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NEW DATA ON MIDDLE DEVONIAN CONODONTS FROM SW-SARDINIA: THE SU NUARGI II SECTION REVISITED

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Key words: Conodonts, Middle Devonian, SW- Sardinia, biostratigraphy, Su Nuargi II, Corti Baccas II.

Abstract. The conodont collection from the nodular limestone beds of the Su Nuargi II outcrop near Domusnovas in SW-Sardinia (Italy) is restudied for the purpose of reassessing the outcrop and updating the conodont collection to the most recent taxonomy. Su Nuargi II is the most important outcrop in the SW of the island exposing Middle Devonian rocks. Forty-five conodont taxa have been identified in the collection, positioning the outcrop within the interval covering the *timorensis* to *latifossatus* zones (Lower to Middle Givetian) slightly widening the interpretation of Olivieri (1985). A new morphotype of *Polygnathus linguiformis linguiformis* is described. The genera *Tortodus* and *Schmidtognathus* are identified for the first time in the Middle Devonian of Sardinia. Additionally, a second Middle Devonian outcrop is discovered in the SW of the Island.

Riassunto. La collezione di conodonti ottenuta dai calcari nodulari nell'affioramento di Su Nuargi II presso Domusnovas (Sardegna sud-occidentale, Italia) è stata ristudiata allo scopo di rivalutare l'affioramento e aggiornare la collezione di conodonti alla tassonomia più recente. Su Nuargi II è l'affioramento più importante nel sud-ovest dell'isola con rocce del Devoniano Medio. Sono stati identificati quarantacinque taxa di conodonti, posizionando l'affioramento nell'intervallo che copre le zone da *timorensis* a *latifossatus* (Givetiano Inferiore e Medio) allargando leggermente l'interpretazione di Olivieri (1985). Un morfotipo nuovo di *Polygnathus linguiformis linguiformis* è descritto. I generi *Tortodus* e *Schmidtognathus* sono stati identificati per la prima volta nel Devoniano Medio della Sardegna. Inoltre, una seconda località di Devoniano Medio è stata scoperta nel sud-ovest dell'isola.

Introduction and geological setting

During the Devonian, the Corso-Sardinian tectonic block, bearing the island of Sardinia, was located close to what is now Southern France, up till the Oligocene-Eocene when it detached and drifted southeastward to its current position, as indicated by paleomagnetic data (Carmignani et al. 1992, 1994). The Paleozoic basement of Sardinia is a small part of the south-verging South European Variscan Chain, evidenced by stratigraphic and structural affinities with other Variscan massifs of southern Europe (Massif Central, Montagne Noire...) (Barca 1998). The Early Carboniferous collision between the Armorica microplate and Gondwana caused deformation of the older Paleozoic basement and affected the structure with various degrees of metamorphism, increasing from south to north (Conti et al. 2001).

Based on these degrees of metamorphism it is possible to distinguish an External Zone in the southwestern part of the island and a Nappe zone consisting of several stacked Nappes (External and Internal Nappes), verging to the SW, interposed between the Metamorphic High Grade Complex (Northern Sardinia) and the External Zone (Fig. 1). Metamorphism was weakest in the External Zone and External Nappes, allowing the preservation of the paleontological content of the rocks. The studied outcrops (stars on Fig. 1) are located in the Sulcis-Igliesente tectonic unit (External Nappe) and are only weakly affected by metamorphism related to Variscan Orogeny magmatism; though the deposits are rather discontinuous and strongly disturbed tectonically, since they are situated close to the Arburese overthrust.

The first Devonian conodonts from this tectonic unit were described by Serpagli et al. (1978) in a paper on the Gedinnian (Lochkovian in current terminology) of the area of Fluminimaggiore and further studied by Olivieri et al. (1981), Gnoli et al. (1982), Mastandrea

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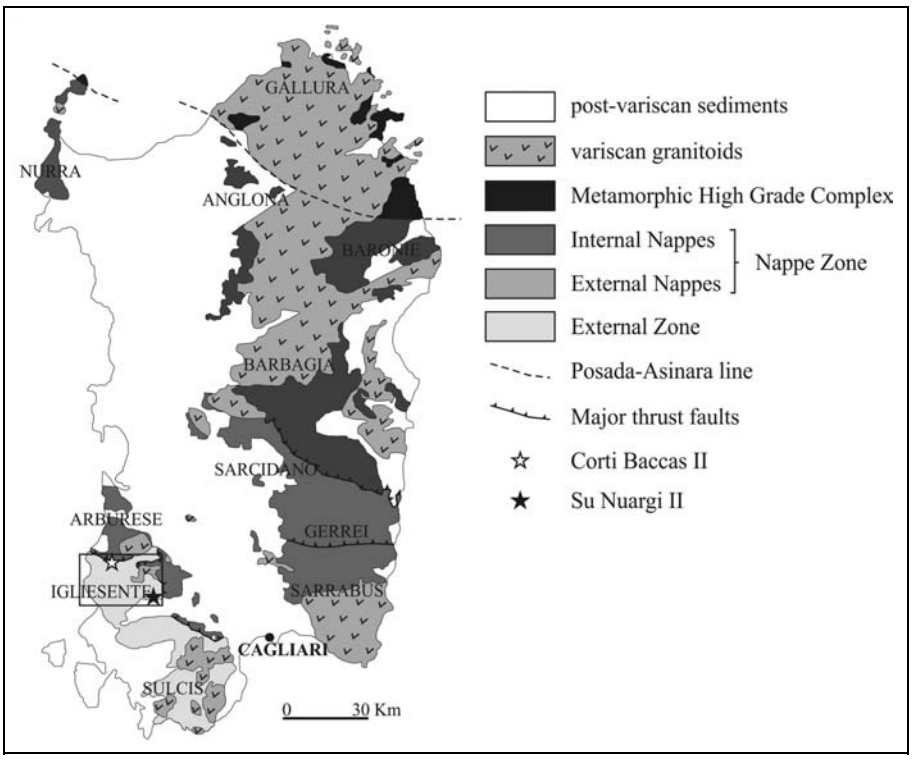


Fig. 1 - Paleozoic basement of Sardinia (modified after Carmignani et al. 1992). Large box indicates the position of Fig. 3.

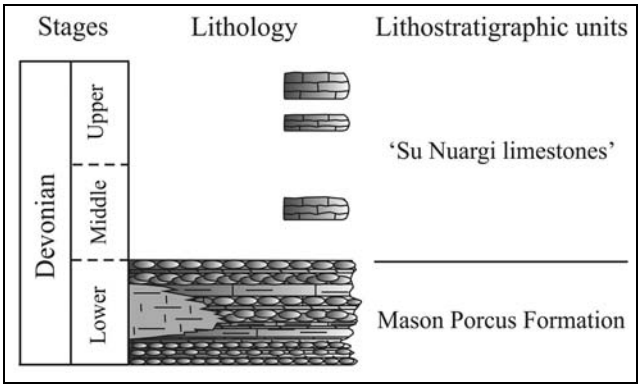


Fig. 2 - Schematic stratigraphic column of the Devonian sequence in SW-Sardinia (modified after Ferretti et al. 1998).

(1985a, b) and Olivieri & Serpagli (1990). The Lower Devonian of SW Sardinia is represented by the Mason Porcus Formation consisting of tentaculite- rich nodular limestones, often thin bedded, and massive limestones alternating with compact dark siltstone and shales (Fig. 2). In the uppermost part of the formation, a conodont assemblage typical for the uppermost Emsian was found in two samples of the Corti Baccas II outcrop, based on the identification of *Polygnathus serotinus*, *Icriodus beckmanni sinuatus* and *Pseudooneotodus beckmanni* (Gnoli et al.1990). The upper boundary of this formation was not found, as it is covered by the overlying Arburese thrust fault. In contrast to Lower Devonian deposits, Middle and Upper Devonian outcrops are rare in the SW of Sardinia. So far, Middle Devonian deposits with conodonts were only found in the Cixerri valley (Olivieri 1985) close to an Upper Devonian outcrop. Leone (1973) mentioned the finding of the Upper Devonian *Palmatolepis* genus at Gutturru Eus, in the Igliesiente area.

The purpose of this research is the reassessment of the famous Su Nuargi II section, based on the conodont collections preserved at the Università di Modena & Reggio Emila (Italy), by updating the conodont biostratigraphy to the current taxonomy. A small second Middle Devonian outcrop in the SW of Sardinia is mentioned for the first time.

Su Nuargi II

Middle Devonian rocks sporadically crop out in the Cixerri valley, a tectonised area not far from the overthrust of the Arburese Unit (Fig. 1). At Su Nuargi, a locality northeast of Domusnovas (Fig. 3), a few blocks of condensed grey to dark grey nodular to massive limestone are found in a field (Fig. 4). They were sampled and studied for conodonts by Olivieri (1985, sequence II) and revealed to be Middle Devonian in age (except for one Frasnian sample), and placed in the Middle and Upper *varcus* zones. So far these were the only Middle Devonian deposits discovered in the western part of the island. The outcrop basically consists of one large block (Fig. 4) and two smaller blocks. In the field it is not clear how these smaller blocks are related to one-another and to the large block, since no deposits closely surrounding the blocks are exposed. The blocks are therefore considered as separate units within the outcrop.

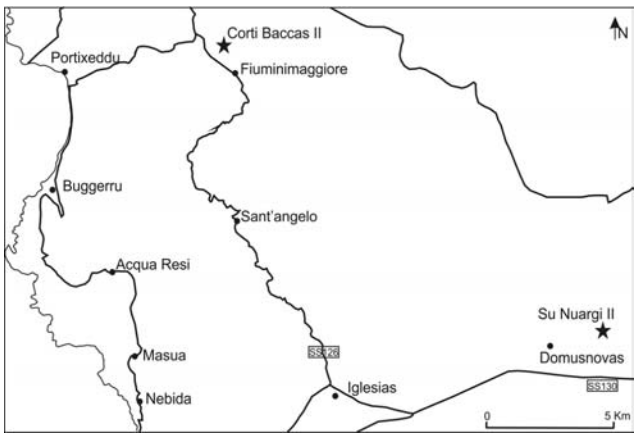


Fig. 3 - Location of the Su Nuargi II and Corti Baccas II outcrops.

These limestones have not formally been named yet due to their scattered occurrence and limited thickness, as well as their unknown relationship to other stratigraphic units. They are unofficially referred to as the Su Nuargi limestones. On the regional geological map (Carmignani 2005), the blocks are still indicated as part of the Mason Porcus Formation (Lower Devonian), surrounded by the Ordovician Rio San Marco Formation and Eocene Cixerri Formation.

Biostratigraphy

Of the ten samples studied, seven are located in the large block and three in the smaller blocks (SN2r, SN2s and SN2t). The conodont fauna from these samples is abundant and moderately well preserved despite their high colour alteration index (CAI 4.5-5). In addition to conodonts, the limestone blocks also contain a fauna of dacryoconarids (tentaculitids), ostracods and rare brachiopod, trilobite and gastropod fragments.

An irregular crack or disconformity running though the larger block separates sample SN2 from the rest of the samples on the block (SN2n- SN2B).

The sample below the apparent disconformity (SN2) contains a conodont assemblage typical for the Upper Frasnian: *Ancyrodella lobata, Icriodus alternatus alternatus, Polygnathus cf. P. webbi* and *Palmatolepis winchelli* (Fig. 4, Tab.1). The combination of *Pa. winchelli* and *Ad. lobata* in the sample restricts it to the lower part of the MN12 Zone (Klapper 1997), corresponding to the upper part of the Lower *rhenana* Zone (Klapper & Becker 1999). In the same sample, two specimens of *Polygnathus linguiformis klapperi* were found, a typical Middle Devonian conodont that ranges from the *eiflius* Zone (alternative zonation of Bultynck 1987) to the top of the *latifossatus* Zone (Aboussalam 2003). This could indicate a reworking of Givetian material during the Late Frasnian or more likely a misplacing of two specimens missing in sample SN2s of the collection (compared to the results of Olivieri 1985).

The conodont taxa identified in the part of the block above the disconformity (samples SN2n-SN2A) indicate a Givetian age. Samples SN2n- 2B contain an assemblage of taxa typical of the Lower and Middle Givetian. In SN2n *P.* cf. *P. rhenanus* is combined with *P. l. linguiformis* and *I. brevis* placing the sample in a position not below the *timorensis* Zone (identification according to Olivieri (1985); the *I. brevis* specimen is currently missing from the collection). The presence of *P. rhenanus* and *P. varcus* in samples SN2o to SN2q is indicative for the *rhenanus/varcus* and *ansatus* zones (Bultynck 1987). Sample SN2o adds *P. l. weddigei* to the fauna diversity of the section and SN2p further contains specimens of *P. ensensis* and *P. pseudofoliatus* ß mt

Fig. 4 - Su Nuargi outcrop with indication of the samples; SN = Su Nuargi Formation. (Photo courtesy of E. Serpagli, Università di Modena e Reggio Emilia).

Su Nuargi II section											
Sample nrs.	SN2	SN2n	SN2o	SN2p	SN2q	SN2A	SN2B	SN2r	SN2s	SN2t	CBII5
Ancyrodella lobata	1										
Ancyrolepis cixerriensis						12					
Belodella devonica						56		1	3		
B. resima					3	19					
B. triangularis					2	26					
Icriodus alternatus alternatus	6										
I. aff. *I. brevis*							6+3jv	2+ 9jv			
I. brevis		1	1						1cf	4,12jv, 1 cf	
I. cf. *I. difficilis*									3	2	
I. lindensis					1						
I. cf. *I. obliquimarginatus*							2			2(1cf)	3+16jv
I. regularicrescens transitional to *I. obliquimarginatus*											1
I. sp A.							1				
I. sp.				4			16		10	3	5
Ozarkodina brevis						9					
O. plana						2					
O. aff. *O. semialternans*						4					
Palmatolepis winchelli	17										
Polygnathus alatus						7					
P. aff. *P. angusticostatus*							3jv				1
P. denisbriceae						2					
P. ensensis				1		34 (1aff)	6+8jv	30(1aff)	4aff	5	9
P. hemiansatus										1	
P. linguiformis klapperi	2?					130				2	3(2aff)
P. l. linguiformis		3jv	2		13	168				11	11
P. l. l. γ4						15			3	3	
P. aff. *P. l. mucronatus*							2jv		1		
P. l. weddigei			6	3	7	27	1+7jv		2	11	9
P. pseudoeiflius						1	1	3	1		
P. pseudofoliatus α mt						1					
P. pseudofoliatus β mt				1	2						
P. rhenanus		1cf	2	2	1						
P. timorensis					1jv	1				5	1
P. varcus			9	15	11	38					
P. webbi	4										
P. xylus						51				3	1
P. sp. A							1				
P. sp. B							1				
P. sp. C						1					
P. sp.	2	6		2	2	4	1	12	9	7	
Schmithognathus latifossatus								2+5jv	3 jv	1 jv	
Schm. aff. *Schm. pietzneri*									1		
Schm. sp. A							1+ 2jv		1	1	
Schm? sp. B										1	
Tortodus bultyncki									1		
T. aff. *T. caelatus*						1					
T. sp. A						1					
T? sp. A								1			
ramiforms	6	7	5	15	25	152	25	26	11	23	
total amount of conodonts	38	18	25	43	68	761	87	92	54	98	60

Tab. 1 - Conodont specimens per sample in the Su Nuargi II and Corti Baccas II outcrop.

(Walliser & Bultynck 2011). Sample SN2q further yields *I. lindensis* and two *Belodella* taxa.

Sample SN2A shows the highest diversity of genera and taxa in the section: 5 genera, 22 taxa. The appearance of *P. alatus* indicates the base of the *ansatus* Zone below this sample (Narkiewicz & Bultynck 2007). The combination with *P. ensensis* restricts the position of the sample to the *ansatus* Zone. The presence of *Ozarkodina* aff. *O. semialternans* might suggest the sample is situated in the upper part of the Zone (Aboussalam 2003). This sample is the stratum typicum for *Ancyrolepis cixerriensis,* described by Olivieri (1985). The taxon is so far only recognized in this section in SW Sardinia and the Poccis section in the Carnic Alps (Spalletta & Perri 1998) where it was found several meters below the first appearance of *O. semialternans*. Based on these two localities, *Ar. cixerriensis* is limited to and might be indicative for the *ansatus* Zone.

Sample SN2B, situated in the uppermost part of the large block (Fig. 4), is not as rich as SN2A and contains *P.* aff. *P. angusticostatus, P. pseudoeiflius, I.* aff. *I. brevis, I.* cf. *I. obliquimarginatus, P.* aff. *P. l. mucronatus, P. l. weddigei, P. ensensis* and a variety of specimens that cannot be linked to known species (*Icriodus* sp. A, *Polygnathus* sp. A-B, *Schmidtognathus* sp. A). The earliest known occurrence of the genus *Schmidtognathus* is in the *latifossatus* Zone. Since *P. ensensis* has never been found higher in the stratigraphy than in the *ansatus* Zone, and *P. pseudoeiflius,* a recently described species of which the total range is not yet known (Walliser & Bultynck 2011), has so far not been found higher than the *timorensis* Zone (Walliser & Bultynck 2011), the co-occurrence of these species and *Schm.* sp. A would indicate reworking. This sample is situated in the *latifossatus* Zone.

Samples SN2r and SN2s were taken in the second block (Fig. 4-5). The presence of *Schm. latifossatus* in sample SN2r indicates its position in the *latifossatus* Zone. Its combination with *P. ensensis* and *P. pseudoeiflius* suggests reworking. Sample SN2s includes *P. ensensis*, *Schm.* aff. *Schm. pietzneri*, *Schm.* sp. A and juvenile specimens of *Schm. latifossatus* and is also a reworked sample in the same biozone.

The third and smallest block (SN2t) also contains a fauna that suggests reworking in the *latifossatus* Zone based on the joint occurrence of *Schm. latifossatus* and *P. ensensis*. This is also the sample containing so far, the only finding of *P. hemiansatus* in Sardinia.

The two specimens identified as *P. linguiformis mucronatus* by Olivieri (1985, pl. 2, fig. 16) in sample SN2t are unfortunately missing in the collection. However, one of those *P. linguiformis mucronatus* specimens was refigured in upper view by Corradini (1998) and allowed a restudy based on the picture. It is here considered as a representative of *P.* aff. *P. l. klapperi*.

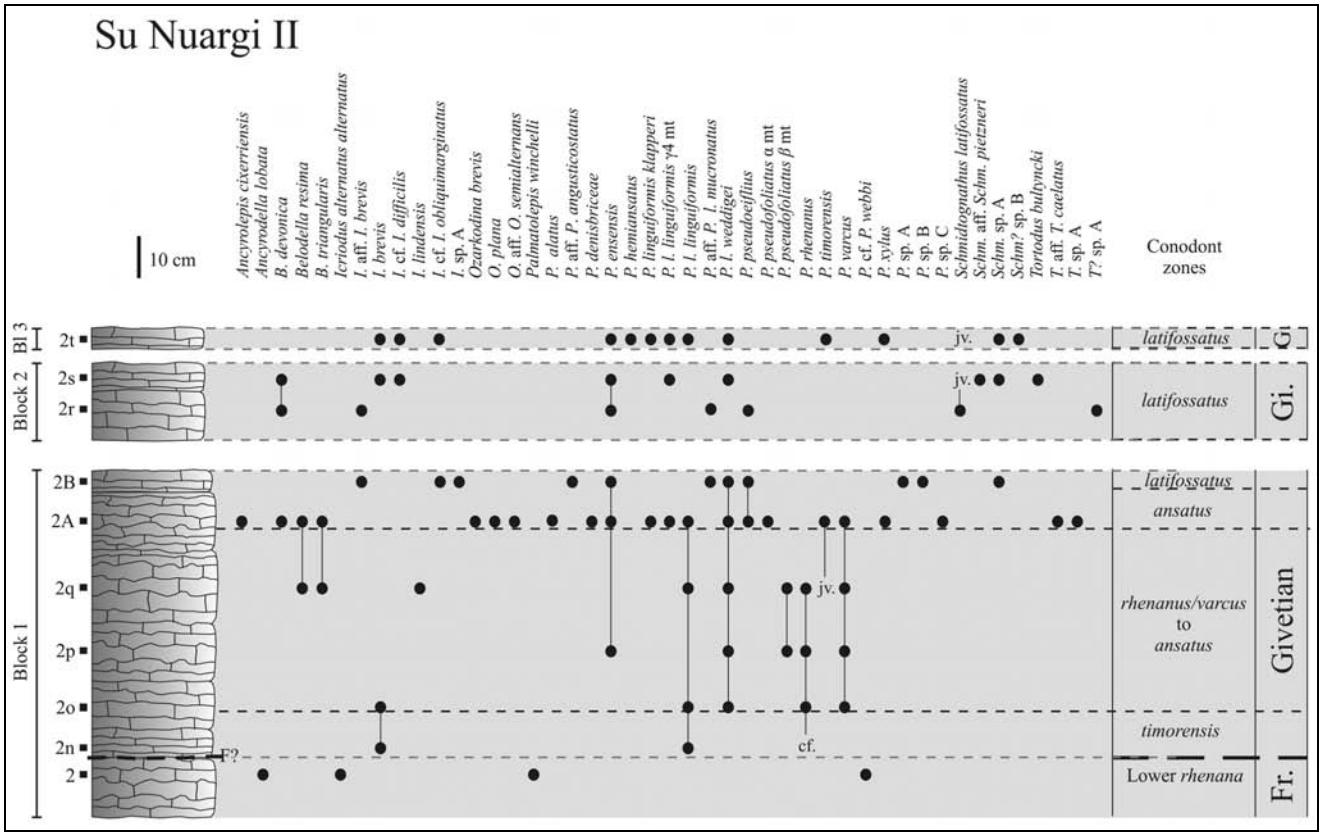


Fig. 5 - Stratigraphic column of the Su Nuargi II section, with indication of the conodont taxa per sample.

Corti Baccas II

The locality NW of the town of Fluminimaggiore was sampled and studied by A. Mastandrea for a small thesis on Lower Devonian conodonts (the section and results were mentioned in Gnoli et al. (1990). The section is entirely Lower Devonian, reaching up into the Emsian *serotinus* Zone. In the Corti Baccas II conodont collection, one sample does not fit into the Lower Devonian sequence and was indicated as a loose sample (CBII5). The conodont fauna indicates it is Middle Devonian.

The sample contains an assemblage of *Polygnathus* aff. *P. angusticostatus* (1), *I. regularicrescens* transitional to *I. obliquimarginatus* (1), *P. linguiformis linguiformis* (11), *P. ensensis* (9), *P. xylus* (1), *P. timorensis* (1), *I.* cf. *I. obliquimarginatus (19)* sensu Aboussalam 2003 (Pl. 23, figs 9-10), *P. linguiformis weddigei* (9), *P. l. klapperi* (1+ 2aff.) and *I.* sp. (5) constraining the biostratigraphic position of the sample to the interval covering the *timorensis- ansatus* zones. The sample is time-equivalent of the Givetian part of the Su Nuargi II outcrop and constitutes hereby a second outcrop of Givetian deposits in SW Sardinia.

Systematic paleontology

The studied specimens are all part of the collections of the Dipartimento di Scienze della Terra (Università di Modena e Reggio Emilia, Italy).

Genus *Icriodus* Branson & Mehl, 1938

Icriodus cf. **I. brevis** Stauffer, 1940

Pl. 1, figs 8a-b, 9a-b

Material: 2 specimens in samples SN2s (1) and SN2t (1).

Remarks. The specimens differ from *I. brevis* by the middle row denticles that are slightly higher than the lateral row denticles. The figure 9 specimen is broken and only shows the posterior part of the specimen with the typical fan-shaped extension. The *I.* aff. *I. brevis* specimens (pl.1, figs. 5a-b and 7a-b) show only part of the *I. brevis* characteristics: in lateral view, the posterior extension of the figure 5 specimen does not show a nice fan-shaped outline with a convex upper margin but instead has an upper margin declining in posterior direction. The figure 7 specimen does show the fan-shaped posterior extension but has a cusp that is not inclined.

Icriodus cf. **I. difficilis** Ziegler & Klapper, 1976 sensu Olivieri, 1985, Pl. 1, fig. 9

Pl. 1, figs 2a-b, 3a-b

1985 *Icriodus* cf. *difficilis* Ziegler & Klapper – Olivieri, pl. 1, fig. 9.

Material: 5 specimens in samples SN2s (3) and SN2t (2).

Description. The figured specimens show the characteristic distinct anteriorly oriented spur with accompanying distinct sinus in the posterior inner margin. The posterior extension of the middle row is formed by 2-3 fused denticles. The lateral row denticles are connected to the denticles of the middle row by thin transverse ridges.

Remarks. The specimens differ from the typical *I. difficilis* by the wider longitudinal spacing of the lateral denticles and the very wide and asymmetric basal cavity.

Icriodus cf. **I. obliquimarginatus** Bischoff & Ziegler, 1957 sensu Aboussalam 2003, Pl. 23, figs 9-10

Pl. 1, figs 6a-b, 11a-b

2003 *Icriodus* cf. *obliquimarginatus* Bischoff & Ziegler – Aboussalam, p. 168, pl. 23, figs. 9-10.

PLATE 1

Fig. 1 - *Icriodus regularicrescens* transitional form to *Icriodus obliquimarginatus*, IPUM n. 28240, upper view, CBII 5, x58.

Figs. 2a-b, 3a-b - *Icriodus* cf. *I. difficilis*, IPUM n. 28241, upper and inner lateral view, SN2s, x53; IPUM n. 28242, inner lateral and upper view, SN2t, x55.

Figs. 4 a-b - *Icriodus* sp. A., IPUM n. 28243, upper and inner lateral view, SN2B, x50.

Figs. 5 a-b, 7a-b - *Icriodus* aff *I. brevis*, IPUM n. 28244, upper and oblique inner lateral view, SN2B, x64; IPUM n. 28246, upper and lateral view, SN2r, x67.

Figs. 6a-b - *Icriodus* cf. *I. obliquimarginatus*, IPUM n. 28245, upper and lateral view, SN2B, x62.

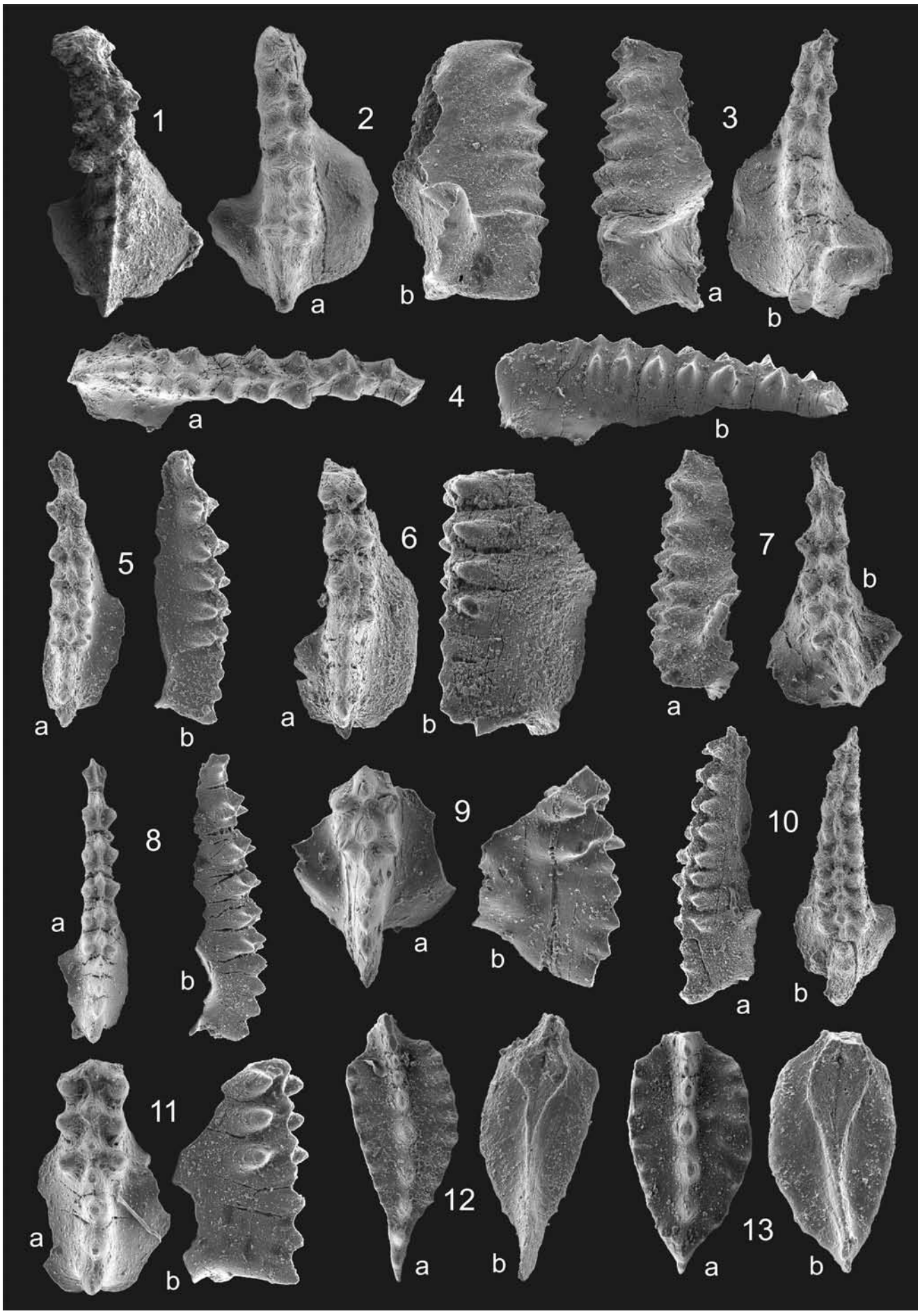
Figs. 8a-b, 9a-b - *Icriodus* cf. *I. brevis*, IPUM n. 28247, inner lateral and upper view, SN2t, x74; IPUM n. 28248, inner lateral and upper view, SN2s, x92.

Figs. 10a-b - *Icriodus lindensis*, IPUM n. 28249, oblique inner lateral and upper view, SN2q, x49.

Figs. 11a-b - *Icriodus* cf. *I. obliquimarginatus*, IPUM n. 28250, upper and inner lateral view, SN2t, x77.

Figs. 12a-b - *Schmidtognathus* sp. A (juvenile specimen), SN2B, IPUM n. 28251, x77.

Figs. 13a-b - *Polygnathus* aff. *P. angusticostatus* (juvenile specimen), SN2B, IPUM n. 28252, x86.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Material: 23 specimens in samples SN2B (2), SN2t (2) and CBII5 (3+16jv).

Remarks. The specimens can be distinguished from *I. obliquimarginatus* sensu Bischoff & Ziegler, 1957, by the posterior denticles of the spindle that are higher than the lateral denticles. This characteristic is also seen in a specimen assigned to the transition between *I. regularicrescens* and *I. obliquimarginatus* by Walliser & Bultynck (2011; pl. 4, figs 20a-b), but in the Su Nuargi specimens, the spindle is not biconvex. Similar specimens were described by Aboussalam (2003) from the upper part of the *ansatus* Zone in the Montagne Noire (France). The Corti Baccas II specimen assigned to the transition between *I. regularicrescens* and *I. obliquimarginatus* (Pl. 1, fig. 1) shows this characteristic and is slightly biconvex.

Icriodus sp. A

Pl. 1, figs 4a-b

Material: 1 specimen in sample SN2B.

Description. The specimen has an elongated, slender spindle that is slightly wider in its anterior half. The lateral denticle rows contain 7 denticles (tip of the spindle is missing) that are set slightly posterior to the corresponding middle row denticles and are connected with them by thin ridges. The middle row denticles of the spindle are connected by thin ridges and extra denticles are seen in the anterior half. The middle row denticles of the posterior part of the spindle are markedly higher than the corresponding lateral row denticles. The posterior middle row extension shows four almost completely fused denticles, declining in height posteriorly. The cusp is the lowest denticle and is slightly inclined. The inner and outer margins of the basal cavity are missing.

Remarks. The specimen can be distinguished from *I. brevis* by the higher middle row denticles on the spindle and the absence of a fan-shaped posterior extension and differs from *I. obliquimarginatus* by the decreasing height of the denticles on the posterior extension.

Genus *Ozarkodina* Branson & Mehl, 1933

Ozarkodina aff **O. semialternans** (Wirth, 1967)

Pl. 3, fig. 14

Material: 4 small specimens in sample SN2A.

Remarks. The specimen shows the typical alternation of narrow and broad denticles in the anterior half of the element as seen in smaller specimens, according to the revised diagnosis of Ziegler et al. (1976). The anterior lower margin is straight, arches up under the cavity but remains straight posteriorly in contrast to typical specimens of *O. semialternans* that have the lower margin declining posteriorly.

Genus *Palmatolepis* Ulrich & Bassler, 1926

Palmatolepis winchelli (Stauffer, 1938)

Pl. 3, fig. 17

1938 *Bryantodus winchelli* n. sp. – Stauffer, p. 423, pl. 48, fig. 33.
1993 *Palmatolepis winchelli* (Stauffer) – Klapper & Foster, p. 24, 26, 31, figs. 13.1, 13.2, 18.1-18.8, 18.10, 18.11, 19.6-19.12, 20.12-20.24.

Material: 17 specimens from sample SN2.

Description. Specimen with a roughly triangular shape. The broad lobe is laterally directed and is flanked by a rather deep sinus anteriorly and a shallow sinus posteriorly. The nodular platform ornamentation is more concentrated near the platform margins. The carina is slightly sigmoidal.

Remarks. The specimen is easily distinguished from *Pa. bogartensis* by its roughly triangular platform outline instead of a semi-circular outline typical for the latter.

Genus *Polygnathus* Hinde, 1879

Polygnathus alatus Huddle, 1934

Pl. 2, fig. 19, 20

1934 *Polygnathus alata* n. sp. – Huddle, p. 100, pl. 8, figs. 19-20.

Material: 7 specimens from sample SN2A.

Remarks. The figured specimen shows the class IIIb symmetry (Lane 1968), the smooth anterior platform half typical of the species and a platform ornamentation of weak ribs, adcarinal grooves that are deep along the whole length of the carina and a carina that finishes before the end of the platform.

P. aff. **P. angusticostatus** Wittekindt, 1966

Pl. 1, figs 13a-b; Pl. 2, fig. 4

Material: 1 specimen in sample CBII5 and 3 juvenile specimens in sample SN2B.

Remarks. The Pl. 2, fig. 4 specimen has a narrower and more asymmetric platform compared to typical *P. angusticostatus* specimens. The posterior extension of the carina is somewhat higher than the carina in

lateral view. The juvenile specimens from sample SN2B (Pl. 1, figs 13a-b) show a nearly straight platform that is slightly bent downward posteriorly. They differ from *P. angusticostatus* by having shallow adcarinal grooves and a rather flat platform.

Polygnathus denisbriceae Bultynck, 1979

Pl 2, fig. 14

1979 *Polygnathus denisbriceae* n. sp. – Bultynck in Brice et al., p. 334- 335, pl. XXVII, figs. 1-8.

Material: 2 specimens in sample SN2A.

Remarks. The specimen assigned to this taxon demonstrates the diagnostic features mentioned in Brice et al. (1979): the free blade slightly shorter than the platform, the sinuous contour of the outer posterior platform margin; the different position at which the anterior platform margins join the free blade and the overall slender and narrow shape of the platform. The platform ornamentation of the specimen consists mainly of small nodes accompanied by some weak ridges on the anterior half of the platform. *P. pseudofoliatus* has a wider platform with more developed ornamentation and a convex outer distal platform margin.

Polygnathus hemiansatus Bultynck, 1987

Pl. 2, fig. 10

1987 *Polygnathus hemiansatus* n. sp. – Bultynck, p. 161-162, pl. 7, figs. 16-27; pl. 8, figs. 1-7.

2011 *Polygnathus hemiansatus* Bultynck – Walliser & Bultynck, p. 12-13, pl.1, figs. 11-17.

Material: 1 specimen in sample SN2t; so far this is the only specimen of *P. hemiansatus* found in Sardinia.

Remarks. The figured specimen demonstrates a constriction in the outer platform margin rising to a point and a short spoon-shaped outward bowing of the outer anterior platform margin and is assigned to the β morphotype of Walliser & Bultynck (2011).

Polygnathus aff. **P. linguiformis klapperi** Clausen, Leuteritz & Ziegler, 1979

Pl. 3, figs 8-9.

Material: 2 specimens from sample CBII5.

Remarks. The specimens show the characteristic curved transition from the outer platform to the tongue and downward bent tongue with distinct ridges but they differ from typical specimens of *P. linguiformis klapperi* by their short tongue. They are distinguished from *P. l. linguiformis* and *P. l. pinguis* by the absence of a high flange in the posterior part of the platform and the absence of a convex bent in the inner platform margin respectively.

Polygnathus linguiformis linguiformis Hinde, 1879

γ4 morphotype

Pl. 3, figs 3-5

2011 *Polygnathus parawebbi* Chatterton – Walliser & Bultynck, pl. 3, fig. 16.

Material: 21 specimens in samples SN2A (15), SN2s (3), SN2t (3).

Description. In this morphotype of *P. linguiformis linguiformis*, the tongue is extremely short, about one-eighth of the length of the platform and is covered with only one or two transversal ridges. The outer platform margin is high, flange-like and its rim is strongly curved in an angle of 90° in the posterior part reaching the short tongue. The margin of the narrow inner platform is nearly straight. The adcarinal troughs are deep anteriorly and become shallow posteriorly. The outer platform is ornamented with coarse ribs, the inner platform with nodes or short ribs.

Remarks. This morphotype differs from the other morphotypes by its extremely short tongue. *Polygnathus parawebbi* can be distinguished from this morphotype by the carina interrupting the ribs on the posterior part of the platform and reaching its posterior tip.

Range. All specimens were found in the *rhenanus/varcus* to *latifossatus* zones interval.

Polygnathus aff. **P. linguiformis mucronatus** Wittekindt, 1966

Pl. 2, fig. 2

Material: 3 specimen in samples SN2B (2) and SN2s (1).

Remarks. The specimen shows a short, wide platform that abruptly ends posteriorly, with short broad ridges at the platform margins. The carina is slightly curved and continues posterior of the platform. On the lower side a large basal pit is situated at the anteriormost end of the platform. The specimen differs from *P. l. mucronatus* by its shallow and wide adcarinal troughs and absence of high platform flanks.

Polygnathus pseudoeiflius Walliser & Bultynck, 2011

Pl. 2, figs 5-8

2011 *Polygnathus pseudoeiflius* n. sp. – Walliser & Bultynck, p. 11, pl. 1, figs. 3-5.

Material: 6 specimens in samples SN2A (1), SN2B (1), SN2r (3) and SN2s (1).

Remarks. The specimens show a rostrum that takes about 1/3 of the total length of the platform. The outer platform margin is strongly curved and expanded posterior of the rostrum. The margins of the rostrum are slightly diagonal typical for this species. The specimens differ from *P. eiflius* by the absence of distinct diagonal ridges on the main part of the platform, as continuation of the rostral margins. The specimen figured on Pl. 2, fig. 7 is broken but nevertheless shows a long and narrow rostrum with parallel margins representing near to one half of the platform. The specimen is juvenile (x77), and shows an expansion of the outer platform that is too wide for a juvenile representative of *P. amphora*. It is considered a juvenile specimen of *P. pseudoeiflius*.

Polygnathus timorensis Klapper, Philip & Jackson, 1970

Pl. 2, figs 11-13

1970 *Polygnathus timorensis* sp. nov. – Klapper, Philip & Jackson, p. 655- 656, pl. 1, figs. 1-3, 7- 10.

1987 *Polygnathus timorensis* Klapper, Philip & Jackson – Bultynck, p. 162, pl. 7, figs. 9-10.

Material: 7 specimens in samples SN2A (1), SN2t (5) and CBII5 (1).

Remarks. Two of the figured specimens (figs 11-12) demonstrate the distinct outward bowing of the outer anterior trough margin, which takes up less than 1/3 of the total length of the outer platform margin. The geniculation points are not opposite. The inner anterior platform margin is serrated. The specimen figured on Pl. 2, fig. 13 has a somewhat longer outer anterior trough margin compared to the total length of the outer platform and is considered a juvenile specimen. The specimens can be distinguished from *P. hemiansatus* by the deeper adcarinal troughs especially in the posterior part of the platform. They differ from *P. rhenanus* by the longer and arrow-like shape of the platform.

Polygnathus cf. **P. webbi** Stauffer, 1938

Pl. 3, figs 15a-b, 16a-b

Material: 2 specimens in sample SN2.

Description. The specimen figured on Pl. 3, fig. 15 has an elongated and narrow platform with a pointed posterior end that is arched downwards. The anterior right inner platform margin is somewhat higher than the anterior left outer platform margin (class IIIb symmetry, Lane 1968) and both margins are slightly compressed in the anterior half. The inner platform margin is nearly straight, the other platform margin convex and widening in the posterior half. The carina is curved in its posterior part and extends somewhat beyond the posterior end of the platform. The adcarinal troughs are deep in the anterior half of the platform and shallower in the posterior half. Broad ridges are developed on the platform margins. The specimen figured on Pl. 3, fig. 16 shows similar characteristics but is wider. These specimens are considered to be left and right-curved juvenile specimens.

Remarks. The specimen can be distinguished from *P. dubius* on the basis of the symmetry and the presence of widening of the posterior outer platform.

Polygnathus sp. **A**

Pl. 2, figs 16a-b

Material: 1 specimen from samples SN2B.

Description. A species of *Polygnathus* with a long moderately slender lanceolate platform covered with

PLATE 2

Fig. 1a-b, 3a-b - *Schmidtognathus latifossatus*, IPUM n. 28253, lower and upper view of a juvenile specimen, SN2r, x78; IPUM n. 28255, upper and lower view, SN2r, x88.

Fig. 2 - *Polygnathus* aff. *P. l. mucronatus*, IPUM n. 28254, upper view, SN2B, x78.

Fig. 4 - *Polygnathus* aff. *P. angusticostatus*, IPUM n. 28256, upper view, CBII5, x50.

Figs. 5, 6 - *Polygnathus pseudoeiflius*, IPUM n. 28257, upper view, SN2r, x75; IPUM n. 28258, upper view, SN2B, x37.

Fig. 7, 8 - *Polygnathus pseudoeiflius* (juvenile specimen), IPUM n. 28259, upper view, SN2s, x77; IPUM n. 28260, oblique inner lateral view, SN2r, x86.

Fig. 9 - *Polygnathus xylus*, IPUM n. 28261, upper view, CBII5, x85.

Fig. 10 - *Polygnathus hemiansatus*, IPUM n. 28262, upper view, SN2t, x68.

Figs. 11, 12 - *Polygnathus timorensis*, IPUM n. 28263, upper view, SN2A, x68; IPUM n. 28264, upper view, CBII5, x74.

Fig. 13 - *Polygnathus timorensis* (juvenile specimen), IPUM n. 28265, upper view, SN2q, x75.

Fig. 14 - *Polygnathus denisbriceae*, IPUM n. 28266, upper view, SN2A, x42.

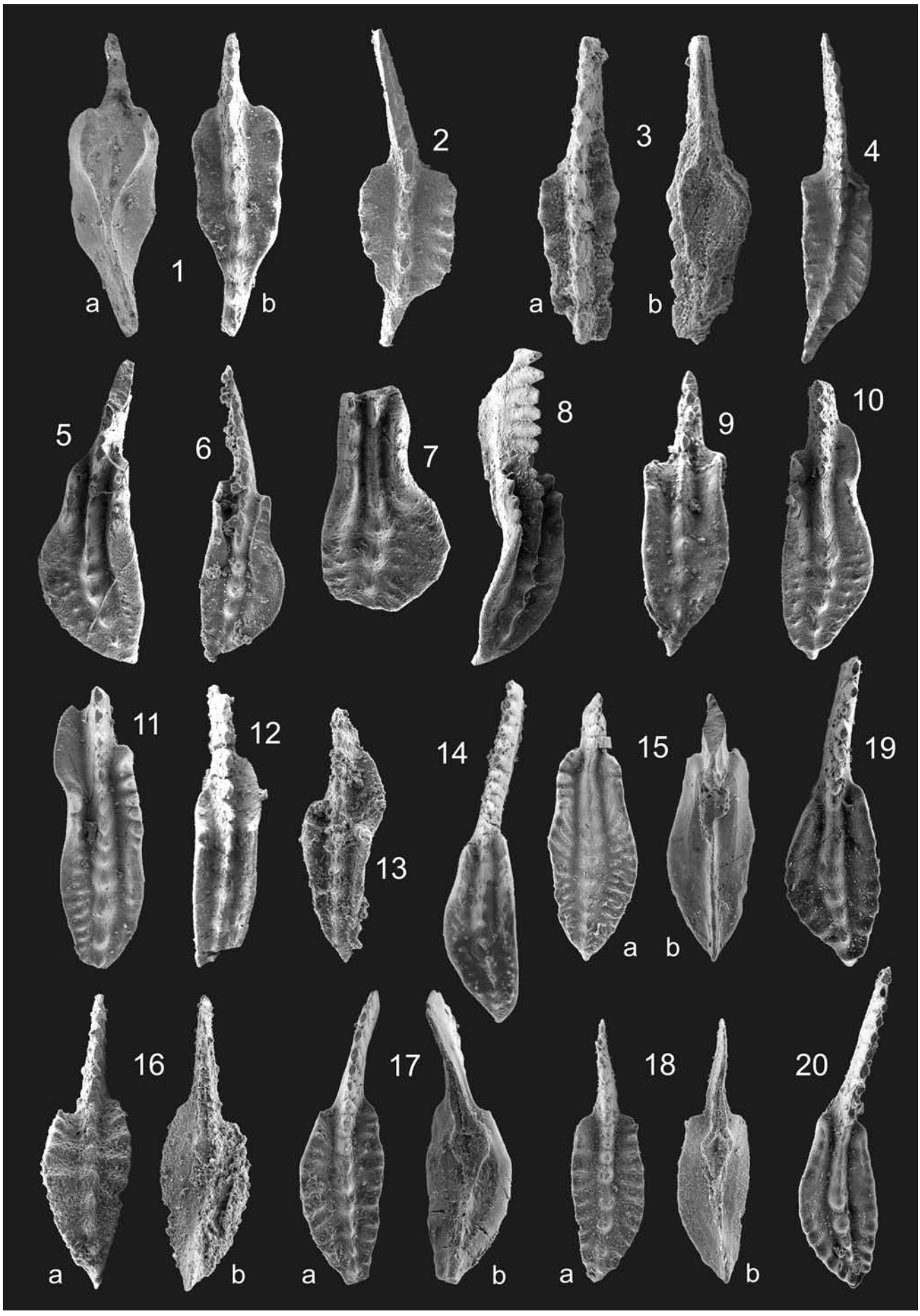
Figs. 15a-b - *Polygnathus* sp. C, IPUM n. 28267, upper view, SN2A, x 56.

Figs. 16a-b - *Polygnathus* sp. A, IPUM n. 28268, upper and lower view, SN2B x61.

Figs. 17a-b - *Schmidtognathus* aff. *Schm. pietzneri*, IPUM n. 28269, upper and lower view, SN2s, x56.

Figs. 18a-b - *Polygnathus* sp. B, IPUM n. 28270, upper and lower view, SN2B, x55.

Fig. 19, 20 - *Polygnathus alatus*, IPUM n. 28271, upper view, SN2A, x64; IPUM n. 28272, upper view, SN2A, x58.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wide transverse ridges separated from the carina by adcarinal troughs. The platform is widest at 1/3 from its anterior end and is slightly asymmetric; the outer platform half is somewhat wider than the inner platform half. The carina is nearly straight, consists of partly merged nodes and reaches the posterior tip of the platform. The inner anterior platform margin reaches the free blades at a more anterior position and at a sharper angle than the outer anterior platform margin. The free blade is somewhat shorter than the length of the platform. The posterior tip is bent downward. On the lower side, a medium sized symmetrical basal pit is situated in the middle of the anterior half of the platform.

Remarks. The specimen can be distinguished from *P. pseudofoliatus* by the overall shape and ornamentation of the platform and the absence of a rostrum. Although it has some features in common with *Schm. pietzneri*, the specimen differs from it by its ornamentation, shape of the basal pit and almost straight platform.

Polygnathus sp. **B**

Pl. 2, figs 18a-b

Material: 1 specimen from sample SN2B.

Description. A species of *Polygnathus* with an asymmetric lanceolate platform covered with wide transverse ridges separated from the carina by adcarinal troughs. The carina consists of partially fused nodes in its anterior part and of separated nodes in its posterior part where it reaches the tip of the platform. The posterior tip is slightly bent downward. The platform is widest at midlength; the inner platform margin is almost straight to very slightly curved, the outer platform margin is distinctly convex in the posterior half of the platform and slightly sinuous in its anterior half. The anterior platform margins join the free blade at the same position. The free blade is about 1/3 of the total length of the element and consists of partly fused denticles. On the lower side a medium sized and rhombic shaped basal pit with broad rims is located on the anterior half of the platform.

Remarks. The specimen can be distinguished from *P.* sp. A, C, and D by its platform outline and from *P. pseudofoliatus* by its outline, ornamentation and straight carina.

Polygnathus sp. **C**

Pl. 2, figs 15a-b

Material: 1 specimen in sample SN2A.

Description. The figured specimen shows a straight lanceolate platform, narrowing in its anterior half with serrated rounded anterior margins. The platform is widest immediately posterior of its mid-length. It is covered with nodes and irregular ribs in the posterior part. In the middle part of the platform a few ribs have a diagonal orientation. The carina is nearly straight and reaches the posterior tip of the platform. The adcarinal troughs are deep and narrow anteriorly and shallower and wider posteriorly. The free blade is broken. The small basal pit is located at the junction between the platform and the free blade.

Remarks. The nearly straight carina distinguishes this specimen from *P. pseudofoliatus*. It differs from *Schm. hermanni* mainly by the position and the size of the basal pit.

Schmidtognathus latifossatus Wirth, 1967

Pl. 2, figs 1a-b, 3a-b

1967 *Polygnathus latifossata* n. sp. – Wirth, pl. 22, figs. 17-19.

1976 *Polygnathus latifossatus* Wirth – Klapper, Ziegler & Johnson, p. 120-121, pl. 3, figs. 11, 17, 18, 20, 27-23.

1985 *Polygnathus latifossatus* Wirth – Olivieri, p. 202, pl. 1, figs. 14-15.

Material: 11 specimens (9 juveniles) from samples SN2r (7), SN2s (3) and SN2t (1).

Remarks. The figured specimens show an incipient narrow platform ornamented with a row of weak nodes. The basal pit is large and occupies nearly the anterior half of the lower platform.

Schmidtognathus aff. **Schm. pietzneri** Ziegler, 1965

Pl. 2, figs 17a-b

Material: 1 specimen from sample SN2s.

Description. The figured specimen has a long platform that tapers in its posterior part (tip is missing). The platform is widest in its middle part and distinctly narrower in its anterior half. The platform is covered with broad ribs separated from the carina by deep adcarinal grooves. The carina is curved. The free blade is shorter than the platform. The posterior platform half is bent downward. The anterior part of the platform is slightly stretched downward and joins the free blade more anteriorly at the inner side than at the other side. An incipient rostrum is visible. The basal cavity is large and asymmetric and is located on the anterior half of the platform.

Remarks. The overall platform shape (widest at midlength instead of in the anterior half) and the ornamentation distinguish the specimen from *Schm. pietzneri*.

Schmidtognathus sp. **A**

Pl. 3, figs 2a-b, 6a-b, 7a-b

Material: 3 specimens in samples SN2t (1), SN2B (1) and SN2s (1) and 2 juvenile specimens in sample SN2B.

Description. The platform has a leaf-like outline, with a slightly sinusoid to straight carina that reaches the posterior end of the platform. The carina is high and consisting of fused nodes in its anterior part and lower and consisting of partly fused nodes in its posterior part. The outer platform margin shows a wide rounded curve in the middle part of the platform and a sinus in the posterior part. The inner platform margin shows a weaker curve. The platform is widest at midlength or immediately anterior of midlength and constricted anteriorly and posteriorly. The anterior platform margins reach the carina at low angle. Coarse ribs on the platform are separated from the carina by wide adcarinal grooves. A few nodes can be developed on the posteriormost part of the platform. The basal pit is large and is located in the anterior half of the lower platform. The free blade is missing in all recovered specimens. One specimen (Pl. 3, fig. 6) shows coarser ornamentation than the other two.

Remarks. The specimen figured on Pl. 1, figs 12a-b has a large basal pit and a somewhat similar platform outline. The small size of the specimen and the positioning of the basal pit at the junction of the platform and the free blade suggest this is a juvenile specimen.

The specimens resemble *Schm*. sp. A described by Mawson & Talent (1989) but show a weak but distinct sinus in the outer posterior platform margin, a feature that is absent in all the figured Mawson & Talent (1989) specimens.

Schmidtognathus? sp. **B**

Pl. 3, figs 1a-b

Material: 1 specimen from sample SN2t.

Description. The figured specimen has an asymmetric lanceolate to triangular shaped platform that is widest in its anterior half. The ornamentation consists of delicate interrupted ridges, separated from the carina by shallow adcarinal troughs. The carina is slightly curved and reaches the posterior tip of the platform. The inner platform margin is nearly straight; the outer platform margin is straight in the posterior half but distinctly curved in the anterior half. The moderate sized distinctly asymmetrical basal pit is located in the anteriormost 1/4 of the lower platform. The free blade is missing.

Remarks. The specimen differs from *Polygnathus* by the clearly asymmetric basal pit. Its platform outline and basal bit are similar to those of *Schm. peracutus* but the specimen can be distinguished from the latter by its platform ornamentation

Genus *Tortodus* Weddige, 1977

Tortodus bultyncki Aboussalam, 2003

Pl. 3, fig. 12

2003 *Tortodus bultyncki* n. sp. – Aboussalam, p. 197, pl. 25, figs. 1-3.

Material: 1 specimen from sample SN2s.

Remarks. The figured specimen shows the typical narrow and smooth platform with a slightly torsioned blade that runs from close to the platform margin on the anterior half, across the platform to the other margin on the posterior half. The denticles are smaller in the middle part of the blade. The species differs from *T. weddigei* by the slender platform shape, the lack of ornamentation on the upper platform and the migration of the blade from one side of the platform to the other.

Tortodus aff. **T. caelatus** (Bryant, 1921)

Pl. 3, fig. 13

Material: 1 specimen from sample SN2A.

Description. The large and broken specimen has a long platform with a carina that is formed by a few high denticles anteriorly and continues into a row of partially fused decreasing nodes posteriorly. The carina is straight. The widest part of the platform is located at midlength. The platform is ornamented with irregularly distributed small nodes and is constricted in its posterior part.

Remarks. The specimen differs from *T. caelatus* by the absence of strong nodes or ridges on the platform and of any torsion of the posterior part although that might be lost for observation due to the broken nature of the specimen. It does bear a close resemblance to the pl. 26, fig. 4 *T. caelatus* specimen of Aboussalam (2003).

Tortodus sp. **A**

Pl. 3, figs 11a-b

Material: 1 specimen from sample SN2A.

Description. The platform, broken anterior of the pit and developed on both sides of the carina, is very gently arched and ornamented with a few small nodes. It narrows anteriorly and posteriorly. The pit is of mod-

erate size, located anterior of the widest part of the platform and inverts to a sharp keel posteriorly. The carina shows a weak torsion and consists of low broad denticles somewhat fused at their bases. It flexes in the posterior part of the platform after migrating from the center of the platform anteriorly to near the posterior platform margin.

Remarks. The specimen is distinguished from *T. beckeri* by the ornamentation on the platform and the absence of the distinct bulging of the outer platform margin. The specimens' platform is rather flat compared to the curved platform of *T. weddigei*.

Tortodus? sp. **A**

Pl. 3, figs 10a-b

Material: 1 specimen from SN2r.

Description. Fragmentary specimen of which only the posterior part of the platform is preserved. The low carina formed by partially fused nodes, is flanked by shallow adcarinal grooves. The platform is ornamented by irregularly distributed small nodes. The carina and posterior part of the platform are bent laterally. The basal cavity is not preserved.

Remarks. This fragment is somewhat similar to the platform of Pl. 3, fig. 13 and is therefore tentatively placed in the *Tortodus* genus. The fragment differs from a fragment of *T. caelatus* by the small size of the platform nodes.

Conclusions

A restudy of the conodont collection of the Su Nuargi II section in SW Sardinia confirms the importance of this section for Middle Devonian conodont biostratigraphy. Updating the collection to the most recent taxonomy allows the distinction of forty five conodont taxa and the positioning of the section in the *timorensis* to *latifossatus* zones (Lower and Middle Givetian), slightly widening the stratigraphic position of the section by Olivieri (1985).

This is the first finding of the *Tortodus* and *Schmidtognathus* genera in Sardinia. In the Corti Baccas II section, a Givetian sample (CBII5) is discovered and positioned in the *timorensis – ansatus* zones interval.

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PLATE 3

Figs. 1a-b - *Schmidtognathus*? sp. B, IPUM n. 28273, lower and upper view, SN2t, x48.

Figs. 2a-b - *Schmidtognathus* sp. A, IPUM n. 28274, lower and upper view, SN2B, x47.

Figs. 3-5 - *Polygnathus linguiformis linguiformis* γ4 morphotype, IPUM n. 28275, upper view, SN2t, x45; IPUM n. 28276, upper view, SN2A, x89; IPUM n. 28277, upper view, SN2A, x60.

Figs. 6a-b - *Schmidtognathus* sp. A, IPUM n. 28278, lower and upper view, SN2t, x30.

Figs. 7a-b - *Schmidtognathus* sp. A, IPUM n. 28279, lower and upper view, SN2s, x36.

Fig. 8, 9 - *Polygnathus* aff. *P. l. klapperi,* IPUM n. 28280, upper view, CBII5, x45; IPUM n. 28281, upper view, CBII5, x45.

Figs. 10a-b - *Tortodus*? sp. A, IPUM n. 28282, upper and lower view, SN2r, x40.

Figs. 11a-b - *Tortodus* sp. A, IPUM n. 28283, upper and lower view, SN2A, x46.

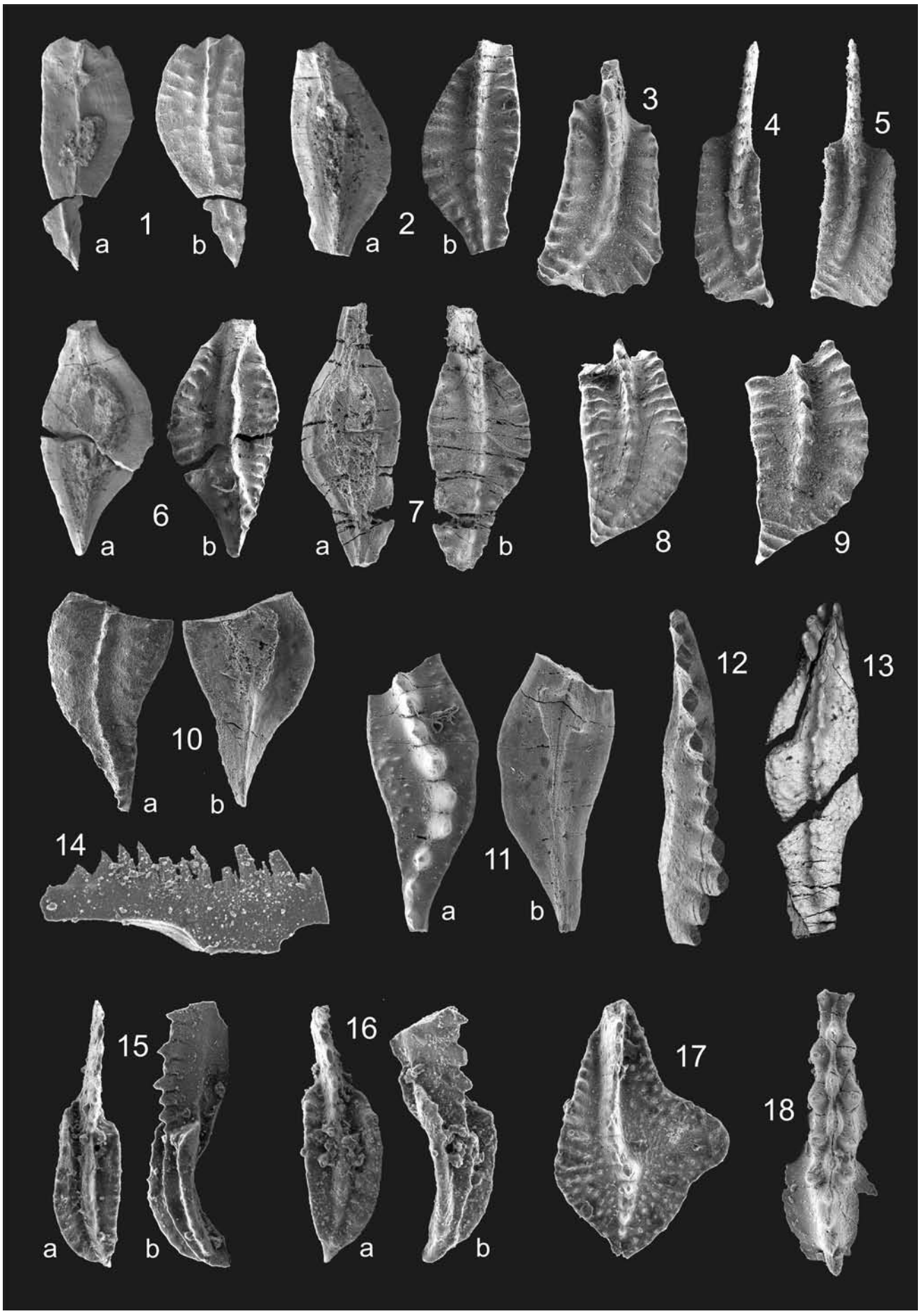
Fig. 12 - *Tortodus bultyncki,* IPUM n. 28284, upper view, SN2s, x63.

Fig. 13 - *Tortodus* aff. *T. caelatus,* IPUM n. 28285, upper view, SN2A, x22.

Fig. 14 - *Ozarkodina* aff *O. semialternans,* IPUM n. 28286, lateral view, SN2A, x128.

Figs. 15a-b,16a-b - *Polygnathus* cf. *P. webbi*, (juvenile specimen) IPUM n. 28327, upper and lateral view, SN2, x93; IPUM n. 28328, upper and lateral view, SN2, x99.

Fig. 17 - *Palmatolepis winchelli*, IPUM n. 29329, upper view, SN2, x60.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