Rend. Soc. Paleont. Ital., 1 (2002): 69-76

The Gerrei tectonic Unit (SE Sardinia, Italy)

CARLO CORRADINI, ANNALISA FERRETTI and ENRICO SERPAGLI

C. Corradini - Dipartimento di Scienze della Terra, Università di Cagliari, via Trentino 51, I-09127 Cagliari (Italy); corradin@unica.it
A. Ferretti, E. Serpagli - Dipartimento del Museo di Paleobiologia e dell'Orto Botanico, Università di Modena e Reggio Emilia, via Università 4, I-41100 Modena (Italy); ferretti@unimo.it, serpagli@unimo.it

The Gerrei tectonic Unit is one of the main units of the External Nappes Zone of Central-Southern Sardinia. It represents the unit bearing the most complete Lower-Middle Palaeozoic sequences, which were only mildly affected by metamorphic effects. Most of its components are not jet officially defined and informal names are still in use in literature (so our citations in inverted commas).

Thick terrigenous sediments, known as San Vito Sandstones (Calvino, 1961) and probably exceeding 500 m in thickness, are present at the base of the Gerrei Unit (Fig. 1). Monotonous alternances of grey micaceous sandstones, quartzites, siltites and pelites grade to levels of violet, greenish or blackish pelites and thick layers of coarse light-grey quartzites and conglomerates. Rare recrystallized grey unfossiliferous limestones are intercalated in the upper part. The age of this part of the Gerrei Unit spans from Middle Cambrian to Early Ordovician (Tremadoc-Arenig) on the basis of a rich acritarch association there recovered (Barca, 1998 and references herein). A wide submarine fan-delta system, swept by turbidity currents, was inferred (Barca & Di Gregorio, 1979; Barca *et al*., 1981; Barca & Maxia, 1982).

The San Vito Sandstones are unconformably covered (Sarrabese Phase) by an "Ordovician volcanic complex" (volcanites, volcanoclastites and epiclastites), up to 400-500 m thick. These volcanic products have calc-alkaline affinity and the composition varies from acid (rhyolites and rhyodacites) to intermediate and basic (andesites and basalts) (Carmignani *et al.*, 1992). The top of the complex ("Porfiroidi" *Auct*.) is represented by whitish rhyolites and grey rhyodacites (flows, ignimbrites and tuffs). The origin of these volcanic products is a magmatic arc, which existed for most of the Ordovician (Arenig to Caradoc), related to subduction of oceanic crust under the North Gondwanian continental margin (Carmignani *et al*., 1992).

The subduction ceased in the Late Ordovician and the following gravitative collapse of the magmatic arc produced extensional stresses associated with basaltic intercalations in terrigenous continental to littoral sediments. Quartzites, sandstones and rarely conglomerates, greyish siltites and argillites with variable carbonatic content were deposited ("Caradocian transgression"). Lateral variations in facies and thickness, mostly at the base of the sequence, reveal the former irregular palaeotopography. The fossil content of this part of the Gerrei Unit is very scarce and limited to reports of cystoids, brachiopods and solitary corals (Helmcke, 1973; Helmcke & Koch, 1974; Naud, 1979). A rich bryozoan association, mostly composed of cryptostome bryozoans, was described by Conti (1990). The topmost calcareous beds, locally silicifed, are constituted by echinoderm-or bryozoan packstones (Fig. 2) intercalated in fossiliferous mudstones with bryozoan, echinoderm, brachiopod and trilobite debris. Rare ostracodes are also present. Conodonts from these limestones have recently documented the Late Ordovician (Ashgill) *Amorphognathus ordovicicus* Zone (Ferretti *et al*., 1998a, b; Ferretti & Serpagli, 1999). The conodont

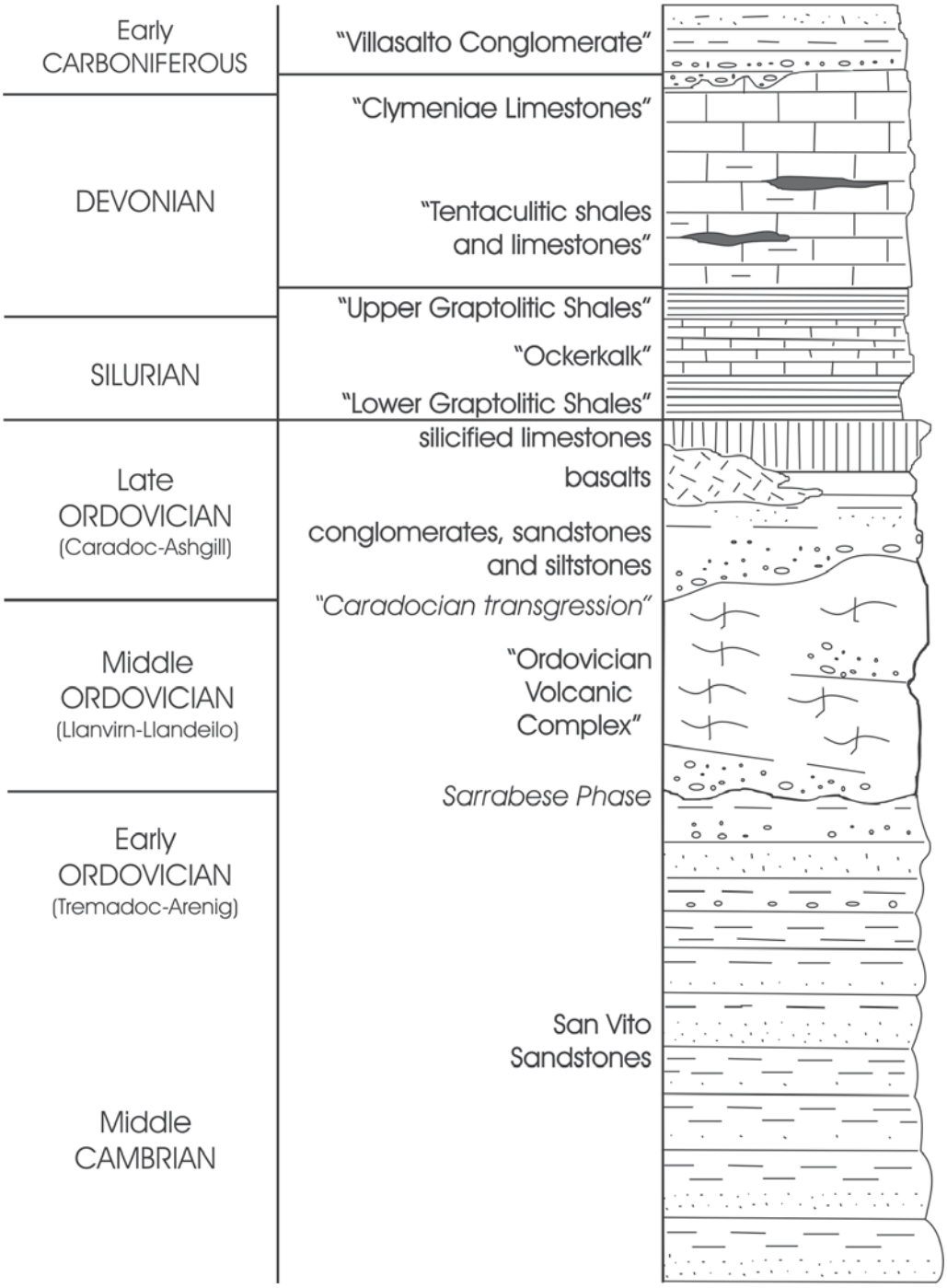


Fig. 1 – Stratigraphic column of the Gerrei tectonic Unit (not to scale). Modified after Corradini *et al*. (2002, in press).

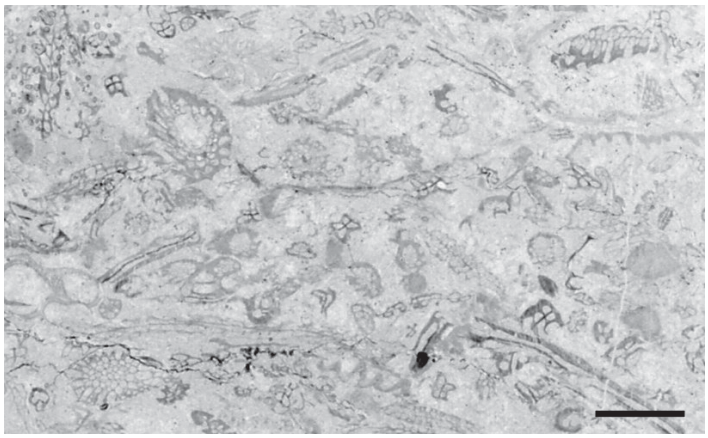


Fig. 2 – Bryozoan packstone with echinoderm debris. Sample Umbrarutta 15, Late Ordovician. Scale bar=2 mm.

association has a typical mixed character and suggests faunistic interchange with both the British and Baltic conodont provinces. Sardinia probably occupied an outer position of lower latitudes compared to the typical North-Gondwanian regions of the circumpolar belt (Ferretti & Serpagli, 1999).

The Silurian and Early Devonian are represented by a calcareous unit ("Ockerkalk") sandwiched between two shaley units ("Lower Graptolitic Shales" and "Upper Graptolitic Shales" respectively) (Fig. 4). A very close situation occurs in Thuringia (Jaeger, 1976, 1977). The "Lower Graptolitic Shales" (30-40 m) are silica-argillaceous and siltitic shales rich in carbon and pyrite ("alum slates"; Jaeger, 1977). Lydites (cherts) are interbedded in the lower part as well as phosphorites occur in the middle-upper part of the unit. Graptolites (Fig. 3) are the most important fossils of this unit. Numerous graptolite zones of Llandovery to earliest Ludlow age have been so far documented (Fig. 4) (Jaeger, 1977; Barca & Jaeger, 1990).

The "Ockerkalk" (25 m thick) is an argillaceous flaser limestone with a blue-grey colour weathered to ochre, from which its name is derived. Crinoidal stems and rare cephalopods are the only macrofossils recognizable in the outcrop. Trace fossils and very small solitary corals were reported from the "Ockerkalk" by Jaeger (1977). The lobolith-horizon with bulbous holdfasts of giant pelagic scyphocrinoids, well known across the Silurian/Devonian boundary along the Northern Gondwana margin, occurs in the upper part of this unit. Microbiofacies analysis reveals fine micritic limestones with a fossil content (ostracodes, brachiopods, thin-shelled bivalves, trilobite and echinoderm fragments, gastropods, sponge spiculae) scattered in the matrix and only locally concentrated in millimetric shell-lags of disarticulated debris (Barca *et al*., 1995; Ferretti & Serpagli, 1996). Phyllocarids (mainly mandibles) were recovered from the conodont heavy-fraction. The precise age location of the unit has been possible with the recent description of a rich conodont fauna of Ludlow-Pridoli age (Fig. 4) spanning from the *Oz. e. hamata* to the *O. e. detortus* zones (Barca *et al*., 1995; Corradini & Olivieri, 1997, Corradini *et al*., 1998, 1999, 2000; Serpagli *et al*., 1998).

The "Upper Graptolitic Shales" (about 30 m) are exclusively composed of alum slates (Barca & Jaeger, 1990). Pelagic graptolites are the only abundant fossils found throughout the unit (Jaeger, 1977). Rare *Ceriatocaris* (Jaeger, 1977) and a single specimen of pterineid bivalve (Barca & Jaeger, 1990) have been so far recorded. According to the composite section proposed by Barca & Jaeger (1990), *Scyphocrinites* also occurs in the lower part

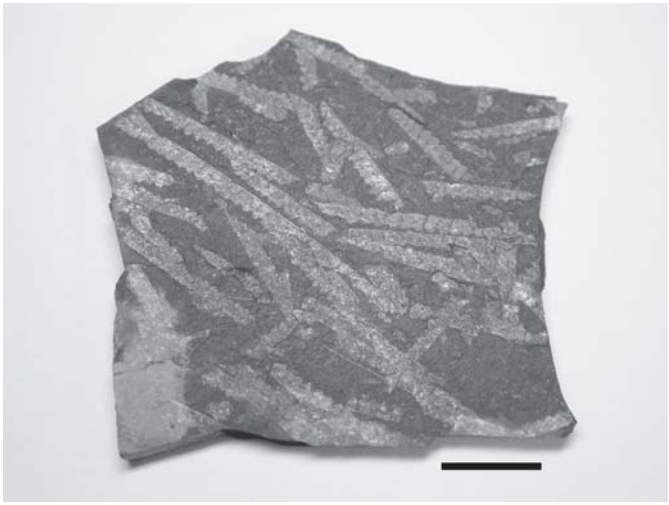


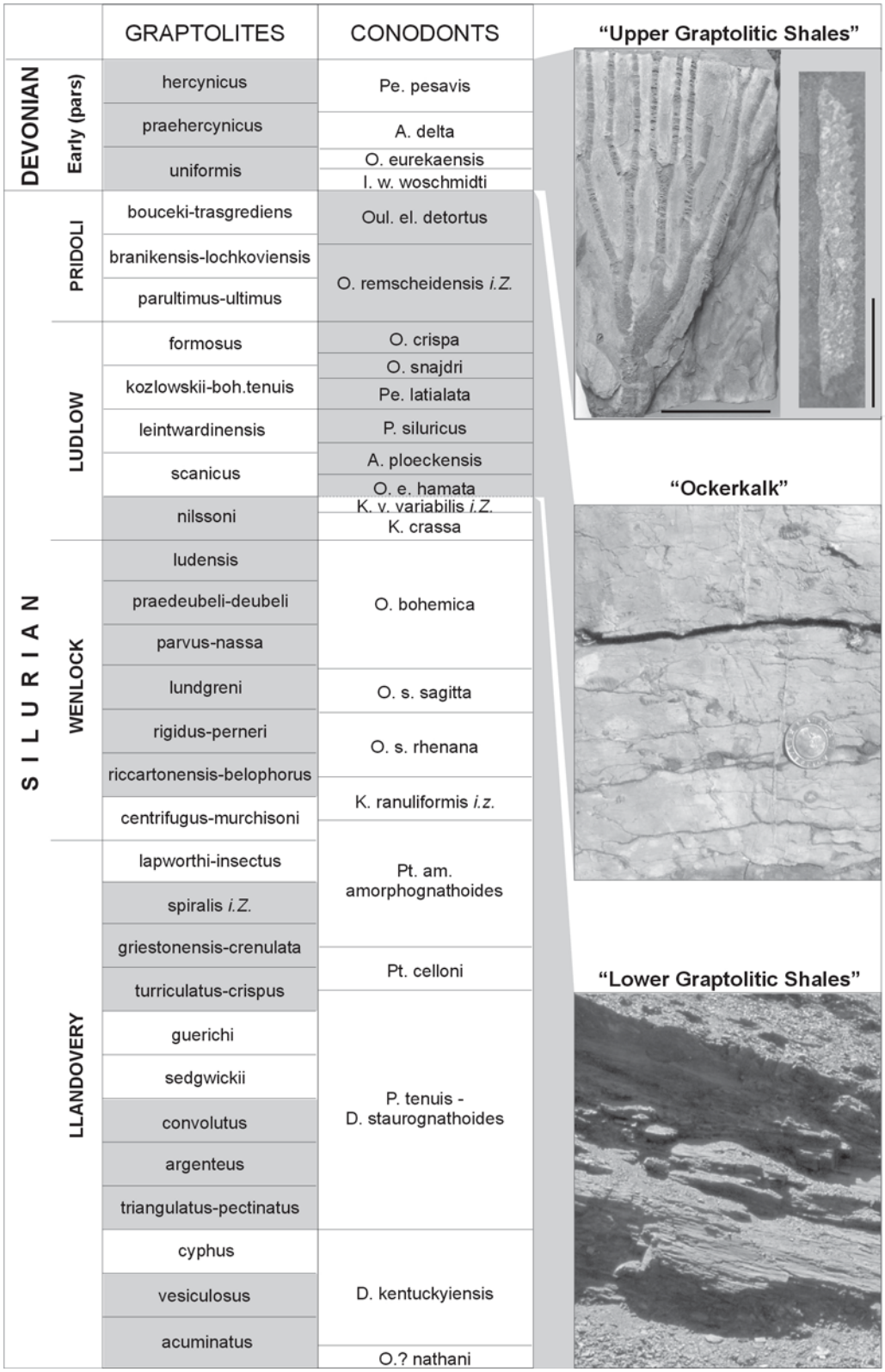
Fig. 3 – "Lower Graptolitic Shales", level with *M. praedeubeli*, (Wenlock), identified by H. Jaeger (1987, pers.com.). Goni Section. Scale bar =1 cm.

of the unit. The lowermost Devonian graptolite biozones *uniformis*, *praehercynicus* and *hercynicus* were documented in the Baccu Scottis section (Jaeger, 1976, 1977). The base of the Devonian is therefore more or less coincident with the "Ockerkalk"-"Upper Graptolitic Shales" boundary.

A few meters of poorly fossiliferous, thin nodular grey limestone may locally cover the shales, which otherwise grade to an alternation of dark and black phyllites and nodular limestones yielding tentaculites (Carosi *et al*., 1992). On the basis of tentaculites, the age of this complex may be referred to the Early Devonian (Late Lochkov-Emsian; Alberti, 1963; Gessa, 1993), or even to the Middle Devonian (Eifelian; Gessa, 1993). The tentaculite unit grades to marly limestones for a thickness difficult to establish owing to possible tectonic repetitions. Conodont data from sporadic outcrops have documented the Middle Devonian, but the absence of continuous undisturbed sections has so far prevented a detailed study.

The succession continues with a thick sequence of massive limestone ("Calcari a Clymeniae"; Lovisato, 1894) yielding clymenids and goniatites in some levels (Fig. 5). Its apparent thickness reaches hundreds of meters but tectonic repetitions are possible (Carmignani *et al*., 1986). Ammonoids, apart a few crinoid stems, are the only abundant macrofossils. Rare brachiopods and fish teeth have been also reported (Corradini, 1998b). The microfacies is always represented by poorly fossiliferous micrites, with a few fossil remains (ostracodes, echinoderms, gastropods, trilobites, etc.) only in the ammonoid-bearing beds (Corradini, 1998a, b). The age of the unit has been investigated on the basis of a rich and well preserved conodont fauna. Part of this massive complex in the Villasalto area was carefully stated as latest Devonian (Famennian) by Olivieri (1965, 1970) and Corradini (1998a, b). Recently, an early Carboniferous age (Tournaisian) for the topmost

Fig. 4 – Stratigraphic distribution of the Silurian-lowermost Devonian units in the Gerrei sub-region (documented biozones are shaded). Photographs on the right: "Lower Graptolitic Shales", Sedda de S'Ortu Section, *turriculatus* Zone; "Ockerkalk", Silius II Section, Pridoli; "Upper Graptolitic Shales", calyx of scyphocrinoid [left], Baccu Scottis Section, scale bar: 4 cm; *M. uniformis* [right], Goni Section, scale bar: 1 cm.


GRAPTOLITES
CONODONTS
DEVONIAN
Early (pars)
SILURIAN
PRIDOLI
LUDLOW
WENLOCK
LLANDOVERY
hercynicus
praehercynicus
uniformis
bouceki-trasgrediens
branikensis-lochkoviensis
parultimus-ultimus
formosus
kozlowskii-boh.tenuis
leintwardinensis
scanicus
nilssoni
ludensis
praedeubeli-deubeli
parvus-nassa
lundgreni
rigidus-perneri
riccartonensis-belophorus
centrifugus-murchisoni
lapworthi-insectus
spiralis i.Z.
griestonensis-crenulata
turriculatus-crispus
guerichi
sedgwickii
convolutus
argenteus
triangulatus-pectinatus
cyphus
vesiculosus
acuminatus
Pe. pesavis
A. delta
O. eurekaensis
I. w. woschmidti
Oul. el. detortus
O. remscheidensis i.Z.
O. crispa
O. snajdri
Pe. latialata
P. siluricus
A. ploeckensis
O. e. hamata
K. v. variabilis i.Z.
K. crassa
O. bohemica
O. s. sagitta
O. s. rhenana
K. ranuliformis i.z.
Pt. am. amorphognathoides
Pt. celloni
P. tenuis - D. staurognathoides
D. kentuckyiensis
O.? nathani
"Upper Graptolitic Shales"
"Ockerkalk"
"Lower Graptolitic Shales"

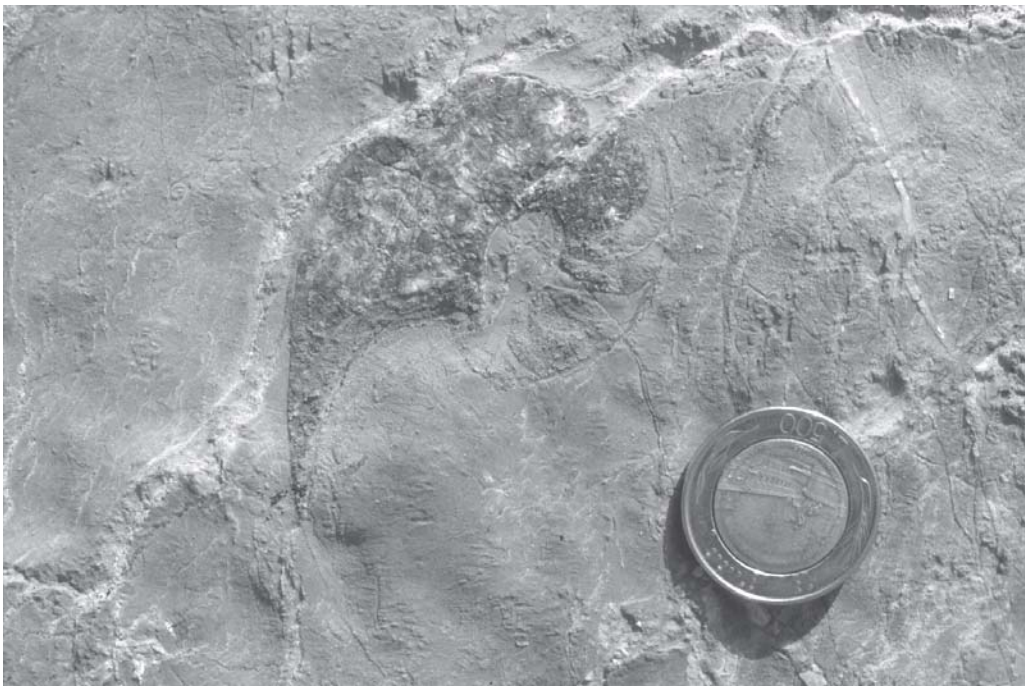


Fig. 5 – Slab of "Clymeniae Limestones". Pranu Scandariu Section, Late Devonian.

levels of the unit exposed in the Monte Taccu area was documented (Barca *et al*., 2000; Corradini *et al*., 2002). Furthermore, Frasnian (Late Devonian) conodonts have been recovered from a few different localities (Corradini, unpublished data). The age of the "Clymeniae Limestones" spans therefore from Late Devonian to Early Carboniferous. A pelagic deposition environment may be supposed, both on the basis of microfacies and absence of benthonic fauna; furthermore, also the conodont biofacies indicate an off-shore environment (Corradini, 1998a, b). During the Early Carboniferous, owing to a decrease of typical pelagic genera, the conodont biofacies analysis suggests a very slight shallowing (Corradini *et al*., in press).

Several dozen meters of sandstones and conglomerates ("Conglomerato di Villasalto", *Auct*.) are present above the "Clymeniae Limestones". They represent the transition to the terrigenous sedimentation which ends the pelagic sequence of the Palaeozoic in SE Sardinia (Teichmüller, 1931; Barca & Spalletta, 1985). These sediments are interpreted as synorogenic deposits accumulated in foredeep basins located between the advancing nappe front of the Sardinian Hercynian Chain and the foreland or "External Zone" represented by the Iglesiente-Sulcis area (Barca, 1991; Barca & Olivieri, 1991; Barca *et al*., 1992; Barca & Eltrudis, 1994). They are represented by irregular alternances of sandstones, quartzites and dark-grey siltites, with frequent intercalations of polygenic conglomerates and breccias bearing clasts of Silurian "lydites" and, rarely, volcanites (Barca, 1991; Di Pisa *et al*., 1992). Calcareous megablocks and olistostromes up to hundreds of meters in size also occur. Abundant conodont faunas provided by some calcareous pebbles and exotic blocks documented various stages of the Devonian (Barca & Spalletta, 1985; Barca & Olivieri, 1991).

Acknowledgements

This research is a contribution to the IGCP Projects 410 *The great Ordovician biodiversification event* and 421 *North Gondwana Mid-Palaeozoic Bioevent/Biogeography Patterns in Relation to Crustal Dynamic*s. Dr. Paolo Serventi and Dr. Alessandro Vescogni are acknowledged for photographic help. Research funded by MIUR grants (resp. E. Serpagli).

References

Alberti, G., 1963, Sul Devoniano inferiore e medio nella Sardegna meridionale: Acc. Naz. Lincei, Rend. Cl. Sc. Mat. Fis. Nat., s. 8, 24 (5): 553-559.

Barca, S., 1991, Phénomènes de resédimentation et flysch hercynien à faciès Culm dans le «synclinal du Sarrabus» (SE de la Sardaigne, Italie): C. R. Acad. Sci. Paris, 313: 1051-1057.

Barca, S., 1998, Structural and stratigraphical outlines of the Sardinian Massif. *In*: Serpagli E. (Ed.), Sardinia Guide-book, ECOS VII: Giorn. Geologia, 60, Special Issue: 1-23.

Barca, S., Carmignani, L., Eltrudis, A., Gattiglio, M. & Pala, L., 1992, Relationship between foredeep deposits and Hercynian nappe building in southeastern Sardinia (Italy). *In* Carmignani, L. & Sassi, F.P. (Eds), Contributions to the Geology of Italy with Special Regard to the Paleozoic Basements: IGCP No. 276, newsletter, 5: 33-44.

Barca, S., Corradini, C., Ferretti, A., Olivieri, R. & Serpagli, E., 1995, Conodont biostratigraphy of the "Ockerkalk" (Silurian) from Southeastern Sardinia: Riv. Ital. Paleont. Strat., 100 (1994): 459-476.

Barca, S., Corradini, C. & Spalletta, C., 2000, Nuovi dati sull'età dei "Calcari a Clymenie" della Sardegna. *In* Cherchi, A. & Corradini, C. (Eds), Crisi biologiche, radiazioni adattative e dinamica delle piattaforme carbonatiche: Accad. Naz. Sci. Lett. Arti di Modena, Collana di studi, 21: 25-28.

Barca, S., Del Rio, M. & Pittau Demelia, P., 1981, Acritarchs in the "Arenarie di San Vito" of South-east Sardinia: stratigraphical and geological implications: Boll. Soc. Geol. It., 100: 369-375.

Barca, S. & Di Gregorio, F., 1979, La successione ordoviciano-siluriana inferiore nel Sarrabus (Sardegna sud-orientale): Mem. Soc. Geol. It., 20: 189-202.

Barca, S. & Eltrudis, A., 1994, Attribution à l'éocarbonifère de flysch des nappes inférieures «a marbles» du Sud-Est de la Sardaigne (Italie): C. R. Acad. Sci., Paris, 319: 1407-1414.

Barca, S. & Jaeger, H., 1990, New geological and biostratigraphical data on the Silurian in SE Sardinia. Close affinity with Thuringia: Boll. Soc. Geol. It., 108 (1989): 565-580.

Barca, S. & Maxia, M., 1982, Assetto stratigrafico e tettonico del Paleozoico del Sarrabus occidentale. *In* Carmignani, L., Cocozza, T., Ghezzo, C., Pertusati, P.C. & Ricci, C.A. (Eds), Guida alla Geologia del Paleozoico sardo: Guide Geol. Reg., Soc. Geol. It.: 87-93.

Barca, S. & Olivieri, R., 1991, Age and source of calcareous rocks into Hercynian flysch-type sediments in Sarrabus (South-western Sardinia): Atti Soc. Nat. Mat. Modena, 122: 49-66.

Barca, S. & Spalletta, C., 1985, Nuove osservazioni sul conglomerato di Villasalto (Carbonifero inferiore-medio, Sardegna): Giorn. Geol., Ser. 3, 46 (1): 25-32.

Calvino, F., 1961, Lineamenti strutturali del Sarrabus-Gerrei (Sardegna sud-orientale): Boll. Serv. Geol. It., 81 (1959): 489-556.

Carmignani, L., Barca, S., Carosi, R., Di Pisa, A., Gattiglio, M., Oggiano, G. & Pertusati, P.C., 1992, Schema del basamento sardo. *In* Carmignani, L., Pertusati, P.C., Barca, S., Carosi, R., Di Pisa, A., Gattiglio, M., Musumeci, G. & Oggiano, G. (Eds), Struttura della Catena Ercinica in Sardegna - Guida all'escursione: 11-38.

Carmignani, L., Gattiglio, M., Maxia, M., Oggiano, G. & Pertusati, P.C., 1986, The geology of Gerrei. *In* Carmignani, L., Cocozza, T., Ghezzo, C., Pertusati, P.C. & Ricci, C.A. (Eds), Guide-book to the excursion on the Paleozoic Basement of Sardinia: IGCP No.5, Newsletter sp. issue: 61-72.

Carosi, R., Gattiglio, M., Musumeci, G. & Oggiano, G., 1992, Geologia della Catena Ercinica in Sardegna - Zona a Falde. *In* Carmignani, L., Pertusati, P.C., Barca, S., Carosi, R., Di Pisa, A., Gattiglio, M., Musumeci, G. & Oggiano, G. (Eds): Struttura della Catena Ercinica in Sardegna - Guida all'escursione: 77-108.

Conti, S., 1990, Upper Ordovician Bryozoa from Sardinia: Palaeontogr. Ital., 77: 85-165.

Corradini, C., 1998a, Conodonti del Devoniano superiore dei "Calcari a Clymeniae" di Villasalto (Sardegna Sud-Orientale): Tassonomia e Biostratigrafia: Unpubl. PhD Thesis, Università di Modena: 1-139.

Corradini, C.,1998b, Famennian conodonts from two sections near Villasalto. *In* Serpagli, E. (Ed.), Sardinia Field Trip Guide-book, ECOS VII: Giorn. Geologia, 60, sp. issue: 122-135.

Corradini C., Barca, S. & Spalletta, C., 2002, Late Devonian-Early Carboniferous conodonts from the "Clymeniae Limestones" of SE Sardinia: Cour. Forsch.-Inst. Senckenberg (in press).

Corradini, C., Ferretti, A. & Serpagli, E., 1999, Updated conodont biostratigraphy of the Sardinian Ockerkalk (late Silurian). *In* Feist, R., Talent, J. & Orth, B. (Eds), Abstract book-Errachidia meeting SDS-IGCP 421, April 23rd-May 1st 1999: 9-11.

Corradini, C., Ferretti, A. & Serpagli, E., 2000, Caratteristiche e correlazione biostratigrafica degli "Ockerkalk" affioranti nella Sardegna Sud-Orientale (Siluriano Sup.). *In* Cherchi, A. & Corradini, C. (Eds), Crisi biologiche, radiazioni adattative e dinamica delle piattaforme carbonatiche: Accad. Naz. Sci. Lett. Arti di Modena, Collana di studi, 21: 87-92.

CORRADINI, C., FERRETTI, A., SERPAGLI, E. & BARCA, S., 1998, The Ludlow-Pridoli Section "Genna Ciuerciu" west of Silius. *In* Serpagli, E. (Ed.), Sardinia Field Trip Guide-book, ECOS VII: Giorn. Geologia, 60, sp. issue: 112-118.

CORRADINI, C., LEONE, F., LOI, A. & SERPAGLI, E., 2001, Conodont stratigraphy of a highly tectonised Silurian-Devonian Section in the San Basilio area (SE Sardinia, Italy): Boll. Soc. Paleont. Ital., 40 (3): 315-323.

CORRADINI, C. & OLIVIERI, R., 1997, Conodont biostratigraphy of some supplementary sections in the Sardinian "Ockerkalk" (Upper Silurian): Boll. Soc. Nat. Torino, 15 (1): 89-100.

CORRADINI, C. & SERPAGLI, E., 1999, A Silurian conodont zonation from late Llandovery to end Pridoli in Sardinia: Boll. Soc. Paleont. Ital., 38 (2-3): 255-273.

DI PISA, A., GATTIGLIO, M. & OGGIANO, G., 1992, Pre-Hercynian magmatic activity in the Nappe Zone (internal and external) of Sardinia: evidence of two Within Plate basaltic cycles. *In* Carmignani, L. & Sassi, F.P. (Eds), Contributions to the Geology of Italy with special regard to the Paleozoic Basements: IGCP Project No. 276, newsletter, 5: 33-44.

FERRETTI, A. & SERPAGLI, E., 1996, Geological outline, community sequence and paleoecology of the Silurian of Sardinia: Riv. It. Paleont. Strat., 102 (3): 353-362.

FERRETTI, A. & SERPAGLI, E., 1999, Late Ordovician conodont faunas from southern Sardinia, Italy: biostratigraphic and palaeogeographic implications: Boll. Soc. Paleont. Ital., 37 (2-3): 215-236.

FERRETTI, A., SERPAGLI, E. & LEONE, F., 1998b, Late Ordovician conodonts from Umbrarutta between Donigala and Lago Mulargia. *In* Serpagli, E. (Ed.): Sardinia Guide-book, ECOS VII: Giorn. Geologia, 60, sp. issue: 202-208.

FERRETTI, A., SERPAGLI E., LEONE F. & LOI A., 1998a, The Late Ordovician section Cea Brabetza near San Basilio. *In* Serpagli, E. (Ed.), Sardinia Guide-book, ECOS VII: Giorn. Geologia, 60, sp. issue: 96-101.

GESSA, S., 1993, Nouvelles données sur les Tentaculites du Dévonien inférieur de la Sardaigne méridionale (Italie): C. R. Acad. Sci. Paris, 317 (II): 235-241.

HELMCKE, D., 1973, Schichtegebundene NE-Metall- und F-Ba-Lagerstätten in Sarrabus-Gerrei Gebiet, SE Sardinien. II Bericht: Zur Stratigraphie des Silur und Unterdevon der Lagerstättenprovinz Sarrabus-Gerrei: N. Jb. Geol. Paläont. Mh., 1973: 529-544.

HELMCKE, D. & KOCH, G., 1974, Schichtegebundene NE-Metall- und F-Ba-Lagerstätten in Sarrabus-Gerrei Gebiet, SE Sardinien. III Bericht: Zur Altersstellung der Porphyroide in der Lagerstättenprovinz Sarrabus-Gerrei: Z. Deutsch. Geol. Ges., 125: 91-98.

JAEGER, H., 1976, Das Silur und Unterdevon vom thuringischen Typ in Sardinien und seine regionalgeologische Bedeutung: Nova Acta Leopoldina, 45 (224): 263-299.

JAEGER, H., 1977, The Silurian-Devonian boundary in Thuringia and Sardinia. *In* Martinsson, A. (Ed.), The Silurian-Devonian boundary: IUGS, s.A, 5: 117-125.

LOVISATO, D., 1894, Il Devoniano nel Gerrei (Sardegna): Atti R. Acc. Lincei, Rend. Cl. Sc. Fis. Mat. Nat., 3: 460-470.

NAUD, G., 1979, Les Shales de Rio Canoni, formation-repère fossilifère dans l'Ordovicien supérieur de Sardaigne orientale. Conséquences stratigraphiques et structurales: Bull. Soc. géol. France, 21 (2): 155-159.

OLIVIERI, R., 1965, L'aspetto della fauna a Conodonti del Devoniano superiore del Gerrei (Sardegna): Boll. Soc. Paleont. Ital., 4(1): 28-63.

OLIVIERI, R., 1970, Conodonti e zonatura del Devoniano superiore e riconoscimento del Carbonifero inferiore nei calcari di Corona Mizziu (Gerrei, Sardegna): Boll. Soc. Paleont. Ital., 8(2): 63-152.

SERPAGLI, E., CORRADINI, C. & FERRETTI, A., 1998, Conodonts from a Ludlow-Pridoli section near the Silius Village. *In* Serpagli, E. (Ed.), Sardinia Field Trip Guide-book, ECOS VII: Giorn. Geologia, 60, sp. issue: 104-111.

TEICHMÜLLER, R., 1931, Zur Geologie des Tyrrenisgebietes Teil 1: Alte und junge krustenbewegungen im Südlichen Sardinien: Abh. ges. Wiss. Göttingen, math-phys Kl., 3: 1-94.