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Ladinian conodont apparatuses from northwestern Sardinia, Italy

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ABSTRACT — A conodont fauna of Middle Triassic age (Fassanian) was recorded from Punta del Lavatoio and Contrada Renuzzo sections (Nurra, northwestern Sardinia, Italy).

The faunal association consists of « Epigondolella » truempyi (*Hirsch, 1971*), Neogondolella longa *Budurov & Stefanov, 1973,* Algherella riegeli (*Mosher, 1968*) *and* Algherella uniformis (*Mosher, 1968*).

The species are described in terms of multielement taxonomy. The apparatuses of « Epigondolella » *and* Algherella *n. gen. are proposed.* « Epigondolella » *has an apparatus composed of seven types of elements.* Algherella *has an apparatus characterized by the lateral bending of the anterior part of the elements.*

According to Kovács & Kozur (1980) and Budurov (1981) the presence of « Epigondolella » truempyi *is indicative of the upper* curionii *Zone (Late Fassanian).*

RIASSUNTO — [Apparati a conodonti ladinici della Sardegna nord-occidentale, Italia] *— Una fauna a conodonti del Trias medio è stata campionata nelle sezioni di Punta del Lavatoio e Contrada Renuzzo (Nurra, Sardegna nord-occidentale, Italia).*

L'associazione a conodonti comprende «Epigondolella» truempyi (*Hirsch, 1971*), Neogondolella longa *Budurov & Stefanov, 1973,* Algherella riegeli (*Mosher, 1968*) *e* Algherella uniformis (*Mosher, 1968*).

Le specie vengono descritte secondo la tassonomia a più elementi. Sono proposti gli apparati di « Epigondolella » *e* Algherella *n. gen.*. « Epigondolella » *ha un apparato costituito da sette morfotipi.* Algherella *ha un apparato caratterizzato da un ripiegamento laterale della parte anteriore degli elementi.*

Secondo Kovács & Kozur (1980) e Budurov (1981) « Epigondolella » truempyi *indica la parte alta della Zona a* curionii *(Fassaniano superiore).*

INTRODUCTION

The Sardinian Triassic deposits were intensively investigated from a sedimentological point of view (Damiani & Gandin, 1973, 1974; Baud *et al.*, 1977; Gandin, 1977, 1979; Gandin *et al.*, 1982). Previously they were referred to the Germanic facies (Törnquist, 1902; Deninger, 1907; Oosterban, 1936), but the discovery of conodonts (Pomesano Cherchi, 1967), algae (Damiani & Gandin, 1974; Gandin, 1979), palynofloras (Pittau Demelia & Del Rio, 1980; 1983) and foraminifera is suggestive of Alpine influences in the depositional setting.

This paper deals with Triassic conodont faunas from northwestern Sardinia and increases to the biostratigraphic knowledge of Sardinian Triassic sediments.

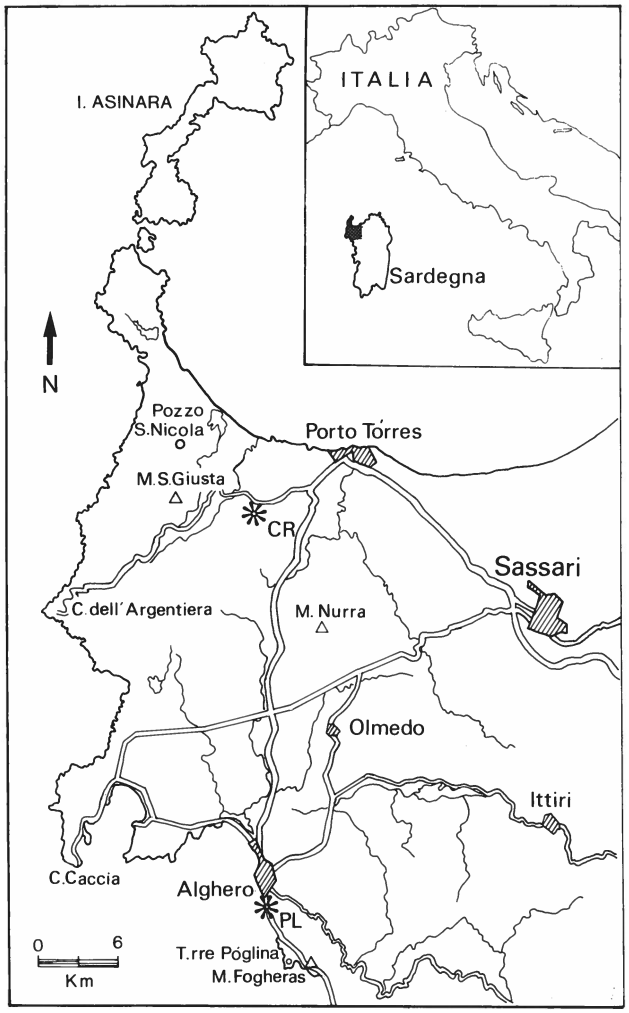
An interpretation of the conodont fauna in terms of multielement taxonomy is given.

SAMPLED SECTIONS

Two sections of Middle Triassic age cropping out in the northwestern Sardinia at Punta del Lavatoio near Alghero and at Contrada Renuzzo near Porto Torres (Text-fig. 1) have been investigated.

— PUNTA DEL LAVATOIO SECTION (Text-fig. 2).

The Triassic carbonate sequence of Punta del La-



Text-fig. 1 - Index map showing collecting localities. PL: Punta del Lavatoio section; CR: Contrada Renuzzo section.

vatoio is delimited by faults and has an estimated thickness of about 75 m. According to Gandin (1979) three members are recognizable.

The lower member consists of interbedded yellow dolomitic marls and gray dolostones. Only a few specimens of pelecypods are present.

The middle member consists of interbedded gray limestones and yellow-brown dolomitic marls. Bioturbated horizons occur.

The upper member consists of pink limestones followed by alternating pink limestones and yellow argillaceous-dolomitic marls.

In the middle and upper members, the fauna is represented by pelecypods, small gastropods, brachiopods and cephalopods. The fossils are usually concentrated in the upper part of the beds. The upper member is characterized by *Diplopora*-rich layers.

— Contrada Renuzzo Section (Text-fig. 2).

The base and the top of the section are covered, and the thickness (100 m) is therefore not representative of the whole sequence.

At the base, thick beds of highly bioturbated limestones occur. Interbedded thin-layered limestones and marls or marly limestones follow. The upper part of the sequence consists of thick beds of massive limestones.

Fossil are frequent in the middle part of the section. They are mainly dasyclad algae, molluscs and brachiopods, sometimes highly concentrated.

— Lithofacies of the samples.

In both sections, the limestones show similar microfacies. They are mainly mudstones and wackestones-packstones.

The mudstone contains few bioclasts of pelecypods and ostracodes. In the upper part of both sections foraminifera are also present. At Punta del Lavatoio they are associated with peloids and oncolitic shreds.

The wackestone-packstone has a micritic matrix with bioclasts including pelecypods, gastropods, echinoderms, brachiopods and foraminifera. At Punta del Lavatoio rare early growth stages of cephalopod occur. At Contrada Renuzzo fragmented tufts of solenoporacean algae, rare worm tubes, oncolites built up by encrusting foraminifera and/or filament algae are present.

The base of the upper member at Punta del Lavatoio is characterized by interbeds of grainstone, consisting of selectively recrystallized grains and micrite intraclasts. Rounded grains with micritic envelopes are interpreted as coated grains or ooids.

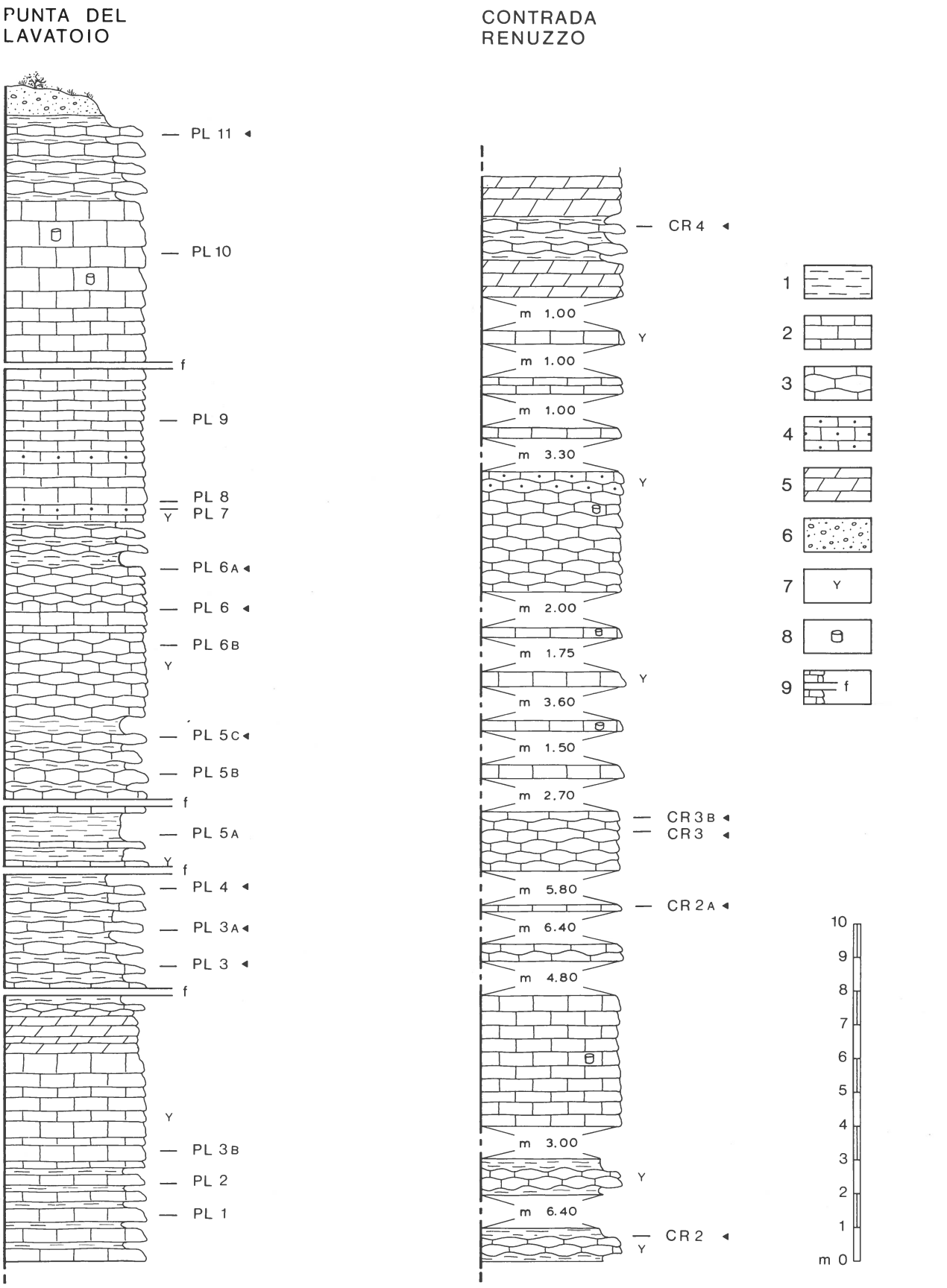
Samples for conodonts were collected only from limestones unaffected by bioturbation and lacking in algae.

Wackestones-packstones are the most productive for conodonts.

In the residues, phosphatic fish scales and teeth are common.

THE CONODONT FAUNA

The conodont fauna of Punta del Lavatoio and Contrada Renuzzo includes *« Epigondolella » truempyi* (Hirsch), *Neogondolella longa* Budurov & Stefanov, *Algherella riegeli* (Mosher) and *Algherella uniformis* (Mosher) (Tab. 1). The specimens are well preserved and show a color alteration index (C.A.I.) of 1 (Epstein *et al.*, 1977).



Text-fig. 2 - Stratigraphic sections of Punta del Lavatoio (PL) and Contrada Renuzzo (CR) showing only the intervals sampled for conodonts. The conodont productive samples are marked with triangles. 1) marl; 2) mudstone, wackestone; 3) nodular limestone; 4) grainstone, packstone; 5) dolostone; 6) Quaternary; 7) bioturbations; 8) *Diplopora*; 9) fault.

	Punta del Lavatoio							Contrada Renuzzo				
	3	3A	4	5C	6	6A	11	2	2A	3	3B	4
« Epigondolella » truempyi												
platform				12	2	4	5	15	1		1	
ozarkodiniform				6			1	3				
hindeodelliform				6			6		1	2		
cypridodelliform				4			1	7	1			
enantiognathiform				5			4	2	1			
diplododelliform				3			2	1				
prioniodiniform							2	4				
Neogondolella longa												
platform								2				
Alghere lla riegeli	3	8	2	68			4					6
Alghere lla uniformis	17	12	1	125			14		1			4

Tab. 1 - Distribution of conodonts in samples from Punta del Lavatoio (PL) and Contrada Renuzzo (CR).

The composition of the conodont fauna shows close similarities with the association recorded by Pomesano Cherchi (1967).

According to Kovács & Kozur (1980) and Budurov (1981), the species *« Epigondolella » truempyi* is indicative of the upper *curionii* Zone. The occurrence of other species is consistent with a Late Fassanian age.

All the illustrated specimens are deposited at the Istituto di Geologia e Paleontologia, University of Bologna. Unfigured specimens are deposited at the Dipartimento di Scienze della Terra, University of Pisa.

SYSTEMATIC PALEONTOLOGY

In describing the conodont fauna, multielement taxonomy is applied. The name of the form genus with the suffix iform is used for the designation of the single elements within the platform apparatuses. For *Alghe-*

EXPLANATION OF PLATE 1

« Epigondolella » truempyi (Hirsch)

platform element

Figs. 1 a-c - a) upper view; b) lower view; c) lateral view. IC 1293, SEM PT26/3333, sample PL 11.
Figs. 2 a-c - a) lateral view; b) upper view; c) lower view. IC 1294, SEM PT26/3338, sample PL 5 C.
Figs. 3 a-c - a) upper view; b) lower view; c) lateral view. IC 1295, SEM PT26/3334, sample PL 6 A.
Figs. 4 a,b - a) lateral view; b) lower view. IC 1296, SEM PT26/3336, sample PL 6.

prioniodiniform element

Fig. 5 - lateral view. IC 1297, SEM PT25/3298, sample CR 2.
Fig. 6 - lateral view. IC 1298, SEM PT25/3297, sample CR 2.

hindeodelliform element

Fig. 7 - lateral view. IC 1299, SEM PT28/3310, sample PL 5 C.

ozarkodiniform element

Fig. 8 - lateral view. IC 1300, SEM PT27/3302, sample PL 11.

cypridodelliform element

Fig. 9 - lateral view. IC 1301, SEM PT27/3300, sample PL 11.

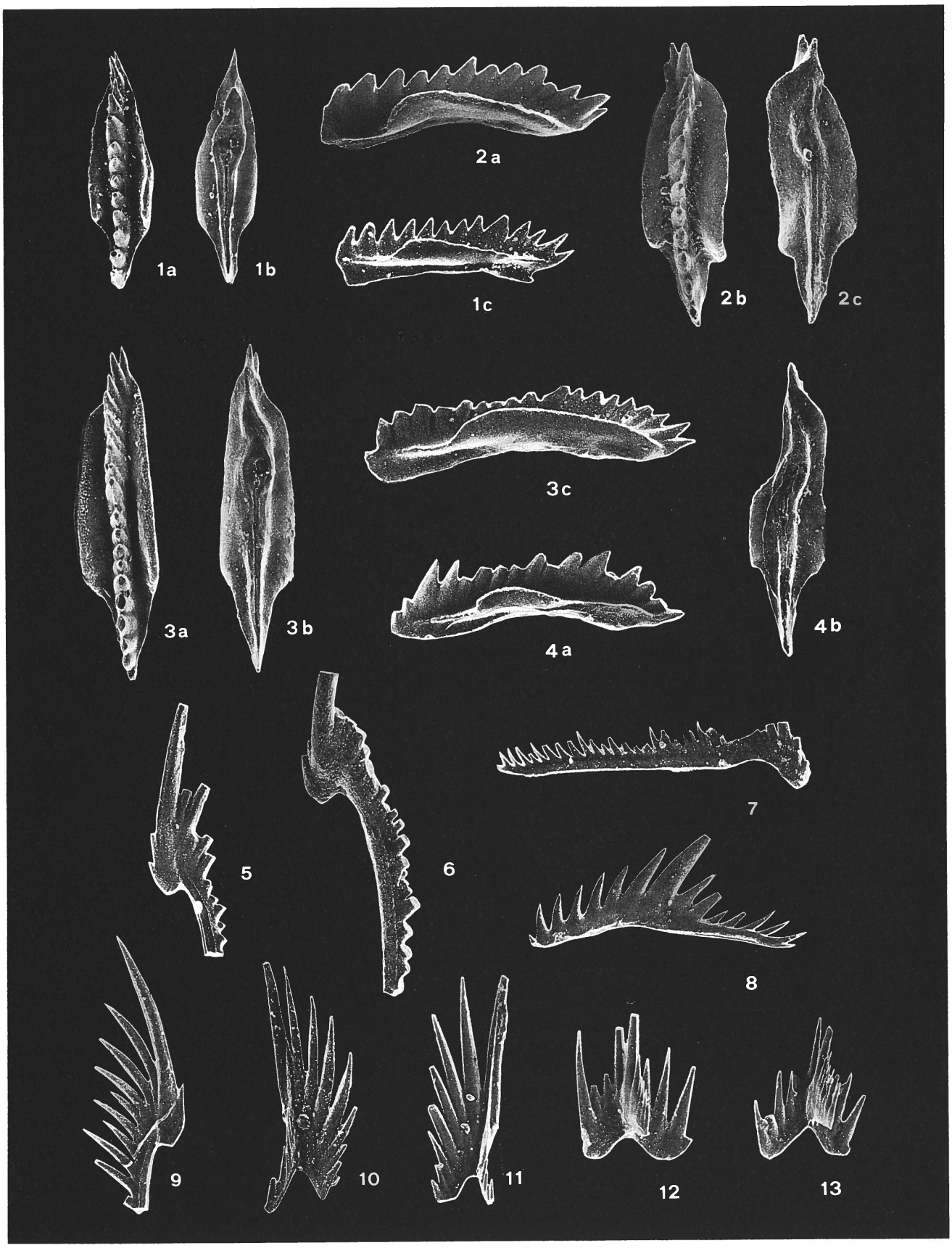
enantiognathiform element

Fig. 10 - antero-lateral view. IC 1302, SEM PT28/3312, sample PL 5 C.
Fig. 11 - antero-lateral view. IC 1303, SEM PT28/3311, sample PL 5 C.

diplododelliform element

Fig. 12 - posterior view. IC 1304, SEM PT28/3308, sample PL 5 C.
Fig. 13 - posterior view. IC 1305, SEM PT28/3307, sample PL 5 C.

All magnifications x 74.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rella n. gen., we apply a descriptive terminology because the elements display a continuous and gradual transition series.

When referring to an original single-element-based taxon we follow the recommendation of Jeppsson & Merrill (1982) by using *sensu*, the name of the author and the year.

Genus EPIGONDOLELLA Mosher, 1968

Type-species — *Polygnathus abneptis* Huckriede, 1958.

« EPIGONDOLELLA » TRUEMPYI (Hirsch, 1971)

Pl. 1, figs. 1-13; pl. 2, figs. 1-4

Platform element

1967 *Polygnathus mungoensis* Diebel - POMESANO CHERCHI, p. 229, pl. 16, figs. 5-17.
1967 *Gondolella milleri* Müller - POMESANO CHERCHI, p. 230, pl. 16, figs. 18-20; pl. 17, figs. 1-3.
1971 *Gladigondolella trümpyi* HIRSCH, pp. 66, 68, pl. 1, figs. 1-10, text-fig. 1.
1972 *Gladigondolella trümpyi trümpyi* Hirsch - HIRSCH, p 815, pl. 1, figs. 1-3.
1972 *Gladigondolella trümpyi denticulata* Hirsch - HIRSCH, p. 815, pl. 1, figs. 4-6.
1972 *Metapolygnathus truempyi* (Hirsch) - KOZUR, pl. 1, fig. 4.
1972a *Epigondolella truempyi* (Hirsch) - KOZUR & MOSTLER, pl. 1, figs. 2-3.
1980 *Metapolygnathus truempyi* (Hirsch) - KOVÁCS & KOZUR, pl. 5, fig. 5.

Ozarkodiniform element

? 1956 *Ozarkodina tortilis* TATGE, p. 138, pl. 5, figs. 10-11.

Hindeodelliform element

? 1956 *Lonchodina suevica* TATGE, p. 134, pl. 5, fig. 16.
? 1956 *Prioniodina latidentata* TATGE, p. 140, pl. 5, fig. 23.
? 1968 *Hindeodella suevica* (Tatge) - MOSHER, p. 928, pl. 114, figs. 16, 18, 21.
? 1968 *Hindeodella latidentata latidentata* (Tatge) - KOZUR, pl. 1, figs. 1-7.
? 1968 *Hindeodella latidentata suevica* (Tatge) - KOZUR, pl. 1, figs. 8, 12.
? 1970 *Hindeodella bicuspidata* KOZUR & MOSTLER, p. 441, pl. 2, figs. 14-15.
? 1974 *Hindeodella suevica* (Tatge) - BUDUROV & STEFANOV, p. 96, pl. 1, figs. 34-37.

Cypridodelliform element

? 1956 *Lonchodina mülleri* TATGE, p. 133, pl. 5, fig. 15.
? 1968 *Cypridodella muelleri* (Tatge) - MOSHER, p. 921, pl. 113, figs. 15-16.

Enantiognathiform element

? 1956 *Apatognathus ziegleri* DIEBEL, p. 433, pl. 5, figs. 1-2.
? 1968 *Enantiognathus ziegleri* (Diebel) - MOSHER, p. 925, pl. 114, figs. 2, 8.

Diplododeliiform element

? 1956 *Roundya magnidentata* TATGE, p. 143, pl. 6, figs. 12-13.
? 1968 *Diplododella magnidentata* (Tatge) - MOSHER, p. 924; pl. 113, fig. 31.

Prioniodiniform element

? 1956 *Metalonchodina mediocris* TATGE, p. 136, pl. 6, fig. 6.
? 1975 *Cypridodella mediocris* (Tatge) - GEDIK, p. 114, pl. 7, figs. 12, 13, 19, 25.

Remarks on the generic assignement — Budurov (1973) established the form genus *Carinella* based on platform elements. Following Krystyn (1983), the name *Carinella* is pre-occupied and we concur that this genus is phylogenetically distinct from *Epigondolella* (Budurov, 1973; Koike, 1982; Krystyn, 1983) and it might deserve a new generic name. Because relationships among Triassic genera are not yet clear, we prefer to use *Epigondolella* in quotation marks. We include in « *Epigondolella* », *Carinella sensu* Budurov, 1973, and elements that have been referred to the apparatus of *Enantiognathus ziegleri* (Diebel) by Kozur & Mostler (1971, p. 11) and to the multielement genus *Cypridodella* Hirschmann by Sweet (in Clark *et al.*, 1981, p. W 156).

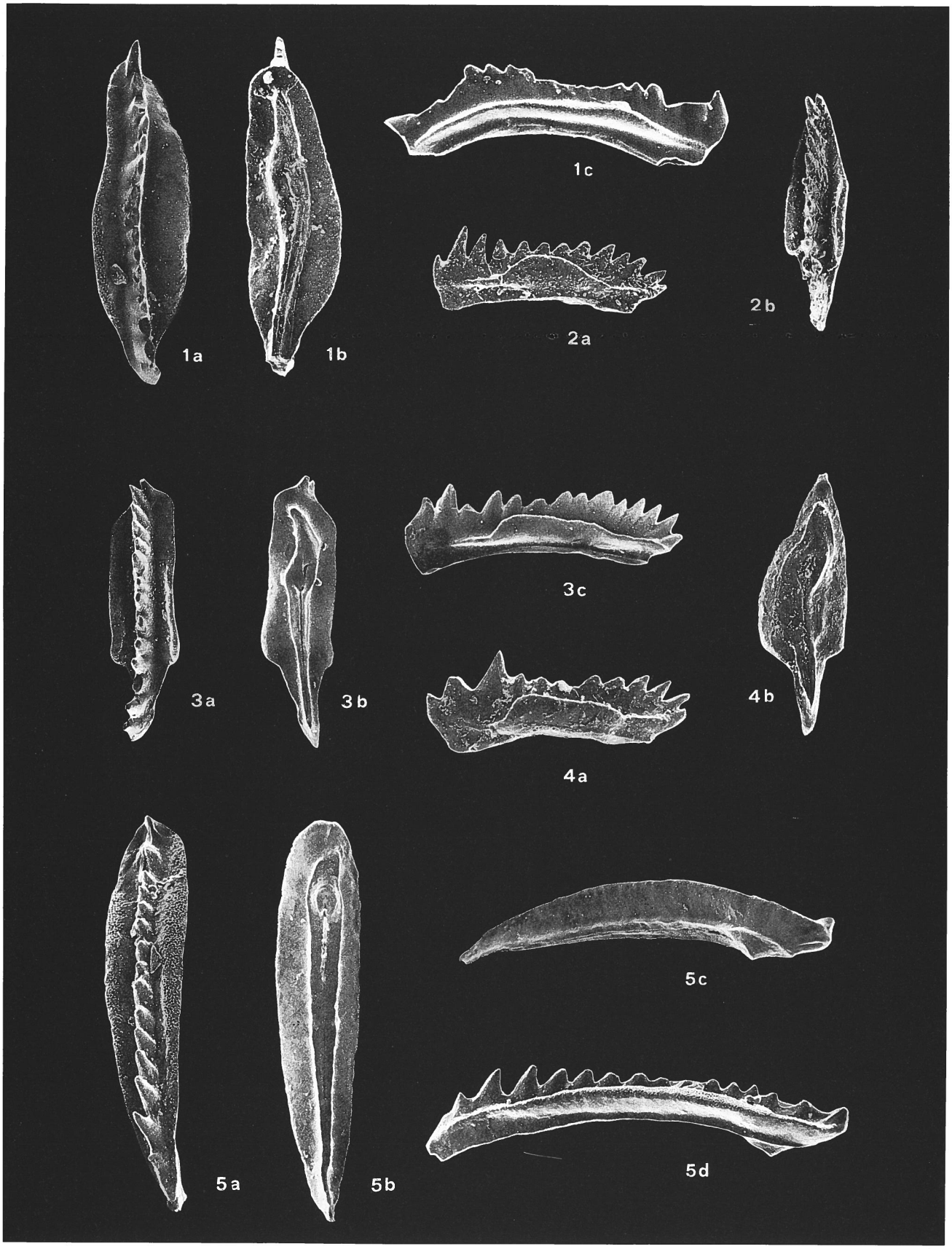
EXPLANATION OF PLATE 2

« Epigondolella » truempyi (Hirsch)
platform element

Figs. 1 a-c - a) upper view; b) lower view; c) lateral view. IC 1306, SEM PT26/3337, sample PL 5 C.
Figs. 2 a,b - a) lateral view; b) upper view. IC 1307, SEM PT26/3335, sample Pl 6 A.
Figs. 3 a-c - a) upper view; b) lower view; c) lateral view. IC 1308, SEM PT24/3114, sample CR 2.
Figs. 4 a,b - a) lateral view; b) lower view. IC 1309, SEM PT24/3115, sample CR 2.

Neogondolella longa Budurov & Stefanov
platform element

Figs. 5 a-d - a) upper view; b) lower view; c) lower-lateral view; d) lateral view. IC 1310, SEM PT24/3117, sample CR 2.
All magnification x 74.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5b
5c
5d

The apparatus of « *Epigondolella* » consists of platform, ozarkodiniform, prioniodiniform, hindeodelliform, cypridodelliform, diplododelliform and enantiognathiform elements (Text-fig. 3). Using the location terminology proposed by Sweet (in Clark *et al.*, 1981), they should correspond in order to Pa, Pb, M and S elements forming a symmetry-transition series.

Thus the apparatus shows close affinities with the natural assemblage described by Rieber (1980, p. 271).

Description — The platform has a lanceolate outline and a free blade in the anterior third of the unit. The element is weakly arched. The platform is more or less asymmetrical and shows a strong constriction in the anterior third. The edges of the platform are upturned. In some specimens the edges are almost parallel to the carina. The carina is usually straight throughout its length, but in a few specimens the last two denticles are bent laterally and/or downward (pl. 1, fig. 2). The denticles are fused at the base and increase in size at both ends of the unit. The cusp is only slightly prominent. The basal field is sigmoidal with an extended and pointed loop. The pit is located in the first third of the posterior half.

The elements of « *Epigondolella* » *truempyi* show similar features, including uniform size, analogous development and distribution of denticles. The white matter is concentrated in the denticles while the rest of the unit is light amber.

Remarks — *Gladigondolella trümpyi sensu* Hirsch, 1971 is the diagnostic element for this multielement species.

Gladigondolella trümpyi trümpyi and *G. trümpyi denticulata sensu* Hirsch, 1972, are here considered to represent the platform element of the species « *Epigondolella* » *truempyi*. In fact in our collections the same sample yielded both forms and transitional forms as well.

The ozarkodiniform and ramiform elements are close to the form species included in our synonymy list. However, we use question marks because the material at hand is not rich enough to evaluate the differences with the elements described in the literature. Additional sections are under study to better define these elements. Moreover, most of the form species included with a question mark in our synonymy list have been found together with different kinds of platform elements.

The apparatus suggested by Hirsch (1981) for the genus *Carinella* shows some similarities with the apparatus of « *Epigondolella* » *truempyi* as it is reco-

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EXPLANATION OF PLATE 3

Algherella riegeli (Mosher)

gentil bent elements

Fig. 1 - lateral view. IC 1311, SEM PT30/3325.
Fig. 2 - lateral view. IC 1312, SEM PT30/3331.

intermediate elements

Fig. 3 - lateral view. IC 1313, SEM PT29/3315.
Fig. 4 - lateral view. IC 1324, SEM PT29/3316.

strongly bent elements

Figs. 5 a,b - a) outer-lateral view; b) inner-lateral view. IC 1315, SEM PT29/3313.
Figs. 6 a,b - a) outer-lateral view; b) inner-lateral view. IC 1316, SEM PT29/3314.

Algherella uniformis (Mosher)

straight elements

Fig. 7 - lateral view. IC 1317, SEM PT29/3322.
Fig. 8 - lateral view. IC 1318, SEM PT29/3323.
Fig. 9 - lateral view. IC 1319, SEM PT29/3324.

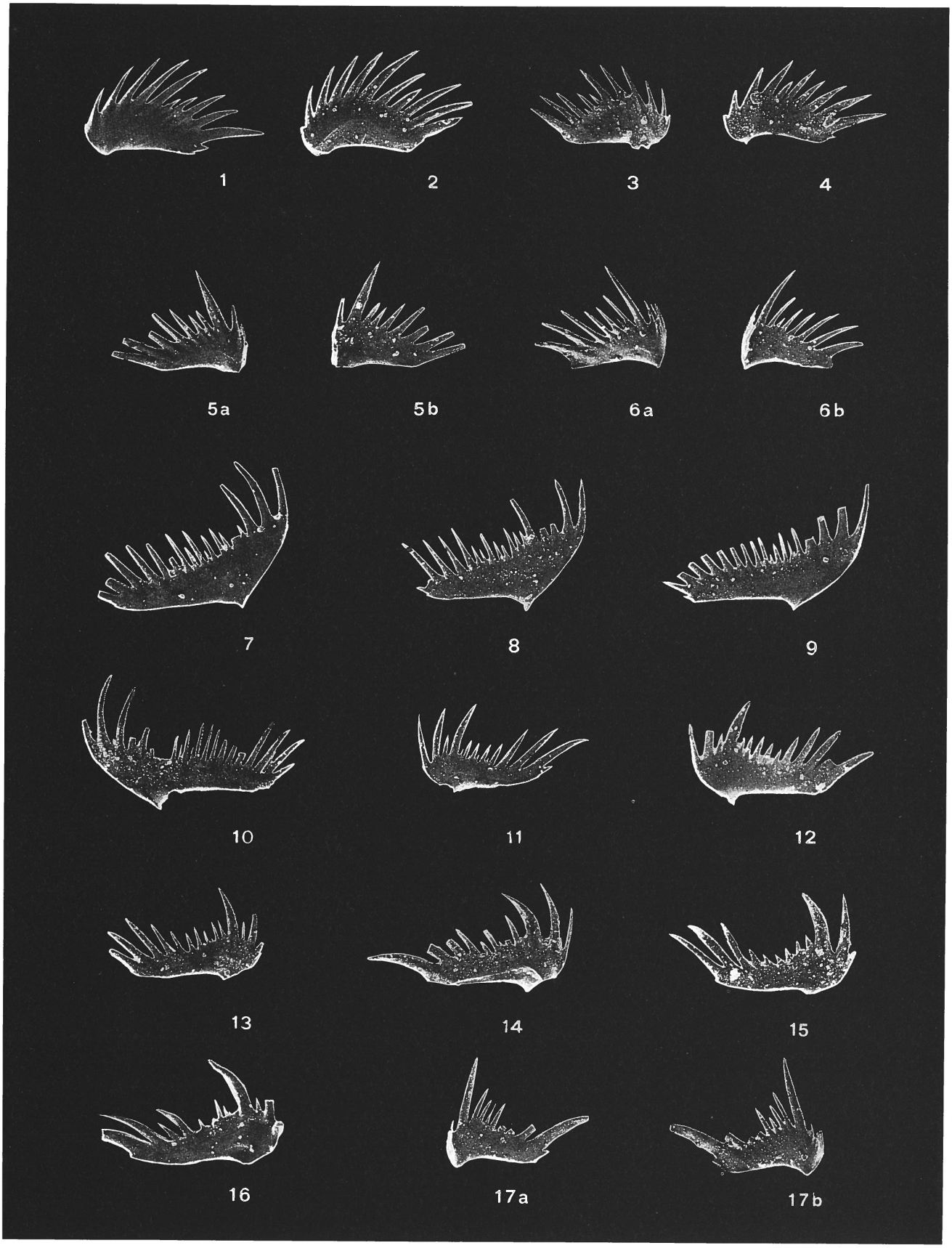
intermediate elements

Fig. 10 - lateral view. IC 1320, SEM PT30/3332.
Fig. 11 - lateral view. IC 1321, SEM PT29/3321.
Fig. 12 - lateral view. IC 1322, SEM PT30/3326.
Fig. 13 - lateral view. IC 1323, SEM PT29/3319.
Fig. 14 - lateral view. IC 1324, SEM PT29/3317.
Fig. 15 - lateral view. IC 1325, SEM PT29/3318.

bent elements

Fig. 16 - lateral view. IC 1326, SEM PT30/3328.
Figs. 17 a,b - a) inner-lateral view; b) outer-lateral view. IC 1327, SEM PT29/3320.

All specimens from sample PL 11.
All magnifications x 74.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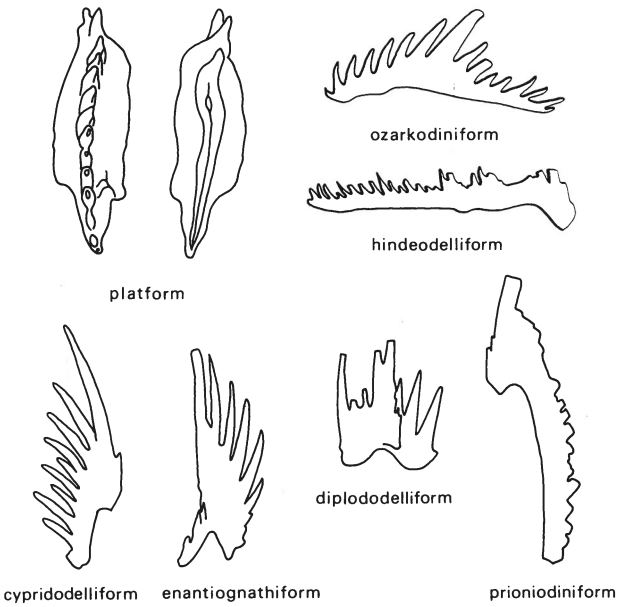

Text-fig. 3 - Outline drawings of the elements of « *Epigondolella* » *truempyi*.

gnized herein. Unfortunately he applied two different notation schemes together, which hinders a direct comparison.

Another Triassic apparatus with a similar composition has been described by Mietto (1982).

Repository — Figured specimens IC 1293 - IC 1309.

Genus NEOGONDOLELLA Bender & Stoppel, 1965

Type-species — *Gondolella mombergensis* Tatge, 1956.

NEOGONDOLELLA LONGA Budurov & Stefanov, 1973
Pl. 2, figs. 5 a-d

Platform element

1973 *Neogondolella longa* BUDUROV & STEFANOV, p. 805, pl. 1, figs. 16-22.
1980 *Gondolella pseudolonga* KOVÁCS, KOZUR & MIETTO, p. 218, pl. 1, figs. 1-4.

Remarks — The features of the specimens under study correspond to the original diagnosis. Only two specimens are present in a single sample (CR 2). Therefore, because « *E.* » *truempyi* is much more abundant and because the same ozarkodiniform and ramiform elements are present also in samples in which *N. longa* is absent, we have referred these elements to « *E.* » *truempyi*.

Discussion — According to Kovács, Kozur & Mietto (1980, p. 219) *G. pseudolonga* has been distinguished from *N. longa* only by the different type of carina. However the original carina descriptions of both species seem to be coincident. On the other hand, in our opinion, the minor differences alone in the carina are not enough to distinguish these two species.

Repository — Figured specimen IC 1310.

Genus ALGHERELLA n. gen.

Type-species — *Hindeodella riegeli* Mosher 1968.

Derivatio nominis — From Alghero, a town of Sardinia.

Diagnosis — The species of *Alghere*lla have apparatuses consisting of thin, laterally compressed denticulated elements having a high base, sharp antero-basal corner and neither basal groove nor basal cavity. The apparatuses of *Alghere*lla are characterized by a transition series with an antero-lateral curvature, i.e. the anterior part of the elements varies from straight or very gently laterally bent to bent laterally. The bending is associated with the development of an anterior process and of a cusp, and with the reduction of the height of the base.

The white matter is particularly concentrated in the attachment area of the denticles; the basal part of the unit is translucent.

ALGHERELLA RIEGELI (Mosher, 1968)
Pl. 3, figs. 1-6

1968 *Hindeodella riegeli* MOSHER, p. 928, pl. 114, fig. 15.
1968 *Hindeodella* (*Neohindeodella*) *triassica triassica* Müller - KOZUR, pl. 2, fig. 15.
1972b *Neohindeodella triassica kobayashii* (Igo & Koike) - KOZUR & MOSTLER, p. 24, pl. 2, figs. 14, 16, ?19; pl. 8, figs. 27, 28, 35.
1972b *Neohindeodella triassica riegeli* (Mosher) - KOZUR & MOSTLER, p. 24, pl. 2, figs. 15, 17, 18; pl. 4, fig. 16; pl. 8, figs. 29, 31-34, 36.
1975 *Hindeodella riegeli* Mosher - BUDUROV & STEFANOV, p. 1, fig. 1.
1975 *Neohindeodella riegeli* (Mosher) - TRAMMER, pl. 21, figs. 1, 3, 4.
1975 *Neohindeodella triassica riegeli* (Mosher) - ZAWIDZKA, pl. 39, fig. 11.
1982 *Neohindeodella* ? aff. *riegeli* (Mosher) - KOIKE, p. 35, pl. 8, fig. 19.

Description — The elements with the very gently bent anterior part are *Hindeodella riegeli sensu* Mosher, 1968.

The specimens referred to *Neohindeodella triassica kobayashii* (Igo & Koike) by Kozur & Mostler (1972) are the intermediate elements.

The elements with a strong bending of the anterior process have a prominent cusp at the point of curvature of the unit. The anterior process carries 3 to 6 denticles and it forms an angle up to 45 degrees with the posterior process.

Repository — Figured specimens IC 1311 - IC 1316.

ALGHERELLA UNIFORMIS (Mosher, 1968)

Pl. 3, figs. 7-17

? 1958 *Hindeodella triassica* Müller - HUCKRIEDE, p. 149, pl. 10, fig. 50.
1968 *Hindeodella uniforma* MOSHER, p. 929, pl. 114, fig. 14.
1968 *Hindeodella* (*Neohindeodella*) *triassica hirschmanni* KOZUR, pl. 2, fig. 13.
1968 *Hindeodella* (*Neohindeodella*) *triassica triassica* Müller KOZUR, pl. 2, figs. 5, 10, 11.
1968 *Hindeodella* (*Neohindeodella*) *triassica triassica ?* Müller - KOZUR, pl. 2, figs. 14, 19.
1972b *Neohindeodella triassica aequidentata* KOZUR & MOSTLER, p. 24, pl. 8, figs. 22, 24-26.
1972b *Neohindeodella triassica triassica* (Müller) - KOZUR & MOSTLER, pl. 7, figs. 12, 13; pl. 8, fig. 30.
1972b *Neohindeodella* cf. *triassica triassica* (Müller) - KOZUR & MOSTLER, p. 24, pl. 13, fig. 10.

Description — The straight elements have been described as *Hindeodella uniforma* by Mosher (1968). The intermediate elements are *Neohindeodella triassica aequidentata sensu* Kozur & Mostler, 1972b. In the bent elements the cusp is prominent but smaller than the last one or two denticles at the posterior end. In our material all the transitional forms among the above mentioned form species are present.

Remarks — *Alghерella uniformis* is characterized by a difference in size of the denticles, i.e. they are higher at the anterior and posterior ends than in the middle part of the unit. In contrast, *Alghерella riegeli* has shorter elements and the denticles have more or less the same height.

Repository — Figured specimens IC 1317 - IC 1327.

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