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The Staffelegg Formation: a new stratigraphic scheme for the Early Jurassic of northern Switzerland

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Abstract The deposits of the Early Jurassic in northern Switzerland accumulated in the relatively slowly subsiding transition zone between the southwestern part of the Swabian basin and the eastern part of the Paris basin under fully marine conditions. Terrigenous fine-grained deposits dominate, but calcarenitic and phosphorit-rich strata are intercalated. The total thickness varies between 25 and 50 m. In the eastern and central parts of N Switzerland, sediments Sinemurian in age constitute about 90% of the total thickness. To the West, however, in the Mont Terri area, Pliensbachian and Toarcian deposits form 70% of the total thickness. Stratigraphic gaps occur on a local to regional scale throughout N Switzerland. Such hiatus comprise a subzone to a stage in time. With respect to lithology and fossil content, the Early Jurassic deposits in northern Switzerland are similar to those in SW Germany. Nonetheless, an exact stratigraphic correlation is hardly possible, particulary in the southern and southwestern Folded Jura where distinct facies changes occur over short distances. Revised existing and new litho- and biostratigraphic data form the base to refine the stratigraphic subdivision of the deposits that have been informally called "Lias". The name Staffelegg Formation is suggested and defined as the mapping unit for the Early Jurassic. The Staffelegg Formation is introduced for Early Jurassic sediments in northern Switzerland between the Doubs River and Mt. Weissenstein in the west and the Randen Hills located north of the city of Schaffhausen in the east. The Staffelegg Formation starts within the Planorbis zone of the Hettangian. The upper boundary to the overlying Aalenian Opalinus-Ton is diachronous. The lithostratigraphic names previously in use have been replaced by new ones, in accordance within the rules of lithostratigraphic nomenclature. The Staffelegg Formation comprises 11 members and 9 beds. Several of these beds are important correlation horizons in terms of allostratigraphy. Some of them correspond to strata or erosional unconformities encountered in the Swabian realm, some of them can be correlated with strata in the Paris basin. The facies transition to the Paris basin is expressed by introduction of a corresponding lithostratigraphic unit.

Keywords Jura Mountains · Staffelegg Formation · Rhaetian · Lias · Lithostratigraphy · Allostratigraphy · Chronostratigraphy

Zusammenfassung Die Sedimente des Früh-Juras der N-Schweiz wurden in dem insgesamt etwas langsamer subsidierenden Übergangsbereich zwischen dem südwestlichen Teil des Schwäbischen Beckens und dem Pariser Becken unter vollmarinen Bedingungen abgelagert. Terrigenklastische Pelite herrschen vor, die von kalkarenitischen und phosphoritreichen Einschaltungen untergliedert werden. Die Mächtigkeit des Früh-Juras variiert zwischen 25 und 50 m. Sedimente des Sinemuriums machen im östlichen und zentralen Bereich der N-Schweiz bis zu 90% der Mächtigkeit aus, nach Westen hingegen, im Mont-Terri-Gebiet, repräsentieren Sedimente des Pliensbachiums und

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Toarciums 70% der Mächtigkeit. Gebietsweise sind für bestimmte Zeitabschnitte des Früh-Juras keine Sedimente überliefert. Solche Hiatus können zeitlich eine Subzone bis Stufe umfassen. Die Abfolgen in der N-Schweiz ähneln hinsichtlich Lithologie und Fossilinhalt denen SW-Deutschlands, sind aber nur bedingt mit der südwestdeutschen stratigraphischen Nomenklatur in Einklang zu bringen, vor allem im Bereich des südlichen und westlichen Faltenjuras. Hier treten engräumig abrupte Fazieswechsel auf. Basierend auf revidierten, bestehenden und neuen litho- und biostratigraphischen Daten wird für die Schichtfolge, die bisher informell als "Lias" bezeichnet wurde, der Name "Staffelegg-Formation" vorgeschlagen und für die N-Schweiz als Kartiereinheit definiert. Die Staffelegg-Formation beginnt mit der Planorbis-Zone des Hettangiums. Die Grenze zur nächst jüngeren Formation, dem Opalinus-Ton, ist heterochron. Die bisher für die frühjurassischen Schichten verwendeten Bezeichnungen wurden durch neue, den heutigen Nomenklatur-Regeln konforme Namen ersetzt. Insgesamt werden für die Staffelegg-Formation 11 Member und 9 Bänke definiert. Etliche dieser Bänke sind im Sinne der Leitflächen-Stratigraphie wichtig: Ein Teil von ihnen lässt sich mit Schichten oder Erosionshorizonten im Schwäbischen Becken korrelieren, ein anderer Teil mit Horizonten im Pariser Becken. Der Faziesübergang zum Pariser Becken führt im westlichen Untersuchungsgebiet zu einer entsprechend angepassten lithostratigraphischen Untergliederung.

Résumé Les dépôts du Jurassique inférieur du nord de la Suisse se sont accumulés dans la zone de transition, en lente subsidence, entre la partie sud-ouest du bassin de Souabe et la partie orientale du bassin de Paris, dans des conditions entièrement marines. Les dépôts terrigènes pélitiques dominent; des couches calcarénitiques et riches en phosphates y sont intercalées. L'épaisseur de ces dépôts varie entre 25 et 50 mètres. Dans les parties orientale et centrale du nord de la Suisse, les sédiments d'âge Sinémurien constituent 90% de cette épaisseur, alors qu'à l'ouest, dans la région du Mont Terri, ceux du Pliensbachien et du Toarcien en constituent 70%. Des lacunes stratigraphiques apparaissent à l'échelle locale et régionale dans tout le nord de la Suisse. Ces hiatus vont de la sous-zone à la étage. Les sédiments du Jurassique inférieur du nord de la Suisse sont similaires à ceux du sud-ouest de l'Allemagne du point de vue lithologique et de leurs fossiles. Une corrélation stratigraphique exacte est cependant difficilement possible, en particulier dans les parties sud et sud-ouest du Jura plissé où de nets changements de faciès apparaissent sur de courtes distances. Sur la base de données litho- et biostratigraphiques existantes et révisées ou nouvelles, nous proposons, pour désigner ces séries appelées jusqu'à présent de manière informelle "Lias", le nom de "Formation de la Staffelegg", qui servira dorénavant d'unité cartographique. Cette formation commence dans la Zone à Planorbes de l'Hettangien. La limite avec les Argiles à Opalinus aaléniennes sus-jacentes est hétérochrone. Les appellations utilisées jusqu'à présent pour ces séries du Jurassique inférieur ont été remplacées par de nouveaux noms en conformité avec les règles de nomenclature qui prévalent de nos jours. Au total, 11 membres et 9 bancs ont été définis pour la Formation de la Staffelegg. Plusieurs de ces bancs représentent d'importants horizons de corrélation en terme de stratigraphie séquentielle: certains correspondent à des couches ou surfaces d'érosion qui se retrouvent dans le bassin de Souabe, d'autres avec des horizons du bassin de Paris. La transition de faciès en direction du bassin de Paris requiert une subdivision lithostratigraphique adaptée en conséquence.

Institutional abbreviations

CTB	Collection of Thomas Bolinger (Olsberg/AG)
FPJ	(collection of the) Fondation Paléontologique Jurassienne, Glovelier/JU
IGUB	(collection of the) Institut für Geologie der Universität Bern
NMB	(collection of the) Naturhistorisches Museum Basel
NMO	(collection of the) Naturmuseum Olten

1 Introduction

1.1 History of Jurassic stratigraphy of northern Switzerland

The term Jurassic is directly linked to the Swiss Jura Mountains (Fig. 1). Alexander von Humboldt recognised the mainly limestone-dominated mountain range of the Swiss Jura Mountains as a separate formation that was not, at the time, included in the established stratigraphic system defined by Abraham Gottlob Werner and named it "Jurakalk" in 1795 (Hölder 1950, 1964). The separation of the term Jurassic into three sections goes back to von Buch (1839). Keferstein (1825), Thurmann (1832), Roemer (1836), and von Buch (1839) were the first who assigned the term "Lias", previously used in England, to the lowest part of the three Jurassic sections (for more details of the term Lias see Arkell 1956; Donovan and Hemingway 1963; Hains and Horton 1969).

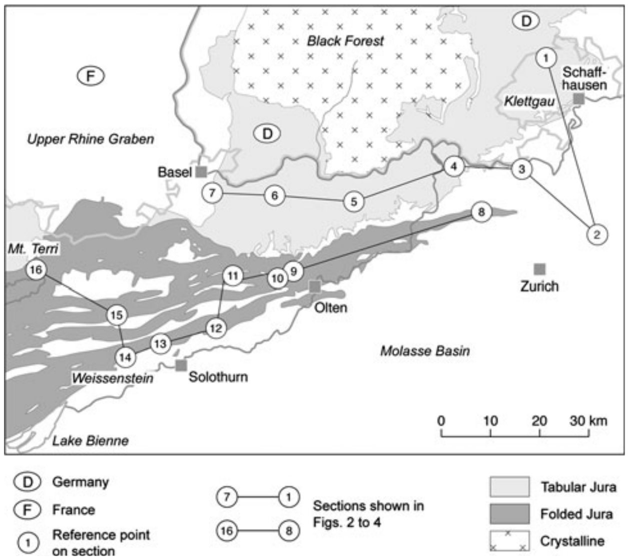


Fig. 1 Geological overview of the study area, situated in northern Switzerland, and legend of symbols used in Figs. 2, 3, 4

The Jurassic stratigraphy of northern Switzerland is closely linked to that of central and western Europe. Although related to the stratigraphic studies in central and western Europe, the Jurassic stratigraphy of northern Switzerland developed differently in many aspects. This is not only due to the more or less pronounced lithologic variations, compared to Mid- and Western Europe, but also to the fact that Switzerland is a multilingual country (Rominger 1846; Studer 1853, 1872; Moesch 1857; Disler 1941; Schweizerische Geologische Kommission, Arbeitsgruppe für Stratigraphische Terminologie 1973). The following institutions have had a considerable influence on Swiss stratigraphic nomenclature:

a) Büro der Schweizerischen Geologischen Kommission (later Geologische Landesaufnahme): Einheitslegende für den Geologischen Atlas der Schweiz 1:25,000 (cf. Lang 1892; Aeppli 1915; Buxtorf and Schwarz 1960),
b) Schweizerische Geologische Kommission, Arbeitsgruppe für Stratigraphische Terminologie (1973) and
c) Schweizerisches Komitee für Stratigraphie (SKS; Remane et al. 2005).

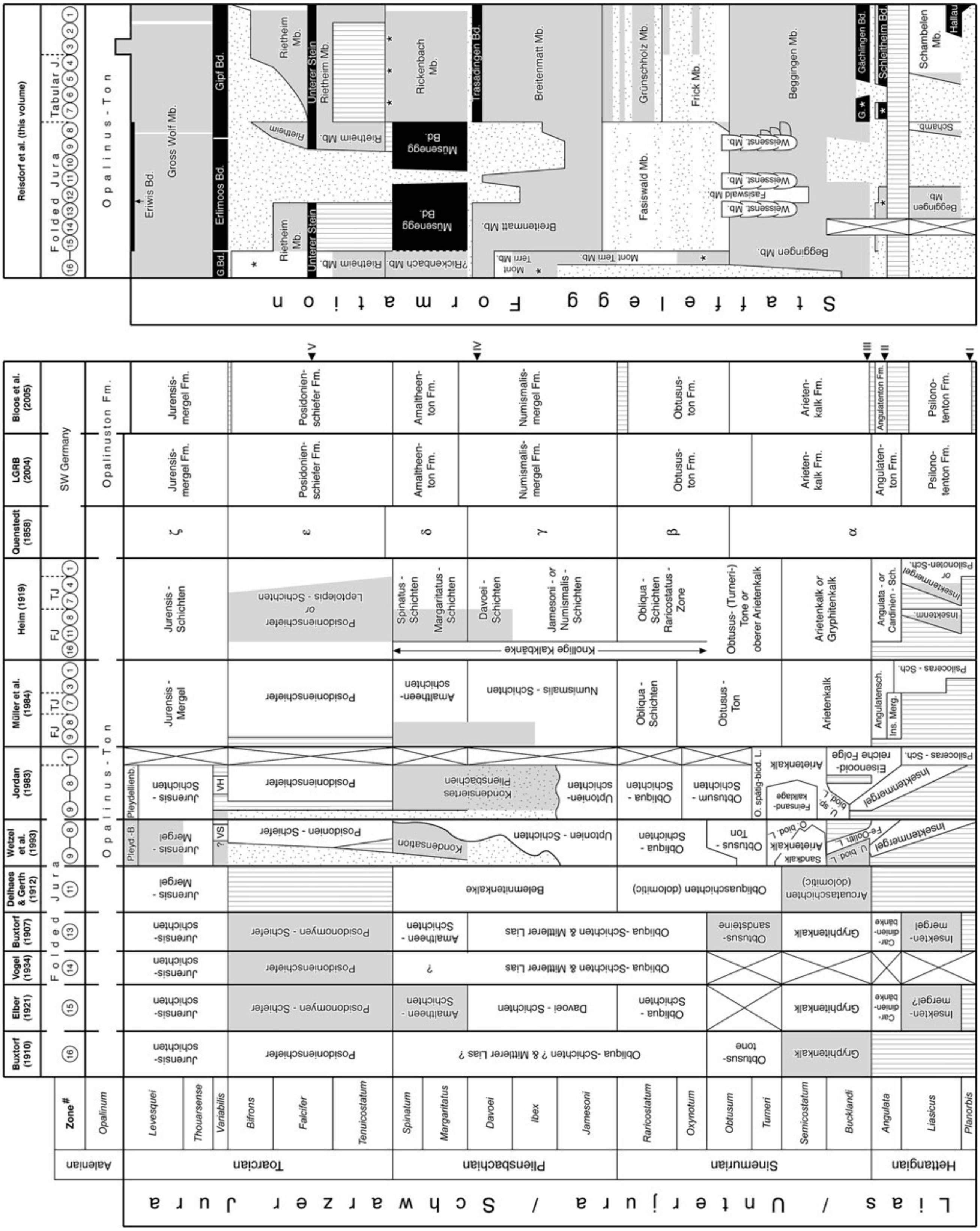
Since Hedberg (1976), the International Commission on Stratigraphy has decided on an internationally valid standard for the stratigraphic classification of rocks that is based on a clear lithostratigraphic concept. The Swiss Committee of Stratigraphy (SKS) has a mandate to enforce this concept in Switzerland (Remane et al. 2005). The Swiss Committee of Stratigraphy receives support in this from the Swiss Geological Survey, which, in turn, is responsible for the publishing of geological maps. Both institutions have a shared responsibility for establishing a database (under development) that is linked to the internet, which names from the Swiss stratigraphy and their validity can be queried (www.stratigrahie.ch).

Unlike in Germany and France, the Early Jurassic stratigraphy in northern Switzerland is mainly based on geological mapping and less on palaeontological studies and, therefore, on lithostratigraphy. The first stratigraphic subdivision of the northern Swiss Mesozoic was established by Peter Merian (1821, 1831). Reflecting his education by Johann Friedrich Ludwig Hausmann at the University of Göttingen, his stratigraphic concept was strongly influenced by the stratigraphic subdivision in northern Germany (Buxtorf 1940). In contrast, Thurmann (1832, 1836) and Gressly (1841, 1853) followed the stratigraphy used in France and England.

Reflecting the pioneering litho- and biostratigraphic studies of Quenstedt (1843, 1858) and Oppel (1856–1858), stratigraphy established in southwestern Germany increasingly influenced that in northern Switzerland (e.g., Rominger 1846; Heer 1852; Marcou 1857a, b; Waagen 1864; Greppin 1870; Mathey et al. 1872). Nonetheless, some elements of the French stratigraphic subdivision were kept (e.g., Gressly 1853; Desor 1856; Rollier 1898; Tobler 1905; Leuthardt 1933). Because of the lack of a uniform nomenclature, French and German terms were mixed along the borders between western and northern Switzerland (e.g., Gressly 1853; Studer 1853, 1872; Mayer-Eymar 1864).

Another attempt to establish a uniform and generally applicable stratigraphical subdivision was the legend for the "Geologischer Atlas der Schweiz 1:25'000", since 1930 (Buxtorf and Schwarz 1960). At this time, the deposits of the Opalinum zone were included in the Liassic (i.e. "Lias"), in accordance with the French nomenclature (e.g., Frank 1930; Bureau der Geologischen Kommission 1936). Later, the mapping unit "Lias" was extended to include the sediments of the Rhaethian as well (e.g., Buxtorf and Christ 1936; Tschopp 1960). However, this use was not made mandatory for all of Switzerland (e.g., Disler 1941; Buser 1952).

During the International Congress on the Jurassic in Luxemburg (1962, Colloque du Jurassique à Luxembourg), a standard stratigraphic subdivision of the Jurassic was recommended. Biostratigraphically, the Liassic spans the period from the Hettangian to the Toarcian (i.e. Planorbis to the Levesquei zone after Dean et al. 1961; see Hölder 1963). According to this definition, the Liassic was biostratigraphically shorter than the Early Jurassic, which also includes the Planorbis to Concavum zones (Hettangian to Aalenian; e.g., Hölder 1962, 1963). Later, in 1967 at the "Colloque du Jurassique à Luxembourg", it was decided to establish a biostratigraphic range for the Early Jurassic


Reisdorf et al. (this volume)
Folded Jura
Tabular J.
Opalinus - Ton
Staffelegg Formation
Gross Wolf Mb.
Eriwis Bd.
Erlimoos Bd.
Gipf Bd.
Rietheim Mb.
Unterer Stein
Rickenbach Mb.
Müsenegg Bd.
Trasadingen Bd.
Breitenmatt Mb.
Grünschholz Mb.
Frick Mb.
Fasiswald Mb.
Beggingen Mb.
Weissenst. Mb.
Mont Terri Mb.
Gächlingen Bd.
Schleitheim Bd.
Schambelen Mb.
Hallau
Bloos et al. (2005)
LGRB (2004)
SW Germany
Opalinuston Fm.
Jurensismergel Fm.
Posidonienschiefer Fm.
Amaltheenton Fm.
Numismalismergel Fm.
Obtususton Fm.
Arietenkalk Fm.
Angulatenton Fm.
Psilonotenton Fm.
Quenstedt (1858)
Heim (1919)
Müller et al. (1984)
Jordan (1983)
Wetzel et al. (1993)
Delhaes & Gerth (1912)
Buxtorf (1907)
Vogel (1934)
Eiber (1921)
Buxtorf (1910)
Zone#
Opalinum
Levesquei
Thouarsense
Variabilis
Bifrons
Falcifer
Tenuicostatum
Spinatum
Margaritatus
Davoei
Ibex
Jamesoni
Raricostatum
Oxynotum
Obtusum
Turneri
Semicostatum
Bucklandi
Angulata
Liasicus
Planorbis
Aalenian
Toarcian
Pliensbachian
Sinemurian
Hettangian
Lias / Unterjura / Schwarzer Jura

◀ **Fig. 2** Names of the Early Jurassic rocks ("Lias") and its subunits previously in use (for legend see Fig. 3). Fe-Oolith. L. = Fe-Oolithische Lagen; FJ = Folded Jura; G. = Gächlingen Bed; G.Bd. = Gipf Bed?; Ins. Merg., Insektenm. = Insektenmergel; O. biod. L. = Obere Biodetritische Lage; O. spätig-biod. L. = Obere spätig-biodetritische Lagen; Pleyd.-B. = Pleydellien-Bank; Pleydellienb. = Pleydellienbank; Schamb. = Schambelen Member; Sch., -sch. = Schichten; TJ = Tabular Jura; U. biod. L. = Untere Biodetritische Lage; U. sp. biod. L. = Untere spätig-biodetritische Lagen; VH = Variabilis-Horizont; VS = Variabilis-Schichten; # = zones sensu Dean et al. (1961), sensu Bloos (1979) and sensu Schlegelmilch (1992); I = Psilonotenbank (e.g., LGRB 2004; Bloos et al. 2005; Etzold et al. 2010); II = Oolithenbank (e.g., Schloz 1972; Bloos et al. 2005; Schmid et al. 2008); III = Kupferfelsbank (e.g., LGRB 2004; Schmid et al. 2008); IV = Davoei-Bank (e.g., Schlatter 1991; LGRB 2004); V = Unterer Stein (e.g., Urlichs 1977; Röhl and Schmid-Röhl 2005); * = likely

congruent to that of the Liassic (i.e. Planorbis to Levesquei zone; Hallam 1975). This stratigraphic nomenclature reached consensus in Switzerland with the foundation of the Arbeitsgruppe für Stratigraphische Terminologie in 1971 (now: Schweizerisches Komitee für Stratigraphie).

The majority of lithostratigraphic terms of the N Swiss Early Jurassic that are in use today were adapted from the stratigraphy of SW Germany (cf. Studer 1872; Buser 1952; Waibel and Burri 1961; Fischer 1969; Müller et al. 1984). Literature from the nineteenth and twentieth centuries contains a large number of names and definitions that differ more or less significantly from the French or SW German nomenclature (Fig. 2). The few of these that became widely known, or were established in the last few years, are shown in Figs. 2 and 4.

To fulfill the rules of stratigraphic nomenclature, it is suggested to introduce the Staffelegg Formation for the strata previously subsumised as "Lias" (Fig. 3). In the stratigraphic scheme suggested here, the individual lithostratigraphic units are all dated chronostratigraphically. With the exclusive use of a chronostratigraphic hierarchy for the terms of geochronology, we are following the nomenclature of the Swiss Committee of Stratigraphy (Remane et al. 2005).

1.2 Palaeogeography and Early Jurassic stratigraphy

The continuous improvement of palaeogeographic reconstructions influenced the stratigraphic classification in northern Switzerland until now. Heer (1865) undoubtedly introduced the most lasting scheme for the Early Jurassic in northern Switzerland but also for the neighbouring areas in southern Germany (e.g., Altmann 1965; Jordan 1983; Schlatter 1990).

Investigation of the Late Triassic and the boundary to the Early Jurassic in northern Switzerland also had a significant influence on the palaeogeographic concepts for the Early Jurassic (e.g., Erni 1926; Hölder 1964; and references therein). It was discussed whether the sandy sediments of the Rhaetian in N Switzerland are Rhaetian or Early Jurassic in age (e.g., Rollier 1898, 1917; Buxtorf 1907 vs. Erni 1910, 1926). Furthermore, the absence of marine Rhaetian sediments in large areas of N Switzerland (Fig. 5) has been interpreted as a stratigraphic gap or caused by later erosion (e.g., Erni 1910 vs. Buxtorf 1907, 1910; Schalch and Peyer 1919; Etzold and Schweizer 2005; Etzold et al. 2010).

The stratigraphic and palaeogeographic considerations were the base to reconstruct the land-sea distribution in Germany and Switzerland in Rhaetian to Sinemurian times (Ehrat 1920; Pratje 1924; Rüger 1924). Particularly the direction of the transgression of the Early Jurassic sea was discussed for a many years (e.g., Wepfer 1925; Hölder 1964). This dispute, known in the literature as the "Stratigrapher War" (Wetzel 1932), chiefly concerned Vollrath's (1924) hypothesis, which, based on the use of the index fossil method, posited that Early Jurassic sediments could not be subdivided into individual biostratigraphic units but could, instead, be grouped into contemporaneous faunal provinces. During and after the 2nd World War, stratigraphic studies on the Triassic-Jurassic boundary in northern Switzerland were restricted to a local geological scale (e.g., Vonderschmitt 1941; Peyer 1943a, b, 1956). The methodological argument was finally provided by Walliser (1956a, b), based on results found in SW Germany, and he proved the opponents of Vollrath's hypothesis right.

2 Materials and methods

While revising the stratigraphy of the Early Jurassic strata in northern Switzerland, the joint subdivision of stratigraphic succesions into lithofacies units and quasi time units was used (see Lutz et al. 2005). Because of the large number of coexisting homonyms (e.g., *Insektenmergel, Obliqua-Schichten*; see Fig. 4) and synonyms (e.g., *Davoei-Schichten, Numismalis-Schichten, Belemnitenkalke*; see Figs. 2, 3), new, unencumbered names for the individual lithostratigraphic units were introduced.

The new stratigraphic subdivision of the northern Swiss Early Jurassic strata is based on data from many different sources (see Table 1). The most significant and high quality data comes from the Klettgau area, Tabular Jura and the eastern Folded Jura. By contrast, because of the rare outcrops, there are only patchy data from the Bernese Jura and Mont Terri area. Based on new and hitherto unpublished sections, and new and revised biostratigraphic data (ammonites, ostracodes), the chrono- and lithostratigraphic

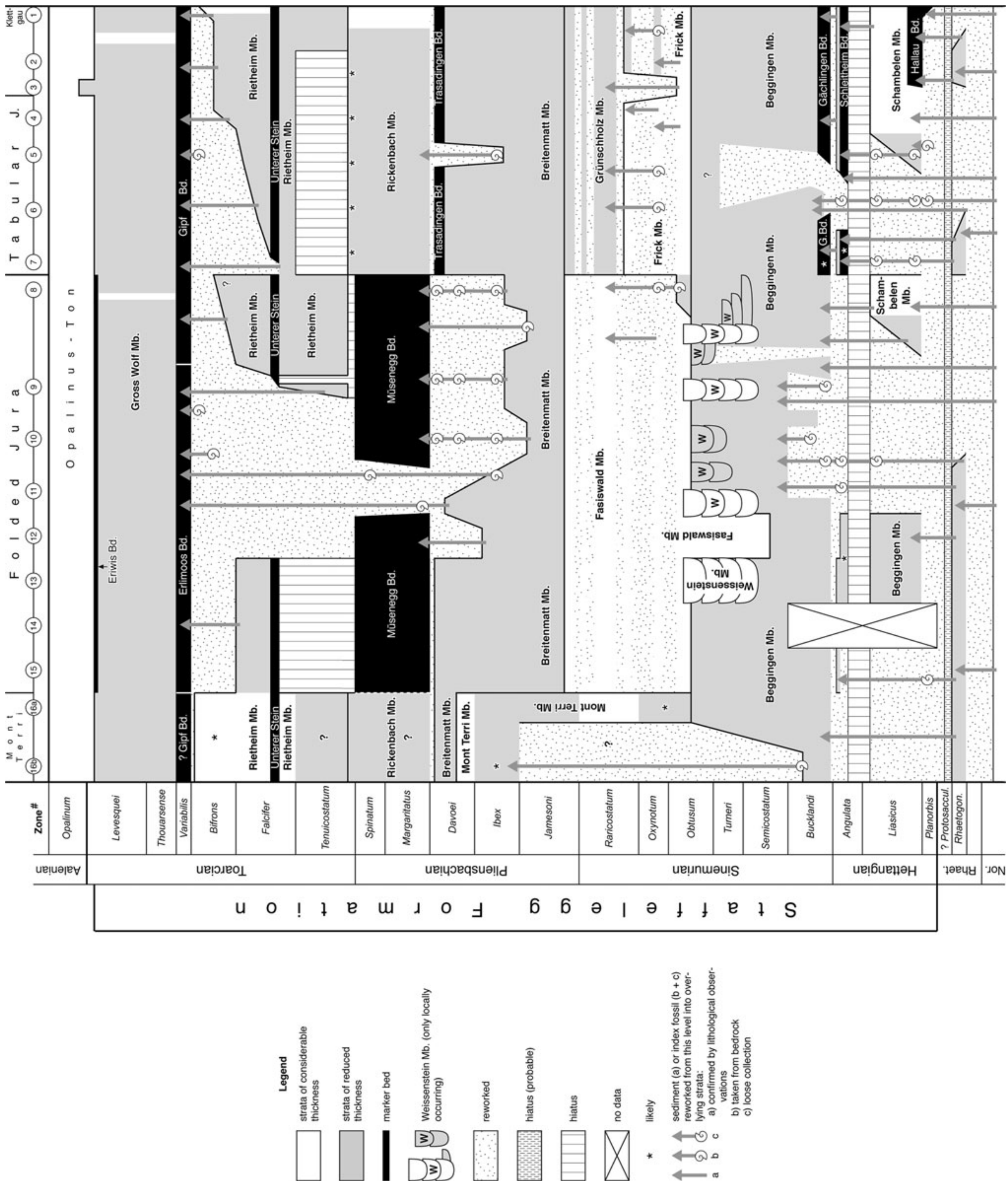
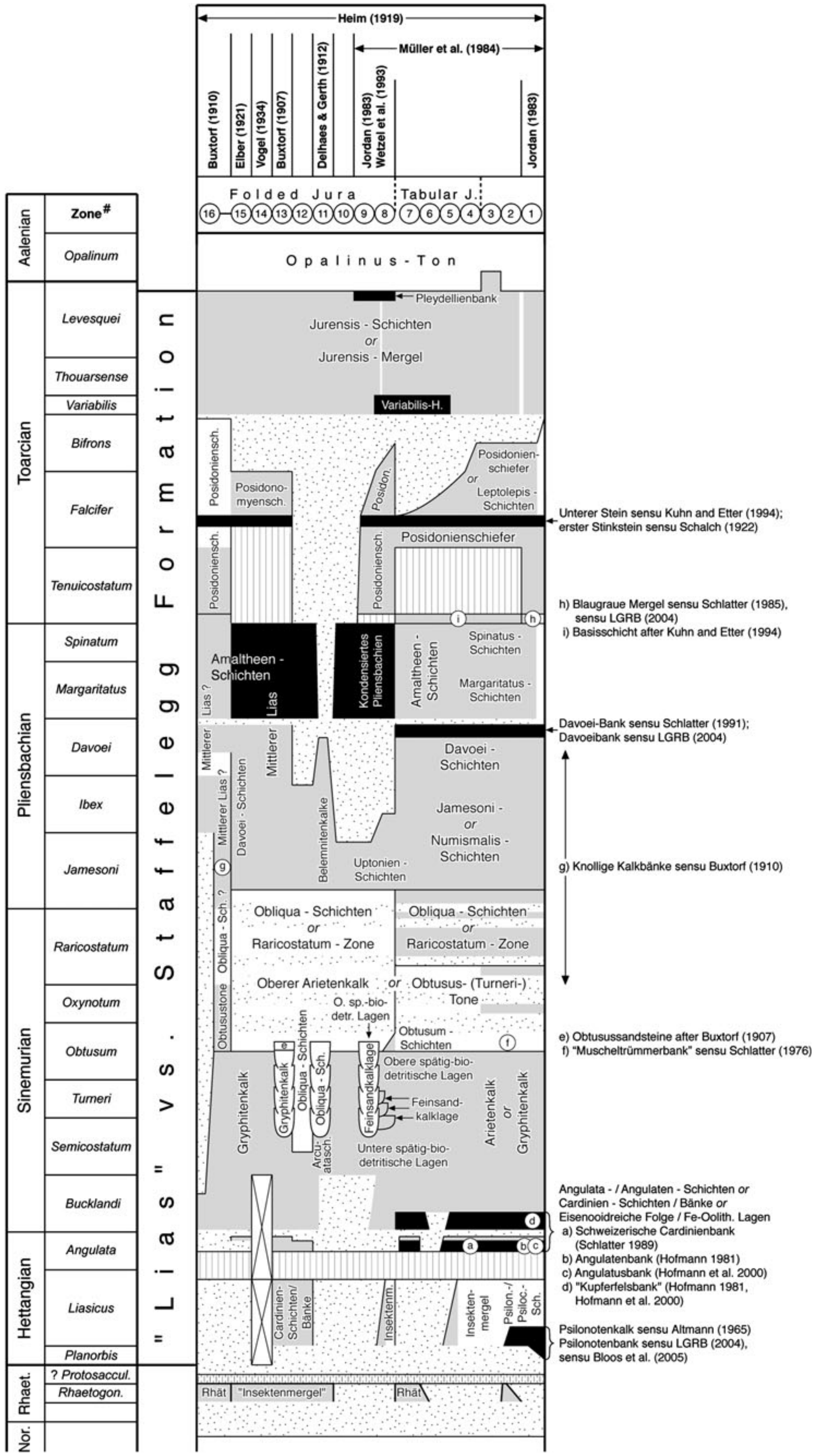


Fig. 3 Early Jurassic biostratigraphy and lithostratigraphy of northern Switzerland. Nor. = Norian; ? Protosaccul. = ? Protosacculina; Rhaet. = Rhaetian; Rhaetogon. = Rhaetogonyaulax; # = zones sensu Dean et al. (1961), sensu Bloos (1979), sensu Brenner (1986) and sensu Schlegelmilch (1992); see also Beutler et al. (2005), von Hillebrandt and Krystyn (2009), Etzold et al. (2010). **1** Klettgau area; **2** Lindau well; **3** Weiach well; **4** eastern Tabular Jura; **5** eastern Aargau Tabular Jura (Fig. 7); **6** western Aargau Tabular Jura (Fig. 8); **7** Basel Tabular Jura (Fig. 9); **8–9** easternmost Folded Jura (Figs. 10, 11, 12); **9** Hauenstein area (see Figs. 13, 14, 15, 16); **10** Bölchen area (see Figs. 17, 18); **11** Passwang area (see Figs. 18, 19, 20, 21); **12** eastern Weissenstein area (see Figs. 22, 23); **13** Weissenstein area (see Fig. 24); **14** Grenchenberg area; **15** Moutier area (see Fig. 25); **16** Mont Terri area (**16a** eastern area: see Fig. 26; **16b** western area: see Fig. 27)

Fig. 4 Former unit names and their revised stratgraphic range (see also Fig. 3). Fe-Oolith. Lagen = Fe-Oolithische Lagen; Insektenm. = Insektenmergel; Nor. = Norian; O. biod. L. = Obere Biodetritische Lage; O. sp.-biodetr. Lagen = Obere spätig-biodetritische Lagen; Posidon./Posidoniensch. = Posidonienschiefer; ? Protosaccul. = ? Protosacculina; Psilon.-/Psiloc.-Sch. = Psilonoten-/Psiloceras-Schichten; Rhaet. = Rhaetian; Rhaetogon. = Rhaetogonyaulax; # = zones sensu Dean et al. (1961), sensu Bloos (1979), sensu Brenner (1986) and sensu Schlegelmilch (1992)



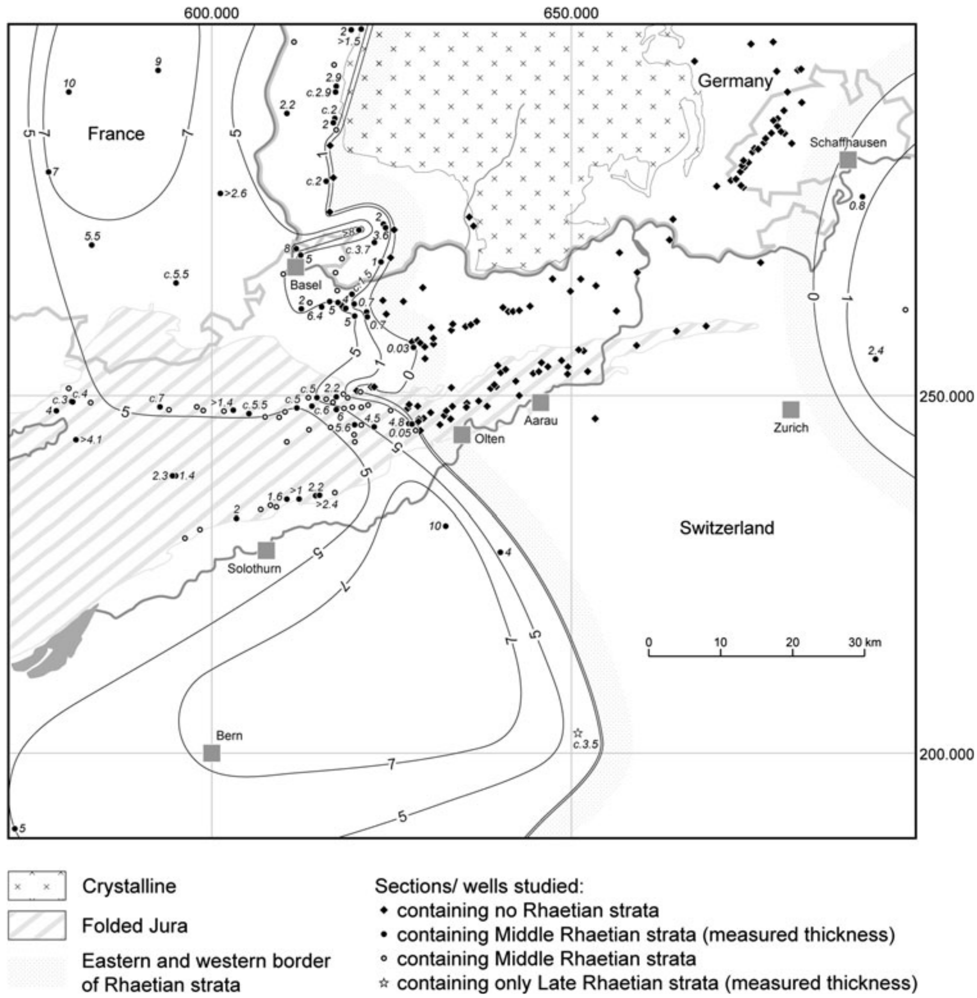


Fig. 5 Isopach map for the Rhaetian rocks in N Switzerland, SE France and SW Germany (data sources as given in Table 1)

classification of the stratigraphic inventory of the whole study area was specified more precisely.

In the past 60 years, knowledge about the facies and thickness of the northern Swiss Early Jurassic has been expanded by exploration wells drilled by the oil- and salt industry, geothermal projects, deep boreholes drilled by Nagra, ground water wells, large construction projects and also by outcrops that were made while economically exploiting Early and Middle Jurassic mudstones (e.g., Büchi et al. 1965; Hauber 1971; 2000; Meyer and Furrer 1995; Mumenthaler et al. 1997; Reisdorf 2001; Nagra 2001; Wetzel and Allia 2003; Häring et al. 2008). In addition, cores, cuttings and unpublished well data were used (see Table 1).

For biostratigraphic purposes, fossils stored in various collections were examined. Fossil finds related to the present stratigraphic scheme are mentioned in text and figures, respectively. In addition, several unpublished diploma and master theses from the Universities of Basel, Bern, Neuchâtel and Zürich, from 1957 to 2008, have been considered; most of them are listed in the publications by Andrey (1974), Jordan (1983), Kuhn and Etter (1994) and Meyer and Furrer (1995).

3 Staffelegg Formation

Names previously in use are given in Fig. 2.

Type locality Buessge (S Thalheim/canton Aargau; coord.: 646.925/253.050 and 649.750/253.000; Jordan 1983; Fig. 10; = section Kaltenbrunnen of Erni 1910: 43).

Underlying strata Knollenmergel/Obere Bunte Mergel or “Rhät” (Middle or Late Keuper).

Overlying strata Opalinus-Ton (Early to Middle Jurassic, Late Toarcian to Early Aalenian, Levesquei to Opalinum zone).

Subdivision in the Klettgau area and Tabular Jura (from base to top) Schambelen Member, Beggingen Member, Frick Member, Grünschholz Member, Breitenmatt Member, Rickenbach Member, Rietheim Member, Gross Wolf Member.

Subdivision in the eastern Folded Jura (from base to top) Schambelen Member, Beggingen Member, Frick Member, Fasiswald Member, Weissenstein Member, Breitenmatt Member, Rietheim Member, Gross Wolf Member.

Subdivision in the western Folded Jura (Mont Terri area; from base to top) Beggingen Member, Mont Terri Member, Breitenmatt Member, ?Rickenbach Member, Rietheim Member, Gross Wolf Member.

Occurrence Northern Switzerland.

Thickness Usually 25–50 m (Fig. 6).

Chronostratigraphic age Early to Middle Jurassic (Planorbis to Opalinum zone; Schlatter 1983a; Nagra 1989, 1990).

Description The Staffelegg Formation is a siltstone-marl-dominated heterogeneous, sedimentary succession. Additionally, limestones and subordinately also sandstones may occur especially in the Sinemurian part. In the Folded Jura, these sediments may make up the major portion of the Staffelegg Formation. Facies changes may occur within short distances in the Folded Jura. The Staffelegg Formation displays a small thickness compared to the occurrences of the Early Jurassic of southeastern France and southwestern Germany. A gradual decrease in thickness can be detected which continues from southwestern Germany into northern Switzerland (Fig. 6; Büchi et al. 1965; Müller et al. 1984).

4 Lithostratigraphic subunits of the Staffelegg Formation

4.1 Schambelen Member

Names previously in use are given in Figs. 2 and 4.

Type locality Schambelen (SW Brugg/canton Aargau; coord.: 659.310/257.000; e.g., Heer 1852; Jordan 1983; temporary exposure; excavation campaign at Schambelen

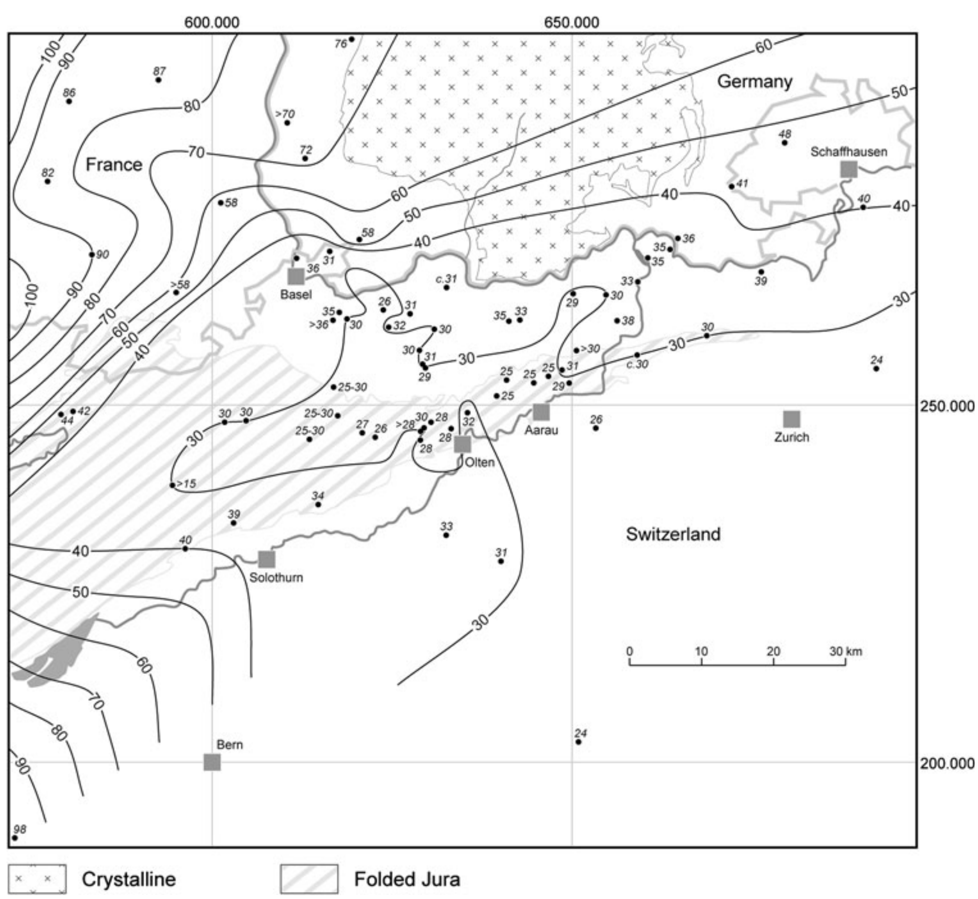
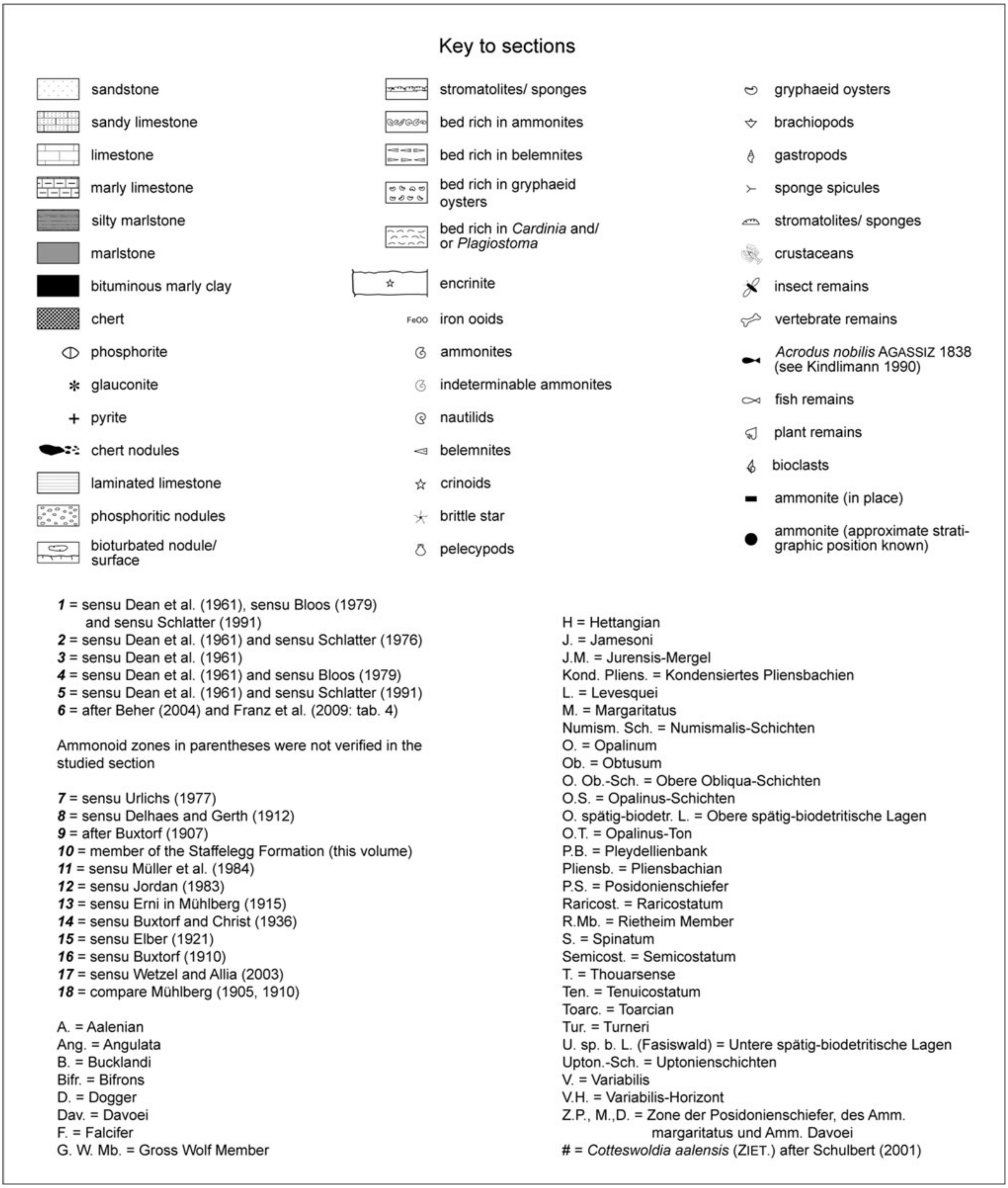


Fig. 6 Isopach map for the Early Jurassic rocks in N Switzerland, SE France and SW Germany (data sources as given in Table 1). Note that especially large uncertainties are attached to the thickness information from wells in the Molasse Basin and the Upper Rhinegraben (in particular for the determination of the Early to Middle Jurassic boundary, but also for the determination of the Early to Late Toarcian boundary; e.g., Pratje 1924; Théobald 1967; Lutz and Cleintuar 1999)



by the Natural History Museum Basel and the Geologisch-Paläontologischer Arbeitskreis Frick in 2004).

Underlying strata Knollenmergel (Zanclodonmergel)/ Obere Bunte Mergel or "Rhät" (Middle and Late Keuper, respectively; e.g., Frey 1969; Jordan 1983; Achilles and Schlatter 1986).

Overlying strata Beggingen Member or Weissenstein Member.

Subdivision Hallau Bed (only in the Klettgau area and in the Zürcher Weinland area at the base of the Schambelen Member).

Occurrence Klettgau area, Zürcher Weinland, Tabular Jura, eastern Folded Jura.

Thickness 0 to ca. 9 m (see Jordan 1983; Bitterli-Brunner and Fischer 1988; Nagra 1990, 1992).

Chronostratigraphic age Early to Late Hettangian (Planorbis to Liasicus zone; Fig. 10; Trümpy 1959; Schlatter 1983a, 1990; Achilles and Schlatter 1986; Maisch et al. 2008).

Description The Schambelen Member is mainly composed of marly terrigenous mudstone. Subordinate amounts of thin, sometimes bituminous, limestone and silt- and sandstone occur (Figs. 7, 10; see Schalch and Peyer 1919; Bader 1925; Jordan 1983; Nagra 2001). The boundary to the underlying strata is marked by an erosional unconformity (see Schalch and Peyer 1919; Altmann 1965; Achilles and Schlatter 1986). With exception of the Basel Tabular Jura, the basal portion of the Schambelen Member is bituminous, thin-bedded and has a carbonate content of 5–8% (see Tanner 1978; Jordan 1983; Schlatter 1983a). In the Klettgau area, this dark grey to black terrigenous mudstone is restricted to the Hallau Bed (= *schwarze, geradschiefrige, posidonienschieferähnliche Mergelschiefer* of Schalch and Peyer 1919; see Achilles and Schlatter 1986). Mudstone with these characteristics belongs to the Liasicus zone in the whole distribution area of the Schambelen Member, and, according to fossils found in Frick and the northern Klettgau area, possibly also to the Planorbis zone (= *Untere, bituminöse Insektenmergel* of Jordan 1983; Figs. 7, 10; Schlatter 1983a; Maisch et al. 2008). This mudstone becomes continuously greenish grey and slightly sandy upwards. The distinctive fine bedding and the bituminous content are then lost (= *Obere, schwaichelähnliche Insektenmergel* of Jordan 1983; Fig. 10). In the Klettgau area, a change to dark, greenish to brownish grey, silty to fine sandy mudstone without distinct fine bedding occurs above the Hallau Bed (= *Schwaichel*; Schalch and Peyer 1919). These sediments belong entirely to the Liasicus zone (Schlatter 1983a). To the Southwest, the Schambelen Member wedges out completely but is also present in the Basel Tabular Jura, although with a different facies (see Tanner 1978; Jordan 1983; Wetzel et al. 1993). There, this sediment is developed as dark grey to blackish, occasionally, fine sandy terrigenous mudstone containing pyrite; its biostratigraphic age was not yet determined unequivocally. Strübin (1901) listed a poorly preserved fragment of a questionable *Psiloceras* sp. from these unbedded sediments from the section Niederschönthal (= Schöntal, coord.: 621.650/261.700).

In addition, the lithostratigraphic affiliation of the limestone from the Gelterkinden—Sissach area, that contains ammonites of the Early Hettangian, is uncertain (*Psiloceras plicatulum* (Qu.), det. F. Wiedenmayer 1980 [NMB J 29354]; *Psiloceras* cf. *distinctum* (Pompecki), det. R. Zingg 1965 [NMB J 9787); *Psiloceras* (*Caloceras*) ex gr. *johnstoni hercynum* W. Lange, det. R. Schlatter 2006 [NMB J 33220; NMB J 33221; NMB J 33230; NMB J 33231]; cf. Berg 1961; Hölder 1964: 12; Bloos 1981).

4.1.1 Hallau Bed

Names previously in use are given in Fig. 4.

Type locality Hallau (Bratelen, Hallauerberg; canton Schaffhausen; coord.: 676.400/284.500; temporary exposure, see Achilles and Schlatter 1986).

Underlying strata Knollenmergel in the Klettgau area, "Rhät" in the Zürcher Weinland area (Middle and Late Keuper, respectively).

Overlying strata The Hallau Bed forms the base of the Schambelen Member.

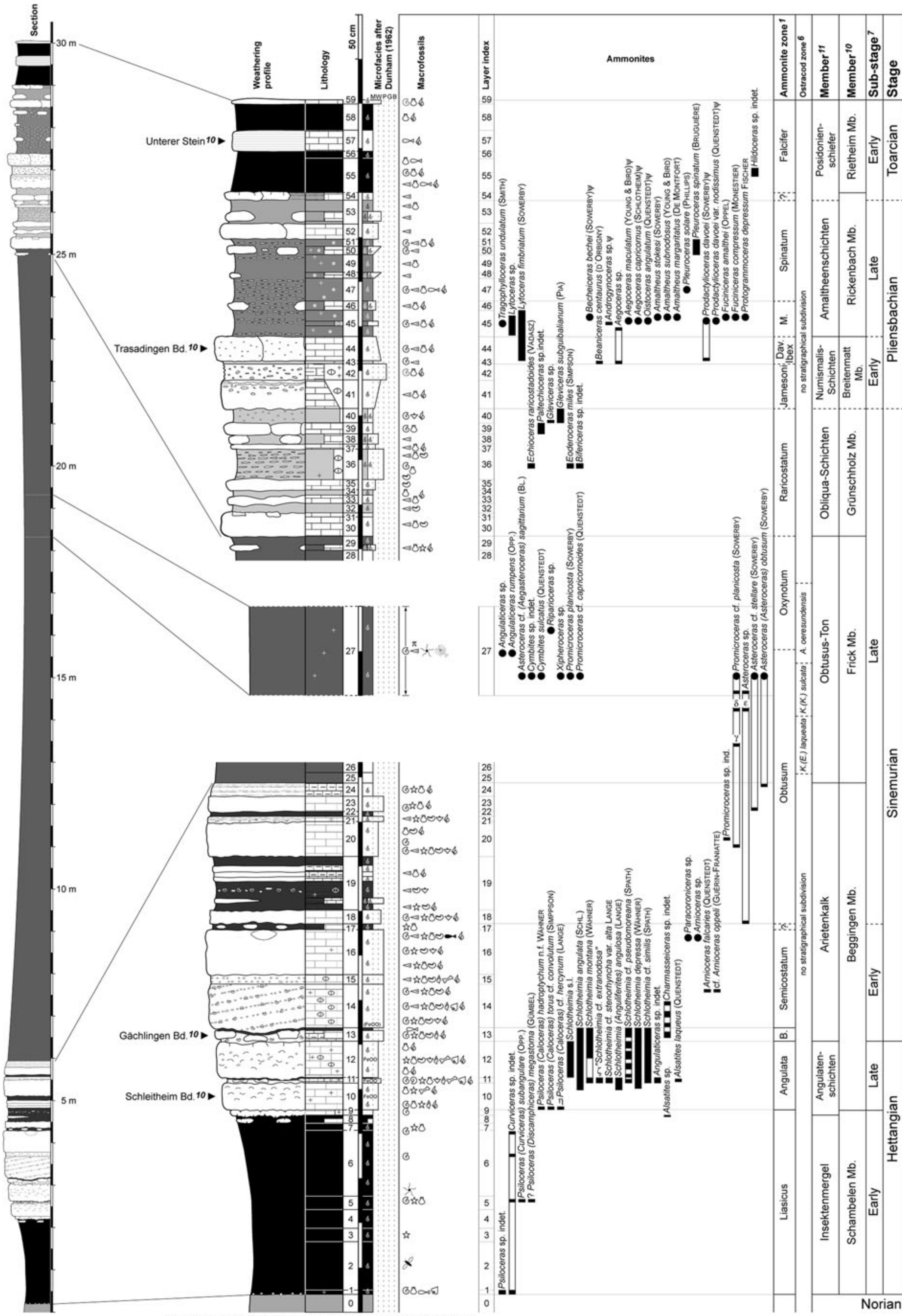
Occurrence Klettgau area, Zürcher Weinland.

Thickness 0 to some 2 m (see Schlatter 1983a; Nagra 1993, 2001).

Chronostratigraphic age Early Hettangian (Planorbis to Liasicus zone, Planorbis to Portlocki subzone; Schlatter 1983a; Achilles and Schlatter 1986).

Description The definition of the Hallau Bed follows the southern German subdivision scheme of Altmann (1965; there called Psilonotenbank, see Bloos et al. 2005 and Etzold et al. 2010). The Hallau Bed is basically understood as a condensation and reworking horizon (Altmann 1965; Bloos et al. 2005). Sediments of the same age from SW Germany contain several levels with ammonite associations (e.g., Altmann 1965; Bloos 1999).

At the type locality Hallau, this condensation horizon begins with a 5–15 cm thick black marl which is rich in echinoderm remains (Schalch and Peyer 1919; Achilles and Schlatter 1986). Two distinct limestone layers follow, being separated by a 70 cm thick, thinly bedded dark brown to black, bituminous terrigenous mudstone (Schalch and Peyer 1919; Altmann 1965; Achilles and Schlatter 1986). The two limestone beds are 10–40 cm thick coquinas which regularly contain middle- to coarse-grained sand and glauconite. The upper limestone layer may contain iron ooids in addition (Schalch and Peyer 1919; Nagra 2001). In the Klettgau area, the limestone of the Hallau Bed can be completely replaced by easily weathering black



Section Frick (Grube Gruhalde, Tonwerke Keller AG, Frick/ AG); coord.: 643.000 / 261.900

◀ **Fig. 7** Detailed section of the Early Jurassic strata at Frick (Gruhalde clay pit). $\boldsymbol{\alpha}$ = position of the boundary between Late Hettangian and Early Sinemurian sensu Hoffmann (1934), Walliser (1956a,b) and Schlatter in Maisch et al. (2008); $\boldsymbol{\beta}$ = position of the boundary between Late Pliensbachian and Early Toarcian sensu Schlatter (1982), Riegraf et al. (1984) and Kuhn and Etter (1994: *Basisschicht*); $\boldsymbol{\gamma}$ = *Promicroceras* cf. *planicosta* (Sow. 1814) at 7.63 m and 9.22 m (W. Etter, pers. comm. 2005); $\boldsymbol{\delta}$ = *Promicroceras* cf. *planicosta* (Sow. 1814) at 16.98 m (W. Etter, pers. comm. 2005); $\boldsymbol{\varepsilon}$ = *Asteroceras* sp. at 15.72 m (W. Etter, pers. comm. 2005); $\boldsymbol{\zeta}$ = "*Schlotheimia* cf. *extranodosa*" (see Maisch et al. 2008: fig. 3); $\boldsymbol{\eta}$ = revision of "*Psiloceras* (*Caloceras*) cf. *johnstoni* (Sow. 1824)" (see Maisch et al. 2008: fig. 3); $\boldsymbol{\pi}$ = compare Etzold et al. (1975); $\boldsymbol{\psi}$ = biostratigraphic range according to Jordan (1960) and Schlatter (1991)

clayey marl (see Altmann 1965). About 3 km SW of Hallau, the lower limestone layer of the Hallau Bed wedges out; therefore, the oldest sediments of the Early Jurassic are represented by roughly 25 cm of dark brown terrigenous mudstone (Altmann 1965). The wells Benken (coord.: 690.989/277.843) and Lindau 1 (coord.: 692.815/255.098) represent the southernmost localities where the Hallau Bed was encountered so far (see Altmann 1965; Frey 1969, 1978; Nagra 2001). The southernmost find of an ammonite from the Hallau Bed to date was reported 3 km SW of Hallau (Wilchingerberg; Altmann 1965: 63).

4.2 Beggingen Member

Names previously in use are given in Figs. 2 and 4.

Type locality Beggingen (Hölderli, canton Schaffhausen; coord.: 682.120/290.980; temporary exposure, Schlatter 1976).

Underlying strata Obere Bunte Mergel or "Rhät" or Schambelen Member.

Overlying strata Fasiswald Member or Weissenstein Member or Frick Member or Mont Terri Member.

Subdivision Schleitheim Bed, Gächlingen Bed.

Occurrence Northern Switzerland.

Thickness From ?0 m in the Folded Jura (Jordan 1983: section Salhöchi, coord.: 641.100/253.650; see Gsell 1968: section Schürmatt, coord.: 640.160/253.160), some 1 m in the Tabular Jura (Buser 1952; Nagra 1984) to ca. 5 m in the Klettgau area (Schalch 1895), to 7 m in the Weissenstein area (Ledermann 1981).

Chronostratigraphic age Early Hettangian (Liasicus zone; Figs. 22, 23) to Late Sinemurian (Obtusum zone; Figs. 7, 8, 10; Schlatter 1976; Jordan 1983 vs. Fig. 12).

Description The Beggingen Member always lies on top of an erosive surface (Figs. 7, 8, 10, 12, 13, 14, 15, 16, 17, 18, 25, 27). It mainly consists of condensed arenitic limestone, that may be dolomitised in some cases (Fig. 18; Müller 1862; Delhaes and Gerth 1912; Jordan 1983). Individual limestone banks may end in a hardground (Fig. 10; see Jordan 1983; Wetzel et al. 1993). The following facies variations can appear at the base of the Beggingen Member:

a) calcareous sandstones (Figs. 17, 22; Lehner 1920; Erni 1910, 1926; Buser 1952: 33p.; Büchi et al. 1965; Nagra 2001), which, in contrast to the Weissenstein Member, are characterised by their abundancy of *Cardinia* sp. or *Gryphaea arcuata* Lam. In general, the calcareous-shelled fossils in these arenites are corroded to a lesser or stronger degree because of diagenetic lime dissolution, bivalves (e.g., *Cardinia*

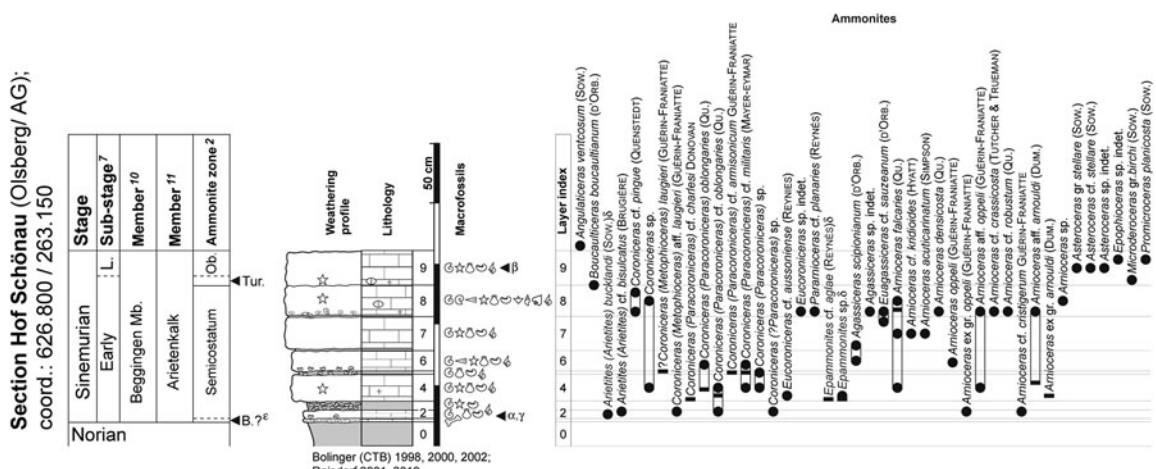
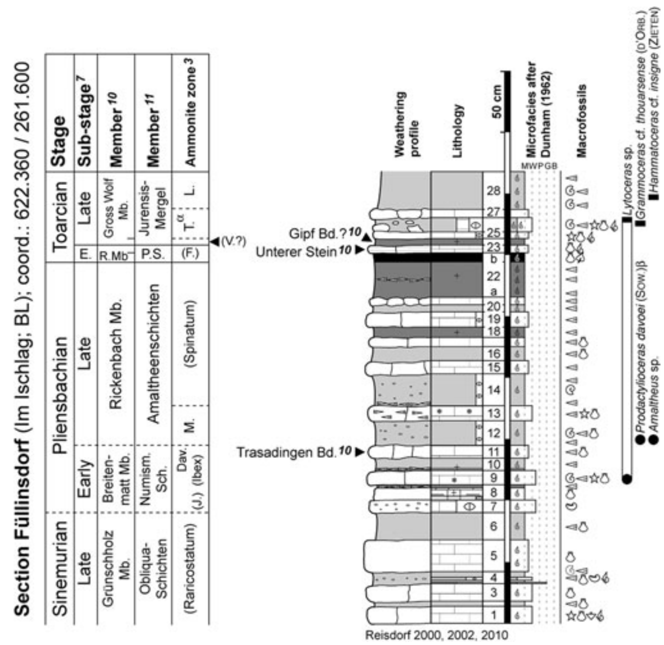


Fig. 8 Detailed section of the Early Jurassic strata at Hof Schönau (Olsberg/AG), temporary exposure. Ammonites have been collected by T. Bolinger (Olsberg/AG; CTB). $\boldsymbol{\alpha}$ = see Pratje (1922); $\boldsymbol{\beta}$ = see Schlatter (1976); $\boldsymbol{\gamma}$ = phosphoritic, *Gryphaea*-bearing, macrofossil-rich encrinite, highly conglomeratic in parts (packstone after Dunham 1962); $\boldsymbol{\delta}$ = reworked?; $\boldsymbol{\varepsilon}$ = loosely collected *Schlotheimia* sp. (NMB J 29358; det. Wiedenmayer 1980), compare the biostratigraphic range of the genus *Schlotheimia* in Fig. 7

Fig. 9 Detailed section of the Early Jurassic strata at Füllinsdorf (Im Ischlag/BL), temporary exposure. $\boldsymbol{\alpha}$ = loosely collected *Lytoceras* cf. *jurense* (Zieten); $\boldsymbol{\beta}$ = for the biostratigraphic range of *Prodactylioceras davoei* (Sow.) see Schlatter (1991)



sp., *Gryphaea* sp.) are often only preserved as external molds (see Lehner 1920; Keller 1922; Waibel 1925).

b) Quartz-conglomerates (Erni 1926);
c) dolomite-conglomerates (Lehner 1920; Erni 1926; Fig. 8);
d) flat pebble conglomerates (Suter 1927); more unfrequently,
e) limestone-breccias (Keller 1922);
f) bonebeds (Lehner 1920; Erni 1926; Suter 1927).

If the erosive contact of the Staffelegg Formation incises down to sediments of the Middle Keuper, then the Beggingen Member often set in with unlayered, light grey to black marls of up to 20 cm thickness (see Erni 1910; Buser 1952; Jordan 1983; Figs. 13, 14, 15, 16). In the oldest layers of the Beggingen Member (Liasicus to Bucklandi zone), bivalves commonly occur, most of which belong to the genera *Cardinia* and *Plagiostoma* (Figs. 7, 10, 24, 25, 27; see Schalch and Peyer 1919; Elber 1921; Maisch et al. 2008). These facies-dependent faunal associations were the reason to give it initially the chronostratigraphically misleading name *Cardinienschichten* (see Schleitheim Bed and Gächlingen Bed). In the Klettgau area and from there in a south-western direction to the Frick area (canton Aargau), the basal layers of the Beggingen Member contain iron-ooids (Figs. 7, 10; see Jordan 1983; Schlatter 1989). In contrast, the upper layers (Bucklandi to Obtusum zone) occur over a larger area in northern Switzerland and consist mainly of locally strongly phosphoritic arenitic limestone which are rich in fossils; the bivalve *Gryphaea arcuata* Lam. occurs in great abundance, locally rock-forming (Figs. 7, 8, 10, 12, 16, 18, 24, 25, 27; see von Buch 1839; Jordan 1983). Marl or marly terrigenous mudstone of small thicknesses is interbedded (Figs. 7, 10, see Buser 1952). In the Folded Jura, the facies of the Beggingen Member interfingers with that of the Weissenstein Member (the Beggingen Member may in such a case even disappear completely, leaving only the Weissenstein Member; see Jordan 1983; Figs. 3, 10, 14, 15, 17, 24).

4.2.1 Schleitheim Bed

Names previously in use are given in Fig. 4.

Type locality 2 km SE of Schleitheim (Buckforen; canton Schaffhausen; coord.: 679.700/287.470; Schlatter 1976).

Underlying strata Obere Bunte Mergel or "Rhät" or Schambelen Member.

Overlying strata The Schleitheim Bed forms the base of the Beggingen Member.

Occurrence Klettgau area, Zürcher Weinland, Tabular Jura, ?Weissenstein area (because of poor outcrop conditions, in contrast to Jordan et al. 2008, the Schleitheim Bed has not been differentiated in the Weissenstein area.).

Thickness 0–65 cm (Brändlin 1911; possibly even up to 130 cm: Buxtorf 1907; Fischer and Luterbacher 1963; Fig. 24).

Chronostratigraphic age Late Hettangian (Angulata zone, Complanata subzone; Schlatter 2001).

Description At the base, the Schleitheim Bed contains a large number of bivalves, especially the genera *Cardinia* and *Plagiostoma*. The Schleitheim Bed always has an erosive base; in the Klettgau area and from there in southwestern direction to the Frick area, these layers are iron ooliths (Fig. 7; Schalch and Peyer 1919; Schlatter 1989; Maisch et al. 2008). In the Tabular Jura of the canton

Table 1 Compilation of data sources used for isopach maps and stratigraphic classification

Authors	Rhaetian (thickness)	Early Jurassic (thickness)	Biostratigraphic information	Lithostratigraphic information
Achilles and Schlatter (1986)	✔		✔	✔
Altmann (1965)	✔		✔	✔
Bader (1925)	✔	✔	✔	✔
Bath and Gautschi (2003)				✔
Beher (2004)			✔	
Bitterli (1960)			✔	✔
Bitterli (1992)		✔[a]		
Bitterli and Strub (1975)			✔	✔[a]
Bitterli-Brunner and Fischer (1988)				✔
Bitterli et al. (2000)	✔	✔		✔
Brändlin (1911)			✔	✔
Braun (1920)			✔	✔
Brenner (1986)	✔			
von Buch (1839)				✔
Büchi et al. (1965)	✔	✔	✔	✔
Bureau der Geologischen Kommission (1930)	✔	✔		✔
Buser (1952)	✔	✔	✔[a]	✔
Buser in Gsell (1968)	✔	✔[a]		
Buxtorf (1901)	✔		✔	✔
Buxtorf (1907)	✔	✔	✔	✔
Buxtorf (1910)	✔	✔		✔
Buxtorf and Troesch (1917)	✔	✔		✔
Buxtorf and Christ (1936)	✔	✔		✔
Debrand-Passard (1984)		✔		
Delhaes and Gerth (1912)	✔	✔	✔	✔
Einsele and Seibold (1961)	✔			
Elber (1921)	✔	✔		✔
Elber (1962)	✔			
Erb in Groschopf et al. (1977)		✔		
Erni (1910)	✔		✔	✔
Erni (1926)	✔		✔	✔
Etter (1990)			✔	✔
Etter and Kuhn (2000)				✔
Etzold and Schweizer (2005) and references therein	✔		✔	✔
Etzold et al. (2010)	✔			
Fischer and Luterbacher (1963)	✔	✔		✔
Fischer et al. (1964)	✔		✔	✔
Fischer (1964)		✔		
Frey (1969)	✔	✔		✔
Frey (1978)				✔
Genser and Sittig (1958)	✔			
Glauser (1936)	✔	✔	✔	✔
Goldschmid (1965)	✔	✔	✔	✔
Gsell (1968)	✔	✔	✔	✔
Gürler et al. (1987)		✔		
Hahn (1971)	✔	✔		✔
Häring (2002)	✔			

Table 1 continued

Authors	Rhaetian (thickness)	Early Jurassic (thickness)	Biostratigraphic information	Lithostratigraphic information
Häring et al. (2008)	✔	✔		
Hauber (1971)	✔	✔	✔	✔
Hauber (1991)	✔	✔		
Hauber (1994)		✔		
Hauber et al. (2000)	✔	✔		
Hess (1962)			✔	✔
Hofmann (1959)				✔
Hofmann (1981)	✔	✔	✔	✔
Hofmann et al. (2000)			✔	✔
Imhof in Jordan (1983)	✔	✔		
Jordan (1960)		✔		
Jordan (1983)	✔	✔	✔[a]	✔[a]
Kämpfe (1984)	✔[b]	✔[b]		
Käß (1954)		✔		
Keller (1922)				✔
Kelterborn (1944)	✔			✔
Knitter and Ohmert (1983)		✔		
Kuhn and Etter (1994)		✔	✔	✔
Ladner et al. (2008)	✔	✔		
Laubscher (1963)	✔	✔		✔
Ledermann (1981)				✔
Lehner (1920)			✔	✔
Lemcke and Wagner (1961)	✔	✔		
Lutz (1964)	✔			
Lutz and Cleintuar (1999)	✔	✔		
Lutz and Etzold (2003)	✔			
Maisch and Reisdorf 2006a, b			✔	✔
Maisch et al. (2008)	✔		✔	✔
Mandy (1907)				✔
Marie (1952)	✔	✔		
Mathey (1883)			✔	
Meyer (1916)	✔	✔		
Meyer and Furrer (1995)			✔	✔
Moesch (1874)	✔	✔		✔
Mühlberg (1905)	✔	✔		✔
Mühlberg (1908)	✔	✔	✔	✔
Mühlberg (1910)		✔		
Mühlberg (1915)	✔	✔	✔	✔
Müller (1862)				✔
Nagra (1984)	✔	✔	✔	✔
Nagra (1989)	✔	✔	✔	✔
Nagra (1990)	✔	✔	✔	✔
Nagra (1992)	✔	✔	✔	✔
Nagra (1993)	✔[c]	✔		✔
Nagra (2001)	✔	✔	✔	✔
Ohmert in Groschopf et al. (1977)		✔		
Persoz (1982)	✔			

Table 1 continued

Authors	Rhaetian (thickness)	Early Jurassic (thickness)	Biostratigraphic information	Lithostratigraphic information
Peters (1964)				✔
Pfirter (1997)				✔
Pratje (1922)	✔	✔	✔	✔
Pratje (1924)	✔	✔		✔
Reisdorf (2001)	✔	✔	✔	✔
Reisdorf et al. (this volume)	✔	✔		
Richter (1987)			✔	✔
Rickenbach (1947)			✔	✔
Rieber (1973)			✔	✔
Riegraf (1986)			✔	
Riegraf et al. (1984)		✔		
Rollier (1910)				✔
Schaeren and Norbert (1989)	✔	✔		✔
Schalch (1880)	✔	✔	✔	✔
Schalch (1893)	✔	✔		
Schalch (1895)		✔		✔
Schalch (1900)	✔	✔		
Schalch (1916)	✔	✔	✔	✔
Schalch (1922)	✔		✔	
Schalch and Peyer (1919)	✔		✔	✔
Schegg et al. (1997)	✔	✔		
Schlatter (1976)		✔	✔	✔
Schlatter (1982)			✔	✔
Schlatter (1983a)	✔	✔		
Schlatter (1983b)			✔	✔
Schlatter (1989)			✔	✔
Schlatter (1990)			✔	
Schlatter (1991)			✔	✔
Schlatter (1999)			✔	✔
Schlatter (2000)			✔	
Schlatter (2001)			✔	
Schmidt et al. (1924)	✔	✔	✔	✔
Senftleben (1923)	✔	✔	✔	✔
Senftleben (1924)	✔	✔		✔
Söll (1965)	✔	✔		
Söll in Ernst (1989)		✔		
Sommaruga and Burkhard (1997: 46)	✔			
Stoll-Steffan (1987)	✔	✔		
Strübin (1901)			✔	✔
Suter (1915)	✔			✔
Suter (1927)	✔			✔
Tanner (1978)	✔			✔
Théobald (1961)	✔	✔		
Théobald (1967)	✔	✔		
Théobald and Maubeuge (1949)		✔		
Tröster (1987)		✔		
Trümpy (1959)			✔	

Table 1 continued

Authors	Rhaetian (thickness)	Early Jurassic (thickness)	Biostratigraphic information	Lithostratigraphic information
Trümpy (1980)		✔		
Tschopp (1960)		✔		✔
Veit and Hrubesch in Groschopf et al. (1977)	✔			
Vogel (1934)			✔	✔
Vollmayr (1971)	✔			
Vollmayr and Wendt (1987)	[a]	[a]	✔	✔
Vonderschmitt (1941)	✔		✔	✔
Vonderschmitt (1942)	✔	✔	✔	✔
Waibel (1925)	✔	✔		✔
Walliser (1956a)	✔		✔	
Walliser (1956b)	✔		✔	
van Werveke (1923)	✔	[a]		
Wetzel et al. (1993)	✔	✔		✔
Wetzel and Reisdorf (2007)				✔
Wirth (1968)	✔[b]	✔[b]		
von Wurstemberger (1876)			✔	✔
Würtenberger (1867)		✔	✔	✔
Ziegler in Jordan (1983)	✔	✔		
Unpublished data				
CSD Colombi Schmutz Dorthe AG (well Wisenberg-Tunnel RB 22; SBB)	✔	✔		
CSD Colombi Schmutz Dorthe AG (well Wisenberg-Tunnel RB 23; SBB)	✔			
Geologisches Büro Dr. H. Schmassmann (well Eich, Magden)	✔	✔		
Geologisches Büro Dr. H. Schmassmann (well Grändel, Zeiningen)	✔	✔		
Geologisches Büro Dr. H. Schmassmann (well Weiere, Magden)	✔	✔		
Geologisches Büro Dr. H. Schmassmann (well Weierboden, Arisdorf)	✔	✔		
Geologisch-Paläontologisches Institut der Universität Basel (wells 34.R.1 to 34.R.4, Adlertunnel, SBB)	✔			
Geologisch-Paläontologisches Institut der Universität Basel (well 34.R.6, Adlertunnel, SBB)	✔			
Geologisch-Paläontologisches Institut der Universität Basel (well 41.R.115, Adlertunnel, SBB)	✔	✔		
Geologisch-Paläontologisches Institut der Universität Basel (wells 41.R.116 to 41.R.118, Adlertunnel, SBB)	✔			
Geologisch-Paläontologisches Institut der Universität Basel (well 41.R.120, Adlertunnel, SBB)	✔			
Geologisch-Paläontologisches Institut der Universität Basel (wells 41.R.123 to 41.R.125, Adlertunnel, SBB)	✔			
Geotechnisches Institut AG (wells 34.R.7 and 34.R.8, Adlertunnel, SBB)	✔			
Geotechnisches Institut AG (well 41.R.131, Adlertunnel, SBB)	✔			
Geotechnisches Institut AG (well 41.R.132, Adlertunnel, SBB)	✔	✔		
Geotechnisches Institut AG (well 41.R.133, Adlertunnel, SBB)	✔			
Geotechnisches Institut AG (wells 71.R.45 and 71.R.57, Umfahrung Sissach)	✔			
Geotechnisches Institut AG (well 71.R.58, Umfahrung Sissach)		✔		
Geotechnisches Institut AG (well 71.R.59, Umfahrung Sissach)	✔			
P.R.E.P.A. (Societé de prospection et exploitations pétrolières en Alsace; well Blodelsheim 1)	✔	✔		
P.R.E.P.A. (Societé de prospection et exploitations pétrolières en Alsace; well Knoeringue 1)	✔	✔		

Table 1 continued

Authors	Rhaetian (thickness)	Early Jurassic (thickness)	Biostratigraphic information	Lithostratigraphic information
P.R.E.P.A. (Societé de prospection et exploitations pétrolières en Alsace; well BPR 5, Hartmannswiller, Soultz)	✔	✔		
P.R.E.P.A. (Societé de prospection et exploitations pétrolières en Alsace; well Illfurth R1)	✔	✔		
Vereinigte Schweizerische Rheinsalinen (well S 29, Schüracher, Pratteln)	✔			
Vereinigte Schweizerische Rheinsalinen (well S 72, Eigental, Muttenz)	✔			
Vereinigte Schweizerische Rheinsalinen (well S 87, Sulz, Muttenz)	✔			
Vereinigte Schweizerische Rheinsalinen (well S 93, Gruetäcker, Muttenz)	✔			
Vereinigte Schweizerische Rheinsalinen (well S 96, Hopferen, Arisdorf)	✔	✔		
Vereinigte Schweizerische Rheinsalinen (well S 111, Eigental, Muttenz)		✔		
Vereinigte Schweizerische Rheinsalinen (wells S 116 and S 119, Auf Wartenberg, Muttenz)	✔			
Wintershall Holding AG (well Meersburg 1)	✔	✔		

[a] Revised by Reisdorf et al. (this volume)

[b] Revised by Stoll-Steffan (1987)

[c] Revised by Etzold and Schweizer (2005: 243) and Etzold et al. (2010)

Aargau (Rietheim – Frick area), the iron oolithic facies changes into a bioclastic packstone facies (see Schalch 1880; Schalch and Peyer 1919). In the Basel Tabular Jura, the Schleitheim Bed is bioclastic packstone (see Erni 1910; Tanner 1978). The ±30 cm thick, black to yellowish marls, in which iron-containing, iron oolith to bioclastic packstone concretions are embedded are an additional facies variation (see Brändlin 1911; Buser 1952).

In the eastern Basel Tabular Jura as well as in the eastern Folded Jura, the Schleitheim Bed is absent because of erosion (Figs. 14 and 17; see Buser 1952). In the Weissenstein area, similar sediments occur again, but here within the basal part of the Beggingen Member (= Schleitheim Bed?; Figs. 23, 24; see Buxtorf 1907). Here, it may display an iron-oolithic facies (Fig. 22).

4.2.2 *Gächlingen Bed*

Names previously in use are given in Fig. 4.

Type locality 1 km WNW of Gächlingen (Lugmer, canton Schaffhausen; coord.: 678.650/284.700; temporary exposure, Schlatter 1976).

Occurrence Klettgau area, Zürcher Weinland, Tabular and Folded Jura (with an interruption possibly extending to the Weissenstein area and the Mont Terri area: In contrast to Jordan et al. 2008, because of poor outcrop conditions, the Gächlingen Bed has not been differentiated there.).

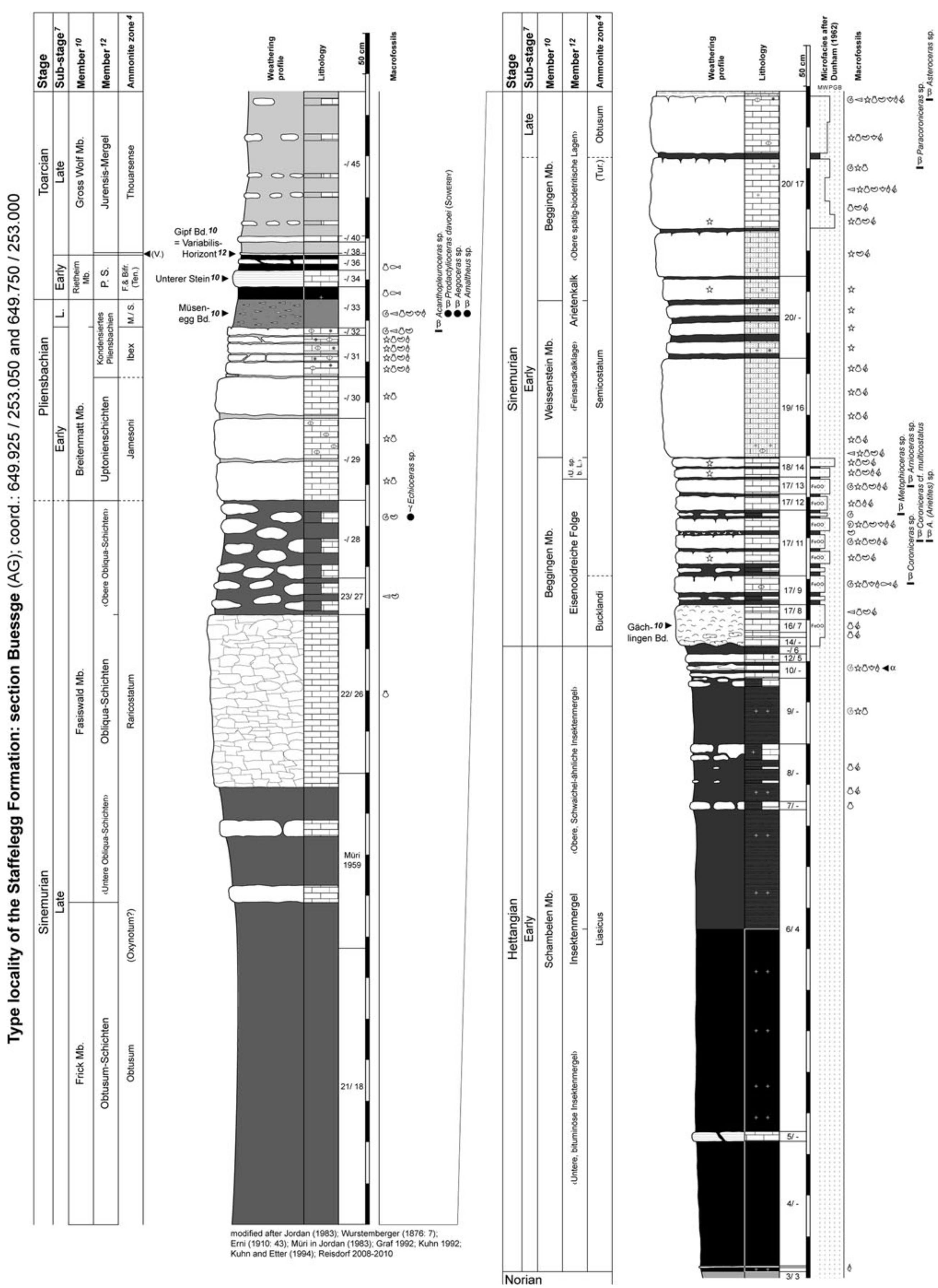
Thickness 0 to ±50 cm (Nagra 2001; Fig. 10).

Chronostratigraphic age Early Sinemurian (Bucklandi zone, Conybeari subzone; Bloos 1976).

Description The Gächlingen Bed is included in the basal beds of the Beggingen Member (e.g., Klettgau area, Tabular Jura; Fig. 7) or at its base (e.g., Folded Jura; Fig. 10). Wacke- to packstone of small thickness, containing iron ooids (see Jordan 1983; Hofmann et al. 2000). Bivalves, especially of the genus *Cardinia*, occur occasionally in rock-forming abundance. Besides the index ammonites of the Bucklandi zone, the Gächlingen Bed can also contain ammonites of the genus *Schlotheimia* (e.g., "*Riesenangulaten*"; see Walliser 1956a; Hahn 1971; Bloos 1976; Maisch et al. 2008).

Laterally, the Gächlingen Bed may change into a duff horizon with concretionary limestone and ultimately wedges out entirely (Fig. 7; see Buser 1952; Hofmann 1981; Nagra 1989; Maisch et al. 2008).

The stratigraphic position of the coquinas (with *Cardinia* and/or *Plagiostoma*) that occur in the western part of the study area (Weissenstein area; section Hautes Roches and Mont Terri area; Buxtorf 1907 vs. Rollier 1910; Elber 1921; Erni 1926; Figs. 22, 23, 24, 25, 27) is not yet resolved beyond doubt. In these sediments, the Bucklandi zone has so far only been proven in the Mont Terri area, using a loosely collected *Angulaticeras angulatoides* (Qu.) (= section Courtemautruy, Fig. 27; note that the *Courtemautruy Bed* of Jordan et al. 2008 is no longer kept because of the lack of suitable outcrops). In addition, it should be mentioned that iron ooids have so far only been found in such limestones in the eastern Weissenstein area (Fig. 22, Erni 1910: 38 vs. Vollrath 1924: 22; Bitterli and Strub 1975; own data).


Type locality of the Staffelegg Formation: section Buessge (AG); coord.: 649.925 / 253.050 and 649.750 / 253.000
Stage
Sub-stage7
Member10
Member12
Ammonite zone4
Weathering profile
Lithology
50 cm
Macrofossils
Microfacies after Dunham (1962)
MWPGB
Toarcian
Pliensbachian
Sinemurian
Hettangian
Norian
Early
Late
Gross Wolf Mb.
Breitenmatt Mb.
Fasiswald Mb.
Frick Mb.
Beggingen Mb.
Weissenstein Mb.
Schambelen Mb.
Jurensis-Mergel
Uptonienschichten
Obliqua-Schichten
Obtusum-Schichten
Arietenkalk
Eisenooidreiche Folge
Insektenmergel
Thouarsense
Jamesoni
Ibex
Raricostatum
(Oxynotum?)
Obtusum
Semicostatum
Bucklandi
Liasicus
Gipf Bd.10 = Variabilis-Horizont12
Unterer Stein10
Müsenegg Bd.10
Gächlingen Bd.10
Müri 1959
Acanthopleuroceras sp.
Prodactylioceras davoei (Sowerby)
Aegoceras sp.
Amaltheus sp.
Echioceras sp.
Paracoroniceras sp.
Asteroceras sp.
Metophioceras sp.
Arnioceras sp.
Coroniceras sp.
Coroniceras cf. multicostatus
A. (Arietites) sp.
modified after Jordan (1983); Wurstemberger (1876: 7); Erni (1910: 43); Müri in Jordan (1983); Graf 1992; Kuhn 1992; Kuhn and Etter (1994); Reisdorf 2008-2010

◀ **Fig. 10** Detailed section of the Early Jurassic strata at Buessge (AG), Type locality of the Staffelegg Formation. Ammonoid zones in parentheses were not verified in the Staffelegg area. α = "*Schlotheimia* sp." (Jordan 1983) = ? *Saxoceras* sp. (see Etzold et al. 1975: 124p. and Urlichs 1977: 16p.); β = data from Jordan (1983); γ = data from Müri in Jordan (1983)

4.3 Weissenstein Member

Names previously in use are given in Figs. 2 and 4.

Type locality Käspisbergli 1 km N of Günsberg (canton Solothurn, see Rollier 1904; coord.: 610.560/235.140; Fig. 24; Buxtorf 1907).

Underlying strata Schambelen Member or Beggingen Member or Fasiswald Member.

Overlying strata Beggingen Member or Fasiswald Member.

Occurrence Eastern Folded Jura to Weissenstein area (see Pratje 1924; Bitterli and Strub 1975; Jordan 1983), well Altishofen 1 (coord.: 639.500/228.000; see Fischer and Luterbacher 1963).

Thickness Up to some 22 m (Fischer and Luterbacher 1963); facies interfingering with the Beggingen Member.

Chronostratigraphic age Early to Late Sinemurian (Semicostatum to Obtusum zone; Figs. 10, 15; Jordan 1983; loosely collected *Promicroceras* sp., E Ulmethöchi/BL, coord.: ca. 616.700/247.800 [NMB J 33219, det. R. Schlatter 2005]).

Description Beige, calcareous sandstones or sandy limestones, respectively, usually 6–22 m thick or sometimes much less (Figs. 10, 12, 13, 14, 15, 24; Delhaes and Gerth 1912; Heim 1919; Fischer and Luterbacher 1963; Wetzel et al. 1993; = *Feinsandkalklage* sensu Jordan 1983). These partially silicified and sometimes dolomitised sediments occasionally contain bluish chert concretions, but very rarely macrofossils which are of biostratigraphic use (Figs. 14, 15, 18, 23; see Delhaes and Gerth 1912; Bitterli and Strub 1975; Jordan 1983). The Weissenstein Member is characterised by spatially close facies-changes and alternations with the Beggingen Member (see Erni 1926; Buser 1952; Jordan 1983; Wetzel et al. 1993) and the Fasiswald Member, respectively (Figs. 10, 14, 15, 17, 24).

The more or less fossil-rich, sandy limestone or calcareous sandstone that are found at the base of the Staffelegg Formation in the Grindel—Erschwil area are, however, not attributed to the Weissenstein Member (see facies variations of the Beggingen Member; see Erni 1910; Lehner 1920; Keller 1922; Waibel 1925).

4.4 Frick Member

Names previously in use are given in Figs. 2 and 4.

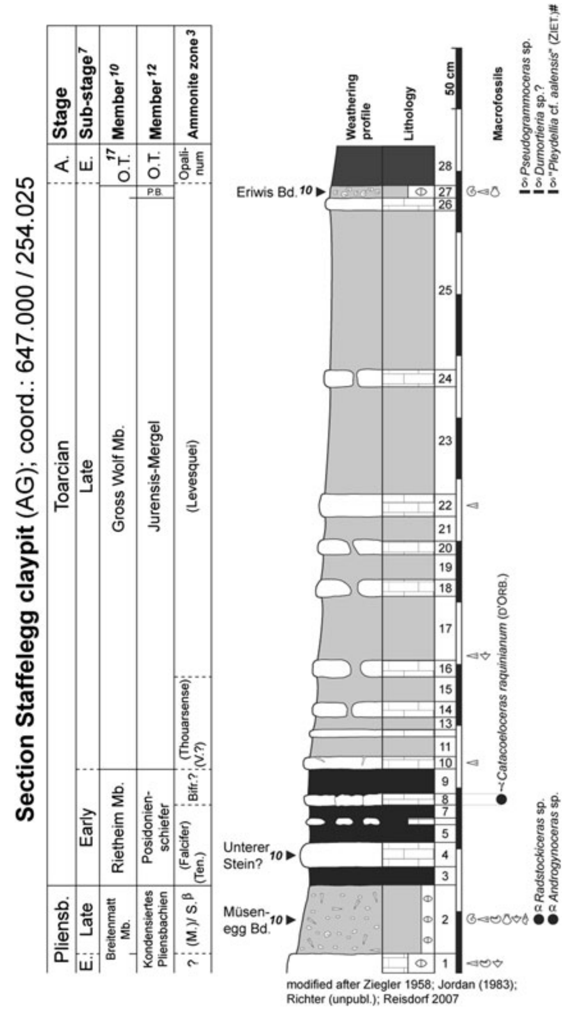


Fig. 11 Detailed section of the Early Jurassic strata at the Staffelegg clay pit (AG). α = data from Jordan (1983); β = loosely collected *Pleuroceras* sp. at the "Staffelberg" (collection of the Geologisches Institut der ETH Zürich; see Jordan 1983); γ = loosely collected (Reisdorf et al. subm.); δ = data from Ziegler in Jordan (1983)

Type locality Gruhalde clay pit in Frick (canton Aargau; coord.: 643.000/261.900; see Beher 2004).

Underlying strata Beggingen Member.

Overlying strata Grünschholz Member or Fasiswald Member.

Occurrence Klettgau area, Tabular Jura, Zürcher Weinland, eastern Folded Jura (here facies interfingering with the Fasiswald Member).

Thickness The maximum thicknesses lie around some 20 m in the Tabular Jura (Fig. 7; Gsell 1968); in the Folded Jura, however, the thicknesses are significantly below 10 m (Fig. 10; Jordan 1983).

Chronostratigraphic age Late Sinemurian (Obtusum to Raricostatum zone, Stellare subzone to

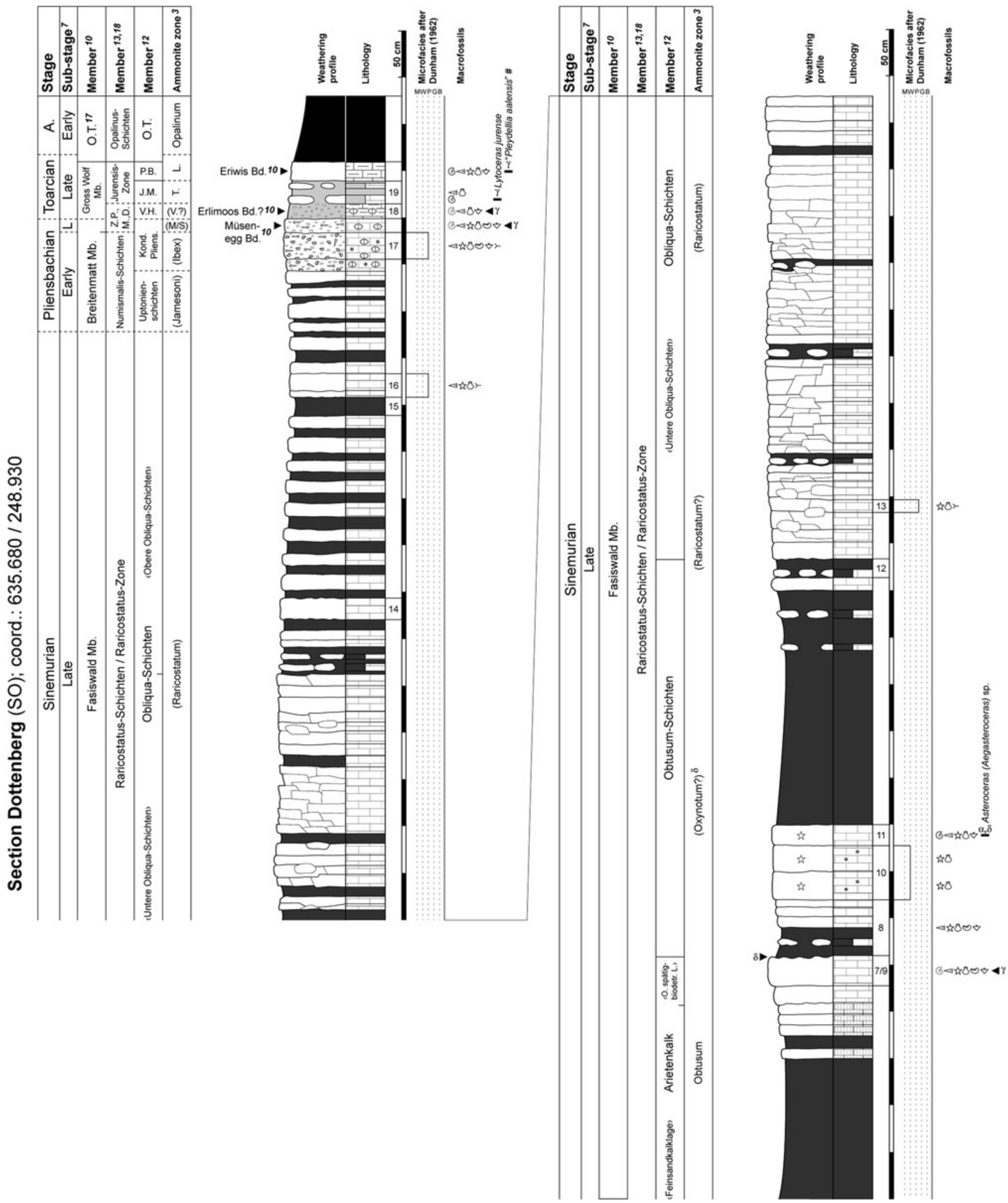


Fig. 12 Detailed section of the Early Jurassic strata at Dottenberg (SO). α = data from Jordan (1983); β = own data; γ = data from Imhof in Jordan (1983); δ = compare Figs. 13, 15, 16, 17 and Etzold et al. (1975), Schlatter (1983b, 1991), Brandt (1985)

Densinodum and Raricostatum subzone; Schlatter 1976, 1983b, 1999; Beher 2004; cf. Fig. 12 vs. Jordan 1983).

Description Generally macrofossil-poor, bioturbated, monotonous succession of dark grey, terrigenous claystones or siltstones, containing mica. (Fig. 7, 10; see

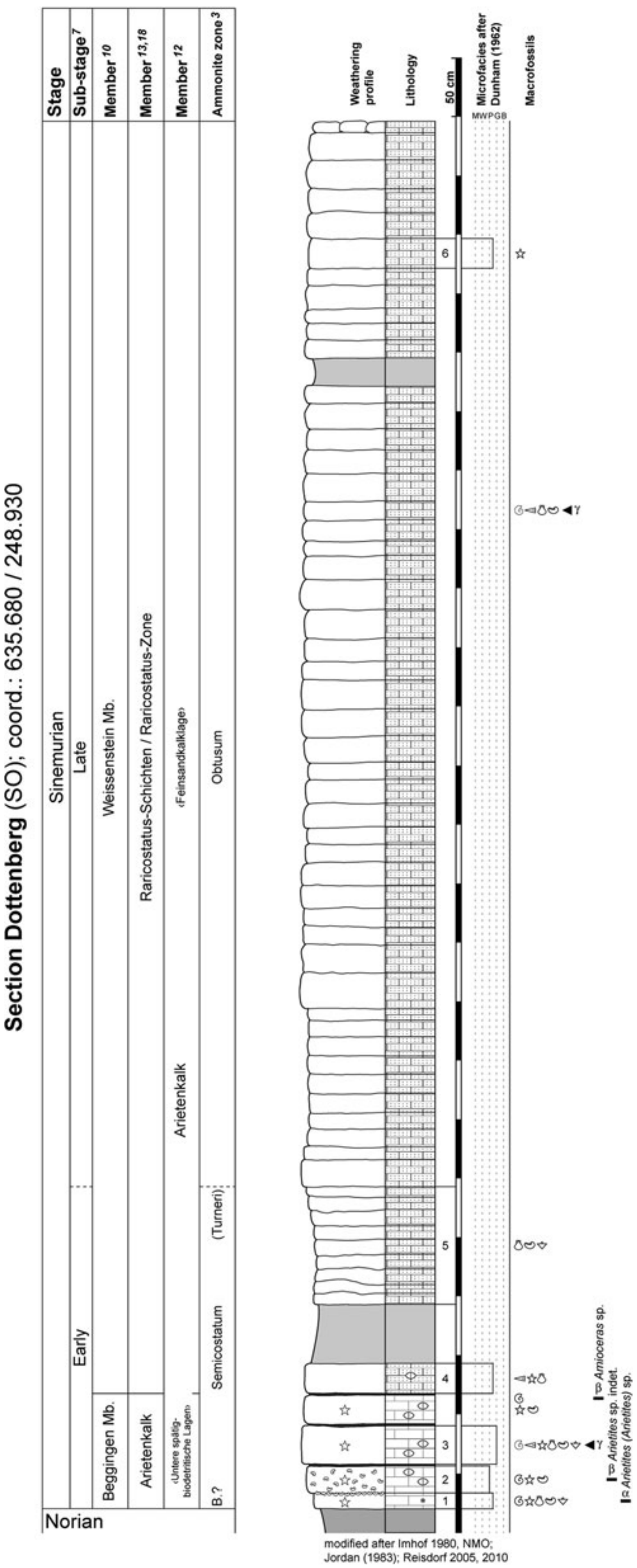


Fig. 12 continued

Hofmann 1959; Frey 1978; Schlatter 1999; Nagra 2001). Interlayering with thin, fine-grained sandstones or layers with marcasite, pyrite or clay iron-stone concretions can occur. Lime- and/or phosphorite concretions are often seen at the top of the Frick Member (see Peters 1964; Nagra 1984, 1990; Schlatter 1991). The youngest sediments of the Frick Member can show different degrees of reworking such as flat pebble conglomerates, reworked ammonites etc. (see Schlatter 1983b, 1991; Beher 2004).

In the occurences of the Frick Member in the eastern Folded Jura, interfingering of facies with the Fasiswald Member is observed.

Towards the southwest, the mudstone succession is significantly thinner than in the Tabular Jura and the Klettgau area, and, increasingly, limestone concretions and limestone beds are intercalated (Fig, 10; see Jordan 1983; Wetzel et al. 1993; Reisdorf 2001).

4.5 Grünschholz Member

Names previously in use are given in Figs. 2 and 4.

Type locality Grünschholz (NW Galten; canton Aargau; coord.: 651.000/265.700; see Buser 1952, outcrop no longer accessible).

Underlying strata Frick Member.

Overlying strata Breitenmatt Member.

Occurrence Klettgau area, Zürcher Weinland, Tabular Jura.

Thickness In the Klettgau area, rarely more than 1 m thick; thickness in the Tabular Jura is rarely more than 1.5 m and never above 2 m (Brändlin 1911; Schalch 1916; Gsell 1968).

Chronostratigraphic age Late Sinemurian to Early Pliensbachian (Raricostatum to Jamesoni zone, Densinodum and Raricostatum to Nodogigas and Taylori subzone; Fig. 7, Schlatter 1983b, 2000).

Description Strata consisting of calcareous marl and predominantly concretionary limestone beds containing glauconite and calcareous phosphoritic concretions (Figs. 7, 9; see Schlatter 1991, 1999). The phosphorite is mainly associated to bioturbated domains. The Grünschholz Member rest on top of an erosive surface that is more or less distinctive (Schlatter 1999; Beher 2004).

4.6 Fasiswald Member

Names previously in use are given in Figs. 2 and 4.

Type locality Fasiswald clay pit (NNW Hägendorf; canton Solothurn; coord.: 629.100/245.100; Fig. 17; cf. Erni in Mühlberg 1915).

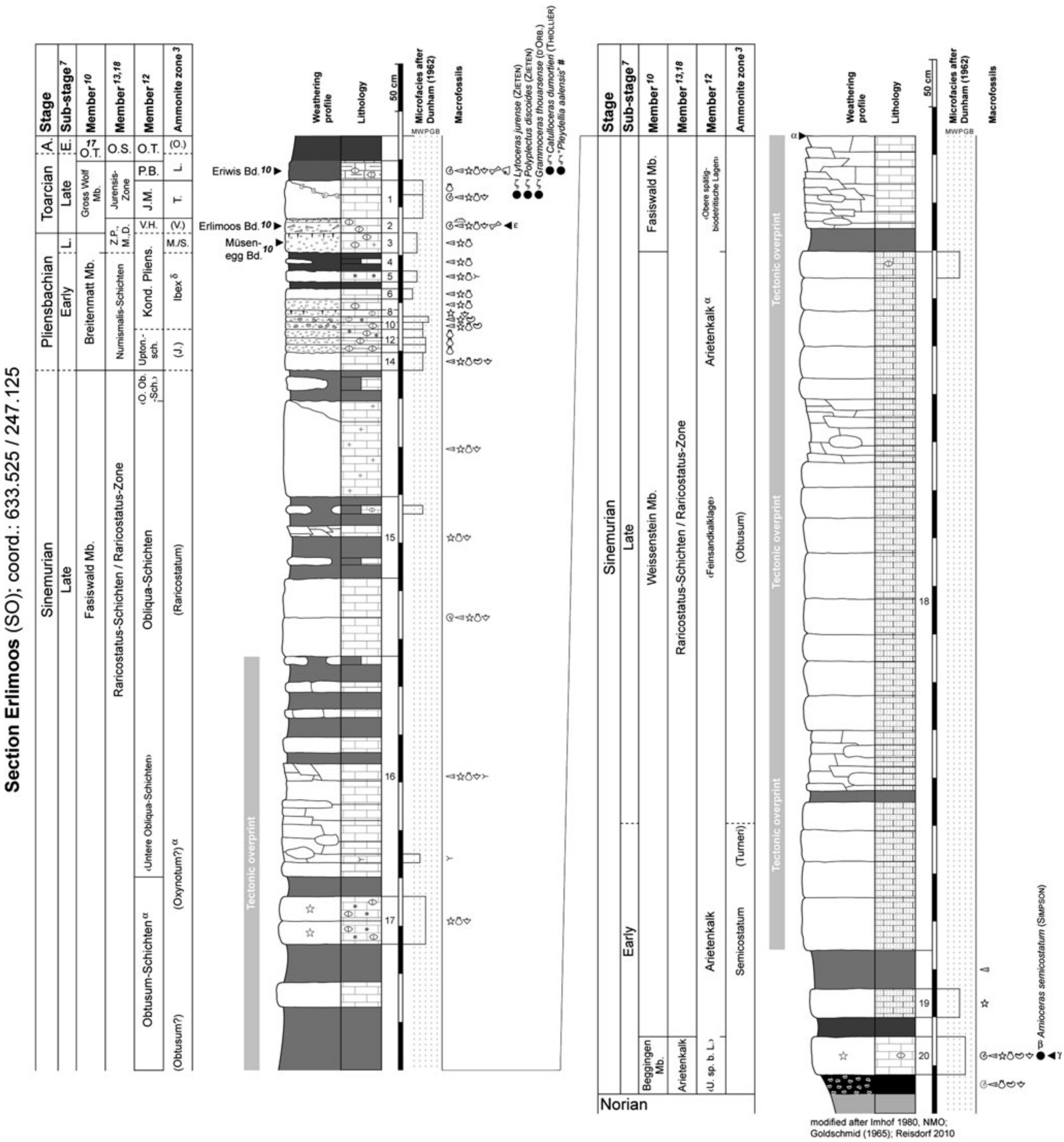


Fig. 13 Detailed section of the Early Jurassic strata at the Erlimoos clay pit (SO). **α** = compare Jordan (1983: section Dottenberg) and Fig. 12; **β** = data from Goldschmid (1965); **γ** = "*Coroniceras* aff. *sauzeanum* (D'ORB.)", "*Coroniceras* aff. *bisculatum* (BRUG.)", "*Arnioceras* cf. *Bodleyi* (HYATT)"; data from Goldschmid (1965); **δ** = loosely collected *Acanthopleuroceras* cf. *maugenesti* (D'ORB.), *Acanthopleuroceras* sp., *Liparoceras* sp., *Beaniceras* cf. *senile* (Buckm.), *Beaniceras* sp. (own data); **ε** = *Lytoceras fimbriatum* (SOW.), *Androgynoceras maculatum* (Y. & B.), *Androgynoceras intracapricornus* (QU.), *Liparoceras bronni* SPATH, *Prodactylioceras davoei* (SOW.), *Amaltheus* cf. *stokesi* (SOW.), *Pleuroceras* sp. indet., *Catacoeloceras raquinianum* (D'ORB.), *Osperlioceras bicarinatum* (ZIETEN) = *Pseudopolyplectus bicarinatus* (ZIETEN), *Hildoceras semipolitum* (BUCKM.); data from Imhof in Jordan (1983); **ζ** = data from Imhof in Jordan (1983)

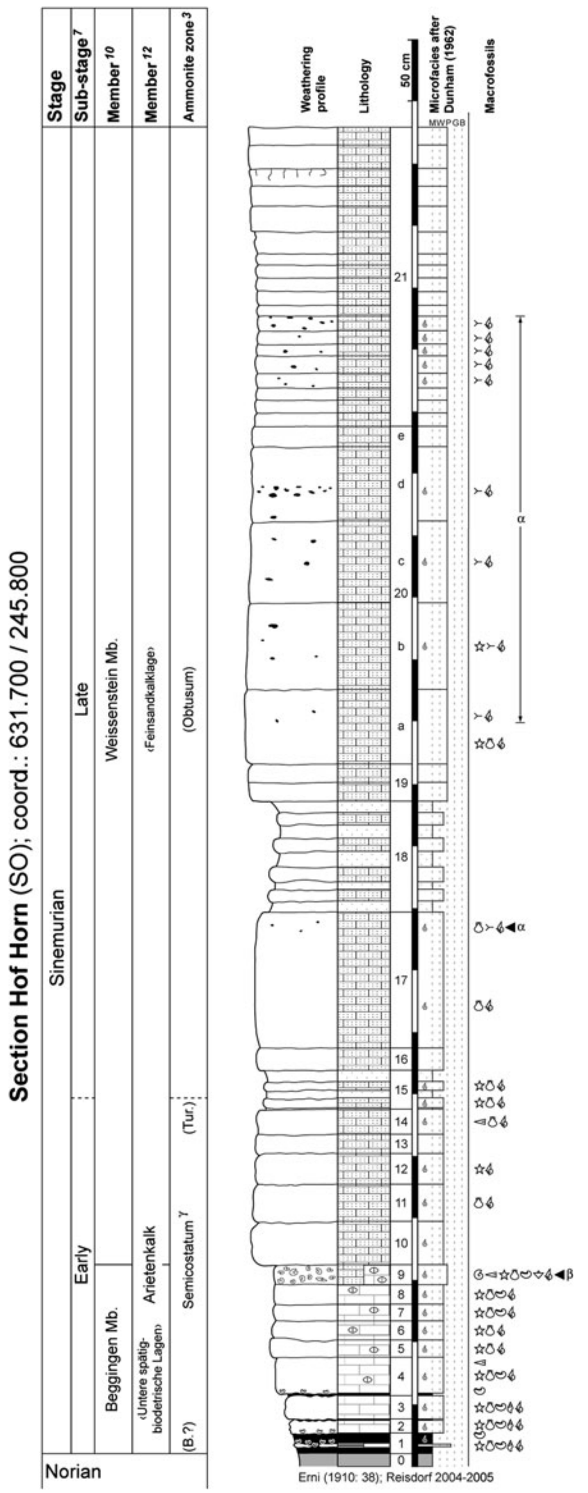


Fig. 14 Detailed section of the Early Jurassic strata at Hof Horn (NW Olten). **α** = whitish and bluish chert nodules (see also Moesch 1874; Buxtorf 1907; Fischer and Luterbacher 1963: 28); **β** = *Arnioceras* sp., *Arnioceras* cf. *cuneiforme* HYATT, *Arnioceras* cf. *robustum* (QUENST.); γ = *Coroniceras multicostatum* (SOW.), loosely collected

Underlying strata Beggingen Member or Weissenstein Member or Frick Member.

Overlying strata Breitenmatt Member.

Occurrence In the entire northern Swiss Folded Jura (except for the Mont Terri area) and areas south of the Folded Jura (i.e. Schafisheim borehole; Nagra 1992); in the eastern Folded Jura there is facies interfingering with the Frick Member; in the southern Jura chains this facies interfingers with the Weissenstein Member; facies interfingering with the Mont Terri Member has not been observed so far.

Thickness Up to ca. 27 m (Fig. 23).

Chronostratigraphic age Early Sinemurian to Early Pliensbachian (Semicostatum to Jamesoni zone; Jordan 1983; Schlatter 1991, 2000; Maisch and Reisdorf 2006a, b; own data).

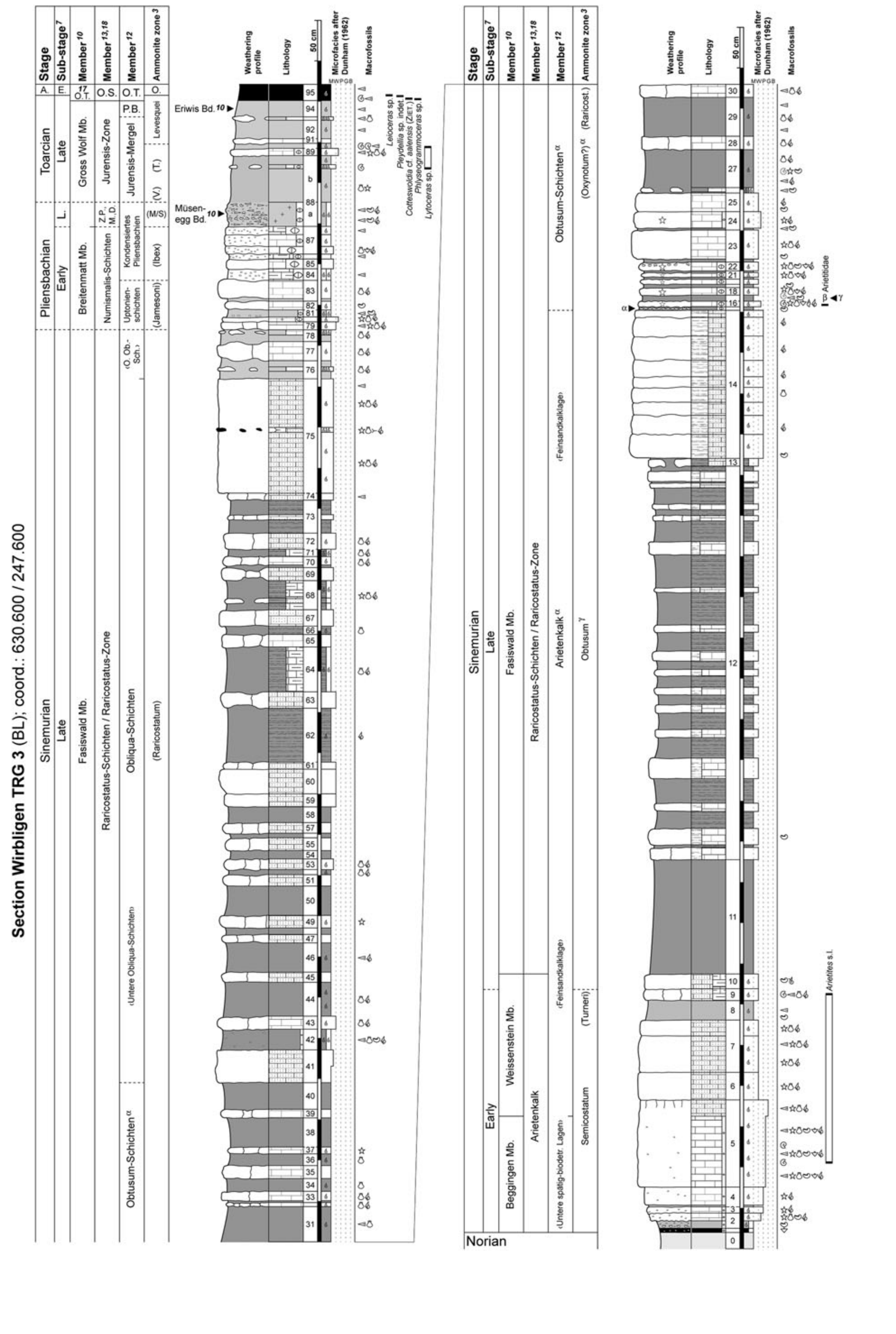
Description The Fasiswald Member consists of alternating brown, light- to dark grey, quartz containing limestone, encrinite, silty-sandy terrigenous mudstone and marl, respectively (Figs. 10, 12, 13, 15 16, 17, 18, 19, 20, 25; see Mühlberg 1908; Delhaes and Gerth 1912; Heim 1919). In the Hauenstein area and from there further to the west, and in the well Schafisheim (coord.: 653.620/246.760), limestone beds are silicified to a varying degree and may contain black chert-concretions which may reach a size of several tens of centimeters (*Spiculaefazies* of Jordan 1983; Figs. 15, 17, 18; see Delhaes and Gerth 1912; Nagra 1992; Maisch and Reisdorf 2006a). *Gryphaea obliqua* (Sow.) occurs in great abundance in the area of the Fasiswald Member (Figs. 15, 17; see Jordan 1983; Wetzel et al. 1993; Reisdorf 2001). Biostratigraphically useful macrofossils are, however, quite rare (Jordan 1983; Beher 2004; Reisdorf own data). As a rule, one to two packages of limestone beds several meters in thickness occur; they may appear as distinct ridges in the landscape (Jordan 1983). Especially in the Weissenstein area, the facies of the Fasiswald Member interfingers with the Weissenstein Member (Fig. 3; see also Fischer and Luterbacher 1963) while in the eastern Folded Jura, the Fasiswald Member overlies the Beggingen Member, Frick Member or the Weissenstein Member (Figs. 10, 12, 13, 15, 16; see Buxtorf 1907; Jordan 1983; Reisdorf 2001).

4.7 Mont Terri Member

Names previously in use are given in Figs. 2 and 4.

Type locality Les Salins (SE Courtemautruy; canton Jura; coord.: 578.800/248.080; Fig. 26).

Underlying strata Beggingen Member.


Section Wirbligen TRG 3 (BL); coord.: 630.600 / 247.600
Stage
Sub-stage7
Member10
Member13,18
Member12
Ammonite zone3
Toarcian
Late
Gross Wolf Mb.
Jurensis-Zone
Jurensis-Mergel
Levesquei
Pliensbachian
Early
Breitenmatt Mb.
Numismalis-Schichten
Uptonien-schichten
Kondensiertes Pliensbachien
(Ibex)
(Jamesoni)
Sinemurian
Late
Fasiswald Mb.
Raricostatus-Schichten / Raricostatus-Zone
Obliqua-Schichten
‹Untere Obliqua-Schichten›
Obtusum-Schichtenα
(Raricostatum)
Eriwis Bd.10
Müsen-egg Bd.10
Weathering profile
Lithology
50 cm
Microfacies after Dunham (1962)
MWPGB
Macrofossils
Leioceras sp.
Pleydellia sp. indet.
Cotteswoldia cf. aalensis (Zieт.)
Phlyseogrammoceras sp.
Lytoceras sp.
Early
Beggingen Mb.
Weissenstein Mb.
Arietenkalk
Arietenkalkα
‹Feinsandkalklage›
‹Untere spätig-biodetr. Lagen›
Semicostatum
(Turneri)
Obtusumγ
(Oxynotum?)α
(Raricost.)
Norian
Arietitidae
Arietites s.l.

◀ **Fig. 15** Detailed section of the Early Jurassic strata at Wirbligen (BL), temporary exposure; modified after Reisdorf (2001). α = compare Jordan (1983: section Dottenberg) and Fig. 12; Etzold et al. (1975), Schlatter (1983b, 1991), Brandt (1985); β = revision of "*Paltechioceras* s.l."; γ = *Xiphoceras* sp. (revision of "*Apoderoceras* sp."; loosely collected)

Overlying strata Breitenmatt Member.

Occurrence Mont Terri area.

Thickness Up to ca. 25 m thick (Buxtorf 1910; Laubscher 1963).

Chronostratigraphic age Late Sinemurian to Early Pliensbachian (?Obtusum to Davoei zone; own data).

Description Middle to dark grey mica bearing terrigenous mudstone and marl with occasional nodular to compact limestone layers are characteristic (Fig. 26; Buxtorf 1910; Glauser 1936; Rickenbach 1947). This member is only rare exposed entirely. According to Buxtorf (1910) and Laubscher (1963) it starts with terrigenous mudstone, which successively changes into a limestone-marl-alternation. The general appearance of the Mont Terri Member resembles therefore the gradual dovetailing of facies of the Frick Member with the Fasiswald Member in the eastern Folded Jura (compare Figs. 10, 15, 16, 19; Pratje 1924; Jordan 1983; Wetzel et al. 1993; Bath and Gautschi 2003).

In spite of their macroscopic similarity, the stratigraphic architecture and the lithological inventory of the Mont Terri Member markedly differ from those of both the Frick Member and the Fasiswald Member. Lithologically, these differences in facies in the Mont Terri area are so pronounced that they should not be seen as mere facial variations. As explained in greater detail below, the character of the Mont Terri Member can be boiled down to the following: The Mont Terri Member stands out, not by dint of its having a unique stratigraphic architecture or a unique lithological inventory, but in fact due to the very lack of such unique qualities.

Buxtorf (1910) measured a 10–12 m thick terrigenous mudstone interval (= *Obtusustone* sensu Buxtorf 1910, Fig. 2) in a temporary exposure SE of Cornol (coord.: ca. 580.550/249.100). This succession is assigned to the here newly introduced basis of the Mont Terri Member (Fig. 3). This mudstone most closely resembles the easternmost occurrences of the Frick Member in the Folded Jura with respect to facies, although it is significantly thicker than the latter (compare section Buessge, Fig. 10; see Jordan 1983; Bath and Gautschi 2003). The more western occurrences of the Frick Member differ more clearly from the basal interval of the Mont Terri Member. More frequent interfingering of the Frick Member with the Fasiswald Member in this area leads to the characteristic broadening of the lithological inventory of the Frick Member, in particular the occurrence of crinoidal mudstone and wackestones as well as one to two prominent *Gryphaea*-rich intervals (*Gryphäenkonglomerathorizonte* after Jordan 1983; Wetzel et al. 1993). Judging by the information in Buxtorf (1910), the latter seems to be absent in the basal part of the Mont Terri Member (see also Vonderschmitt 1942).

The upper part of the Mont Terri Member (= *knollige Kalkbänke* after Buxtorf 1910; Laubscher 1963; Fig. 4) resembles the Fasiswald Member: In the type section Les Salins (Fig. 26), this limestone-marl-alternation is about 13 m thick and does not exhibit the characteristic lithological inventory of the Fasiswald Member, namely calcarenites in spiculae-facies or without spiculae, encrinites linked to *Gryphaea*-rich intervals, as well as one to two packages of limestone beds several meters in thickness.

The biostratigraphic range of the Mont Terri Member is not completely clear yet and is based on the current knowledge of unexpectedly heterogeneous stratigraphic features (Fig. 3). Hitherto, ammonites are only known from the limestone-marl-alternation of the Mont Terri Member (own data; cf. Mathey 1883). In the type section Les Salins (Fig. 26) as well as in the tectonically overprinted partial section S of Cornol (coord.: 579.950/249.500; *Aegoceras* sp., ?*Oistoceras* sp., own data) and SSW of Courtemautruy (coord.: 578.100/248.050; *Echioceras* sp.; *Aegoceras* sp., own data), ammonite finds document the Raricostatum and Davoei zones for this stratigraphic level and therefore indicate that deposition continued to the late Early Pliensbachian (Fig. 3).

The stratigraphic position of the Sinemurian/Pliensbachian boundary could not be identified precisely in the type section of the Mont Terri Member (Fig. 26). The above mentioned partial section SSW Courtemautruy, however, yielded a precise localisation of the biostratigraphic boundary. In that partial section, the oldest sediments of the Pliensbachian (Jamesoni and Ibex zones) in the Mont Terri area are rather thin: here, *Echioceras* sp. (Raricostatum zone) and *Aegoceras* sp. (Davoei zone) occur in close proximity in a monotonous interval consisting of marls and a few nodular limestones or limestone beds. These limestones can be classified as mudstones to wackestones.

The stratigraphic constellation exposed in the partial section of SSW of Courtemautruy (Fig. 26) suggests that neither the Sinemurian-/Pliensbachian-boundary nor the Ibex/Davoei zone-boundary can be found in a belemnite- and gryphaeid-rich wackestone to packstone or phosphoritic limestone/marl-alternation in the area where the Mont Terri Member is present (compare Breitenmatt Member; see Jordan 1983; Maisch and Reisdorf 2006a, b). This definition of the boundary, however, conflicts with the situation in the Courtemautruy section (Fig. 27), which lies about 500 m southwest of the type section Les Salins and which, for the most part, represents the Beggingen Member.

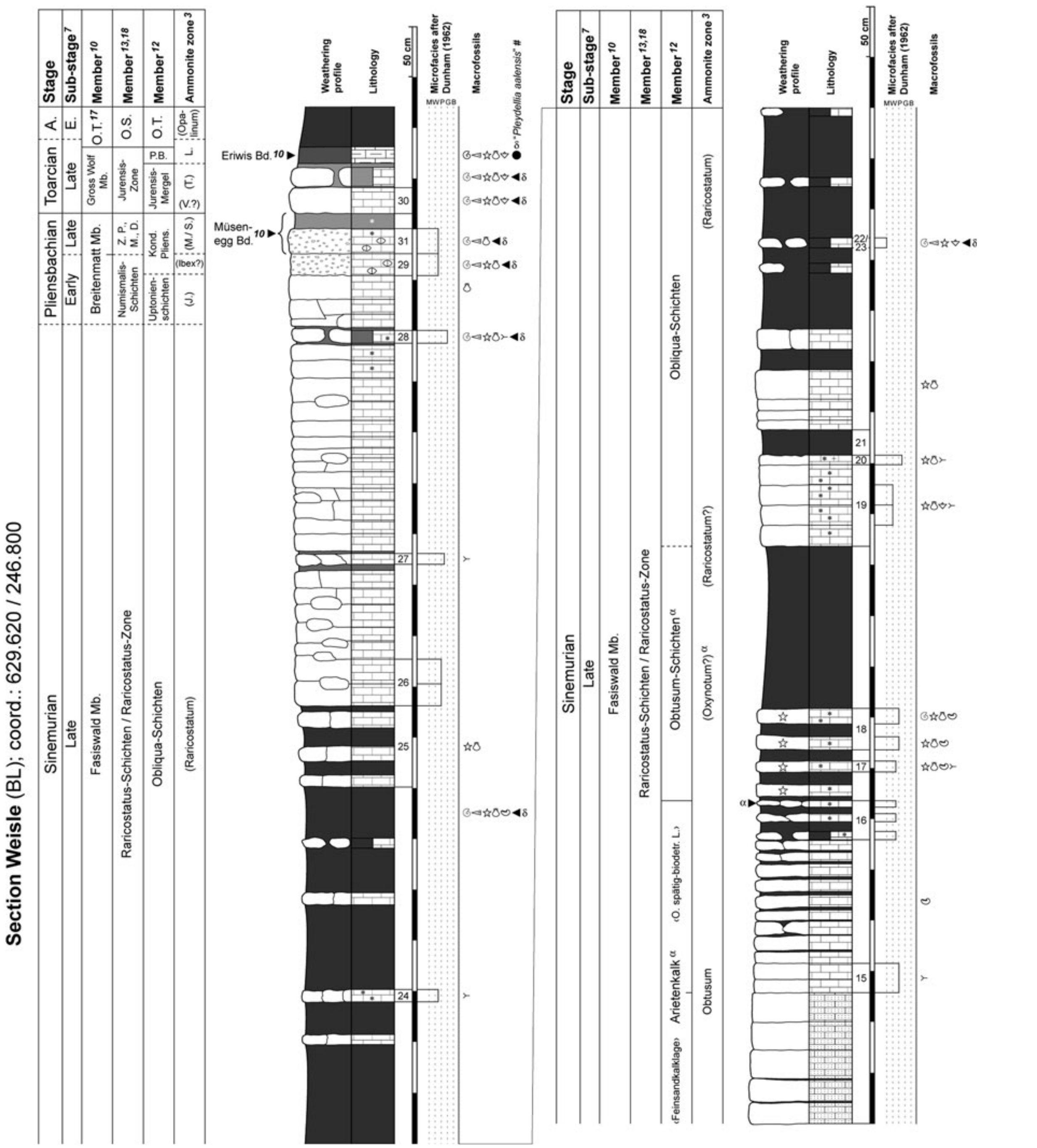


Fig. 16 Detailed section of the Early Jurassic strata at Weisle (BL); see also Erni (1926) and Goldschmid (1965). **α** = compare Jordan (1983: section Dottenberg) and Fig. 12; Etzold et al. (1975); Schlatter (1983b, 1991); Brandt (1985); **β** = data from Goldschmid (1965); **γ** = reworked?; **δ** = data from Imhof in Jordan (1983); **ε** = own data; **ζ** = "*Arnioceras hartmanni* (Oppel)", data from Goldschmid (1965); **η** = loosely collected *Microderoceras* sp. (own data)

In this section, a *Coroniceras* sp. (Bucklandi zone) was found in situ in a bioclastic packstone, which is rich in gryphaeid oysters at the base and lies below an ammonite breccia (own data). In the marl layer, which contains gryphaeid oysters, limestone- and phosphorite-concretions, immediately below this packstone, however, the ammonite *Beaniceras* sp. of the middle Early Pliensbachian Ibex zone was found (own data). All additional ammonites found in this outcrop (all collected loosely, not in situ) are from the Early Sinemurian. Determination of the ostracod-fauna collected at this locality did not yield a proper solution for this unexpected biostratigraphic contradiction (Fig. 27). A

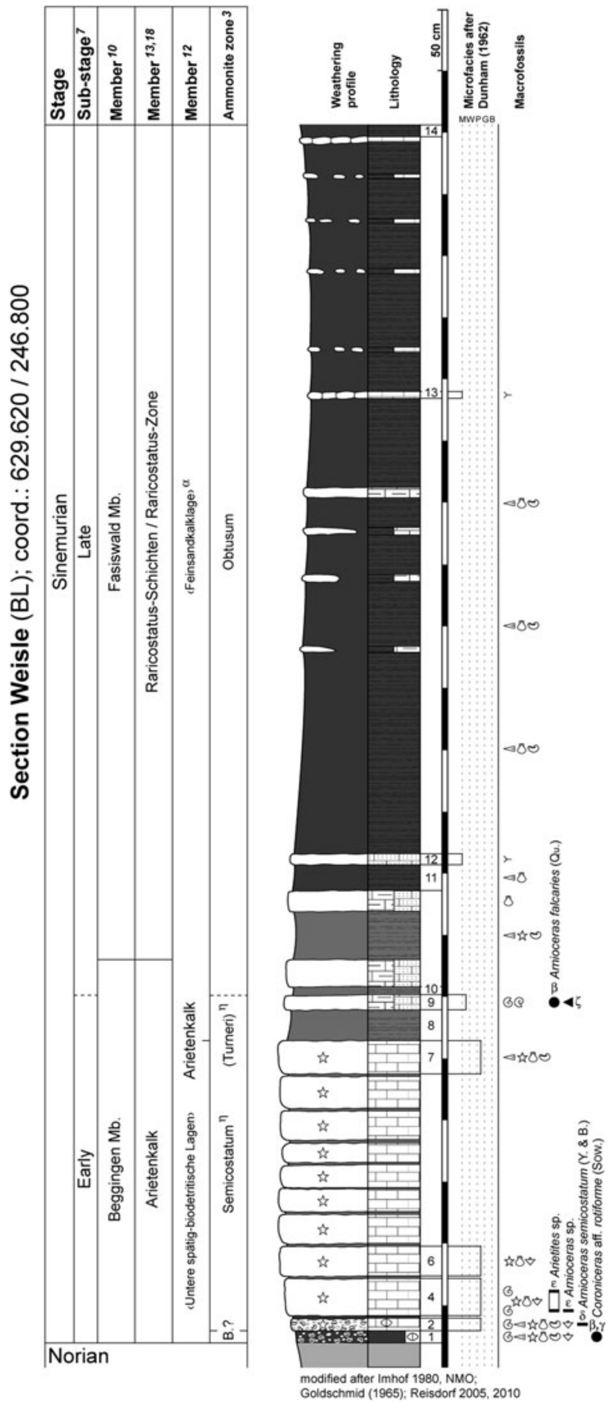


Fig. 16 continued

closer examination of the section of Courtemautruy yielded no distinct evidence for a tectonic overprint by folding or thrusting.

Based on the available bio- and lithostratigraphical data from the study area, two differing possible positions of the boundary between the Beggingen Member and the Mont Terri Member are shown in the stratigraphic scheme of the Staffelegg Formation (Fig. 3). In the eastern Mont Terri region, the position of this boundary is purely based on lithostratigraphic correlation with areas to the eastern Folded Jura (= boundary within the Obtusum zone; Fig. 3).

Based on the section Courtemautruy, the proposed boundary differs significantly from that of the traditional stratigraphic nomenclature: for the western Mont Terri area, the boundary is set at a diachronous erosional base that reaches from the Ibex zone to the Bucklandi zone (cf. Frank 1926: 404; Söll 1965: 157; Kant 1972: 29).

4.8 Breitenmatt Member

Names previously in use are given in Figs. 2 and 4.

Type locality Breitenmatt (ESE Gansingen; canton Aargau; coord.: 654.040/265.280; Buser 1952; outcrop no longer accessible).

Underlying strata Grünschholz Member or Fasiswald Member or Mont Terri Member.

Overlying strata Rickenbach Member or Rietheim Member or Gross Wolf Member (Erlimoos Bed).

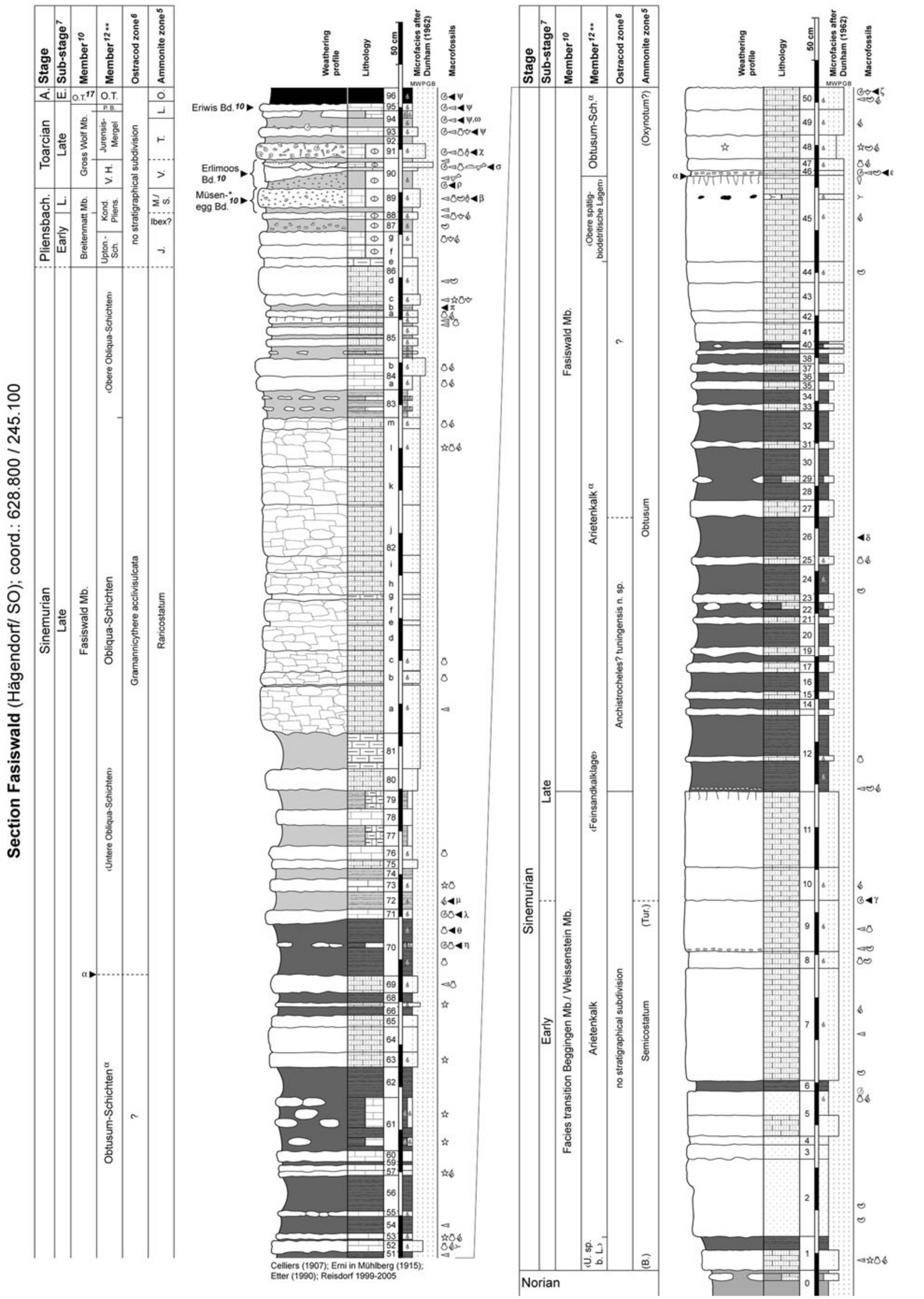
Subdivision Trasadingen Bed and Müsenegg Bed.

Occurrence Northern Switzerland.

Thickness Smallest thickness of ±50 cm in the Tabular Jura and the Klettgau area (Fig. 9; Schalch 1880: 225; Buxtorf 1901: 21; Buser 1952: 61p.); thickest occurrences together with the Müsenegg Bed (±4 m in the Weissenstein area; Buxtorf 1907); without the Müsenegg Bed the thickness can still be well above 2 m (maximum of 2.8 m in the Klettgau area; Hofmann 1981). In the Mont Terri area, the Breitenmatt Member is ca. 1.7 m thick.

Chronostratigraphic age Early to Late Pliensbachian (Jamesoni to Spinatum zone; Jordan 1983; Schlatter 1991, 2000; Maisch and Reisdorf 2006a, b).

Description Interval rich in fossils, consisting of marls and phosphoritic, predominantly concretionary limestones; belemnites and gryphaeid oysters dominate the macrofauna; presence of ichnofossils results in a spotted appearance (Figs. 7, 9, 10, 12, 13, 15 16, 17, 18, 19, 20, 26; see Braun 1920; Glauser 1936; Rickenbach 1947; Gsell 1968; Schlatter 1991). Belemnite-rich (so-called belemnite battlefields) horizons of Early Pliensbachian age containing glauconite can provide a strong gamma-log signal (Nagra 1984, 1990, 2001). Partial silicification of calcareous fossils is also often seen (especially in gryphaeid oysters; e.g., Mandy 1907; Jordan 1983).


Section Fasiswald (Hägendorf/ SO); coord.: 628.800 / 245.100
Stage
Sub-stage7
Member10
Member12 **
Ostracod zone6
Ammonite zone5
Weathering profile
Lithology
50 cm
Microfacies after Dunham (1962)
MWPGB
Macrofossils
Pliensbach.
Toarcian
Sinemurian
Early
Late
Breitenmatt Mb.
Gross Wolf Mb.
Fasiswald Mb.
Obliqua-Schichten
‹Obere Obliqua-Schichten›
‹Untere Obliqua-Schichten›
Obtusum-Schichten α
Gramannicythere acclivisulcata
no stratigraphical subdivision
Raricostatum
Eriwis Bd. 10
Erlimoos Bd. 10
Müsen-* egg Bd. 10
Celliers (1907); Erni in Mühlberg (1915); Etter (1990); Reisdorf 1999-2005
Norian
Facies transition Beggingen Mb./ Weissenstein Mb.
Arietenkalk
Arietenkalk α
‹Feinsandkalklage›
Obtusum-Sch. α
‹Obere spätig-biodetritische Lagen›
Anchistrocheles? tuningensis n. sp.
Semicostatum
Obtusum
(Oxynotum?)

◀ **Fig. 17** Detailed section of the Early Jurassic strata at the Fasiswald clay pit (W Olten). α = compare Jordan (1983: section Dottenberg) and Fig. 12; see also Etzold et al. (1975); Schlatter (1983b, 1991); Brandt (1985); β = "*0.15 m Grauer Kalk, Gryphaea cymbium*" of Celliers (1907: 17); see also Delhaes and Gerth (1912); γ = *Microderoceras* sp. (own data); δ = ostracods (own data, det. E. Beher 2004): *Anchistrocheles? tuningensis* Beher, *Bairdia molesta*; ε = *Asteroceras* sp. (reworked?, own data, compare Schlatter 1983b; finder: C.A. Meyer, Basel 2009); ζ = *Aegasteroceras* gr. *simile* Spath (own data, biostratigraphic range according to Schlatter 1983b, 1991); η = *Echioceras* s.l. (own data); θ = ostracods (own data, det. E. Beher 2004): *Acrocythere oeresundensis*, *Acrocythere michelseni*, *Bairdia molesta*, *Bairdia? extracta*, *Cytherelloidea modesta*, *Gramannicythere acclivisulcata*, *Gammacythere ubiquita*, *Isobythocypris tatei*, *Ledahia* sp., *Ogmoconcha amalthei*; λ = *?Echioceras* s.l. (own data); μ = ostracods (own data, det. E. Beher 2004): *Acrocythere oeresundensis*, *Bairdia molesta*, *Bairdia praehilda*, *Cardobairdia liassica*, *Cuneoceratina amlingstadtensis*, *Cytherella* sp., *Cytherelloidea lacertosa*, *Gammacythere ubiquita*, *Isobythocypris tatei*, *Ledahia bispinosa*, *Nanacythere* sp., *Ogmoconcha amalthei*, *Ogmoconchella* sp. 1 (Beher 2004), *Polycope* sp.; π = ostracods (own data, det. E. Beher 2004): *Cytherelloidea modesta*, *Ledahia bispinosa*, *Progonoidea auleata*; ρ = *Lytoceras* sp., *Liparoceras* (*Parinodiceras*) gr. *zieteni* (Trueman), *Aegoceras* sp., *Derolytoceras* sp. (own data); σ = *Lytoceras* sp.; χ = *Lytoceras* sp., *Liparoceras* sp., *Haugia* sp.? (own data; see also Erni in Mühlberg 1915); ψ = faunal list in Etter (1990); ω = *Lytoceras* sp., *Grammoceras* (gr. *fallaciosum*) sp. (own data); * = in the Fasiswald section, the Müsenegg Bed can even be completely eroded (see Erni in Mühlberg 1915); ** = see also Erni in Mühlberg (1915)

Distinct hardgrounds are sometimes developed in the Breitenmatt Member (Jordan 1983; Müller et al. 1984; Nagra 1992; Wetzel et al. 1993). In general, the Breitenmatt Member is significantly thinner than age-equivalent sediments in southern Germany and eastern France (see Vonderschmitt 1942; Gwinner et al. 1967: Table 1; Wirth 1968; Etzold et al. 1975; Debrand-Passard 1984). In the Mont Terri area, the facies of the Breitenmatt Member is limited to the Davoei zone, including a thin phosphoritic interval that has been attributed to the Mont Terri Member by Jordan et al. (2008: fig. 14.31). However, in the remaining study area, the Breitenmatt Member represents a highly condensed interval that, together with the Müsenegg Bed, can span all the ammonite-zones of the Pliensbachian (Fig. 3; see Pratje 1924; Schlatter 1991; Wetzel and Reisdorf 2007). In addition, the Breitenmatt Member has been exposed to pronounced synsedimentary and postsedimentary erosion and reworking processes (see Müller et al. 1984; Brandt 1985; Schlatter 1991). It's biostratigraphical extent is therefore only incompletely preserved, especially in the Folded Jura (Figs. 3, 19 and 20; Schlatter 1991; Wetzel et al. 1993).

4.8.1 *Trasadingen Bed*

Names previously in use are given in Fig. 4.

Type locality A now filled up pit 200 m SW of Trasadingen (Kilchstieg, canton Schaffhausen; coord.: 674.100/280.050; Schalch 1880).

Underlying strata The Trasadingen Bed represents the uppermost bed of the Breitenmatt Member in the Tabular Jura and the Klettgau area.

Overlying strata Rickenbach Member.

Occurrence Klettgau area, Zürcher Weinland, Tabular Jura, ?Mont Terri area.

Thickness Up to 30 cm (Fig. 7).

Chronostratigraphic age Early Pliensbachian (Davoei zone, Davoei and Oistoceras subzones; Schlatter 1991).

Description Middle grey, splintery marly limestone which has a spotted appearance because of their burrows (Figs. 7 and 9; Schalch 1880, 1916; Schlatter 1991). This most conspicuous lithostratigraphic horizon of the Breitenmatt Member wedges out laterally and passes into a calcareous marl (see Brändlin 1911; Schlatter 1991). In the study area, the biostratigraphy of this bed correlates with the first and last occurrence of the ammonite *Prodactylioceras davoei* (Sow.) within a limestone layer (see Brändlin 1911; Schlatter 1991; see also Fig. 26).

4.8.2 *Müsenegg Bed*

Names previously in use are given in Figs. 2 and 4.

Type locality Müsenegg (S Schinznach; canton Aargau; coord.: 652.570/253.350; Jordan 1983).

Underlying strata The Müsenegg Bed represents the uppermost bed of the Breitenmatt Member in the Folded Jura, except in the Mont Terri area.

Overlying strata Rietheim Member or Gross Wolf Member.

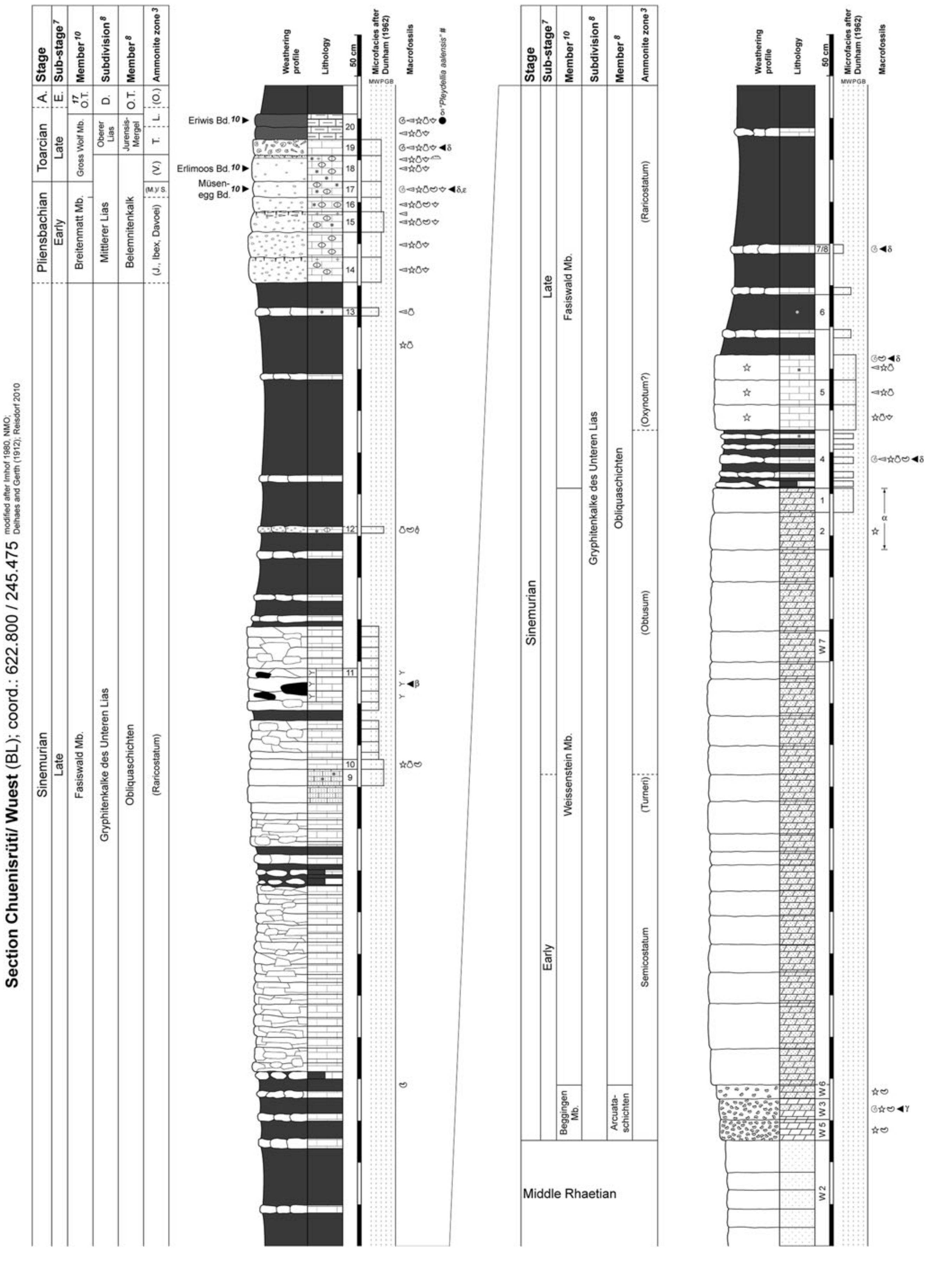
Occurrence Folded Jura (except for the Mont Terri area).

Thickness From 0 to 70 cm thick (Figs. 17, 19, 23).

Chronostratigraphic age Late Pliensbachian (Margaritatus to Spinatum zone; Fig. 18; see Buxtorf 1907; Hess 1962; Jordan 1983; Maisch and Reisdorf 2006a, b).

Description Condensed phosphoritic marl and/or one marly limestone bed (Figs. 10, 11, 13, 15 16, 17, 21, 23). The Müsenegg Bed can be capped by a hardground (Figs. 13, 23; Wetzel et al. 1993). The distinct, irregular light to dark grey spotted appearance of the Müsenegg Bed is characteristic; it is caused by the diverse ichnofauna occurring in these strata (Jordan 1983; Wetzel and Reisdorf 2007). Bivalves of the genus *Gryphaea* are the most conspicuous component of the macrofauna (see Erlimoos Bed).

Therefore, the petrography of the Müsenegg Bed is sometimes difficult to differentiate from that of older layers


Section Chuenisrüti/ Wuest (BL); coord.: 622.800 / 245.475
modified after Imhof 1980, NMO; Delhaes and Gerth (1912); Reisdorf 2010
Stage
Sub-stage
Member
Subdivision
Member
Ammonite zone
Weathering profile
Lithology
50 cm
Microfacies after Dunham (1962)
MWPGB
Macrofossils
Toarcian
Late
Gross Wolf Mb.
Oberer Lias
Jurensis-Mergel
Pliensbachian
Early
Breitenmatt Mb.
Mittlerer Lias
Belemnitenkalk
(J., Ibex, Davoei)
Eriwis Bd.
Erlimoos Bd.
Müsenegg Bd.
"Pleydellia aalensis" #
Sinemurian
Late
Fasiswald Mb.
Gryphitenkalke des Unteren Lias
Obliquaschichten
(Raricostatum)
(Oxynotum?)
(Obtusum)
Early
Weissenstein Mb.
(Turneri)
Semicostatum
Beggingen Mb.
Arcuata-schichten
Middle Rhaetian

◀ **Fig. 18** Detailed section of the Late Triassic and Early Jurassic strata at Chuenisrüti and Wuest (BL). α = *Obtusussandsteine* after Buxtorf (1907); β = see also Delhaes and Gerth (1912); compare Figs. 13, 15, 16; γ = "*Arietites*" (Erni 1910, 1926); δ = data from Imhof in Jordan (1983); compare Etzold et al. (1975), Schlatter (1983b, 1991) and Brandt (1985); ε = "*Amaltheus costatus*" (approximate stratigraphic position after Delhaes and Gerth 1912)

of the Breitenmatt Member. In such case, a certain stratigraphic classification can only be achieved with index fossils of the Late Pliensbachian. The biostratigraphically orderless appearance of index fossils like ammonites, foraminifers and ostracods indicates substantial reworking and bioturbation during the deposition of the Müsenegg Bed (Hess 1962; Jordan 1983; Wetzel and Reisdorf 2007).

4.9 Rickenbach Member

Names previously in use are given in Figs. 2 and 4.

Type locality 700 m NNE of Rickenbach ("Hintern Egg" = Waldegg, canton Baselland; coord.: 631.180/260.320; Buxtorf 1901; the section is not accessible at the present time).

Underlying strata Breitenmatt Member.

Overlying strata Rietheim Member (Schlatter 1982; cf. Joachim 1970: 16; Etzold et al. 1975).

Occurrence Klettgau area, Zürcher Weinland, Tabular Jura, ?Bernese Jura (Elber 1921), ?Mont Terri area (Fig. 26).

Thickness In the Tabular Jura, minimal thicknesses are probably around 25 cm (Nagra 1990); the questionable Rickenbach Member in the Mont Terri area is also only a few decimeters thick (Fig. 26; see Glauser 1936; Bitterli 1960); maximum thickness is significantly above 5 m in the Klettgau area (Schalch 1880; possibly up to ca. 10 m?, Hofmann 1981); in the Tabular Jura, thickness of around 2 m is observed (see Buxtorf 1901).

Chronostratigraphic age Late Pliensbachian to Early Toarcian (Margaritatus to Tenuicostatum zone, Stokesi to Paltum subzone; Figs. 7, 9; Schlatter 1982, 1985: 13, 1991).

Description Condensed interval of reduced thickness (except in the northern Klettgau area; see Schalch 1916; Gsell 1968; Nagra 2001 and references therein), consisting of glauconitic, phosphoritic, fossil-rich (especially rich in belemnites; so-called belemnite battlefields) marls and concretionary limestones (Figs. 7, 9, 26; see Brändlin 1911; Pratje 1924; Buser 1952). At the top of the

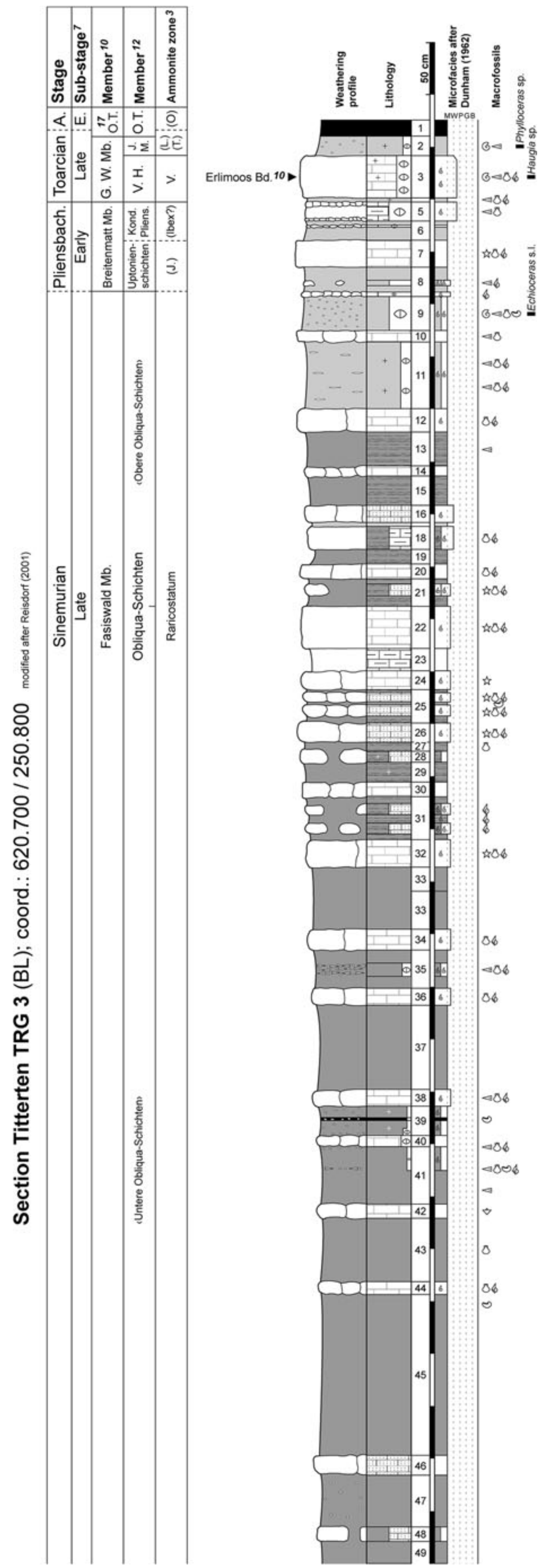


Fig. 19 Detailed section of the Early Jurassic strata at Titterten TRG ▶ 3 (BL), temporary exposure; modified after Reisdorf (2001)

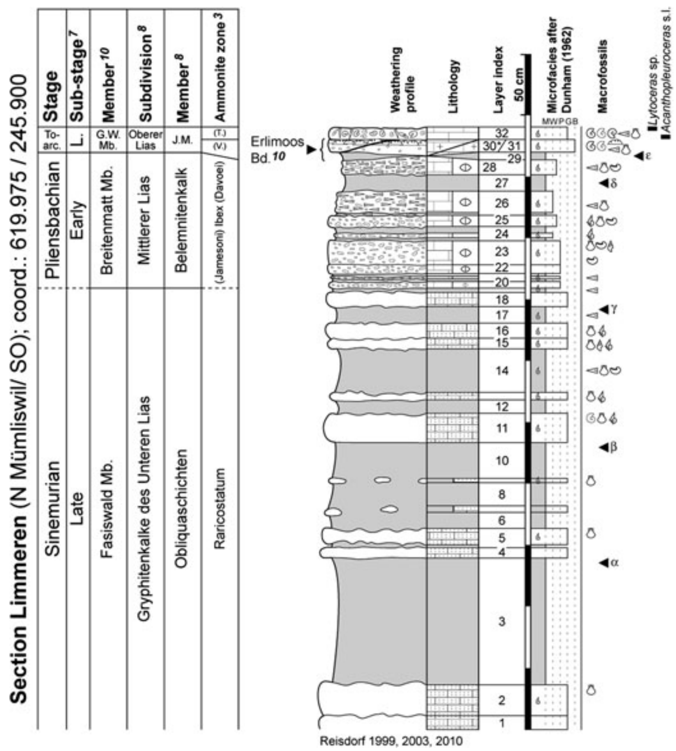


Fig. 20 Detailed section of the Early Jurassic strata at Limmeren (N Mümliswil/SO; see section "Limmernbach SW Ramisgraben", Delhaes and Gerth 1912). $\boldsymbol{\alpha}$ = ostracods (own data, det. E. Beher 2004; for the stratigraphic range of the ostracods see Beher 2004 and Franz et al. 2009): *Acrocythere michelseni*, *A. oeresundensis*, *Gramannicythere acclivisulcata*, *Gramannicythere* sp. 1; $\boldsymbol{\beta}$ = ostracods (own data, det. E. Beher 2004): *Ektyphocythere vitiosa*, *Gramannicythere acclivisulcata*; $\boldsymbol{\gamma}$ = ostracods (own data, det. E. Beher 2004): *Bythocypris postera*, *Cytherelloidea lacertosa*, *C. modesta*, *Gammacythere ubiquita*, *Liasina vestibulifera*, *Ogmoconcha amalthei*; $\boldsymbol{\delta}$ = ostracods (own data, det. E. Beher 2004): *Bairdia molesta*, *Cardobairdia* sp. 1 Beher, *Ogmoconcha amalthei*; $\boldsymbol{\varepsilon}$ = ostracods (own data, det. E. Beher 2004): *Kinkelinella sermoisensis*, *Ledahia bispinosa*, *L. mouherense*, *Ogmoconcha* sp., *Paracypris* sp. (*semidisca*?); * = note the erosional unconformity between beds 30 and 31

Rickenbach Member, bluish grey marls (= *Blaugraue Mergel* sensu Schlatter 1982) can be found in the Klettgau area and in the Tabular Jura, greenish grey to blackish grey clayey marls occur (= *Basisschicht* of Kuhn and Etter 1994; Fig. 7), both in small thicknesses.

4.10 Rietheim Member

Names previously in use are given in Figs. 2 and 4.

Type locality Rietheim (canton Aargau; coord.: 662.910/ 271.865; outcrop in the bed of a stream; see Kuhn and Etter 1994).

Underlying strata Rickenbach Member or Breitenmatt Member.

Overlying strata Gross Wolf Member.

Subdivision Unterer Stein.

Occurrence Klettgau area, Zürcher Weinland, Tabular Jura, eastern Folded Jura to Hauenstein area, Weissenstein area, Bernese Jura, Mont Terri area.

Thickness The thickness of about 10 m in the Klettgau area decreases towards the south and southwest (Tabular Jura and Folded Jura) markedly to a few centimetres (see Elber 1921; Riegraf 1985: 62; Kuhn and Etter 1994; Nagra 2001; Reisdorf 2001). By contrast, the Rietheim Member attains a thickness of some 20 m in the Mont Terri area (Fig. 26; Rickenbach 1947; Bitterli 1960; Contini and Lamaud 1978). Additionally, the Rietheim Member does not occur areawide in the Folded Jura due to erosion (Figs. 13, 15 16, 17, 18, 19, 20, 21, 23; see Erlimoos Bed; see Kuhn and Etter 1994; Reisdorf 2001).

Chronostratigraphic age Early Toarcian (Tenuicostatum to Bifrons zone, Paltum to Crassum subzone; Schlatter 1982; Richter 1987; Kuhn and Etter 1994; Maisch and Reisdorf 2006a, b).

Description Bituminous, predominantly thinly bedded shale and marl layers which can be clearly separated from the under- and overlying members by their brownish, dark grey to black colour (Figs. 7, 9 10, 11, 26; see Bitterli 1960; Richter 1987; Kuhn and Etter 1994; Nagra 2001). Thin limestone beds and calcareous concretions occur in

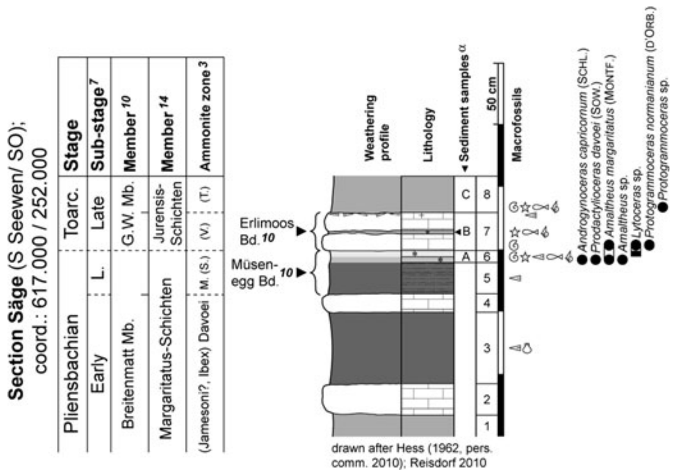


Fig. 21 Detailed section of the Early Jurassic strata at Säge (S Seewen/SO), drawn after Hess (1962, pers. comm. 2010). α = (A, B, C) faunal list of the ostracod and foraminiferal assemblages in Hess (1962), compare Riegraf (1985); see also Bitterli (1960), Richter (1987) and Tröster (1987)

addition in the Rietheim Member (Figs. 7, 10, 11, 26; see Senftleben 1923; Pratje 1924; Kuhn and Etter 1994; Nagra 2001). These are prominent in thin Early Toarcian sections. Where the Rietheim Member reaches large thickness (Klettgau area, Mont Terri area), the limestone beds are outweighed by siliciclastic sediments.

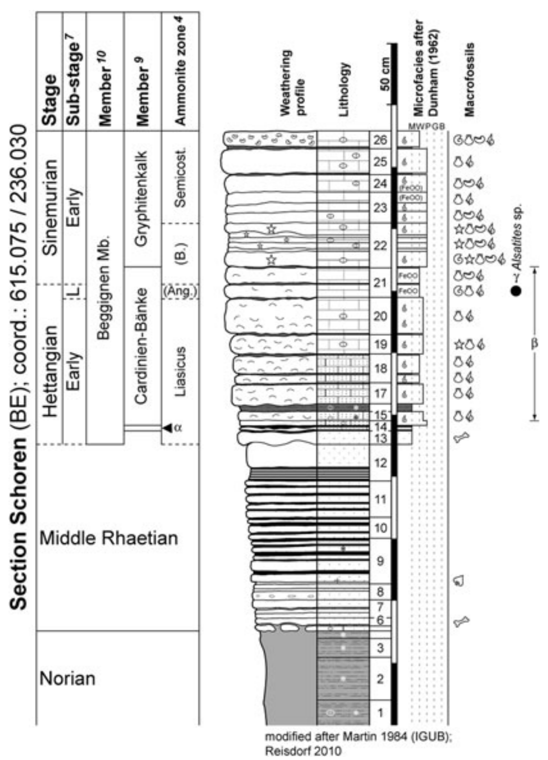


Fig. 22 Detailed section of the Late Triassic and Early Jurassic strata at Schoren (BE). α = "*Insektenmergel*" (compare Fig. 24); β = beds rich in *Plagiostoma* (Rollier 1910); γ = reworked? (see Schloz 1972; Schlatter 1988 and Fig. 7)

Some of the limestone beds are important lithostratigraphic markers that can be correlated as far as France and southwestern Germany (cf. Riegraf et al. 1984: 14p.; Kuhn and Etter 1994; Röhl et al. 2001). The most important marker bed for the Early Toarcian in northern Switzerland, the Unterer Stein, is usually developed even the Rietheim Member is very thin (Fig. 9; see Buxtorf 1907; Elber 1921; Vogel 1934; Jordan 1983).

4.10.1 *Unterer Stein (in the rank of a bed)*

Names previously in use are given in Fig. 4.

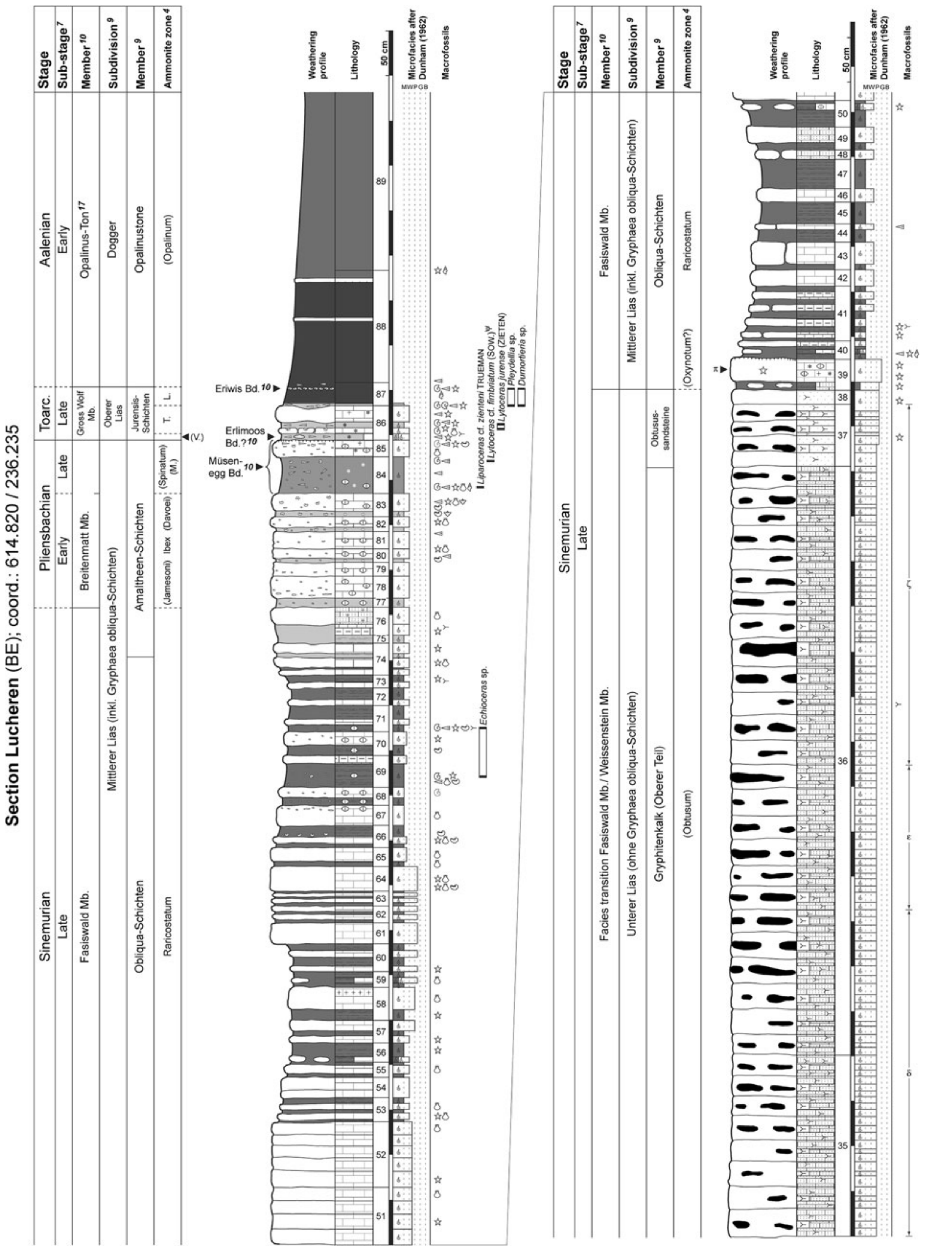
Type locality Bad Boll (SSW Göppingen, southern Germany; Oppel 1856–1858).

Occurrence Klettgau area, Zürcher Weinland, Tabular Jura (may wedge out laterally in the Basel Tabular Jura), eastern Folded Jura to the Hauenstein area, Bernese Jura, Weissenstein area, Mont Terri area.

Thickness 0 up to 25 cm (e.g., Kuhn and Etter 1994; Maisch and Reisdorf 2006a, b), in the Mont Terri area roughly twice as thick (e.g., Rickenbach 1947).

Chronostratigraphic age Early Toarcian (Falcifer zone, Exaratum subzone; Kuhn and Etter 1994; Röhl et al. 2001).

Description As a rule, the Untere Stein (= *erster Stinkstein*; von Wurstemberger 1876) is included in the basal layer interval of the Rietheim Member (Figs. 7, 9 10, 11, 26; e.g., Elber 1921; Pratje 1924; Kuhn and Etter 1994). It may also represent the basal layer of the Rietheim Member (e.g., in the Weissenstein area; Buxtorf 1907; Vogel 1934) and/or its topmost bed, for instance in the eastern Folded Jura (Jordan 1983). It is a distinct, bituminous limestone



Section Lucheren (BE); coord.: 614.820 / 236.235
Stage
Sub-stage
Member
Subdivision
Member
Ammonite zone
Weathering profile
Lithology
50 cm
Microfacies after Dunham (1962)
MWPGB
Macrofossils
Sinemurian
Late
Fasiswald Mb.
Obliqua-Schichten
Raricostatum
Pliensbachian
Early
Late
Breitenmatt Mb.
Mittlerer Lias (inkl. Gryphaea obliqua-Schichten)
Amaltheen-Schichten
(Jamesoni) Ibex (Davoei)
(Spinatum) (M.)
Toarc.
Gross Wolf Mb.
Oberer Lias
Jurensis-Schichten
T. L.
(V.)
Aalenian
Opalinus-Ton
Dogger
Opalinustone
(Opalinum)
Eriwis Bd.
Erlimoos Bd.?
Müsen-egg Bd.
Liparoceras cf. zienteni TRUEMAN
Lytoceras cf. fimbriatum (SOW.)
Lytoceras jurense (ZIETEN)
Pleydellia sp.
Dumortieria sp.
Echioceras sp.
Facies transition Fasiswald Mb / Weissenstein Mb.
Unterer Lias (ohne Gryphaea obliqua-Schichten)
Gryphitenkalk (Oberer Teil)
(Obtusum)
Obtusus-sandsteine
(Oxynotum?)

◀ **Fig. 23** Detailed section of the Early Jurassic strata at Lucheren (BE). **α** = beds rich in *Plagiostoma* (Rollier 1910); **β** = bluish chert nodules (see also Buxtorf 1907; Fischer and Luterbacher 1963 = 28); γ = whitish chert nodules; **δ** = bluish and grey chert nodules; ε = greyish black chert nodules; ζ = bluish and grey to dark grey chert nodules; **π** = compare Figs. 12, 13, 15, 16, 17, 18; **ψ** = for the biostratigraphic range of *Lytoceras* cf. *fimbriatum* (Sow.) see Schlatter (1991)

bed exhibiting clear lamination and having conchoidal-splintery fractures (Kuhn and Etter 1994; Etter and Kuhn 2000).

4.11 Gross Wolf Member

Names previously in use are given in Figs. 2 and 4.

Type locality Gross Wolf clay pit (canton Aargau; coord.: 645.725/253.350; Jordan 1983).

Underlying strata Rietheim Member or Breitenmatt Member.

Overlying strata Opalinus-Ton.

Subdivision (1) The Gross Wolf Member has the Gipf Bed or the Erlimoos Bed, respectively, at the base. Which of these two basal layers that is developed is strongly dependent on the next lower member. (2) In the eastern Folded Jura, but also in the occurrences in the Molasse basin to the south, the Eriwis Bed forms the uppermost bed of the Gross Wolf Member (see Jordan 1983; Nagra 1992).

Occurrence Northern Switzerland.

Thickness The minimum thickness is ±60 cm (eastern Folded Jura; Figs. 13, 16, 19); maximum thickness is around 5.3 m in the eastern Folded Jura and 6.1 m in the Molasse basin (Fig. 11; Jordan 1983; Nagra 2001; some 19 m in the Buix well?, Schmidt et al. 1924: 13).

Chronostratigraphic age Late Toarcian to Early Aalenian (Variabilis to Opalinum zone; Tröster 1987; Nagra 1989, 1990, 1992; Etter 1990; Maisch and Reisdorf 2006a, b).

Description Condensed interval consisting of grey phosphoritic marls and concretionary marly limestones with pyrite and abundant macrofossils (especially belemnites and ammonites; Figs. 9 10, 11, 12, 13, 15 16, 17, 18, 19, 20, 21; see Elber 1921; Vogel 1934; Tröster 1987; Reisdorf 2001). However, unlike the sediments of the Sinemurian and Pliensbachian, the Gross Wolf Member seems to be almost completely barren of gryphaeid oysters (Senftleben 1923: 22 mentions a possible exception). The fossil-rich basal and topmost beds of the Gross Wolf Member deserve special attention (= Gipf Bed or Erlimoos Bed respectively; Eriwis Bed). They are stratigraphic index beds in the study

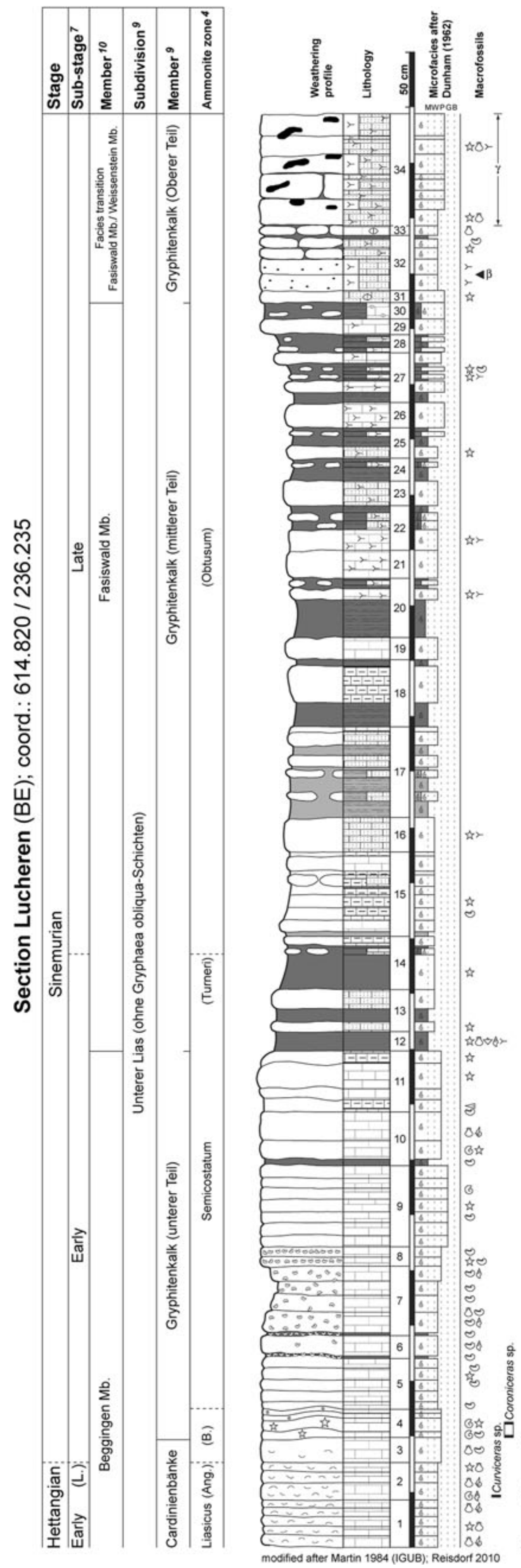


Fig. 23 continued

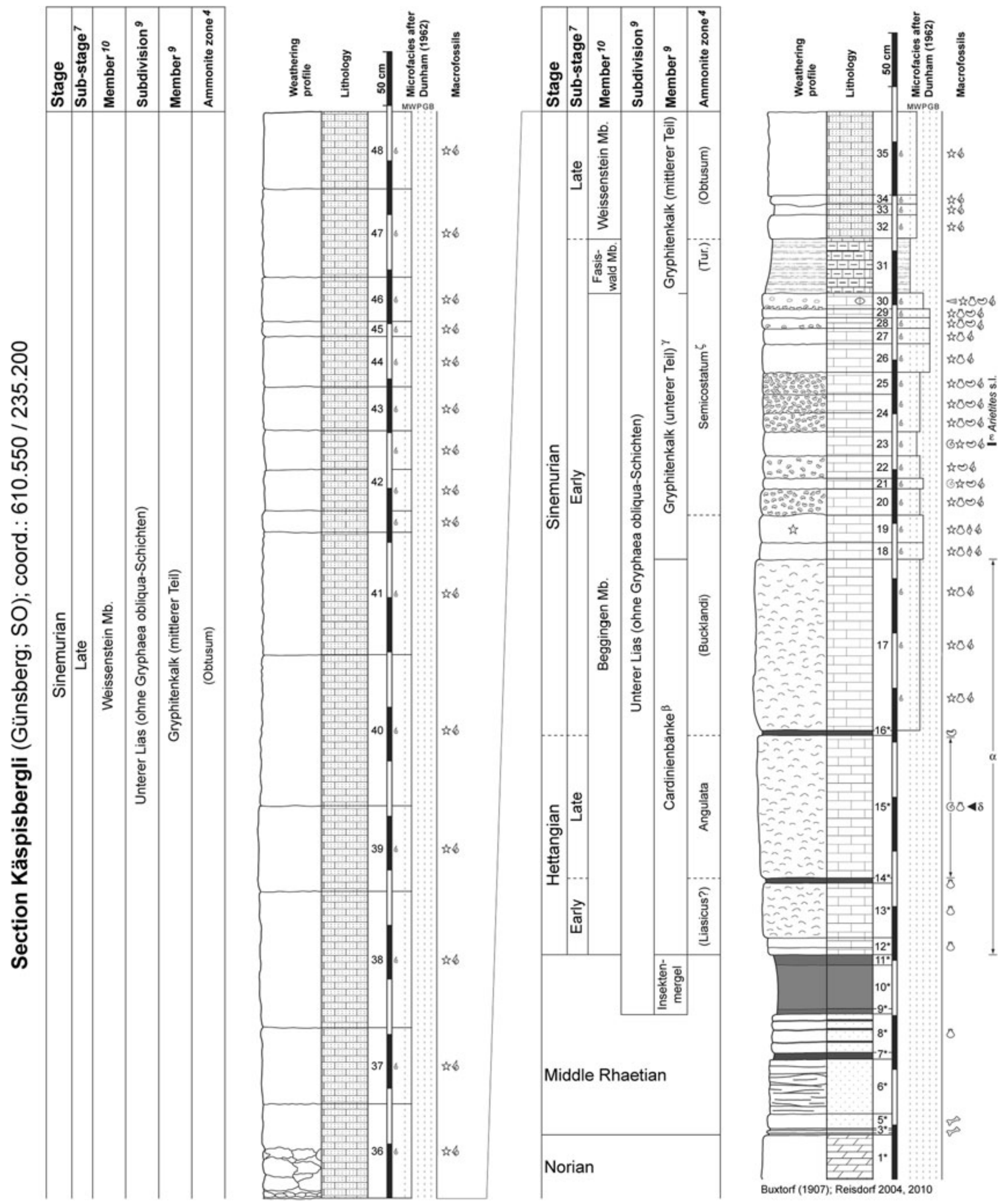
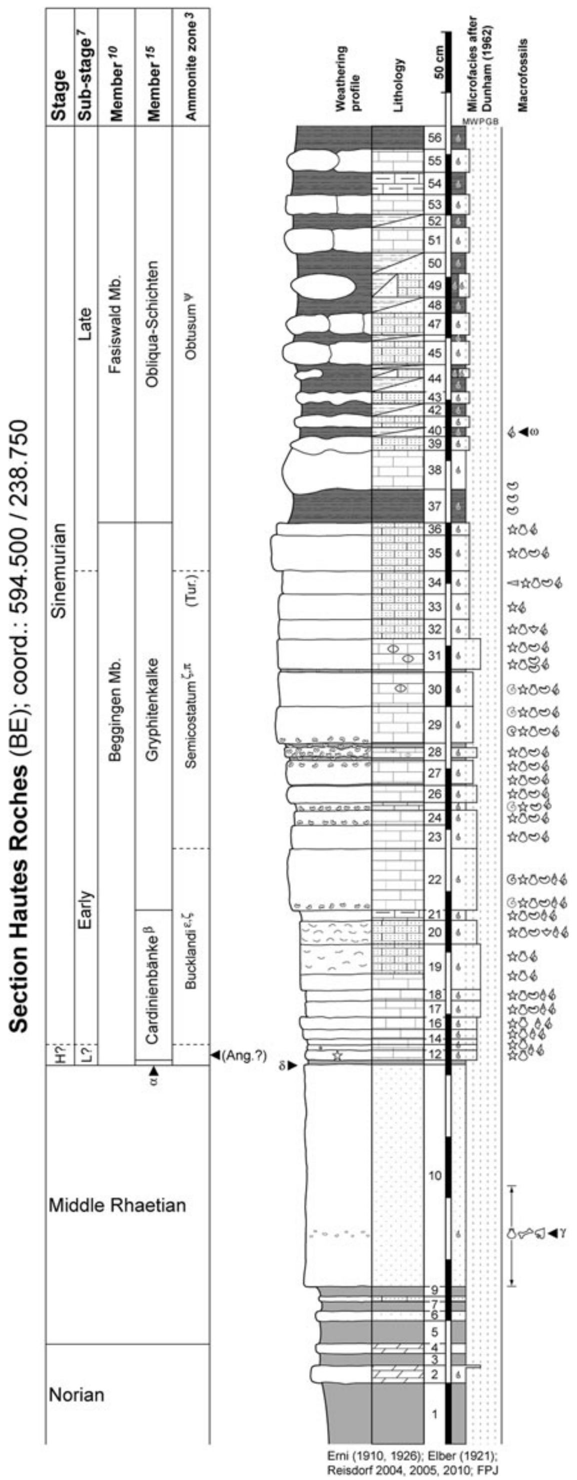


Fig. 24 Detailed section of the Late Triassic and Early Jurassic strata at Käspisbergli (Günsberg; SO). ***α*** = beds rich in *Plagiostoma* (Rollier 1910); ***β*** = "*Grès à Cardinia, Gressly 1862*" in Waagen (1864); ***γ*** = "*Calcaire à Gryphées Gressly 1862*" in Waagen (1864); ***δ*** = "*Schlotheimia angulata*" (Buxtorf 1907); ***ε*** = see also Bitterli and Strub (1975); ***ζ*** = loosely collected: *Euagassiceras* sp. (own data); "*A. bisulcatus*" (see Waagen 1864); * = data from Buxtorf (1907)

area (see Jordan 1983; Nagra 1992; Kuhn and Etter 1994). Also, sediments of the Thouarsense zone have been observed, amalgamated in an ammonite- and belemnite-rich limestone bed in the thin occurrences in the Hauenstein—Passwang area (Figs. 13, 17, 18, 20; cf. Fischer 1964: 86p.; Etzold 1980; Riegraf et al. 1984: 61).

The boundary between the Gross Wolf Member and the Opalinus-Ton is not identical to the biostratigraphic boundary between the Early and Middle Jurassic. The latter can lie either within the Gross Wolf Member or within the Opalinus-Ton in northern Switzerland (see Nagra 1984, 1989, 1990; Etter 1990; Reisdorf et al. subm.; cf.



◀ **Fig. 25** Detailed section of the Late Triassic and Early Jurassic strata at Hautes Roches (BE). **?** = uncertain biostratigraphic affiliation (compare with Fig. 22); α = "*Insektenmergel*"? (compare with Fig. 22); β = see also Erni (1910, 1926) vs. Vollrath (1924: 22) and Frank (1930: 385); γ = see also Erni (1910, 1926) and Elber (1921); δ = loosely collected *Waehneroceras* sp. (= *Curviceras*), reworked? (own data); ε = *Arietites* (*Arietites*) cf. *bisulcatus* (Brugiére), data from B. Hostettler (FPJ, 2005); ζ = *Coroniceras* sp. (loosely collected, own data); π = *Arnioceras* cf. *oppeli* (Guérin-Franiatte), *Arnioceras* cf. *ceratitoides* (Qu.) (own data); *Arnioceras* cf. *oppeli* (Guérin-Franiatte), *Arnioceras* cf. *falcaries* (Qu.), *Arnioceras* cf. *robustum* (Qu.), data from B. Hostettler (FPJ, 2005); ψ = *Microderoceras* sp., *Asteroceras* cf. *alamanicum* (Guérin-Franiatte), data from B. Hostettler (FPJ, 2005); ω = ostracods (own data, det. E. Beher 2004): *Acrocythere oeresundensis*, *Bairdia*? *extracta*, *Bairdia molesta*, *Bythocypris postera*, *Isobythocypris tatei*, *Ledahia bispinosa*, *Ogmoconcha* aff. *amalthei*, *Paracypris* sp., *Paracypris alemannica*

Franz and Nitsch 2009). The sedimentological expression of the boundary between these two stratigraphic units is mainly characterised by a sharp change in colour from predominantly grey marl in the Gross Wolf Member to dark grey to black mica-bearing, silty terrigenous mudstone in the Opalinus-Ton (see Etter 1990; Nagra 2001; Wetzel and Allia 2003).

4.11.1 Gipf Bed

Names previously in use are given in Figs. 2 and 4.

Type locality Gipf clay pit (SW Frick; canton Aargau; coord.: 642.125/261.775; Rieber 1973).

Underlying strata Rietheim Member.

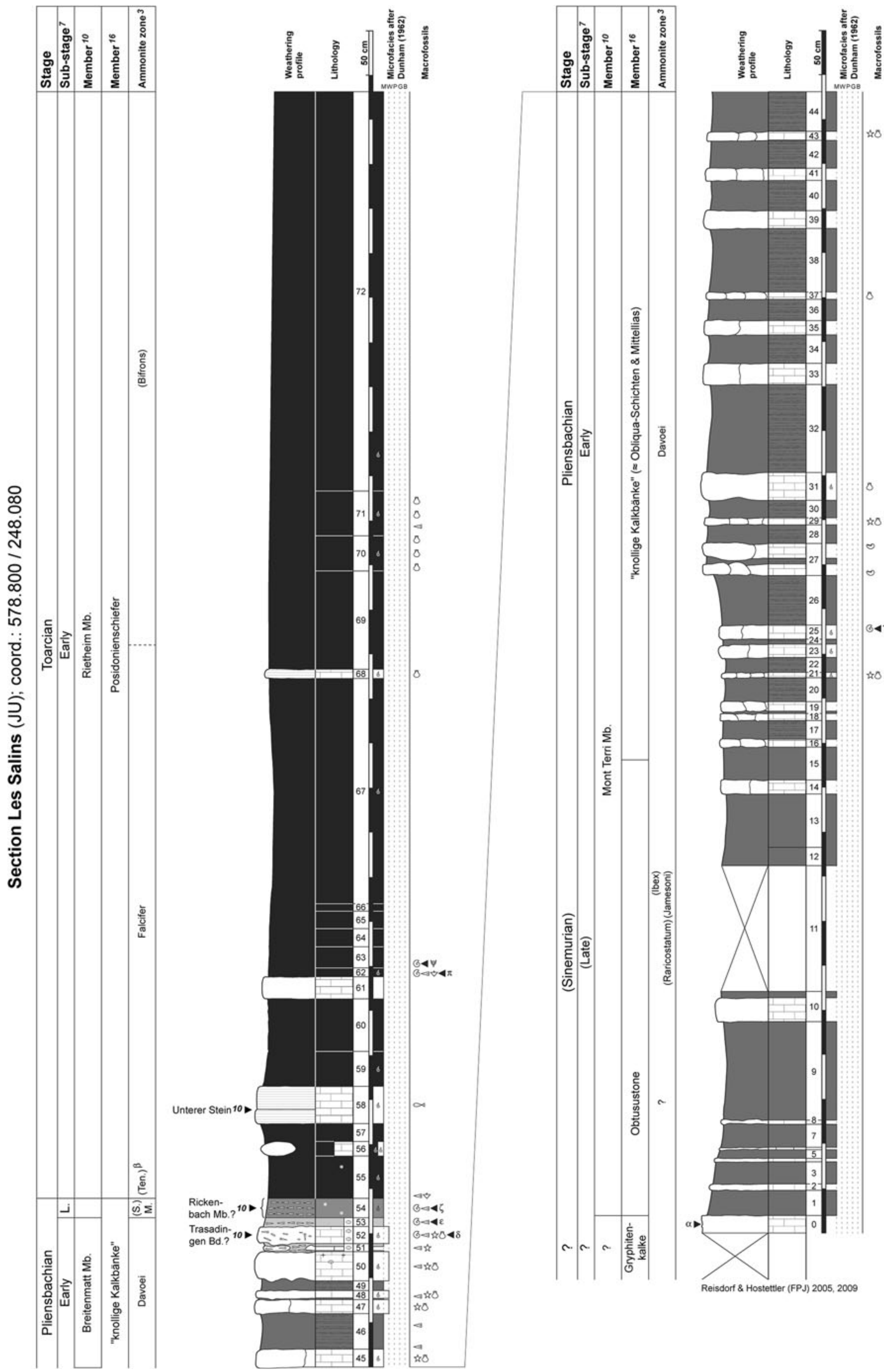
Overlying strata The Gipf Bed forms the basal layer of the Gross Wolf Member.

Occurrence The Gipf Bed is only developed within the area where the Rietheim Member is present (Fig. 3): Klettgau area, Zürcher Weinland, Tabular Jura, eastern Folded Jura and possibly also in the Mont Terri area. In the Hauenstein area, there is a significant reduction in thickness and facies interfingering with the Erlimoos Member is observed (see Jordan 1983; Wetzel and Reisdorf 2007).

Thickness 0 to some 175 cm (see Jordan 1983; Richter 1987; Tröster 1987).

Chronostratigraphic age early Late Toarcian (Variabilis zone; Rieber 1973; Jordan 1983; cf. Knitter and Ohmert 1983; Knitter and Riegraf 1984; Richter 1987; Etzold et al. 1989; Kuhn and Etter 1994).

Description The facies of the Gipf Bed varies widely in the study area. This facies variation is mainly related to the thickness of the Gipf Bed. Essentially, the observed facies are condensed, yellowish to grey, glauconite-bearing, sometimes pyritic and sometimes bituminous marls, rich in fossils (especially belemnites; Jordan 1983; Nagra 1990; Kuhn and Etter 1994; cf. Fischer 1964). Concretionary limestone layers of up to about 20 cm thickness can be intercalated in the thickest intervals of these marls (Richter 1987; Tröster 1987; Kuhn and Etter 1994; cf. Fischer 1964). In addition, the Gipf Bed can contain limestone clasts that originate from the Rietheim Member or, in the


Section Les Salins (JU); coord.: 578.800 / 248.080
Stage
Sub-stage7
Member10
Member16
Ammonite zone3
Weathering profile
Lithology
50 cm
Microfacies after Dunham (1962)
MWPGB
Macrofossils
Pliensbachian
Early
L.
Breitenmatt Mb.
"knollige Kalkbänke"
Davoei
(S.) M.
(Ten.)β
Toarcian
Early
Rietheim Mb.
Posidonienschiefer
Falcifer
(Bifrons)
Unterer Stein10
Ricken-bach Mb.?10
Trasadin-gen Bd.?10
(Sinemurian)
(Late)
Pliensbachian
Early
Mont Terri Mb.
"knollige Kalkbänke" (≈ Obliqua-Schichten & Mittellias)
Gryphiten-kalke
Obtusustone
Davoei
(Ibex)
(Raricostatum) (Jamesoni)
Reisdorf & Hostettler (FPJ) 2005, 2009

◀ **Fig. 26** Detailed section of the Early Jurassic strata at Les Salins (SE Courtemautruy/JU). α = compare Fig. 27; β = compare Richter (1987: 141), Pharisat et al. (1993) and Kuhn and Etter (1994); γ = *Aegoceras* cf. *maculatum* (Y. & B.); note the large minimal thickness solely for the sediments of the Davoei zone (at least 7.8 m); δ = *Becheiceras* sp., *Prodactylioceras davoei* (Sow.); ε = *Lytoceras fimbriatum* (Sow.), *Becheiceras* sp., *Androgynoceras capricornus* (Schl.), *Oistoceras angulatum* (Qu.), *Prodactylioceras davoei* (Sow.), *P. davoei enode* (Qu.); ζ = *Lytoceras fimbriatum* (Sow.), *Amaltheus* cf. *stokesi* (Sow.), *Amaltheus bifurcus* (Howarth), see also Schmidt et al. (1924), Glauser (1936) and Vonderschmitt (1942); π = *Dactylioceras* sp., *Discina* sp.; ψ = *Dactylioceras* sp.

case of oolithic clasts, may even be derived from the Gipf Bed itself (Richter 1987 vs. Rieber 1973; Kuhn and Etter 1994). The bituminous facies is characterised by one bioturbated layer, where it is thinly developed, and even by several, if thicker (Riegraf et al. 1984: 61pp.; Richter 1987), which then resemble the youngest layers of the

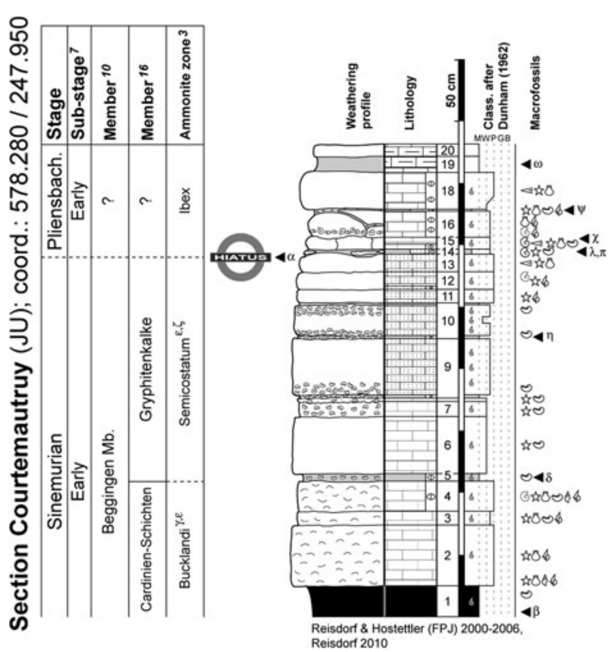


Fig. 27 Detailed section of the Early Jurassic strata at Courtemautruy (JU). α = no indications for disturbances caused by postjurassic tectonic processes or landslides could be detected in this sedimentary succession (section established by Reisdorf 2005); β = compare Buxtorf (1910); γ = loosely collected *Angulaticeras angulatoides* (Qu.); δ = ostracods (own data, det. E. Beher 2004): *Bairdia fortis*, *Isobythocypris tatei*, *Ledahia* sp., *Ogmoconcha* sp.; ε = loosely collected *Arietites* sp., *Arietites* s.l.; ζ = loosely collected *Paracoroniceras* s.l.; η ostracods (own data, det. E. Beher 2004): *Bairdia molesta*, *Cardobairdia liasica*, *Ledahia* sp., *Pseudohealdia*? sp.; λ = *Beaniceras* sp.; π = ostracods (own data, det. E. Beher 2004): *Bairdia fortis*; χ = *Coroniceras* sp.; ψ = ostracods (own data, det. E. Beher 2004): *Bairdia molesta*, *Cardobairdia liasica*, *Isobythocypris tatei*; ω = ostracods (own data, det. E. Beher 2004): *Bairdia fortis*, *Bairdia molesta*, *Bairdia michelseni*?, *Bairdiacypris anisica brevis*, *Bythocypris postera*, *Cardobairdia* sp. 3, *Cardobairdia liasica*, *Isobythocypris tatei*, *Ledahia* sp., *Ogmoconcha* sp., *Ostracode* E, *Paracypris*? *redcarensis* (Beher 2004)

Rietheim Member (e.g., *Fucoidengrenzbank* of Kuhn and Etter 1994; see Richter 1987). In the thinnest occurrences (40 cm and less) that are occur in the western Tabular Jura and the eastern Folded Jura, the marly facies of the Gipf Bed can merge laterally with a ferruginous or iron oolithic limestone which is occasionally overgrown by stromatolites (Fig. 10, Rieber 1973; Jordan 1983; Kuhn and Etter 1994; cf. Knitter and Riegraf 1984; Riegraf 1986).

4.11.2 Erlimoos Bed

Names previously in use are given in Figs. 2 and 4.

Type locality Erlimoos clay pit (NE Olten; canton Solothurn; coord.: 633.400/247.050; Fig. 13).

Underlying strata Rietheim Member (including Unterer Stein) or Breitenmatt Member (including Müsenegg Bed).

Overlying strata The Erlimoos Bed forms the base of the Gross Wolf Member.

Occurrence Hauenstein area to Bernese Jura and adjacent areas to the south in the Molasse Basin (see Jordan 1983; Nagra 1992; Figs. 17, 20). In the Hauenstein area facies interfingering occurs between the Erlimoos Bed and the Gipf Bed (see Kuhn and Etter 1994; Maisch and Reisdorf 2006a, b).

Thickness 0–40 cm (e.g., Figs. 19, 20).

Chronostratigraphic age Early Late Toarcian (Variabilis zone; Imhof in Jordan 1983; Kuhn and Etter 1994; Reisdorf 2001).

Description Strongly condensed, phosphoritic, glauconitic marls rich in fossils or marly limestone of small thickness (Figs. 12, 13, 17 18, 19, 20, 21; see Erni in Mühlberg 1915; Jordan 1983; Kuhn and Etter 1994). In addition, clasts and even boulders occur, as well as macrofossils that display evidence of reworking, such as phosphatised ammonites (Fig. 19; see Erni in Mühlberg 1915; Imhof in Jordan 1983; cf. Groschopf et al. 1977: 115p.). In the Hauenstein area, the Erlimoos Bed also contains disarticulated and often fragmented reptilian skeletal elements (= exhumed and reworked vertebrate fragments of the Rietheim Member?; Figs. 13, 17; see Meyer and Furrer 1995; Reisdorf et al. subm.).

The biostratigraphically orderless appearance of index fossils (ammonites, ostracods, foraminifers) indicates substantial reworking and bioturbation during the formation of the Erlimoos Bed (see Hess 1962; Jordan 1983; Richter 1987; Wetzel and Reisdorf 2007). In some areas, the erosive base cuts down to the Ibex zone, possibly even down to the Jamesoni zone of the Breitenmatt Member (Figs. 3, 17; see Erni in Mühlberg 1915; Jordan 1983; Wetzel et al. 1993).

The Erlimoos Bed and certain phosphoritic layers of the Pliensbachian (see Breitenmatt Member and Müsenegg Bed) may have a quite similar appearance. In contrast to the Breitenmatt Member (including the Müsenegg Bed), the Erlimoos Bed is, however, often overgrown by sponges in phosphoritic preservation and pyritised stromatolites: Even larger surfaces may be encrusted here without significant gaps (Figs. 13, 17, 18, 20; see Jordan 1983; cf. Ohmert 1976; Etzold 1980). This stratigraphic level is detectable even in drill cores because of its peculiar facies. An additional feature of the Erlimoos Bed is the absence of gryphaeid oysters, unlike the Breitenmatt Member.

4.11.3 Eriwis Bed

Names previously in use are given in Figs. 2 and 4.

Synonym Erimis Bed (Jordan et al. 2008).

Type locality Eriwis (canton Aargau; coord.: 652.000/256.250; Etter 1990; Kuhn and Etter 1994).

Underlying strata The Eriwis Bed forms the topmost layer of the Gross Wolf Member.

Overlying strata Opalinus-Ton (e.g., Etter 1990; Wetzel and Allia 2003; Franz and Nitsch 2009).

Occurrence Eastern Folded Jura and adjacent areas to the south in the Molasse basin of the Swiss Midland (Fig. 23; see Buxtorf 1907; Jordan 1983; Nagra 1992; Pfirter 1997).

Thickness ?0 to ca. 30 cm (Figs. 19, 23; see Fischer and Luterbacher 1963; Jordan 1983).

Chronostratigraphic age Late Toarcian (Levesquei zone; Aalensis subzone; Etter 1990; Reisdorf et al. subm.).

Description Only a few centimetre thick, condensed horizon of the Aalensis subzone (see Etter 1990; Wetzel and Reisdorf 2007; Reisdorf et al. subm.; cf. Etzold 1980). Occasionally brownish, sometimes reddish, dark grey marl layer which may pass laterally into a marly limestone (Figs. 11 11, 12, 13, 15 16, 17, 18, 23). This phosphoritic condensed horizon is characterised by its abundance of ammonites (especially the genera *Cotteswoldia* and *Pleydellia*, among others also *C. aalensis* Zieten 1832) and belemnites (Jordan 1983; Etter 1990; Nagra 1992; cf. Etzold et al. 1989). Based on these characteristics, the Eriwis Bed is clearly and visibly separated from the overlying Opalinus-Ton (see Jordan 1983; Etter 1990; Reisdorf 2001). The latter is characterised by dark grey to black, partially silty to sandy terrigenous mudstone and marl with mica (Etter 1990; Reisdorf 2001; Wetzel and Allia 2003). In the Schafisheim well the lithostratigraphic boundary between the Gross Wolf Member and the Opalinus-Ton is set below a 15 cm thick, reworked horizon that contains iron ooids and Mid-Jurassic foraminifera. This mudstone horizon is noteworthy because it also contains corroded ammonites of the Late Toarcian (*Cotteswoldia aalensis* Zieten 1832; Tröster 1987; Nagra 1992).

5 Concluding remarks

The total thickness of the Early Jurassic deposits in northern Switzerland is around 25–50 m and thus is significantly thinner than in the adjacent areas of Germany and France (Fig. 6). Lithostratigraphic units of the Early Jurassic that are conformable with the southwest German or eastern French nomenclature therefore only occur in reasonable thickness in the northernmost Tabular Jura (Hofmann 1981; Debrand-Passard 1984; Hofmann et al. 2000, 2002; Bloos et al. 2005). The often small thickness of the majority of the northern Swiss Early Jurassic strata, however, only qualify the complete stratigraphic interval as a mappable unit (= Staffelegg Formation).

In the Klettgau area, the Tabular Jura and the eastern Folded Jura, up to 90% of the total thickness is represented by Sinemurian deposits. By contrast, Pliensbachian and Toarcian deposits account for up to 70% of the total thickness of the Early Jurassic in the western Folded Jura (Mont Terri area). The Early Jurassic strata of the Klettgau area and the Tabular Jura show strong analogies to the facies in southwestern Germany. Significant changes in facies occur towards the south, accompanied by a gradual decrease in thickness (Figs. 3, 6). In addition, stratigraphic gaps occur on a local to regional scale throughout northern Switzerland (Fig. 3). Such hiatus may span a subzone to a stage in time**.** Consequently it is not always possible to fully reconcile the Early Jurassic sediments, especially of the Folded Jura, with the stratigraphic nomenclature of southwestern Germany (cf. Bloos et al. 2005; Schmid et al. 2008). Especially, in the southernmost and westernmost Folded Jura and in the Molasse Basin abrupt facies changes occur. The impression of strongly differentiated facies patterns is intensified by the folding of the Jura Mountains that led to a shortening of original distances (cf. Laubscher 1965, 2008).

In the westernmost part of the study area (Mont Terri area) the facies and thickness of the Early Jurassic strata show stronger affinities to those found in eastern France than in southwestern Germany (cf. Vonderschmitt 1942; Théobald 1967; Debrand-Passard 1984; Pharisat et al. 1993). The most striking is that thickness of Sinemurian to Toarcian strata is remarkably thicker than to the East, in particular the Early Toarcian bituminous deposits (Fig. 26; Rickenbach 1947; Bitterli 1960; Contini and Lamaud

1978). The strata of the Late Sinemurian to Early Pliensbachian in the Mont Terri area distinctly differ from the sediments of the same age to the east (Fig. 3). The lithology in the Mont Terri area requires a new member (= Mont Terri Member) that differs from the previous stratigraphic nomenclature of northern Switzerland. Because of lacking outcrops in a area east of the Mont Terri it is impossible to precisely define the lateral extent of the Mont Terri Member. The maximum age of this member in the eastern Mont Terri area is Obtusum zone, based solely on lithostratigraphic correlation. The dating in the western Mont Terri area is, however, based on an ammonite of the Ibex zone that was found just above strata of the Semicostatum zone (Fig. 27). Consequently, the base of the Mont Terri Member is heterochronous. Following this interpretation, the erosion during the Early Pliensbachian that cut down into the strata of Early Sinemurian age is likely to have occurred in some parts of the Mont Terri area (Fig. 3).

The Early Jurassic strata in northern Switzerland can be subdivided into three facies domains: (1) Klettgau area, Tabular Jura and immediately adjacent areas of the Molasse basin (mainly corresponding to the facies in southwestern Germany, i.e. Swabian Basin), (2) eastern Folded Jura and immediately adjacent area of the Molasse basin (with a discrete "northwestern Swiss facies" of the Swabian Basin) and, (3) Mont Terri area (Folded Jura; facies that shows a strong affinity to the eastern Paris Basin in its stratigraphic architecture).

The main characteristics of the stratigraphic architecture of these three facies domains are represented by 11 members and 9 beds in the Staffelegg Formation. The members that have been defined for the Folded Jura differ significantly from the classification schemes previously in use for the Early Jurassic of northern Switzerland. The beds defined within the Staffelegg Formation serve as connecting elements between the traditional and new stratigraphic nomenclature. They represent supraregional marker beds with the exception of the Müsenegg Bed and the Eriwis Bed. Some of the beds are developed as thin strata in the sense of allostratigraphy (Hallau Bed, Müsenegg Bed, Gipf Bed; cf. Lutz et al. 2005). Namely the Hallau Bed (Planorbis to Liasicus zone), Schleitheim Bed (Angulata zone), Gächlingen Bed (Bucklandi zone), Trasadingen Bed (Davoei zone) and the Unterer Stein (Falcifer zone) have lithostratigraphic equivalents in southwestern Germany (Fig. 2).

Only one of these beds, Unterer Stein, can be traced with some confidence to the Mont Terri area and from there to France (cf. Riegraf et al. 1984: 14p.; Pharisat et al. 1993; Kuhn and Etter 1994). The questionable Trasadingen Bed in the Mont Terri area (Fig. 26) could be correlatable to the so-called Banc à Davoei in France (cf. Debrand-Passard 1984: 136). The Gipf Bed and Erlimoos Bed, in contrast, correlate with erosion horizons of the Variabilis zone in southwestern Germany and eastern France (cf. Rieber 1973; Debrand-Passard 1984; Knitter and Ohmert 1983). The Gipf Bed and Erlimoos Bed occur in characteristic development south of the Rhine River, in particular when they are thin. The same is true for the Müsenegg Bed (Margaritatus to Spinatum zone) and the Eriwis Bed (Aalensis subzone) that only occur in the Folded Jura and in the Molasse Basin to the south.

The Staffelegg Formation is introduced for Early Jurassic sediments in northern Switzerland between the Doubs River and the Mount Weissenstein in the West and the Randen Hills north of the city of Schaffhausen in the East. To the South and East, in boreholes in the Molasse Basin, a transition to a facies more proximal to the Vindelician land mass was observed (cf. Büchi et al. 1965; Trümpy 1980; Stoll-Steffan 1987). Early Jurassic strata underneath the frontal part of Imbricated Molasse (e.g., well Entlebuch 1; Vollmayr and Wendt 1987) and those of the Lake Constance area cannot be consistently subdivided into the members and beds of the Staffelegg Formation (cf. Stoll-Steffan 1987). For these occurrences additional lithostratigraphic units are required to account for the coastal facies of the Swabian Basin. An extension of the Staffelegg Formation to the area of Lake Bienne (well Hermrigen, coord.: 584.600/214.880) and to areas further to the west is not advisable, however, since the Early Jurassic occurrences in these areas are developed in the facies of the Rhodanian Basin (cf. Fischer and Luterbacher 1963; Büchi et al. 1965; Jordan et al. 2008 and references therein).

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References

Achilles, H., & Schlatter, R. (1986). Palynostratigraphische Untersuchungen im "Rhät-Bonebed" von Hallau (Kt. Schaffhausen) mit einem Beitrag zur Ammonitenfauna im basalen Lias. *Eclogae geologicae Helvetiae, 9*, 149–179.

Aeppli, A. (1915). *Geschichte der Geologischen Kommission der Schweizerischen Naturforschenden Gesellschaft*. Basel: Kommissions-Verlag von Georg & Cie.

Altmann, H. J. (1965). Beiträge zur Kenntnis des Rhät-Lias-Grenzbereichs in Südwest-Deutschland. *Ph.D. dissertation*, University of Tübingen, Tübingen.

Andrey, J.-D. (1974). Geologie de la partie orientale du massif des Bruns (Préalpes fribourgeoises). *Ph.D. dissertation*, University of Fribourg, Switzerland.

Arkell, W. J. (1956). *Jurassic Geology of the World*. Edinburgh and London: Oliver & Boyd.

Bader, F. (1925). Beiträge zur Geologie des nordöstlichen Tafeljura zwischen Aare und Rhein. *Ph.D. dissertation*, University of Zurich, Zürich, Switzerland.

Bath, A., & Gautschi, A. (2003). Geological Setting and Sample Locations. In F.J. Pearson, D. Arcos, A. Bath, J.-Y. Boisson, A.M. Fernández, H.-E. Gäbler, E. Gaucher, A. Gautschi, L. Griffault, P. Hernán & H.N. Waber (Eds.): *Mont Terri Project: Geochemistry of Water in the Opalinus Clay Formation at the Mont Terry Rock Laboratory. Berichte des BWG, Serie Geologie, 5*, (pp. 30–35). Bern: Bundesamt für Bauten und Logistik Vertrieb Publikationen.

Beher, E. (2004). Ostracodenfauna und Biostratigraphie im Ober-Sinemurium von Süddeutschland und Nordschweiz. *Stuttgarter Beiträge zur Naturkunde Serie B (Geologie und Paläontologie), 349*, 1–171.

Berg, D. (1961). Geologie des Schwarzwaldrandes zwischen Badenweiler und Kandern. *Berichte der Naturforschenden Gesellschaft zu Freiburg i.Br., 51*, 5–40.

Beutler, G., Ernst, R., Heunisch, C., Kelber, K.-P., Oppermann, K., Schulz, E., & Seegis, D. (2005). Biostratigraphie. In Deutsche Stratigraphische Kommission (Ed.), *Stratigraphie von Deutschland IV, Keuper, Courier Forschungsinstitut Senckenberg, 253* (pp. 31–64). Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller).

Bitterli, P. (1960). Bituminous Posidonienschiefer of Mont Terri, Jura Mountains. *Bulletin der Schweizerischen Vereinigung von Petroleum-Geologen und -Ingenieuren, 26*, 41–48.

Bitterli, T. (1992). Die tektonische Materialbilanz im östlichen Faltenjura. Modellierung der dreidimensionalen Kinematik der Weissenstein-, Farisberg- und Passwang-Antiklinalen und Rückschlüsse auf Sockelstrukturen. *Ph.D. dissertation*, University of Basel, Basel.

Bitterli, T., Graf, H. R., Matousek, F., & Wanner, M. (2000). *Geologischer Atlas der Schweiz 1:25 000, Blatt 1050 Zurzach (Atlasblatt 102), Erläuterungen*. Bern: Bundesamt für Wasser und Geologie.

Bitterli, P. H., & Strub, G. (1975). Bericht über die Exkursion der Schweiz paläontologischen Gesellschaft ins Balmberggebiet. *Eclogae geologicae Helvetiae, 68*, 77–682.

Bitterli-Brunner, P., & Fischer, H. (1988). *Geologischer Atlas der Schweiz 1:25 000, Blatt 1067 Arlesheim (Atlasblatt 80), Erläuterungen*. Bern: Landeshydrologie und -geologie.

Bloos, G. (1976). Untersuchungen über Bau und Entstehung der feinkörnigen Sandsteine des schwarzen Jura α (Hettangium und tiefstes Sinemurium) im schwäbischen Sedimentationsbereich. *Arbeiten aus dem Institut für Geologie und Paläontologie an der Universität Stuttgart N.F., 71*, 1–269.

Bloos, G. (1979). Über den Jura am Großen Haßberg (Unterfranken, N-Bayern) mit Bemerkungen zum Rät. *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 44*, 1–53.

Bloos, G. (1981). Zur Stratigraphie und Ammonitenfauna des marinen Hettangiums (Unterer Lias) in Oberfranken (N-Bayern). *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie)*, *78*, 1–59 pp.

Bloos, G. (1999). *Neophyllites* (Ammonoidea, Psiloceratidae) in the earliest Jurassic of South Germany. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 211*, 7–29.

Bloos, G., Dietl, G., & Schweigert, G. (2005). Der Jura Süddeutschlands in der Stratigraphischen Tabelle von Deutschland 2002. *Newsletters on Stratigraphy, 41*, 263–277.

Brändlin, E. (1911). Zur Geologie des nördlichen Aargauer Tafeljuras zwischen Aare und Fricktal. *Verhandlungen der Naturforschenden Gesellschaft in Basel, 22*, 57–148.

Brandt, K. (1985). Sea-level changes in the Upper Sinemurian and Pliensbachian of Southern Germany. In U. Bayer & A. Seilacher (Eds.), *Lecture Notes in Earth Sciences, Sedimentary and Evolutionary Cycles, 1* (pp. 113–126). New York: Springer.

Braun, L. (1920). Geologische Beschreibung von Blatt Frick. *Verhandlungen der Naturforschenden Gesellschaft in Basel, 31*, 189–242.

Brenner, W. (1986). Bemerkungen zur Palynostratigraphie der Rhät-Lias-Grenze in SW-Deutschland. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 173*, 131–166.

Büchi, U. P., Lemcke, K., Wiener, G., & Zimdars, J. (1965). Geologische Ergebnisse der Erdölexploration auf das Mesozoikum im Untergrund des schweizerischen Molassebeckens. *Bulletin der Schweizerischen Vereinigung von Petroleum-Geologen und -Ingenieuren, 15*, 7–38.

Bureau der Geologischen Kommission. (1930). *Geologischer Atlas der Schweiz 1:25 000, Geologische Kommission der Schweizerischen Naturforschenden Gesellschaft. Geologische Kommission der Schweiz. naturforsch. Gesellschaft, Geologischer Atlas der Schweiz 1:25000, Blättern 92 Movelier, 93 Soyhières, 94 Delémont, 95 Courrendlin (Atlasblatt 1), Erläuterungen nach Angaben von H. Liniger & W.T. Keller*. Bern: A. Francke A.G.

Bureau der Geologischen Kommission. (1936). *Geologischer Atlas der Schweiz 1:25 000, Blätter 92 Movelier, 93 Soyhières, 94 Delémont, 95 Courrendlin (Atlasblatt 1) Erläuterungen nach Angaben von H. Liniger und W.T. Keller*. Bern: A. Francke AG.

Buser, H. (1952). Beiträge zur Geologie von Blatt Bözen (Nr. 33) im Schweizerischen Tafeljura unter besonderer Berücksichtigung

des Rhät und unteren Lias in den Nachbargebieten. *Ph.D. dissertation*, University of Zurich, Zürich.
Buxtorf, A. (1901). Geologie der Umgebung von Gelterkinden im Basler Tafeljura. *Beiträge zur Geologischen Karte der Schweiz*, N.F., 11. Lieferung, 1–106.
Buxtorf, A. (1907). Geologische Beschreibung des Weissensteintunnels und seiner Umgebung. Separatdruck aus den *Beiträgen zur Geologischen Karte der Schweiz*, N.F., 21. Lieferung, 1–125.
Buxtorf, A. (1910). Einige Bemerkungen über das Rhät im schweizerischen Juragebirge und den Gebirgsbau der Vorbourg-Kette. *Eclogae geologicae Helvetiae, 11*, 358–365.
Buxtorf, A. (1940). Die Anfänge der geologischen Erforschung des nordschweizerischen Juragebirges. Rektoratsrede gehalten am 22. November 1940. *Basler Universitätsreden, 11*, 1–23.
Buxtorf, A., & Christ, P. (1936). *Geologischer Atlas der Schweiz 1:25 000, Blätter 96 Laufen, 97 Bretzwil, 98 Erschwil, 99 Mümliswil, Erläuterungen verfasst unter Benutzung eines Entwurfs von R. Elber*. Bern: A. Francke AG.
Buxtorf, A., & Schwarz, O. P. (1960). *Hundert Jahre Schweizerische Geologische Kommission. Organ der Schweizerischen Naturforschenden Gesellschaft 1860–1960*. Bern: Kümmerly & Frey, Geographischer Verlag.
Buxtorf, A. & Troesch, A. (1917). *Geologie des Grenchenbergtunnels mit der Berücksichtigung der hydrographischen und thermischen Verhältnisse und der Tunnelbeben*. Bern: Separatdruck aus dem Schlussbericht an das schweizerische Post- und Eisenbahndepartement über den Bau der normalspurigen Hauptlinie Münster-Lengnau (Grenchenbergtunnel 8578 m) erstattet von der Berner-Alpenbahn-Gesellschaft Bern-Lötschberg-Simplon.
Celliers, I. B. (1907). Geologische Untersuchungen in der Umgebung von Eptingen, Baselland. *Ph.D. dissertation*, University of Freiburg i. Breisgau, Freiburg i.B., Germany.
Contini, D., & Lamaud, P. (1978). Paleogeographie et Paleoecologie du Toarcien inferieur du Jura et de la Bordure Meridionale des Vosges. *Annales Scientifiques de l'Universite de Besancon, Geologie, 29*, 21–36.
Dean, W. T., Donovan, D. T., & Howarth, M. K. (1961). The liassic ammonite zones and subzones of the north-west European province. *Bulletin of the British Museum (Natural History), Geology, 4*, 435–505.
Debrand-Passard, S. (1984). Synthèse géologique du Sud-Est de la France. Volume 1: Stratigraphie et paléogeographie. *Mémoire du Bureau de recherches géologiques et minières, 125*, 1–615.
Delhaes, W., & Gerth, H. (1912). Geologische Beschreibung des Kettenjura zwischen Reigoldswil (Baselland) und Oensingen (Solothurn). *Geologische und palæontologische Abhandlungen N.F., 11*, 1–97.
Desor, E. (1856). *Les tunnels du Jura. Revue Suisse, 15. Novembre 1856*. Neuchâtel: Imprimerie de Charles Leidecker et A. Combe.
Disler, C. (1941). *Stratigraphischer Führer durch die geologischen Formationen im Gebiet zwischen Aare, Birs und Rhein*. Basel: B. Wepf & Co. Verlag.
Donovan, D. T., & Hemingway, J. E. (1963). Fascicule 3 a X: Jurassique. In P. Pruvost (Ed.), *Lexique Stratigraphique International; Volume 1, Europe, Fascicule 3 a, Angleterre Pays de Galles (W.F. Whittard & S. Simpson)* (pp. 1–394). Paris: Centre National De La Recherche Scientifique.
Dunham, R. J. (1962). Classification of carbonate rocks according to depositional texture. In W. E. Ham (Ed.), *Classification of Carbonate Rocks. American Association of Petroleum Geologists Memoir, 1* (pp. 108–121). Tulsa: American Association of Petroleum Geologists.
Ehrat, H. (1920). Die Rhätformation und Rhät-Liasgrenze in Schwaben. *Ph.D. dissertation*, University of Tübingen, Tübingen.
Einsele, G., & Seibold, E. (1961). Die geologische Kartierung der Rohrgräben beim Bau der Bodensee-Fernwasserversorgung. *Jahreshefte des Geologischen Landesamtes Baden-Württemberg, 4*, 183–264.
Elber, R. (1921). Geologie der Raimeux- und der Velleratkette im Gebiete der Durchbruchtäler von Birs und Gabiare (Berner Jura). *Verhandlungen der Naturforschenden Gesellschaft in Basel, 32*, 38–93.
Elber, D. (1962). Die Geologie des Gebietes von Langenbruck an oberen Hauenstein. *Ph.D. dissertation*, University of Basel, Basel.
Erni, A. (1910). Das Rhät im schweizerischen Jura. *Eclogae geologicae Helvetiae, 11*, 5–54.
Erni, A. (1926). Zur Rhätfrage im Schweizer Juragebirge. *Centralblatt für Mineralogie, Geologie und Paläontologie, Abteilung B, 7*, 241–253.
Ernst, M. (1989). Das Mesozoikum der Vorbergzone auf Blatt Kandern/Südbaden (TK 8211): Kartierung, Stratigraphie und Paläogeographie unter besonderer Berücksichtigung der Fazies im Braunjura, speziell des Hauptrogenstein. *Ph.D. dissertation*, University of Freiburg i. Breisgau, Freiburg i.B..
Etter, W. (1990). Paläontologische Untersuchungen im Unteren Opalinuston der Nordschweiz. *Ph.D. dissertation*, University of Zurich, Zürich.
Etter, W., & Kuhn, O. (2000). An articulated dragonfly (Insecta, Odonata) from the Upper Liassic Posidonia Shale of Northern Switzerland. *Palaeontology, 43*, 967–977.
Etzold, A. (1980). *Geologische Karte von Baden-Württemberg 1:25 000. Herausgegeben vom Geologischen Landesamt Baden-Württemberg. Erläuterungen zu Blatt 7126 Aalen*. Stuttgart: Landesvermessungsamt Baden-Württemberg.
Etzold, A., Franz, M., & Heunisch, C. (2010). Die Forschungsbohrung Trossingen (Baden-Württemberg) und Ausführungen zum Knollenmergel und Oberkeuper der Umgebung. *LGRB-Informationen, 25*, 105–142.
Etzold, A., Hahn, W., & Koerner, U. (1975). Keuper, Jura und Tertiär in Bohrungen der Planungsgemeinschaft BN-Stollen zwischen Bodensee und Neckar. *Jahreshefte des Geologischen Landesamtes Baden-Württemberg, 17*, 89–255.
Etzold, A., Ohmert, W., & Balle, T. (1989). Toarcium und unterstes Aalenium im Gebiet der oberen Jagst nordöstlich Aalen. *Jahreshefte des Geologischen Landesamtes Baden-Württemberg, 31*, 23–68.
Etzold, A., & Schweizer, V. (2005). Der Keuper in Baden-Württemberg. In Deutsche Stratigraphische Kommission (Ed.), *Stratigraphie von Deutschland IV, Keuper, Courier Forschungsinstitut Senckenberg, 253* (pp. 214–258). Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller).
Fischer, W. (1964). Die *jurensis*-Schichten (Oberes Toarcien) im Vorland der Schwäbischen Alb. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 120*, 81–106.
Fischer, H. (1969). Einige Bemerkungen zur «Übersichtstabelle zur Geologie der weiteren Umgebung von Basel». *Regio Basiliensis, 10*, 234–238.
Fischer, H., Hauber, L., & Oesterle, H. (1964). Das Rhät und der untere Lias in der Baugrube des Schulhauses Erlimatt in Pratteln. *Tätigkeitsberichte der Naturforschenden Gesellschaft Baselland, 24*, 93–102.
Fischer, H. & Luterbacher, H. (1963). Das Mesozoikum der Bohrungen Courtion I (Kt. Fribourg) und Altishofen (Kt. Luzern). *Beiträge zur Geologischen Karte der Schweiz*, 145, N.F. 115, 1–40.
Frank, M. (1926). Beiträge zur Kenntnis des Lias β in Nordbayern. *Centralblatt für Mineralogie, Geologie und Paläontologie, Abteilung B, Jahrgang, 1926*, 400–414, 439–445.
Frank, M. (1930). Beiträge zur vergleichenden Stratigraphie und Bildungsgeschichte der Trias-Lias-Sedimente im alpin-germanischen Grenzgebiet der Schweiz. *Neues Jahrbuch für*

Mineralogie, Geologie und Paläontologie (B), 64. Beilageband, 325–426.

Franz, M., & Nitsch, E. (2009). Zur lithostratigraphischen Gliederung des Aalenium in Baden-Württemberg. *LGRB-Informationen, 22*, 123–146.

Franz, M., Tesakova, E., & Beher, E. (2009). Documentation and revision of the index ostracods from the Lower and Middle Jurassic in SW Germany according to Buck (1954). *Palaeodiversity, 2*, 119–167.

Frey, M. (1969). Die Metamorphose des Keupers vom Tafeljura bis zum Lukmaniergebiet. *Beiträge zur Geologischen Karte der Schweiz, Neue Folge, 137*, 1–160.

Frey, M. (1978). Progressive Low-Grade Metamorphose of a Black Shale Formation, Central Swiss Alps, with Special Reference to Pyrophyllite and Margarite Bearing Assemblages. *Journal of Petrology, 19*, 95–135.

Genser, H., Sittig, E. (1958). Neue geologische Untersuchungen am Gaisbühl bei Freiburg i. Br. *Berichte der Naturforschenden Gesellschaft zu Freiburg i.Br.*, 48, 139–145.

Glauser, A. (1936). Geologische Beschreibung des Kartengebietes von Blatt Montfaucon im Berner Jura. *Verhandlungen der Naturforschenden Gesellschaft in Basel, 47*, 65–124.

Goldschmid, H. O. (1965). Die Geologie des Faltenjura zwischen Olten und Unterem Hauenstein. *Tätigkeitsberichte der Naturforschenden Gesellschaft Baselland, 24*, 15–91.

Greppin, J.-B. (1870). Description géologique du Jura Bernois et de quelques districts adjacents. *Matériaux pour la carte géologique de la Suisse, 8. livraison*, 1–357.

Gressly, A. (1841). Observations Géologiques sur le Jura Soleurois. *Neue Denkschriften der Allgemeinen schweizerischen Gesellschaft für die gesamten Naturwissenschaften, 5*, 1–112.

Gressly, A. (1853). Übersicht der geologischen Verhältnisse der Umgebungen Oltens in Bezug auf den Hauenstein-Tunnel. Nach einer Kopie des Originals im Escher'schen Nachlaß in Zürich, mit einigen stratigraphischen Berichtigungen von Prof. Dr. L. Rollier (1928) versehen und mit der Reproduktion von 18 Clichés geologischer Profilzeichnungen. S.-A. *Mitteilungen der Naturforschenden Gesellschaft Solothurn*, 8, 1–40.

Groschopf, R., Kessler, G., Leiber, J., Maus, H., Ohmert, W., Schreiner, A., et al. (1977). *Erläuterungen zur geologischen Karte Freiburg im Breisgau und Umgebung 1:50 000*. Stuttgart: Landesvermessungsamt Baden-Württemberg.

Gsell, F. (1968). Geologie des Falten- und Tafeljuras zwischen Aare und Wittnau und Betrachtungen zur Tektonik des Ostjura zwischen dem Unteren Hauenstein im W und der Aare im E. *Ph.D. dissertation*, University of Zurich, Zürich.

Gürler, B., Hauber, L., & Schwander, M. (1987). Die Geologie der Umgebung von Basel mit Hinweisen über Nutzungsmöglichkeiten der Erdwärme. *Beiträge zur Geologischen Karte der Schweiz*, N.F., 160. Lieferung, 1–33.

Gwinner, M., Rieber, H., & Wurster, P. (1967). Bericht über die Exkursion der Schweizerischen Geologischen Gesellschaft in die Germanische Trias und den Schwäbischen Jura in Südwürttemberg vom 1. bis 4. Oktober 1967. *Eclogae geologicae Helvetiae, 60*, 621–637.

Hahn, W. (1971). Der Jura. In K.F.J. Sauter & M. Schnetter (Eds.), *Die Wutach. Naturkundliche Monographie einer Flusslandschaft. Die Natur- und Landschaftsschutzgebiete Baden-Württembergs, 6* (pp. 117–133). Freiburg i.Br.: Selbstverlag des Badischen Landesvereins für Naturkunde und Naturschutz e.V.

Hains, B. A., & Horton, A. (1969). *British Regional Geology: Central England*. London: Her Majesty's Stationary Office.

Hallam, A. (1975). *Jurassic Environments*. Cambridge: Cambridge University Press.

Häring, M. O. (2002). Sondierbohrung Otterbach, Basel. Der erste Schritt zur Entwicklung eines geothermischen Heiz-Kraftwerks nach dem Hot-Dry-Rock Verfahren. *Bulletin für angewandte Geologie, 7*, 19–30.

Häring, M. O., Schanz, U., Ladner, F., & Dyer, B. C. (2008). Characterisation of the Basel 1 enhanced geothermal system. *Geothermics, 37*, 469–495.

Hauber, L. (1971). Zur Geologie des Salzfeldes Schweizerhalle—Zinggibrunn (Kt Baselland). *Eclogae geologicae Helvetiae, 64*, 163–183.

Hauber, L. (1991). Ergebnisse der Geothermiebohrungen Riehen 1 und 2 sowie Reinach 1 im Südosten des Rheingrabens. *Geologisches Jahrbuch, Reihe E, Geophysik*, 48, 167–184.

Hauber, L. (1994). Die Geologie des Bözbergtunnels der Nationalstrasse N3. *Brugger Neujahrsblätter, 104*, 85–104.

Hauber, L., Noher, H. P., Meyer, M., & Horal, G. (2000). Geologie im Bereich Adlertunnel. *tec, 21*(49–50), 9–12.

Hedberg, H. D. (1976). *International Stratigraphic Guide*. New York: John Wiley and Sons.

Heer, O. (1852). *Die Lias-Insel des Aargau's*. Zürich: Kiesling.

Heer, O. (1865). *Die Urwelt der Schweiz*. Zürich: Schulthess.

Heim, A. (1919). *Geologie der Schweiz. Band 1: Molasseland und Juragebirge*. Leipzig: Tauchnitz.

Hess, H. (1962). Mikropaläontologische Untersuchungen an Ophiuren. *Eclogae geologicae Helvetiae, 55*, 595–656.

Hoffmann, K. (1934). Ueber den unteren Lias der Langenbrückener Senke. I. *Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereines N. F., 23*, 107–131.

Hofmann, F. (1959). Zusammenhänge zwischen Entstehungsbedingungen und Beschaffenheit toniger Sedimente mit gleichartigem Ausgangsmaterial an einem Beispiel aus dem Tertiär des Kantons Schaffhausen (Schweiz). *Eclogae geologicae Helvetiae, 51*, 980–989.

Hofmann, F. (1981). *Geologischer Atlas der Schweiz 1:25'000, Blatt 1031 Neunkirch (Atlasblatt 74), Erläuterungen*. Schweizerische Geologische Kommission.

Hofmann, F., Schlatter, R., & Weh, M. (2000). *Geologischer Atlas der Schweiz 1:25000, Blatt 1011 Beggingen (Südhälfte) mit SW-Anteil von Blatt 1012 Singen (Atlasblatt 97), Erläuterungen*. Wabern: Bundesamt für Landestopographie.

Hofmann, F., Schlatter, R., & Weh, M. (2002). *Geologische Karte von Baden-Württemberg 1 : 25 000, Erläuterungen zum Blatt 8217 Tengen-Wiechs a. R.*. Freiburg i. Br.: Landesamt für Geologie, Rohstoffe und Bergbau Baden-Württemberg.

Hölder, H. (1950). Schwäbische Juraforschung zu Quenstedts Zeit. *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*, 106. Jahrgang, 1–17.

Hölder, H. (1964). *Jura—Handbuch der stratigraphischen Geologie, IV*. Stuttgart: Enke-Verlag.

Joachim, H. (1970). Geochemische, sedimentologische und ökologische Untersuchungen im Grenzbereich Lias delta/epsilon (Domerium/Toarcium). *Arbeiten aus dem Geologisch-Paläontologischen Institut der Universität Stuttgart (TH), Neue Folge, 61*, 1–243.

Jordan, R. (1960). Paläontologische und stratigraphische Untersuchungen im Lias delta (Domerium) Nordwestdeutschlands. *Ph.D. dissertation*, University of Tübingen, Tübingen.

Jordan, P. (1983). Zur Stratigraphie des Lias zwischen Unterem Hauenstein und Schinznach (Solothurner und Aargauer Faltenjura). *Eclogae geologicae Helvetiae, 76*, 355–379.

Jordan, P., Wetzel, A., & Reisdorf, A. G. (2008). Jurassic. Swiss Jura Mountains. In T. McCann (Ed.), *The Geology of Central Europe. Volume 2: Mesozoic and Cenozoic* (pp. 880–889). London: The Geological Society of London.

Kämpfe, Ch. (1984). Tiefbohrungen in Baden-Württemberg und umgebenden Ländern. *Arbeiten aus dem Institut für Geologie und Paläontologie an der Universität Stuttgart N.F., 80*, 1–313.

Kant, R. (1972). Der untere Lias im Bereich der Frickenhofer Höhe (Ostwürttemberg). *Jahreshefte des Geologischen Landesamts Baden-Württemberg, 14*, 17–37.

Käß, W. (1954). Konkretionäre Phosphatanreicherungen in Südwestdeutschland. *Arbeiten aus dem Institut für Geologie und Paläontologie an der Universität Stuttgart*, N.F., 1–74.

Keferstein, C. (1825). *Tabellen über die vergleichende Geognosie. Ein Versuch*. Halle: Hammerde und Schwetsuhke.

Keller, W. T. (1922). Geologische Beschreibung des Kettenjura zwischen Delsbergbecken und Oberrheinischer Tiefebene enthalten auf den Siegfriedblättern Burg (6), Soyhières (93) und Courrendlin (95). *Ph.D dissertation*, University of Basel, Basel.

Kelterborn, P. (1944). Beobachtungen im Mont-Terri-Gebiet zwischen Courgenay und Asuel. *Eclogae geologicae Helvetiae, 37*, 207–216.

Kindlimann, R. (1990). Ein Nachweis von *Acrodus nobilis* Agassiz aus dem Sinemurien der Tongrube Gruhalde, Frick, Kt. Aargau (Nordschweiz). *Eclogae geologicae Helvetiae, 83*, 829–844.

Knitter, H., & Ohmert, W. (1983). Das Toarcium der Schwärze bei Badenweiler (Oberrheingebiet S Freiburg). *Jahreshefte des Geologischen Landesamts Baden-Württemberg, 25*, 233–281.

Knitter, H., & Riegraf, W. (1984). Biostratigraphie des oberen Toarcium von Blumberg Achdorf/Wutach und Weilheim/Teck. *Jahreshefte des Geologischen Landesamts Baden-Württemberg, 26*, 57–97.

Kuhn, O., & Etter, W. (1994). Der Posidonienschiefer der Nordschweiz: Lithostratigraphie, Biostratigraphie und Fazies. *Eclogae geologicae Helvetiae, 87*, 113–138.

Ladner, F., Schanz, U., & Häring, M. O. (2008). Deep-Heat-Mining-Projekt Basel–Erste Erkenntnisse bei der Entwicklung eines Enhanced Geothermal System (EGS). *Bulletin für angewandte Geologie, 13*, 41–54.

Lang, F. (1892). Die künftige Aufgabe der schweizer. Geologischen Kommission. *Basler Nachrichten, Montag, 5. Oktober 1892, 48. Jg., Nr. 267*, 1–2.

Laubscher, H. P. (1963). *Schweizerische Geologische Kommission, Organ der Schweiz. naturforsch. Gesellschaft, Geologischer Atlas der Schweiz 1:25000, Blatt 1085 St-Ursanne (Atlasblatt 40), Erläuterungen*. Bern: Kümmerli & Frey AG.

Laubscher, H. P. (1965). Ein kinematisches Modell der Jurafaltung. *Eclogae geologicae Helvetiae, 58*, 231–318.

Laubscher, H. (2008). 100 years Jura décollement hypothesis: how it affects Steinmann's (1892) "Schwarzwaldlinie". *International Journal of Earth Sciences, 97*, 1231–1245.

Ledermann, H. (1981). Geologie der Region Solothurn und Führer zum Geologischen Wanderweg über die Weissensteinkette. *Mitteilungen der Naturforschenden Gesellschaft des Kantons Solothurn, 30*, 3–86.

Lehner, E. (1920). Geologie der Umgebung von Bretzwil im nordschweizerischen Juragebirge. *Beiträge zur geologischen Karte der Schweiz*, N.F., XLVII. Lieferung, des ganzen Werkes 77. Lieferung, II. Abteilung, 1–61.

Lemcke, K., & Wagner, R. (1961). Zur Kenntnis des vortertiären Untergrundes im Bodenseegebiet. *Bulletin der Schweizerischen Vereinigung von Petroleum-Geologen und -Ingenieuren, 27*, 9–14.

Leuthardt, F. (1933). Zur Geschichte der geologischen Erforschung des Basler Jura. *Tätigkeitsbericht der Naturforschenden Gesellschaft Baselland, Jahrgänge 1930–1932, 9*, 91–144.

LGRB. (2004). Unterjura in Baden-Württemberg (Lithostratigraphisches Übersichtsschema). *Landesamt für Geologie, Rohstoffe und Bergbau (LGRB) im Regierungspräsidium Freiburg*. http://www.lgrb.uni-freiburg.de/lgrb/download_pool/lith_t_uj_m.pdf.

Lutz, M. (1964). Stratigraphische und tektonische Untersuchungen am südwestlichen Schwarzwaldrand zwischen Wiesetal und Hochrhein. *Oberrheinische geologische Abhandlungen, 13*, 75–122.

Lutz, M., & Cleintuar, M. (1999). Geological results of a hydrocarbon exploration campaign in the southern Upper Rhine Graben (Alsace Centrale, France). *Bulletin for applied Geology, 4*, 3–80.

Lutz, M., & Etzold, A. (2003). Der Keuper im Untergrund des Oberrheingrabens in Baden. *Jahreshefte des Geologischen Landesamts Baden-Württemberg, 39*, 55–110.

Lutz, M., Etzold, A., Käding, K.-C., Lepper, J., Hagdorn, H., Nitsch, E., et al. (2005). Lithofazies und Leitflächen: Grundlagen einer dualen lithostratigraphischen Gliederung. *Newsletters on Stratigraphy, 41*, 211–223.

Maisch, M. W., & Reisdorf, A. G. (2006a). Evidence for the longest stratigraphic range of a post-Triassic Ichthyosaur: a *Leptonectes tenuirostris* from the Pliensbachian (Lower Jurassic) of Switzerland. *Geobios, 39*, 491–505.

Maisch, M. W., & Reisdorf, A. G. (2006b). Erratum to the article "Evidence for the longest stratigraphic range of a post-Triassic Ichthyosaur: a *Leptonectes tenuirostris* from the Pliensbachian (Lower Jurassic) of Switzerland". *Geobios, 39*, 743–746.

Maisch, M. W., Reisdorf, A. G., Schlatter, R., & Wetzel, A. (2008). A large skull of *Ichthyosaurus* (Reptilia: Ichthyosauria) from the Lower Sinemurian (Lower Jurassic) of Frick (NW Switzerland). *Swiss Journal of Geosciences, 101*, 617–627.

Mandy, J.T. (1907). Geologische Untersuchungen in der Umgebung des Hauenstein-Tunnels. *Ph.D. dissertation*, University of Freiburg i. Breisgau, Freiburg i.B.

Marcou, J. (1857a). Le Jura. Première lettre sur le Jura. Adressée au Docteur Albert Oppel. *Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich*, 2. Jahrgang, 49–75.

Marcou, J. (1857b). Le Jura. Deuxième lettre sur le Jura. Adressée au Docteur Albert Oppel. *Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich*, 2. Jahrgang, 143–168.

Marie, M. (1952). Nouveaux résultats des explorations pétrolières en Alsace (Bas-Rhin), France. *Bulletin der Vereinigung Schweizerische Petroleum-Geologen und -Ingenieure, 19*, 31–40.

Mathey, F. (1883). Coupes géologiques des tunnels du Doubs. *Nouveaux mémoires de la Société helvétique des sciences naturelles, 29*, 1–21.

Mathey, F., Lang, F., & Greppin, J. B. (1872). Tunnels dub Doubs. Rapport des Experts Géologiques. In Verwaltungsrathes der bernischen Jurabahngesellschaft (Ed.), *Bericht und Anträge des Verwaltungsrathes der bernischen Jurabahngesellschaft an den Regierungsrath zu Händen des Großen Rathes des Kantons Bern betreffend die Ausführung des ganzen jurassischen Bahnnetzes gemäß den Bestimmungen des Decretes vom 2. Februar 1867* (Beilage 6). Biel: Buchdruckerei W. Gaßmann.

Mayer-Eymar, C. D. W. (1864). Tableau synchronistique des terrains jurassiques. *1 lithographierte Falttafel*. Zürich.

Merian, P. (1821). *Beiträge zur Geognosie. Erster Band*. Basel: Schweighauser'sche Buchhandlung.

Merian, P. (1831). *Beiträge zur Geognosie. Zweiter Band*. Basel: Schweighauser'sche Buchhandlung.

Meyer, L. (1916). Le Sondage de Charmois. *Bulletin de la societe belfortaine d'Emulation, 34*, 22–50.

Meyer, C. A., & Furrer, H. (1995). Taphonomie und paläoökologische Rekonstruktionen: Beispiele aus dem Mesozoikum des Jura. *Eclogae geologicae Helvetiae, 88*, 711–720.

Moesch, C. (1857). Das Flözgebirge im Kanton Aargau. *Neue Denkschriften der allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften, 15*, 1–80.

Moesch, C. (1874). Der südliche Aargauer Jura und seine Umgebungen. *Beiträge zur Geologischen Karte der Schweiz*, 10. Lieferung, 1–53.

Mühlberg, F. (1905). Erläuterungen zur geologischen Karte des unteren Aare-, Reuss- und Limmat-Tales in 1:25 000. (Spez.-Karte 31). *Eclogae geologicae Helvetiae, 8*, 487–538.

Mühlberg, F. (1908). *Geologische Karte der Schweiz, Erläuterungen zur geologischen Karte der Umgebung von Aargau 1:25 000*. Bern: A. Francke.

Mühlberg, F. (1910). *Geologisches Gutachten über den Bau des projektierten Hauenstein-Basis-Tunnel auf Verlangen der Generaldirektion verfasst. Beilage Nr. 11*. Bern: Schweizerische Bundesbahnen (Generaldirektion).

Mühlberg, F. (1915). *Geologische Karte der Schweiz, Erläuterungen zur Geologischen Karte des Hauensteingebietes (Waldenburg-Olten) 1:25, 000 (Spezialkarte Nr. 73)*. Bern: A. Francke.

Müller, A. (1862). Geognostische Skizze des Kantons Basel und angrenzende Gebiete. *Beiträge zur Geologischen Karte der Schweiz*, 1–71.

Müller, W. H., Huber, M., Isler, A., & Kleboth, P. (1984). *Erläuterungen zur Geologischen Spezialkarte Nr. 121 der zentralen Nordschweiz 1:100 000 mit angrenzenden Gebieten von Baden-Württemberg*. Baden: Nationale Genossenschaft für die Lagerung radioaktiver Abfälle (NAGRA) und Schweizerische Geologische Kommission.

Mumenthaler, T., Meyer, C. & Sigg, J. (1997). Rohstoffe für die Ziegelindustrie. In: Schweizerische Geotechnische Kommission (Ed.), *Die mineralischen Rohstoffe der Schweiz* (pp. 23–63). Zürich: Schweizerische Geotechnische Kommission.

Nagra (1984). Die Kernbohrung Beznau. Nagra Technischer Bericht NTB 84-34, *Beiträge zur Geologie der Schweiz, Geotechnische Serie*, Lieferung 66, 1–111.

Nagra (1989). Sondierbohrung Weiach Untersuchungsbericht (Gemeinde Weiach, Kanton Zürich, Schweiz), Textband. Nagra Technischer Bericht, NTB 88-08. *Beiträge zur Geologie der Schweiz, Geotechnische Serie*, Lieferung 73, 1–183.

Nagra (1990). Sondierbohrung Riniken Untersuchungsbericht (Gemeinde Riniken, Kanton Aargau, Schweiz), Textband. Nagra Technischer Bericht NTB 88-09. *Beiträge zur Geologie der Schweiz, Geotechnische Serie*, Lieferung 74, 1–125.

Nagra (1992). Sondierbohrung Schafisheim Untersuchungsbericht (Gemeinde Schafisheim, Kanton Aargau, Schweiz), Textband. Nagra Technischer Bericht, NTB 88-11. *Beiträge zur Geologie der Schweiz, Geotechnische Serie*, Lieferung 84, 1–183.

Nagra (1993). Sondierbohrung Siblingen: Untersuchungsbericht. Textband. Nagra Technischer Bericht NTB 90-34. *Beiträge zur Geologie der Schweiz, Geotechnische Serie*, Lieferung 86, 1–130.

Nagra (2001). *Sondierbohrung Benken Untersuchungsbericht. Textband. Nagra Technischer Bericht NTB 00-01*. Wettingen: Nagra.

Ohmert, W. (1976). Das Toarcium-Profil von Ballrechten (Oberrheingebiet südlich Freiburg). *Jahreshefte des Geologischen Landesamts Baden-Württemberg, 18*, 79–103.

Oppel, A. (1856–1858). Die Juraformation Englands, Frankreichs und des südwestlichen Deutschlands, nach ihren einzelnen Gliedern eingetheilt und verglichen. *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg*, *12*, 121–556.

Persoz, F. (1982). Inventaire minéralogique, diagenèse des argiles et minéralostratigraphie des séries jurassiques et crétacées inférieures du Plateau suisse et de la bordure Sud-Est du Jura entre les lacs d' Annecy et de Constance. *Beiträge zur Geologischen Karte der Schweiz*, N.F., 155.

Peters, T. J. (1964). Tonmineralogische Untersuchungen an einem Keuper-Lias-Profil im Schweizer Jura (Frick). *Schweizerische Mineralogische und Petrographische Mitteilungen, 44*, 1–30.

Peyer, B. (1943a). Beiträge zur Kenntnis von Rhät und Lias I. Über Rhät und Lias von Hallau (Kt. Schaffhausen). *Eclogae geologicae Helvetiae, 36*, 303–314.

Peyer, B. (1943b). Beiträge zur Kenntnis von Rhät und Lias. Die Echinodermenreste aus den Schwaicheln der Angulatuszone von Hallau. *Eclogae geologicae Helvetiae, 36*, 315–326.

Peyer, B. (1956). Über Zähne von Haramiyden, von Triconodonten und wahrscheinlich synapsiden Reptilien aus dem Rhät von Hallau. *Schweizerische Paläontologische Abhandlungen, 72*, 1–72.

Pfirter, U. (1997). *Geologischer Atlas der Schweiz 1:25000, Feuille 1106 Moutier (Feuille 96 de l'Atlas), Notice explicative*. Wabern: Office fédéral de topographie.

Pharisat, A., Contini, D., & Frickert, J.-C. (1993). Early Jurassic (Lower Toarcian) "Ichthyosaurs" from Franche-Compte, France. *Revue de Paléobiologie, Volume spécial, 7*, 189–198.

Pratje, O. (1922). Lias und Rhät im Breisgau (Erster Teil). *Mitteilungen der Großherzoglichen Badischen Geologischen Landesanstalt, 9*, 277–352.

Pratje, O. (1924). *Die Juratransgression im Bereiche von Schwarzwald und Vogesen. - Eine paläogeographische Studie der Rhät- und Liasschichten*. Frankfurt a.M.: Verlag Willy Ehrig.

Quenstedt, F. A. (1843). *Das Flözgebirge Württembergs. Mit besonderer Rücksicht auf den Jura*. Tübingen: Laupp.

Quenstedt, F. A. (1858). *Der Jura*. Tübingen: Laupp.

Reisdorf, A. (2001). Neue Lias-Profile entlang der Transitgasleitung der TRG 3: Wirbligen (BL) und Titterten (BL). *Archäologie und Museum, Berichte aus Archäologie und Kantonsmuseum Baselland, 43*, 43–48.

Reisdorf, A. G., Maisch, M. W., & Wetzel, A. (subm.). First record of the leptonectid ichthyosaur *Eurhinosaurus longirostris* (Owen et Jäger in V. Jäger, 1856) from the Early Jurassic of Switzerland and its stratigraphic framework. *Swiss Journal of Geosciences*.

Remane, J., Adatte, T., Berger, J.-P., Burkhalter, R., Dall'Agnolo, S., Decrouez, D., et al. (2005). Richtlinien zur stratigraphischen Nomenklatur. *Eclogae geologicae Helvetiae, 98*, 385–405.

Richter, H. (1987). Die Mikrofauna des unteren Toarciums der Nordschweiz. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 176*, 137–155.

Rickenbach, E. (1947). Die Vorkommen von bituminösen Schiefern. *Beiträge zur Geologie der Schweiz, Geotechnische Serie, Lieferung, 26*, 44–54.

Rieber, H. (1973). Fauna und Stratigraphie einer oolithischen Kalkbank aus dem Toarcium von Gipf (Kanton Aargau). *Eclogae geologicae Helvetiae, 66*, 657–665.

Riegraf, W. (1985). Mikrofauna, Biostratigraphie und Fazies im unterem Toarcium Südwestdeutschlands und Vergleiche mit benachbarten Gebieten. *Tübinger Mikropaläontologische Mitteilungen, 3*, 1–232.

Riegraf, W. (1986). Stratigraphische Verbreitung der Ammonitengattung *Catacoeloceras* im Toarcium Europas. *Senckenbergiana Lethaea, 67*, 305–313.

Riegraf, W., Werner, G., & Lörcher, F. (1984). *Der Posidonienschiefer. Biostratigraphie, Fauna und Fazies des südwestdeutschen Untertoarciums (Lias epsilon)*. Stuttgart: Enke Verlag.

Roemer, F. A. (1836). *Die Versteinerungen des norddeutschen Oolithen-Gebirges*. Hannover: Hahn'sche Hofbuchhandlung.

Röhl, H.-J., & Schmid-Röhl, A. (2005). Lower Toarcian (Upper Liassic) Black Shales of the Central European Epicontinental Basin: A Sequence Stratigraphic Case Study from the SW German Posidonia Shale. *SEPM (Society for Sedimentary Geology) Special Publications, 82*, 165–189.

Röhl, H.-J., Schmid-Röhl, A., Oschmann, W., Frimmel, A., & Schwark, L. (2001). Erratum to "The Posidonia Shale (Lower Toarcian) of SW-Germany: an oxygen-depleted ecosystem controlled by sea level and palaeoclimate". *Palaeogeography, Palaeoclimatology, Palaeoecology, 169*, 273–299.

Rollier, L. (1898). Deuxième supplément à la description géologique de la partie jurassienne de la feuille VII de la carte géologique de la Suisse au 1:100,000. *Matériaux pour la Carte géologique de la Suisse*, Nouvelle Série, 8. livraison, 1–206.

Rollier, L. (1904). *Carte speziale N° 32. Carte tectonique d'Envelier et du Weissenstein par Dr. Louis Rollier. Report des feuilles 110 et 112 de l'Atlas topographique de la Suisse. Levée de 1890 à 1895*. Zürich: Commission géologique suisse.

Rollier, L. (1910). Troisième supplément à la description géologique de la partie jurassienne de la feuille VII de la carte géologique de la Suisse au 1:100 000. *Matériaux pour la Carte géologique de la Suisse*, Nouvelle Série, 25. livraison, 1–230.

Rollier, L. (1917). Résumé stratigraphique des terrains secondaires (mésozoiques) du Jura et des contrées environnantes. *Mémoires de la Société paléontologique Suisse*, Vol. 42, Fossiles nouveaux ou peu connus, tome 1er, fascicule 6, 619–633.

Rominger, C.L. (1846). Vergleichung des Schweizer Jura's mit der Württembergischen Alp. *Neues Jahrbuch für Mineralogie, Geognosie und Petrefaktenkunde*, Jahrgang 1846, 293–306.

Rüger, L. (1924). Versuch einer Paläogeographie der süddeutschen Länder an der Trias-Jura Wende. *Verhandlungen des Naturhistorisch-Medizinischen Vereins zu Heidelberg N.F., 15*, 95–184.

Schaeren, G., & Norbert, J. (1989). Tunnels du Mont Terri et du Mont Russelin—La traversée des "roches à risques"; marnes et marnes à anhydrite. *Société suisse des ingénieurs et des architectes, Documentation, SIA D, 037*, 19–24.

Schalch, F. (1880). Die Gliederung der Liasformation des Donau-Rhein-Zuges. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, 1*, 177–266.

Schalch, F. (1893). Die geologischen Verhältnisse der Bahnstrecke Weizen-Immendingen mit besonderer Berücksichtigung der zwischen Fützen und Zollhaus entstandenen Braunjura-Aufschlüsse. *Mitteilungen der Großherzoglichen Badischen Geologischen Landesanstalt, 2*, 137–230.

Schalch, F. (1895). Über einen neuen Aufschluss in den Untersten Schichten des Lias bei Beggingen, Kanton Schaffhausen. *Mitteilungen der Großherzoglichen Badischen Geologischen Landesanstalt, 3*, 253–258.

Schalch, F. (1900). Über einen neuen Aufschluß an der Keuper-Liasgrenze bei Ewattingen a d. Wutach. *Mitteilungen der Großherzoglichen Badischen Geologischen Landesanstalt, 4*, 51–61.

Schalch, F. (1916). *Geologische Spezialkarte des Grossherzogtums Baden. Erläuterungen zu Blatt Wiechs-Schaffhausen (Nr. 145)*. Heidelberg: Carl Winter's Universitätsbuchhandlung.

Schalch, F. (1922). *Geologische Spezialkarte von Baden. Erläuterungen zu Blatt Griessen (Nr. 157)*. Heidelberg: Carl Winter's Universitätsbuchhandlung.

Schalch, F., & Peyer, B. (1919). Über ein neues Rhätvorkommen im Keuper des Donau-Rheinzuges. *Mitteilungen der Badischen geologischen Landesanstalt, 8*, 263–315.

Schegg, R., Leu, W., Cornford, C., & Allen, P. A. (1997). New coalification profiles in the Molasse Basin of Western Switzerland: implications for the thermal and geodynamic evolution of the Alpine Foreland. *Eclogae Geologicae Helvetiae, 90*, 79–96.

Schlatter, R. (1976). Die Stufe des Lotharingium im unteren Lias des Klettgau (Kanton Schaffhausen, Schweiz). *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 121*, 1–21.

Schlatter, R. (1982). Zur Grenze Pliensbachian-Toarcian im Klettgau (Kanton Schaffhausen, Schweiz). *Eclogae geologicae Helvetiae, 75*, 759–771.

Schlatter, R. (1983a). Erstnachweis des tiefsten Hettangium im Klettgau (Kanton Schaffhausen, Schweiz). *Mitteilungen der Naturforschenden Gesellschaft Schaffhausen, 32*, 159–175.

Schlatter, R. (1983b). Ein Fund von *Aegasteroceras* ex gr. *simile* Spath (Ammonoidea) aus dem Lotharingium des Wutachgebietes (Baden-Württemberg). *Jahresberichte und Mitteilungen des oberrheinischen geologischen Vereins N. F., 65*, 243–256.

Schlatter, R. (1985). Eine bemerkenswerte Ammonitenfauna aus dem Grenzbereich Pliensbachium/Toarcium der Baar (Baden-Württemberg). *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 102*, 1–27.

Schlatter, R. (1988). Alsatites schalchi nov.sp. (Ammonoidea) aus der Oolithenbank (Hettangium) von Pfohren (Baar, Baden-Württemberg). *Mitteilungen der Naturforschenden Gesellschaft Schaffhausen, 33*, 27–38.

Schlatter, R. (1989). Ein geologischer Querschnitt durch den Randen von Schleitheim, nach Schaffhausen bis Thayngen (Exkursion H am 30. März 1989). *Jahresberichte und Mitteilungen des Oberrheinischen Geologischen Vereins*, Neue Folge, 71, 149–165.

Schlatter, R. (1990). Neubestimmung von zwei «Phylloceraten» (Ammonoidea) aus dem unteren Lias der Nordschweiz und Süddeutschlands. *Eclogae geologicae Helvetiae, 83*, 793–797.

Schlatter, R. (1991). Biostratigraphie und Ammonitenfauna des Ober-Lotharingium und Unter-Pliensbachium im Klettgau (Kanton Schaffhausen, Schweiz) und angrenzender Gebiete. *Schweizerische Paläontologische Abhandlungen, 113*, 1–133.

Schlatter, R. (1999). Erstnachweis der *denotatus*-Subzone (Unter-Lotharingium) im Klettgau (Kanton Schaffhausen, Schweiz). *Profil, 16*, 121–124.

Schlatter, R. (2000). Erstnachweis der *taylori*-Subzone (Lias, Unter-Pliensbachium) im Wutachgebiet (Baden-Württemberg). *Jahreshefte der Gesellschaft für Naturkunde in Württemberg*, 156. Jahrgang, 67–72.

Schlatter, R. (2001). Erstnachweis der Unterfamilie Arietitinae Hyatt (Ammonoidea) aus der "Oolithenbank" (Hettangium, Angulata-Zone) Südwestdeutschlands. *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 303*, 1–5.

Schlegelmilch, R. (1992). *Die Ammoniten des süddeutschen Lias. 2., neubearbeitete und ergänzte Auflage*. Stuttgart: Gustav Fischer Verlag.

Schloz, W. (1972). Zur Bildungsgeschichte der Oolithenbank (Hettangium) in Baden-Württemberg. *Arbeiten aus dem Institut für Geologie und Paläontologie an der Universität Stuttgart, NF, 67*, 101–212.

Schmid, D. U., Leinfelder, R. R., & Schweigert, G. (2008). Jurassic. Southern Germany. In T. McCann (Ed.), *The Geology of Central Europe. Volume 2: Mesozoic and Cenozoic* (pp. 864–873). London: The Geological Society of London.

Schmidt, C., Braun, L., Paltzer, G., Mühlberg, M., Christ, P. & Jacob, F. (1924). Die Bohrungen von Buix bei Pruntrut, und Allschwil bei Basel. *Beiträge zur Geologie der Schweiz, Geotechnische Serie*, 10. Lieferung.

Schulbert, C. (2001). Die Ammonitenfauna und Stratigraphie der Tongrube Mistelgau bei Bayreuth (Oberfranken). *Beihefte zu den Berichten der Naturwissenschaftlichen Gesellschaft Bayreuth e.V., 4*, 1–183.

Schweizerische Geologische Kommission, Arbeitsgruppe für Stratigraphische Terminologie (1973). Empfehlungen zur Handhabung der stratigraphischen, insbesondere lithostratigraphischen Nomenklatur in der Schweiz. Recommendations pour l'utilisation de la nomenclature stratigraphique (particulièrement lithostratigraphique) en Suisse. *Eclogae geologicae Helvetiae*, 66, 479–492.

Senftleben, G. (1923). Beiträge zur geologischen Erkenntnis der Westlägern und ihrer Umgebung. *Ph.D. dissertation*, University of Zurich, Zürich.

Senftleben, G. (1924). *Erläuterungen zur geologischen Karte der West-Lägern und ihrer Umgebung in 1:10 000*. Männedorf (Zürich): Kartographische Anstalt J. Flach.

Söll, H. (1965). Der Lias in zwei Schürfbohrungen im Markgräflerland (Südbaden). *Jahreshefte des Geologischen Landesamtes Baden-Württemberg, 7*, 149–180.

Sommaruga, A., & Burkhard, M. (1997). Interpretation of seismic lines across the rhomb shaped Val de Ruz basin (internal Folded Jura). In O. A. Pfiffner, P. Lehner, P. Heitzmann, S. Mueller, &

A. Steck (Eds.), *Deep structure of the Swiss Alps: results of the NRP 20* (pp. 45–53). Basel: Birkhäuser.

Stoll-Steffan, M.-L. (1987). Sedimentpetrographische Untersuchungen der Lias alpha- und Rhätsandsteine im westlichen Deutschen Alpenvorland. *Bochumer geologische und geotechnische Arbeiten, 24*, 1–188.

Strübin, K. (1901). Neue Untersuchungen über Keuper und Lias bei Niederschönthal (Basler Tafeljura). *Verhandlungen der Naturforschenden Gesellschaft in Basel, 13*, 586–602.

Studer, B. (1853). *Geologie der Schweiz. Zweiter Band. Nördliche Nebenzone der Alpen. Jura und Hügelland*. Bern: Stämpflische Verlagshandlung, Friedrich Schulthess.

Studer, B. (1872). *Index der Petrographie und Stratigraphie der Schweiz und ihrer Umgebungen*. Bern: Verlag der J. Dalp'schen Buch- und Kunsthandlung, K. Schmid.

Suter, R. (1915). Geologie der Umgebung von Maisprach (Schweizerischer Tafeljura). *Verhandlungen der Naturforschenden Gesellschaft in Basel, 16*, 9–64.

Suter, R. (1927). Ueber einen Rhät-Liasaufschluss an der neuen Strasse Reigoldswil-Bretzwil (erbaut 1926). *Verhandlungen der Naturforschenden Gesellschaft in Basel, 38*, 476–481.

Tanner, K. M. (1978). Die Keuper-Lias Fundstelle von Niederschönthal, Kanton Baselland. *Bulletin der Schweizerischen Vereinigung von Petroleum-Geologen und -Ingenieuren, 44*, 13–23.

Théobald, N. (1961). La dépression liasique des feuilles au 50.000^{e} de Vesoul et Lure. *Bulletin de la carte géologique de la France, 261 tome, 57*, 43–48.

Théobald, N. (1967). Les sondages profonds de la partie méridionale du fossé rhénan. Renseignements généraux sur l'évolution du fossé rhénan. *Annales scientifiques de l'Université de Besançon, Géologie, 3 Série, fascicule, 3*, 3–24.

Théobald, N., & Maubeuge, P. L. (1949). Paléogéographie du Jurassique inférieur et moyen dans le Nord-Est de la France et le Sud-Ouest de l'Allemagne. *Berichte der Naturforschenden Gesellschaft zu Freiburg im Breisgau, 39*, 249–320.

Thurmann, J. (1832). Essai sur les soulèvemens jurassiques du Porrentruy. *Mémoires de la Société d'Histoire Naturelle de Strasbourg*, 1–84.

Thurmann, J. (1836). Essai sur les soulèvemens jurassiques. Second cahier. *Mémoires de la Société d'Histoire Naturelle de Strasbourg*.

Tobler, A. (1905). *Tabellarische Zusammenstellung der Schichtenfolge in der Umgebung von Basel*. Basel: C.F. Lehndorff, Akademische Buchhandlung.

Tröster, J. (1987). Biostratigraphie des Obertoarcium und der Toarcium/Aalenium Grenze der Bohrungen Weiach, Beznau, Riniken und Schafisheim (Nordschweiz). *Eclogae geologicae Helvetiae, 80*, 431–447.

Trümpy, R. (1959). Hypothesen über die Ausbildung von Trias, Lias und Dogger im Untergrund des Schweizerischen Molassebeckens. *Eclogae geologicae Helvetiae, 52*, 435–448.

Trümpy, R. (1980). *Geology of Switzerland—a guide-book—Part A: An Outline of the Geology of Switzerland*. Basel: Wepf & Co. Publishers.

Tschopp, R. (1960). Geologie des Gebietes von Siegfriedblatt Miécourt. *Beiträge zur Geologischen Karte der Schweiz N.F., 110*, 1–62.

Urlichs, M. (1977). The Lower Jurassic in Southwestern Germany. *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie), 24*, 1–41.

van Werveke, L. (1923). Schichtenfolge in einer Tiefbohrung bei Sierenz im Oberelsaß (Tertiär, Jura und Keuper). *Mitteilungen der Badischen Geologischen Landesanstalt, 9*, 391–405.

Vogel, H. (1934). Geologie des Graitery und des Grenchenbergs im Juragebirge. *Beiträge zur Geologischen Karte der Schweiz*, N.F., 26. Lieferung, 2. Abteilung, 43–72.

Vollmayr, T. (1971). Zur Geologie des Feldes Pfullendorf-Ostrach. *Bulletin der Schweizerischen Vereinigung von Petroleum-Geologen und -Ingenieuren*, 37, 1–20.

Vollmayr, T., & Wendt, A. (1987). Die Erdgasbohrung Entlebuch 1, ein Tiefenaufschluß am Alpennordrand. *Bulletin der Schweizerischen Vereinigung von Petroleum-Geologen und -Ingenieuren, 53*, 67–79.

Vollrath, P. (1924). Die Transgression des Jurameeres zwischen Schwäbischer Alb und Schweizer Jura. *Centralblatt für Mineralogie, Geologie und Paläontologie, 1*, 18–26, 53–59, 71–82.

von Buch, L. (1839). *Über den Jura in Deutschland*. Berlin: Druckerei der Königlichen Akademie der Wissenschaften.

von Hillebrandt, A., & Krystyn, L. (2009). On the oldest Jurassic ammonites of Europe (Northern Calcareous Alps, Austria) and their global significance. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 253*, 163–195.

von Wurstemberger, A. R. V. (1876). Über den Lias Epsilon. *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg, 32*, 193–233.

Vonderschmitt, L. (1941). Bericht über die Exkursionen der Schweizerischen Geologischen Gesellschaft im nordschweizerischen Jura. 8.-11. September 1941. *Eclogae geologicae Helvetiae, 34*, 199–208.

Vonderschmitt, L. (1942). Die geologischen Ergebnisse der Bohrungen von Hirtzbach bei Altkirch (Ober-Elsass). *Eclogae geologicae Helvetiae, 35*, 67–99.

Waagen, W. (1864). *Der Jura in Franken, Schwaben und der Schweiz verglichen nach seinen palaeontologischen Horizonten*. München: Hermann Manz.

Waibel, A. (1925). Geologie der Umgebung von Erschwil (Gebiet der Hohen Winde). *Beiträge zur Geologischen Karte der Schweiz*, N.F., 55.

Waibel, A., & Burri, F. (1961). Fascicule 7 a: Jura et Fossé du Rhin, Juragebirge und Rheintalgraben. In P. Pruvost (Ed.), *Lexique Stratigraphique International; Volume 1, Europe, Fascicule 7, Suisse (Rutsch, R.F.)* (pp. 1–314). Paris: Centre National De La Recherche Scientifique.

Walliser, O. H. (1956a). Chronologie des Lias α_3 zwischen Fildern und Klettgau (Arietenschichten, SW-Deutschland). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 103*, 181–222.

Walliser, O. H. (1956b). Stratigraphie des Lias α_3 zwischen Fildern und Klettgau (Arietenschichten, SW-Deutschland). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 103, 281–311.

Wepfer, E. (1925). Kritische Bemerkungen zur Gliederung des unteren Lias durch Vollrath und durch Pratje. *Centralblatt für Mineralogie, Geologie und Paläontologie, Abteilung B*, 287–289.

Wetzel, R. (1932). „Leitfossil gegen Leithorizont" und die mittelwürttembergische Psilonotenbank. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, 67. Beilage-Band, Abteilung B, 455–467.

Wetzel, A., & Allia, V. (2003). Der Opalinuston in der Nordschweiz: Lithologie und Ablagerungsgeschichte. *Eclogae geologicae Helvetiae, 96*, 451–469.

Wetzel, A., Allia, V., Gonzales, R., & Jordan, P. (1993). Sedimentation und Tektonik im Ostjura. *Eclogae geologicae Helvetiae, 86*, 313–332.

Wetzel, A., & Reisdorf, A. G. (2007). Ichnofabrics elucidate the accumulation history of a condensed interval containing a vertically emplaced ichthyosaur skull. *SEPM (Society for Sedimentary Geology) Special Publications, 88*, 241–251.

Wirth, E. (1968). Das Mesozoikum im Untergrunde der Schwäbischen Alb zwischen Münsingen und Meßkirch. *Zeitschrift der Deutschen Geologischen Gesellschaft, 117*, 855–894.

Würtenberger, L. (1867). Die Schichtenfolge des Schwarzen und Braunen Jura im Klettgau. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, Jahrgang 1867, 39–59.