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BIOSTRATIGRAPHIC DISTRIBUTION OF UPPER SCYTHIAN AMMONITES IN THE REFERENCE AREA OF MUĆ GORNJI VILLAGE, CROATIA

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In 1983 a group of researchers (HERAK *et al.*, 1983) suggested that Muć Gornji village in Croatia should be a reference area for the European Upper Scythian. The palaeo-faunistic and lithostratigraphical characteristics of this locality supported the proposition. The standard section is set along the bed of Zmijavac brook in Muć Gornji. The main part of the locality is in the Muć and Sutina village areas; the slopes in the north of the Muć-Sutina Valley are built of Lower Triassic layers. In the 1983–1991 period and later, I collected ammonites, with biostratigraphic control, in the wider area of Muć for the Natural History Museum Collection in Split. I also made precise biostratigraphic surveys, including of the standard section. The results present an important addition to the biostratigraphic scale published by HERAK *et al.* (1983:97). The biostratigraphically more significant ammonite species belong to the genera *Tirolites, Dinarites* and *Carniolites*. The Muć-Sutina locality is shown on the enclosed topographical map.

Key words: ammonites, biostratigraphy, Upper Scythian, standard section, Muć village, Croatia

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Godine 1983. skupina istraživača (HERAK *et al.*, 1983) predložila je selo Muć Gornji u Hrvatskoj za referentno područje europskog gornjeg skita. Prijedlog je obrazložen peleofaunističkim i litostratigrafskim karakteristikama lokaliteta. Standardni profil određen je duž korita potoka Zmijavca u Muću Gornjem. Glavni dio lokaliteta nalazi se na području sela Muć i Sutina; naslage donjeg trijasa izgrađuju obronke na sjevernoj strani mućko-sutinske udoline. U periodu 1983–1991, te nešto kasnije sakupljao sam uz biostratigrafsku kontrolu na širem području Mućа amonite za zbirku Prirodoslovnog muzeja u Splitu. Također, izvršio sam precizna biostratigrafska mjerenja uključujući standardnu sekciju. Rezultati predstavljaju značajnu dopunu biostratigrafske skale koju su objavili HERAK *et al.* (1983: 97). Biostratigrafski, važnije vrste amonita pripadaju rodovima *Tirolites, Dinarites* i *Carniolites*. Mućko-sutinski lokalitet prikazan je na priloženoj topografskoj karti.

Ključne riječi: amoniti, biostratigrafija, gornji skit, standardni profil, selo Muć, Hrvatska

INTRODUCTION

The Muć Upper Scythian fossil fauna was first investigated and published by KITTL (1903). His monographic work does not contain any biostratigraphic data. Every fossil hunter will easily notice four horizons, very rich in ammonites: from the lower horizons, one very rich in *Tirolites cassianus* and other tirolites of the same life form, the central lower horizon very rich in *Dinarites dalmatinus*, the central upper horizon very rich in *T. seminudus* and the upper horizon very rich in *Carniolites carniolicus*. This vertical distribution of ammonites can form a skeleton biostratigraphic scale. The problem lies in some very diagenetically damaged ammonites. The life form is mostly identifiable as tirolitid or dinaritid, but species identification is an entirely different problem. It is necessary to collect a lot of specimens to be able to separate those sufficiently preserved. The material must be carefully conserved, which is the most difficult part of the work. Thus a collection accomplished by a set of field data must also have enough well preserved ammonites. So far only the collection of the Natural History Museum in Split fulfils this condition. There is enough well preserved material for a population study to be carried out. The aim of this discussion is more precise and narrow: a survey of the linear biostratigraphic distribution of Upper Scythian ammonites in Muć, especially in the standard section (see map, p. 264). A set of data necessary for an objective critical view is added to the basic part of the discussion.

AMMONITE SPECIES IN THE STANDARD SECTION

Tirolites haueri* var. *minor KITTL 1903:58

T. haueri var. *minor* is an infraspecific form of *T. haueri* (HAUER) MOJSISOVICS 1882: 71–72.

T. cassianus (QUENSTEDT)

Pl. IV, Fig. 1; Pl. I, Fig. 1, 2; Text-Fig. 2, Fig. 3, 4.

Ceratites cassianus QUENSTEDT, 1845; *T. cassianus*, – MOJSISOVICS, 1882.

T. smiriagini (AUERBACH) MOJSISOVICS 1882:73–74, *T. turgidus* MOJSISOVICS 1882:72 and *T. multispinatus* KITTL 1903:58 can also be included in the broader frame of the *T. cassianus* population. Biostratigraphically speaking, they are in the immediate proximity of *T. cassianus*.

T. darwini MOJSISOVICS 1882:73, Pl. III, Fig.1

Pl. I, Fig. 3; Text-Fig. 2, Fig. 5, 6.

T. darwini presents a taxonomic problem. According to its whorl and sculpture, it belongs to the tirolites represented by *T. cassianus*. *T. cassianus* though looks much more like *Tompophiceras morpheos* (POPOV) 1961 /DAGYS & ERMAKOV 1996:407, 409/, and is probably an infraspecific form of the *T. morpheos* species. The picture in MOJSISOVICS (1882: Pl. III, Fig. 1) is very important because it shows the lateral part of the suture. That part is often visible in distorted specimens, like the one shown here in Pl. I, Fig. 3. It will be sufficient for identification when more preserved specimens have been collected. But the whole suture, shown in Text-Fig. 2, Fig. 5, 6, is important for a precise identification. In the collection there are 74 preserved specimens of *T. darwini*, and ca 170 specimens determined with a great probability as *T. darwini*, i.e. there is no possibility of confusing a specimen of *T.* cf. *darwini* with an infraspecific form of *T. cassianus*. KITTL's description of *T. darwini* is complicated and bad – it is a mixture of few tirolites and tirolitoides with a ceratitic characteristic of a lateral lobe.

T. prior (KITTL)

Pl. V, Fig. 5, 6.

Ceratites (Paraceratites) prior KITTL 1903; *T. prior*, – GOLUBIĆ, 1999a.

T. rectangularis MOJSISOVICS

Pl. IV, Fig. 2; Text-Fig. 2, Fig. 11, 12.

T. rectangularis MOJS. 1882; *T. dimidiatus* KITTL 1903; *T. repulsus* KITTL 1903; *T. rotiformis* KITTL 1903.

T. seminudus MOJSISOVICS

Pl. IV, Fig. 6.

T. seminudus MOJS. 1882; *T. quenstedti* MOJS. 1882; *T. dinarus* MOJS. 1882; *T. robustus* KITTL 1903; *T. paucispinatus* KITTL 1903; *T. distans* KITTL 1903; *T. angustus* 1903; *T. undulatus* KITTL 1903; *T. hybridus* KITTL 1903; *T. subillyricus* KITTL 1903.

The above mentioned infraspecific forms, as well as other so far undescribed ones, are very abundant in the Muć locality in the horizon with the typical form of *T. seminudus*. Some forms are probably differentiated enough to be considered a species – *T. illyricus* MOJSISOVICS 1882:66 is probably among them.

Diaplococeras licanum (HAUER)

Pl. V, Fig. 2; Text-Fig. 3, Fig. 1.

Ceratites licanus HAUER 1865; *Dinarites licanus*, – MOJSISOVICS 1882; *Diaplococeras licanum*, – HYATT 1900.

Dinarites dalmatinus (HAUER)

Pl. I, Fig. 4; Text-Fig. 2, Fig. 7, 8.

Ceratites dalmatinus HAUER 1865; *Dinarites dalmatinus*, – MOJSISOVICS 1882; *Dinarites nudus* MOJSISOVICS 1882; *Dinarites laevis* TOMMASI 1902; *Dinarites evolutior* KITTL 1903; *Dinarites multicostatus* KITTL 1903.

There are many infraspecific forms, all of them in the horizon with the typical form of *D. dalmatinus*.

D. tirolitoides KITTL 1903

Pl. I, Fig. 5; Pl. IV, Fig. 4; Text-Fig. 2, Fig. 13, 14.

Carniolites carniolicus (MOJSISOVICS)

Pl. IV, Fig. 5

Tirolites carniolicus MOJS. 1882; *Tirolites serratelobatus* KITTL 1903; *Tirolites heterophanus* KITTL 1903; *Carniolites carniolicus*, – ARTHABER 1911.

In the Muć locality there are many infraspecific forms and a few already differentiated species that are very closely related to *C. carniolicus* – this can clearly be seen in the Split collection, but is unknown among the experts.

Carniolites monoptychus (KITTL)

Tirolites (Hololobus) monoptychus KITTL, 1903; *Carniolites monoptychus*, – GOLUBIĆ, 1999a.

This is a carniolite, with a possible subgenus status (*Hololobus*). More preserved specimens showed that KITTL's suture diagram of *H. monoptychus* is correct. The same can be seen in the best-preserved specimens of all carniolites found in Muć, i.e. the suture is simple, goniatitic, with a single, ventral (and also dorsal) lobe. In this case I have completely separated the facts from their interpretation. This suture type can be one of the results of the late stage in carniolite evolution. Still, nothing can be proved with the abundant older palaeontological material. *C. monoptychus* is a relatively rare species.

RARE AMMONITE SPECIES FOUND IN THE WIDER AREA OF THE STANDARD SECTION

It is easy to find the most common species in a narrowly made section, but everything else depends on luck. The fossil material being diagenetically damaged, rare species found remain unidentified. So a wider section area can give more accurate data on species number. To gain an objective insight into species number, here is the following text:

Pseudodinarites mohamedanus (MOJSISOVICS)

Dinarites mohamedanus MOJSISOVICS, 1882; *Pseudodinarites mohamedanus*, – HYATT, 1900.

Meekoceras disciforme KRAFFT (in KRAFFT & DIENER, 1909:45–47)

Pl. II, Fig. 3–6; Text-Fig. 2, Fig. 9, 10.

Stacheites prionoides KITTL 1903

Pl. I, Fig. 6; Text-Fig. 3, Fig. 2.

Very rare. One damaged but still identifiable is shown in Pl. I, Fig. 6, and the suture line of one fragment in Text-Fig. 3, Fig. 2.

Pseudokymatites svilajanus (KITTL)

Kymatites svilajanus KITTL, 1903; *Pseudokymatites svilajanus*, – SPATH, 1934.

Mangyshlakites mirificus SHEVYREV 1968.

The suture is shown in Text-Fig. 3, Fig. 3.

The unique specimen from Muć was found in marl layers above the *T. darwini* but beneath the lower *T. prior* level.

Tompophiceras sp.

Pl. II, Fig. 1; Text-Fig. 3, Fig. 4.

If we leave the question of the taxonomic position of *T. darwini* aside, the presence of the genus *Tompophiceras* is evident from the findings of rare fragments of it in the upper level of *T. darwini*. One such fragment is shown in Pl. II, Fig. 1, and the suture in Text-Fig. 3, Fig. 4.

Tirolites toulai KITTL 1903

The taxonomic problem being same as in *T. darwini*, it belongs to the group of rare species represented by *T. darwini*.

Dalmatites morlaccus KITTL 1903

A relatively rare species.

Diaplococeras nudus n. sp.

Pl. III, Fig. 1–5.

Holotype: Natural History Museum Split, Inv. No. 1088.

Holotype measurements: Holotype measures about one half of the original specimen – life chamber and a part of the phragmocone with four suture lines. The external diameter measures 50 mm, internal diameter 16 mm, proportion of height **h** and width **l** of the life chamber is 1.45, and the evoluteness of the coil displayed by the proportion of external and internal diameters measures 0.32.

Derivatio nominis: *nudus* – smooth, very reduced sculpture.

Locus typicus: Sutina near Muć, Croatia.

Stratum typicum: clayish marl Upper Scythian limestone.

Diagnosis: medium evolute and medium flat ammonite with broad plain ventral side of the whorl. Lateral walls of the coil are uniformly mildly curved. Suture ceratitic with two rounded lateral lobes. Ventral lobes narrow and sharp.

Description: regarding the shell, *D. nudus* is similar to *Plococeras asiaticus* SHEVYREV 1968:164, and the important difference is the shape of the ventral lobes. In *D. nudus* the proportion of the width of plain ventral side of the coil and lateral width of the coil measures 0.73, passing over from the lateral to the ventral side is almost sharp. Umbilical wall is steep and high, in passing over to the lateral wall rounded. On the phragmocone there are slight radial ribs with slight internal and external knots, and the youngest part of the phragmocone and the life chamber are smooth.

Collection: more preserved specimens are: Inv. No. 809, 957 and 1088.

Discussion

I mentioned some older sources that enable one to know exactly what species we are dealing with, and some more recent, necessary ones. I had in sight the result of a taxonomic revision in KUMMEL (1969:492–497 and 506–507), which represents too wide a concept of a palaeontological population, in which a species becomes lost. Therefore the result can not be used for a biostratigraphic distribution survey, where short phases in species evolution are necessarily represented, and the concept of a palaeontological population is more locally determined.

SHORT DESCRIPTION OF THE BIOSTRATIGRAPHIC DISTRIBUTION OF AMMONITES IN THE MUĆ – SUTINA AREA

I. *Tirolites haueri* horizon: Most specimens are found in the upper level of the horizon. Along the horizon the distribution of specimens is distinctively irregular. In the horizon there are no other ammonite species.

II. *Tirolites cassianus* horizon: the typical form of *T. cassianus* is very abundant in the lower part of the horizon in the limestone pebbles, which measure up to 12 cm. Above, in the layers of marl and clay, there are »*Tirolites*« *darwini* and »*Tirolites toulai*, and a group of other species represented by *T. cassianus*. Up to now, in some older papers (MOJSISOVCS, 1882; KITTL, 1903) *T. smiriagini*, *T. turgidus* and *T. multispinatus* have been described, leaving the possibility that they are species or merely subspecies of *T. cassianus*, as well as some other specimens which are probably only varieties of *T. cassianus*. Of the rare species in the levels with »*T.*« *darwini* it is necessary to mention species of the genus *Pseudodinarites*, of which *P. mohamedanus* has been described, as well as very rare specimens of a doubtful KITTL genus *Bittnerites* (KITTL, 1903:66–68), rare species of the genus *Tompophiceras*, and the rare KITTL species *Tirolites spinosior* KITTL 1903:62 which can be found in the top part of the horizon. In the top part of the horizon there are also unique specimens of *Mangyshlakites mirificus* and *Stacheites prionoides*. The list is not final. The distribution of ammonites along the horizon is irregular.

III. *Tirolites prior* horizon: On the lowest level of the horizon there are *T.* aff. *prior* (Pl. V, Fig. 4) and *Diaplococeras nudus*. On the next level, vertically less than 1 m away, there is *T.* aff. *cassianus* (pl. IV, Fig. 3). Just above there is a typical *T. prior* (KITTL's *Paraceratites prior*). In the next levels there is *T. prior*. There can be up to six levels with *T. prior*, but only one or two are rich in specimens. In one microlocality in Muć Gornji and three microlocalities in Sutina I discovered a synchronized appearance of *D. nudus* with tirolites in all levels of the horizon. In the top layers of the horizon there are *Diaplococeras circumplicatus* MOJSISOVICS 1882:8–9, a questionable MOJSISOVICS species, more probably KITTL's *Dinarites (Hercegovites) diocletiani* KITTL 1903:23–24, the recently described species *Diaplococeras malici* GOLUBIĆ 1998:149, and *Meekoceras discforme*. Along the horizon, ammonites are irregularly distributed.

IV. *Diaplococeras licanum* horizon: Along the vertical axis of the horizon there are up to four levels (Zmijavac: four levels) with *D. licanum* and its varieties (GOLUBIĆ

1998: 145), and the recently described species *Diaplococeras tridentatus* GOLUBIĆ 1998: 147–148 and *D. jazinkae* GOLUBIĆ 1998:145–146 – they belong to the group of species of the genus represented by *D. licanum* (there are more of them, but they can not be described now since they are represented only by the life chamber). Ammonites in the horizon are scarcely distributed. From rare fragments of diagenetically damaged specimens, it can be concluded that in the horizon there are *M. disciforme*, *D.* cf *nudus* and *D.* aff *nudus*. In the top layer of thinly layered marl (up to 2 m) I found two specimens of *Pseudokymatites svilajanus*, and one damaged specimen of certain species of the *Pseudokymatites* genus.

V. The *Dinarites dalmatinus* horizon: Different varieties of *D. dalmatinus* can often be found together, and in this thick horizon no evolutionary change of the species can be observed in the vertical axis. From the lowest level to the top *Tirolites rectangularis* is present but rare.

VI. The *Tirolites rectangularis* horizon: more specimens of *T. rectangularis* can be found on the lowest level of the horizon, but it is still rare. In the top level there are *T. rectangularis* and rare species of the genus *Pseudokymatites*: *P. svilajanus* and the recently described species *P. involutus* GOLUBIĆ 1999b:444–445.

VII. The *Tirolites seminudus* horizon: Different varieties of *T. seminudus* that KITTL described as a different species (KITTL, 1903:39–44, 45–48, 52) can often be found together. Distribution of specimens along the horizon is irregular. In the Zmijavac locality there are four levels rich in *T. seminudus*, and in other levels it is found more separately or scarcely.

VIII. The *Dinarites tirolitoides* horizon: As well as the dominant but relatively rare species *D. tirolitoides*, in this horizon the rare species *Dalmatites morlaccus* can be found.

IX. The *Carniolites carniolicus* horizon. The typical form of *C. carniolicus* is present in the whole horizon together with different varieties of *C. carniolicus*. *C. carniolicus* represents a group of very closely related species, two of which have recently been described: *C. superior* GOLUBIĆ 1999:442 and *C. neorichianus* GOLUBIĆ 1999b:443. *C. idrianus* (MOJSISOVICS) is relatively rare and is probably a subspecies of *C. carniolicus*. All carniolite specimens that have been found so far in horizon IX are related to *C. carniolicus*, and different varieties of *C. carniolicus* are dominant.

X. The *Carniolites monoptychus* horizon: In the horizon there are rare specimens of *C. monoptychus* and *C. superior*.

Discussion

Before the present research, the stock of ammonite species in the Dalmatian Upper Scythian was not known well enough, and the collected material could not be used for a statistical review of varieties, nor for the research into morphological characteristics. At the moment there is an open question of the biostratigraphic distribution of the species of the recently described genus *Sutinaites* GOLUBIĆ 1999b: 441–442. I found those rare ammonites in the top layers of horizon VIII and in horizon IX, but I could not precisely determine the levels of their appearance. More detailed description of horizons was published in my paper GOLUBIĆ (1999a:630–639) in Croatian, and in its summary in English I gave taxonomic data for 38 species classified into 15 genera and 8 families, but the list is still not complete.

SEDIMENTS

The Upper Scythian sediments in Muć are described in the paper by ŠĆAVNIČAR & ŠUŠNJARA (1983:9–14), initially in KERNER (1916:9–14). The main sediments are mostly thinly layered biodetritic limestones and various clay layers, mostly marls. Fine silicate sand and silt are regularly admixed, and in the central part of the layers, in tje *T. seminudus* horizon, finely grained silicate clastites and silt are present more significantly. Generally speaking, the layers represent a limestone-marl shallow sea complex. Considering the biostratigraphic and not the geological topic, I would mention some rocks to which so far no attention has been paid in the research:

a) Limestone pebbles with accessory gypsum, which account for ca 1% of total limestone, are distributed along the column of layers. Gypsum is dovetailed in the form of small clods that are clearly seen with naked eye in the pebble sections. The spongily corroded pebble surfaces exposed to atmospheric conditions show they contain small clods of an acid mineral in different quantities. More of such lenses clearly mark the edges of horizons with ammonites, where they come in shorter series and with more gypsum.

b) The occurrence of small tectonic Upper Scythian breccias. They are mostly re-settled during the intrabasin sediment dynamics. They are composed of sharp-edged limestone gravel that was cemented shortly after being crushed. More often, separate pieces of gravel dovetailed in sediments of different composition can be found. That gravel can be found as solid limestone or small-clastitic core in concentrically layered knots in turbidite composition. In relation to weak tectonic movements during the Upper Scythian and to intrabasin re-settlement of non-diagenetized and already diagenetized layers, there are diagenetic damages to the fossils and a disarranged primary sequence of shell settlement to the bottom. The proportions were not big, and in the main locality there are no mixed ammonites from the different horizons. I carefully investigated the whole locality and found all turbidite forms described by STANLEY (1988:15–76) for the Cretaceous formation of St. Croix, Virgin Islands. The resemblance is complete because physical-oceanographical cause of turbidite occurrence is always the same. Only the proportions and presence of individual forms are different. The Triassic in Croatia has not yet been investigated in this sense, and there is a lack of results concerning fossil distribution, at least in the form of a preliminary report on turbidite research.

c) Layers of uniformly thinly layered homogeneous light-grey limestone, uniformly layered homogeneous clayish limestone, uniform layers of laminated clay and uniform layers of laminated silt – all with very few macrofossils – point to periods of very undisturbed settlement area. There is a close link between layer physiognomy and fossil fauna.

d) Layers mainly built of fossils and life traces of soft-bodied endobionts. Also frequent are pebbles and thinner layers full of gastropod and bivalve fossils, but often of a uniform composition. Next are pebbles and layers full of worm life traces, their tube-shaped shells being filled with limestone detritus after their death. In a way this structure resembles coral rocks but in terms of origin the two are not connected in any way. This clearly demonstrates a period of domination by a specific endobiont palaeozoocenosis. There are few kinds of very dense worm colony traces. More specimens of *T. prior* are connected with such structures in the lower part of the layers, and in the upper part *C. carniolicus*. This is an obvious ambiental connection. In some periods small worm-like endobionts prevailed, and sections of their channels give a grained look to the sediment surface (physiognomically »grained« limestone).

Discussion

I mentioned these layers because during my field work I usually observed the connection between the fossils and their environment, i.e. forms that can be explained by physical-oceanographical phenomena and forms that point to palaeozoocenosis in the succession, sometimes with rapid changes. The research into ambiental significance exceeds the limits of the topic given by the linear biostratigraphic distribution of only one part of palaeomalacofauna. However, it is necessary to mention these frequently observed phenomena.

PRELIMINARY BIOSTRATIGRAPHIC RESEARCH IN MUĆ

The initial biostratigraphic observations on the Bukovik Mt. in Sutina were published by KRYSTYN (1974:31–39). On the microlocation marked 73/17 (along the road in the west of Bukovik) he found tirolites that he identified as *D. cassianus*, and along them he also mentions *D. licanum* and *D.* cf *dalmatinus*. I measured that profile from the top Upper Scythian layer to the lower level with *D. licanum*, and collected ammonites there many times. I found rare specimens of *T. haueri* at the height of 6.3 m and 4 meters above it, at 44 m, a deformed pebble with tirolites, at 40.7 m a level with more specimens of *T. darwini* (this site was mentioned by KRYSTYN, i.e. here he found tirolites in the 2 meter high horizon of marl), a little above a few specimens of *T. darwini* and along with them at the height of 41.5 m one preserved specimen of *T. cassianus* var. *tenuis* MOJSISOVICS (1882:71). I did not find ammonites in the layers above. At the heights of 64.3, 65.9 and 69.4 m I found levels rich in *T. prior*, and above these levels a few findings of *Diaplococeras nudus* n.n. to ca 116 m, the lowest level with *D. licanum*. I precisely noted findings of *D. nudus*, but previously I made a mistake collecting single specimens of *T. prior* on sites where they were rare and not making precise notes. This refers to a somewhat lower level of *T. prior* occurrence, and to registering findings of single specimens in the area defined by the above-mentioned levels. The next microlocation in KRYSTYN (1974), marked 73/16 is situated in the area of the *C. carniolicus* horizon on the southwestern slope of Bukovik but closer to the top. Here KRYSTYN mentions:

Tirolites bi-idrianus (3×), *T. carniolicus* (4×), *Stacheites* cf *prionoides* (1×), *S.* cf *concavus* (3×) and *Dinarites*? sp. ind. (1×). At the microlocality 73/31 (toponym is not given but it is definitely Jazinka, right below a little elevation on the southern edge of Gornja Suvova) in the area from 8 to 12 m under the dolomites KRYSTYN mentions *T. carniolicus* (11×) and *T. mangyshlakensis* (SHEYREV) (1×). My opinion on the *T. mangyshlakensis* finding: specimen shown in Pl. 1 (KRYSTYN, 1974) is very damaged and resembles *H. monoptychus*. Although I cannot tell what it is, it might perhaps be *Carniolites mangyshlakensis* SHEYREV 1968: 168–169, Text-Fig. 57, Pl. X, Fig. 6. A similar ammonite life form is often found among carniolites, but without the suture diagram it is impossible to identify the species. As for the *Stacheites* species whose identification is still unfinished, the problem could be solved more easily with better preserved specimens. The suture in the genus *Stacheites* is usually explicitly ceratitic with two lateral lobes and with big ventral lobes, and is essentially different from a very simple goniatitic carniolite suture. The whorl form is not reliable because of frequent cases of convergence, which represents a problem in dealing with damaged material. Perhaps *S. prionoides* would be a suitable identification. In Pl. I, Fig. 6 I give a very damaged specimen with natural grinding on the lateral side. Clearly seen in the picture are two lateral lobes and clear traces of teeth in a few lobes. In Text-Fig. 3, Fig. 2, the suture diagram of one phragmocone fragment with a damaged ventral side is shown. In Pl. II, Fig. 2 a slightly damaged specimen of *Carniolites superior* GOLUBIĆ (1997:249, 258) is shown. Its whorl form is very similar to *M. disciforme* (Pl. II, Fig. 3–6) but also to *Stacheites* species. The main difference is a simple suture in *C. superior*, shown in Text-Fig. 2, Fig. 1, 2. The same applies to *S. concavus* SHEYREV (1968:Text-Fig. 58). I found all fragmentarily damaged specimens, which I can connect only conditionally with the genus *Stacheites*, in the lower part of the layers. Also, the question of the thickness of the *C. carniolicus* layers on Mt. Bukovik remains open. They are a lot thicker than KRYSTYN thought. Their thickness amounts to at least 80 m. I measured them only provisionally, i.e. from the length and inclination in the field, and I used the minimal value. The results of the next phase of the research are given in the paper by HERAK *et al.* (1983). There is only one problem in the left column with biostratigraphic positions of ammonites on page 97: high levels with *T. cassianus* from ca 140 m to ca 210 m in the layers column. In this biostratigraphic span I found only *T. rectangularis* varieties. This tirolite species' whorl and sculpture are very similar to that of tirolites represented by *T. cassianus*.

Except for this short morphological study, I carefully studied the material from the standard section which was given to the Geological Department of the Croatian Natural History Museum in Zagreb by Mr Herak. That material is still marked with field numbers given in the paper by HERAK *et al.* (1983:99–102). I could with certainty recognize damaged specimens of *T. haueri* and *T. prior*, and specimens without a preserved phragmocone that could, based on their size and sculpture variations, be *T. darwini*. This material from three lower horizons of layers is correctly marked according to the levels of its finding, i.e. the distribution of *T. haueri*, *T.* cf *darwini* and *T. prior* is clear. A well-preserved specimen of *D. licanum* from the horizon with *D. licanum* is interesting because such findings are generally rare.

Tirolites are determined as *T. cassianus*, i.e. some as *T.* cf *cassianus*, which is correct in the case of damaged material. Higher in the layers column, the only problem is incorrect determination of *T. rectangularis*, but the collected material does not allow more than determination of the life form represented by *T. cassianus*. The next material can be determined, except for one specimen of *D. laevis* in the high level of dinarite occurrence. This is a damaged specimen of *D. tirolitoides* – a wide lateral saddle and a little lateral lobe extremely shifted to the margin while ventral side is damaged. Further up are levels with *C. carniolicus*.

Discussion

The result of the biostratigraphic research by HERAK *et al*. (1983) represents the first correct and complete information on the biostratigraphic distribution of fossils in the Upper Scythian of Muć. I had in mind only ammonites consisting of more fossil groups that are biostratigraphically researched into and mentioned in the paper. There are many determinations still open, which clearly points to the problem making research into the fossil fauna of the European Upper Scythian harder from the beginning: diagenetically damaged fossil material.

BASIC BIOSTRATIGRAPHIC SCALE

Text-Fig. 1.

This is based on the vertical distribution of dominant characteristic ammonite species, from which every one is represented by the results of shorter evolutionary stages of one variable species. Levels with infraspecific forms of the same species are presented as the horizon determined by that species.

Key species are:

1. *T. haueri*
2. *T. cassianus*
3. *T. darwini*
4. *T. prior*
5. *T. rectangularis*
6. *D. dalmatinus*
7. *T. seminudus*
8. *D. tirolitoides*
9. *C. carniolicus*
10. *C. monoptychus*

The biostratigraphic distribution of those species clearly shows there was a long period of tirolite life form functionality predominance, which keeps an evolute whorl for a long time, and type of sculpture in more expressed sculpture variability, and is present in a wide marine area. During the end of the Upper Scythian period, tirolitids were suddenly replaced by carniolites with only a residue of tirolitide sculpture, and with whorl resembling dinaritids. In this stage,in the biostratigraphic area of the ca 100 m high column of layers in the main locality of Muć-Sutina, *C. carniolicus* stands out for its explicit individual variability, all the way from the lowest to the highest levels of the horizon. Here the evolutionary succession of the life form can be seen, which in this stage of research should be considered separately from the phylogeny of the Upper Scythian ammonites. *D. dalmatinus* is also important, here represented by many infraspecific forms and characterized by great individual variability in a long biostratigraphic sequence. It points to the period during which dinaritoide life form had (in a so far unknown marine area of Lower Triassic Tethys) an advantage, probably caused by the disappearance of tirolitids, that again appear but as a result of the evolution of the population of only one species, from which numerous infraspecific forms of *T. seminudus* emerge, with explicit individual variability. In this period tirolitide life form is no longer a solution that can follow palaeoecological successions in the Tethys area, and then carniolites emerge as the last stage. So the main biostratigraphic scale of ten horizons enables a precise orientation in the succession of dominant European Upper Scythian ammonite life forms, i.e. recognisability of stages in the changes.

BIOSTRATIGRAPHIC SCHEME EXPLANATION

I. Biostratigraphic scheme of the standard section of Upper Scythian on Zmijavac locality in Muć Gornji

Text-Fig. 4, I. a, b.

A – limestone

B – clayish limestone

C – laminated clay

D – limestone full of worm-life traces

E – marl

F – »grained« limestone (a grained physiognomy of layers rich in tiny endobiont life traces)

G – homogenic, uniformly thin-layered limestone of light-grey colour

H – limestone with a significant addition of silicate silt

I – clayish limestone with frequent worm-life traces

J – finely grained silicate clastites

K – laminated silicate silt with addition of finely grained clast

L – laminated silicate silt with pebbles of finely grained clast

M – laminated clay (illitic composition) with a significant addition of silicate silt and some finely grained clast

N – thin pebbles of limestone in clayish sediments and silt

O – position of ammonites

P – marginal occurrence of ammonites in the horizon

R – frequent worm life traces

A numbered ammonite species list is included in the scheme.

II. Biostratigraphic scheme of a segment of a column of layers from the level with *T. haueri* to the upper level with *T. darwini* near the hamlet of Šegovići, Muć Gornji

Text-Fig. 4. II.

A – limestone

B – limestone rich in mussel *Bakevelia* sp.

C – clayish limestone

D – layer of marl pebbles and limestone

E – pebble-like layered marl

F – uniformly thin layered marl

Remark: positions of ammonite species are marked in the scheme

III. Biostratigraphic scheme of the lower part of Upper Scythian layers on Mt. Bukovik in Sutina – from the level with *T. cassianus* to the lowest level with *D. licanum* compared to zjr two key levels of the main tirolite occurrence in the Zmijavac locality (standard section)

Text-Fig. 4. III.

A – marl

B – uniformly thin layered marl

C – clayish limestone

D – limestone

E – distinctly knobbly-layered limestone

F – limestone rich in worm-life traces

G – limestone with many tiny endobiont life traces (»grained« limestone)

H – pebble-like unevenly layered marl

I – thin sheets of laminated marl

J – marginal occurrence of *T. darwini*

K – limestone pebbles full of very small specimens of *Natiria* sp.

L – frequent worm-life traces

M – position of ammonites

A numbered species list is included in the scheme.

IV. Comparison between the *T. seminudus* horizon in the standard section (Zmijavac, Muć Gornji) and the *T. seminudus* horizon on Mt. Bukovik (Sutina). Differences in layer width and the presence of certain kinds of sediments are ambiental Upper Scythian.

Text-Fig. 4. IV.

A – marl

B – limestone

C – limestone rich in silicate silt

D – clayish limestone

E – finely grained silicate clastites

F – laminated silicate silt

G – light-coloured, uniformly layered limestone rich in silicate silt
H – laminated clay rich in silicate silt
I – uniformly thin layered marl
J – undulating thin layered marl
K – limestone rich in silicate silt and finely grained clast
L – laminated clay
M – pebbles of silicate finely grained clastite
N – thin pebbles of limestone
O – pebbles of laminated clay
P – rough clast
R – limestone pebbles with accessory gypsum
S – position of *T. seminudus*

ADDITION TO THE DISCUSSION

Enclosed are photographs of sediments that in the author's opinion represent an important part of the objective description of the biostratigraphic information condensed in the given schemes.

Text-Fig. 5.

A: Detail of a pebble with small snails, *Natiria* sp., characteristic of higher levels with *T. prior* and all levels with *D. licanum*, i.e. all levels with *Diaplococeras* species, covered with *M. disciforme*. *Natiria* sp. is just one of the species (except for ammonites) specific for this biostratigraphic sequence.

Text-Fig. 6.

B-1: Sponge-like corrosion of limestone in the marl sediment, originating from an accessory acid mineral – a little clump of gypsum.

Text-Fig. 7.

B-2: The same limestone layer a little further away is less corroded because the amount of gypsum varies. Locality: Zmijavac, *D. licanum* horizon.

Text-Fig. 8.a.

C-1: Part of a small tectonic breccia of undetermined age composed of sharp-edged gravel limestone from the *T. haueri* horizon is shifted along the level surface of shifting in a recent rift to the limestone sediments just below the level with *T. cassianus*. The contact between limestone sediment and marl in the level of *T. darwini* (shifting level surface) was exposed by the author by removing ca 2 m^3 of marl in 1965 (photo taken in 1999).

Text-Fig. 8.b.

C-2: Insert from C-1 photo. Breccia surface has been geologically recently shaped. Locality: Šegovići hamlet.

Text-Fig. 9.

D: Rock transported by slow land-sliding from nearby turbidite sediments. 1. – insert of silicate firm sandstone included in clayish limestone. 2. – contact between unevenly layered limestone and clayish limestone. 3. – recent breakage of silicate sandstone pebble, slightly moved from its original position. Locality: above Šegovići, *T. seminudus* horizon.

Text-Fig. 10.

E: In the bottom there is an uncovered upper surface of silt-limestone pebble with very characteristic calcitic vertical fragments of one Crinoidea species (numerous white spots). 1 and 2 are silted structures formed by sorting and (slow) movements of undiagenetized sediment. 3 is enclosed sharpened stone of silicate composition (more often only sharp-edged or much less sharpened stones are found, individually or in groups) – this is a result of transportation of material from broken, already diagenetized pebbles. These forms are regular components in turbidite composition. 4 is a small roughly grained clastitic limestone pebble of Upper Scythian age which has recently been moved from its original position through terrain shifting (the other part is still included in the same turbidite sediments). Locality: above Šegovići – *T. seminudus* horizon.

Discussion

Examples of ambiental peculiarities (A and B) are shown, as well as examples of geological and physical-oceanographical phenomena effects, which often cause the primary sequence of sedimentation to be disturbed. In the main locality of Muć – Sutina I have not found an example of intrabasin re-settlement which would cause the ammonites to be transported from horizon to horizon, horizons being determined according to the main biostratigraphic scheme. Lots of very local differences in width and type of sediment and in fossil grouping originate from the Upper Scythian time – as a result of ambiental local particularities, but these differences are (on average) not important. Turbidites are of greater importance (D and E), as significant indicators of ambiental characteristics. Apparent ambiental particularities of Upper Scythian are frequent and originate from more recent tectonic movements, with present movements being also included. The system of recent rifts can be seen in the anisian carbonate complex that is here found above Lower Scythian sediments. The same forms are visible in the Lower Triassic, but are often masked and at first sight insignificant. This marl-limestone complex with some silt sediments and generally with lots of mica in the rock composition behaves plastically. There can be movements, shifting and sliding here, without clearly seen contacts. Example C-1 was discovered by digging out the shifting level surface. Uniformly thin pebble-like marl that covers it completely was found crushed in a small water eroded ravine and the sediment was just bent. Measuring the ammonite position here would result in mistake. Limestone layers showed significant lateral shifting along one of the main rifts. It is questionable if the standard section is well chosen considering the possibilities of continuity of taking measurements along the section. The choice was very good because these sections with small influence of factors to the relations among horizons can be found 1 km east from Zmijavac. In the rest of this area one should watch out for the rift system and distribute measurements, in the sense of adding pieces of the section or changing direction over the section. So out of the few sections (all in the area of Muć Gornji) that can serve as a standard, the best one has already been chosen (HERAK *et al.*, 1983), because it is more accessible than the others, and the area is less steep.

THE PROBLEM OF THE DETERMINATION OF BIOSTRATIGRAPHICALLY MORE IMPORTANT TIROLITES AND DINARITES

The fossil material is diagenetically damaged. This fact makes an accurate identification more difficult. I solved that problem by collecting a lot of specimens, careful cleaning and by morphological analysis of damaged and less damaged material. Now it is clear which characteristics of fossil cores are originally preserved, and which are a result of different degrees of damage. I precisely studied the characteristics of pseudosutures, which are very common. I also measured the whorl of the more preserved ammonite specimens. The measured dimensions of the whorl are: external diameter »D«, internal diameter »d«, external or peripheral length »O« of the outer coil, internal or seam length »o« of the outer coil, height »h« of the outer coil and width »l« of the outer coil (sequence of »h« and »l« values between the ribs of the coil are taken, with marked point O to which certain measurement corresponds, and the result is given as the arithmetical mean of »h« and »l«). The derived biometrical values are the evoluteness of the coil »E« as a proportion »d/D« and flatness of the outer coil »P« as a proportion »h/l« reduced for 1, i.e. the flatness equals zero when height and width of the coil are the same. I showed the length of the life chamber »OC« as a percent of peripheral length that relates to the chamber. The sculpture of the outer coil, I presented with the number »n« of well expressed ribs, the number »in« of weak inter-ribs and the number »m« of weak ribs which often follow after the last expressed rib. The results are given as arithmetical mean »$\overline{X}$« defined by standard deviation »σ« and median »M« of the cumulative sequence, which points to the importance of extreme results for the arithmetical mean. Data for more important species:

Tirolites haueri

	N	$\overline{X}$	σ	M
D	33	46.7	5.9	45.5
E	33	0.44	0.02	0.44
P	27	0.09	0.046	0.085
OC	33	55%	4	55%
n	33	9.7	1.9	10
in	33	2.3	2.33	1.5
m	33	1.3	1.9	0

Tirolites cassiaus

	N	$\overline{X}$	σ	M
D	44	54	9.4	51.5
E	44	0.44	0.025	0.44
P	33	0.08	0.07	0.07
OC	44	55.5%	4.5	55%
n	42	12	3.1	11
in	42	2.3	1.8	1.5
m	42	4.7	5	3

Tirolites darwini

	N	$\overline{X}$	σ	M
D	27	52	8.6	50
E	27	0.445	0.027	0.45
P	22	0.13	0.09	0.13
OC	26	55.5%	4.8	55%
n	27	12	3.5	10
in	27	3	2.6	2.5
m	27	3.5	4.5	1

Tirolites prior

	N	$\overline{X}$	σ	M
D	39	51	9	48
E	39	0.4	0.02	0.4
P	25	0.275	0.1	0.29
OC	28	58%	4.8	58.5%
n	32	11	2.2	10
in	32	1.3	1.5	1
m	32	0.4	0.75	0

Tirolites rectangularis

	N	$\overline{X}$	σ	M
D	47	39.6	6.1	38
E	47	0.454	0.026	0.45
P	32	0.2	0.1	0.215
OC	47	59%	5	60%
n	44	11.6	3.5	10.5
in	44	1.5	1.7	1
m	44	1.6	2.8	0

Tirolites seminudus

	N	$\overline{X}$	σ	*M*
D	55	39.5	5.9	38.5
E	55	0.4	0.024	0.4
P	47	0.14	0.085	0.135
OC	55	60%	6	60%
n	53	5	1.8	5
in	53	0.45	0.9	0
m	53	0.28	0.5	0

Dinarites dalmatinus

	N	$\overline{X}$	σ	*M*
D	54	45	7.5	45.5
E	54	0.26	0.04	0.25
P	53	0.67	0.18	0.62
OC	38	63%	11	61%
n	52	2.5	3.5	0

Dinarites tirolitoides

	N	$\overline{X}$	σ	*M*
D	43	39	7	38
E	43	0.33	0.037	0.32
P	36	0.3	0.12	0.3
OC	35	62%	15	61%
n	44	5	4.5	3.5

Carniolites carniolicus

	N	$\overline{X}$	σ	*M*
D	76	54	8	54
E	76	0.26	0.04	0.26
P	47	0.96	0.24	0.97
OC	72	56%	9	54%
n	76	3	1.5	3

Meekoceras disciforme

	N	$\overline{X}$	σ	*M*
D	13	40.5	3.7	41
E	13	0.276	0.02	0.27
P	13	0.51	0.08	0.51
OC	9	62%	7	60%
n	9	0	0	0
lv/l	9	0.6	0.05	0.62

Tirolites cassianus typical form

	N	$\overline{X}$	σ	M
D	22	57	10	54.5
E	22	0.44	0.026	0.44
P	16	0.07	0.04	0.075
OC	22	56%	5	56%
n	22	11	1.9	11
in	22	2	2.4	1
m	22	5.5	5.7	4.5

This review of arithmetic means and medians shows which biometric characteristics are statistically significant for species identification, and which are not. There is no difference in given characteristics between some of the species, i.e. *T. cassianus* and *T. darwini*. Differential characteristics are found in suture diagrams and they are significant. Characteristics with great dispersion around the arithmetic mean are noticeable, as well as the influence of certain extreme results on the difference between arithmetic mean and median. This is the consequence of the expressed individual variability of those characteristics. Even smaller diagenetic deformations, expressed as balanced positive and negative aberrations that affect standard deviation, havean influence on the flatness »P«. In *T. cassianus* group there are 22 specimens of typical *cassianus* form and 22 specimens infraspecific forms: *T. smiriagini*, *T. turgidus* and *T. multispinatus*. This is the reason for giving the results for the typical *T. cassianus* form from this group separately. Groups of typical *T. cassianus* and *M. disciforme* are too small. This is the result of the very few well-preserved specimens available. For *M. disciforme* I also give the value of the proportion of width »lv« of the ventral side of the coil and coil width »l« (»lv/l«), because this characteristic is significant as a differential in relation to the dinarites. Statistical groups can be completed by fragmentary specimens with individually preserved characteristics only if this fragment can be precisely identified by its suture line. This way the population concept of the research can be established. As for the very variable sculpture, it is important to add: for values »in« and »m« for the *cassianus* group, 31% of the results equals zero, and for *cassianus* 27%; for *T. rectangularis* »in« equals zero in 39% of cases, »m« in 59% cases; for *T. prior* »in« equals zero in 34% of cases, »m« in 75% cases; for *T. seminudus* »in« and »m« equal zero in 75% of cases. In conclusion, the variation of the sculpture given by »m« is not characteristic of *T. prior* and *T. seminudus*.

The life form of tirolites is biostratigraphically significant. Using basic biometric data and the suture diagram, I showed how the species can be distinguished, and that some of their characteristics are very similar i.e. statistically insignificant. These small ammonites generally have very similar whorls and sculptures, and a very simple ceratitic suture, which in some of them lost its ceratitic characteristic. I give data on ammonites of tirolite life forms, which I separated from SHEVYREV (1968):

genus *Bernhardites* SHEVYREV, 1965:170 (SHEVYREV, 1968:86), genus *Dzulfites* SHEVYREV 1965b:172 (SHEVYREV, 1968:89), genus *Paratirolites* STOYANOW, 1910 (SHEVYREV, 1968:89), genus *Abichites* SHEVYREV 1965 (SHEVYREV, 1968:94). The next source is DAGYS & ERMAKOV (1996:407–409), the genus *Tompophiceras*, with special attention to *T. pascoei* (SPATH) and *T. morpheos* (POPOV), which are very similar to *T. toulai* and *T. darwini* – especially in the characteristic ventral lobes. In this group of tirolite ammonites, differential characteristics can be seen in the suture diagram: in the way the simple ceratite characteristic is expressed, in the more expressed and more distant from the seam lateral lobe, and in the size and shape of the ventral lobes. The other characteristics are a topic for the statistical elaboration of the whorl and sculpture, and those characteristics are often very similar in tirolites. This is also the case with tirolite ammonites from Muć. It would be important for this biostratigraphic paper to give data for a form of *T. prior* which I positively identified as *Paraceratites prior* KITTL 1903:29, Pl. XI, Fig. 4a, 4b, 13, because it is biostratigraphically important as a characteristic and dominant species of the third horizon. The suture diagram shown in KITTL (Pl. XI, Fig. 4b) is accurate. My material corresponds to the KITTL's description. It can be clearly distinguished from other tirolites. Specimens which I collected are mostly damaged but there are enough of them with a preserved suture and a specific variation of sculpture: strong external spines on the end of very weak ribs which often have internal strenghtening, that develops into a weak internal knot in sculpture variations. Also for *T. prior* sculpture a sequence of strong spines to the very end of the coil is characteristic, as well as absence of sequence of weak ribs towards the end of the coil in *T. cassianus* and »*T.*« *darwini*. In *T. prior* spines are often broken because of the sediments dynamics, but their base can be regularly clearly seen – I showed two damages of that kind in Pl. V, Fig. 5, 6, and six specimens in paper GOLUBIĆ, 1999a, Pl. IV, Fig. 4, 5, 6; Pl. V, Fig. 1, 2, 3 (specimen in Pl. IV, Fig. 6 has a common form of the pseudosuture). But in the third horizon there are other rare tirolites, some of them being very similar to *T. prior*, and some to *T. cassianus*. In the lowest level of the third horizon there is *Tirolites* aff *prior*, represented in the collection by few intact, mostly subadult specimens, because adults are either fragmented or very deformed. A fragment of an adult specimen's phragmocone with a well preserved suture is shown in Pl. V, Fig. 3. In the next level which is vertically distant (on microlocalities that were not disturbed by the sediments dynamics or later tectonic movements) from 0,6 to 1,8 m there is a tirolite very similar to *T. cassianus*. Almost all material is very deformed. I could separate only cca ten specimens for biometrics. The suture line is questionable. It has a ceratitic characteristic but ventral lobes are not preserved. Phragmocone shown in Pl. V, Fig. 4 has clear traces of long ventral lobes, which connect it with group represented by *T. darwini*. Also juvenile form of *T. cassianus* can not be excluded – I showed a specimen very similar to *T. cassianus* in Pl. IV, Fig. 3. I found similar specimens, but very rarely, one by one and in higher levels of horizon, beneath the top level with *T. prior.* I can give very few data for these tirolites from the III horizon:

Tirolites aff *prior*

	N	$\overline{X}$	σ	M
D	13	38.5	6	46.8
E	13	0.4	0.02	0.4
P	13	0.12	0.094	0.09
OC	12	61%	3.6	61%
n	12	10	2.7	10
in	12	2	1.8	2
m	12	0.33	1.1	0

Tirolites cf *cassianus*

	N	$\overline{X}$	σ	M
D	12	44	7	45.5
E	10	0.43	0.02	0.4
P	10	0.24	0.74	0.235
OC	12	56%	6.5	56.5%
n	12	11	2.6	11.5
in	12	2	1.3	2
m	12	1	1.5	0.5

Better data are not accessible so far. It can be seen that one of these tirolites belongs to the *Tirolites prior* group, and that the other one resembles *T. cassianus*. In museums (except for the Natural History Museum in Split) material from the third horizon of Upper Scythian layers in Dinaric area is missing. In the rich collection from Muć and other parts of Croatia, collected by fra Josip Marko Malić in the end of the XIX century (Deposited in the Naturhistorisches Museum Wien, known as the Kittl's collection) specimens of *Paraceratites prior* are missing, according to KITTL (1903:29) there are seven of them.

Discussion

I enclosed this chapter to the biostratigraphic paper having in mind problems with identification and classification of Upper Scythian ammonites from the times of pioneer research to the present time. One of the reasons is surely diagenetically damaged material. Most of the specimens collected are very damaged, and a lot of them look like *Tirolites* sp., shown in Pl. V, Fig. 1: only life chamber in some clayish limestone. I left such material in the field, and took only much better material for the collection. Still, in statistical unions, number »N« in the same union is different for certain characteristic measured, because this characteristic is not preserved enough. Next question is whether I noticed differences among specimens of the same species from different levels of horizon – having in mind different varieties and subspecies. Often different varieties are synchronous. It is very important to have synchronous samples. I deposited one such sample of *T. seminudus* in the Croatian Natural History Museum, the measurements were:

	N	$\overline{X}$	σ	M
D	24	38	4	37
OC	24	60%	3	61%
n	24	4.6	1.3	5

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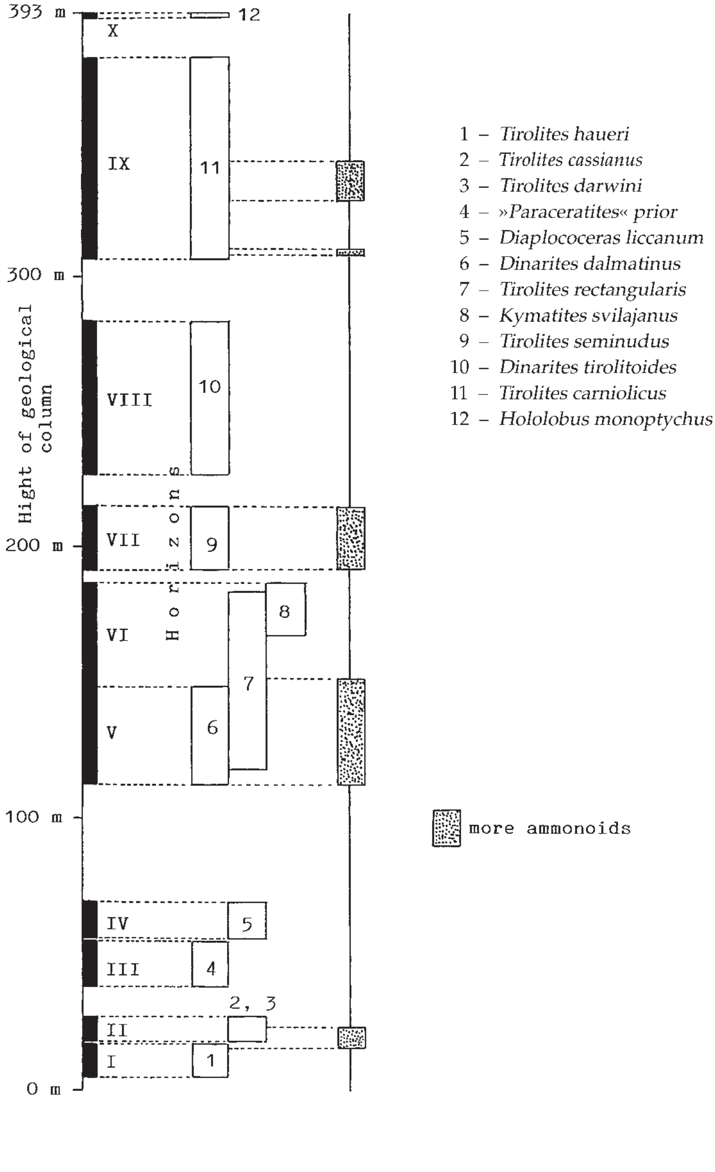
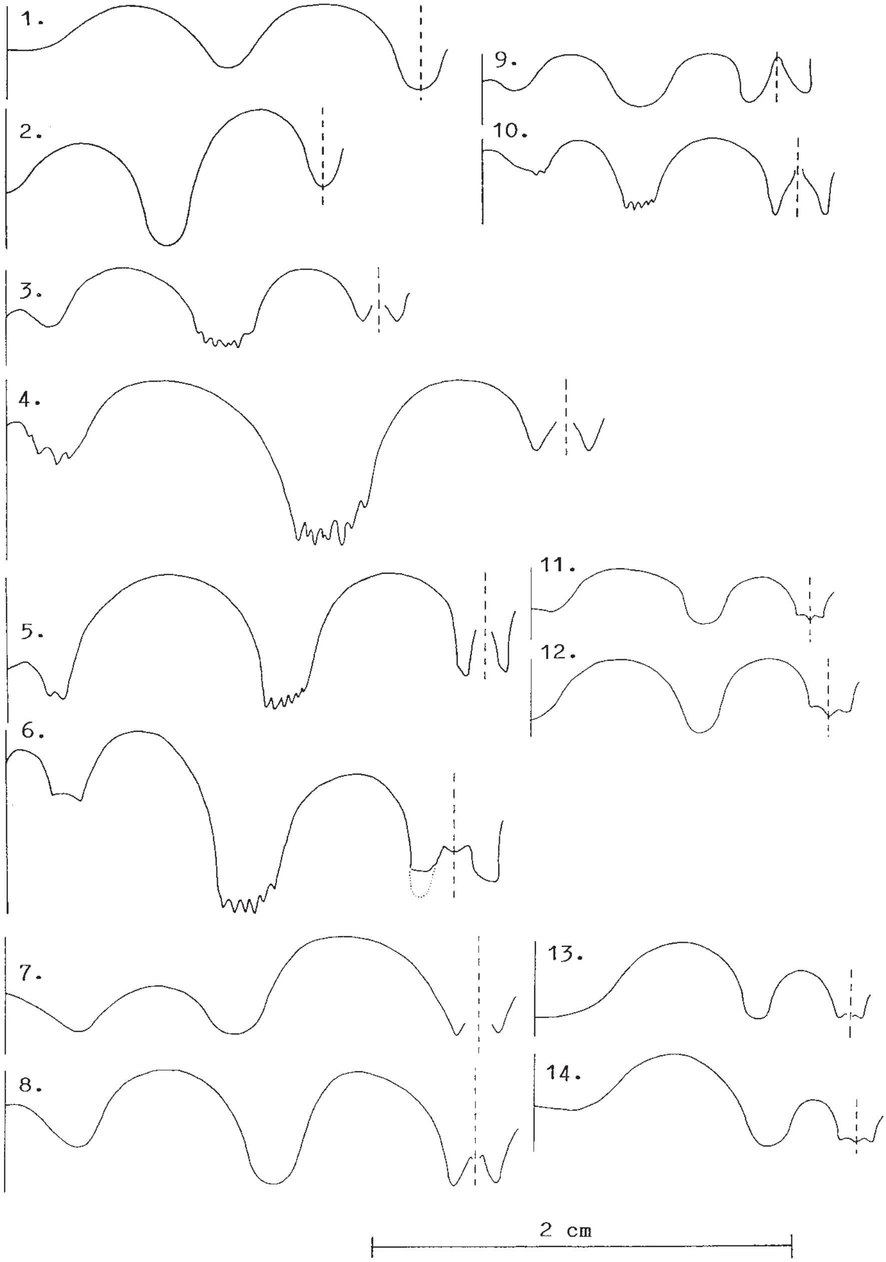
Text-fig. 1. Basic biostratigraphic scale

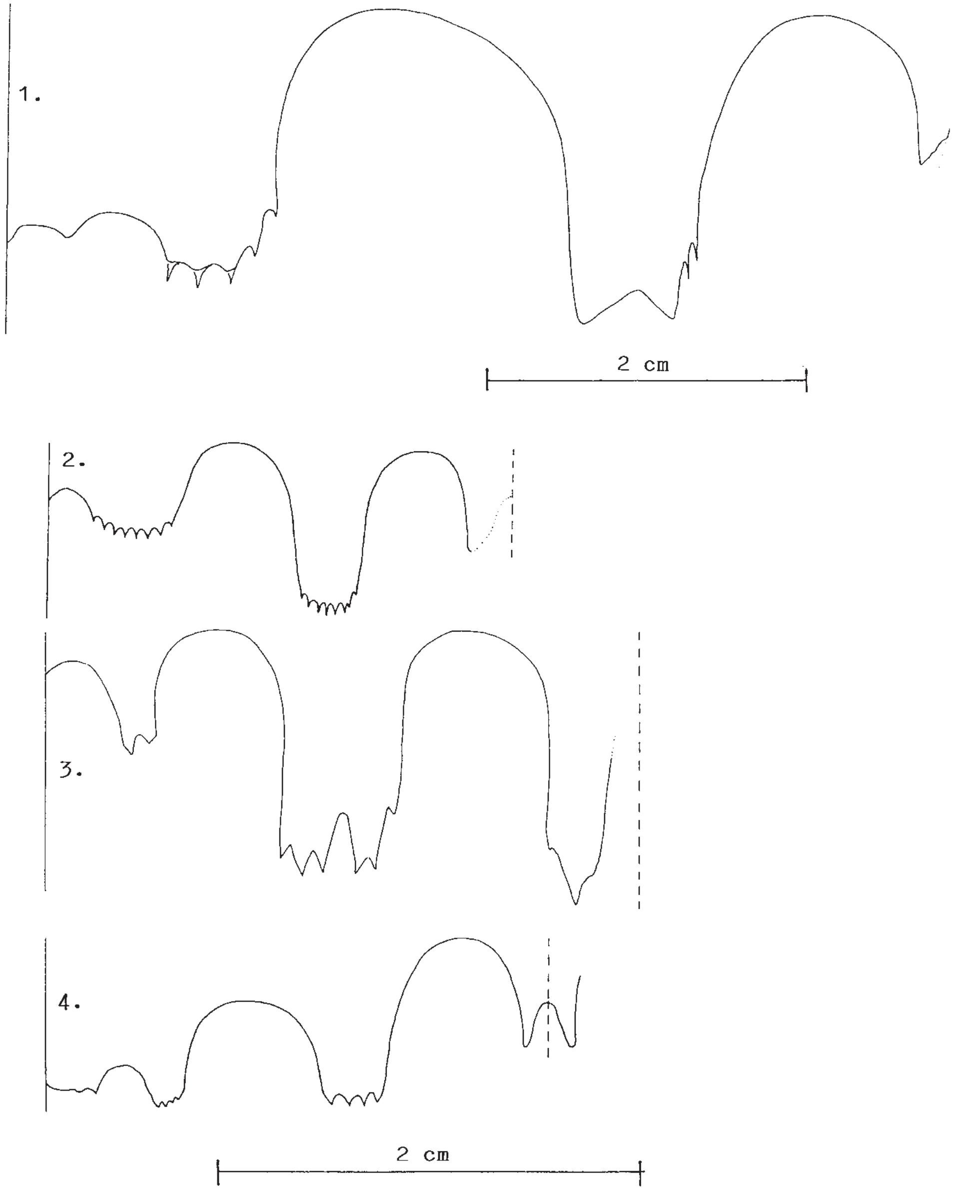


Text-fig. 2.



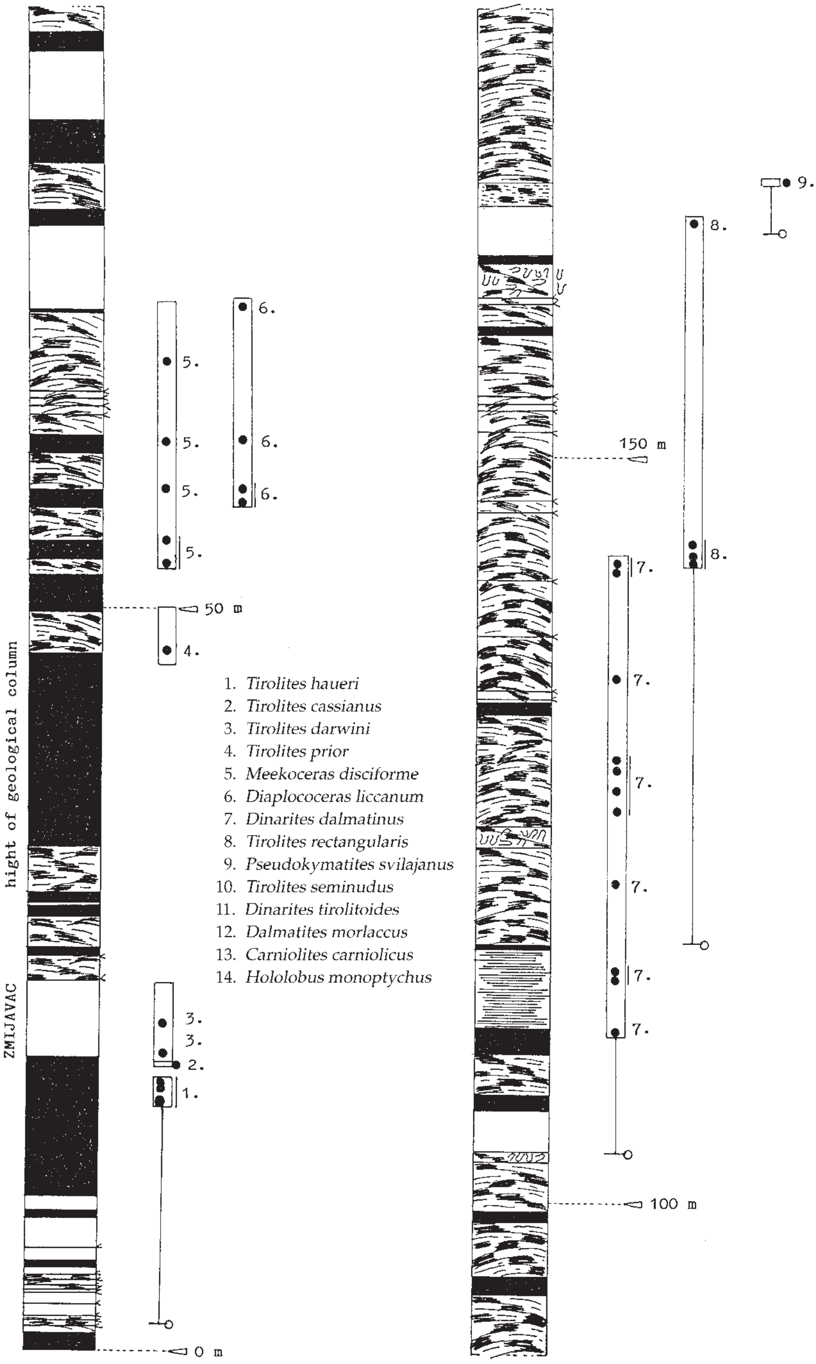
Suture: 1., 2. *Carniolites superior*; 3., 4. *Tirolites cassianus*; 5., 6. *Tirolites darwini*; 7., 8. *Dinarites dalmatinus*; 9., 10. *Meekoceras disciforme*; 11., 12. *Tirolites rectangularis*; 13., 14. *Dinarites tirolitoides*

Text-fig. 3.

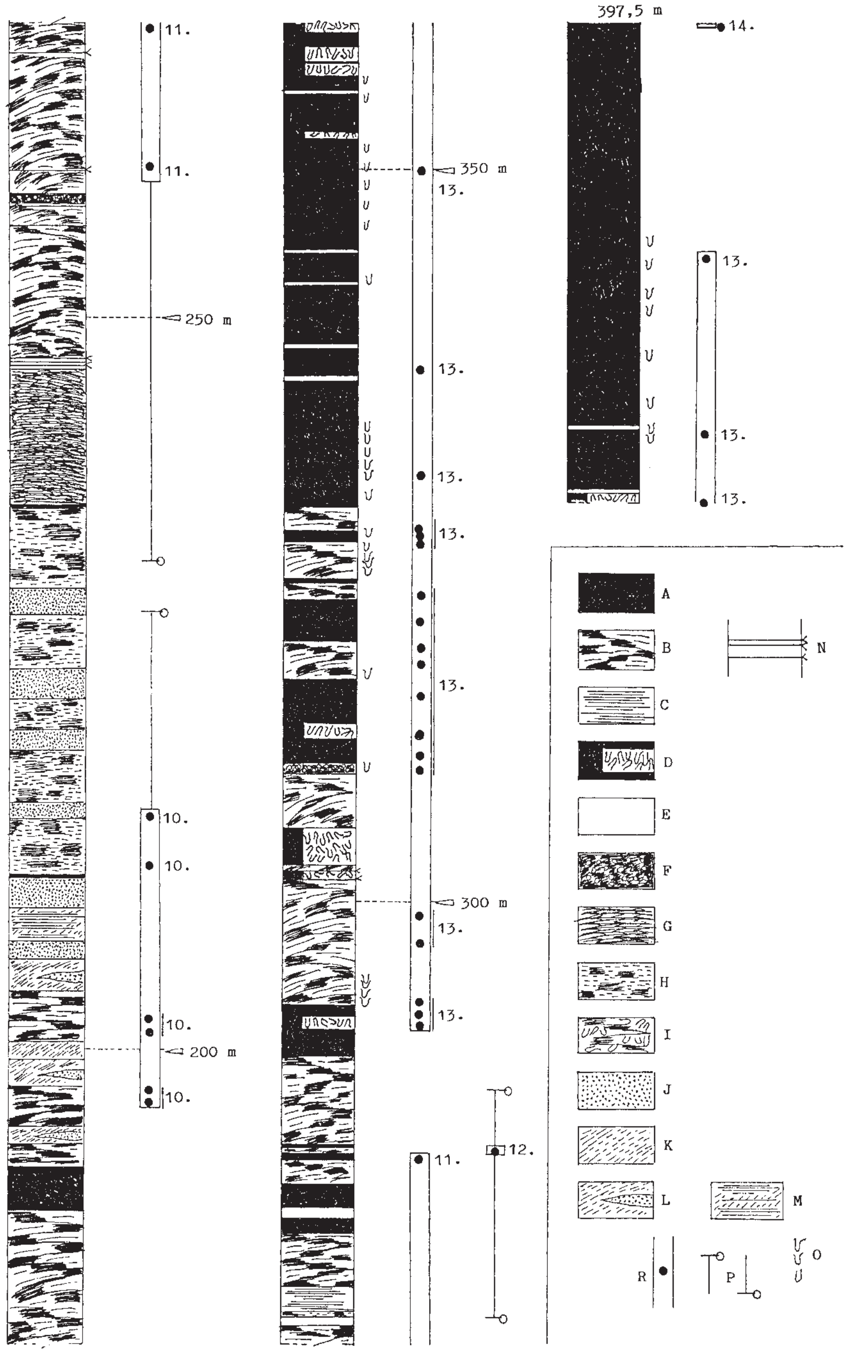


Suture: 1. *Diaplococeras liccanum*; 2. *Stacheites prionoides*; 3. *Mangyshlakites mirificus*; 4. *Tompophiceras* sp.

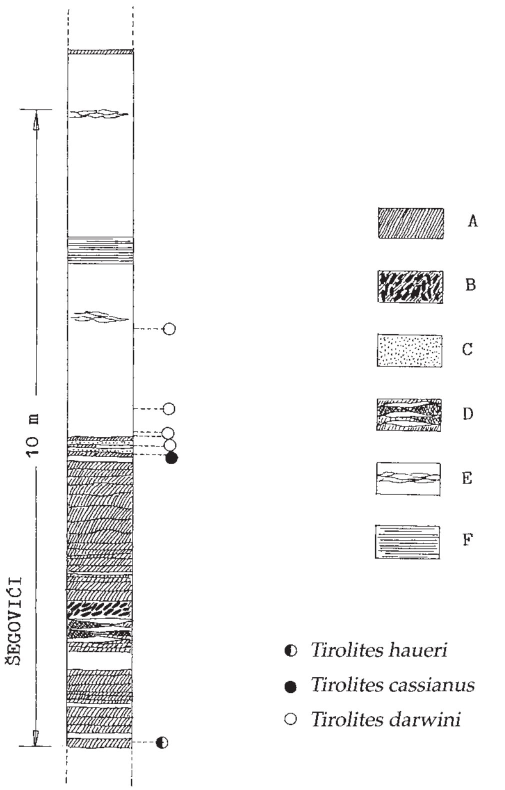
Text-fig. 4.–I. a. Standard section

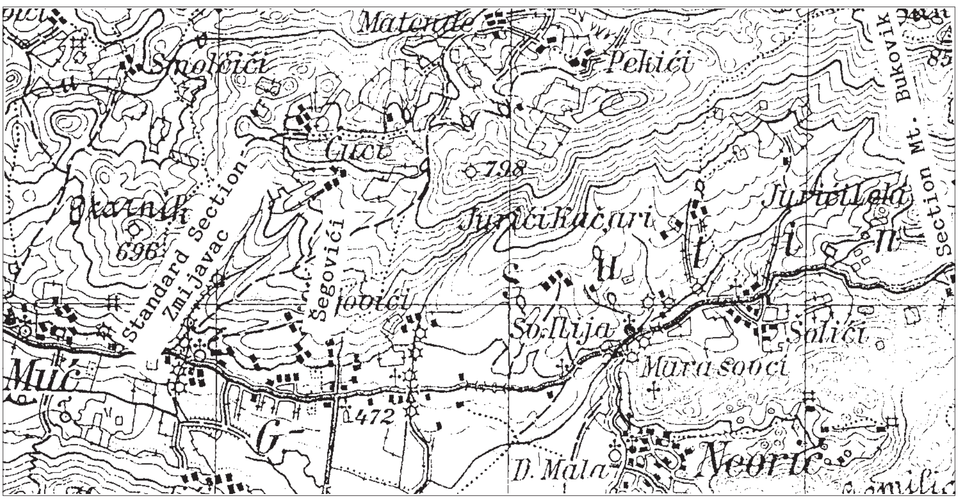


Text-fig. 4.–I. b. Standard section



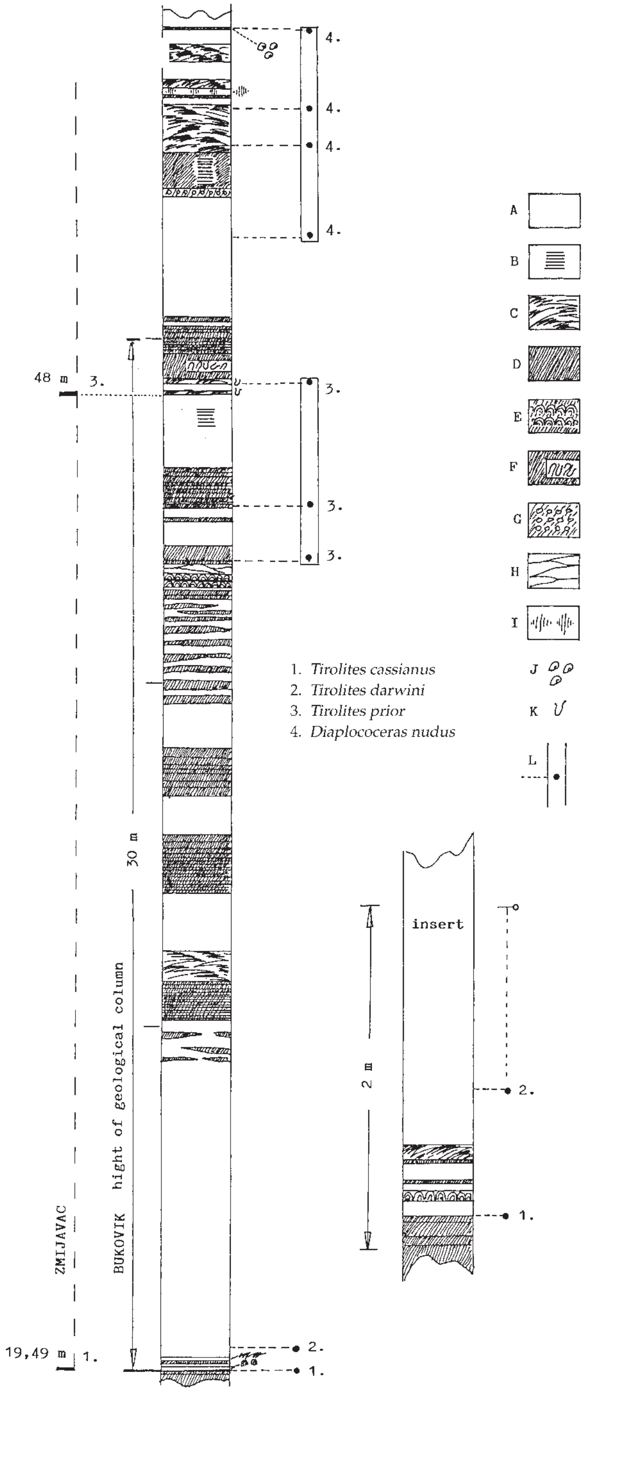
Text-fig. 4.–II.



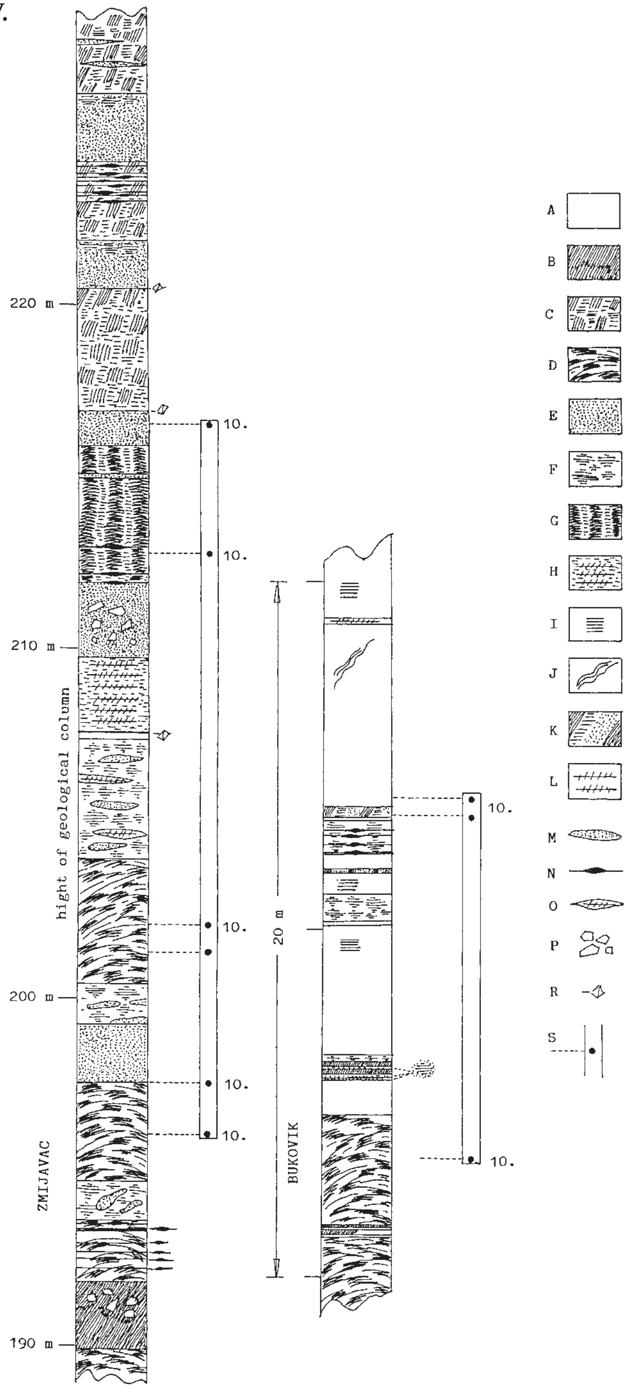


Muć village in Dalmatia, Croatia

Text-fig. 4.–III.



Text-fig. 4.–IV.


220 m
210 m
200 m
190 m
hight of geological column
ZMIJAVAC
BUKOVIK
20 m
10.
A
B
C
D
E
F
G
H
I
J
K
L
M
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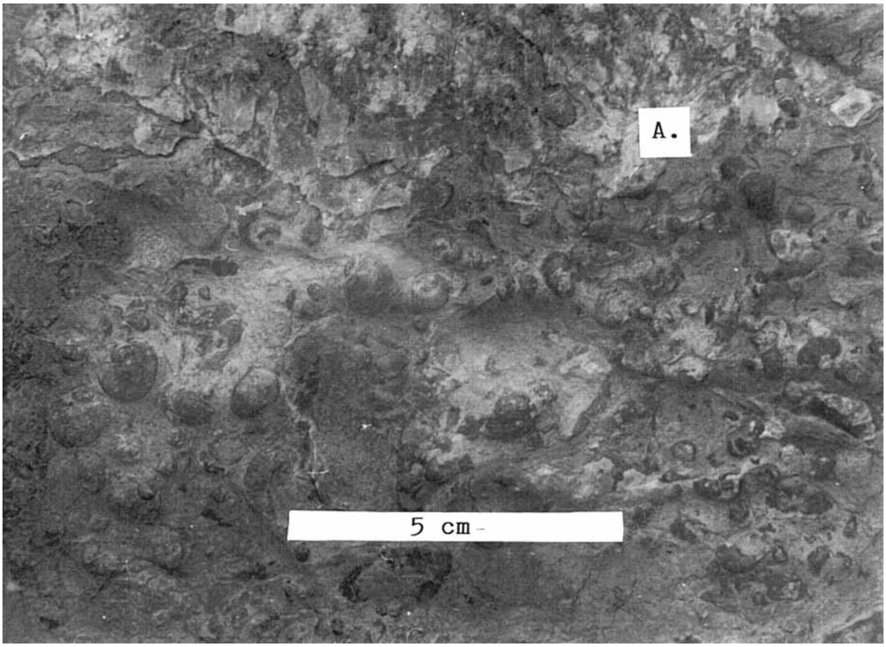
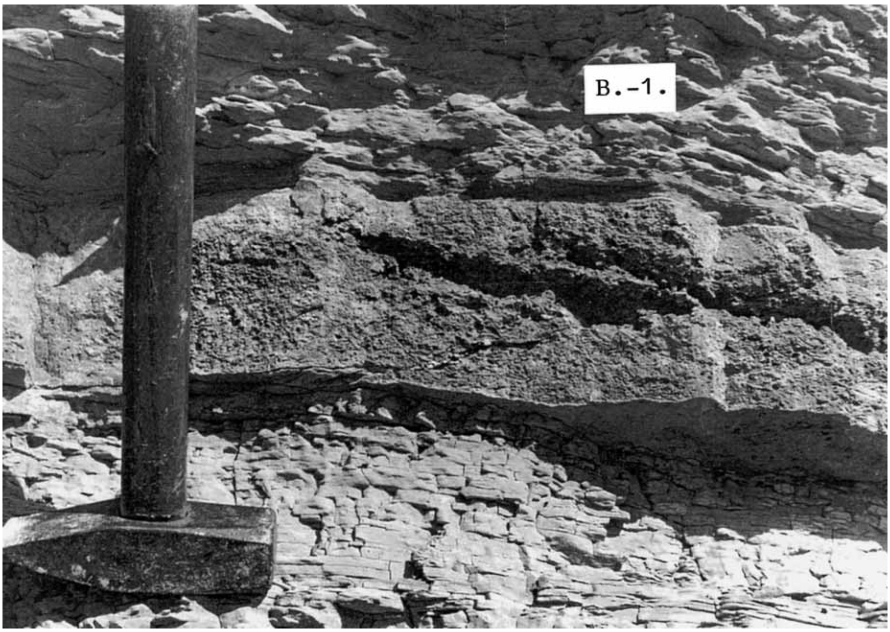
O
P
R
S



Text-fig. 5.



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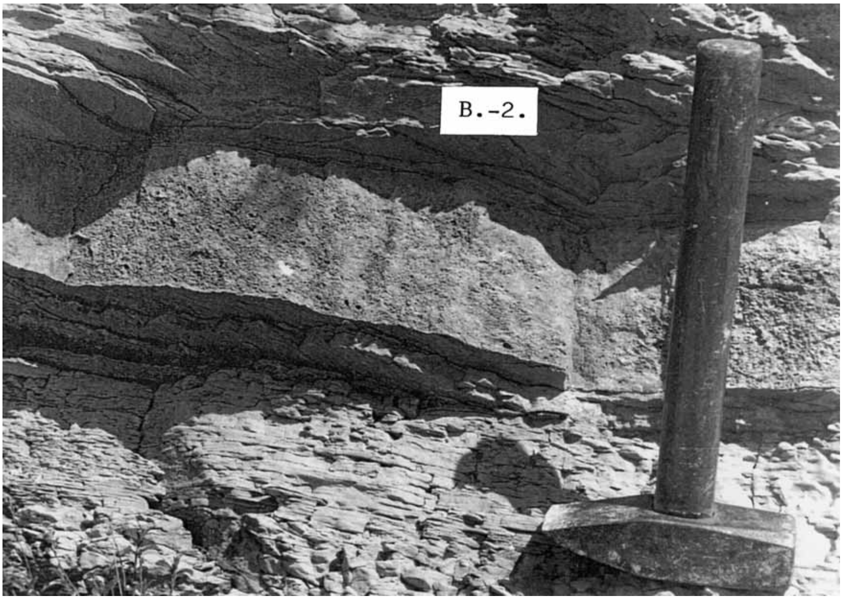
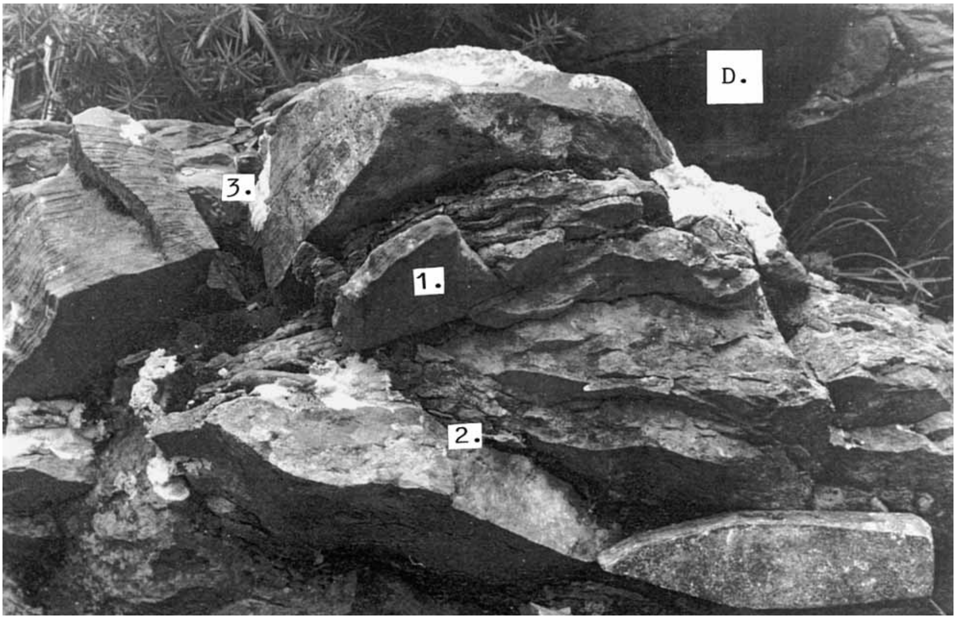
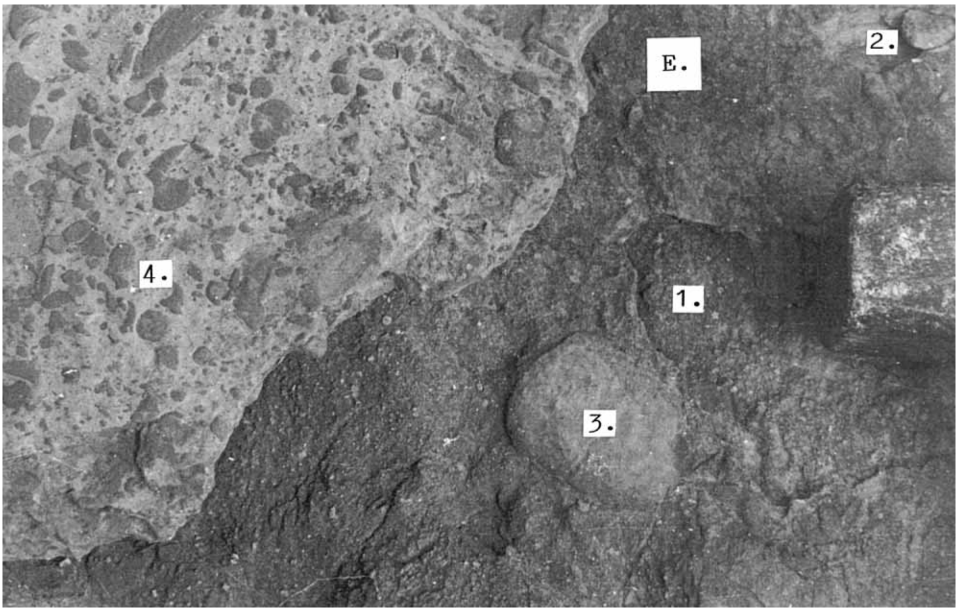


Text-fig. 7.

Text-fig. 8 a,b.

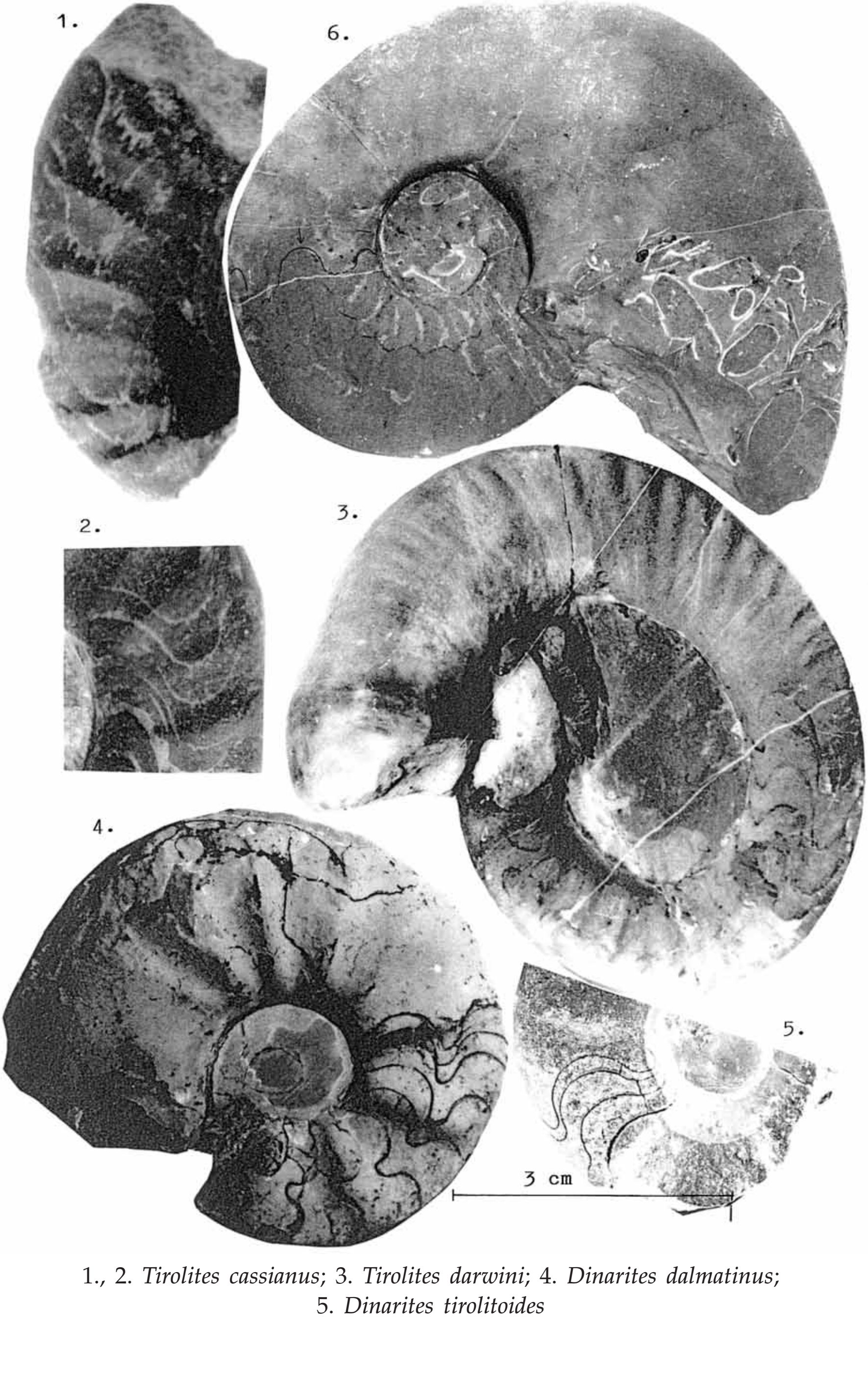


Text-fig. 9.



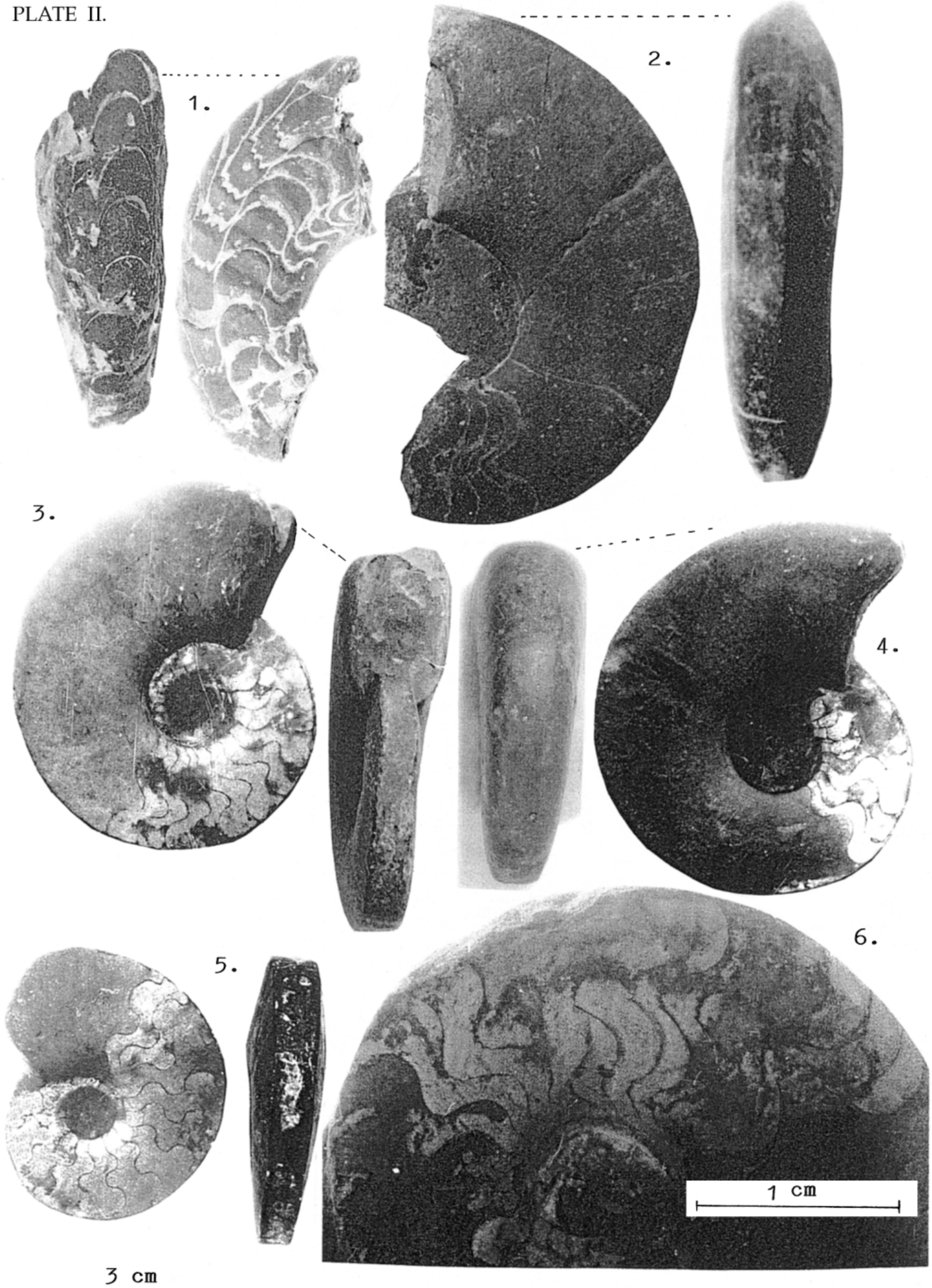
Text-fig. 10.

PLATE I.



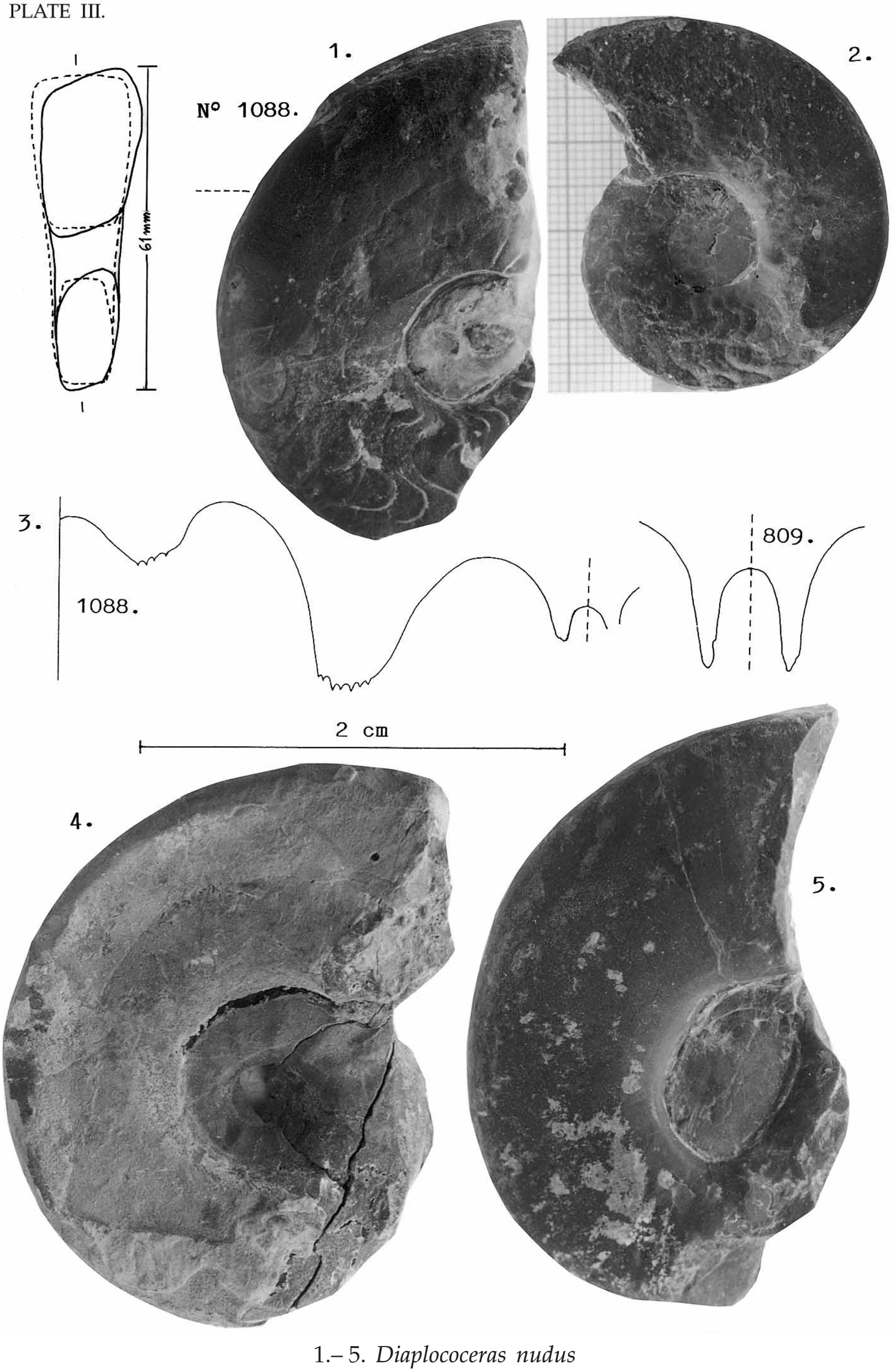
1., 2. *Tirolites cassianus*; 3. *Tirolites darwini*; 4. *Dinarites dalmatinus*;
5. *Dinarites tirolitoides*

PLATE II.



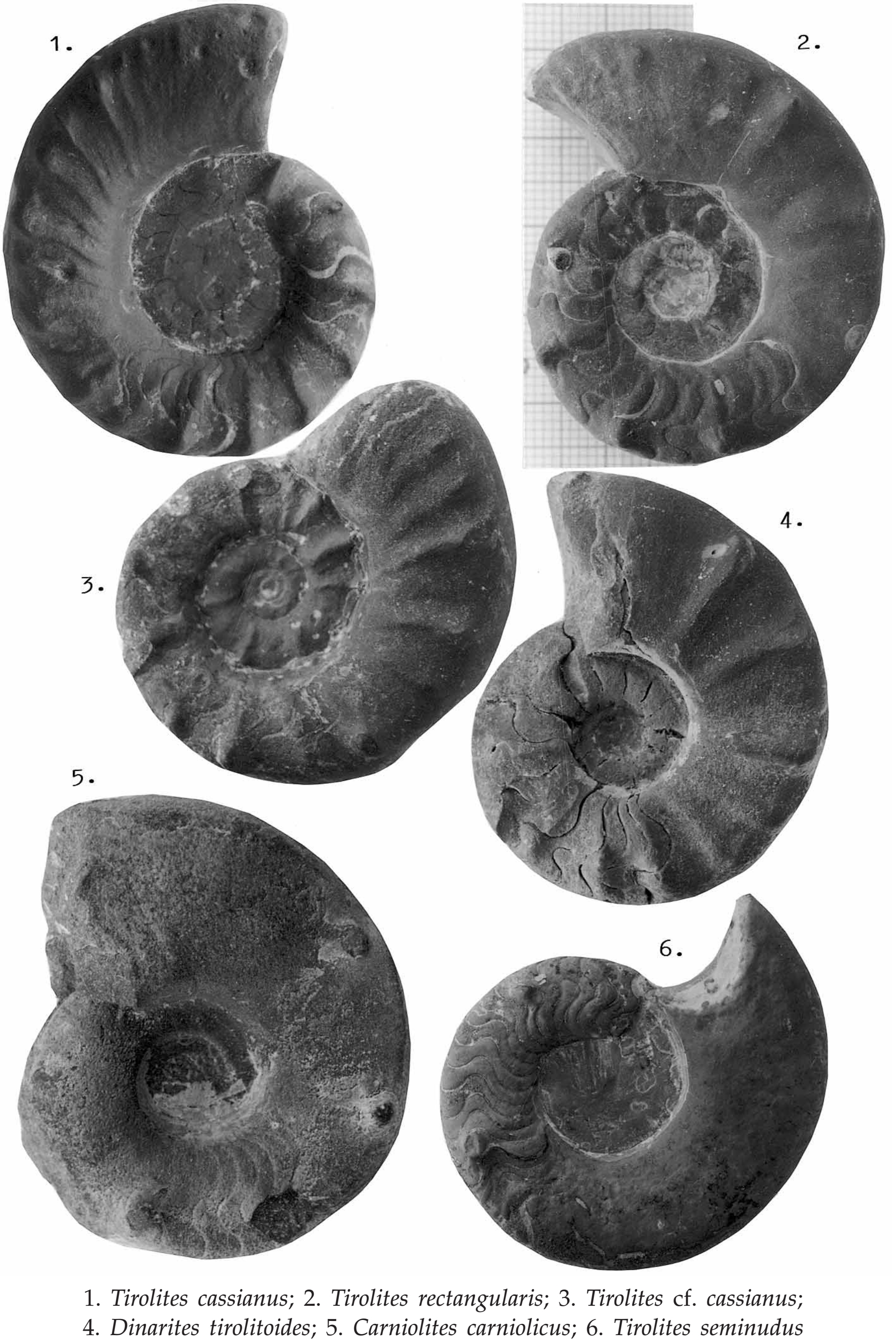
1. *Tompophiceras* sp.; 2. *Carniolites superior*; 3.– 6. *Meekoceras disciforme*

PLATE III.



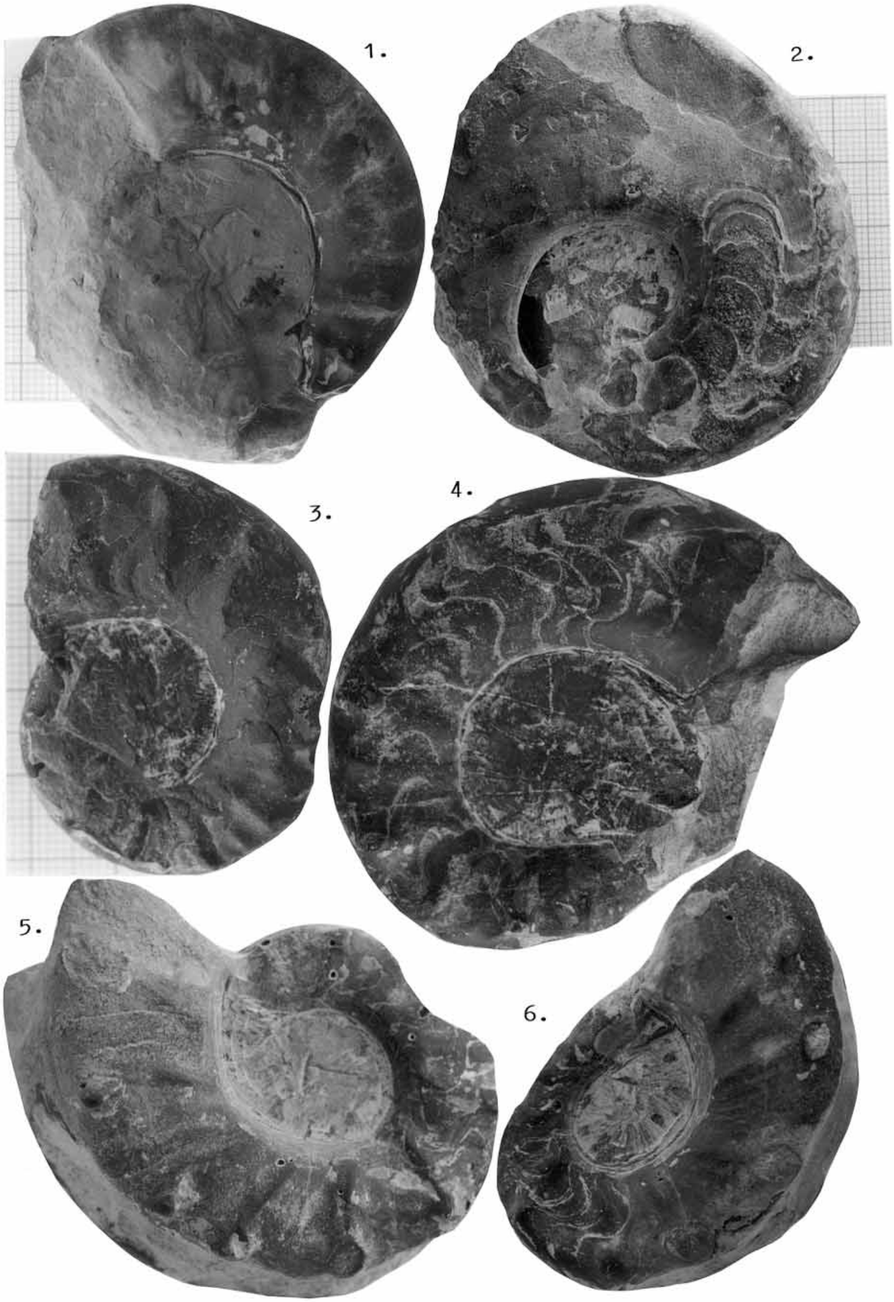
1.– 5. *Diaplococeras nudus*

PLATE IV.



1. *Tirolites cassianus*; 2. *Tirolites rectangularis*; 3. *Tirolites* cf. *cassianus*; 4. *Dinarites tirolitoides*; 5. *Carniolites carniolicus*; 6. *Tirolites seminudus*

PLATE V.



1. *Tirolites* sp.; 2. *Diaplococeras liccanum*; 3. *Tirolites* aff *prior*; 4. *Tirolites* cf. *cassianus*; 5., 6. *Tirolites prior*