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A Silurian conodont biozonation from late Llandovery to end Přídolí in Sardinia (Italy)

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ABSTRACT – The standard Late Llandovery -Top Přídolí conodont zonation between the top of the celloni *Zone and the latest Přídolí* detorta *Zone is revised on the basis of data from the Silurian System of Sardinia. Fifteen biointervals have been recognized; among them, one zone is here newly named (*Oz. exc. hamata*) and three more zones (*K. crassa, K. v. variabilis *interval Zone and* Pe. latialata*), proposed and sporadically used in some previous biozonations, are reintroduced. The scheme provided for Sardinia fits well in other part of the world, like the Cellon section.*

RIASSUNTO – [Biozonatura a conodonti del Siluriano (Llandovery terminale-Přídolí) in Sardegna] *– La ricca fauna a conodonti siluriani della Sardegna ha consentito di proporre una biozonatura del Siluriano per l'intervallo compreso tra la parte alta del Llandovery e il tetto del Přídolí. Integrando dati di entrambe le facies post-Llandoveriane presenti nell'isola, sono stati riconosciuti quindici biointervalli, uno dei quali viene proposto per la prima volta (*Oz. exc. hamata *Zone); altri tre, non più utilizzati da tempo (*K. crassa *Zone,* K. v. variabilis *interval Zone and* Pe. latialata *Zone), sono stati reintrodotti, anche se con significato leggermente diverso rispetto agli schemi in cui erano presenti. La biozonatura sarda è particolarmente dettagliata nel Ludlow, dove ha un potere di risoluzione medio di 1,25 Ma, cioé maggiore sia di quelle fino ad ora proposte, che di quella a graptoliti. Occorre infine precisare che lo schema di biozonatura del Siluriano basato sulla Sardegna può essere facilmente applicato anche in molte aree, non solo del Gondwana, ma anche di altri paleocontinenti, quali Laurussia e Baltica.*

A partly revised version of the global standard conodont zonation for the Wenlock-Přídolí interval, which apparently fits better with the Sardinian sequences, is proposed to replace the more recent one appearing in Silurian Time n°3 (Nowlan, 1995).

Conodont data from Sardinia derives from research carried out during the past three decades by one of us (E.S.) and more recently in connection with the preparation of the ECOS VII pre-symposium field-trip on the island.

This paper, which includes full discussion of all biozones, associated fauna and worldwide relationships, is the complete and updated version of a short note that appeared in the ECOS VII-Sardinia Field Trip Guidebook (Corradini & Serpagli, 1998a). It also takes into consideration the discussion following the talk presented on June 25, 1998, at the ECOS VII meeting (Corradini & Serpagli, 1998b).

The first conodont zonation for the Silurian was proposed by Walliser (1964), who based his scheme primarly on the Cellon Section (Carnic Alps, Austria), taking in account also data from Bohemia and Spain. The author defined twelve successive appearance zones spanning the Silurian and the lowermost Devonian. Several of these zones have been widely recognized, but the difficulties of applying the complete scheme in other part of the world (mainly in the Llandovery part, which is not completely exposed in Cellon; Schönlaub, 1971) have led to the development of many local zonations.

Cooper (1980) listed and provisionally correlated ten zonal schemes provided for part of the Silurian System of North America, Europe and Australia. Cooper advocated the use of biostratigraphical datum planes to assist correlations, but only a few authors have adopted this approach. Furthermore, other local zonations have been published, increasing further the number of conodont names applied to Silurian biostratigraphical intervals.

Aldridge & Schönlaub (1989), considering all the available data, provided a new scheme, which is a "step on the path to the development of a reference biozonation" (p. 275). Their global zonation has been reported also in the Newsletter of the Subcommission of Silurian Stratigraphy (Silurian Times n°1; May 1993).

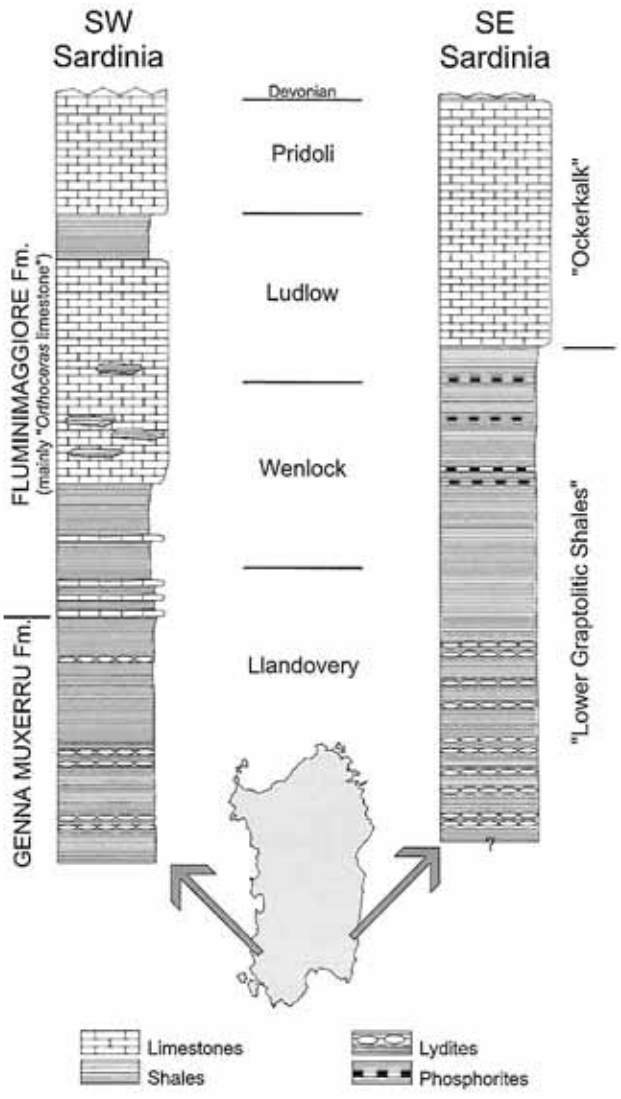
Finally, two years later, a new Conodont Global Zonation chart appeared in Silurian Times n°3 (Nowlan, 1995). It should be pointed out that, despite the fact that this scheme is quite different from the others, it has never been justified or discussed.

OUTLINE OF THE SILURIAN OF SARDINIA

Silurian rocks are exposed, discontinuously, only in southern Sardinia. Two distinct and peculiar situations occur in the SE part (Gerrei and Sarrabus sub-regions) of the island and in the SW part (Iglesiente and Sulcis sub-regions) (Text-fig. 1). They compare mainly to the Silurian sequences exposed in Thuringia

and Bohemia respectively. Their mutual relationships are still unclear (Ferretti & Serpagli, 1996).

In SE Sardinia (Gerrei Tectonic Unit) the Silurian and Lower Devonian are represented by the classical Thuringian facies triad: "Lower Graptolitic Shales" (LGS) - "Ockerkalk" (OK) - "Upper Graptolitic Shales" (UGS). Here, the Silurian starts with graptolitic silica-argillaceous and silty shales ("Lower Graptolitic Shales"; 30-40 m), particularly rich in carbon and pyrite ("alum slates"; Jaeger, 1977) and interbedded with lydites in the lower part. This unit extends into the early Ludlow, at least up to the *nilssoni* Zone (Barca & Jaeger, 1990). The succeding "Ockerkalk" (25 m thick) is an argillaceous limestone with a blue-grey colour weathering to ochre (so the name) and having a typical irregular flaser texture.



Text-fig. 1 - Sketch stratigraphical columns of the Silurian of Sardinia

Such informal unit is equivalent to part of the Fluminimaggiore Fm. of SW Sardinia. The poor fauna is mainly composed of a few nautiloids (Gnoli, 1993), rare ostracodes, brachiopods, thin-shelled bivalves, trilobite fragments, gastropods, sponge spiculae, phyllocarids (mainly mandibles) and crinoids. All these organisms are scattered in a micritic limestone, only locally concentrated in thin wackestone bands of disarticulated debris (Corradini *et al.*, 1998a). A rich conodont fauna, spanning from early Ludlow to late Přídolí , has been recovered from these limestones.

In SW Sardinia the oldest Silurian rocks belong to the Genna Muxerru Fm.; this consists of 20-25 m of graptolitic silica-argillaceous and silty shales, interbedded with lydites in the lower part (Gnoli *et al.*, 1990). The Fluminimaggiore Fm. overlies the Genna Muxerru Fm. Its thickness, estimated only indirectly because of the strong tectonism, is 45-50 m. The formation spans from late Llandovery to earliest Lochkov. Black calcareous lenticular layers alternate with dark non-calcareous pelites and shales. Plastic deformation and cleavage strongly alter the shales while limestone blocks preserve fossils mostly in three dimensions (Gnoli *et al.*, 1980). The black colour and the bituminous smell reflect a high content of organic matter. The fauna is dominated by cephalopods and bivalves, associated with pelagic ostracodes, graptolites, conodonts, forams, chitinozoans and muellerisphaerids, whereas gastropods, brachiopods, trilobites and phyllocarids are rare. Graptolites are frequently found packed together in peculiar pseudo-lenticular calcareous bodies (Ferretti *et al.*, 1998a).

Continuous sections are present only in the SE of Sardinia (Ockerkalk facies), so our proposals are most sound for the interval lower Ludlow - Přídolí (i.e. from *scanicus* to *transgrediens* Zone); in the SW, in fact, the zones are recognized almost exclusively from spot outcrops (named blocks-BK) and therefore the proposals in the interval top-Llandovery-lower Ludlow (pre *scanicus*) are provisional.

THE SILURIAN BIOZONATION IN SARDINIA

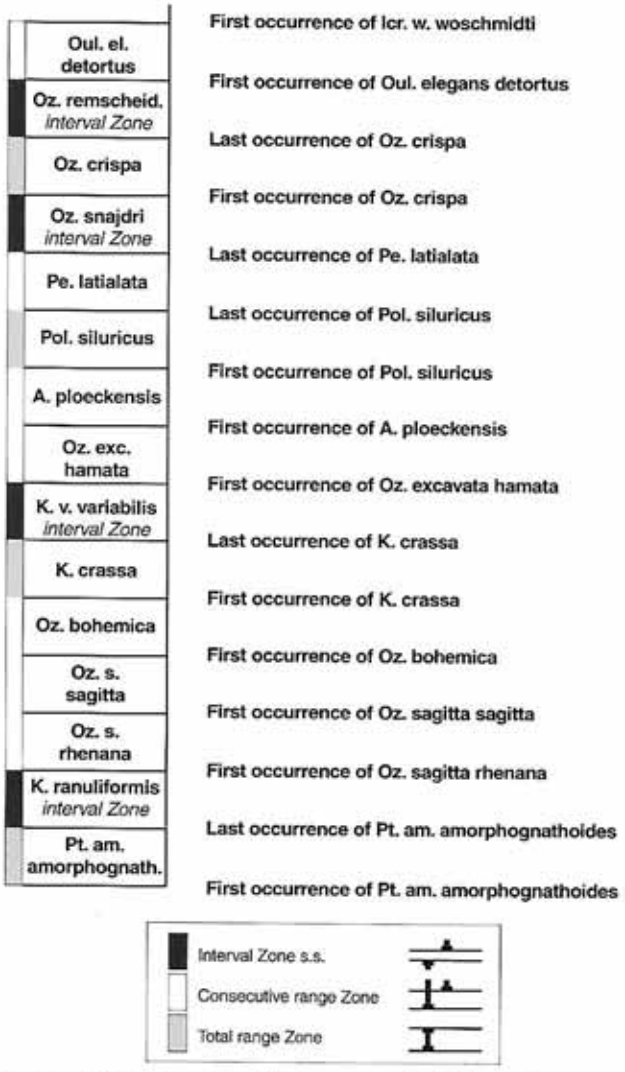
Our proposed biozonation scheme (Text-fig. 2) divides the top Llandovery - end-Přídolí into fifteen zones. Fourteen of them have been reported in Sardinia, while the *Oz. s. rhenana* Zone has not been documented to date in the island. Therefore, this biointerval has been defined using data from other areas.

One zone is newly named (*Oz. e. hamata*) and three are re-introduced (*K. crassa*, *K. v. variabilis* and *Pe. latialata*), having been sporadically used by different authors. The Sardinian biozonation is most detailed for the Ludlow, which is divided into 8 biointervals, i.e. two more than the Left Hand Standard Column (Silurian Times, 3).

It should be pointed out that this biozonation is not a phyletic one, as the boundaries between the zones are defined by FO and LO of different taxa, not always phylogenetically related. Four biozones are "total range zones", with lower and upper boundaries defined by the FO and the LO of the index taxon respectively; four are "interval Zones s.s.", *i.e.* the index species, because its long range, does not define either the lower boundary or the upper boundary, which are marked by disappearance or appearance of other species. All the other intervals are "consecutive range zones" (Text-fig. 2).

The zones are here defined and discussed with regard to lower and upper boundaries, important associated conodonts and areas of occurrence; they are also correlated with conodont zones established elsewhere and/or (tentatively) with graptolite zones.

It should be pointed out that taxa listed as "associated conodonts" may occur only in a part of the corresponding zone. Global lists do not include Sardinian record, which sometimes may have a slightly wider range (i.e.: *Coryssognathus dubius* and *Ps. bicornis*). Finally, in order to avoid long list of names, each finding is not followed by the reference of the recording author.



Text-fig. 2 -The Sardinian Silurian Conodont Biozonation

Pterospathodus am. amorphognathoides Zone

Lower limit

First occurrence of *Pterospathodus am. amorphognathoides.*

Upper limit

Last occurrence of *Pterospathodus am. amorphognathoides.*

Historical

This is one of the less controversial conodont Silurian zones which, after being established by Walliser (1964) in his pioneer conodont zonal scheme for the Silurian System, has been recognized in many sections through the world and is widely used to date beds across the Llandovery/Wenlock boundary. Its success is mainly due to easy identification of the marker whose biostratigraphical importance was never doudted.

The proposal of Bischoff (1986) to substitute this taxon range Zone with a new assemblage zone has been rejected by Männik & Aldridge (1989), because the base of the *amorphognathoides* biozone is determined by the first appearance of specimens with platform ledges. According to Männik (1998) such specimens belong to the subspecies *Pt. am. amorphognathoides,* while specimens without this feature belong to other subspecies of the *amorphognathoides* group, like *Pt. am. angulatus*. In this respect, the zone fits the concept of the *amorphognathoides* Zone as originally defined by Walliser (1964).

Global Data

Pt. am. amorphognathoides has been widely reported from Europe, North America, China, Malaya and Australia.

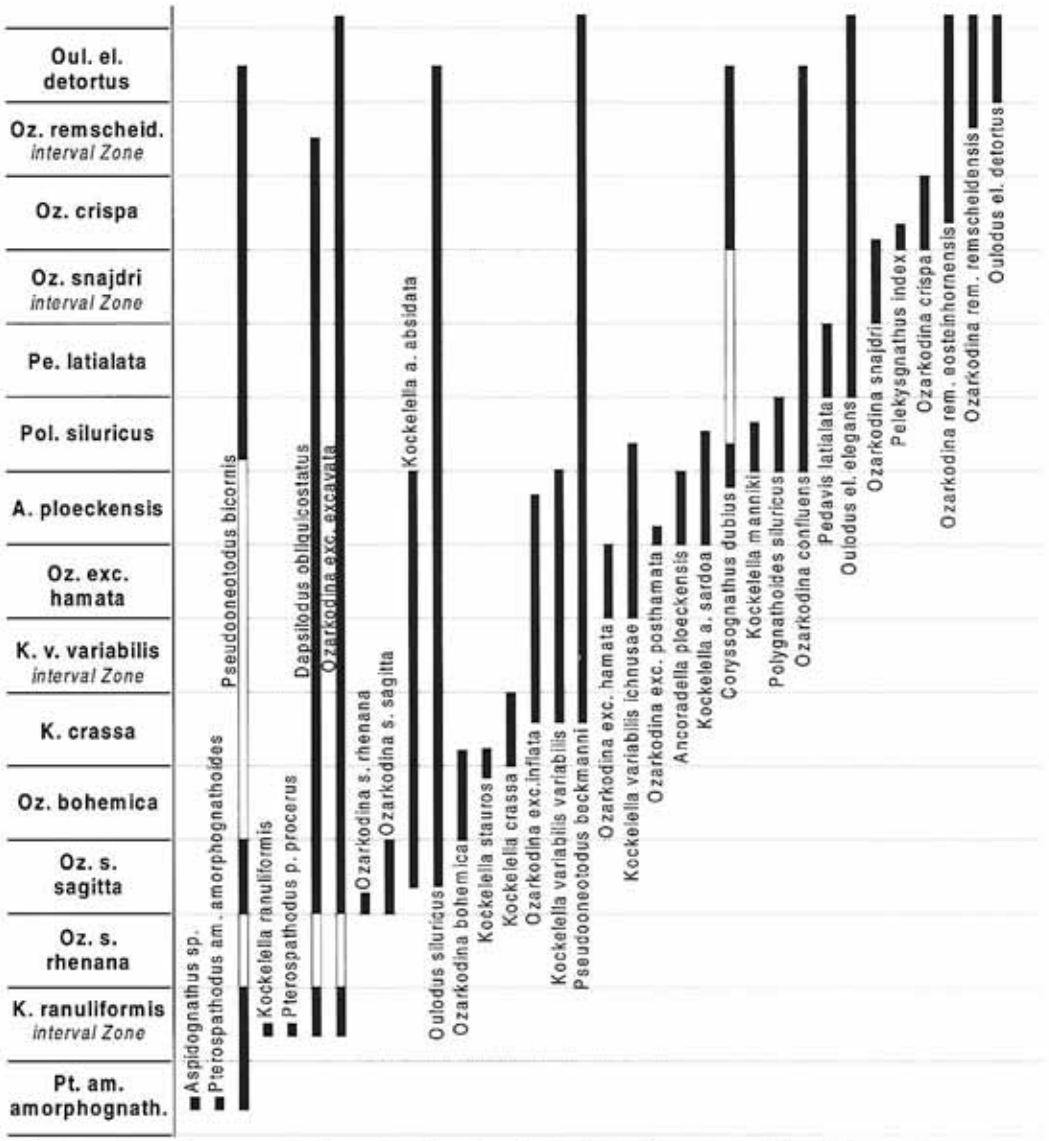
Sardinian data

Up to date the biozone has been recognized only in one sample (SAD-BK 3) from the Hercynian Arburese Tectonic Unit of SW Sardinia (Capo Frasca Area) (Barca *et al.*, 1992).

Associated conodonts

Sardinia - *Pterospathodus am. amorphognathoides* Walliser, *Apsidognathus* sp. (formerly identified as *Aulacognathus* cf. *kuheni* by Barca *et al.*, 1992), *Pseudooneotodus bicornis* Drygant.

World - *Pterospathodus. am. amorphognathoides* Walliser, *Pt. celloni* (Walliser), *Pt. pennatus procerus*



Text-fig. 3 -Distibution of conodont taxa in Sardina, plotted against the Sardinian biozonation. Thirty-five conodont species and subspecies, belonging to 13 genera, have been reported from the Silurian limestones of Sardinia.

(Walliser), *Pt. p. rhodesi* (Savage), *Apsidognathus tuberculatus* Walliser, *A. barbarajeanae* (Savage), *A. ruginosus* Mabillard & Aldridge, *A. walmsleyi* Aldridge, *Astrolecignathus milleri* Over & Chatterton, *A. newti* Over & Chatterton, *Aulacognathus kuehni* Mostler, *A. chapini* (Savage), *A. nelsoni* Over & Chatterton, *A. bullatus bullatus* (Nicoll & Rexroad), *Belodella silurica* Barrick, *Carniodus carnulus* Walliser, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Daps. praecipuus* Barrick, *Daps. sparsus* Barrick, *Decoriconus fragilis* (Branson & Mehl), *Distomodus staurognathoides* (Walliser), *Icriodella? sandersi* Mabillard & Aldridge, *Johnognathus huddlei* Mashkova, *Kockelella ranuliformis* (Walliser), *Oulodus petilus* (Nicoll & Rexroad), *Oul. fluegeli* (Walliser), *Ozarkodina excavata excavata* (Branson & Mehl), *Oz. hadra* (Nicoll & Rexroad), *Oz. proclinata*, *Oz. australensis* Bischoff, *Oz. gulletensis* (Aldridge), *Pseudooneotodus beckmanni* (Bischoff & Sannemann), *Ps. bicornis* Drygant, *Ps. boreensis* Bischoff, *Ps. panuarensis* Bischoff, *Ps. tricornis* Drygant, *Pseudopygodus scaber* Drygant, *"Pyrsognathus" obliquus* Bischoff, *Walliserodus sancticlari* Cooper, *W. blackstonensis* and several panderodids (*Panderodus simplex, P. u. unicostatus*).

Remarks

Following the revision of the *Pterospathodus* lineage (Männik, 1998), it is more appropriate to name this biozone after the subspecies *Pt. am. amorphognathoides*, rather than just the species.

No more remarks can be added because limestones belonging to this interval are only sporadically represented in Sardinia within the black graptolitic shales which dominated Llandovery sedimentation.

Kockelella ranuliformis interval Zone

Lower limit
Last occurrence of *Pterospathodus am. amorphognathoides.*
Upper limit
First occurrence of *Ozarkodina sagitta rhenana.*

Historical
This biozone was introduced by Barrick & Klapper (1976) and is used in the official Silurian biostratigraphic column (Silurian Times n.3, 1995). However, according to Jeppsson (1994), Jeppsson *et al.* (1994) and Jeppsson (1997) this interval can be subdivided in greater detail.

Global Data
The *K. ranuliformis* interval Zone has been reported from North America (Oklahoma, Barrick & Klapper, 1976) and Australia (Bischoff, 1986).

Sardinian data
To date this biozone has been recognized only in one sample (ARG C) from the Domusnovas Area (SW Sardinia) (Corradini *et al.*, 1998b).

Associated conodonts
Sardinia - *Kockelella ranuliformis* (Walliser), *Ozarkodina exc. excavata* (Branson & Mehl), *Pterospathodus pennatus procerus* (Walliser), *Dapsilodus obliquicostatus* (Branson & Mehl), *Pseudooneotodus bicornis* Drygant.

World – *Kockelella ranuliformis* (Walliser), *K. walliseri* (Helfrich), *Belodella silurica* Barrick, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Daps. praecipuus* Barrick, *Daps. sparsus* Barrick, *Decoriconus fragilis* (Branson & Mehl), *Distomodus staurognathoides* (Walliser), *Oulodus petilus* (Nicoll & Rexroad), *Oul. siluricus* (Branson & Mehl), *Oul. sinuosus* Bischoff, *Ozarkodina exc. excavata* (Branson & Mehl), *Oz. gulletensis* (Aldridge), *Oz. hadra* (Nicoll & Rexroad), *Pseudooneotodus beckmanni* (Bischoff & Sannemann), *Ps. bicornis* Drygant, *Ps. boreensis* Bischoff, *Ps. panuarensis* Bischoff, *Ps. tricornis* Drygant, *Walliserodus sancticlairi* Cooper and several panderodids.

Remarks
As pointed out by Barrick & Klapper (1976, p.66), in the Cellon Section this biointerval probably correlates with the 25 cm shale interval between samples C.12A and C.12B

Ozarkodina sagitta rhenana Zone

Lower limit
First occurrence of *Ozarkodina sagitta rhenana.*
Upper limit
First occurrence of *Ozarkodina sagitta sagitta.*

Historical
Walliser (1964) named a biointerval more or less equivalent to this one as the *patula* Zone. In Cellon *Oz. s. rhenana* is apparently missing.
In North America Barrick & Klapper (1976) suggested that this interval is better zoned using *Kockelella amsdeni* as the index species, and this proposal has been followed in Australia (Bischoff, 1986).
The *Oz. s. rhenana* Zone was proposed by Aldridge & Schönlaub (1989) as the lowermost of the two phyletic zones of the *sagitta* lineage to subdivide most of the Sheinwoodian.
In the recent biostratigraphical chart (Silurian Times n.3), this interval is, however, subdivided into a "*O. sagitta rhenana - K. patula* Zone" below and a "Not Zoned" Interval above. Jeppsson (1994, 1997) goes further, proposing to split the same interval into several biozones.

Global Data
Oz. s. rhenana has been reported from Europe, North America and Australia.

Sardinian data
This post-*ranuliformis* - pre-*sagitta* interval is probably represented in Sardinia by black shales and this explains why it is not recorded. We cannot, however, exclude that narrow calcareous horizons, may occur in this highly tectonized part of the sequence, and could be sampled in the future.

Associated conodonts
World - *Ozarkodina s. rhenana* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Oz. gulletensis* (Aldridge), *Belodella silurica* Barrick, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Daps. praecipuus* Barrick, *Daps. sparsus* Barrick, *Decoriconus fragilis* (Branson & Mehl), *Kockelella absidata* Barrick & Klapper, *K. amsdeni* Barrick & Klapper, *K. corpulenta* (Viira), *K. latidentata* Bischoff, *K. patula* Walliser, *K. ranuliformis* (Walliser), *K. walliseri* (Helfrich), *Ouodus equierectus* Kleffner, *Oul. siluricus* (Branson & Mehl), *Panderodus recurvatus* (Rhodes), *P. u. unicostatus* (Branson & Mehl), *Pseudooneotodus beckmanni* (Bischoff & Sannemann), *Ps. bicornis* Drygant and *Walliserodus sancticlari* Cooper.

Remarks

Kockelella patula, which is present in much of the interval, but probably not in the uppermost part, is the most important associated taxon which can help recognition of this zone, specially when *Oz. s. rhenana* is missing.

In the Cellon Section this zone can be recognized in the *K. patula* bearing samples C.12B-D, as well as in the succeeding samples C.12E-C.13B, before the first occurrence of *Oz. s. sagitta*.

Ozarkodina sagitta sagitta Zone

Lower limit

First occurrence of *Ozarkodina sagitta sagitta*

Upper limit

First occurrence of *Ozarkodina bohemica*

Historical

This biozone was introduced by Walliser (1964) and has been regarded as a valid zone in many later biozonations. In Nevada, (Barrick & Klapper, 1976) a zonation based on species of *Kockelella* has been used at this level, because the *sagitta* lineage is uncompletely represented. However, this zone is of global use although under its present definition is shorter than that in Walliser's original biozonation.

Global Data

Oz. sagitta sagitta has been reported from Europe and North America. The Australian record (Simpson & Talent, 1995) must be taken with caution because the figured specimen (Pl. 10, fig. 12) is doubtful and the accompanying taxa are usually characteristic of younger strata.

Sardinian data

The *Oz. sagitta sagitta* Zone has been recognized from the Fluminimaggiore Fm. of SW Sardinia, both in the *Orthoceras* limestone and in the graptolite packstone at Sentiero Flumini (Serpagli, 1971), Perd'e Fogu (Ferretti *et al.*, 1998b), Argiola (Corradini *et al.*, 1998b) and Galemmu (near Fluminimaggiore, unpublished data).

Age in terms of graptolites - On the basis of the occurrence of *M. flemingii*, two samples (SF-BK 10 and SF-BK 11), with *Oz. s. sagitta*, have been regarded by Jaeger (pers. comm., 20/07/1987) to be upper Wenlock in age, not higher than Zone 31.

Associated conodonts

Sardinia - *Ozarkodina s. sagitta* (Walliser), *Oz. s. rhenana* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella absidata* Barrick & Klapper, *Oulodus siluricus* (Branson & Mehl), *Pseudooneotodus bicornis* Drygant, *Panderodus* sp.

World - *Ozarkodina s. sagitta* (Walliser), *Oz. s. rhenana* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Belodella silurica* Barrick, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Decoriconus fragilis* (Branson & Mehl), *Kockelella absidata* Barrick & Klapper, *K. corpulenta* (Viira), *K. ranuliformis* (Walliser), *K. stauros* Barrick & Klapper, *K. subglobovi* Mashkova, *K. walliseri* (Helfrich), *Oulodus equirectus* Kleffner, *Oul. siluricus* (Branson & Mehl), *Panderodus recurvatus* (Rhodes), *P. u. unicostatus* (Branson & Mehl), *Pseudooneotodus beckmanni* (Bischoff & Sannemann), *Ps. bicornis* Drygant and *Walliserodus sancticlari* Cooper,

Remarks

This biointerval has been recognized in many sections through the world. The range of the *Oz. s. sagitta* Zone is more or less coincident with the *lundgreni* graptolite Zone (Jeppsson, 1994, 1997) and, therefore, it is widely used to date early Homerian beds. However, according to Aldridge (1985), the first occurrence of *Oz. s. sagitta* in Britain is just below the base of the Homerian.

Ozarkodina bohemica Zone

Lower limit

First occurrence of *Ozarkodina bohemica*

Upper limit

First occurrence of *Kockelella crassa*

Historical

Aldridge (1975) noted that the *sagitta* Zone of Walliser may be subdivided in narrow intervals, because he recognized a chronological sequence from *Oz. s. rhenana* into *Oz. s. bohemica*. At the same time Helfrich (1975) introduced the *Oz. boh. bohemica* Zone to define an upper Wenlock-lowermost Ludlow interval in the Central Appalachian Mts. However, in Nevada, even though this species is present, Barrick & Klapper (1976) used a *Kockelella* based biozonation.

This zone, after sporadic usage (i.e.: China, Lin Bao-yu, 1983), appears definitely, with slighty different spans, in all recent Silurian biostratigraphic columns (Aldridge & Schönlaub, 1989; Silurian Times n.1, 1993; Silurian Times n.3, 1995).

Several faunal intervals based on the occurence of *Oz. bohemica bohemica*, sometime associated with other conodont taxa, have been recognized by Jeppsson *et al.* (1994) in the Baltic region.

Global Data

Oz. bohemica has been widely reported from Europe, North America and China.

Sardinian data

The *Oz. bohemica* Zone has been recognized in the *Orthoceras* limestone and in the graptolite packstone of the Fluminimaggiore Fm. (SW Sardinia) at Sant'Antonio Donigala, Capo Frasca area (Barca *et al.*, 1992) and at Sentiero Flumini and Galemmu, near Fluminimaggiore (unpublished data).

Associated conodonts

SARDINIA - *Ozarkodina bohemica* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella a. absidata* Barrick & Klapper, *K. stauros* Barrick & Klapper and *Oulodus siluricus* (Branson & Mehl).

WORLD - *Ozarkodina bohemica* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Oz. s. sagitta* (Walliser), *Belodella silurica* Barrick, *Coryssognathus dubius* (Rhodes), *Ctenognathus murchisoni* Pander, *Dapsilodus obliquicostatus* (Branson & Mehl), *Decoriconus fragilis* (Branson & Mehl), *Kockelella a. absidata* Barrick & Klapper, *K. ranuliformis* (Walliser), *K. stauros* Barrick & Klapper, *K. subglobovi* Mashkova, *K. walliseri* (Helfrich), *Oulodus equirectus* Kleffner, *Oul. siluricus* (Branson & Mehl), *Panderodus recurvatus* (Rhodes), *P. u. unicostatus* (Branson & Mehl), *Pseudooneotodus beckmanni* (Bischoff & Sannemann), *Ps. bicornis* Drygant and *Walliserodus sancticlari* Cooper.

Remarks

In the Cellon Section the *Oz. bohemica* Zone is missing and probably it corresponds to the narrow black shales interval between samples C15A and C15B$_1$.

KOCKELELLA CRASSA ZONE

Lower limit

First occurrence of *Kockelella crassa*

Upper limit

Last occurrence of *Kockelella crassa*

Historical

This biozone, after being introduced by Walliser (1964), who reported the index (Pb element) from 3 samples from the Cellon Section (C.15B$_2$, C.15C, C.16A), was not used elsewhere. It has never been used in North America, even though in some areas the index is clearly documented (Oklahoma, Barrick & Klapper, 1976), and in all recent Silurian biostratigraphic columns (Aldridge & Schönlaub, 1989; Silurian Times n.3, 1995) the zone has been omitted and the interval included in the *Oz. boh. bohemica* Zone. Aldridge & Schönlaub (1989, p.277) justified that omission, because "*Oz. crassa* is rare outside central Europe" and "with the apparatus totally unknown, identifications based only on Pb elements must be treated with caution".

More recently Schönlaub (in Kriz *et al.*, 1993, p. 829) regards "*Oz. crassa*" as an index species and Kleffner (1995) in his Silurian Composite Standard recognized an "*O. ? crassa* chronozone".

In a draft column kindly supplied by Jeppsson (27/06/1997) a *K. stauros* n.ssp.-*O. crassa* Zone is placed in the lower Gorstian, in correlation with the graptolite *N. nilssoni* Zone.

Global Data

Austria: (Cellon Profile): *K. crassa* is documented from samples C.15B$_1$, C.15B$_2$, C.15C and C.16A (refer to Serpagli & Corradini, 1999).

Bohemia: *K. crassa* is reported at Vysoky Ujezd Section and at Butovice Section from levels also bearing the graptolite *C. colonus* (Schönlaub *in* Kriz *et al.*, 1993) and at Muslovka Quarry (Walmsley *et al.*, 1974).

Gotland: Fåhræus (1967) reported a single Pb element from the Middle Hemse Beds.

North America: (Clarita Fm., Oklahoma): "*Oz.*" *crassa* occurs in the "topmost bed of the Fitzhugh Member at locality M 2, together with the first Clarita occurrence of *K. variabilis*" (Barrick & Klapper, 1976, p. 67).

Australia: in the Yass Basin this species is present in a higher stratigraphical position than elsewhere (Link & Druce, 1972) and this occurrence needs confirmation.

Sardinian data

This interval has been recognized in SW Sardinia in the Fluminimaggiore Fm., both in the *Orthoceras* limestone and in the graptolite packstone. Pa and Pb elements of the marker occur in some localities of the Fluminimaggiore area (Sentiero Flumini, Serpagli, 1971; Perd'e Fogu, Ferretti *et al.* 1998b; Galemmu, unpublished data), whereas the Pa only has been recorded in the Capo Frasca area (Barca *et al.*, 1992).

AGE IN TERMS OF GRAPTOLITES - On the basis of the occurrence of *C. colonus,* one sample (SF-BK 17), where the index *Kockelella crassa* is also present, has been regarded by Jaeger to belong to the *nilssoni* (=*colonus*) Zone (pers. comm., 20/07/1987).

Associated conodonts

SARDINIA - *Kockelella crassa* (Walliser), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella a. absidata* Barrick & Klapper, *K. v. variabilis* Walliser, *K. stauros* Barrick & Klapper, *Ozarkodina bohemica* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Oulodus siluricus* (Branson & Mehl) and *Pseudooneotodus beckmanni* Bischoff & Sannemann.

WORLD - *Kockelella crassa* (Walliser), *Belodella silurica* Barrick, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Decoriconus fragilis* (Branson & Mehl), *Kockelella a. absidata* Barrick & Klapper, *K. stauros* Barrick &

Klapper, *K. v. variabilis* Walliser, *Oulodus siluricus* (Branson & Mehl), *Ozarkodina bicornuta* (Helfrich), *Oz. bohemica* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Oz. roopaensis* Viira, *Panderodus recurvatus* (Rhodes), *P. u. unicostatus* (Branson & Mehl), *Pseudooneotodus beckmanni* (Bischoff & Sannemann) and *Ps. bicornis* Drygant.

Remarks

The highly characteristic Pa and Pb elements of the marker makes always easy to recognize this zone.

On the basis of the co-occurrence of conodonts and graptolites it is possible to correlate the *K. crassa* Zone and the *C. colonus* Zone. This has been verified in Bohemia (see above) and in Sardinia (sample GALE BK-23).

Kockelella v. variabilis and *Oz. exc. inflata* have their first occurrences in the upper part of this zone.

The Sardinian data justify the reintroduction of the *K. crassa* Zone as a Total Range Zone to recognize strata of Lowermost Ludlow age. This interval is more or less equivalent to that referred to the *K. stauros* Zone in Silurian Times 3 (1995), but the range of *K. stauros* seems to be older (Barrick & Klapper, 1976, p. 64; Kleffner, 1995). Some clarification about the variability of that species or its stratigraphical position is required.

Kockelella variabilis variabilis interval Zone

Lower limit

Last occurrence of *Kockelella crassa.*

Upper limit

First occurrence of *Ozarkodina excavata hamata.*

Historical

This zone is reintroduced here. Its meaning is, however, slightly different from that in all previously proposed schemes (Barrick & Klapper, 1976; Lin Bao-yu, 1983; Viira & Männik, 1997). In Spain, a *K. variabilis* Zone has recently been used to identify strata between the first occurrence of the nominal species and that of *Po. siluricus* (Valenzuela Rios, 1996; Sarmiento *et al.*, 1998).

Global Data

This interval Zone can be recognized in many sections around the world. For instance, In the Cellon Section the *K. v. variabilis* interval Zone can be identified from sample C.16B to C.17A.

Sardinian data

This interval has been recognized in the southwestern part of the island from the localities of Perd'e Fogu (Ferretti *et al.*, 1998b), Galemmu (near Fluminimaggiore) and Funtanamare (on the western coast, south of Nebida) (unpublished data).

Associated conodonts

Sardinia - *Kockelella v. variabilis* Walliser, *K. a. absidata* Barrick & Klapper, *Dapsilodus obliquicostatus* (Branson & Mehl), *Ozarkodina exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Oulodus siluricus* (Branson & Mehl), *Pseudooneotodus beckmanni* Bischoff & Sannemann.

World - *Kockelella v. variabilis* Walliser, *K. a. absidata* Barrick & Klapper, *K. stauros* Barrick & Klapper, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Oul. siluricus* (Branson & Mehl), *Ozarkodina exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Oz. roopaensis* Viira and *Panderodus u. unicostatus* (Branson & Mehl).

Remarks

In Sardinia, between the last occurrence of *K.crassa* and the first occurrence of *Oz. excavata hamata,* there is an interval without any really characteristic taxon, except *Kockelella v. variabilis* and some Pa elements of *Oz. excavata* bearing an unusually well developed cusp. Jeppsson (pers. comm., 27.06.1997) refers specimens with the same feature to *Oz. excavata* n. ssp. S, and uses this subspecies to define an "*Oz. excavata* n. ssp. S interval" in the Early Ludlow, correlatable with the lower part of the *L. scanicus - S. chimera* Zone. In Sardinia, such specimens of *Oz. excavata* are not, however, restricted to this part of the Silurian and, pending a definition of this new taxon, we prefer to use *K. v. variabilis* to name this interval.

Ozarkodina excavata hamata Zone

Lower limit

First occurrence of *Ozarkodina excavata hamata.*

Upper limit

First occurrence of *Ancoradella ploeckensis.*

Historical

This biozone is newly proposed here.

Global Data

The *Oz. exc. hamata* Zone can mostly be recognised, by the occurrence of the index subspecies, in Europe an North America:

Austria: Cellon Section (C.17B, C, D) (Walliser, 1964; corrected occurrence notified by Jeppsson, pers. com.); Eisenerz (Flajs, 1967);

Gotland (Jeppsson, pers. comm., 27.06.1997);

Nevada: Roberts Mts. Fm. (Klapper & Murphy, 1975).

Sardinian data

The *Oz. exc. hamata* Zone has been identified both in the *Orthoceras* limestone facies of SW Sardinia (Perd'e

Fogu near Fluminimaggiore; Ferretti *et al.*, 1998b) and in the southeastern part of the island, where in two sections (Silius I° and Monte Fruccas) it has been reported just above the contact between the "Lower Graptolite Shales" and the limestones in the Ockerkalk facies (Corradini & Olivieri, 1997; Serpagli *et al.*, 1998).

AGE IN TERMS OF GRAPTOLITES - On the basis of the occurrence of *S. chimaera* and *P. dubius* one sample (GALE-BK 23), where the index *Oz. exc. hamata* is also present, has been regarded by Jaeger (pers. comm., 20/07/1987) as belonging to the *S. chimaera* Zone.

Associated conodonts

SARDINIA - *Ozarkodina exc. hamata* (Walliser), *Oz. exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella a. absidata* Barrick & Klapper, *K. v. variabilis* Walliser, *K. v. ichnusae* Serpagli & Corradini, *Oulodus siluricus* (Branson & Mehl), *Pseudooneotodus beckmanni* Bischoff & Sannemann.

WORLD - *Ozarkodina exc. hamata* (Walliser), *Oz. confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Oz. roopaensis* Viira, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella a. absidata* Barrick & Klapper, *K. v. variabilis* Walliser, *K. v. ichnusae* Serpagli & Corradini, *Oul. siluricus* (Branson & Mehl) and *Panderodus u. unicostatus* (Branson & Mehl).

Remarks

In Sardinia, below the entry of *A. ploeckensis*, there is a narrow interval characterized by *Oz. excavata hamata*. Furthermore, from reserveded information provided us by Jeppsson (pers. comm. 27/06/97), *A. ploeckensis* has its first occurrence in Cellon in sample C.18 and not C.16A, so there is also an interval there below the entry of *A. ploeckensis* that can be identified using *Oz. exc. hamata* as marker.

The occurrence of *Oz. exc. hamata* in Nevada (Pete Hanson Creek Section IIE) and in Gotland below the entry of *A. ploeckensis*, as in the Carnic Alps and Sardinia, indicates that this biozone can be used not only locally, but also worldwide. In addition, the occurrence of graptolites of the *chimaera* Zone in horizons intercalated with the conodont bearing samples (Klapper & Murphy, 1975, fig.7, p.13) allows a good correlation with the graptolite zonation. Thus, the *Oz. excavata hamata* Zone is here formally introduced as a standard zone for the biostratigraphy of Sardinia to define a narrow interval below the *A. ploeckensis* Zone and seems to be valuable also for worldwide correlations.

Kockelella v. ichnusae has its first occurrence at the base of this zone, while *Oz. confluens* makes its entry in the upper part.

ANCORADELLA PLOECKENSIS ZONE

Lower limit

First occurrence of *Ancoradella ploeckensis.*

Upper limit

First occurrence of *Polygnathoides siluricus.*

Historical

This biozone was introduced by Walliser (1964), who reported the index from seven samples from the Cellon Section, the lowermost of which (C.16A) has subsequentely been show to bear specimens different from typical *A. ploeckensis* (Jeppsson, pers. com. 27.6.97). Therefore the biozone has a more restricted distribution, than originally envisaged by Walliser (1964).

This biozone has been regarded as a valid zone in many later biozonations and it is globally applicable, with only few local exceptions (e.g.: Central Appalachians, Eastern Baltic, Britain). According to Silurian Time n°3 (1995) this interval can be used to identify strata across the Gorstian-Ludfordian boundary, but, at least in Sardinia, the index species is not abundant.

Global Data

Australia: New South Wales (Link & Druce, 1972; Simpson & Talent, 1995)

North America: Nevada (Klapper & Murphy, 1975); Canada: Canadian Arctic Archipelago (Cornwallis Island, Uyeno, 1977, and Ellesmere Island, Uyeno, 1980, 1990); Canadian Cordillera (McCracken, 1991); Yukon and Nortwestern territories (Lenz & McCracken, 1989).

Europe: Bohemia (Marble Quarry) (Kriz *et al.*, 1986); Gotland (Hemse beds) (rare) (Fåhræus, 1969; Jeppsson *et. al.*, 1994)

Sardinian Data

The *A. ploeckensis* Zone has been recognized in many localities, either from the Ockerkalk facies of South-East (Silius I°, Riu Murru de Callus, Genna Arrela, San Basilio Fenugu) (Barca *et al.*, 1995; Corradini & Olivieri, 1997; Serpagli *et al.*, 1998), or from the "*Orthoceras* limestone" facies (Sant'Antonio Donigala, Su Nuargi, Perd'e Fogu, Sentiero Flumini, Galemmu) of the southwestern part of the island (Barca *et al.*, 1992; Ferretti *et al.*, 1998b).

AGE IN TERMS OF GRAPTOLITES - On the basis of the occurrence of *S. fritschi-linearis*, one sample (SF-BK 12), where the index *A. ploeckensis* is also present, has been regarded as belonging to the *leintwardinensis* Zone (Rickards *et al.* 1996, text-fig 9b).

Associated conodonts

SARDINIA - *Ancoradella ploeckensis* Walliser, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella a. absidata*

Barrick & Klapper, *K. a. sardoa* Serpagli & Corradini, *K. v. variabilis* Walliser, *K. v. ichnusae* Serpagli & Corradini, *Oulodus siluricus* (Branson & Mehl), *Ozarkodina exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Oz. exc. posthamata* (Walliser) and *Pseudooneotodus beckmanni* Bischoff & Sannemann.

WORLD - *Ancoradella ploeckensis* Walliser, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella a. absidata* Barrick & Klapper, *K. a. sardoa* Serpagli & Corradini, *K. v. variabilis* Walliser, *K. v. ichnusae* Serpagli & Corradini, *Oulodus siluricus* (Branson & Mehl), *Ozarkodina confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. exc. inflata* (Walliser), *Oz. exc. posthamata* (Walliser) and *Panderodus u. unicostatus* (Branson & Mehl), as well as a few endemic species like *Oz. roopaensis* Viira.

Remarks

As the index species not particularly abundant in Sardinia, this zone can partly be identified by the occurrence of *K. a. sardoa* or *Oz. exc. posthamata*: both have the same first occurrence, but the latter ranges only within the lower part of the interval.

Oz. exc. inflata became extinct within this zone, while *Kockelella v. variabilis* reaches the top.

POLYGNATHOIDES SILURICUS ZONE

Lower limit

First occurrence of *Polygnathoides siluricus.*

Upper limit

Last occurrence of *Polygnathoides siluricus.*

Historical

This is one of the less controversal Silurian conodont zones which, after being established by Walliser (1964), has been recognized in many sections throughout the world and widely used to date early Ludfordian beds. However, it should be pointed out that the recent recovery of the marker from central Asia (Koren & Walliser, 1998) seems to extend the time span of the zone to most of this stage. The success of this zone is mainly due to the easy identification of the marker whose biostratigraphical importance has never been disputed.

In North America, however, where the species was first recognised, the interval is not always recognisable because in some areas like Central Appalachians the index species is apparently missing.

Global Data

The index species *Po. siluricus* has been widely reported from middle Ludlow of Europe, North Africa, North America, central Asia, South China and Australia. A claimed occurrence of this biozone in South America (Hünicken & Sarmiento, 1986) is based on disputable data.

Sardinian Data

The *Po. siluricus* Zone has been recognized in many localities (Sant'Antonio Donigala, Su Nuargi, Perd'e Fogu, Sentiero Flumini, Galemmu) from the southwestern part of the island (Serpagli, 1971; Barca et al., 1992; Ferretti *et al.*, 1998b; plus unpublished data) as well as in a lot of sections from SE Sardinia (Genna Ciuerciu, Silius I°, Riu Murru de Callus, Genna Arrela, San Basilio Fenugu) (Barca *et al.*, 1995; Corradini & Olivieri, 1997; Corradini *et al.*, 1998c; Serpagli *et al.*, 1998; plus unpublished data).

Associated conodonts

SARDINIA - *Polygnathoides siluricus* Branson & Mehl, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella absidata absidata* Barrick & Klapper, *K. a. sardoa* Serpagli & Corradini, *K. maenniki* Serpagli & Corradini, *K. v. ichnusae* Serpagli & Corradini, *Oulodus siluricus* (Branson & Mehl), *Ozarkodina confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Pseudo-oneotodus beckmanni* Bischoff & Sannemann and *Ps. bicornis* Drygant.

WORLD - *Polygnathoides siluricus* Branson & Mehl, *Ancoradella ploeckensis* Walliser, *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Kockelella absidata absidata* Barrick & Klapper, *K. a. sardoa* Serpagli & Corradini, *K. maenniki* Serpagli & Corradini, *K. v. ichnusae* Serpagli & Corradini, *Oulodus siluricus* (Branson & Mehl), *Ozarkodina confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. fuereri* Lane & Ormiston, *Oz. snajdri* (Walliser) and *Panderodus u. unicostatus* (Branson & Mehl), as well as few endemic species like *Oz. roopaensis* Viira.

Remarks

Recently, *Po. siluricus* has been recovered in South Tien Shan (central Asia) from slightly younger strata than previously occurrencies (Koren & Walliser, 1998). Because these authors, as well as Jeppsson (pers. com., september 1994), believe that early and late forms can be recognised within *Po. siluricus*, it seems possible that in future this zone could be subdivided into two parts, and that the conventional *Po. siluricus* Zone could correspond to the lower one. We await information on the whole conodont association occurring with *Po. siluricus* in central Asia.

The FAD or the LAD of the marker is coincident with that of other members of the association: *Kockelella maenniki* appears at the base of the zone and seems to be exclusive to the lower part, whereas *K. absidata* s.l.

became extinct at the top of this interval.

In Sardinia *K. v. ichnusae* is not present in the upper part of the zone, whereas elsewhere it is reported up to the top (e.g. Cellon Section). *A. ploeckensis* has its last occurrence in the lower part of the biozone.

Pedavis latialata Zone

Lower limit

Last occurrence of *Polygnathoides siluricus.*

Upper limit

Last occurrence of *Pedavis latialata.*

Historical

This biozone was first introduced by Walliser (1964), who reported the index species from the Cellon section in three samples (C.25, C.27, C.28A). The biozone has been regarded as valid by Klapper & Murphy (1975), Uyeno (1980, 1990) and Drygant (1984).

In 1980 Schönlaub (*in* Chlupac *et al.*, 1980) denoted it to subzone rank, regarding *latialata* to be restricted to the basal part of the newly established *snajdri* Zone. Kriz *et al.* (1986) and Aldridge & Schönlaub (1989) did the same and considered *latialata* as a total-range sub-biozone occurring in the lower part of the *snajdri* Zone, which, according to them, is a more useful index species then the rarer *latialata*, being recognized more widely.

No record of this zone (or sub-zone) is present on the left hand columns reproduced on the 1995 (n.3) issue of "Silurian Times"; however only the zones (and not the sub-zones) were considered.

Finally, Kleffner (1995) in his Silurian composite standard chronostratigraphic chart regards *Pe.latialata* as a valid chronozone.

Global Data

Carnic Alps (Cellon Profile): *Pe. latialata* has its first occurrence just above the disappearance of *Po. siluricus* and disappears almost two meters before the first occurrence of *Oz. crispa.*

Nevada: In the Birch Creek II Section *Pe. latialata* occurs in sample 921 whereas *Po. siluricus* is present in the preceding sample 920 (Klapper & Murphy, 1975).

Canadian Arctic Archipelago: No detailed data are available. However, *Pe. latialata* is present in the lower part of the Devon Island Fm. whereas *Po. siluricus* occurs in the uppermost part of the underlying Douro Fm (Uyeno, 1980, 1990).

Bohemia: The first record of *Pe. latialata* from Bohemia is from the upper part of the Kopanina Fm. in Pozáry Quarry (Mehrtens & Barnett, 1976). Later, Schönlaub (1980) recorded *Pe. latialata* from Jarov Quarry, near Koledník, probably just above the *siluricus* interval, together with *Oz. snajdri.* Kríz *et al.* (1986) remarked on the occurrence of *Pe. latialata* in the lower 1-2 meters of *snajdri* Zone in Muslovka, Koledník and Marble quarries, then just above the *Po. siluricus* occurrence. They also recorded, in the Marble Quarry section, *Pe.* cf. *latialata* in beds bearing either *Po. siluricus* or *Oz. crispa.*

Central Asia: *Pe. latialata* has been reported in South Tien Shan from levels also bearing *Oz. crispa* (Koren & Walliser, 1998), apparently in a younger stratigraphical position than elsewhere.

Sardinian data

In Sardinia, *Pe. latialata* has been reported from the "Ockerkalk", cropping out in the southeastern part of the island. The species has been recognized from an horizon slightly above the last occurrence of *Po. siluricus* and just below the first appearance of *Oz. snajdri*, in Silius I° and Genna Ciuerciu sections (Barca *et al.*, 1995; Serpagli *et al.*, 1998; Corradini *et al.*, 1998c).

Associated conodonts

Sardinia - *Pedavis latialata* (Walliser), *Dapsilodus obliquicostatus* (Branson & Mehl), *Oulodus el. elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Ozarkodina confluens* (Branson & Mehl), *Oz. excavata excavata* (Branson & Mehl), *Panderodus recurvatus* (Rhodes), *Pseudooneotodus beckmanni* Bischoff & Sannemann, *Ps. bicornis* Drygant.

World – *Pedavis latialata* (Walliser), *Pe. thorsteinssoni* Uyeno, *Belodella devonica* Stauffer, *Coryssognathus dubius* (Rhodes), *Oulodus el. elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Ozarkodina confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. snajdri* (Walliser), *Oz.* sp. nov. A of Klapper & Murphy 1975 and *Panderodus u. unicostatus* (Branson & Mehl).

Remarks

The Sardinian data justify the reintroduction here of the *Pe. latialata* Zone as valid biozone for the recognition of strata just above the last occurrence of *Po. siluricus*. Therefore, the *Pe. latialata* Zone fits between the *Po. siluricus* Zone and the *Oz. snajdri* interval Zone, which is restricted to the interval between the LO of *Pe. latialata* and the FO of *Oz. crispa.*

All available data on the stratigraphic distribution of *Pe. latialata* fit very well with our proposal, except the newly and preliminarly reported ones from central Asia (Koren & Walliser, 1998). The Bohemian occurrence of specimens close to *Pe. latialata* in the the Marble Quarry Section (Kriz *et al.*, 1986) either with *Po. siluricus* or with *Oz. crispa* also need clarification.

Oul. el. elegans has its first occurrence at the base of the zone.

OZARKODINA SNAJDRI INTERVAL ZONE

Lower limit
Last occurrence of *Pedavis latialata.*
Upper limit
First occurence of *Ozarkodina crispa.*

Historical
The stratigraphical importance of *Oz. snajdri* was first recognized by Walliser (1964), although with a slightly different placement than in all subsequent zonations; the author, in fact, placed the "*snajdri* horizon" in the upper part of the *siluricus* Zone, but the data available to him come only from Bohemian samples.

Rexroad & Nicoll (1971) made useful biostratigraphical correlations in North America on the basis of the occurrence of *Oz. snajdri*, while Helfrich (1975), proposing a local biozonation in the Central Appalachian Mts., introduced *Oz. snajdri* at rank of biozone and placed it between two biozones, with index taxa (*Sp. bicornutus* and *Sp. tillmani*) apparently endemic to N. America.

In Europe the *Oz. snajdri* Zone was proposed only in 1980 by Schönlaub (in Chlupac *et al.*, 1980), who suggested use of the nominal taxon to indicate the interval between the *siluricus* and *crispa* biozones. Aldridge & Schönlaub (1989) placed its lower limit at the LAD of *Po. siluricus* and the upper one with the FAD of *Oz. crispa*. This definition has been used up to date, including in the "Left Hand Column" reported in Silurian Time no.3.

Global Data
The index species *Oz. snajdri* has been widely reported in Europe (Bohemia, British Isles, Austria and Estonia), North America (Missouri, Indiana, New York, Virginia, W. Virginia and Maryland) and Australia.

Sardinian Data
The *Oz. snajdri* Zone has been recognized only in the southeastern part of the island, where the nominal species has been reported in the Genna Ciuerciu and Silius I° sections from a thin level just above the occurrence of *Pe. latialata* and slightly below the first occurrence of *Oz. crispa* (Barca *et al.*, 1995; Serpagli *et al.*, 1998; Corradini *et al.*, 1998c).

Associated conodonts
SARDINIA - *Ozarkodina snajdri* (Walliser), *Oz. confluens* (Branson & Mehl), *Oz. excavata excavata* (Branson & Mehl), *Dapsilodus obliquicostatus* (Branson & Mehl), *Oulodus elegans elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Panderodus recurvatus* (Rhodes), *Pseudooneotodus beckmanni* Bischoff & Sannemann, *Ps. bicornis* Drygant.

WORLD – *Ozarkodina snajdri* (Walliser), *Oz. confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. tillmani* (Helfrich), *Belodella devonica* Stauffer, *Coryssognathus dubius* (Rhodes), *Oulodus el. elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Panderodus u. unicostatus* (Branson & Mehl), *Pe. thorsteinssoni* Uyeno and *Pseudooneotodus bicornis* Drygant.

Remarks
The index species is long-ranging, spanning from the *Po. siluricus* Zone to the *Oz. crispa* Zone. However, because of the proposed reintroduction of the *Pe. latialata* Zone, the range of the *Oz. snajdri* interval Zone is reduced to between the LAD of *Pe. latialata* and the FAD of *Oz. crispa*. In Sardinia the FO of *Oz. snajdri* has been always reported just above the LO of *Pe. latialata*, without any co-occurrence between the two species, and in many sections there is also no co-occurrence of *Oz. snajdri* and *Oz. crispa*.

OZARKODINA CRISPA ZONE

Lower limit
First occurence of *Ozarkodina crispa.*
Upper limit
Last occurence of *Ozarkodina crispa.*

Historical
This biozone was first introduced by Walliser (1964), who reported the index species from the Cellon section in samples C.30A, C.31A, C.32 and from one level in the Santa Creu Section (Spain). Helfrich (1975) and Klapper & Murphy (1975) recognized the *crispa* Zone in different areas of North America (Central Appalachian and Nevada respectively). Schönlaub, after have questioned (1980) whether the *crispa* Zone should be considered a valid biozone or a sub-biozone of the *eosteinhornensis* Zone, late Aldridge & Schönlaub (1989) accepted the *crispa* Zone as a total range zone. This definition has been used to date, including in the "Left Hand Column" reported in Silurian Time n.3.

Global Data
Oz. crispa has been widely reported from the late Ludlow of Europe, North America, South China, Indonesia and Australia. Recently it has been also reported from late Ludlow and Prídolí of central Asia (Koren & Walliser, 1998).

Sardinian Data
In Sardinia, *Oz. crispa* has been reported from some sections (Genna Ciuerciu, Silius I°, Riu Murru de Callus and S. Basilio Fenugu) in the southeastern part of the island (Barca *et al.*, 1995; Serpagli *et al.*, 1998; Corradini *et al.*, 1998c; unpublished data).

Associated conodonts

SARDINIA - *Ozarkodina crispa* (Walliser), *Oz. confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. rem. eosteinhornensis* (Walliser), *Oz. snajdri* (Walliser), *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Oulodus elegans elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Panderodus recurvatus* (Rhodes), *Pelekysgnathus index* Klapper & Murphy, *Pseudooneotodus beckmanni* Bischoff & Sannemann and *Ps. bicornis* Drygant.

WORLD – *Ozarkodina crispa* (Walliser), *Oz. confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. rem. eosteinhornensis* (Walliser), *Oz. snajdri* (Walliser), *Belodella devonica* Stauffer, *Coryssognathus dubius* (Rhodes), *Oulodus el. elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Panderodus u. unicostatus* (Branson & Mehl), *Pedavis thorsteinssoni* Uyeno and *Pelekysgnathus index* Klapper & Murphy.

Remarks

The recent data of Koren & Walliser (1998), stressing a Přídolí occurrence of *Oz. crispa* (up to the lowermost part of the *bouceki-transgrediens* Zone), offer up discussion on the span of this zone, which up to now has been one of the less controversial worldwide conodont intervals (Text-fig. 4). In Gondwanan sections, for instance, where graptolite data are also available (Bohemia, Cellon), *Oz. crispa* became extinct just below the first occurrence of *Monograptus parultimus* (Kriz *et al.*, 1986), indicating the LAD of *Oz. crispa* as the best conodont datum to approximate the Ludlow-Přídolí boundary.

Sardinian data do not contribute to solving this problem, because we have no levels, either in the SW or in the SE, where *Oz. crispa* occurs together with graptolites. However, in agreement with Gondwanan data and pending a complete study of the whole conodont fauna associated with *Oz. crispa* in central Asia, we prefer to consider the *Oz. crispa* Zone as a total range Zone in the latest Ludlow.

Oz. rem. eosteinhornensis has its first occurrence within this zone.

OZARKODINA REMSCHEIDENSIS INTERVAL ZONE

Lower limit

Last occurence of *Ozarkodina crispa.*

Upper limit

First occurrence of *Oulodus elegans detortus.*

Historical

Walliser (1964) first recognised this interval, naming it "*eosteinhornensis* Zone", as the youngest Silurian conodont zone. Subsequently the nominal species has also been reported from the late Ludlow, together with *Oz. crispa* and *Oz. snajdri*, and immediately the problem of the definition of this zone arose. Schönlaub (in Kriz *et al.*, 1986) suggested that this zone should be regarded an "assemblage zone" possibly defined by the absence of *Oz. crispa, Oz. snajdri* and *Oz. confluens* (pag. 336).

Jeppsson (1988) proposed a more detailed subdivision of the Přídolí and his "*eosteinhornensis* s.s. Zone" is more restricted than other concepts. Aldridge & Schönlaub (1989) went back to a wider concept of the *eosteinhornensis* Zone and defined it as an interval zone between the LAD of *Oz. crispa* and the FAD of *I. w. woschmidti*, thus ranging more or less troughout the whole Přídolí .

Finally, in the "Left Hand Column" reported in Silurian Time n.3 the zone has been split in two parts: a wider *Oz. remscheidensis* interval Zone below and a narrow *Oz. eosteinhornensis - Oul. el. detorta* Zone above.

Global Data

The *Oz. rem. eosteinhornensis* Zone has been widely reported from Europe, North America, South China, Malaya and Australia, but, as pointed out in the historical review, with slightly different concepts among various authors.

Sardinian Data

The *Oz. remscheidensis* interval Zone has been recognized in many sections from SE Sardinia (Genna Ciuerciu, Silius I°, Riu Murru de Callus, Genna Arrela, Ponte Monte Lora, San Basilio Fenugu) (Barca *et al.*, 1995; Corradini & Olivieri, 1997; Corradini *et al.*, 1998c; Serpagli *et al.*, 1998; Leone *et al.*, in press), as well in the Mason Porcus section (Gnoli *et al.*, 1988; Olivieri & Serpagli, 1990), Argiola (Corradini *et al.*, 1998b) and in other localities (Sentiero Flumini, Galemmu) from the southwestern part of the island (unpublished data).

Associated conodonts

SARDINIA – *Ozarkodina rem. eosteinhornensis* (Walliser), *Oz. rem. remscheidensis* (Ziegler), *Oz. confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Oul. elegans elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Pseudooneotodus beckmanni* Bischoff & Sannemann, *Ps. bicornis* Drygant.

WORLD – *Ozarkodina rem. eosteinhornensis* (Walliser), *Oz. rem. remscheidensis* (Ziegler), *Oz. confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. snajdri parasnajdri* Viira & Aldridge, *Belodella devonica* Stauffer, *B. resima* Philip, *Coryssognathus dubius* (Rhodes), *Oulodus el. elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Panderodus*

u. unicostatus (Branson & Mehl) and *Pelekysgnathus index* Klapper & Murphy.

Remarks

Previously in Sardinia we have used the name "*eosteinhornensis* Zone" to "indicate" rocks of the whole Pridoli (see below, in the discussion of the *Oul. el. detortus* Zone).

The conodont frequency in Sardinia through this interval is very low, but it is possible to note that:
(a) *Oz. rem. eosteinhornensis* α-morph (*sensu* Olivieri & Serpagli, 1990) has a long range, from near the base of the *crispa* Zone to the whole *detortus* Zone (Sardinia), or even to the lowermost Devonian (Bohemia).
(b) The morphotype β (sensu Olivieri & Serpagli, 1990) has its first occurrence in the upper part of the biozone, more or less coincident with the appearance of *Oz. rem. remscheidensis* (at least in Sardinia). The entry of *Oz. rem remscheidensis* also occurs more or less at the same time in North America and has been used to indicate the base of an informal "uppermost *eosteinhornensis* Zone" (Klapper & Murphy, 1975).

We agree with the compromise of defining this interval zone on the name of the species *Oz. remscheidensis* (and not on one of its subspecies), thereby leaving open the possibility of a more detailed subdivision of this interval (Jeppsson, 1988; Jeppsson *et al.*, 1994). This seems to be possible only in non tectonized areas with well preserved and abundant faunas, like Gotland and Bohemia.

Oulodus elegans detortus Zone

Lower limit

First occurence of *Oulodus elegans detortus.*

Upper limit

First occurrence of *Icriodus u. woschmidti.*

Historical

This bio-interval has been recognized in Southern Sweden by Jeppsson (1975) as the "*Ligonodina el. detorta* fauna" and erected to biozone rank by the same author (Jeppson, 1988) to represent the latest Silurian conodont zone, at the top of the Přídolí. It has been officially accepted on the"Left Hand Column" of "Silurian Times 3 (1995), where it is indicated as the "*Oz. eosteinhornensis - Oul. el. detorta* Zone".

Global Data

Being recently introduced, this biozone has been recognized only in Bohemia (Jeppsson, 1988), Oklahoma (Barrick & Klapper, 1992), Gotland and Estonia (Jeppsson *et al.*, 1994; Viira & Männik, 1997), Spain (Sarmiento *et al.*, 1998), central Asia (Koren & Walliser, 1998) and Morocco (Haude & Walliser, 1998), but, according to Jeppsson (1988), it also occurs in the Cellon Section (C.45-C.46A), Poland (Chelm core) and the former Spanish Sahara.

Sardinian Data

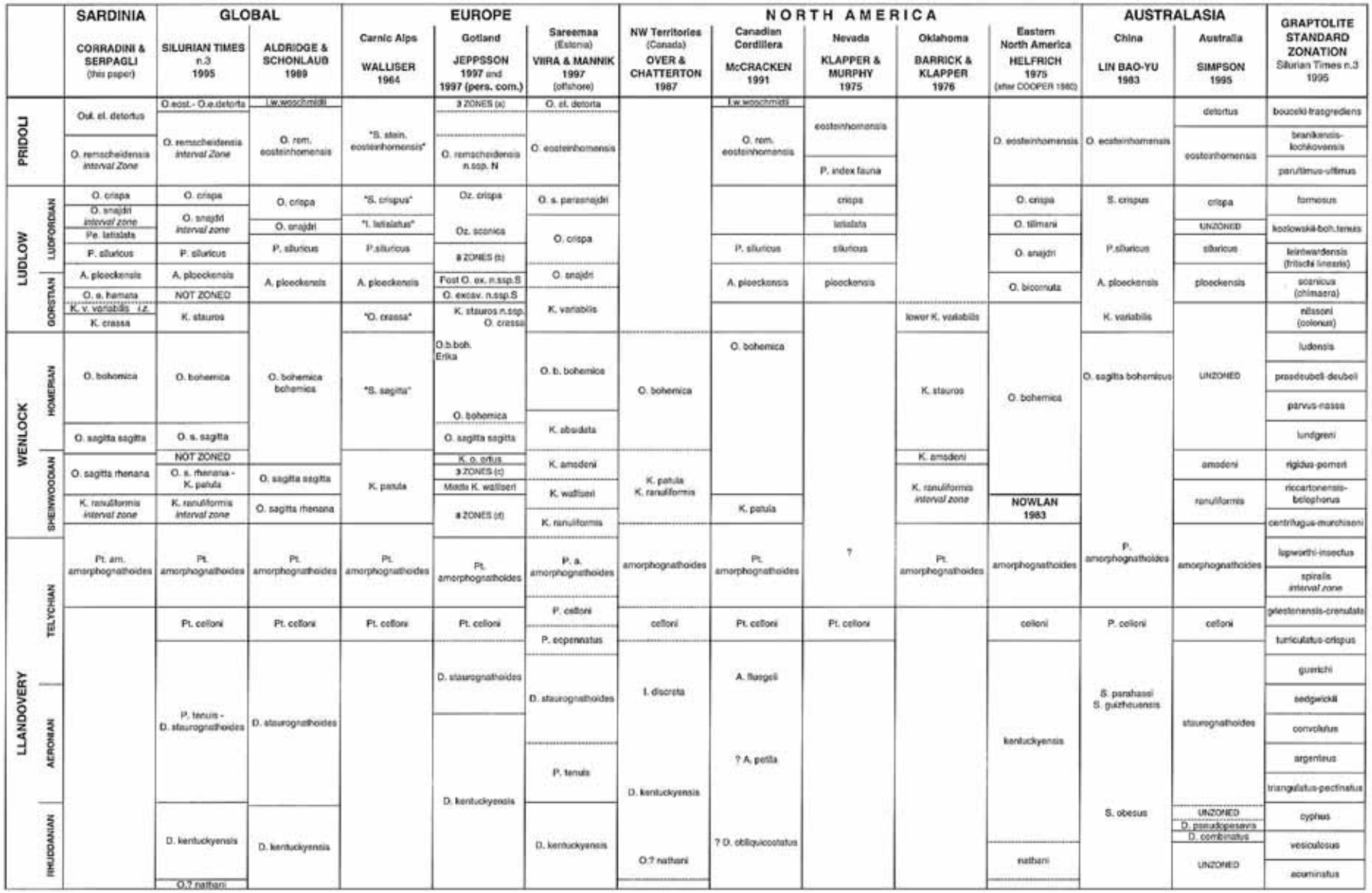
The *Oul. el. detortus* Zone has been recognized in some sections from SE Sardinia (Genna Ciuerciu, Silius I°, Genna Arrela, San Basilio Fenugu) (Barca *et al.*, 1995; Corradini & Olivieri, 1997; Corradini *et al.*, 1998c; Serpagli *et al.*, 1998; and unpublished data), as well as in the Mason Porcus section (Gnoli *et al.*, 1988; Olivieri & Serpagli, 1990), Argiola (Corradini *et al.*, 1998b) and in other localities (Sentiero Flumini, Roia is Tintionis) from the southwestern part of the island (unpublished data). In these sections this interval has formerly been considered as a subzone.

Associated conodonts

SARDINIA - *Oulodus elegans detortus* (Walliser), *Oul. elegans elegans* (Walliser), *Oul. siluricus* (Branson & Mehl), *Coryssognathus dubius* (Rhodes), *Dapsilodus obliquicostatus* (Branson & Mehl), *Ozarkodina confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. rem. remscheidensis* (Ziegler), *Oz. rem. eosteinhornensis* (Walliser) (α and β morph.), *Pseudooneotodus beckmanni* Bischoff & Sannemann and *Ps. bicornis* Drygant.

WORLD – *Oulodus elegans detortus* (Walliser), *Oul. elegans elegans* (Walliser), *Belodella anfracta* Barrick & Klapper, *B. coarctata* Barrick & Klapper, *B. devonica* Stauffer, *B. mira* Khodalevich & Chernikh, *Dvorakia amsdeni* Barrick & Klapper, *Dv. philipi* (Drygant), *Ozarkodina confluens* (Branson & Mehl), *Oz. exc. excavata* (Branson & Mehl), *Oz. rem. remscheidensis* (Ziegler), *Oz. rem. eosteinhornensis* (Walliser), *Panderodus u. unicostatus* (Branson & Mehl) and *Pseudooneotodus beckmanni* Bischoff & Sannemann.

Text-fig.4 - Comparative scheme of the main Silurian conodont biozonations proposed by different authors in various part of the world. In the right column the Graptolite Standard is illustrated. For graphical reasons it was impossible to include all the biozones in the Jeppsson column.The intervals not fully reported are here clarified:
a. *Oul. elegans detorta* Zone; *Oz. remscheidensis* Zone; *Oz. eosteinhornensis* s. str..
b. *P. equicostatus*; not named interval; upper *P. siluricus*; middle *P. siluricus*; lower *P. siluricus*; *Oul. siluricus* acme; *A. ploeckensis*; *O. excavata* n.ssp.A.
c. post *K. walliseri* interregnum; uppermost *K. walliseri* range; *K. patula.*
d. middle *K. walliseri*; lower *K. walliseri*; *O. s. rhenana*; upper *K. ranuliformis*; lower *K. ranuliformis*; upper *P. procerus*; lower *P. procerus*; upper *Ps. bicornis*; lower *Ps. bicornis.*


SARDINIA
CORRADINI & SERPAGLI (this paper)
GLOBAL
SILURIAN TIMES n.3 1995
ALDRIDGE & SCHONLAUB 1989
EUROPE
Carnic Alps
WALLISER 1964
Gotland
JEPPSSON 1997 and 1997 (pers. com.)
Sareemaa (Estonia)
VIIRA & MANNIK 1997 (offshore)
NORTH AMERICA
NW Territories (Canada)
OVER & CHATTERTON 1987
Canadian Cordillera
McCRACKEN 1991
Nevada
KLAPPER & MURPHY 1975
Oklahoma
BARRICK & KLAPPER 1976
Eastern North America
HELFRICH 1975 (after COOPER 1960)
AUSTRALASIA
China
LIN BAO-YU 1983
Australia
SIMPSON 1995
GRAPTOLITE STANDARD ZONATION
Silurian Times n.3 1995
PRIDOLI
LUDLOW
LUDFORDIAN
GORSTIAN
WENLOCK
HOMERIAN
SHEINWOODIAN
LLANDOVERY
TELYCHIAN
AERONIAN
RHUDDANIAN
O. crispa
O. snajdri interval zone
Pe. latilata
P. siluricus
A. ploeckensis
O. s. hamata
K. v. variabilis i.z.
K. crassa
O. bohemica
O. sagitta sagitta
O. sagitta rhenana
K. ranuliformis interval zone
Pt. am. amorphognathoides
Pt. celloni
P. tenuis - D. staurognathoides
D. kentuckyensis
O.? nathani
Out. el. detortus
O. remscheidensis interval Zone
O. ost.- O.e.detorta
O. rem. eosteinhomensis
I.w.woschmidti
O. crispa
O. snajdri interval zone
P. siluricus
A. ploeckensis
NOT ZONED
K. stauros
O. sagitta sagitta
NOT ZONED
O. s. rhenana - K. patula
K. ranuliformis interval zone
Pt. amorphognathoides
Pt. celloni
D. staurognathoides
D. kentuckyensis
O. crispa
O. snajdri
P. siluricus
A. ploeckensis
O. sagitta sagitta
K. ranuliformis interval zone
Pt. amorphognathoides
Pt. celloni
D. staurognathoides
D. kentuckyensis
"S. stein. eosteinhomensis"
"S. crispus"
"I. latilatus"
P. siluricus
A. ploeckensis
"O. crassa"
"S. sagittu"
K. patula
Pt. amorphognathoides
Pt. celloni
D. staurognathoides
D. kentuckyensis
3 ZONES (a)
O. remscheidensis n.ssp. N
Oz. crispa
Oz. sconica
8 ZONES (b)
Fost O. ex. n.ssp.S
O. excav. n.ssp.S
K. stauros n.ssp. O. crassa
O.b.boh. Erika
O. bohemica
O. sagitta sagitta
K. o. orbus
3 ZONES (c)
Mixite K. walliseri
8 ZONES (d)
Pt. amorphognathoides
Pt. celloni
D. staurognathoides
D. kentuckyensis
O. el. detorta
O. eosteinhomensis
O. s. parasnajdi
O. crispa
K. variabilis
O. b. bohemica
K. absidata
K. amsdeni
K. walliseri
K. ranuliformis
P. a. amorphognathoides
P. celloni
P. eopennatus
D. staurognathoides
P. tenuis
D. kentuckyensis
O. bohemica
K. patula K. ranuliformis
amorphognathoides
celloni
I. discreta
D. kentuckyensis
O.? nathani
O. bohemica
K. patula
Pt. amorphognathoides
Pt. celloni
A. fluegeli
? A. petila
? D. obliquicostatus
eosteinhomensis
O. rem. eosteinhomensis
P. index fauna
crispa
latilatis
P. siluricus
A. ploeckensis
K. stauros
K. amsdeni
K. ranuliformis interval zone
K. patula
?
Pt. celloni
kentuckyensis
lower K. variabilis
K. stauros
K. amsdeni
K. ranuliformis interval zone
Pt. amorphognathoides
D. eosteinhomensis
O. crispa
O. tillmani
O. snajdri
O. biconnuta
O. bohemica
NOWLAN 1983
amorphognathoides
celloni
nathani
O. eosteinhomensis
S. crispus
P.siluricus
A. ploeckensis
K. variabilis
O. sagitta bohemicus
P. amorphognathoides
P. celloni
S. parahassi
S. guizhouensis
S. obesus
detortus
eosteinhomensis
crispa
UNZONED
silaricus
ploeckensis
UNZONED
amsdeni
ranuliformis
amorphognathoides
celloni
staurognathoides
UNZONED
D. pseudopesavis
D. combinatus
UNZONED
boucekl-trasgrediens
brankensis-lochkovensis
parultimus-ultimus
formosus
kozlowskii-boh.tenuis
lelntwardensis (fritschi linearis)
scanicus (chlmaera)
nilssoni (colonus)
ludensis
praedeubeli-deubeli
parvus-nassa
lundgreni
rigidus-pomeri
riccartonensis-bolophorus
centrifugus-murchisoni
lapworthi-insectus
spiralis interval zone
gleistenensis-crenulata
turriculatus-crispus
guerichi
sedgwickii
convolutus
argenteus
triangulatus-pectinatus
cyphus
vesiculosus
acuminatus

Remarks

In Sardinia this bio-interval has been used several times as a subzone (e.g.: Barca *et al.*, 1995; Corradini & Olivieri, 1997), but the easy recognition of the index subspecies in many sections and localities, both in the Ockerkalk and in the "*Orthoceras* limestone", makes it more appropriate to regard this interval as a true zone.

It is interesting to point out that in one section in SE Sardinia (Genna Ciuerciu) a lobolith bearing level occurs at the level of the entry of *Oul. el. detortus* (Barca *et al.*, 1995; Corradini *et. al.*, 1998c), in agreement with data from Morocco, as recorded by Haude & Walliser (1998). It cannot therefore be excluded that there is a stratigraphical tie between the base of the *Oul. el. detortus* and the first occurrence of scyphocrinoids with cirrus loboliths in North Gondwana.

In the Left Hand column (Silurian Times 3, 1997) this biointerval was indicated as the "*O. eosteinhornensis- O.e.detorta* Zone", but we consider it should be named using only one index (*Oul. el. detortus*) and not two, at least until the various subspecies of the *Oz. remscheidensis* group are better known.

DISCUSSION AND CONCLUSION

A comparision between the Sardinian Biozonation proposed here (mainly based on the one preliminarly proposed in the ECOS VII Sardinia Field Trip Guidebook; Corradini & Serpagli, 1998a) and the main schemes provided for different part of the world is shown in Text-fig. 4; the graptolite standard zonation is also tentatively reported on the right side of the figure.

The main differences between our proposals and the other schemes can be summarized as follows:

- the Sardinian Silurian Conodont Zonation provides increased detail in Ludlow time, which is subdivided in eight biointervals. Only the subdivision proposed by Jeppsson (pers. com.) is more detailed, but this is probably not appropriate for worldwide use.
- the post-*bohemica* - pre-*ploeckensis* interval can be subdived into three: *K. crassa* Zone, *K. v. variabilis* interval Zone and *Oz. exc. hamata* Zone, providing a more detailed division of the Gorstian than in any previous zonation.
- the *K. crassa* Zone, as here interpreted, corresponds to the lower part of the "*stauros* Zone" of Silurian Times 3. As pointed out above, the range of *K. stauros* seems to extend into older strata than the first occurrence of *K. crassa*; thus we belive that to confirm a *K. stauros* Zone it is necessary to clarify either the variability of that species or its stratigraphical position. A correlation between this interval and the equivalent graptolite *nilssoni* (*colonus)* Zone (lower part) seems to be well estabilished.
- the *Oz. exc. hamata* Zone is here formally proposed as a standard zone to span a narrow interval just below the *A. ploeckensis* Zone.
- the *Pe. latialata* Zone is reintroduced as a valid biozone to recognize strata just above the *Po. siluricus* Zone; thus, the *Oz. snajdri* interval Zone is shorter than reported previously.
- the *Oul. el. detortus* Zone identifies the top Pridoli beds.

Some conodont zones are widely reported around the world (*Pt. am. amorphognathoides*, *Oz. s. sagitta*, *Oz. bohemica*, *A. ploeckensis*, *Po. siluricus*, *Oz. crispa* and *Oz. remscheidensis* i.Z.), even if sometimes with slightly different definitions and time ranges. However, in some areas (Estonia) the absence of important markers, like *Po. siluricus*, complicates correlations between these regions and elsewhere.

It is also difficult to correlate the preliminary data from central Asia (Koren & Walliser, 1998), where the stratigraphical distribution of some important taxa, like *Po. siluricus*, *Pe. latialata* and *Oz. crispa*, appears to be quite different from elsewhere. Only when the whole conodont fauna from that area is studied and illustrated will it be possible to state if that preliminary data can be used for global or local correlations.

As pointed out in the regional occurrences of the various zones described above, the biozonation scheme proposed for Sardinia also applies well to many sections in different localities around the world. For instance, in the Cellon Section, the reference section for Silurian conodont biostratigraphy, all our biozones can be recognized (Text -fig. 5). Here, the *detortus* Zone has been identified by Jeppsson (1988) from beds 45 to 46A, and another zone not recognized by Walliser (1964), the *snajdri* Zone, is identifiable as an interval-zone between the last occurrence of *Pe. latialata* and the first occurence of *Oz. crispa* (C.28B-C.30). The *Oz. bohemica* Zone corresponds to the narrow black shales interval between samples C.15A and C.15B$_1$. It is more difficult to identify divisions of the interval between the last occurrence of *Pt. amorphognatoides* and the first occurrence of *Oz. s. sagitta*, because *Oz. s. rhenana* is apparently missing. However, if *K. patula* is exclusive to the *rhenana* Zone, its entry in sample C.12B may suggest that the *ranuliformis* interval Zone is limited to the narrow black shale horizon between samples C.12A and C.12B and that the *rhenana* Zone can be placed from C.12B to C.13B.

To conclude, our proposal seems to be of pratical use for Silurian biostratigraphy globally, and therefore more generally useful than extremely detailed schemes, sometimes based on not yet defined or endemic taxa; such detailed zonations are, however, good when related to particular facies of limited areas.

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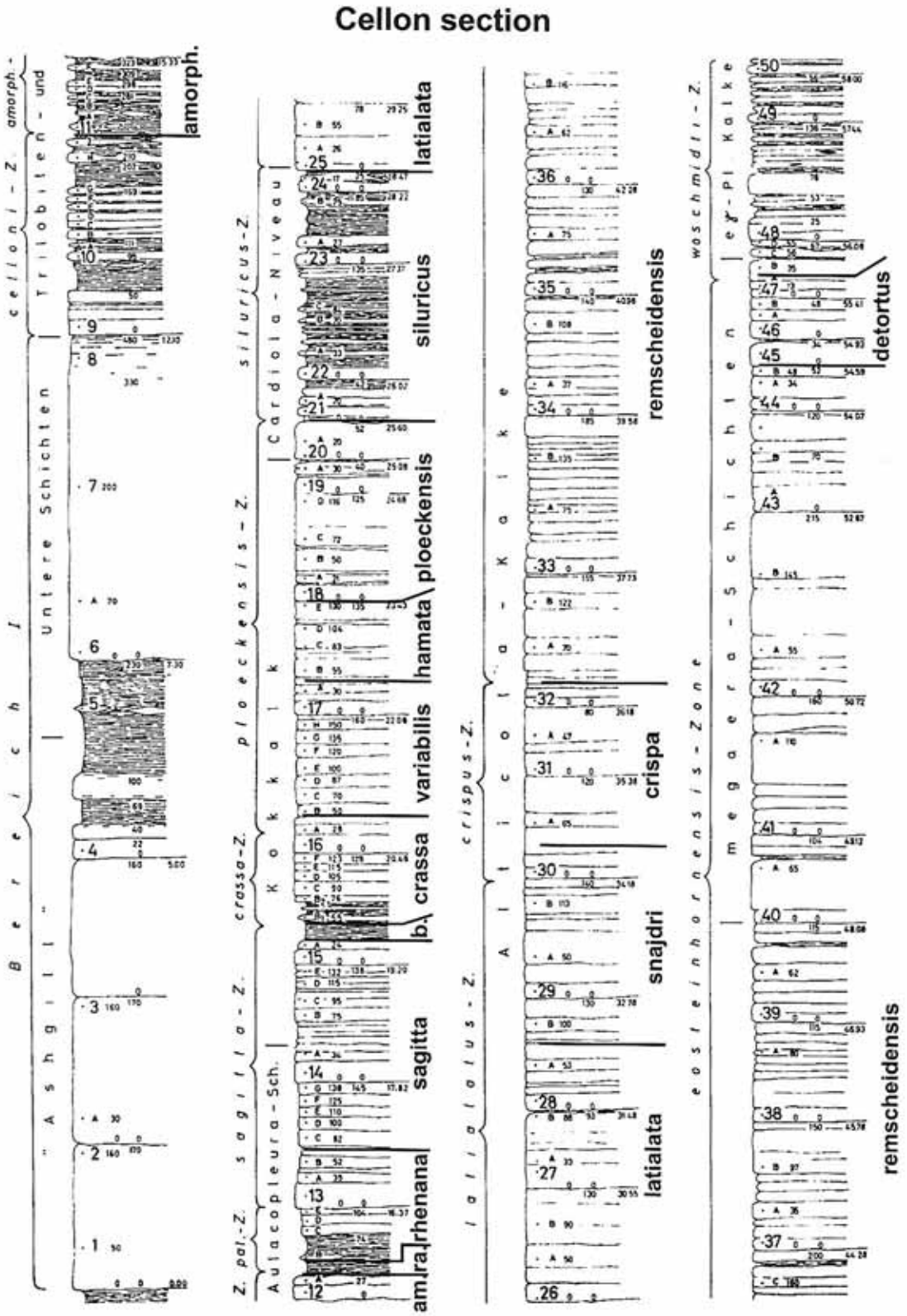

Text-fig. 5 - The Sardinian Conodont biozonation plotted against the Cellon section (Walliser, 1964). All our zones have been identified. See the text for discussion.

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