The Sardinian Ordovician unconformity

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Introduction and historical background

In the Hercynian anchi-epimetamorphic basement of Central-Southern Sardinia has been long recognized an "eo-Caledonian" important angular unconformity, referable to a compressive tectonic phase. This unconformity has been named "Fase sarda" (Stille, 1939) in the SW Sardinia (Iglesiente-Sulcis), or "Fase sarrabese" (Calvino, 1962) in the SE Sardinia (Sarrabus-Gerrei).

In the Iglesiente-Sulcis area, first information about the presence of an unconformity in the Lower Paleozoic successions was given by Zoppi (1888). Nevertheless, Novarese & Taricco (1923) and Novarese (1924) were the first authors to substantiate by data a folding phase linked to the Caledonian orogenetic cycle. They referred this phase to the Late Cambrian; moreover, they interpreted the "Puddinga", the first deposit covering the unconformity, as a post-tectonic basal conglomerate.

Afterwards, this tectonic phase was inserted as "Fase sarda" in the Stille's scheme (1939), and largely accepted by the scientists (e.g. Teichmüller, 1931; Havre, 1932).

In particular, Cadish (1938) described in Cambrian rocks large E-W folds discordantly covered by Ordovician sediments, and interference pattern structures between fold systems normally directed. These structures were successively detailed also by Vardabasso (1956) in the area located between Narcao and Villamassargia (Northern Sulcis). Other name has been proposed for this unconformity: "Discordanza cambro-ordoviciana" (Cocozza & Valera, 1966), "Movimenti sardi" (Schneider, 1974).

The presence of the "Fase sarda" in the Iglesiente-Sulcis area was also rejected on the base of different interpretations (Grawlich, 1955; Brower, 1965; Del Bono, 1965).

It is also necessary to remind that in the first XX century many scientists believe in the presence of a wide stratigraphic gap, involving the Late Cambrian and, partially, the Early Ordovician, although the signalling of *Dictyonema (D. flabelliforme*, *D. socialis)* by Novarese (*in* Taricco, 1920).

Recently, on the base of new findings of *Dictyonema*, and Acritarchs studies, Barca *et al*. (1987) referred the upper part of the "Cabitza Slates Fm." (Pillola, 1991) to the Early Ordovician (Tremadocian), and in this way they fitted the "Fase sarda" between the Early and the Late Ordovician, so allowing the correlation with the "Fase sarrabese" of SE Sardinia (Calvino, 1962). In fact, this tectonic phase has been also referred to the Middle Ordovician (Barca *et al*., 1988).

These new data, together with the documentation of the presence of Late Cambrian (trilobites, Pillola *et al*., 1998 and cited literature) in the Iglesiente-Sulcis Paleozoic succession, allow to re-date the stratigraphic gap of the "Fase sarda", now placed between the Tremadocian-Arenigian (age of the top of the "Cabitza Slates") and the Caradocian-Ashgillian (age of the first fossiliferous sediments covering the unconformity).

The tectonic phase of SE Sardinia ("Fase sarrabese") was firstly documented by Calvino (1962, 1967). In the Sarrabus area Calvino indeed evidenced an important angular unconformity between the Cambrian or Cambro-Ordovician "Arenarie di San Vito" Formation and an overlaid, mixed volcano-sedimentary, locally fossiliferous (Late Ordovician) complex. On the base of these data, Calvino referred the "Fase sarrabese" to an age comprised between the Cambrian and the Ordovician.

Successively, the precise datation of the "Arenarie di San Vito" Formation, based on the finding of Middle-Late Cambrian and Early Ordovician Acritarchs (Barca *et al.*, 1982b, 1984, 1988; Naud & Pittau Demelia, 1987) in the Sarrabus-Gerrei area, allowed to more precisely place this tectonic phase between the Tremadocian-Arenigian and the Upper Caradocian (age of the first fossiliferous sediments) (Barca *et al.*, 1987, 1988).

During these years, also the "Postgotlandiano" of the allochthonous Arburese Unit (Barca *et al.*, 1982a) and the "Formazione di Solanas" (Minzoni, 1975) of Central Sardinia (Sarcidano, Barbagia), lithologically corresponding to the "Arenarie di San Vito" of Sarrabus-Gerrei, were attributed to the Cambrian-Early Ordovician on the base of findings of Acritarchs (Barca *et al.*, 1982a; Tongiorgi *et al*., 1982, 1984; Albani *et al*., 1985). In this way, the presence of the "Fase sarrabese" was extended to all

the Hercynian "Outer Nappe Zone" (Arburese, Central to SE Sardinia). The Sarrabus strong angular unconformity was successively confirmed and analysed by several authors (Naud, 1981; Barca & Maxia, 1982; Carmignani *et al*., 1992, 2001).

The "Fase sarda" of SW Sardinia

In the autochthonous Paleozoic basement of the Iglesiente-Sulcis, corresponding to the "External Zone" or Foreland of the Sardinian part of South European Hercynian Chain (Carmignani *et al*., 1992, 2001), the authors agree with the presence of a deformation phase preceding the Hercynian Orogeny, as formerly mentioned, named "Fase sarda" (Stille, 1939).

This tectonic phase involved the pre- Late Ordovician formations, that have been compressed in E-W folds and deeply eroded before Caradocian times.

The presence of important "eo-Caledonian" deformations in the Iglesiente-Sulcis area results adequately documented by the marked angular unconformity between the Early Cambrian – Early Ordovician succession and the overstanding "Puddinga" coarse clastic metasediments ("Formazione di M. Argentu" *pars*: Laske *et al*., 1994) referable to the Middle? – Late Ordovician.

This unconformity is of regional importance because of its evidence, both at outcrop scale in several localities of SW Sardinia (Nebida, Masua, Gonnesa, Villamassargia, Domusnovas, ecc.), and at

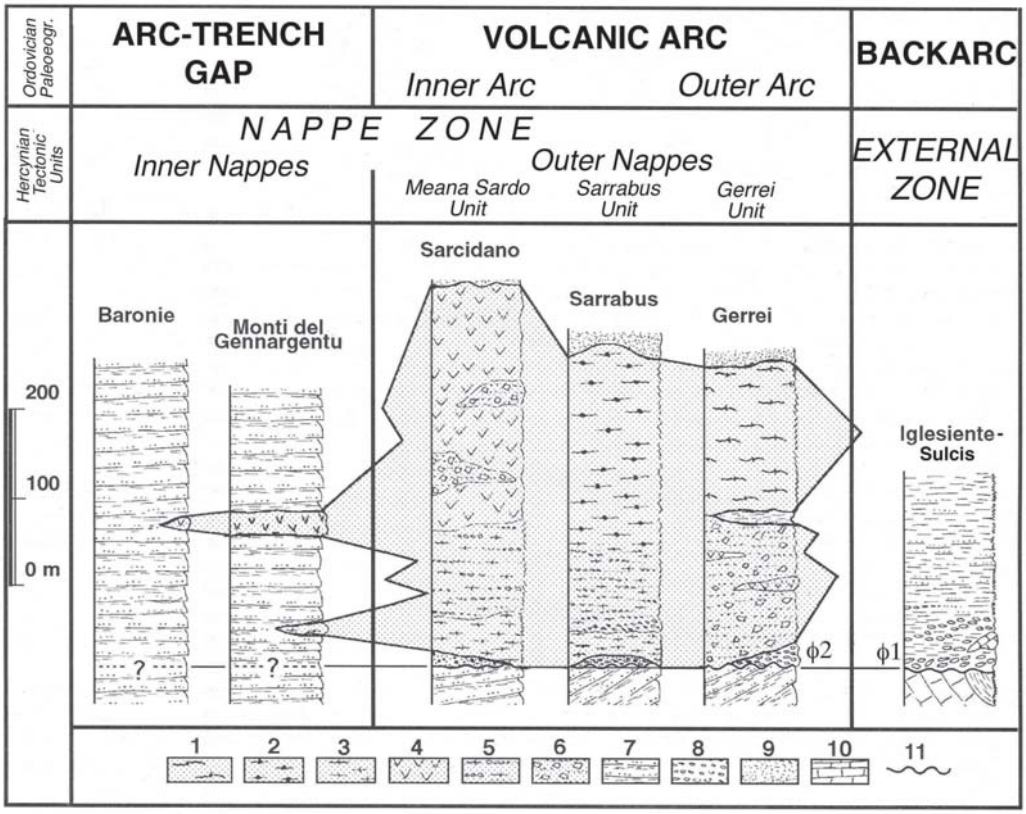

Fig. 1 - Sardinian Ordovician successions framed in their relative palaeogeographic position before the hercynian thrusting: the grey colour evidences the Middle Ordovician Volcanic Complex. 1. Metarhyodacites with "augen" structure ("Porfiroidi" *Auct*.). 2. Metadacites and metarhyodacites ("Porfidi grigi"). 3. Metarhyolites (" Monte Corte Cerbos Fm."). 4. Metandesites and matadacites ("Serra Tonnai Fm."). 5. Metamorphic products from reworked volcanics ("Manixeddu Fm."). 6. Metamorphic products from reworked, intermediate volcanics. 7. Metasandstones and schists. 8. Metaconglomerates. 9. Metarcoses and quartzites. 10. Cambro-Lower Ordovician succession of the "External Zone" (Iglesiente - Sulcis). 11. Sardic Unconformity: F1 = "Fase sarda"; F2 = "Fase sarrabese" (after Carmignani *et al*., 1992, mod.).

cartographic scale, since the wide E-W folds (e.g. Iglesias Syncline, Gonnesa Antycline), involving the Lower Cambrian – Lower Ordovician formations, are cutted towards W, where they are covered unconformably by the "Puddinga" metaconglomerates.

The Caledonian age of these wide E-W folds, preceding the main Hercynian N-S compressive structures also interesting the post-"Fase sarda" successions Late Ordovician to Early Carboniferous in age, was demonstrated by the refolding of the E-W folds axial surfaces by the Hercynian N-S folds, either at outcrop or cartographic scale. Decametric E-W folds are well exposed e.g. in the metasediments of the Iglesias Group (Pillola, 1991) (Middle Cambrian - Early Ordovician) in the Iglesias Sinclyne and along the Nebida-Masua coast, as in the Nebida Group (Pillola, 1991) formations (Early Cambrian) in the Canalgrande area, and in the nucleus of the Gonnesa Anticline.

These are always concentric folds without scistosity, having a vertical to subvertical axial plane, probably reflecting the geometry of the wide E-W eo-Caledonian folds.

Nevertheless, Arthaud (1970) supposed an E-W Hercynian phase co-axial with the E-W eo-Caledonian phase, developed before the main N-S Hercynian phase.

Effectively, at the present stage of knowledge, most of the authors agree with the recognition in the Iglesiente-Sulcis area of four deformative phases, subjected to a low to very low metamorphism, referable both to the "Fase sarda" and to the Hercynian folds (Arthaud, 1970; Carmignani *et al.*, 1992, 2001).
1) "Fase sarda": E-W open folds, involving the Early Cambrian – Early Ordovician succession (pre "Fase sarda" succession), without important deformations or metamorphism.
2) First Hercynian Phase: E-W folds, emphasizing the former Caledonian structures.
3) Second Hercynian Phase: approximately N-S folds, with a penetrating, very inclined axial foliation. This main deformation phase produced variously sized deformations (overthrusts and folds).
4) Third Hercynian Phase: variously oriented folds associated with a weak deformation.

According to Eltrudis *et al*. (1995) and Annino (1995), in coincidence to the Iglesiente Sardic Unconformity should exist also a "metamorphic discordance". In fact the successions posed under the discordance show epimetamorphism characters, in contrast to the succession posed over the discordance, characterized by anchimetamorphism features. This "metamorphic discordance" should be due to the increase of the geothermal influx, linked with the mantle rising melts deriving from the Middle Ordovician subduction processes (see below).

The "Puddinga" deposits

The post-Sardic Unconformity Ordovician succession starts with the "Formazione di Monte Argentu" (Laske *et al.*, 1994), made up by the typical "Puddinga" deposits, now named "Membro di Punta sa Broccia". This member is formed by polygenic and etherometric metaconglomerates and metabreccias, with clasts varying in size from 10 to 100 cm, containing arenaceous to hematitic cement, red to purplish in colour.

The clasts derive mainly from the erosion of the "Cabitza Slates Fm.", and subordinately from the metalimestones and metadolostones of the Gonnesa Group (Pillola, 1991). Rarely metasandstones of the fragments deriving from the Nebida Group are present.

In the "Puddinga" deposits cropping out with up to 150 m of thickness along the Nebida-Masua cliffs, variously sized (from 10 up to 100 m) calcareous and dolomitic olistholites and megabreccias are included. These deposits has been attributed to the synsedimentary tectonics (Brusca & Dessau, 1968).

From the Iglesiente to the Sulcis area, the "Puddinga" thickness progressively thins out.

Towards the top, clasts became finer, and take place metamicroconglomerates cemented by pelites and hematite, gradually changing to the "Membro di Riu Is Arrus", formed by alternations of greyish metasandstones and metasiltites, locally fossiliferous, containing Arthropoda (*Taricoia arrusensis*; Taricco, 1922) and algae, and rare coarse metaconglomerate lenses.

The "Formazione di M. Argentu" terminates upward with the "Membro di Medau Murtas", made up by metasiltites, metapelites and rare metaconglomerates, with a typical purplish colour with greenish bands and rare fossil tracks.

The total thickness of the "Formazione di M. Argentu" is estimated from 200 to 320 m (Laske *et al.*, 1994).

In missing of significant fossils, the chronostratigraphic attribution of the "Formazione di M. Argentu" is defined at the base throughout the age of the oldest formations eroded by the Sardic Unconformity (Early Ordovician, Barca *et al.*, 1987), and at the top by the fossiliferous (Late Caradocian – Ashgillian) levels found in the overlaid "Formazione di M. Orri" and "Formazione di Portixeddu" (Laske *et al.*, 1994).

The "Formazione di M. Argentu" has been referred to different sedimentary environments: coastal-marine (Novarese, 1924; Teichmüller, 1931); alluvial (Poll, 1966); deep marine (Schneider, 1974), or finally, fluvial to deltaic environment (Cocozza *et al.*, 1974). Recently Martini *et al.* (1991) improved the sintectonic characters of the "Puddinga" metaconglomerates in the Nebida area, and made a detailed sedimentary analysis, distinguishing at the base alluvial fan-deltas, gradually passing to shallow littoral plains, and, finally, to coastal alluvial plains.

The "Fase Sarrabese" of SE Sardinia

While in the Iglesiente – Sulcis (External Zone) the deformation stuctures induced by the "Fase sarda" are clearly recognizable, since in this area the following Hercynian deformations have been weak, in the Eastern Sardinia (Nappe Zone) the effects of the pre-Hercynian deformations and metamorphism referable to the "Fase sarrabese" are not so clearly recognizable in the outcrops, because of stronger Hercynian deformations that have hardly obliterated the eo-Caledonian structures.

Nevertheless, in Eastern Sardinia there are some important elements that improve well-defined eo-Caledonian tectonic deformations Middle Ordovician in age. These are the following:

1) The angular unconformity ("Discordanza sarrabese") that in the Sarrabus separates the sedimentary succession of the "Arenarie di San Vito" (Calvino, 1962, 1967), Middle Cambrian – Early Ordovician in age (Barca *et al.,* 1982b, 1984, 1988; Naud & Pittau Demelia, 1987) from the overlaid Middle Ordovician volcanic complex ("Porfidi bianchi" and "Porfidi grigi"; Calvino, 1962, 1967). After Calvino (1967) and Naud (1981), this unconformity locally should show angular discordance values close to 90°.

2) In all the "Nappe Zone" a thick and areally diffuse subaerial calc-alkaline magmatism (Memmi *et al.*, 1983) from post-Tremadocian to pre-Late Caradocian in age is present. The magmatic complex covers the local Cambrian -Early Ordovician successions (the "Arenarie di San Vito" in the Sarrabus-Gerrei and the "Formazione di Solanas" in the Sarcidano, Barbagia).

3) At the base of the "Discordanza sarrabese" unconformity crop out diffusely coarse metasandstones and polygenic metaconglomerates containing pebbles of sedimentary and volcanic rocks, overlaying the "Arenarie di San Vito" and the "Formazione di Solanas", so testifying wide and extended emersions during the Middle Ordovician times (e.g. "Conglomerato di Rio Ceraxa": Barca & Maxia, 1982).

Geodinamic importance of the Ordovician Unconformity

The thick metavolcanic complex that in all the "Nappe Zone" of Central and South-eastern Sardinia covers unconformably the Cambrian – Early Ordovician metasediments, developed between the Arenigian and the Caradocian times, giving place both to effusive and pyroclastic products, both to intrusives (e.g. the Capo Spartivento Orthogneiss in the Sulcis area). The composition of these products varies from rhyolitic to andesitic, and, rarely, up to basaltic.

These magmatites have a calc-alkaline affinity (Memmi *et al.,* 1983), and have been referred to a volcanic arc activity (Garbarino *et al*., 1981) or interpreted as late- to post-orogenic products (Memmi *et al.*, 1983).

In every case, this magmatic cycle should be reported to an important and wide Ordovician geodynamic event, that takes place accompanied by tectonic movements, unconformities and magmatic activity with analogue composition, affinity and age in almost all the Hercynian South European massifs (Portugal, Spain, Pyrenees, Montagne Noire, Maures, Eastern Alps, ecc.: Cocozza & Valera, 1965; Carmignani *et al.*, 1992, 2001; Annino, 1995, and cited literature).

Effectively, the calc-alkaline character of the magmatic activity, the prevalence of acidic products, together with wide amounts of pyroclastites, and the presence of granitoid intrusions are characteristic of an orogenetic suite with involvement of continental crust (Tommasini *et al*., 1995).

So, the hypothesis of the development of a volcanic arc posed on continental crust is better documented. This arc should be connected with an oceanic crust subduction, as suggested by the gradual

increase of the acid content of the volcanics from NE to SW Sardinia, and by the probable younging of the magmatic activity in the same direction (Di Pisa *et al*., 1992; Carmignani *et al*., 1992, 1994).

The described data should indicate a volcanic arc of andine type, progressively shifting from NE to SW during Arenigian to Caradocian times, in the geodynamic frame that developed during the convergence between Gondwana and Armorica paleocontinents (Carmignani *et al*., 1992, 1994). This convergence was activated by the crustal extension of the Rheic Ocean, with following relative removal between Gondwana and Baltica (Scotese & Mc Kerrow, 1991).

The Gondwana-Armorica convergence gave place to the progressive disappreance of the interposed South-Armorican ocean, because of the subduction under the Gondwana plate, so determining the development of an arc-trench system during the Middle Ordovician times.

The south-verging gradual shift of the magmatic arc caused compressive movements along the north-gondwanian margin, where the Sardinia and others South-European areas was located. These movements determined here the development of folding, emersion and sub-aerial erosion phenomena on the Cambrian-Lower Ordovician formations.

In the supposed Ordovician arc-trench system (Fig.1) (Carmignani *et al*., 1992, 1994), the Iglesiente-Sulcis area should be the corresponding of a back-arc basin, characterized by absence of the calc-alkaline volcanism and by rapid syntectonic sedimentation with wide olistholites ("Puddinga" deposits). This area was compressed and deformed throughout thrusts and folds ("Fase sarda") by the migration of the magmatic arc towards SW.

The importance of this compressive eo-Caledonian tectonics and of the related deformations probably decreased towards the arc zones, corresponding to the Outer Nappe Zone (Sarrabus, Gerrei, Arburese, Sarcidano, ecc.), just characterized by thick volcanic successions, by thin conglomerates without olistholites, and by a sedimentary hiatus ("Discordanza sarrabese") interposed between the volcano-sedimentary complex and the lower sedimentary successions Cambrian – Early Ordovician in age ("Arenarie di San Vito", "Formazione di Solanas").

The subduction processes were interrupted during Late Ordovician times. Consequently, the magmatic arc and the neighbouring areas collapsed: this promoted the late Caradocian marine transgression ("Trasgressione caradociana"). The deposits linked to this new sedimentary cycle ("Hercynian Sedimentary Cycle") cover unconformably both the arc volcanic products (Outer Nappe Zone), both the Iglesiente-Sulcis Cambrian- Early Ordovician sedimentary formations ("Caledonian Sedimentary Cycle").

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References

Albani, R., Di Milia, A., Minzoni, N.& Tongiorgi, M., 1985, Nuovi dati palinologici e considerazioni geologiche sulla età delle Arenarie di Solanas (Cambro-Ordoviciano, Sardegna Centrale): Atti Soc. Tosc. Sci. Nat., Mem. Ser. A, 91: 1-20.

Annino, E., 1995, Gli eventi stratigrafici, tettonici e magmatici legati alla "Fase Sarda" (Ordoviciano medio) nella Sardegna centro-meridionale ed in alcuni settori paleozoici sud-europei:Tesi di Dottorato di Ricerca in Scienze della Terra, Consorzio Genova-Cagliari-Torino, VIII Ciclo: 213 pp.

Arthaud, F., 1970, Étude tectonique et microtectonique comparée de deux domaines Hercyniens: Les nappes de la Montagne Noire (France) et l'anticlinorium de l'Iglesiente (Sardaigne): Publ. Univ. Sciences et Techniques du Languedoc, Série Géologie Structurale, 1: 175 pp.

Barca, S., Cocozza, T., Del Rio, M., Pillola, G.L. & Pittau Demelia, P., 1987, Datation de l'Ordovicien inférieur par *Dictyonema flabelliforme* et Acritarches dans la partie supérieure de la formation "Cambrienne" de Cabitza (SW de la Sardaigne, Italie): conséquences géodynamiques: C. R. Acad. Sci. Paris, 305(2): 1109-1113.

Barca, S., Cocozza, T., Del Rio, M. & Pittau Demelia, P., 1982a, Discovery of Lower Ordovician Acritarchs in the "Postgotlandiano" sequence of South Western Sardinia (Italy): age and tectonic implications: Boll. Soc. Geol. It., 100: 377-392.

Barca, s., Del Rio, M., Minzoni, N. & Pittau Demelia, P., 1984, Presenza di Tremadociano ad Acritarchi in unità tettoniche erciniche a Sud del lago di Mulargia (Sardegna centrale): Riv. It. Paleont. Strat., 89: 315-334.

Barca, S., Del Rio, M. & Pittau Demelia, P. 1982b, Acritarchs in the "Arenarie di San Vito" of south-east Sardinia: stratigraphical and geological implications: Boll. Soc. Geol. It., 100: 369-375.

Barca, S., Del Rio, M. & Pittau Demelia, P., 1988, New geological and stratigraphical data and discovery of Lower Ordovician acritarchs in the San Vito Sandstone of the Genn'Argiolas Unit (Sarrabus, Southeastern Sardinia): Riv. It. Paleont. Strat., 94: 339-360.

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: Soc. Geol. It., Guide Geol. Region.: 87-93.

Brouwer, H., 1965, Esiste la fase sarda in Sardegna? *In* Del Bono, G.L., Relazione generale su una nuova possibile interpretazione della serie cambro-ordoviciana dell'Iglesiente. Ass. Min. Sarda, 70 (8): 86-89.

Brusca, C. & Dessau, G., 1968, I giacimenti piombo-zinciferi di S.Giovanni (Iglesias) nel quadro della geologia del Cambrico sardo: L'Industria Mineraria, 19: 470-494, 533-556, 597-609.

Cadisch, J., 1938, Zur Geologie des Insel Sardinien mit Beobachtung über ihre Erzlagerstätten: Geol. Rundsch., 29: 52-71.

Calvino, F.,1962, Lineamenti strutturali del Sarrabus-Gerrei: Boll. Serv. Geol. d'It., 81 (4-5): 489-556.

Calvino, F., 1967, Note illustrative della Carta Geologica d'Italia. F°227 "Muravera": Boll. Serv. Geol. d'It., 60 pp.

Carmignani, L., Carosi, R., Di Pisa, A., Gattiglio, M., Musumeci, G., Oggiano, G. & Pertusati, P.C., 1994, The Hercynian chain in Sardinia (Italy): Geodinamica Acta, 7: 31-47.

Carmignani, L., Oggiano, G., Barca, S., Conti, P., Salvadori, I., Eltrudis, A., Funedda, A. & Pasci, S., 2001, Geologia della Sardegna. Note illustrative della Carta Geologica della Sardegna a scala 1:200.000: Mem. Descr. Carta Geol. d'It., Serv. Geol., 60: 283 pp.

Carmignani, L., Pertusati, P.C., Barca, S., Carosi, R., Di Pisa, A., Gattiglio, M., Musumeci, G. & Oggiano, G., 1992, Struttura della Catena Ercinica in Sardegna. Guida all'Escursione. Gruppo Informale di Geologia Strutturale: 177 pp.

Cocozza, T., Jacobacci, A., Nardi, R. & Salvadori, I., 1974, Schema stratigrafico-strutturale del Massiccio Sardo-Corso e minerogenesi della Sardegna: Mem. Soc. Geol. It., 13: 85-186.

Cocozza, T. & Valera, R., 1966, Nuove osservazioni sulla "discordanza cambro-ordoviciana" nella zona di Nebida (Sardegna sud-occidentale): Res. Ass. Min. Sarda, 71 (7): 58-71.

Del Bono, G.L., 1965, Relazione generale su una nuova possibile interpretazione della serie cambrico-ordoviciana dell'Iglesiente: Res. Ass. Min. Sarda, 70: 5-80.

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), Contribution to the Geology of Italy with special regard to the Paleozoic basement. A volume dedicated to Tommaso Cocozza: I.G.C.P. Project N° 276, Newsl., 5: 33-44.

Eltrudis, A., Franceschelli, M., Gattiglio, M. & Porcu, R., 1995, Discontinuous metamorphic zonation in the Palaeozoic units of the Hercynian chain of SW Sardinia, Italy: evidence from structural and illite cristallinity data: Schwez. Mineral. Petrogr. Mitt., 75: 201-211.

Garbarino, C., Maccioni, L., Padalino, G., Tocco, S. & Violo, M., 1981, Le mineralizzazioni stratiformi di solfuri misti della Sardegna centrale quale prodotto di un vulcanismo di margine continentale di età ordoviciana: proposta di un modello geodinamico e genetico: Mem. Soc. Geol. It., 22: 145-150.

Grawlich, J.M., 1955, Osservazioni sulla scistosità nei terreni paleozoici dell'Iglesiente (Sardegna), significato dell'anagenite: Boll. Soc. Geol. It., 72: 3-7.

Havre, H., 1932, Esquisse géologique de l'Iglesiente: Ass. Min. Sarda, A. 37, 3: 17-24.

Laske, R., Bechstädt, T. & Boni, M., 1994, The post-Sardic Ordovician series. *In* Bechstädt, T. & Boni, M. (Eds), Mem. Descr. Carta Geol. D'It., 48: 115-146.

Martini, I.P., Tongiorgi, M., Oggiano, G. & Cocozza, T., 1991, Ordovician alluvial fan to marine shelf transition in SW Sardinia, Western Mediterranean Sea: tectonically ("Sardic Phase") influenced clastic sedimentation: Sedimentary Geology, 72: 97-115.

Memmi, I., Barca, S., Carmignani, L., Cocozza, T., Elter, F.M., Franceschelli, M., Gattiglio, M., Ghezzo, C., Minzoni, N., Naud, G., Pertusati, P.C. & Ricci, C.A., 1983, Further geochemical data on the Pre-Hercynian igneous activities of Sardinia and on their geodinamic significance: I.G.C.P. N°5, Newsl., 5: 87-91.

Minzoni, N., 1975, La serie delle formazioni paleozoiche a Sud del Gennargentu: Boll. Soc. Geol. It., 94: 347-365.

Naud, G., 1981, Confirmation de l'existence de la discordance angulaire anté-ordovicienne dans le Sarrabus (Sardaigne sud-orientale) : conséquences géodynamiques. C. R. Acad. Sci. Paris, 292: 1153-1156.

Naud, G. & Pittau Demelia, P., 1987, Première decouverte d'acritarches du Cambrien moyen à supérieur basal et du Tremadoc-Arenigien dans la basse vallée du Flumendosa: mise en evidence d'un nouveau temoin de la Phase Sarde en Sardaigne orientale: I.G.C.P. N°5, Newsl., 7: 85-86.

Novarese, V., 1924, Contributo alla geologia dell'Iglesiente: la serie paleozoica: Boll. Uff. Geol. d'It., 49 (1922-23): 1-107.

Novarese, V. & Taricco, M., 1923, Cenni sommari sul Paleozoico dell'Iglesiente: Boll. Soc. Geol. It., 4: 316-325.

Pillola, G.L., 1991, Trilobites du Cambrien inférieur du SW de la Sardaigne, Italie: Paleontogr. Ital., 78: 1-174.

Pillola, G.L., Leone, F. & Loi, A., 1998, The Cambrian and Early Ordovician of SW Sardinia: Giorn. Geologia, s. 3°, 60, Spec. Issue, ECOS VII-Sardinia Guide-book: 25-38.

Poll, J.J.K., 1966, The geology of the Rosas-Terraseo area, Sulcis, South Sardinia. Leidse Geol. Med., 35: 117-208.

Schneider, H.H., 1974, Revision des Altpaläozoikums Sardiniens insbesondere des sardischen konglomerates: N. Jb. Geol. Paläont. Abh., 146: 78-103.

Scotese, C.F. & Mc Kerrow, W.S., 1991, Ordovician plate tectonic reconstruction. *In* Burnes & Williams (Eds), Advances in Ordovician Geology: Geological Survey of Canada: 271-282.

Stille, H., 1939, Bemerkungen betreffend die "Sardische" Faultung und den Ausdruck "Ophiolitisch": Z. dt. geol. Ges., 91: 771-773.

Taricco, M., 1920, Rinvenimento di *Dictyonema* nel Cambriano della Sardegna: Boll. Soc.Geol. It., 39 (1-2): 39-40.

Taricco, M., 1922, Sul Paleozoico del Fluminese (Sardegna): Boll. R. Com. Geol. It., 48, (1920-1921): 1-22.

Teichmüller, R., 1931, Zur Geologie des Thyrrhenisgebietes. Teil 1: Alte und junge krustenbewegungen im südlichen Sardinien: Ges. Wiss. Göttingen, Math.-Phys. Kl., Nachrichten, 3: 857-950.

Tommasini, S., Poli, G. & Halliday, A.N., 1995, The role of sediment subduction and crustal growth in Hercynian plutonism: isotopic and trace element evidence from the Sardinia-Corsica batholith: J. Petrol., 36: 1305-1332.

Tongiorgi, M., Albani, R. & Di Milia, A., 1984, The Solanas Sandstones of Central Sardinia: new Paleontological data (Acritarchs) and an attempt of geological interpretation (a "post-sardinian" molasses): Bull. Soc. géol. France, 26: 665-680.

Tongiorgi, M., Bellagotti, E., Di Milia, A. & Trasciatti, M., 1982, Prima datazione su basi paleontologiche (Acritarchi) della Formazione di Solanas (Tremadociano-Arenigiano)(Meana Sardo, Sardegna Centrale). *In* Carmignani, L., Cocozza, T., Ghezzo, C., Pertusati, P.C. & Ricci, C.A. (Eds), Guida alla Geologia del Paleozoico Sardo: Soc. Geol. It., Guide Geol. Region.: 127-128.

Vardabasso, S., 1956, La fase sarda dell'orogenesi caledonica in Sardegna: Geot. Symp. Zu Ehren H. Stille: 120-128, Stuttgart.

Zoppi, G., 1888, Descrizione geologico-mineraria dell'Iglesiente: Mem. Descr. Carta Geol. d'It., Serv. Geol., 4: XII-154.