the formation in creeks. The lowermost part of the formation was excavated by R. & S. Gygi in 1974 in a quarry at Summerhalde in the Hemmental valley 2.5 km north-northwest of Schaffhausen, LK 1031 Neunkirch. This is section RG 239 that was published by Gygi (1990b, p. 69) and is located at coordinates 688.070/286.340.

Even without outcrops, the marly Schwarzbach Formation can be easily discerned in the landscape, because it forms a distinct terrace between the escarpment of the limestones of the Villigen Formation below and the slight escarpment of what is now called the Felsenkalk Formation (Schweigert 1995) above. The Schwarzbach Formation occurs in the Klettgau valley and in the Randen hills and beyond in southern Germany. Würtenberger & Würtenberger (1866) could date it with a rich ammonite fauna. According to Gygi (1990b), the formation begins in the latest Planula Chron.

2.38 **Solothurn turtle limestone** (Gressly 1838–1841)
Member of the Reuchenette Formation

This member was named by Gressly (1838–41, p. 157) "calcaire à Tortues de Soleure". The type area is in the quarries at the localities called Steingruben (LK 1127 Solothurn) and Kreuzen (LK 1107 Balsthal) at the northern city limit of Solothurn. The quarries are closed today (see map in figure 12 by Thalmann 1966).

The Solothurn turtle limestone is a marginal marine sediment with a thickness of 11 m according to Lang & Rütimeyer (1867, p. 11). It is characterized by a mass occurence of nerineid gastropods. According to Gygi (2000b, Pl. 41, section RG 433), the facies of the Solothurn turtle limestone begins 38.6 m above the base of the Reuchenette Formation in the quarry north of Wäberhüsli at Oberdorf, 5 km northwest of Solothurn. The equivalent of the Solothurn turtle limestone in this section RG 433 are beds no. 46–51. The thickness of the limestone between the base of the Reuchenette Formation and the base of the Solothurn turtle limestone cannot be measured at Solothurn, but it is of the order of 35 m. Thalmann (1966, p. 89) regarded the Solothurn turtle limestone to be the uppermost member of his Reuchenette Formation. This member occurs only near Solothurn. There is no record of ammonites in the member.

2.39 **Sornetan Member** (Gygi 2000b). Previously "Terrain à chailles"). Member of the Bärschwil Formation
Synonymy: Gygi (2000b, p. 53)

The Sornetan Member was renamed by Gygi (2000b, p. 53). The new name replaces the misleading term Terrain à chailles. The French word chaille means a chert nodule. The nodules in the Sornetan Member are exclusively carbonate. The study of numerous thin sections through nodules and limestone bands in the Sornetan Member (Gygi 2000b, Pl. 21, 24, 31 and 34) revealed that the only silica in the nodules is in rare, fine-grained detrital quartz grains. The new name of the member refers to the village of Sornetan, Canton Bern, LK 1105 Bellelay, where there is a fairly good natural outcrop of the upper part of the member in the Gorges du Pichoux (section RG 314, see lower part of plate 21 in Gygi 2000b). The reference section of the Sornetan Member is in the clay pit of Hinter Chestel 500 m south of the village of Liesberg, Canton Baselland, LK 1086 Delémont. This is the lower part of section RG 306 which is represented as plate 31 in Gygi (2000b). In 1980 the Sornetan Member cropped out from base to top in the clay pit of Hinter Chestel which now serves as a waste dump.

The Sornetan Member is 46 m thick in the reference section RG 306. It is a blue-gray marl with bands of ellipsoidal carbonate concretions which are called sphérites in French. There are also continuous beds of limestone. Ammonites dominate the macrofauna in the lower part and bivalves *(Pholodomya)* in the upper part. Brachiopods occur in the whole member. The lower boundary is drawn where the first band of carbonate nodules appears above the Renggeri Member. The upper boundary is where hermatypic corals appear, the nodules change to an irregular shape and the macrofossils are partly chertified. It could be established with ammonites that the lower half of the member belongs to the Cordatum Subchron of the Cordatum Chron (Gygi & Marchand 1993). An unknown thickness represents the Densiplicatum Subchron at Liesberg (*Gregoryceras tenuisculptum* Gygi S 1874 in the Musée jurassien des sciences naturelles at Porrentruy, see Gygi 1977, p. 473). The upper part of the member was laid down during the Antecedens Subchron of the Transversarium Chron (Gygi 1995, Fig. 25) according to the ammonite cast J 31672 in the Museum of Natural History Basel. The geographical range of the Sornetan Member is represented in the two palaeogeographical maps 3 and 4 in Gygi (1990c).

2.40 **Steinebach Member** (Gygi 1969)
Member of the Balsthal Formation
Synonymy: Gygi (2000b, p. 61)

The Steinebach Member (Steinibach-Schicht) was named by Gygi (1969, p. 85). The name is derived from Steinebach creek (spelled Steinibach by Gygi 1969) which carved the small gorge north of the old church in the village of Balsthal, Canton Solothurn, LK 1107 Balsthal. The gorge is west of Mt. Holzflue and can be seen in figure 4 in Gygi (1969). The member crops out in a small old quarry beside a forest road at coordinates 619.410/241.350 in section RG 9 and the revised section RG 438 which was measured at the same locality. Section RG 438 is represented as plate 44 in Gygi (2000b) and is the type section (beds 1–25 of RG 438).

The base of the Steinebach Member is not exposed in the type section. The Effingen Member below is covered by soil. The uppermost bed of the member, no. 25, is a porous, yellowish-white carbonate oolite which weathers out as a hollow 8 m above the road. Most of the ooids of bed 25 do not break under the hammer. There is thin cross-bedding in bed 25. The same unit also crops out in section RG 450 (figure 37 in Gygi 2000b) at Chluser Roggen, Balsthal SO. The mean thickness of the Steinebach Member is about 15 m. It is mostly an oosparite and is often cross-bedded. In the type section it contains small oncoids. The lower boundary is transitional as in the unpublished section RG 448 in the Mösliloch quarry 1 km west of the village of Egerkingen, Canton Solothurn, LK 1108 Murgenthal. The upper boundary is clear-cut and is a palaeosol with "raggioni" (Mutti 1994) in the unpublished section RG 4 at Brocheni Flue, 1 km west-southwest of Waldenburg, Canton Baselland, LK 1088 Hauenstein (bed 40, rock samples Gy 48–50), and in bed no. 3 of the unpublished section RG 15 in Horngraben valley east of Eggli, 2.5 km south of the village of Aedermannsdorf, Canton Solothurn, LK 1107 Balsthal (rock sample Gy 238). The Steinebach Member can only be dated by means of mineral stratigraphy (correlations H and I of Gygi & Persoz 1986, plate 1A) and sequence stratigraphy (sequence boundary O 7 of Gygi *et al.* 1998, Fig. 2) to be of the middle Bimammatum Chron. The member occurs on a strip between the

Hauptmumienbank Member and the Olten Member as is represented in the palaeogeographical map in Gygi (1990c, Fig. 7).

2.41 **St-Ursanne Formation** (Bolliger & Burri 1970)
Synonymy: (Gygi 2000b, p. 54)

The St-Ursanne Formation was named by Bolliger & Burri (1970, p. 69). The name replaces the "middle and upper Rauracien" that was commonly used for 100 years in the sense of Greppin (1870, p. 75). The name is derived from the small medieval town of St-Ursanne, Canton Jura, LK 1085 St-Ursanne. Bolliger & Burri (1970, p. 69) stated that the quarry of the lime works at St-Ursanne was the type locality. This section was published by Pümpin (1965, Pl. 1, section 2). The only natural outcrop in which the St-Ursanne Formation is exposed from base to top is the cliff of Peute Roche below point 957.9, 900 m west-southwest of Vellerat, Canton Jura, LK 1106 Moutier. These are sections RG 389 and RG 451 which are represented as plate 24 in Gygi (2000b). Gygi & Persoz (1986, Pl. 1A) demonstrated that there is an obvious subdivision of the St-Ursanne Formation into a lower and an upper part.

The St-Ursanne Formation is 92 m thick at the cliff of Peute Roche near Vellerat. This is probably near the maximum of the thickness of the formation. The minimum thickness of 35 m was recorded in the unpublished section RG 397 along the road west of Schlossfelsen rock at Kleinlützel, Canton Solothurn, LK 1086 Delémont. The St-Ursanne Formation is the pure limestone sediment of a carbonate platform that was formed on top of the argillaceous submarine prodelta bank of the Bärschwil Formation. The lower boundary of the St-Ursanne Formation is often transitional. The upper boundary is normally well-defined and can be a limonitic crust like in the drinking water well near Bressaucourt, Canton Jura, 4 km southwest of Porrentruy, LK 1085 St-Ursanne (see plate 18 in Gygi 2000b). This is sequence boundary O 5 of Gygi et al. (1998). The ammonites as figured by Gygi (1995) and the mineral stratigraphical correlation C of Gygi & Persoz (1986, plate 1A) indicate that the age of the St-Ursanne Formation is the later part of the Antecedens Subchron and the Luciaeformis Subchron of the Transversarium Chron (Fig. 2). The St-Ursanne Formation occurs in northwestern Switzerland (Gygi 1990c, Fig. 5). Its distal time equivalent is the Pichoux Formation. The boundary between the two formations is formed by a belt of individual coral bioherms that did not form a barrier reef (Gygi & Persoz 1986, Pl. 1A).

2.42 **Tiergarten Member** (Bolliger & Burri 1970)
Member of the St-Ursanne Formation
Synonymy: Gygi (2000b, p. 56)

The Tiergarten Member ("Tiergarten-Oolith") was named by Bolliger & Burri (1970, p. 71), after the Tiergarten gorge of the Gabiare creek 3 km southeast of the village of Vicques, Canton Jura, LK 1086 Delémont. The type locality is a poor outcrop in the upper St-Ursanne Formation 1.5 km west of Vermes, Canton Jura, along the road near the southern end of the Tiergarten gorge (LK 1106 Moutier) at coordinates 600.900/241.900. Bolliger & Burri (1970) introduced their new name for all the oolites of the St-Ursanne Formation. Gygi & Persoz (1986, Pl. 1A) showed that the oolites in the lower St-Ursanne Formation were both vertically and areally separated from the oolites in the upper St-Ursanne Formation. Therefore, Gygi (2000b, p. 55) renamed the oolite of the lower St-Ursanne Formation Delémont Member. The Tiergarten Member *sensu stricto* (Gygi 2000b, p. 56) includes only the oolites of the upper St-Ursanne Formation between the distal part of the Grellingen Member below and the Vorbourg Member or Günsberg Formation, respectively, above.

The thickness of the Tiergarten Member *sensu stricto* is highly variable like that of the whole St-Ursanne Formation. The dominant lithology is oolitic grainstone. There are also coral patch reefs in the distal Tiergarten Member. The delimitation of the Tiergarten Member below is clear-cut. It is the boundary between the biomicritic Grellingen Member below and the oolitic grainstone above. This boundary is the transgressive surface above sequence boundary O 4 of Gygi et al. (1998, Fig. 2). The upper boundary of the Tiergarten Member is often difficult to discern when the overlying Günsberg Formation is also oolitic. A corroded bedding plane, sometimes incrusted with limonite, can be the only indication for the presence of this important sequence boundary O 5. No ammonites are known of the Tiergarten Member. The member can be dated only by the mineral stratigraphic correlations B and C by Gygi & Persoz (1986, Pl. 1A) and by the ammonites found in the coeval Buix Member (see Gygi 1995). The age is the latest Antecedens Subchron and the Luciaeformis Subchron of the Transversarium Chron (Fig. 2). The Tiergarten Member rims the carbonate platform of the upper St-Ursanne Formation. The fringe of coral bioherms which mark the distal margin of the St-Ursanne Formation probably grew in somewhat deeper water and is unlike a barrier reef.

2.43 **Vellerat Formation** (Bolliger & Burri 1970)
Synonymy: Gygi (2000b, p. 58)

The Vellerat Formation was named by Bolliger & Burri (1970, p. 71). The name refers to the village of Vellerat, Canton Jura, LK 1106 Moutier. The type locality is along the road from Courrendlin to Vellerat at coordinates 595.100/241.800. Bolliger & Burri (1970, p. 72) included in their Vellerat Formation what is now the Günsberg Formation and the Steinebach Member of the Balsthal Formation. Gygi (2000b, Fig. 40 = Fig. 2 of this paper) restricted the Vellerat Formation to the lagoonal facies of the Vorbourg, Röschenz (= "Natica"), Hauptmumienbank and Bure (= "Humeralis") Members. The Günsberg Formation with its oolite shoals and coral bioherms rims the proximal facies of the lower Vellerat Formation *sensu stricto* against the basinal Effingen Member.

The mean thickness of the Vellerat Formation is about 55 m. The lithology is very variable (see descriptions of Vor-

bourg, Röschenz, Hauptmumienbank and Bure Members). Characteristic fossils are stromatolites and oncoids. No ammonites have as yet been found in the Vellerat Formation. It is the merit of Bolliger & Burri (1967) to have suggested for the first time that the shallow water Vorbourg and Röschenz (="Natica") Members were time-equivalent with the basinal Effingen Member. This assumption was based on fine-grained detrital quartz that occurs in all the three members. Bolliger & Burri (1967) adopted the view of Ziegler (1962, p. 42) that the quartz was of aeolian origin. This correlation was confirmed by the mineral stratigraphic correlations C – H by Gygi & Persoz (1986, Pl. 1A). Gygi (1995, Fig. 2) could further corroborate the correlation with three ammonites that were found by three different persons in the Günsberg Formation. The geographical range of the Röschenz Member, the Günsberg Formation and the Effingen Member is represented in the palaeogeographical map no. 6 in Gygi (1990c).

2.44 **Verena Member** (Desor & Gressly 1859)
Member of the Balsthal Formation
Synonymy: Gygi (2000b, p. 62)

The Verena Member was named by Desor & Gressly (1859, p. 75) "Calcaire blanc de Ste-Vérène". The name is derived from the hermitage of St. Verena 2 km north of Solothurn at coordinates 607.220/230.400, LK 1107 Balsthal. The site is depicted by Gygi (2000b, Fig. 36) and is to be considered as the type locality. Antenen (1995, Fig. 5) indicated that the Verena Member crops out in the northernmost part of the Verena gorge. Only the uppermost part (thickness: ca. 12 m) of the member is visible at the type locality.

Earlier authors disagreed about the interpretation of this unit (see discussion in Gygi 2000b, p. 63). The interpretation by Bolliger & Burri (1970, p. 74) turned out to be the best and was adopted by Gygi (2000b, figure 39 = figure 1 in this paper). The mean thickness of the member interpreted in this sense is 45 m (Gygi 2000b, p. 63). The member is mostly carbonate oolite with a complicated diagenetic history. Partial dolomitization and dedolomitization of the limestone blurred the oolitic texture in many localities so much that the rock may be mistaken for lime mudstone on freshly broken surfaces. Macrofossils are uncommon in the Verena Member. Locally, nerineid gastropods are abundant. Coral bioherms occur north of Lommiswil, Canton Solothurn and near Seehof, Canton Bern (see Gygi 2000b, p. 63). The proximal and the distal boundaries of the Verena Member are a transition. The delimitation against the Laufen Member below is indicated by a change in colour. The Laufen Member has a light brownish tinge, whereas the Verena Member above weathers with an almost pure white surface. The Laufen Member is typically well-bedded and the Verena Member is massive (Gygi 2000b, Fig. 35). The upper boundary of the massive Verena Member is conspicuous where the overlying Reuchenette Formation is well-bedded (Gygi 2000b, fig. 38). No ammonites are known from the Verena Member. Only the mineral stratigraphical correlations J and K by Gygi & Persoz (1986, Pl. 1A) indicate that the Verena Member is coeval with the Letzi Member in Canton Aargau which is of the Planula Chron.

2.45 **Villigen Formation** (Gygi 1969)

The name Villigen Formation was proposed by Gygi (1969, p. 68) and replaces the unit called Geissberg-Schichten by Moesch (1857, p. 57). Gygi's name is derived from the village of Villigen, Canton Aargau, LK 1070 Baden. The type locality is the rock called Schrannechopf at coordinates 657.700/264.080. This name does not appear on the map LK 1070. The type section RG 62 in Gygi (1969, Pl. 17) was assembled from several partial sections which are located on both sides of the small valley south of Schrannechopf (see Gygi 1969, p. 61/62). Gygi (1969, p. 67) excluded the Geissberg Member *sensu* Moesch (1863) from the Villigen Formation, because he thought it was only a regional limestone facies of the uppermost Effingen Member. Gygi & Persoz (1986, p. 407) corrected this erroneous correlation. They included the Geissberg Member *sensu stricto* (Moesch 1863) in the Villigen Formation and thereby made the formation easily mappable.

The Villigen Formation is 53.4 m thick in the type section. Bedded micritic limestone is the dominant lithology. The Crenularis Member and the Knollen Bed are glauconitic intercalations. Bivalves are common in the lower part of the formation in Canton Aargau whereas ammonites dominate in the upper part in northeastern Canton Aargau. Ammonites and siliceous sponges are the most abundant macrofossils of the formation in Canton Schaffhausen. The lower boundary of the formation is transitional and is in the upper Hypselum Subzone (Gygi 1995, Fig. 23). The upper boundary is well-defined between the pure limestone of the Villigen Formation below and the marly limestone of the Baden Member and the lowermost Schwarzbach Formation above. The upper boundary coincides with the top of the Galar Subzone to conclude of the numerous ammonites *Sutneria galar* (Oppel) mainly from section RG 239 at Summerhalde near Schaffhausen (Gygi 2000b, Pl. 13, Fig. 3). The Villigen Formation occurs in Canton Aargau, Canton Schaffhausen and in adjacent southern Germany.

2.46 **Vorbourg Member** (Ziegler 1962, *non* Greppin 1893)
Member of the Vellerat Formation
Synonymy: Gygi (2000b, p. 58)

Greppin (1893, p. 16) called the well-bedded limestones of the lowermost Reuchenette Formation near Delémont "Couches du Vorbourg". The type section would be RG 366 west of the Vorbourg chapel at Delémont, Canton Jura, LK 1086 Delémont (Pl. 23 in Gygi 2000b, beds no. 113–141). This was disregarded by subsequent authors. Ziegler (1962, p. 21), without knowledge of Greppin's name, again proposed a Vorbourg Member in the same section, but for a different unit. He stated that his unit was synonymous with the "Plattige Kalke" of Laubscher (1948, p. 9) and the "Plattenkalke" of Ziegler (1956, p. 51). But it is evident from plate II/15 by Ziegler (1962) that

he included the massive limestone of the uppermost St-Ursanne Formation at the type locality, on which the Vorbourg chapel is built, in his Vorbourg Member. This is bed no. 12 in section RG 366 which forms a prominent ridge through which leads the cut of the road along which Gygi (2000b, plate 23) measured his section RG 366. Ziegler (1962) also included the lowermost 6.2 m of the Röschenz Member in the Vorbourg Member. A consensus developed among subsequent authors that the name Vorbourg Member should be used *sensu* Ziegler (1962), but that it is to be restricted to what Ziegler (1956) called Plattenkalke. These are beds no. 13–24 in section RG 366 (Gygi 2000b, Pl. 23) which is the type section.

The Vorbourg Member *sensu stricto* is only 10–17 m thick. It consists of thick-bedded, mostly micritic, pure limestones. Fossils are rare. Oncoids, stromatolites, tidal channels and mud-cracked bedding planes, but no ammonites were recorded. The lower boundary is where the first distinct bedding plane, often with a limonite crust, appears above the massive Buix or Tiergarten Member, respectively. The upper boundary is where the first thick marl intercalation indicates the base of the Röschenz Member. The mineral stratigraphic correlation C by Gygi & Persoz (1986, Pl. 1A) is evidence that the Vorbourg Member is time-equivalent with the lowermost Effingen Member (Fig. 2). The Vorbourg Member occurs in northwestern Switzerland above the St-Ursanne Formation.

### 2.47 **Wangen Member** (Moesch 1867)
Member of the Villigen Formation

The name Wangen Member (Wangenerschichten) was proposed by Moesch (1867, p. 162). It refers to the village of Wangen west of Olten, Canton Solothurn, LK 1088 Hauenstein. According to Moesch (1867, p. 165), several old quarries at Wangen at coordinates ca. 632.330/244.080 are the type locality. The Wangen Member at the type locality is a local facies of porous, white, chalk-like limestone that Gygi (2000b, Fig. 39) assigned to the distal part of the Balsthal Formation (see this paper, Fig. 1) . This facies extends to Mt. Born west of Olten where it is represented by the beds 42 and 44 of section RG 21 on plate 18 in Gygi (1969). According to correlation J by Gygi & Persoz (1986, Pl. 1A), the age of the Wangen Member at the type locality is the early Planula Chron.

In Canton Aargau, Moesch (1867) assigned the limestones between the glauconitic Crenularis Member below and the slightly glauconitic Knollen Bed above to the Wangen Member. This is what he called "Caprimontanaschichten" and "Weisse Kalke" in 1863. The "Weisse Kalke" of Moesch (1863) are porous, white, chalk-like limestones, found by Gygi (1969, Pl. 19) to occur between Effingen, Bözberg, Mt. Geissberg and Würenlingen in northern Canton Aargau. The "Weisse Kalke" are a regional facies like that of the typical Wangen Member, but their occurrence is restricted to Canton Aargau. It is evident from plate 19 in Gygi (1969) that the chalk-like white limestones of Canton Aargau are below the Knollen Bed that coincides with correlation J by Gygi & Persoz (1986). The "Weisse Kalke" (Moesch 1863) in Canton Aargau are therefore older than the Wangen Member (Moesch 1867) at the type locality.

The name Wangen Member became well-known by way of the geological maps by Mühlberg. It can be read from the caption to the geological map of "Unteres Aare-, Reuss- und Limmat-Tal" by Mühlberg (1904) that this author included the Letzi Member of Moesch (1863) in his Wangen Member, probably because he could not find the excellent marker bed of the Knollen Bed. Gygi (1969, Pl. 17, section 62) measured the historically important section along the road from Villigen to Mt. Geissberg. He found that the road crosses the Knollen Bed at the elevation of ca. 525 m. Mühlberg (1905, p. 507) stated that the Crenularis Member crossed the road at this elevation and thereby included the typical white limestone below the Knollen Bed in his Crenularis Member. The Wangen Member of Mühlberg (1904) in this section includes the Knollen Bed as well as the Letzi, Baden and lower Wettingen Members, but not the Wangen Member of Moesch (1867) (see discussion by Gygi 1969, p. 71). Gygi (1969) and Gygi & Persoz (1986) used the name Wangen Member like Moesch (1867), but only in Canton Aargau. The reference section of the member in this revised sense are beds 38–58 in section RG 62 at Villigen, Canton Aargau (Gygi 1969, Pl. 17) even though the member is not entirely exposed along the road. A complete section of the revised Wangen Member is accessible in the old quarry above the northern entrance of the Bözberg railway tunnel 2 km south of the village of Effingen, LK 1069 Frick. This is the unpublished section RG 57 at coordinates 650.220/258.150 (see Gygi 1969, Pl. 19).

The mean thickness of the Wangen Member *sensu* Gygi (1969) is 10–12 m. The member is a well-bedded, micritic, non-porous limestone with a light beige colour. The upper part of the member is a chalk-like, white and porous limestone only in the Bözberg-Geissberg area mentioned above. Bivalves are the most common macrofossils of the Wangen Member. No diagnostic ammonites were found by Gygi (1969). The member is between the mineral stratigraphical correlations I and J by Gygi & Persoz (1986, Pl. 1A). The lower boundary of the member is above the biostratigraphical correlation VII by these authors which is based on the ammonite *Epipeltoceras bimammatum* (Quenstedt) that is figured by Gygi (2000b, plate 10, figure 4). The upper boundary is marked by the Knollen Bed and coincides with the sequence boundary O 8 of Gygi *et al.* (1998). Gygi (1969, Pl. 16, section 82, bed 134) found the ammonite *Subnebrodites schroederi* (Wegele) of the Planula Chron half a meter above the Knollen Bed at Siblingen, Canton Schaffhausen, LK 1031 Neunkirch. It follows from this that the Küssaburg and the Wangen Members are of the Hauffianum Subchron although the ammonite *Taramelliceras hauffianum* (Oppel) was never found in Switzerland. The geographical range of the Wangen Member *sensu* Gygi (1969) is in northern Canton Aargau. The member is confined in the west by the Olten Member. North of the Rhine river the Wangen Member grades into the Küssaburg Member.

2.48 **Wangental Member** (Würtenberger & Würtenberger 1866). Member of the Villigen Formation

The Wangental Member (Wangental-Schichten) was named by Würtenberger & Würtenberger (1866, p. 32) after the valley called Wangental that extends from the German-Swiss border to the west, to the village of Osterfingen, Canton Schaffhausen, LK 1031 Neunkirch. The authors did not designate a type locality. Gygi (1969, Pl. 16, section RG 78) measured a section that begins at coordinates 679.125/277.450, 2 km south of Osterfingen in the eastern branch of Mülitobel, a small valley on the south side of Wangental valley. In this section, the Wangental Member is exposed with its base and top. Section RG 78 can therefore be regarded as the type section of the Wangental Member.

The Wangental Member is 24.6 m thick in the type section. According to Gygi (1969, Pl. 19), the thickness increases from the type section to the north-northeast and is about 40 m at Immendingen southwest of Tuttlingen in southern Germany (section RG 91 in Gygi 1969, Pl. 19). The member consists of well-bedded, micritic limestones with marly seams between the limestone beds. The marly interbeds can be as thick as 45 cm as for instance bed 65 of the type section. The lower boundary of the member is at the top of the glauconitc Knollen Bed. The upper boundary is where the succession becomes marly and weathers back (see section RG 239 at Summerhalde near Schaffhausen in Gygi 1990b, p. 69). The prevailing macrofossils are ammonites. *Subnebrodites schroederi* (Wegele) was found near the base of the member in section RG 82 near Siblingen, Canton Schaffhausen (specimen mentioned *in* Gygi 1969, plate 16, bed 134) which is figured in Gygi (2000b, Pl. 13, Fig. 4). *Sutneria galar* (Oppel) occurs in the type section near the top of the member (mentioned *in* Gygi 1969, Pl. 16, section RG 78, bed 87). The Wangental Member thus represents the Planula Chron. It is the time equivalent of the Letzi Member in Canton Aargau. The Wangental Member occurs in the Klettgau valley and in the Randen hills and can be traced from there to the Swabian Alb in southern Germany. North of the Rhine river it grades into the Letzi Member of Canton Aargau.

2.49 **Wettingen Member** (Moesch 1867)
Member of an unnamed Formation

Moesch (1867, p. 193) introduced the Wettingen Member (Wettingerschichten) into the stratigraphical literature. The name is derived from the township of Wettingen southeast of Baden, Canton Aargau, LK 1070 Baden. Moesch (1867) did not designate a type locality, but on page 195 he wrote that the debris of the landslide of 1718 at the locality Berg northeast of Wettingen consisted mainly of limestone blocks of the Wettingen Member. This seems to be the locality from which he collected most of his macrofossils from that member. The locality Berg cannot be rated as type locality, because it is not an outcrop. The Wettingen Member is an erosion relict everywhere in Canton Aargau. The stratigraphical upper boundary of the unit is therefore nowhere preserved.

Gygi (1969) did not measure long sections of the Wettingen Member. His sections RG 62 on Mt. Geissberg southwest of Villigen and RG 70 in the large quarry of Mellikon, both in Canton Aargau, include only the lowermost part of the member. At the base of the member is well-bedded micritic limestone in both sections. The ammonite *Idoceras balderum* (Oppel) occurs in both sections in the well-bedded micrite at the base of the member. The specimen from bed 124 in section RG 62 at Villigen, Canton Aargau, is figured *in* Gygi (2000b, Pl. 14, Fig. 3). This ammonite proves that the base of the Wettingen Member is in the lower Divisum Zone of the Kimmeridgian Stage in Canton Aargau. The typical Wettingen Member occurs only in Canton Aargau and in western Canton Zürich at the eastern end of Mt. Lägeren.

2.50 **Wildegg Formation** (Gygi 1969)

The Wildegg Formation was proposed by Gygi (1969, p. 64). The name refers to the village of Wildegg (which is a part of the township of Möriken), Canton Aargau, LK 1089 Aarau. The type sections were at the time RG 37 in the quarry of Jakobsberg east of the village of Auenstein and a borehole (RG 37a) north of Gerstenhübel hill on the territory of Veltheim, Canton Aargau. The road cut through Steibitz (a name which is not mentioned on LK 1089 Aarau) from the quarry of Jakobsberg to the quarry of Unteregg was opened up later. The quarry of Unteregg and the road cut are section RG 226 that was published by Gygi (1973, Fig. 3). The type section of the formation is now composed of section RG 226 in the lower part and RG 37 in the upper part of the Wildegg Formation.

The thickness of the Wildegg Formation was measured to be 215 m at the type locality. It grows to about 265 m near Riniken, Canton Aargau. This is the greatest known thickness of the formation (Gygi 1990c, Fig. 6). The Birmenstorf Member below has a thickness of only 4.5 m at Veltheim. This member is a succession of micritic limestones and marls with a mass occurrence of siliceous sponges and abundant ammonites. In the lowermost 10 m of the Effingen Member above, siliceous sponges can also be abundant. This makes the delimitation of the two members difficult. The Effingen Member is mostly blue-gray marl. Intercalated are successions of marly or pure limestones. The thickest and purest limestone succession is that of the mappable Gerstenhübel Beds (see above). The lower boundary of the Wildegg Formation is clear-cut where the Birmenstorf Member is present. The upper boundary is mostly transitional. Sedimentation of the formation began at a low rate in a water depth that was greater than 100 m (Gygi 1999, Fig. 2). This is documented by the rich macrofauna of siliceous sponges and ammonites in the Birmenstorf Member. The upper Effingen Member was laid down at a much greater rate. Because of this, the water depth greatly decreased during deposition of the upper Effingen Member

(Gygi 1986, Fig. 3C). Macrofossils are therefore rare in the upper part of the member where microfossils prevail (Ghasemi et al. 1999, Gygi & Stumm 1965, Oertli 1959). The Effingen Member is heterochronous, because it consists of prograding clinoforms (Gygi & Persoz 1986, Pl. 1A). The geometry of these clinoforms is evidence that the water depth at the beginning of deposition of the Effingen Member was greater than 100 m, even when differential subsidence under sediment load is taken into account (Gygi 1986, Fig. 3B). At Péry, Canton Bern, the whole formation is of the Bifurcatus Chron. At Auenstein, Canton Aargau, the formation begins in the Transversarium Chron. Sedimentation ended in the Hypselum Subchron of the Bimammatum Chron as is indicated by the ammonite *Euaspidoceras hypselum* (Oppel) which is figured in Gygi (2000b, Pl. 10, Fig. 1). The Wildegg Formation can be traced from southeastern France through northern Switzerland to southern Germany.

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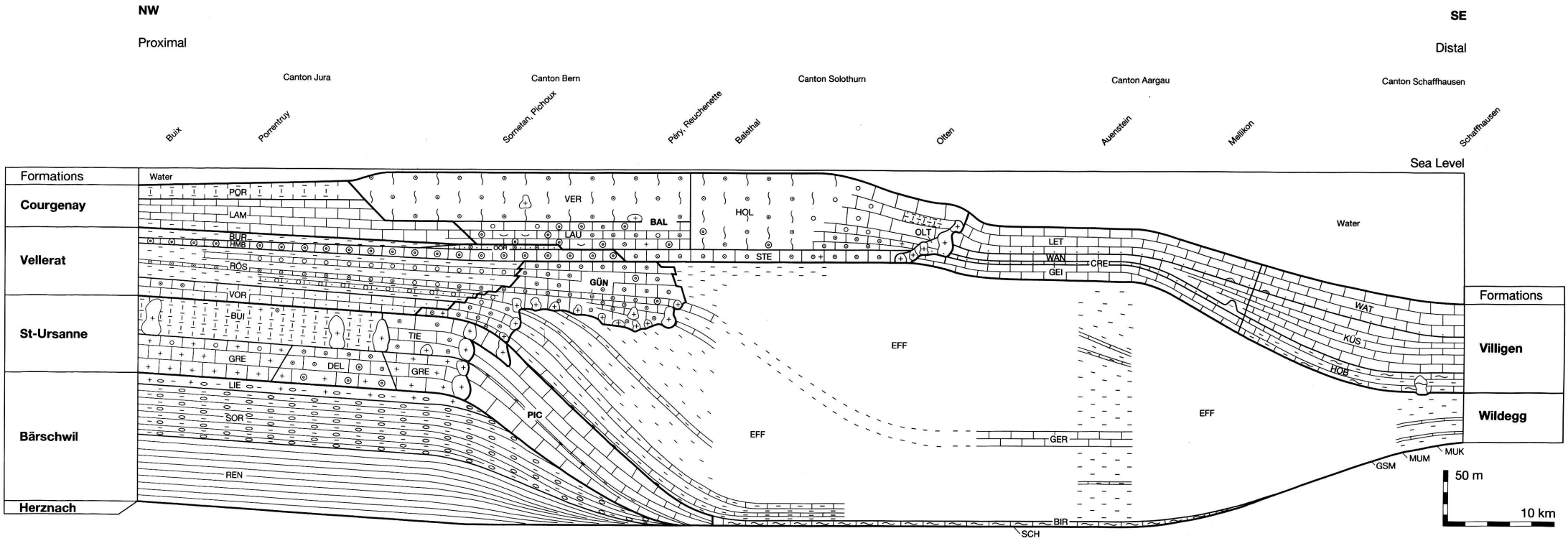


Fig. 1: Section perpendicular to depositional strike of the formations and members of the Oxfordian Stage in northern Switzerland. The upper surface of the section shows the calculated depositional profile at the end of the Oxfordian according to Gygi (1986). The depositional profile at the beginning of the Oxfordian was relatively flat and is represented in fig. 3A by Gygi (1986). The profile of the bottom of the section as drawn in this figure is the result of differential subsidence under a varying amount of sediment (Gygi 1986, fig. 3). Thicknesses are averaged and compacted.The age of the formations and members is indicated in fig. 2. Refigured from Gygi (2000b) with permission of Birkhäuser Verlag, Basel.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BAL | Balsthal Formation | GSM | Glaukonitsandmergel Bed | MUK | Mumienkalk Bed | STE | Steinebach Member |
| BIR | Birmenstorf Member | GÜN | Günsberg Formation | MUM | Mumienmergel Bed | TIE | Tiergarten Member |
| BUI | Buix Member | HMB | Hauptmumienbank Member | OLT | Olten Member | VER | Verena Member |
| BUR | Bure Member | HOB | Hornbuck Member | OOR | Oolithe rousse Member | VOR | Vorbourg Member |
| CRE | Crenularis Member | HOL | Holzflue Member | PIC | Pichoux Formation | WAN | Wangen Member |
| DEL | Delémont Member | KÜS | Küssaburg Member | POR | Porrentruy Member | WAT | Wangental Member |
| EFF | Effingen Member | LAM | La May Member | REN | Renggeri Member | WIL | Wildegg Formation |
| GEI | Geissberg Member | LAU | Laufen Member | RÖS | Röschenz Member | | |
| GER | Gerstenhübel Beds | LET | Letzi Member | SCH | Schellenbrücke Bed | | |
| GRE | Grellingen Member | LIE | Liesberg Member | SOR | Sornetan Member | | |

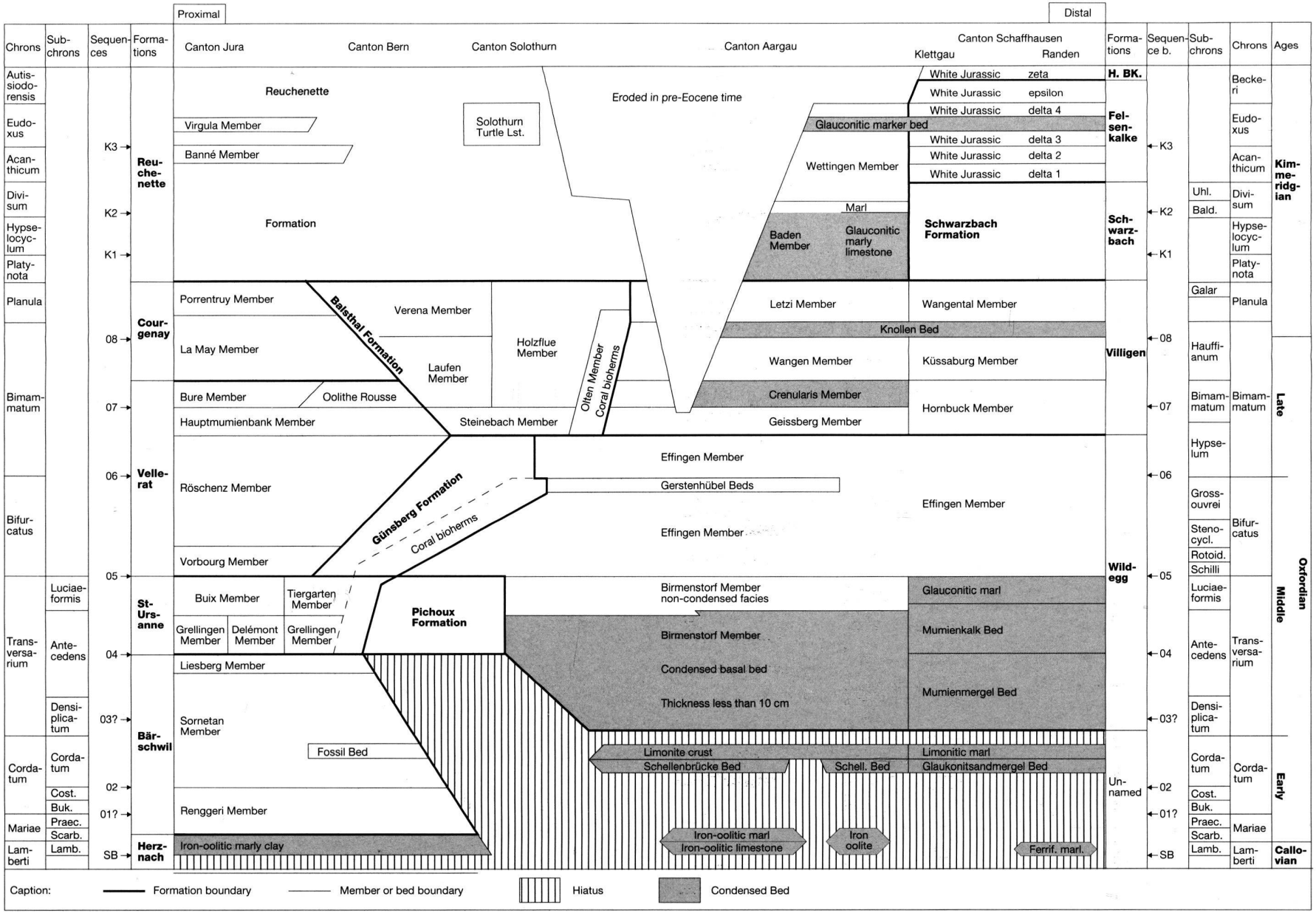


Fig. 2: Chronostratigraphic position of the formations, members and beds. Sequence boundaries from Gygi *et al.* (1998), where the full sequence stratigraphical interpretation can be found. Refigured from Gygi (2000b) with permission of Birkhäuser Verlag, Basel.