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First Evidence of Hercynian Lower Carboniferous Flyschoid Deep-Water Sediments in the Lycian Nappes, Southwestern Turkey

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Abstract

For the first time, a deep-water Lower Carboniferous siliciclastic turbidite-olistostrome unit with many lydites (partly distally turbiditic) can be dated in the Incirbeleni Formation of the Tavas Nappe (Lycian nappes) in southwestern Turkey. These nappes belong to a southern Hercynian Upper Devonian to Lower Carboniferous flysch Belt that is also known from the Karaburun Zone in western Turkey. A conodont fauna, consisting mainly of *Gnathodus bilineatus* and few *Lochriea commutata* without nodose *Lochriea* species allows the dating of cherty limestone olistoliths as middle to early late Viséan age (Viséan 2 to lower Viséan 3). The Lower Carboniferous Hercynian deep-sea turbidites and olistostromes confirm a northern origin for the Lycian nappes and a minimum north-south nappe transport of approximatly 200 km. Nevertheless, the Tavas Nappe originated to the south of the Izmir-Ankara Zone because the ophiolites of the Izmir-Ankara Zone follow in nappe position above the Tavas Nappe.

1. INTRODUCTION

According to GÖRÜR et al. (1997) who expressed the prevailing view, only the Istanbul Block and parts of the Sakarya Zone in northwestern Turkey had a Hercynian history. South of the Istanbul block, the Palaeotethys is assumed in parts of the Sakarya Zone, and its Upper Triassic to Middle Jurassic southward directed subduction is regarded as the reason for the Upper Triassic opening of Neotethys within the marginal part of Gondwana (ŞENGÖR, 1984, 1985).

The main Neotethyan suture zone is assumed in the Izmir-Ankara Belt. South of this suture zone, from the Karaburun Zone in the north to the Beydağlari Autochthon in the south, the Silurian to Late Palaeozoic history was believed to be that of a shallow shelf on the northern part of Gondwana. This view was strengthened by the fact that Silurian to Permian deep-water sediments could not be found or not be dated in this area, whereas shallow water deposits of this age are known, especially from the Middle Carboniferous to Permian, but partly also from the Silurian to Lower Carboniferous.

This general Palaeozoic development was assumed also for the Tavas Nappe of the Lycian nappes in the study area, where shallow-water, partly lagoonal and continental development continued in the Triassic (GRACIANSKY, 1968, 1972; ERAKMAN et al., 1982; ŞENEL et al., 1994).

New results since 1995 question the previously generally accepted view of the Silurian to Permian shallow-water Gondwana shelf development that reached northwards beyond the Neotethyan suture zone (Izmir-Ankara Belt). KAYA & KOZUR (1995) discovered for the first time pelagic conodonts in the Devonian of the Karaburun Zone and KOZUR (1997a, c, d, in press) dated the Karareis "Formation" sensu ERDOĞAN et al. (1990, 1995) by conodonts, Muellerisphaerida and Radiolaria as Silurian to Early Carboniferous. The rocks can be subdivided according to KOZUR (op. cit.) into a Silurian oceanic sequence of shales and lydites and mafic volcanics, a Late Caledonian Upper Silurian to Pragian flyschoid siliciclastic turbidite-olistostrome unit with distal turbiditic lydites, an Upper Devonian limestone, shale and chert sequence, an Upper Famennian to lower Viséan Hercynian turbidite-olistostrome unit, and an upper Viséan transitional sequence (rich in ammonoids, brachiopods, crinoids, trilobites, conodonts, ostracods, radiolarians) to the molasse type shallow-water Serpukhovian-Bashkirian Alandere Formation. The transitional sequence contains subduction related felsic to intermediate tuffs. Viséan rocks of the transitional sequence were found also by CARIDROIT et al. (1997). They contain the same fossils but were misidentified as upper Tournaisian, and assumed to be blocks in the "Triassic" Karareis "Formation". Thick, very low-grade metamorphic siliciclastic rocks were tentatively assigned without fossil evidence to the Ordovician (KOZUR, 1997a, d).

In the Bolkardağ Zone, a flyschoid siliciclastic turbidite-olistostrome unit with distal turbiditic lydites and felsic tuffs was reported and assigned to the Early Carboniferous by ÖZCAN et al. (1988). It was subsequently subdivided and dated by GÖNCÜOĞLU & KOZUR (in press) as a Llandovery-Wenlock deep-sea shale-chert sequence with tuffs, and a Late Caledonian Upper Silurian to Pragian flyschoid sequence. Thus, the Cale-

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donian development is identical both in the Karaburun and Bolkardağ zones. A Hercynian deep-water sequence could not be dated in the Bolkardağ Unit (not present?), where Carboniferous shallow water rocks (mainly limestones) are present. DÜRR et al. (1995) reported a similar, but metamorphic sequence from the Menderes Massif. According to these authors, an (?)Early Carboniferous flyschoid series overlies black quartzites (? metamorphic lydites) and basic volcanics, but this dating is not fossil-proven because of its metamorphic overprint. Therefore, a Hercynian deep water development can be neither proven nor excluded in the Menderes Massif.

A very interesting Lower Carboniferous deep water sequence of similar tectonic position to the Tavas Nappe is known from the lower Nohutluk Formation, of the Çataloturan Nappe of the Aladağ Mountains, at the western end of the Eastern Taurus Belt. Lower Carboniferous radiolarian-rich turbiditic cherty limestones and rare mudstones are overlain by shallow water limestones and sandstones (upper Nohutluk Formation) of middle Viséan to Bashkirian age (TEKELI et al., 1984). The Nohutluk Fomation is unconformably overlain by the shallow water Permian Arkaççа Formation which is overlain by variegated shallow water limestones, mudstones, marls and dolomites of Triassic age. The cherty limestone olistoliths in the siliciclastic deep-sea turbidites and radiolarites of the Incirbeleni Formation of the Tavas Nappe are similar to the cherty limestones of the lower Nohutluk Formation that yielded, however, a slightly older Tournaisian - Lower Viséan foraminiferal assemblage (TEKELI et al., 1984). As these foraminifers are shallow water species, they may have been redeposited in the calciturbidites. Alternatively, the upper range of this foraminiferal fauna may be Viséan 2. Conodont and radiolarian data from the lower Nohutlar Formation are not available.

Immediately north of the stable Gondwana, a continuous Serpukhovian to Lower Triassic (and younger) deep-water trough was found extending from Crete to western Sicily (KOZUR & KRAHL, 1987; CATALANO et al., 1991; KOZUR, 1989, 1993) and further to the east in NE Iraq and Oman (BECHENNEC et al., 1989; VAŠIČEK & KULLMANN, 1988) which should be also present at least in SE-Turkey. This southern deep-sea trough had, during the Permian, no connection with the Karakaya Zone of NW-Turkey as the Dorashamian radiolarian faunas of Sicily and the Karakaya Complex are totally different (KOZUR, 1993, 1997b). Moreover, the Karakaya Ocean opened only in the latest Permian (KOZUR & KAYA, 1994; KOZUR, 1997b). Opinions concerning a continuous Middle Carboniferous to Permian oceanic trough are based on the stratigraphic misinterpretation of red Dorashamian radiolarites as Artinskian to Sakmarian by OKAY & MOSTLER (1994), as shown by KOZUR (1997b); the oldest Permian pelagic sediments (pelagic limestones) of the Karakaya Zone are of latest Dzhulfian age (KOZUR & KAYA, 1994).

Thus, both the presence of Hercynian flysch with lydites and other deep-water sediments, and (further in the south) the presence of Permian Tethyan deep water sediments should be expected in southern Turkey.

Bedded lydites (black radiolarites) of Late Permian age were reported from the radiolarite-rich, siliciclastic turbidite-olistostrome deep-water sequence of the Incirbeleni Formation of the Tavas Nappe, at the Nişangah Tepe locality close to the Yayla Ağiliovasi (ERAKMAN et al., 1982; ŞENEL et al., 1994; ŞENEL, 1997). These radiolarites and cherty limestone olistoliths from the siliciclastic turbidite-olistostrome of the Incirbeleni Formation were investigated. The deep-water character of this flyschoid sequence could be confirmed. However, the age of this sequence was proven by conodonts to be Early Carboniferous.

2. LOCATION

The investigated section northwest of Teke peninsula (Western Taurides) lies in a rather remote area in SW Turkey between Fethiye and Çameli, but east of the road that connects these two towns. The investigated outcrop is SW of the Nişangah Hill (Fig. 1). 1000 m W of the sampled outcrop there are a few summer houses for shepherds, and this place is named by the shepherds as the Ağiliovasi Yayla. Lydites and cherty limestone olistoliths of a siliciclastic turbidite-olistostrome sequence with many lydites were sampled from the Incirbeleni Formation, which had been assigned according to fusulinid faunas from assumed under- and overlying formations to the Murgabian (ERAKMAN et al., 1982; ŞENEL et al., 1994), corresponding to the lower-middle Wordian of the international stage subdivision.

3. GEOLOGICAL SETTING

The Tavas Nappe is the lowermost nappe of the Lycian nappes. It is tectonically underlain by the Yeşilbarak Nappe which consists of two structural units, the Gömbe and Yavuz units. The lower structural unit (Gömbe Unit) is represented by Upper Cretaceous limestones (Gebeler Fm.) and Upper Lutetian-Burdigalian sandstones and shales (Elmali Fm.). The upper structural unit (Yavuz Unit) consists of an upper Lutetian to Priabonian flysch. The Yeşilbarak Nappe, in turn, rests tectonically on the Beydağlari Autochthon consisting of the Cretaceous Beydağlari Formation, the Upper Palaeocene-Middle Eocene Dişitaştepe Formation, and the Lower Miocene Sinekçi Formation.

According to ERAKMAN et al. (1982) and ŞENEL et al. (1994), the Tavas Nappe is subdivided into the Karadağ Unit of tectonically lower position, tectonically overlain by the Tekedere Unit.

The Karadağ Unit consists of the following formations (from the bottom to the top):

Sazak Formation (?Upper Devonian shales, limestones),

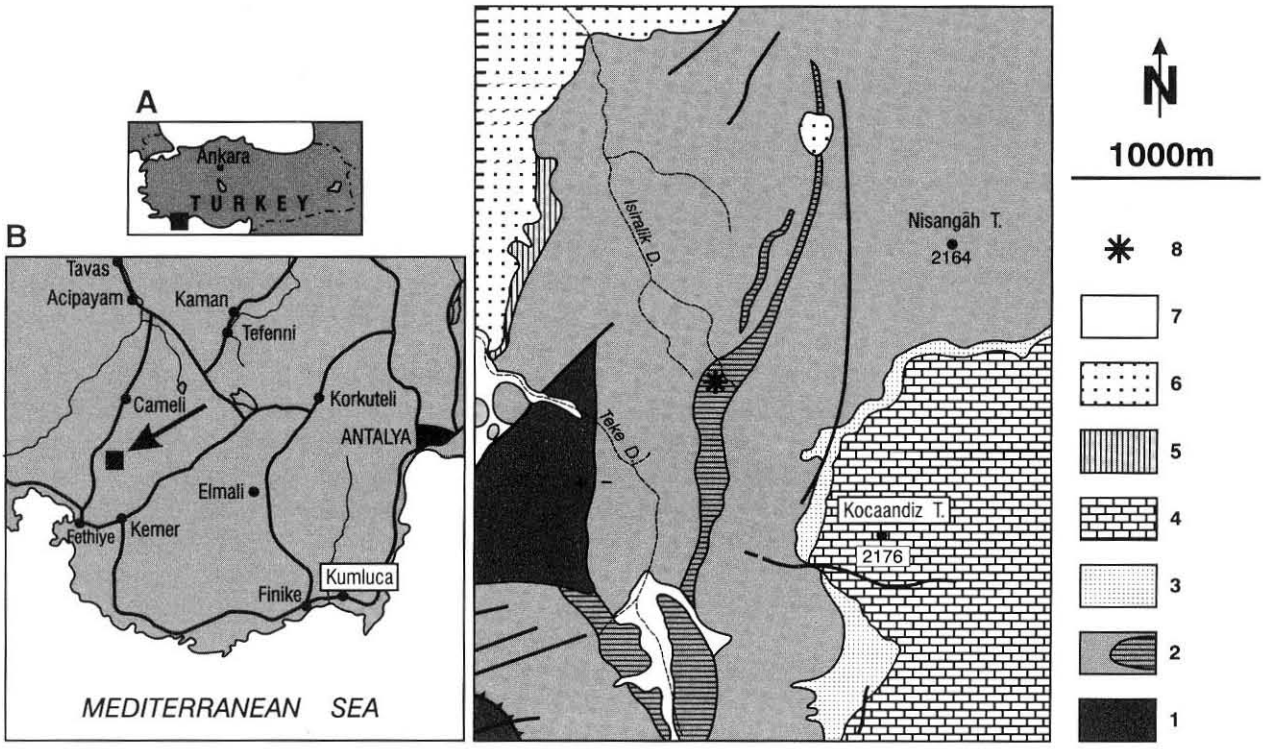

Fig. 1 Location map. Rectangles: Position of the study area within Turkey (A) and, more detailed, within southwestern Turkey (B). Detailed map of the location in the right. Legend: 1) Karadağ Unit consisting in the study area of Kiloluk, Akkavak, Saritaş, Karapinar and Belenkavak formations; 2) Tekedere Unit consisting of Çatakdere, Incirbeleni and Nişangahtepe formations; horizontally hatched area: Main occurrence of bedded cherts and some limestone olistoliths, narrow stripe in the NE are limestones; 3) Çenger Formation; 4) Agaçli Formation; 5) Serpentinite (Marmaris ophiolite nappe); 6) Pliocene Çameli Formation (lacustrine deposits); 7) Quaternary; 8) Sampling point.

Kiloluk Formation (Middle Carboniferous bioclastic limestones, dolomites, dolomitic limestones),

Akkavak Formation (Lower Permian crystalline limestones, dolomites, shales),

Saritaş Formation (?Upper Anisian to Lower Ladinian sandstones),

Karapinar Formation (Ladinian black limestone),

Belenkavak Formation (Carnian-Norian sandstones, siltstones, shales).

The Tekedere Unit is thrust over the Karadağ Unit. The thrust boundary is still preserved in the southwestern corner of the study area (Fig. 1), but often masked by later block faulting (e.g., in the western part of the investigated area, where the block with the Karadağ Unit is relatively elevated (+) against the Tekedere Unit (-), as shown in Fig. 1).

According to ŞENEL et al. (1994) and ŞENEL (1997), the Tekedere Unit consists of the following formations (from the bottom to the top):

Çatakdere Formation (crystalline limestones),

Incirbeleni Formation (shales, sandstones, limestone "lenses", lydites, volcanics), and the

Nişangahtepe Formation (dolomites, limestones).

The Çatakdere Formation contains, according to ŞENEL (1997), the following fossils (algae and foraminifers): *Mizzia velebitana* (SCHUBERT), *Globivalvulina vanderschmitti* REICHEL, *Hemigordius renzii* REICHEL, *Neoschwagerina craticulifera* SCHUBERT, *Pachyphloia* sp., *Staffella* sp., and *Neofusulina* sp.

The Nişangahtepe Formation contains the following fossils: *Mizzia velebitana* (SCHUBERT), *Colaniella* sp., *Geinitzina* sp., *Globivalvulina graeca* REICHEL, *Hemigordius renzii* REICHEL, *Neoschwagerina* sp., and *Pachyphloia* sp. (ŞENEL, 1997). Both formations were assigned to the Murgabian (= Lower-Middle Wordian). They were deposited in a shallow shelf environment.

The Incirbeleni Formation was assumed to be situated in normal stratigraphic order between these two formations (ŞENEL et al., 1994). As it has not yielded any fossils, this formation was also assigned to the Murgabian (ERAKMAN et al., 1982; ŞENEL et al., 1994; ŞENEL, 1997). ŞENEL (1997) did not exclude a Carboniferous age. This, however, would exclude a position of the Incirbeleni Formation between the Çatakdere and Nişangahtepe formations.

The placement of the Incirbeleni Formation between two stable carbonate platform successions of the same age was not logical for sedimentological-facial reasons. The Incirbeleni Formation is composed of mafic vol-

canics, partly pillow lavas, overlain by shales, bedded lydites and clastics of turbiditic character (graded shales, siltstones, sandstones, in the upper part also microconglomerates and quartzitic sandstones). Moreover, it also contains limestone olistoliths. This sequence does not fit into a contemporaneous carbonate platform sequence.

Our discovery of Lower Carboniferous conodonts in the Incirbeleni Formation definitely excludes it from the assumed sequence Çatakdere Formation - Incirbeleni Formation - Nişangahtepe Formation. There are two possible explanations for the present juxtaposition: (1) The Incirbeleni Formation on one side and the Çatakdere Formation & Nişangahtepe Formation on the other side belong to different units, tectonically juxtaposed to each other. (2) The Çatakdere Formation and the Nişangahtepe Formation are parts of the original cover beds of the deep-sea Incirbeleni Formation that was later partly tectonically sliced into these carbonate platform rocks.

The tectonic emplacement of the Incirbeleni Formation is also indicated by the fact that it is accompanied by an adjacent melange zone. This zone contains beige quartzites, lydites, reddish radiolarites and red limestones with volcanics. We have not yet investigated the age of these rocks.

After a lengthy hiatus, the Rhaetian to lower Liassic Çenger Formation transgressively overlies different older units of the Tavas Nappe. The Çenger Formation consists of a bauxite layer, reddish conglomerates, sandstones and siltstones (MONOD et al., 1983. It is followed by the Liassic Agaçli Formation (dolomites and algal limestones) and the upper Toarcian to Maastrichtian Babadag Formation (cherty limestones, at the base upper Toarcian ammonitico rosso). After an unconformity, there is an Upper Palaeocene to Lower Miocene flysch with some alkali basalts. We could not find in the field evidence that the Çenger Formation is sealing an Early Cimmerian overthrust of the Tekedere Unit on the Karadağ Unit.

The tectonically higher nappes of the Lycian nappe system (Bodrum Nappe, Dumanlidağ Nappe, Marmaris Ophiolite Nappe, Gülbahar Nappe, and Domuzdağ Nappe in ascending order) are in the study area only represented by serpentinites of the Marmaris Ophiolite Nappe (Fig. 1).

The Pliocene Çameli Formation covers different units of the Tavas Nappe and the Marmaris Ophiolite Nappe. It consists of lacustrine deposits.

4. RESULTS

Only the Incirbeleni Formation was investigated, both the cherty limestone olistoliths and the lydites. The conodont fauna of the cherty limestone olistoliths is rich in specimens but consists only of two determinable species presented by the diagnostic Pa elements and by the other elements of the apparatus. The fauna is dominated by *Gnathodus bilineatus* (ROUNDY) (Pl. 1, Figs. 1-3), whereas *Lochriea commutata* (BRANSON & MEHL) (Pl. 1, Fig. 4) is rare. MEISCHNER (1970) recognized that such a fauna occurs in the middle Viséan (V 2 and lower V 3). Below this level, *G. bilineatus* is not present. Both species range up to the lower Namurian. However, in the upper Viséan (upper V 3) and lower Namurian (Serpukhovian), they are accompanied by *Lochriea* species that displaces nodes or ribs on the cup of the Pa element, such as *L. cruciformis* (CLARKE), *L. mononodosa* (RHODES, AUSTIN & DRUCE), *L. multinodosa* (WIRTH), *L. monocostata* (PAZUKHIN & NEMIROVSKAYA), *L. nodosa* (BISCHOFF), *L. senckenbergica* NEMIROVSKAYA, PERRET & MEISCHNER, and *L. ziegleri* NEMIROVSKAYA, PERRET & MEISCHNER (e.g. MEISCHNER, 1970; HIGGINS, 1974; HIGGINS & WAGNER-GENTIS, 1982; RILEY, 1993; SKOMPSKI et al., 1995). Moreover, in this level, also different subspecies of *Gnathodus girtyi* HASS occur, such as *G. girtyi girtyi* HASS, *G. girtyi collinsoni* RHODES, AUSTIN & DRUCE, *G. girtyi intermedius* GLOBENSKY, *G girtyi rhodesi* HIGGINS, *G. girtyi simplex* DUNN, and *G. girtyi soniae* RHODES, AUSTIN & DRUCE (HIGGINS, 1975).

None of these species were found in the limestone olistoliths of the Incirbeleni Formation. The absence of *G. girtyi* may be caused by the great water depth or provincialism, because this species is also not present in the very rich upper Viséan deep-water conodont faunas of the Karaburun Peninsula, but *Lochriea* species with sculptured cup are very common in the upper Viséan of the Karaburun peninsula (KOZUR, 1997a, c, d). Therefore, a middle Viséan (V 2 and early V 3) age for the limestone olistoliths is indicated.

The lydites are very rich in radiolarians, but unfortunately, they could not be dissolved from the rocks. Conodonts are rare in the lydites and are only represented by indeterminable broken forms. An exact age determination is impossible for radiolarians that are enclosed in the rock. However, there were no recognized forms characteristic for beds younger than Early Carboniferous. Older ages can be neither excluded nor proven for a part of the lydites.

5. CONCLUSIONS

1. The sequence of the Incirbeleni Formation of the Tavas Nappe (Lycian nappes) is the southernmost discovered Hercynian oceanic to suboceanic sequence in Turkey. It consists of mafic volcanics and pillow lavas, overlain by shales and bedded radiolarites (mainly lydites), deposited below the CCD, overlain by siliciclastic turbidites, olistostromes, turbiditic sandstones, greywackes and microconglomerates.

2. The southernmost previously known occurrence of Hercynian deep-water sequences that ended in the uppermost Early Carboniferous, and were mostly overlain by Serpukhovian to Middle Carboniferous shallow-water deposits (by this a Palaeotethyan origin can be

excluded), is in the Karaburun Zone (KOZUR, 1997a, c). The Incirbeleni Formation is lithologically very similar to the Hercynian siliciclastic turbidite-olistostrome unit of the Karaburun Zone. It may originally have been a part of this zone. Derivation from areas originally to the south is not possible because there a Gondwana shallow-water shelf was present in Hercynian time. This proves a northern origin for the Lycian nappes, and requires a minimum north-south nappe transport of about 200 km. The Lower Carboniferous Hercynian deep-sea turbidites and olistostromes confirm a northern origin of the Lycian nappes and a minimum north-south nappe transport of about 200 km. However, the Tavas Nappe originated somewhat south of the Izmir-Ankara Zone because the ophiolites of the Izmir-Ankara Zone follow in nappe position immediately above the Tavas Nappe.

The lower Nohutluk Formation of the Çataloturan Nappe in the Aladağ Mountains probably represents the outer shelf-slope of the southern Hercynian ocean, at the transiton to the Lower Carboniferous Perigondwana carbonate platform.

3. The olistoliths of cherty limestones contain a conodont fauna of Viséan 2 - Lower Viséan 3. The bedded lydites have a radiolarian fauna not younger than Early Carboniferous. As most of the thicker bedded cherts (mostly lydites) are not yet dated, a pre-Carboniferous age cannot be excluded for parts of the deep-water sequence.

4. Probable overlying beds (uninvestigated) of the Tekedere Unit consist of molasse type crinoidal limestones, sandstones, volcanics, volcanic conglomerates that were probably originally overlain by platform carbonates with Middle Permian (Guadalupian) fusulinids (Çatakdere and Nişangahtepe formations).

5. If the corals of the Sazak Formation of the Karadağ Unit are correctly determined and give a late Devonian age, as so far assumed (e.g. ŞENEL, 1997), then the Tavas Nappe would consist of two basically different nappes, one for the Karadağ Unit with a typical Devonian-Carboniferous shallow-water Gondwana shelf development, and a second nappe with the Hercynian deep-water development, overlain by a molasse type and carbonate platform shallow water development of (?)Middle Carboniferous to Middle Permian age.

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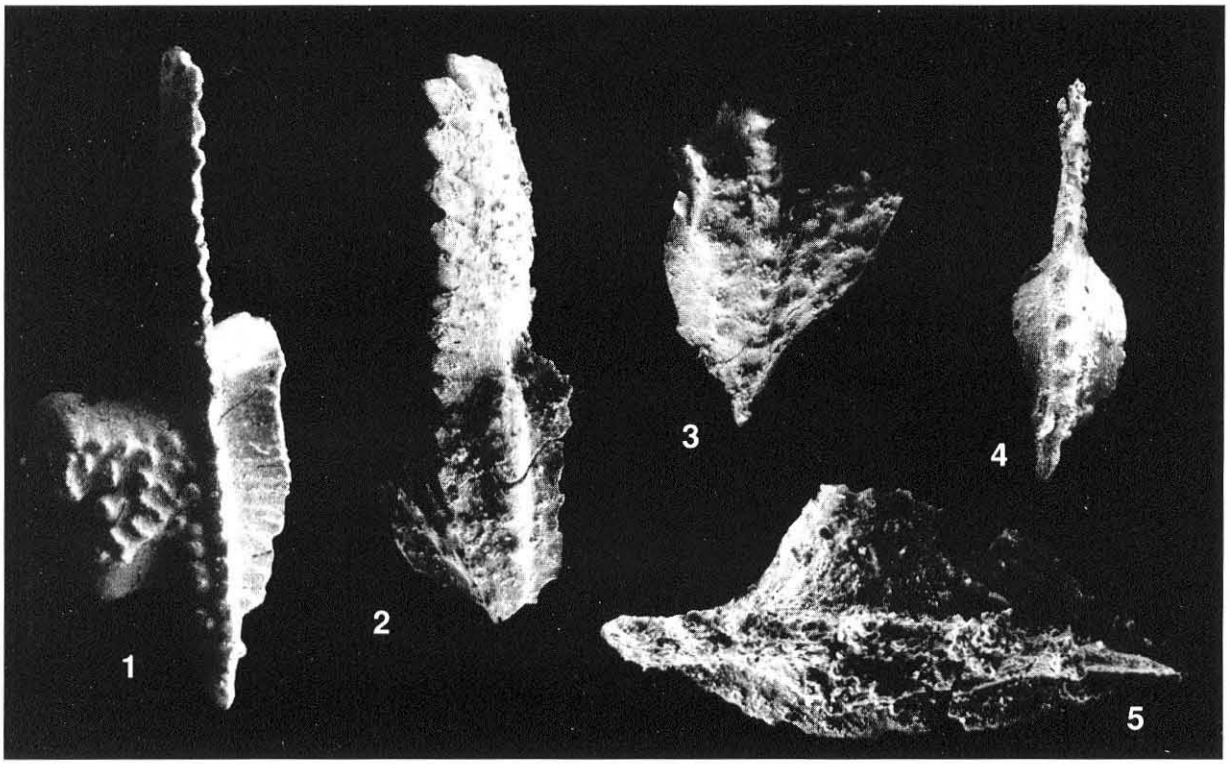

PLATE I

The figured material is housed in the Geological Institute of the Innsbruck University. All figured specimens are from sample 96/640, middle Viséan cherty limestone olistolith within the Incirbeleni Formation SW of the Nişangah Hill at Ağiliovasi Yayla, SW Turkey.

1-3 *Gnathodus bilineatus* (ROUNDY); Fig. 1: upper view, x 50, rep.-no. 23297/III-19; Fig. 2: oblique lateral-upper view, x 100, rep.-no 23297/III-24; Fig. 3: upper view of a specimen with broken free blade, x 80, rep.-no. 23297/III-20.

4 *Lochriea commutata* (BRANSON & MEHL), upper view, x 100, rep.-no. 23297/III-21.

5 *Gnathodus* sp., upper view of a juvenile specimen, x 200, rep.-no. 23297/III-22.

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