# Jurassic of the Eastern Alps

Thomas HOFMANN
Vienna

## 1. Introduction

The differentiation of various facies zones developed during Triassic times ends in the Jurassic. During the Early and Middle Jurassic basin sediments are dominating. There is just some evidence indicating the existence of carbonate platforms (e.g. Lienz Dolomites, BLAU 1989). In contrast, during the Malmian great carbonate platforms with large shallow water sedimentation areas existed (Autochthonous Late Jurassic, Northern Calcareous Alps, Waschberg-Zone, Prättigau).

For a comprehensive overview only the most important and well known areas will be discussed. Some minor evidences for shallow water sedimentation areas which are derived from the study of pebbles are just mentioned below. The source of some Upper Jurassic pebbles of several flysch sediments (FLÜGEL & FAUPL 1987) or of sediments in the Helvetic Zone (FAUPL & SCHNABEL 1987) is not well known. Some large olistoliths in the "Buntmergelserie" yield even a typical Late Jurassic algal assemblage (SCHWINGENSCHLÖGEL 1981). They could be derived from a now eroded, during Jurassic time uplifted block, surrounded by deeper marine sediments (FLÜGEL & FAUPL 1987).

Some comments on the Jurassic paleogeography may help for better understanding of the today's situation (fig. 1) being a result of Alpine orogeny. Before Alpine orogeny, during Cretaceous and Paleogene, the southernmost belt was the Eastern Alpine Unit. This is the root of the Northern Calcareous Alps. To the north the Central – Tethyan Region with the Penninic ocean occured. Part of this sedimentary realm is found e.g. in the Prättigau. Further to the north, the sedimentary unit of the Helvetic Zone was located. In the northernmost belt, fringing even southern parts of the Bohemian Massif, during the Late Jurassic a connection between Bavaria to Czechia existed. These sediments were even in the 19th century recognized as a non–Alpine element and were called "outer alpine", or "germanotype facies". Fossils like *Diceras* sp. or algal – sponge bioherms as they are typical for this most northern sedimentary area, are not known from the Alpine realm. During Cretaceous and Tertiary times these carbonate platforms were covered by several kilometers of molasse-type sediments. As a result of Alpine orogeny some parts of these (now covered) carbonate platforms were pressed up to the surface through a thick pile of molasse sediments, forming the "Klippen" of the Waschbergzone. These rootless "Klippen" which are now exposed at the eastern border of the Bohemian Massif (Ernstbrunn, Staatz, Falkenstein, Pavlovske vrchy,...) are the only remains of the "germanotype facies" at the surface.

The entire Eastern Alpine Unit was overthrusted over the Penninic sediments during Alpine orogeny, therefore sediments which where primarily deposited south of the Penninic ocean are now in the north of it. Due to these movements, the Penninic Sulzfluh Limestone of the Prättigau shows strong diagenetic alterations, whereas the Plassen Limestone (which was overthrusted over the former) is better preserved.

The Helvetic Zone, which may contain some Late Jurassic limestone pebbles and even olistoliths in the marly sediments, was overthrusted in the same way by the Northern Calcareous Alps. Only a small line of Helvetic sediments (together with the Flysch zone) is visible between the Molasse zone and the Northern Calcareous Alps. This tectonic situation should be kept in mind with regard to paleobiogeographic considerations.

### 2. Lias

Although BÖHM (1992: 95) states that there are no evidences of algae during the Liassic in the Northern Calcareous Alps, he found some deeper marine stromatolites (BÖHM 1992; BÖHM & BRACHERT 1993 (=below the photic zone). These stromatolites could be caused by some blue – green algae, like *Frutexites* sp. (for discussion see BÖHM & BRACHERT 1993).

From the Early Liassic of the Lienz Dolomites (= western part of the Gailtal Alps), the Lavanter Breccia yields some components showing shallow-water influence. BLAU & SCHMIDT (1988) have recorded oncoids (1cm ) as shallow–water indicators from this formation, without giving any detailed description, as clear proove of shallow-water. In addition, BLAU (1989) described "stromatolitic" crusts covering foraminifera. The dasyclad *Palaeodasycladus mediterraneus* (PIA) should be kept in mind as a significant fossil for Liassic sediments in the Southern Alps.

### 3. Dogger

In general for the Dogger a similar situation as for the Lias must be assumed. Basin sediments were dominating and there is no evidence for shallow – water carbonate platforms. BÖHM & BRACHERT (1993) reported some deeper marine stromatolites from the "Klauskalk" in a comparable bathymetric position as in the Liassic described above. In conclusion BÖHM & BRACHERT (1993) found that *Frutexites* sp. is a common component of deep–water stromatolites, acting mainly as a dweller instead of a constructor of these stromatolites.

### 4. Malm

The Late Jurassic is an important geological period for calcareous algae. This is due to the Callovian transgression that overstepped the Middle Jurassic basins. As a result, great areas with shallow-water sedimentation with intensive carbonate sedimentation arose.

#### 4.1. Autochthonous Late Jurassic

All the information on the autochthonous Late Jurassic is based on the intensive drilling activities of the past decades.

For the south–western part of the Bohemian massif NACHTMANN & WAGNER (1987) reported the development of an extensive carbonate platform during the Late Jurassic (fig. 2). In the western part of the basin some Oxfordian and Kimmeridgian algal– sponge banks up to 200 m thickness are capped by coral reefs. In the eastern part they interfinger with oolithic grainstones, sponge biostromes, coral reefs and sometimes with lagoonal, semi–restricted banks. These banks are characterised by "birdseyes" and "black pebbles", indicating a very shallow regime. During the Purbeckian (= Early Berriasian) the whole carbonate platform was covered by thin–bedded fine crystalline dolomites, cherty limestones,

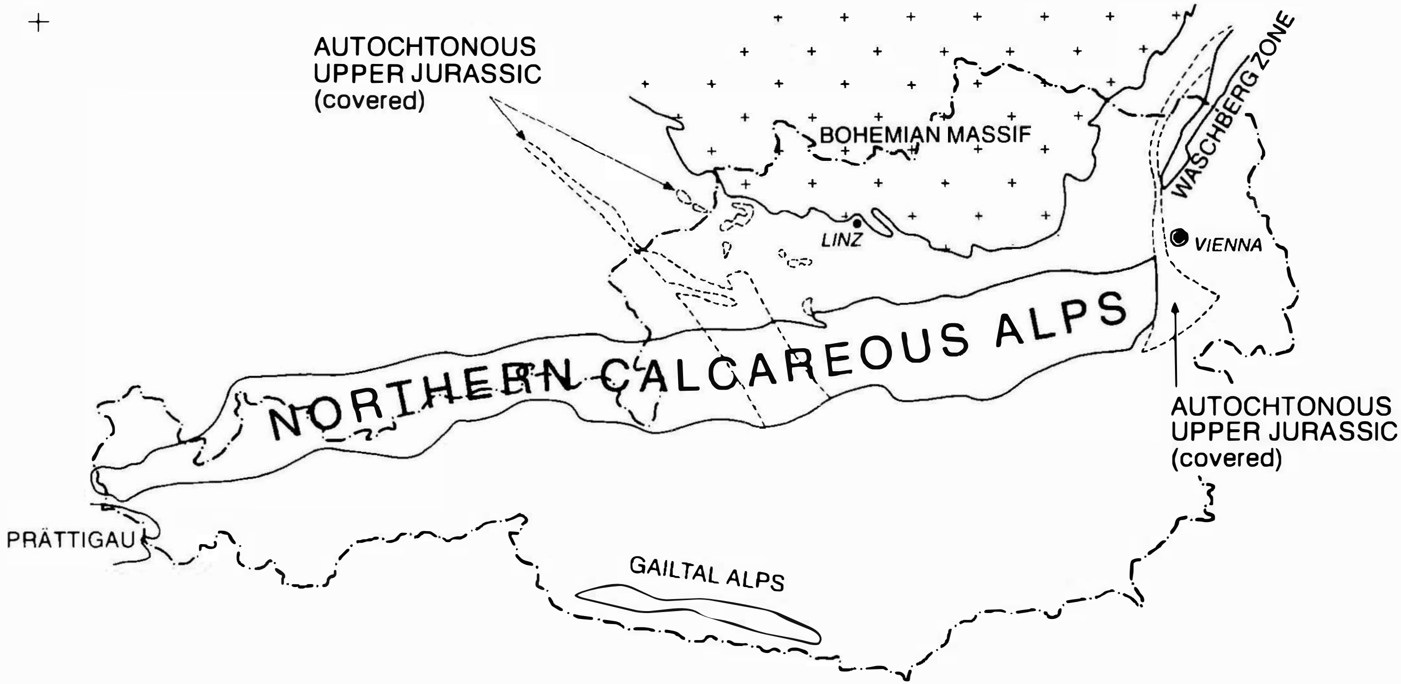
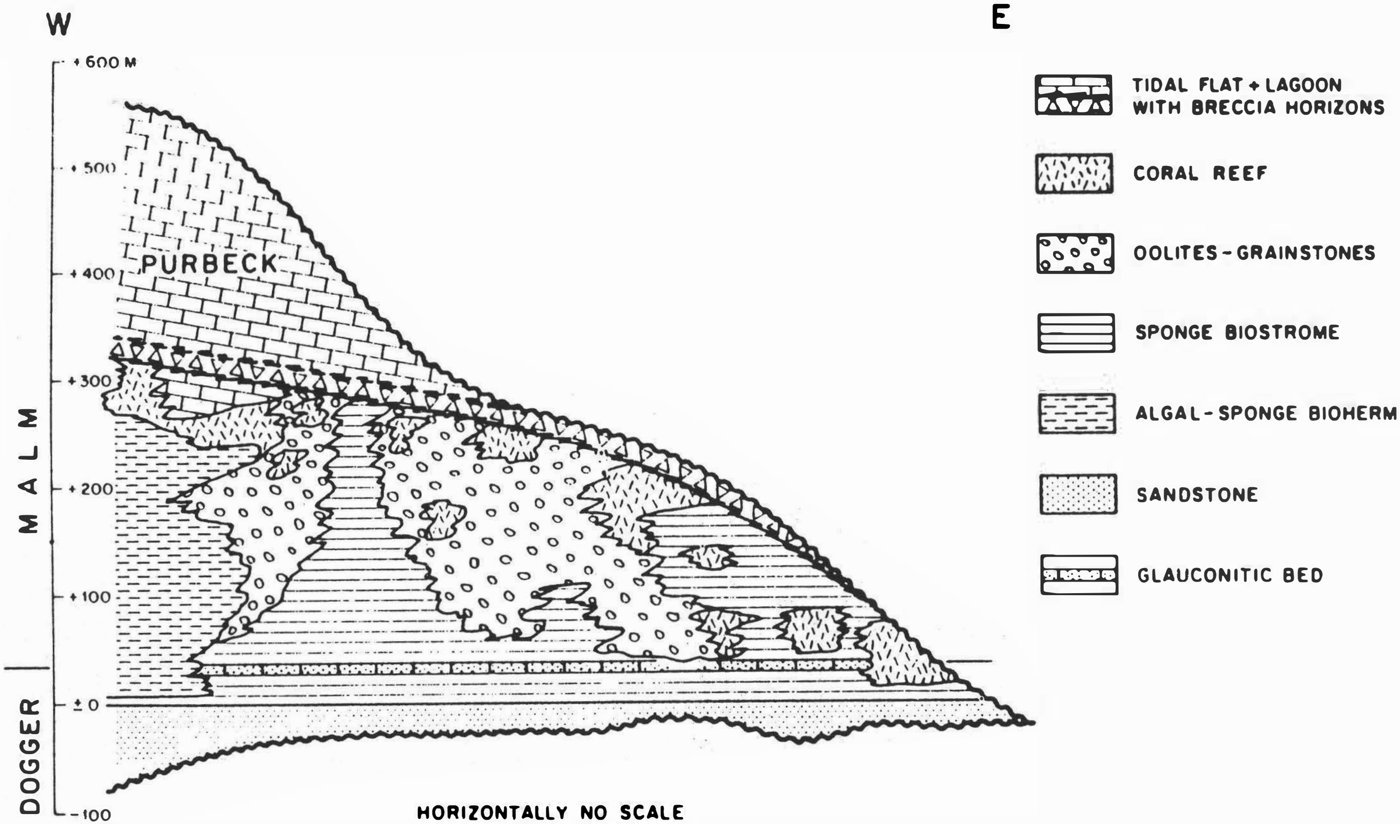



Fig. 1: Distribution of Jurassic sediments in Austria (after SAUER et al. 1992).

Fig. 2: Distribution of Jurassic sediments in the subcrop of the Molasse in Upper Austria and Salzburg (from NACHTMANN & WAGNER 1987).




A2

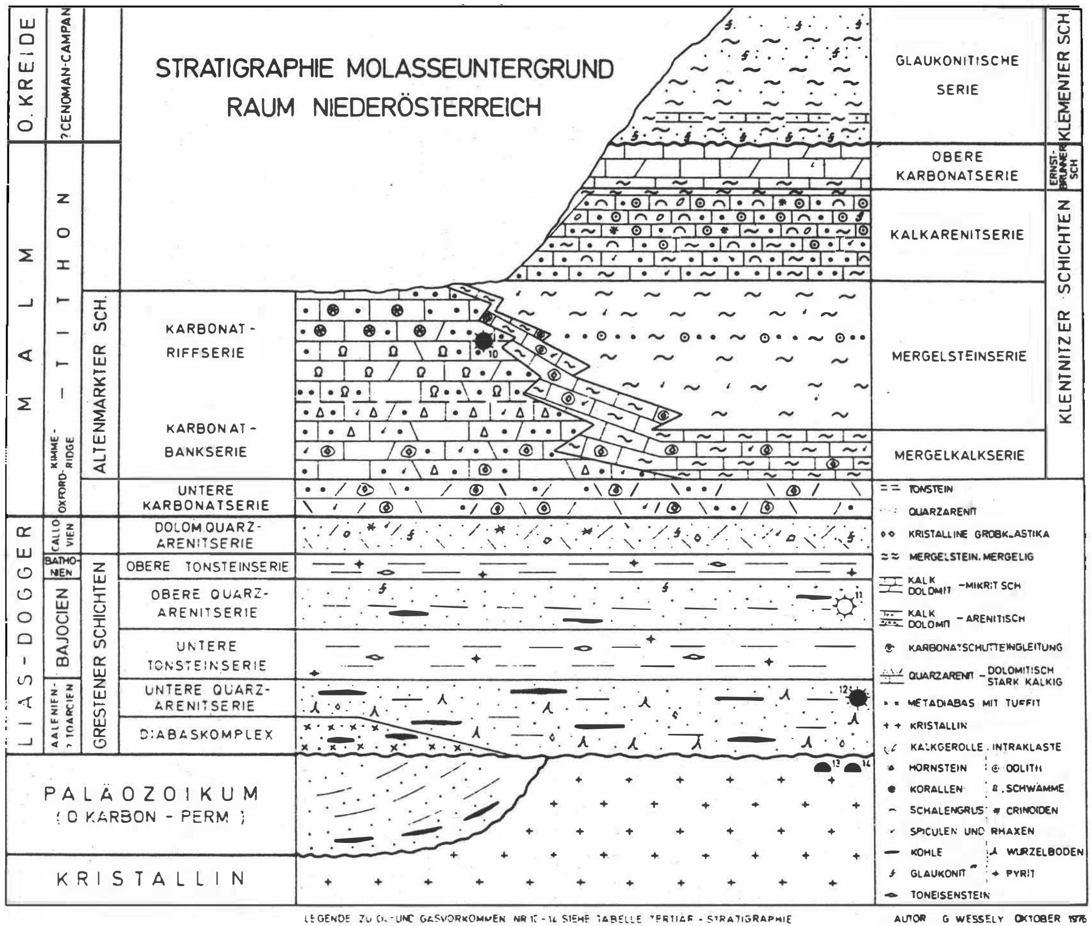



Fig. 3: Distribution of sediments in the subcrop of the Molasse in Lower Austria (from BRIX et al. 1977).

breccias and stromatolites. Characeae indicate some freshwater influence (NACHTMANN & WAGNER 1987).
For the eastern part, fringing the Bohemian Massif, some detailed information was worked out by LADWEIN (1976). Additionally, a lot of information is available from Czechian geologists. A comprehensive overview is given by ELIAS & WESSELY (1990). During the Oxfordian and Kimmeridgian up to 750 m of platform carbonates (Altenmarkt Formation) developed (fig. 3). In the upper part some algal – sponge carbonates are found, the top of this formation is built by coral reefs (= "Karbonatriffserie"). Laterally the reef complexes are replaced sometimes by oolithic – bioclastic deposits (SAUER et al. 1992). During the Tithonian this sequence was covered by the terrigenous, bioclastic Kurdejov Formation (= "Kalkarenitserie"), overlain by the Ernstbrunn Limestone (= "Obere Karbonatserie").

**Flora of the Autochthonous Jurassic from Upper Austria**
(STEIGER, pers. comm.)

*Bacinella irregularis* RADOICIC,
*Lithocodium aggregatum* ELLIOTT,
*L. morikawai* ENDO,
*Tubiphytes* sp.,
*Globochaeta alpina* LOMBARD,
*Campbelliella striata* (CAROZZI),
*Clypeina jurassica* FAVRE & RICHARD,
*Macroporella praturloni* DRAGASTAN,
*Nipponophycus* sp.,
*Petrascula bursiformis* ETALLON,
*M.* cf. *embergeri* BOUROULLEC & DELOFFRE,
*Salpingoporella annulata* CAROZZI,
*S. pygmaea* (GÜMBEL),
*Solenopora jurassica* PFENDER.

**4.2. Waschberg zone**

This tectonic unit separates the Molasse zone in the west from the Vienna Basin in the east. The hilly character of the landscape is due to the Upper Jurassic thrust sheets of the Ernstbrunn Limestone and the Klentnice Formation, which are tectonically uplifted remains of the Autochthonous Jurassic. The latter is the equivalent of the Kurdejov Formation (= "Kalkarenitserie") and the Altenmarkt Formation in the underground. In fact, only a few details are known about the Klentnice Formation, because of lacking outcrops at the surface.
Fossils of the Tithonian Ernstbrunn Limestone (ZEISS & BACHMAYER, 1989; REHANEK 1987) are matter of scientific interest since more than 200 years (HAIDINGER 1775). More than 50 years ago dasyclad algae were described for the first time (BACHMAYER 1941). KAMPTNER (1951) described *Cayeuxia dörflesiana*, recently HOFMANN (1992) applied simple statistical methods on *Salpingoporella pygmaea* (GÜMBEL). Some detailed information is achieved by several works of ELIAS and ELIASOVA (e.g. ELIAS 1981, ELIAS 1992, ELIAS & ELIASOVA 1986).

**Algal flora of the Ernstbrunn Limestone**
(ELIAS & ELIASOVA 1986, HOFMANN 1990, BACHMAYER 1941, KAMPTNER 1951, REHANEK 1987)

*Bacinella irregularis* RADOICIC,
*Lithocodium* sp.,
*Thaumatoporella parvovesiculifera* RAINERI,
*Koskinobullina socialis* CHERCHI & SCHROEDER,
*Tubiphytes* sp.,

*Marinella lugeoni* PFENDER,
*Acicularia* sp.,
*Girvanella* sp.,
*Solenopora* sp.,
*Arabicodium* sp.,
*Cayeuxia doerflesiana* KAMPTNER,
*C. piae* FROLLO,
*C. moldavica* FROLLO,
*Nipponophycus* cf. *ramosus* YABE & TOYAMA.
*Griphoporella* sp.,
*G. ehrenbergi* BACHMAYER,
*Petrascula piai* BACHMAYER,
*P. bursiformis* (BERNIER),
*Macroporella praturloni* DRAGASTAN,
*Heteroporella* sp.,
*H. lemmensis* BERNIER,
*H.* aff. *lusitanica* RAMALAHO,
*H. morillonensis* BERNIER,
*Pseudocymopolia* sp.,
*Campbelliella striata* (CAROZZI),
*Neoteutloporella socialis* (PRATURLON),
*Neoteutloporella* sp.,
*Teutloporella obsoleta* CAROZZI,
*Salpingoporella annulata* CAROZZI,
*S. katzeri* CONRAD & RADOICIC,
*S. pygmaea* (GÜMBEL),
*S. steinhauseri* (CONRAD, PRATURLON & RADOICIC),
*Linoporella capriotica* OPPENHEIM,
*L. svilajensis* SOKAC & VELIC,
*L.* aff. *elliotti* PRATURLON,
*Triploporella* sp.,
*Clypeina solkani* CONRAD & RADOICIC,
*C. jurassica* FAVRE & RICHARD,
*Actinoporella podolica* ALTH,
*Sarfatiella dubari* CONRAD & PEYBERNES.

### 4.3. Prättigau

At the border between Austria and Switzerland, in the geographical area of the Rätikon at the top of the mountains there are to be found some remains of a grey limestone called Sulzfluh Limestone. The most intensive study on algae of this Late Kimmeridgian to Middle Tithonian limestone which was originally deposited in an intrabasinal platform of the Penninic realm (pers. comm. OBERHAUSER) is the thesis of OTT (1969). Three different facies zones can be distinguished:
- micrite facies
- intrasparite facies (*Clypeina jurassica* FAVRE & RICHARD and *Campbelliella striata* [CAROZZI])
- oolith facies.

**Algal flora from the Sulzfluh Limestone**
(OTT 1969)

*Bacinella irregularis* RADOICIC,
*Cayeuxia austriaca* FENNINGER,
*C. doerflesiana* KAMPTNER,
*C. moldavica* FROLLO,
*C. americana* JOHNSON,
*C. kurdistanensis* ELLIOTT,
*C. piae* FROLLO,
*C. mediterranea* HERAK,
*Marinella lugeoni* PFENDER,
*Acicularia* sp.,
*Clypeina jurassica* FAVRE & RICHARD,
*Teutloporella* aff. *obsoleta* CAROZZI,
*Salpingoporella* sp.,
*S. mühlbergii* (LORENZ),
*Pseudoepimastopora jurassica* ENODO,
*Campbelliella striata* (CAROZZI).

### 4.4. Northern Calcareous Alps

The study of the Plassen Limestone, the Tressenstein Limestone and the Oberalm Beds started in the sixties by members of the University of Graz. The relation of these different formations within the carbonate platform is shown in fig. 4.

FENNINGER (1966) was the first to distinguish a micritic from a sparitic dominated Plassen Limestone facies. Some detailed microfacial analysis was made later by STEIGER & WURM (1980) who found a highly differentiated facies pattern (fig. 5).

**Algal flora from the Plassen Limestone, Barmstein Limestone and Tressenstein Limestone**
(FENNINGER 1966, FENNINGER & HOLZER 1972; , FENNINGER & HÖTZL 1967, FLÜGEL 1964; FLÜGEL & FENNINGER 1966, HÖTZL 1966; STEIGER & WURM 1980; MOSSBAUER 1989; MANDL & HOFMANN 1993)

*Bacinella irregularis* RADOICIC,
*Lithocodium morikawai* ENDO,
*L. aggregatum* ELLIOTT,
*Pseudolithocodium* sp.,
*Tubiphytes* sp.,
*Thaumatoporella parvovesiculifera* RAINERI,
*Koskinobullina socialis* CHERCHI & SCHRÖDER,
*Muniera baconica* (DEECKE),
*Cayeuxia* sp.,
*C. austriaca* FENNINGER,
*C. anae* DRAGASTAN,
*C. moldavica* FROLLO,
*C. piae* FROLLO,
*Pycnoporidium lobatum* YABE & TOYAMA,
*Nipponophycus ramosus* YABE & TOYAMA,
*Arabicodium* sp.,
*Solenopora* sp.,
*S.* cf. *sudakensis* MASLOV,
*S. jurassica* BROWN,
*Actinoporella podoloica* ALTH,
*Macroporella* sp.,
*Pseudoclypeina* sp.,
*Salpingoporella johnsoni (DRAGASTAN)*,
*ygmaea* (GÜMBEL),
*S. annulata* CAROZZI,
*S. grudii* CONRAD & RADOICIC,
*S. sellii* (CRESCENTI),
*Clypeina jurassica* FAVRE & RICHARD,
*C. solkani* CONRAD & RADOICIC,
*C. parvula* CAROZZI,
*Petrascula bursiformis* ETALLON,
*Nipponophycus* sp.,
*Pseudoepimastopora* sp.,
*Pseudoepimastopora jurassica* ENDO,
*Griphoporella* sp.,
*Macroporella praturloni* DRAGASTAN,
*Campbelliella striata* (CAROZZI),
*Heteroporella lemmensis* BERNIER,
*Teutloporella obsoleta* CAROZZI,
*Neoteutloporella socialis* (PRATURLON),
*Cymopolia* sp.

## 5. Paleobiogeographical conclusions

Starting in the last century when geologists recognized the different faunistic character of the "Alpine" Plassen Limestone and the "outer – alpine" Ernstbrunn Limestone, this challenge is now up to the algae. Comparing the algae listed above, it is evident, that most of them are common in the Alpine, the Penninic and in the Outer Alpine realm. Many of them are even cosmopolitan like *Salpingoporella annulata* CAROZZI. As an exception, up till now only *Triploporella* sp. and *Linoporella* sp. are known only from the Ernstbrunn Limestone, so they can be designed as "outer – alpine" genera.

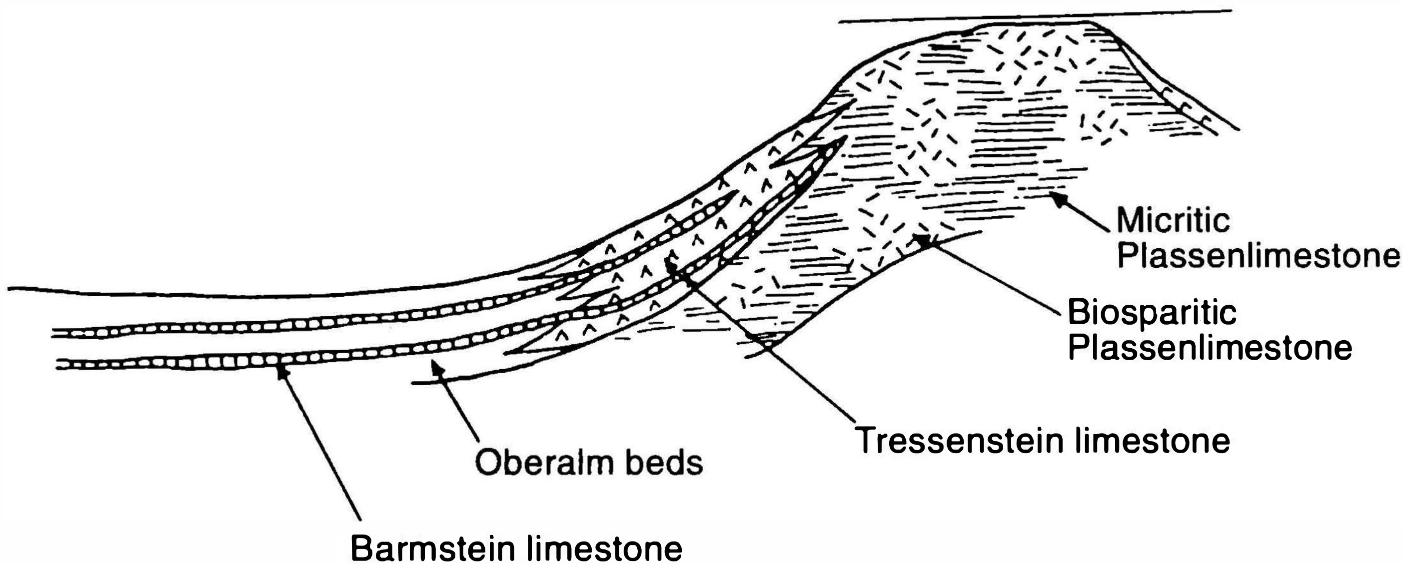
### 6. Acknowledgements

The author wishes to thank W. Piller (University of Vienna) for some useful advices in discussion. Special thanks are due to A. Schumacher (Museum of Natural History, Vienna) for her help with the photographs and to J. Ruthner (Geological Survey of Vienna) for the drawings.

For the permission to get unpublished floras special thanks are due to L. Wagner (Rohölaufsuchungs Ges.mbH, Vienna) and T. Steiger (Univ. Munich).

H. Reuss has to be thanked for his permission to carry out works in the animal-park of Ernstbrunn.

Fig. 4: Geological situation of the Malmian carbonates in the Northern Calcareous Alps (from FLÜGEL & FENNINGER 1966).



# Facies model of the Upper Jurassic Plassen limestones

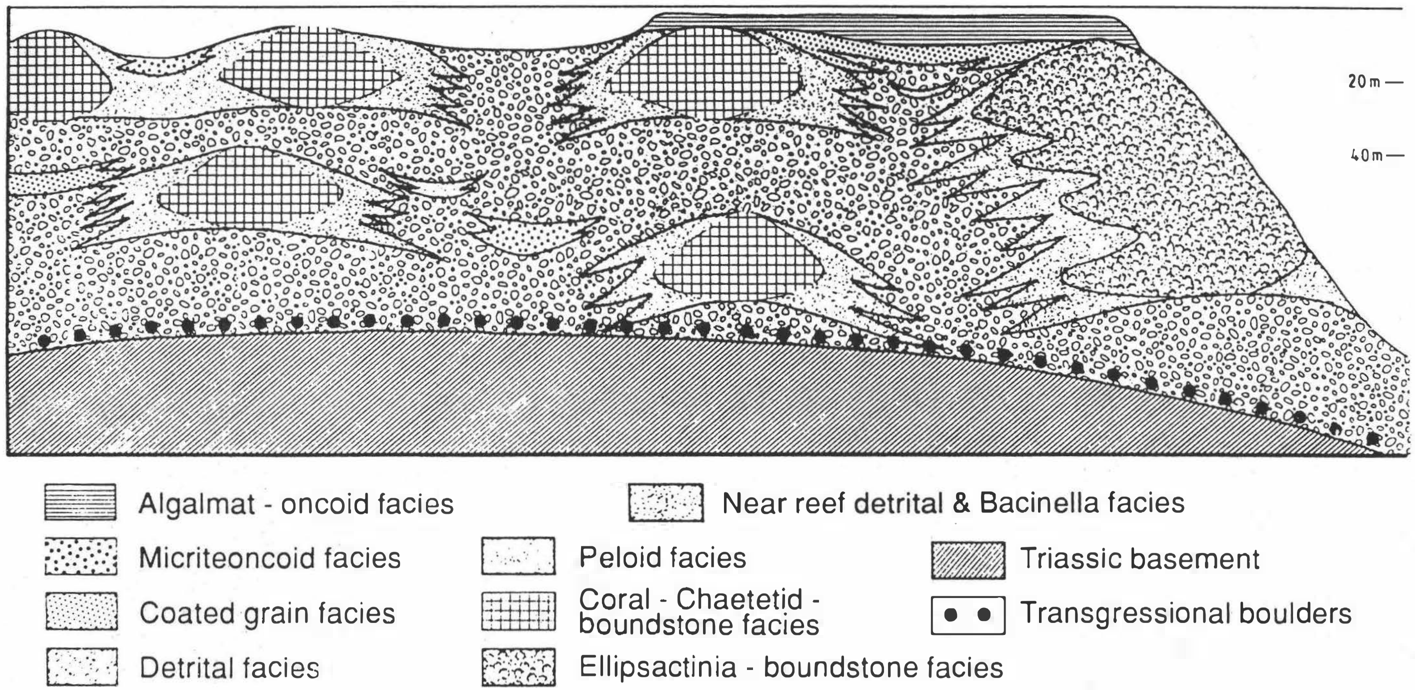



Fig. 5: Facies model of the Late Jurassic Limestones (from STEIGER & WURM 1980).

ABEL, O. (1899): Die Beziehungen des Klippengebietes zwischen Donau und Thaya zum alpin -karpathischen Gebirgssysteme.- Verh. d. k. k. geol. Reichsanstalt, 15 & 16: 374-381; Vienna.

BACHMAYER, F. (1941): Zwei neue Siphonea verticillatae aus dem Jurakalk von Dörfles und Klafterbrunn (Nieder - Donau).- Verh. d. Zool. Bot. Ges., LXXX/LXXXI: 237 240, 6 figs.; Vienna.

BACHMAYER, F. (1948): Neue Untersuchungen Über Diceraten aus dem "Ernstbrunner Kalk".- Ann. Nat. hist. Mus., 56: 564-568, 2 pls., Vienna.

BACHMAYER, F. (1957): Das Mesozoikum der niederösterreichischen Klippen.- Z. dtsch. geol. Ges., 109/2: 659-660; Hannover.

BLAU, J. (1989): Eine autochthone Foraminiferenvergesellschaftung liassischer Kleinhöhlen aus den Lienzer Dolomiten.- Geol. Palöont. Mitt. Innsbruck, 16: 138-140, 3 figs.; Innsbruck.

BLAU, J. & SCHMIDT (1988): Tektonisch kontrollierte Sedimentation im Unterlias der Lienzer Dolomiten (Österreich, Osttirol, Kärnten). Mitt. Ges. Geol. Bergbaustud. Österr., 34/35: 185-207, 3 figs., 4 pls.; Vienna.

BÖHM, F. (1992): Mikrofazies und Ablagerungsmilieu des Lias und Dogger der Nordöstlichen Kalkalpen.- Erl. geol. Abh., 121: 57 -217, 78 figs., 11 pls.; Erlangen.

BÖHM, F. & BRACHERT, T. (1993): Deep-water stromatolites and *Frutexites* Maslov from the Early and Middle Jurassic of S-Germany and Austria.- Facies, 28: 145-168, 9 figs., pl.33-37; Erlangen.

BOUE, A. (1830): Resume des observations sur l'age relatif des depots secondaires dans les Alpes autrichiennes.- Journal de Geol. 1, 50--86, pls. 2- 6; Paris.

BRIX, F.; KRÖLL, A. & WESSELY, G. (1977): Die Molassezone und deren Untergrund in Niederösterreich.- Erdöl-Erdgas Z., Spec. Iss., 93: 12-35, 8 figs.; Vienna - Hamburg.

ELIAS, M. (1981): Facies and paleogeography of the Jurassic of the Bohemian Massif.- Sbor. geol. Ved., 35: 75-144, 9 figs., 8 pls.; Praha.

ELIAS, M. (1992): Sedimentology of the Klentnice Formation and the Ernstbrunn Limestone (Zdanice - Subsilesian unit of the Outer West Carpathians). Ves. Ceskeho geol. ustavu, 67, 3: 179-193, 6 figs., 2 pls.; Praha.

ELIAS, M. & ELIASOVA, H. (1984): Facies and paleogeography of the Jurassic in the western part of the Outer Flysch Carpathians in Czechoslovakia. Sbornik geol. ved., 39: 105-170, 12 pls.; Praha.

ELIAS, M. & ELIASOVA, H. (1986): Elevation facies of the Malm in Moravia.- Geol. Zbornik, Geol. Carpathica, 37, 4: 533-550, 8 pls.; Bratislava.

ELIAS, M. & WESSELY , G. (1990): The autochthonous Mesozoic on the eastern flank of the Bohemian Massif - an object of mutual geological efforts between Austria CSSR. -In: MINARIKOVA,D. & LOBITZER,H. (eds.): Thirty years of geological cooperation between Austria and Czechoslovakia: 78 -- 83, 4 figs.; Praha.

FAUPL, P. & SCHNABEL, W. (1987): Ein Breccienvorkommen bei Scheibbs (Niederösterreich). Zur Kenntnis paläogener Grobklastika aus der Buntmergelserie. Jb. geol B. A., 130/2: 153-161, 4 figs.; Vienna.

FENNINGER, A.(1966): Riffentwicklung im oberostalpinen Malm.- Geol. Rdsch., 56: 171-185, 8 figs.; Stuttgart.

FENNINGER, A. & HOLZER, H. L. (1972): Fazies und Paläogeographie des oberostalpinen Malm.- Mitt. Geol. Ges. Wien, 63: 52-141, 19 pls.; Vienna.

FENNINGER, A. & HÖTZL, H. (1967): Die Mikrofauna und -flora des Plassen- und Tressensteinkalkes der Typuslokalitäten (Nördliche Kalkalpen).- N. Jb. Geol. Paläont. Abh., 128/1: 1-37, 5 pls.; Stuttgart.

FLÜGEL, E. (1964): Ein neues Vorkommen von Plassenkalk (Ober-Jura) im Steirischen Salzkammergut, Österreich.- N. Jb. Paläont. Abh., 120/2: 213-232, pls. 11-12; Stuttgart.

FLÜGEL, H. W. & FAUPL, P. (1987) [Eds.]: Geodynamics of the Eastern Alps.- 418 pp.; Vienna. (Deuticke).

FLÜGEL, H. & FENNINGER, A. (1966): Die Lithogenese der Oberalmer Schichten und der mikritischen Plassenkalke (Tithonium, Nördliche Kalkalpen). N. Jb. Geol. Paläont. Abh., 123/3: 249-280, 10 figs., 4 pls.; Stuttgart.

GLAESSNER, M. (1931): Geologische Studien in der äußeren Klippenzone.- Jb. geol. B.-A., 81: 1-23; Vienna.

HAIDINGER, K. (1785): Beschreibung einer seltenen Versteinerung aus dem Geschlechte der Gienmuscheln.- Physik. Arbeiten der einträchtigen Freunde in Wien (Aufgesamm. von Ignaz Edlen von Born).- 1/3, 2. pls.; Vienna.

HOFMANN, T. (1990): Der Ernstbrunner Kalk im Raum Dörfles (Niederösterreich). Mikrofazies und Kalkalgen.- Unpubl. Diplomarb., 164 pp., 22 figs., 18 pls.; Vienna.

HOFMANN, T. (1992): Some aspects on the classification of *Salpingoporella pygmaea* (calcareous algae) from the Ernstbrunn Limestone (Tithonian) of Lower Austria. Proc. PEPC Conf. (1991): 281-287, 2 figs., 1 pl.; Vienna.

HÖTZL, H. (1966): Zur Kenntnis der Tressenstein Kalke (Ober-Jura, Nördliche Kalkalpen).- N. Jb. Geol. Paläont. Abh., 123/3: 281-310, 10 figs., 5 pls.; Stuttgart.

JÜTTNER, K. (1933): Zur Stratigraphie und Tektonik des Mesozoikums der Pollauer Berge.- Verh. Naturf. Ver Brünn, 64: 15-31, 4 figs.; Brno.

KAMPTNER, E. (1951): Über das Auftreten der Codiaceen Gattung *Cayeuxia* FROLLO im Ober - Jura von Ernstbrunn (Niederösterreich). Sitz. ber. Öst. Akad. Wiss., Mathem. - naturw. Kl., Abt. I, 160/3 & 4; Vienna.

KRAJEWSKI, K., P. (1983): Albian pelagic phospate-rich macrooncoids from the Tatra Mts (Poland). In: PERYT, T. (ed.): Coated grains: 344-357, 10 figs.; Berlin (Springer).

LADWEIN, H. W. (1976): Sedimentologische Untersuchungen an Karbonatgesteinen des autochthonen Malm in Niederösterreich (Raum Altenmarkt Staatz). Unpublished Thesis, Univ. Innsbruck, 135 pp., 43 figs., Innsbruck.

MANDL, G. & HOFMANN, T. (1993): Bericht über geologische Untersuchungen auf ÖK 66 Gmunden im Steinbruch Klarbach.- Jb. Geol. B. A., Vienna (In press).

MOSSBAUER, L. (1989): Tektonik und Fazies in der südlichen Reichraminger Decke westlich der Krummen Steyrling, nördlich des Sengsengebirges (Oberösterreich). -- Unpubl. Diplomarb. Univ. Vienna, 147 pp., 82 figs, Vienna.

NACHTMANN, W. & WAGNER, L. (1987): Mesozoic and Early Tertiary evolution of the Alpine foreland in Upper Austria and Salzburg, Austria. - Tectonophysics, 137: 61-76, 9 figs.; Amsterdam.

OTT, W. E. (1969): Zur Geologie des Sulzfluhkalkes (Malm) in Graubünden und Vorarlberg.- Unpubl. Thesis, 187 pp., 17 tabs., 10 pls.; Darmstadt.

REHANEK, J. (1987): Biostratigrafie a facialni vyvoj karbonatatoveho Malmu jv svahu Ceskeho masivu.- Miscell. micropal. II/1: 251-282, 10 pls., Hodonin.

RIDING, R. (1977): Skeletal stromatolites. - In: FLÜGEL, E. (ed.): Fossil algae: 57 - 60, 1 fig.; Berlin (Springer).

SAUER, R., SEIFERT, P. & WESSELY, G. (1992): Guidebook to excursions in the Vienna Basin and adjecent Alpine -- Carpathian thrustbelt in Austria (Contributions by: PILLER, W., KLEEMANN, K., FODOR, L., HOFMANN, T., MANDL, G. & LOBITZER, H.).- Mitt. Österr. Geol. Ges., 85: 1-264, 200 figs., 7 tabs.; Vienna.

SCHWINGENSCHLÖGEL, R. (1981): Geologie der Kalkvoralpen und der subalpinen Zone im Raum Kirchberg/Pielach in Niederösterreich.-- Mitt. Ges. geol. Bergbaustud. Österr., 27: 39-86, 7 figs., 2 pls.; Vienna.

STEIGER, T. & WURM, D. (1980): Faziesmuster oberjurassischer Plattform-Karbonate (Plassen-Kalke, Nördliche Kalkalpen, Steirisches Salzkammergut, Österreich).- Facies, 2: 241-284, pls. 25-30; Erlangen.

TOLLMANN, A. (1966): Die alpidischen Gebirgsbildungs-Phasen in den Ostalpen und Westkarpaten.- Geotekt. Forsch., 21, 156 pp.; Stuttgart.

TOLLMANN, A. (1985): Geologie von Österreich, Vol. 2, 710 pp.; Vienna (Deuticke).

ZEISS, A. & BACHMAYER, F (1989): Zum Alter der Ernstbrunner Kalke (Tithon; Niederösterreich).- Ann. Naturhist. Mus. Wien, 90, A: 103-109; Vienna.