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Hierlatzkalk – a Peculiar Austro-Hungarian Jurassic Facies

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With 12 Figures

Österreich
Ungarn
Salzkammergut
Transdanubien
Bakony
Hierlatzkalk
Lias
Brachiopoden

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Hierlatzkalk – eine typisch österreichisch-ungarische Jura-Faziesentwicklung

Zusammenfassung

Ein Vergleichsstudie von Vorkommen im Bakony-Gebirge und im Typus-Gebiet in Österreich führte zum Schluß, daß der Hierlatzkalk im Zeitraum Sinemurien–Pliensbachien in der Nähe von submarinen Störungszonen gebildet wurde. In seiner typischen Ausbildung besteht er hauptsächlich aus Brachiopoden- und/oder Ammonitenschalen, untergeordnet aus Fragmenten von Gastropoden, Bivalven und Crinoiden. Seine Diagenese ist charakterisiert durch zwei oder mehrere Phasen sparitischer Zementation, alternierend mit mikritischer Infiltration. Die Vorkommen dieses „Hierlatzkalkes sensu stricto" sind ausschließlich auf die Austroalpinen Einheiten und Ungarn beschränkt.

Hierlatzi Mészkő – egy sajátos „osztrák–magyar" jura-fácies

Összefoglalás

A dunántúli-középhegységi (bakonyi) és az ausztriai típusterület előfordulásainak összehasonlító vizsgálata alapján az a következtetés adódott, hogy a Hierlatzi Mészkő a sinemuri–pliensbachi idején, a tengeralatti vetőzónák környezetében, neptuni telérek és „lejtőlábi" törmelékkúpok formájában halmozódott fel. Tipikusnak csak akkor tekinthető, ha főként Brachiopoda és/vagy apró Ammonitesz héjak alkotják, melyek mellett a csiga, kagyló és crinoidea vázak alárendeltek, továbbá, ha diagenezisében mikrites infiltrációval váltakozó, többfázisú pátitos cementáció ismerhető fel. Ez a szűkebb értelemben vett Hierlatzi Mészkő a szerző ismeretei szerint kizárólag Ausztriában és Magyarországon fordul elő.

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Abstract

A comparative study of occurrences in the Transdanubian Central Range (Bakony Mts.) and in the type area in Austria has led to the conclusion that Hierlatz limestone was formed during the Sinemurian–Pliensbachian, near submarine fault zones, in the form of Neptunian dykes and scarp breccias or taluses. In its typical form it consists mainly of brachiopod and/or minor ammonite shells, and subordinately of skeletal fragments of gastropods, bivalves and crinoids. Its diagenesis is characterized by two or more phases of sparitic cementation alternating with micritic infiltration. As far as the author knows the occurrence of this "sensu strictu" Hierlatz limestone is restricted to the Austroalpine units and Hungary.

1. Introduction

Geologists working in the Jurassic areas in the Transdanubian Central Range are familiar with the white-red variegated Hierlatz limestone that is extremely rich in fossils and has sometimes a fairly aesthetic appearance. I have considered it as one of my favourite rocks since the time I was a student. My prejudice is enhanced by the fact that in the last twenty years I have studied mainly Liassic brachiopods which can be collected in the largest amount and in the easiest way from the Hierlatz limestone.

The great variability of the Jurassic formations in the Transdanubian Central Range has admonished me to consider whether the type of rock referred to as Hierlatz limestone corresponds to the classical conception and whether it is identical with the rock described from the type area in the Alps. During a previous study trip of mine (1975) the answer I was given to the above topic was "yes" seeming to be reassuring, because the rich fossil collection and a few rock fragments taken from the Hierlatzberg and preserved in the collection of the Geologische Bundesanstalt in Vienna have exhibited the same features as those known from the Bakony Mountains. Consequently, the notion I have had of the Hierlatz limestone is that generally it is represented by well preserved brachiopod and/or ammonite skeletons, in which intermediate cavities are filled partly by (mainly pink or yellow) micrite, partly by snow-white, fibrous and sparry calcite. After a further abridgement of this rather brief and outlined description, there are two features of greatest importance left, which are as follows: the brachiopod-lumachelle character and the light colour.

However, the concept of Hierlatz limestone was, here and there and from time to time, as largely distorted that the final result will not correspond even to the above – rather limited – definition. For example, the rock I was shown in the Liassic "mantle series" of the Low Tatra Mts. as Hierlatz limestone was a dark grey, almost black, compact crinoid-brachiopod bearing limestone. It is also astonishing that in his monumental comprehensive work TOLLMANN (1976) describes the Hierlatzkalk, in a clear and well illustrated way, as a coarse crinoid bearing limestone and assigns the brachiopod bearing rock type to a separate formation referred to as "Lias Brachiopodenkalk" (p. 318–321).

Inasmuch as some uncertainties were visible in the Hungarian interpretation, it seemed to be justified to study this topic repeatedly and more thoroughly. A current research project led by Dr. J. HAAS (Budapest) has enabled me to see, on a short study trip, the type area in the vicinity of Hallstatt, and to carry out comparative field observations and to take samples there under the kind guidance of Dr. G. SCHÄFFER (Geologische Bundesanstalt, Wien). Results of this comparative study are incorporated in Part Two of this paper. However, as Part One, a review on the research history intended to describe the gradual distortion in the interpretation of Hierlatzkalk is also required.

2. Review on Research History

The famous Austrian alpinist and geographer Fr. SIMONY, born in Bohemia and presumed to be of Hungarian origin, was the first to find the rich fauna locality of the Hierlatz Berg assigned to the Dachstein Group. As he describes, here

" ... from the brachiopod limestone ... at least 50 different species of brachiopods, gastropods, cephalopods and crinoids have been found, of which the first one is by far the most frequent." (SIMONY, 1850, p. 656).

Reporting on the study of the fauna, SUESS (1852) was the first to use the term "Hierlatzer Schichten". However, no description of rocks concerning the formation was given, except for assigning it to the Liassic.

It was LIPOLD (1852, p. 92) who gave the earliest, appraisable but still valid description of the Hierlatzkalk. This description is as follows:

" ... partly light grey and white, slightly crystalline, but in major part reddish-white spotted and light-red limestone with a great amount of fossils that are frequently accumulated so as to cause the rock to seem to consist of fossils only. However, it is frequent that they exhibit only a white and crystalline structure in the reddish, compact limestone. Fossils include a great variety of cephalopods, predominantly minor ammonite, gastropods and crinoids, and particularly a large amount of brachiopods."

This description that has been valid hitherto is so appropriate that there is almost nothing to add to it. The description that HAUER (1853) gave on the Hierlatz beds is only shorter, but is, in its sense, the same as the aforesaid one. The only reason why HAUER's name is mentioned here is the fact that he is likely to have been the one who transplanted the concept of Hierlatz limestone to Hungary during the regular geological mapping work carried out in the Austro-Hungarian Monarchy.

STUR (1871) gave a detailed description on the different facies and faunas of Hierlatzkalk and gave a significant extension to the conception through the following part of a sentence, being the first to state that the rock

" ... is very frequently developed completely as crinoidal limestone." (STUR, 1871, p. 436).

This superficial remark that is likely to have been based on a rather correct observation, namely that in most cases the Hierlatz limestone turns (both laterally and upwards) to crinoidal limestone or interfingers therewith, has allowed some of the later authors to consider the Hierlatz limestone as a predominantly crinoid limestone.

GEYER (1886a), for example, who wrote, otherwise, magnificient monographs dealing with the ammonites and brachiopods of the Hierlatz limestone, gives the following explicit statement:

"Die Hierlatzfacies wurde als Crinoidenkalkfacies bezeichnet." (Translation: the Hierlatz facies is considered to be a crinoidal limestone facies; p. 238).

And although WÄHNER (1886) immediately objected to and argued against this distortion, in the Austrian geological literature this concept has been predominant till today – perhaps owing to GEYER's reputation – which is truly reflected by the Austrian Encyclopaedia of Stratigraphy (KUEHN, 1962), in the essential work of TOLLMANN (1976) and even in the recent papers (e. g. BÖHM, 1986).

Fortunately, the opinion of Hungarian geologists was not hit by such a great distortion.

Of the earliest research workers BÖCKH (1874, p. 23) mentions light red limestone mottled with white veins and spots from Urkut, in' which the

" ... organische Einschlüsse bestehen ... überwiegend aus Brachiopoden ... "

and

" ... gleicht in petrographischer Beziehung zum Verwechseln dem sogenannten Hierlatzkalk der Alpen ... "

According to KOCH (1875, p. 115) the basement of Szesztra Hill at Kardosrét is

" ... compact, red and white variegated Hierlatzkalk including its characteristic brachiopods ... "

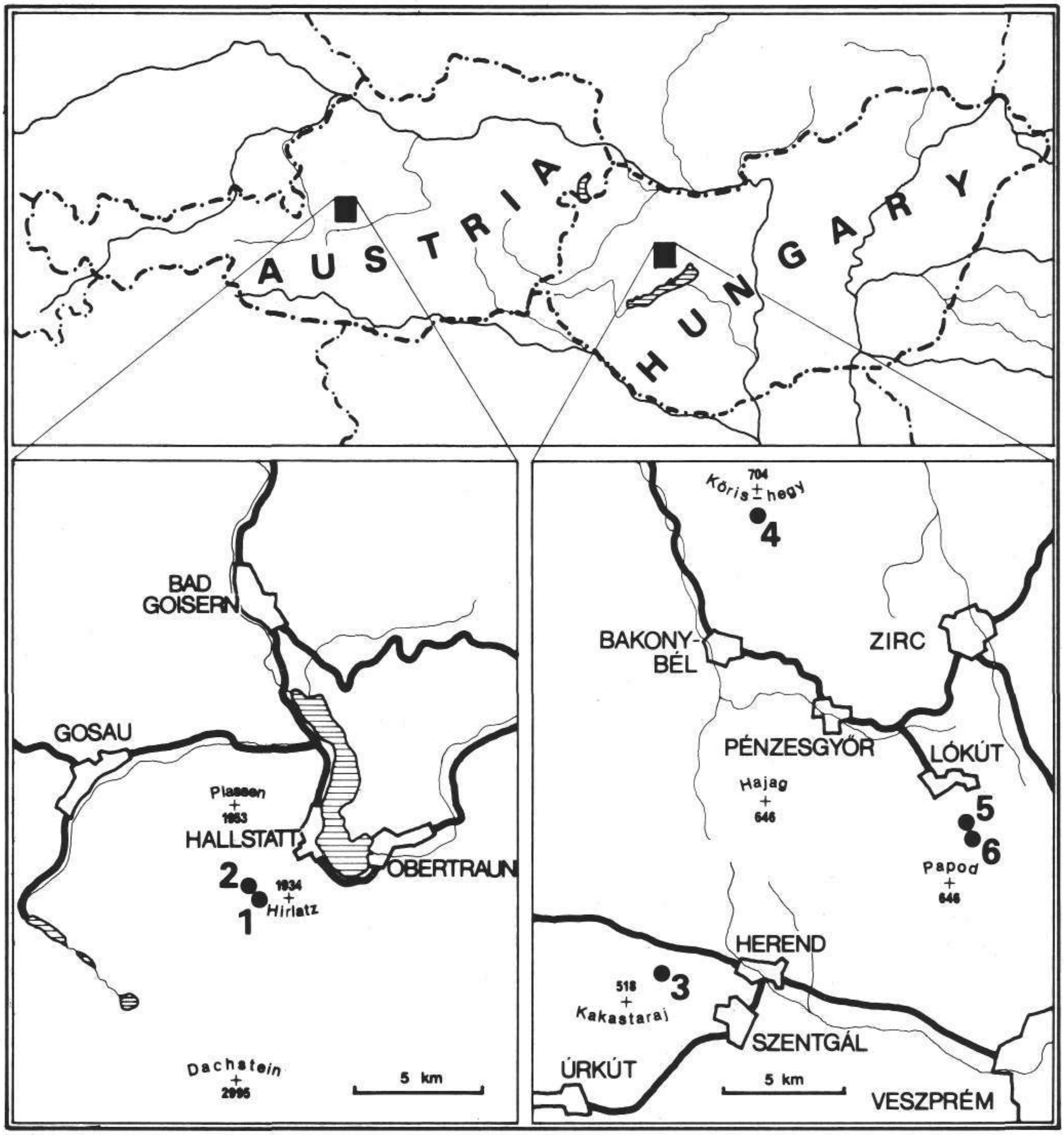


Fig. 1.
Layout of areas involved in the comparison, including the indication of localities of samples studied and referred to in the text.
1 = Hierlatz; 2 = Mitterwand; 3 = Tűzköves-hegy; 4 = Kőris-hegy; 5 = Kericser; 6 = Papod-alja.

At another part the fact that the "typical Hierlatzkalk" contains no crinoids is emphasized.

It was VADÁSZ who started shifting the concept towards "crinoidal direction". In his work (VADÁSZ, 1911, 12–16) the "crinoid and brachiopod facies" in the S Bakony Mts. were considered to be identical with the "Hierlatz beds", whereas the red brachiopod beds were not.

NOSZKY (1945, p. 132) considers the

" ... *white, pink, brick-red white-veined brachiopod-ammonite limestone* ... "

to be of Hierlatz type. However, in his posthumous work (NOSZKY, 1972, p. 81) the attention is called to the opinion that

" ... *the boundary between formations of brachiopod-crinoid, and crinoid-brachiopod limestone facies cannot be clearly drawn, with the formation types in many cases turning into each other* ... "

In recent decades this improved interpretation of Hierlatz limestone (e. g. VIGH, 1961; KONDA, 1970) shifting, for some authors, slightly towards the classical "ammonite-brachiopod" (e. g. VÖRÖS, 1970a; GALACZ & VÖRÖS, 1972; CSIMA & MÉSZÁROS, 1979) or "crinoidal" (e. g. CSÁSZÁR, 1984; HAAS et al., 1984) directions has appeared in the Hungarian geological literature.

3. Comparative study

During my short study trip – the programme of which included several Jurassic occurrences in the N Alps – I spent only one day on the type area of the Hierlatzkalk. Samples were collected from several metres wide, Liassic brachiopod Hierlatzkalk fissure fillings on the Hierlatzwand belonging to the Dachstein Mts.

On current maps the type locality is uniformly indicated as Hirlatz, therefore it is the correct name to use as a geographical name. However, all authors in the classical literature – except for LIPOLD (1852) – referred to it as Hierlatzkalk or Hierlatz Schichten, therefore it is justified by priority and the established usage of the word to adhere to this way of writing when using it as a rock name.

Another sampling site of importance was Mitterwand, at a distance of nearly 1 km from the former one, where the Hierlatz limestone appears as member of the enormous Jurassic megabreccia (Grünanger Schichten [SCHÄFFER, 1975, 1982]). Materials taken from Hungary and involved in the comparison are from various sites of the Bakony Mts. (Fig. 1).

It was mainly the material from the Bakony Mts., that was subject to a detailed study. In addition, it has allowed me to observe the variability of facies of Hierlatz limestone as well as its connection with other rock types and facies. Therefore, the major part of conclusions drawn are based on materials taken from Hungary, whereas both the type area in Austria and material taken therefrom is considered to be rather an "Urquelle", an indispensable basis for comparison.

3.1. Lithology

Hierlatz limestone samples taken from the type area and those considered to be typical in the Bakony Mts. exhibit essential similarites, in regard with their principal lithological features listed below.

The rock is composed mainly of skeletons and fragments of brachiopods and ammonites, and subordinately of those of bivalves, gastropods and crinoids, which are cemented by white, sparry calcite (Figs. 2, 3, 4 and 5). The subordinate skeletal fragments may become, in some nests, rock-forming by enrichment. Red, pink or yellow, micritic fillings of cavities, appearing as geopetal structures are also frequent. Here and there the micritic matrix may become dominant in lenticular bodies. Owing to all those listed before, the rock has a typically variegated appearance. Extraclasts from older Jurassic formations, and Dachsteinkalk may also occur. For extraclasts and biogenic components alike, manganese oxide coatings or crusts are very rare. In general, the rock is poorly stratified, thick bedded or massive.

Its microfacies is biosparite or biomicrite of grainstone or packstone texture, including transitions between the two types. Among the biogenic components the relatively intact brachiopod (Figs. 6 and 7) and minor ammonite (Figs. 8 and 9) skeletons are dominant, but echinoderm skeletal components and benthic small foraminifers also occur in a large amount. Subordinately ostracods, sponge spicules, as well as coral and calcareous sponge fragments can

Fig. 2.
Brachiopod Hierlatz limestones, predominantly with sparite.
Hallstatt, Hirlatzwand; Sinemurian.

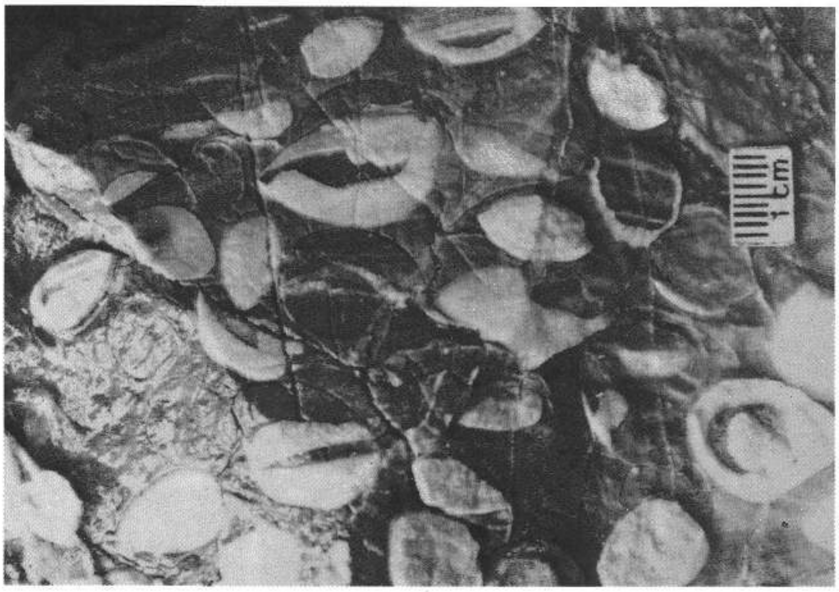


Fig. 3.
Brachiopod Hierlatz limestone, predominantly with micritic matrix, and sparite forming geopetal structures.
Hallstatt, Mitterwand; Sinemurian.

also be observed. A part of the biogenic components and extraclasts shows the traces of bioerosion (Fig. 10). No organic encrusting occurs.

The diagenesis exhibits rather specific features. There are at least two phases that can be distinguished in the cement segregation of the sparite. In the first, earliest diagenetic stage grains and the walls of inner or intermediate cavities were coated by radial-fibrous "isopachous" cement (Fig. 11). Sometimes prior to (Fig. 6) but in most cases immediately subsequent to it (Figs. 7 and 11) varying amounts of micrite were infiltrated into the cavity system; geopetal fillings are frequent. Sometimes micrite is completely missing (Fig. 10), or fills the rest of pore space (Fig. 7). After the completion of the micritic phase the second, late diagenetic sparite development took place, in which coarse-grained, mosaic-like sparite segregated in the cavities that had remained (Figs. 6, 8, 9 and 10). Around the skeletal parts of echinoderms sparite appears as syntaxial rim. The original material of ammo-

Fig. 4.
Hierlatz limestone, with minor ammonites, including the banded alternation of micrite and sparite, and a great amount of geopetal structures.
Lókút, Kericser; Pliensbachian.

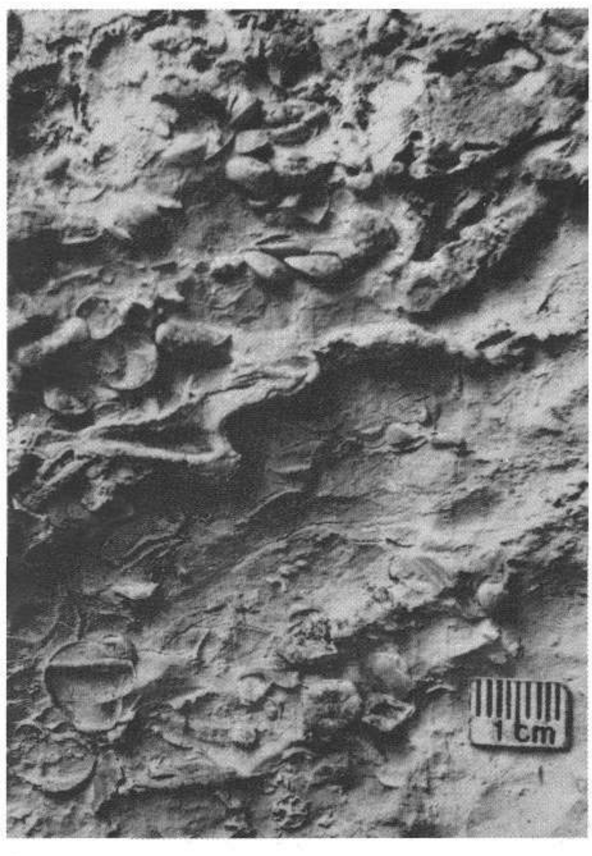


Fig. 5.
Brachiopod Hierlatz limestone with subordinate gastropod content, predominantly with micritic matrix and slumping structures.
Bakonybél, Kőris-hegy; Sinemurian.

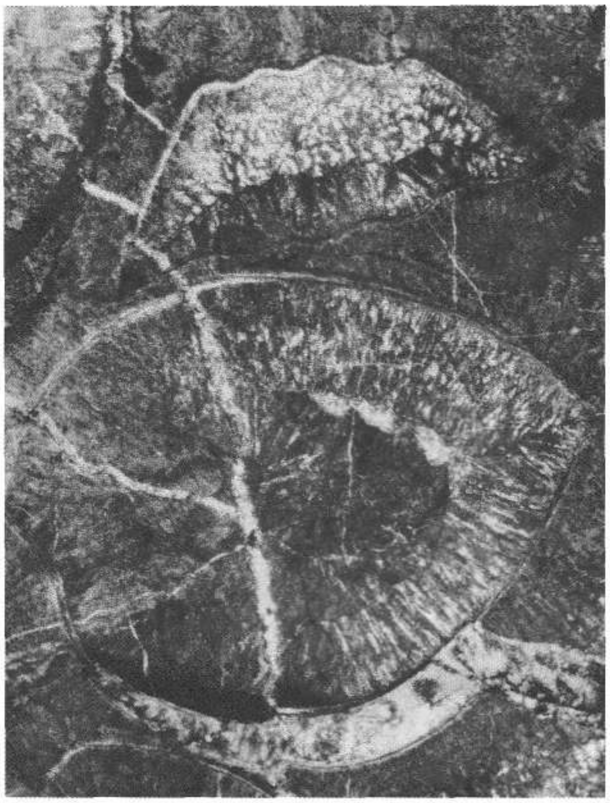


Fig. 6.
Hierlatz limestone, biosparite, grainstone, with brachiopods.
Previous to the first, radial-fibrous sparite generation, a small amount of micrite was deposited in the valve shown in the middle.
Hallstatt, Hirlatzwand; Sinemurian, ca. 8×.

nite and other aragonite mollusc shells was replaced by sparry calcite (Figs. 8 and 10); brachiopods have kept their original, fibrous and porous shell structure (Fig. 7).

3.2. Stratigraphic Relationships

As concerns the typical occurrences of Hierlatz limestone in the Northern Limestone Alps we can mostly rely upon the classical work of GEYER (1886a), in which mainly large fillings are described. As a result of detailed investigations carried out in recent decades a more varied range of information is available on stratigraphic conditions of Hierlatz limestone found in the Transdanubian Central Range (VIGH, 1961; MÉSZÁROS, 1968, 1971, 1980; KONDA, 1970; CSÁSZÁR, 1984; VÖRÖS, 1986).

Summing up it can be stated that the Hierlatz limestone has two main ways of deposition, namely the "fissure-filling" and the "bed-like" types.

The "fissure-filling" type appears, in most cases, as a subvertical Neptunian dyke, with the dyke width ranging from a few centimetres to more than ten metres. The depth of dykes may attain, in proportion to this, even several hundred metres. Dyke walls are formed by Upper Triassic Dachsteinkalk or Lower Jurassic Dachsteinkalk-type Kardosrét limestone (in the Bakony only). Inside the dykes "stratification" parallel with the dyke wall and pointing to a repetitive opening cannot be generally observed. However, the sparitic or micritic bends and nests occurring in many cases chaotically point to the fact that repetitive openings might have taken place during which the previous, not completely consolidated material might have collapsed.

The "bed-like" type can be traced in elongated, several kilometres long and several hundred metres wide stripes. These rock bodies with their thickness of several tens of metres are supported on a fault zone (a simultaneously active fault zone) and are associated with scarp breccia and megabreccia on one side, whereas on their other side they are interfingered generally with well stratified crinoid limestone or other "basin facies". The underlying is generally Dachsteinkalk with uneven surface, or Kardosrét limestone, or a breccia consisting of their detritus; or nearly contemporaneous basinal deposit in the distal zones of interfingering. Transition towards the overlying beds is generally gradual as the crinoidal and micritic features become stronger and stronger. Clear bedding surfaces can be observed only sporadically. Stratification is indicated rather by the orientation of fossils, by the

Fig. 7.
Hierlatz limestone biomicrite/sparite, packstone, with brachiopods.
Previous to the micritic phase, radial-fibrous sparite was precipitated inside the brachiopods.
Hallstatt, Mitterwand; Sinemurian, ca. 8×.

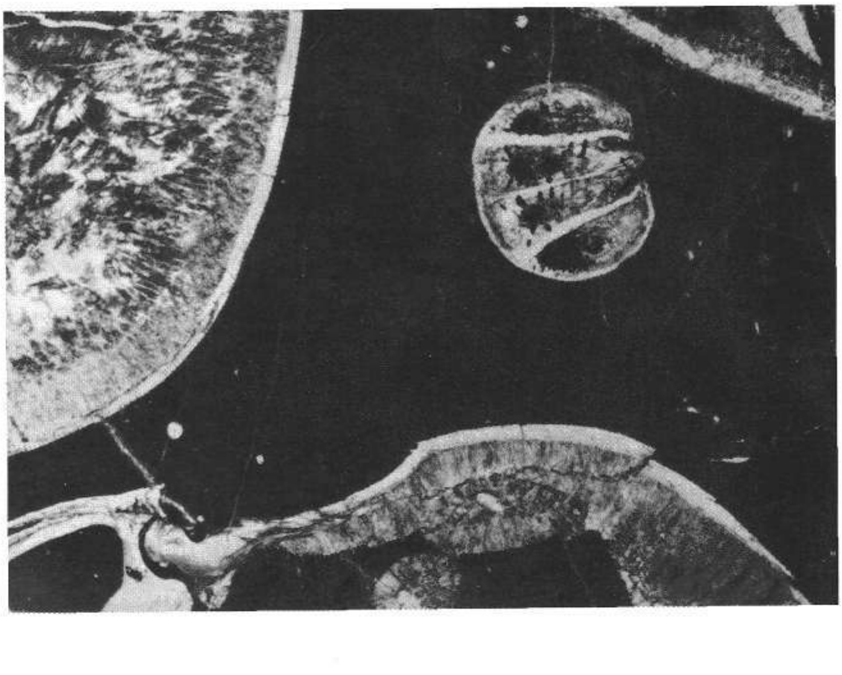
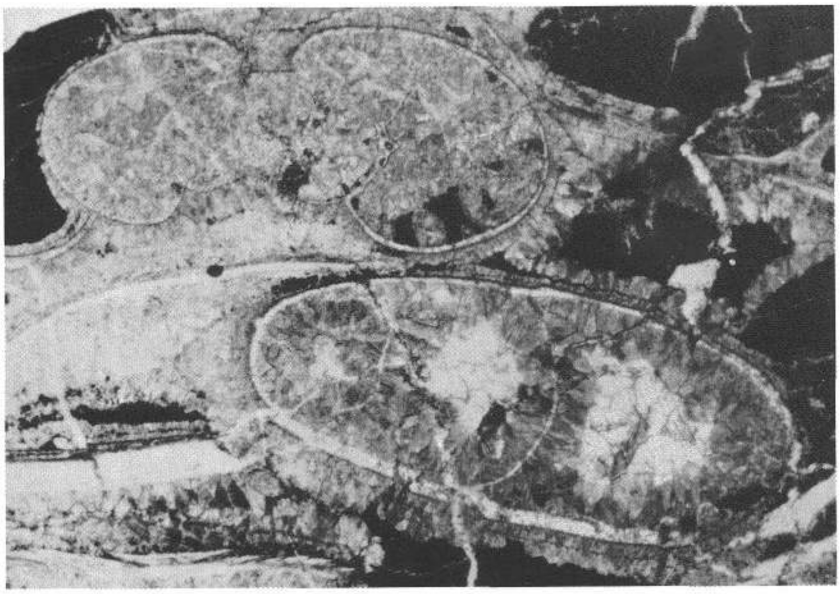


Fig. 8.
Hierlatz limestone biosparite/micrite, grainstone, with minor ammonite.
Cavities remaining after the first radial-fibrous sparitic cementation are filled partly by mosaik-like sparite (at the bottom) and partly by micrite (top right).
Hallstatt, Hirlatzwand; Sinemurian, ca. 8×.



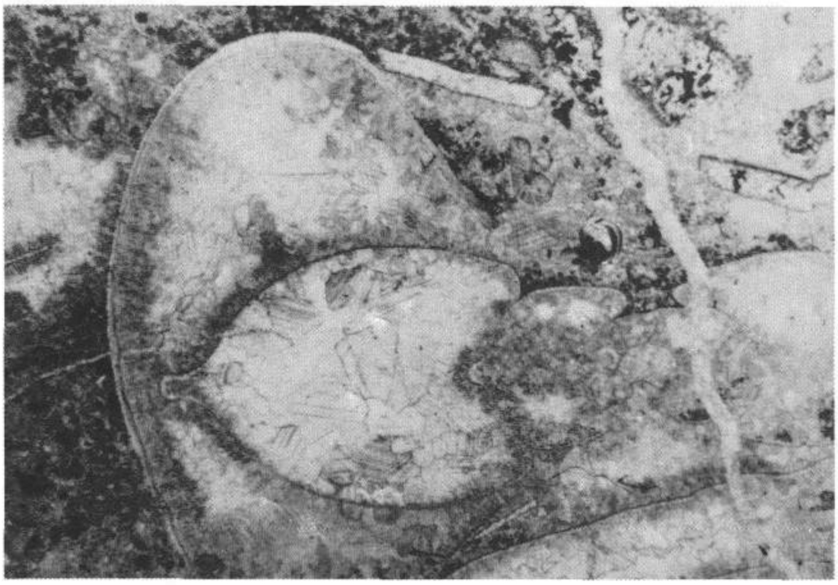


Fig. 9.
Hierlatz limestone: biosparite, grainstone with small amonite.
The "isopachous" radial-fibrous sparite that precipitated during the first phase is well separated, due to its darker shade, from the later, mosaic-like sparite.
Szentgál, Tűzköves-hegy; Sinemurian, ca. 8×.

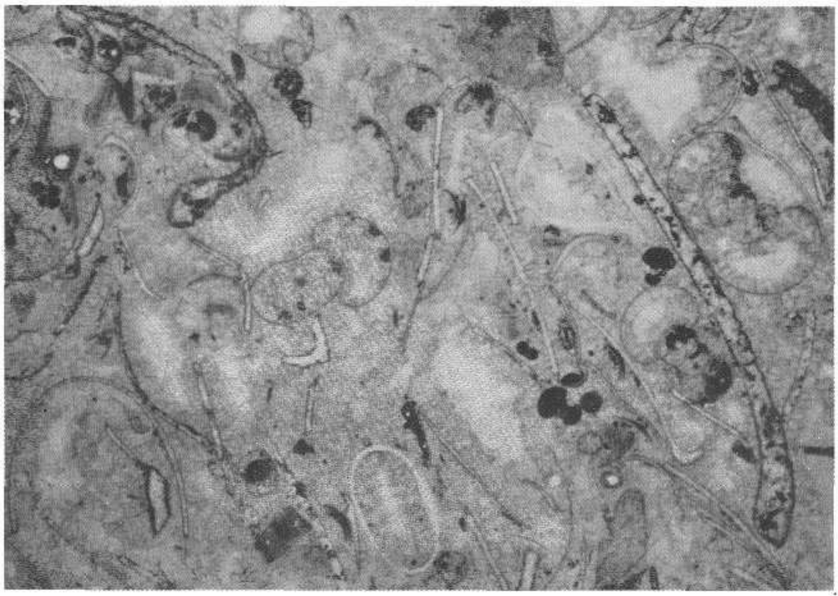


Fig. 10.
Hierlatz limestone, biosparite, grainstone, containing minor ammonite, shell detritus and foraminifers.
Some of the larger shell fragmensts are heavily bioeroded (Micro-borings).
Szentgál, Tűzköves-hegy; Sinemurian, ca. 8×.

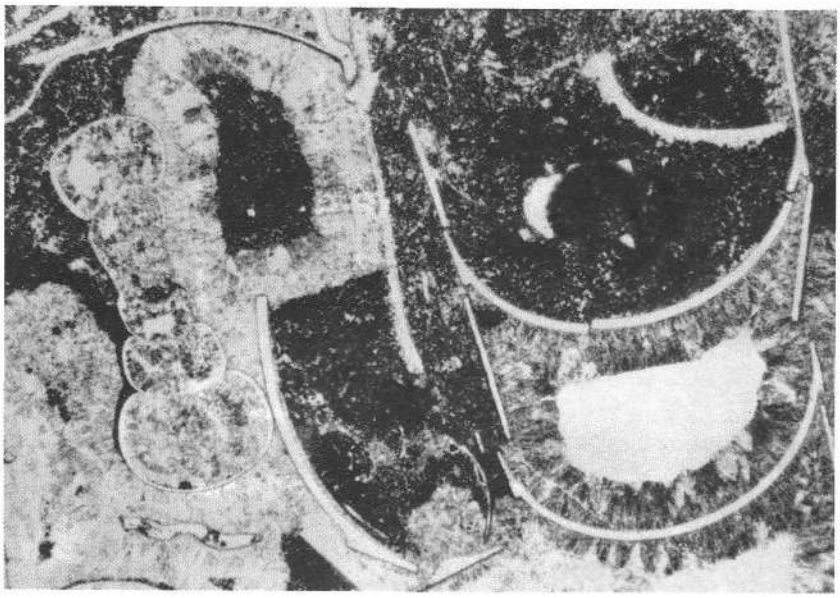


Fig. 11.
Hierlatz limestone, biosparite/micrite, grainstone, with cephalopods.
The upper chamber of *Atractites* shown on the right side was filled by micrite, whereas its two lower chambers by sparite, in two phases (radial-fibrous followed by mosaic-like). As shown top left, the radial-fibrous cementation was followed by another micritic phase.
Lókút, Papod-alja; Pliensbachian, ca. 8×.

geopetal structures and – rarely – by the alternation of sparitic and micritic beds.

3.3. Age

Considering that the classical descriptions of fauna of the type area (GEYER, 1886b, 1889) are not based on detailed, bed-by-bed collected material, the only conclusion they allow us to draw is the fact that Hierlatz limestone is "mainly" Sinemurian. Pliensbachian forms also occur, but no data pointing to Hettangian are known. In the Transdanubian Central Range a considerable advance has been represented by the detailed studies, based on bed-by-bed collection, of GÉCZY (1970, 1971, 1972, 1976). Based on reliable biostratigraphic data the Hierlatz limestone is dated Upper Sinemurian and Pliensbachian – in the Bakony Mts. – except for the uppermost Pliensbachian *Spinatum* Zone. However, it should be noted that no reliable, up-to-date and published data are available on some rather important Hierlatz limestone occurrences (for example: Úrkút: Csárda Hill, Fenyőfő: Kék Hill) therefore Lower Sinemurian cannot be excluded.

Hierlatzkalk type limestones are also frequent in the upper parts of the Jurassic, e. g. in the Bajocian-Bathonian (Mitterwand, Bakony Mts.) and in the Tithonian (Bakony and Gerecse Mts.). In spite of their striking lithological similarity and apparent genetical identity it is not recommended to refer to them as to Hierlatz limestone, otherwise this conception might be extended either to the Middle Triassic "Recoaro" limestone or to some Paleozoic limestones. As Hierlatz limestone is not known either in the Hettangian or in the Toarcian–Aalenian at all, these two gaps allow us to limit the concept in time.

3.4. Palaeoenvironment and Palaeotectonic Setting

It is since the very beginning that extreme opinions on the way how Hierlatz limestone was developed as well as on its palaeoenvironmental evaluation have collided. GEYER (1886a) considered Hierlatz limestone as a coastal deposit of a shallow sea transgressing on a dissected limestone basement. Conversely, WÄHNER (1886) assumed a deeper water environment and pointed out, among other things, that the fauna of the variegated cephalopodal limestone – that was considered to be relatively deep marine as early as at that time – shows, not quantitatively, but qualitatively, the same faunal spectrum as that of Hierlatz limestone, thus the latter may not be a coastal formation either.

The dispute has also reached Hungary. VIGH (1961), MÉSZÁROS (1968) and KONDA (1970) unanimously interpreted the Hierlatz limestone as deposits of coastal, shallow bays with waving of the sea. However, fossils that are generally well preserved (double valved brachiopods, ammonites and gastropods with rich ornament cannot be considered to have been washed by the waves of the sea, therefore GÉCZY (1970) raised the idea assuming that the fossils of Hierlatz limestone had been transported from the adjacent, more shallow (but not coastal) areas into the deeper parts of the basin. Following this idea we have established our conception saying that Hierlatz limestone was deposited in fissures and on the side and foot of "seamounts", where the mass of skeletal material carried into the depth locally surpassed the sedimentation of calcareous mud (GALÁCZ & VÖRÖS, 1972; VÖRÖS, 1974).

Convincing examples for redepositions taking place on submarine slopes inside the open-sea region have been reported from a great number of sites of the Mediterranean Jurassic (BERNOULLI, 1967; HUDSON & JENKYNS, 1969; BERNOULLI & JENKYNS, 1974). It seems that this approach becomes more and more widely applied in Hungarian (HAAS et al., 1984) and in Austrian (BÖHM, 1986) territories.

According to an updated sedimentological model (VÖRÖS, 1986, 1989; GALÁCZ, 1988) Hierlatz limestone is a specific "by-pass margin" deposit associated with submarine rocky slopes. The "Dachsteinkalk platform" in broader sense, subsided in the beginning of the Jurassic and was broken into blocks along normal faults. Submarine ridges with elevated position as well as deeper basins were formed. Due to the sweeping of currents hardly any sedimentation took place on the submarine elevations. Fissures opening from time to time in response to extensional tectonics acted as

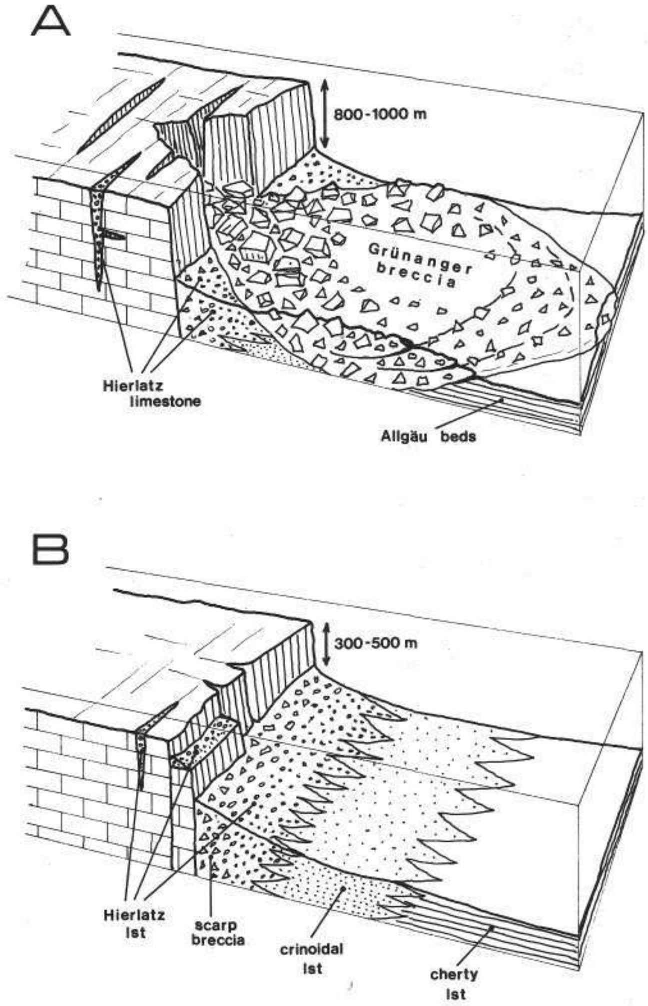


Fig. 12.
A sketch model of sedimentation of Jurassic fault slopes (by-pass margin), also including the demonstration of differences between the Hierlatz (A) and Bakony (B) types.
In both cases the Hierlatz limestone was deposited in vertical fissures attached to fault zones and taluses.

traps, catching the skeletal clasts and deposits swept there as well as the skeletons of organisms that had lived on the rocky wall of fissures. Fault zones bordering the submarine ridges appeared in some cases as huge excarpments with a height of several hundred metres and partly having a staggered form. These scarps were unsuitable for sedimentation, but acted as initial zones for gravitational sedimentary movements. Clasts or blocks of different size of the bedrock (Dachsteinkalk or Kardosrét limestone) broken by repetitive tectonic movements and bioerosion fell to the foot of the slope, accumulation there in the form of taluses and scarp breccias respectively. Occasionally, enormous stone avalanches were launched, causing large megabreccia bodies to develop. The bare and rocky slopes offered excellent opportunity for benthic organisms (brachiopods, crinoids, gastropods, bivalves, etc.) to adhere as well as a great number of niches. Ammonites laid their ovules on the rocky basement also and the young ammonites remained in these circumstances instead of the open sea until they reached the size of a few centimetres (VÖRÖS, 1970b). Skeletons of perished organisms were transported towards the basin by gravity and without being significantly broken. Large and less rolling skeletons (brachiopods, ammonites and other molluscs) were deposited in taluses. Crinoid skeletal pieces behaving as sand grains were transported for a greater distance and formed beds interfingering with the fine-grained calcareous mud found in the interior of the basin. Elevating over the surface of the deposit, the limestone blocks of the scarp breccia allowed rich benthic assemblages to flourish locally.

The fissure-filling deposits and the mass of skeletons accumulated in taluses were rather rapidly cemented, and this early diagenetic cement prevented, in many cases, calcareous mud from seeping into the intermediate cavities.

From palaeoenvironmental and palaeotectonic aspects Hierlatz limestone may be of fissure-filling or "talus" type. The fauna of the latter type is mixed from ecological point of view, since here the reworked fossils coming from shallower regions were mixed with the in-situ fauna components living in deeper water.

The model described before and elaborated for the Bakony Mts. is also applicable for the region of Hallstatt and its vicinity. The only essential difference between the two areas might be the height of the fault zone – and thus of the slope. In the vicinity of Hierlatz the northern edge of the Dachsteinkalk is likely to have been subsided into a depth of almost 1000 m (Fig. 12A).

Wide and several hundred metres deep vertical fissures may have been formed along the large and rather active fault zone; huge blocks (nearly kubic kilometres) may have been broken out of the edge that had been broken up and had remained without support, and, as a result, megabreccias were developed. In the Bakony Mts. the escarpment attached with the fault zone is likely to have been only a few hundred metres high (Fig. 12B). Therefore the associated phenomena are proportionally less dramatic; the Neptunian dykes are smaller, whereas breccias are thinner and occur in narrower zones.

4. Conclusions

As shown by the comparative study, the Hierlatzkalk found in the classical type area in Austria and in the areas studied in Transdanubia exhibits essentially identical features. According to an updated definition Hierlatz limestone is a peculiar formation that can be sufficiently described both lithologically and genetically, based mainly on the fossil content, diagenesis, stratigraphic age and the palaeo-environmental-palaeotectonic position. Thus the Hierlatz limestone is a sediment attached to Sinemurian–Pliensbachian submarine fault zones ("by-pass margin") and deposited in the form of Neptunian dykes and submarine taluses. This sediment consisting of a great mass of skeletons of assemblages living on the rock base (brachiopods, minor ammonites, bivalves, gastropods, crinoids) is characterized by polyphase sparitic cementation and geopetal structures.

Crinoid-brachiopod formations attached to submarine slopes and developed by reworking are extremely wide-spread in the Mediterranean Liassic. I have had personal opportunity to study these formations, ranging from Sicily through the Appennines and the Alps to the W Carpathians. In addition to the great number of identical features I have always found essential differences as compared to Hierlatz limestone. As far as I currently know, the typical Hierlatz limestone corresponding to the above definition occurs only in the Northern Limestone Alps and the Transdanubian Central Range, and, though some of the Austroalpine localities belong to Bavaria, I would not hesitate to say that the Hierlatz limestone is a peculiar, "Austro-Hungarian" facies.

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