# Proceedings of the XVth International Congress on Carboniferous and Permian Stratigraphy

## Edited by Theo E. Wong

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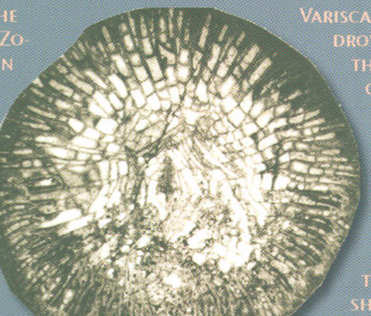

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# Tectonostratigraphic imbrications along strike-slip major shear zones: an example from the Early Carboniferous of SW European Variscides (Ossa-Morena Zone, Portugal)

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## Abstract

The Porto–Coimbra–Tomar shear zone is a linear fault zone, trending NNW from Porto to Tomar in the crystalline polymetamorphosed belt of the Iberian Variscides. This zone is 1 to 5 km wide and contains a very characteristic and ubiquitous tectonostratigraphy. The Porto–Coimbra–Tomar shear zone is located in the Western Iberian Line, which delineates a major tectonic corridor extending for more than 520 km, from Tomar (Portugal) to Finisterre (Galicia, Spain). The Porto–Coimbra–Tomar shear zone has been interpreted as a fundamental crustal tectonic boundary, represented locally by dextral strike-slip faults and thrusts. Early Carboniferous brittle deformed metasedimentary sequences in the northernmost region (Porto–Albergaria-a-Velha metamorphic belt, NW Portugal) of the Ossa-Morena Zone contain black shales of very low to low-grade metamorphism. These metapelitic imbrications form a discrete NNW-trending structure within the Porto–Coimbra–Tomar shear zone, which remain subparallel to the observed major regional structures (shear zones, thrusts and/or overthrusts). Along the major imbricated accidents these discrete strike-slip basins, clearly show a tectonic sigmoidal shape. These black shales are overhanged and then imbricated in an Upper Proterozoic metamorphic substratum (Arada Unit). A multi-disciplinary approach of the organic-rich rocks from Albergaria-a-Velha/Sernada do Vouga (Aveiro, NW Portugal) region took advantage of the use of tectonostratigraphy, structural geology, geomorphology, palynology, organic petrology and clay mineralogy combined methods. Geodynamic implications for the Iberian Variscides of the Palaeozoic basement framework are discussed.

*Keywords:* Black shales, Early Carboniferous, Iberian Massif, Ossa-Morena Zone, Porto–Tomar–Ferreira do Alentejo shear zone, tectonic imbrications.

## Introduction

Integrated studies of tectonostratigraphy, structural geology, geomorphology, palynology, organic petrology and clay mineralogy in a specific regional pattern of very low-grade metamorphism, represent a powerful tool to study the geotectonic evolution of internal zones of metamorphic belts (e.g., Robinson, 1987; Schieber et al., 1998; Merriman & Frey, 1999; Martínez-Poyatos et al., 2001). Variscan very low- to low-metamorphism has been reported for pelitic sequences in the Iberian Massif by several authors (e.g., Munhá, 1983; Martínez-Poyatos et al., 2001; Abad et al., 2001). In particular, very low-metamorphism has been reported in the Albergaria-a-Velha region (Porto–Coimbra–Tomar shear zone), as indicated by the observation of monotonous black pelitic Paleozoic sequences (Chaminé, 2000; Chaminé et al., 2003a). The Porto–Coimbra–Tomar shear zone constitutes a dextral-lateral shear zone of sigmoidal multiscale geometry, stretching from Porto to Tomar (W Portugal), over more than 300 km (Fig. 1). This is a NNW–SSE trending morphostructure, slightly overprinted on the ENE–WSW regional faults (Gama Pereira, 1987; Chaminé, 2000; Araújo et al., 2003). The Porto–Coimbra–Tomar shear zone is an imbricated thrust belt, controlled by 'en-échellon' folds and dextral strike-slip parallel overthrusts, of several slices of unlike Paleozoic metapelitic tectonostratigraphical units. In fact, out-of-sequence faults are a kind of thrust commonly found in orogenic belts (e.g., McKerrow et al., 1977; Morley, 1988; Stone et al., 1997; Little & Mortimer, 2001). The study of the landforms and deposits developed by active tectonic processes can, thus, provide relevant information about the fault-generated mountain fronts (Silva et al., 1993, 2003).

The Iberian Massif corresponds to one of the widest exposures of the SW European Variscides basement (e.g., Matte & Ribeiro, 1975; Martínez-Catalán, 1990; Martínez-Catalán et al., 1997; Shelley & Bossière, 2000; Llana-Fúnez & Marcos, 2001). The western margin of the Porto–Coimbra–Tomar shear zone is part of a narrow tectonic corridor, NNW-SSE, which belongs to the northernmost sector of the Portuguese Ossa-Morena Zone (OMZ) of the Iberian Massif (e.g., Lefort & Ribeiro, 1980; Quesada et al., 1990; Dias & Ribeiro, 1993; Ribeiro et al., 1990; Chaminé et al., 2003a). Ossa-Morena Zone bounds tectonically to Central-Iberian Zone (CIZ) along the Porto–Coimbra–Tomar shear zone (e.g., Gama Pereira, 1987; Dias & Ribeiro, 1993). This mega-domain is located alongside the western border of the Porto–Tomar–Ferreira do Alentejo major shear zone (Chaminé, 2000; Chaminé et al., 2003a; Ribeiro et al., 2003). Moreover, this major shear zone corresponds to a transcurrent fault characteristic of an interplate setting, that would have been active during the early phases of the Variscan orogen (Late Silurian

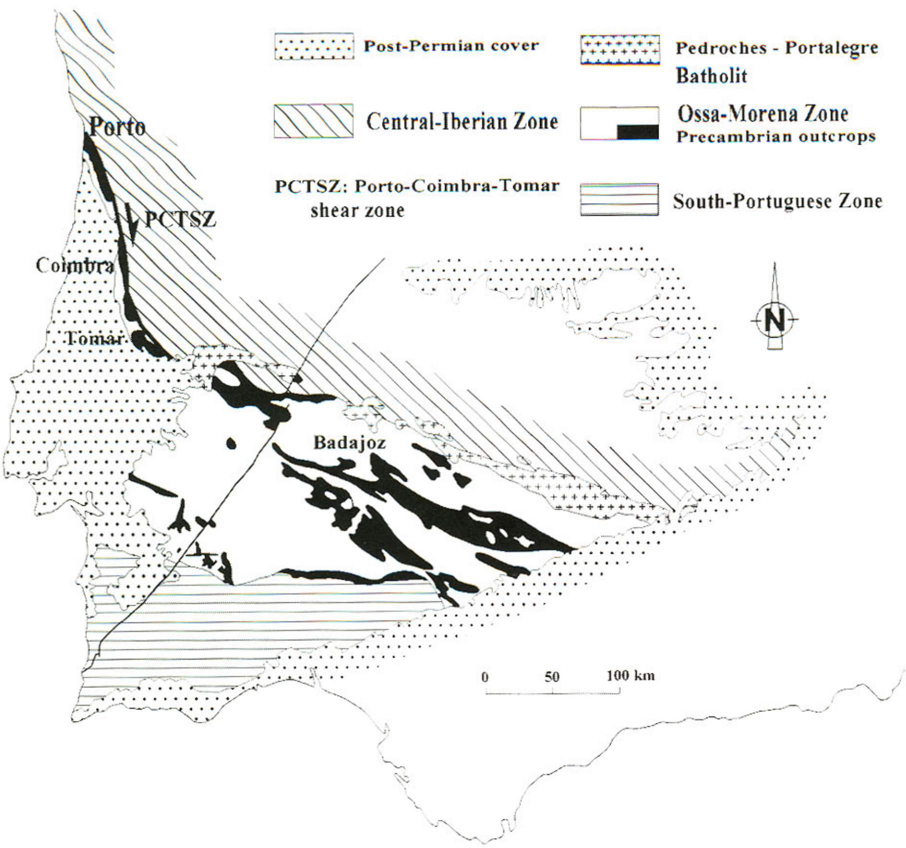


Fig. 1. Schematic map of the Variscan Belt in the Western Iberia, with regional tectonostratigraphic units and Porto–Coimbra–Tomar shear zone (adapted from Quesada et al., 1990).

to Early Devonian) and, probably, the whole Variscan Wilson cycle (Chaminé et al., 2003a).

The purpose of this work is to present and discuss the main results of a multi-disciplinary study of Early Carboniferous tectonostratigraphic out-of-sequence units from the northernmost domain of the Ossa-Morena Zone (Porto–Albergaria-a-Velha metamorphic belt, NW Portugal).

## Multi-disciplinary overview

The present work reviews the available geological data on Upper Paleozoic (Lower Carboniferous) metasedimentary rocks from the Albergaria-a-Velha area. These data were also improved through the multidisciplinary approach of this study. In this context, black shale samples were systematically collected along general WSW–ENE geotraverses in the Albergaria-a-Velha/Sernada do Vouga region (near Aveiro town). The Lower Carboniferous samples were studied by complementary analytical and methodological approaches, such as palynology, organic petrology, clay mineralogy, metamorphic petrology and structural geology. For laboratory analyses, several unaltered samples of shales (gently deformed and unmetamorphosed rocks) were carefully collected in order to reduce the effects of weathering.

### *Geotectonic and geomorphologic setting*

The Porto–Coimbra–Tomar shear zone formed as an accretionary thrust complex during the Variscan times. These shear zone comprises relative autochthonous and parautochthonous tectonostratigraphic units of low- to high-grade metamorphic rocks, as well as allochthonous units, of medium- to high-grade, assumed of Late Proterozoic times (e.g., Gama Pereira, 1987; Beetsma, 1995; Chaminé, 2000; Noronha & Leterrier, 2000; Fernández et al., 2003, and references therein). Middle-Upper Paleozoic black shales were reported, for the first time, on this Ossa-Morena Zone border by Chaminé (2000), Fernandes et al. (2001) and Moço et al. (2001), as indicated by the observation of monotonous black metapelitic materials imbricated on Late Proterozoic substratum (according to Beetsma, 1995). These internal scattered and widespread basins constitute a NNW-SSE trending structure located in the Portuguese part of the Ossa-Morena Zone, about 30 km from the Atlantic shoreline.

The regional tectonostratigraphic background (Fig. 2; Table 1), in the Albergaria-a-Velha region, comprises a well-structured substratum composed of garnetiferous black-greenish phyllites (Chaminé, 2000; Fernandez et al., 2003) interbedded with lydite lenses and amphibolites (Arada Unit; Chaminé, 2000). Radiometric dating indicated a Late Proterozoic age for this material (Beetsma, 1995). This metapelitic substratum is imbricated with Late Devonian black shales bearing carbonate metasomatic rocks (Albergaria-a-Velha Unit; Chaminé et al., 2003a) and Early Carboniferous black shales interbedded with thin siltstone lenses (Sernada do Vouga Unit; Chaminé et al., 2003a). These imbricated structures present variable thickness, ranging 50 to 500 m (Fig. 3).

The metapelitic basement is covered largely by post-Triassic sediments (e.g., Telles Antunes et al., 1979; Brum Ferreira, 1980, 1991; Ribeiro, 2002; Araújo et al., 2003, and references therein). The topographic configuration of the Albergaria-a-Velha region consists of a littoral platform characterised by a very regular planation surface gently dipping to the West, culminating around 180 m, and East bounded by a series of elevated hill ranges (300 m on the top). The flatness of this surface is interrupted by a meridian graben of plane top hills morphology down-lifted 20 m to 40 m in relation to the adjacent littoral platform. These hills are separated by deeply incised river valleys under regional tectonic control (Fig. 4), particularly from the Porto–Coimbra–Tomar shear zone (s.str.). Two major fault branches, the S. João-de-Ver thrust sheet and the Porto–Albergaria-a-Velha–Tomar shear system, dominate the Albergaria-a-Velha sector, in a NNW–ESE direction (Chaminé, 2000). In the latter fault system a dextral strike-slip faulting is associated with transpressive kinematics triggered by the post-orogenic collapse of the structure along the ancient Porto–Coimbra–Tomar thrust planes. These processes generated a multitude of discrete ENE-WSW to NE-SW regional fault systems (e.g., Sernada do Vouga–Vouga River fault).

### *Palynostratigraphy*

Samples were processed using standard treatment techniques (Traverse, 1988) involving maceration with HCl and HF, followed by oxidation of the residues with dry Schulze mixture (short oxidation times, of about 1 to 5 minutes were required). Organic residues, generally scarce, were systematically cleaned and concentrated during maceration procedures. Strew mounts and permanent glass slides were prepared for transmitted light microscopic examination and subsequently studied and photographed. Samples, residues, and slides are stored in the archives of GIPEGO laboratories (Department of Geology, University of Porto).

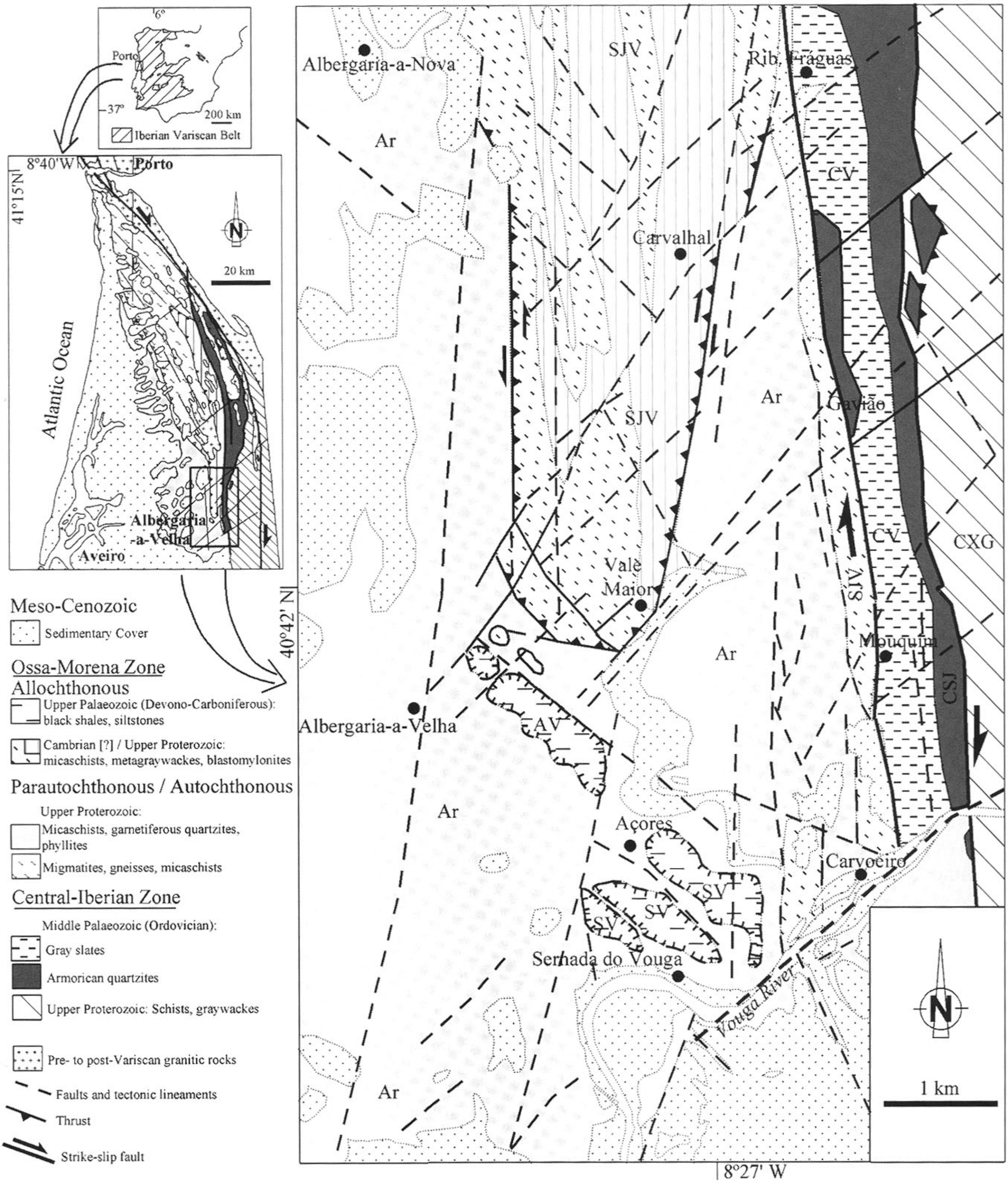


Fig. 2. Regional geotectonic framework of Albergaria-a-Velha area in the Porto–Coimbra–Tomar shear zone (Ossa-Morena Zone, NW Portugal) (adapted from Chaminé, 2000; Gomes & Barra, 2001 and H.I. Chaminé & A. Gomes unpublished geological and geomorphological mapping). Explanation (see Table 1): (i) Ossa-Morena Zone Units – SJV: S. João-de-Ver Unit, SV: Sernada do Vouga Unit, AV: Albergaria-a-Velha Unit; Ar: Arada Unit; (ii) Central-Iberian Zone Units – CV: Carvoeiro Unit; CSJ: Caldas de S. Jorge Unit.

Table 1. Summary of stratigraphic and tectonometamorphic features of Porto–Albergaria-a-Velha metamorphic belt (Ossa-Morena Zone/Central-Iberian zone)

| Tectonostratigraphy | Tectonometamorphic events | Timing | Orogeny | Source |
|---|---|---|---|---|
| Porto–Albergaria-a-Velha platform | | | | |
| • Sedimentary cover | Diagenesis, rifting process, tectonic inversion | Post-Triassic/ Quaternary | Alpine | Telles Antunes et al. (1979), Ribeiro (2002), Araújo et al. (2003) |
| Metasedimentary substratum | | | | |
| Ossa-Morena Zone | | | | |
| *Allochthonous* | | | | |
| • Sernada do Vouga Unit | Very low-grade metamorphism, organic-rich rocks | Carboniferous (Namurian) Devonian (Givetian/ Frasnian) | Late Variscan | Chaminé (2000), Fernandes et al. (2001), Chaminé et al. (2003) |
| • Albergaria-a-Velha Unit | | | | |
| • S. João-de-Ver Unit | Middle- to high-grade metamorphism, folding in higher-grade areas, thrusting | Cambrian [?]/upper Proterozoic | Pre-Variscan | |
| *Parautochthonous/Autochthonous* | | | | |
| • Arada Unit | Early deformation, low- to high-grade metamorphism, peak metamorphism (*ca.* 311 Ma), folding in higher-grade areas | Upper Proterozoic | | |
| • Espinho Unit | | | | |
| • Lourosa and Pindelo Units | | | | |
| • Lordelo do Ouro e Foz do Douro Units | Post-metamorphism deformation, cross-folding, shear zones, thrusting, extensional cleavage | | Pre- and post-Variscan; Cadomian [?] | Beetsma (1995), Chaminé (2000), Fernandez et al. (2003) |
| Central-Iberian Zone | | | | |
| *Parautochthonous/Autochthonous* | | | | |
| • Caldas de S. Jorge and Carvoeiro Units | Low-grade metamorphism (greenschist facies), folding, variscan structures pre- to syn-peak metamorphism, shear zones, fabric development | Ordovician | Variscan | Chaminé (2000) |
| • Schist-graywacke Complex | | Upper Proterozoic | | |
| Granitic rocks | | | | |
| • Lavadores granite | Post-tectonic granite | 298±12 Ma | Pre- to post-Variscan | Martins et al. (2001) |
| • Oliveira de Azeméis–Feira–Lourosela granitic belt | Granitic antiform structure | 320±3 Ma; 379±12 Ma; 421±4 Ma; 419±4 Ma | | Serrano Pinto (1979), Chaminé (2000) |
| • Ossela–Milheirós de Poiares blastomylonitic belt | Granitic synform structure | | | |
| • Foz do Douro Complex | Shear zones, mylonitic fabric | 575 ± 5 Ma; 607 ± 17 Ma; 1.05 Ga (model age) | Cadomian | Noronha & Leterrier (2000) |

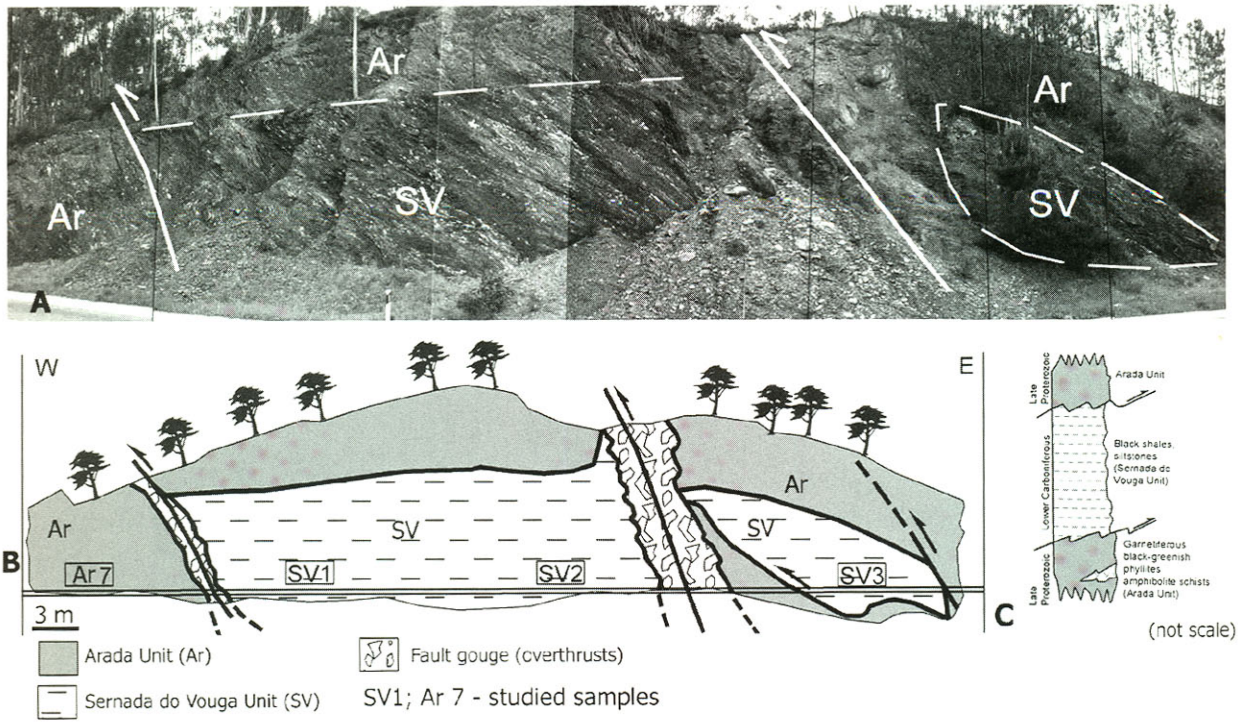


Fig. 3. Field tectonostratigraphic features showing the location of black shales studied in Albergaria-a-Velha/Sernada do Vouga region.

A palynological study has shown that some of the black shale outcrops of Albergaria-a-Velha–Sernada do Vouga contain a good number of palynomorphs, with sporomorphs from the Early Carboniferous (Fig. 5).

Sporomorphs clearly dominate over acritarchs, the latter being mostly sphaeromorphs or pteromorphs, with the apparent absence of polygonomorphs or acanthomorphs. Most of the acritarchs (s.l.) and some (rare) chitinozoans are interpreted as reworked. Fragments of vegetal tissues are very abundant, giving to the overall aspect of the organic residue a distinctive character; preservation is generally quite good.

The palynomorph assemblage is characterised, mainly, by the presence of *Reticulatisporites carnosus*, *Savitrisporites nux*, *Spelaeotriletes* cf. *arenaceus*, *Microreticulatisporites* spp., *Lycospora* sp. and *Densosporites anulatus*, suggesting an Early Namurian age (according to Smith & Butterworth, 1967; Clayton et al., 1977). Apart from reworked thick-walled acritarchs, *Tasmanites* sp. and chitinozoans, reworked spores also occur, as *Cyrtospora cristifer* and *Discernisporites micromanifestus* (Late Famennian/-Tournaisian), *Raistrikia nigra* (Viséan), and *Cristatisporites triangulatus*, *Emphanisporites* sp. and *Ancyrospora* sp. (Middle/Late Devonian), among others.

*Organic petrology and metamorphism*

The petrographic characterisation of the organic-rich samples was performed both on whole-rock polished blocks and light fraction (organic concentrates obtained by heavy liquid separation) slides, prepared according to the techniques described in Moço et al. (2001). Microscopic examination was carried out using a microscope equipped with both reflected white and blue light. The terminology used to identify and describe the organoclasts is the one proposed by the International Committee for Coal and Organic Petrology.

The organic petrology characterisation, on whole-rock and light fraction, indicated that the organic matter of the Lower Carboniferous black shales comprises mainly sporinite, followed in decreasing order of significance by inertinite and vitrinite. The sporinite are often well preserved. Rare zooclasts, probably remains of marine organisms, are also present. The organic matter observed can be classified as type II–III. The observation of the fluorescence colour of sporinite in organic concentrates using transmitted white light, allowed the determination of the Thermal Alteration Index (Staplin, 1969) as 3+. The maturation, measured by mean random vitrinite reflectance ($R_r$, %), is at the level of catagenesis (ranged, $R_r = 1.3\%$ and 1.5%). This range reflects the minor quantity of vitrinite particles suitable for measurement. Free HC were observed mainly as matrix impregnations, fractures and cavity fillings.

Organic petrology analysis of the Upper Proterozoic substratum (Arada Unit) shows a very poor organic content, which is lower than that of the Upper Paleozoic section. The organic particles, always very small,

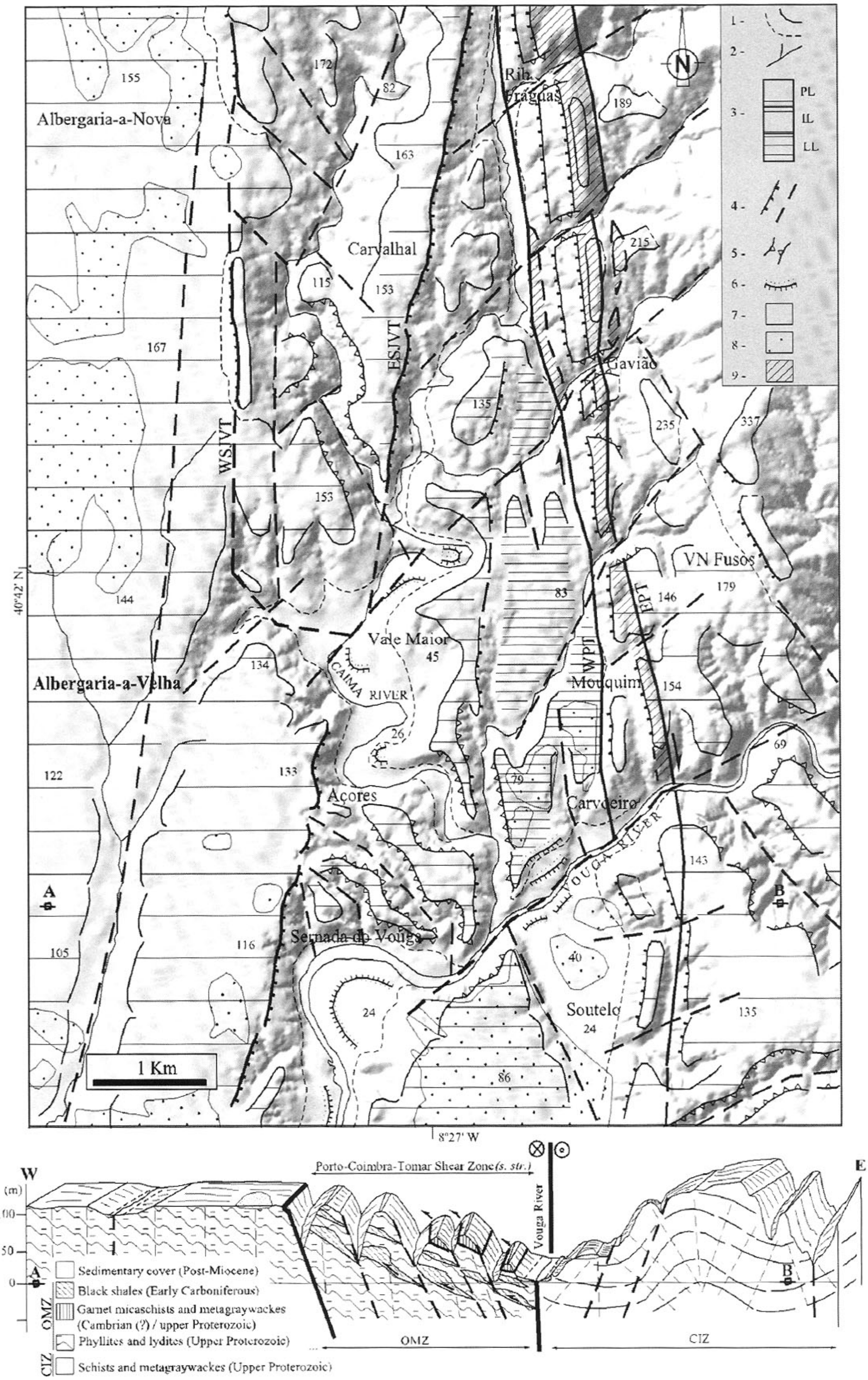


Fig. 4. Morphotectonic map of Albergaria-a-Velha region. Image from the digital terrain model of the studied area, generated by kriging from digitisation of elevation contour lines of the 1:25,000 scale. Ground resolution is 10 m. Shadowed image of the digital terrain model, artificially illuminated from the West, marked with regional morphotectonic interpretation. Explanation: (1) slope top and base; (2) main stream lines; (3) flat surfaces (PL – littoral platform level, IL – intermediate level, LL – low level); (4) fault scarp and tectonic lineament systems; (5) fluvial gully; (6) Quaternary fluvial terraces; (7) Quaternary alluvium; (8) post-Late Tertiary sedimentary cover; (9) Ordovician quartzites (CIZ). Major regional tectonic lineaments: S. João-de-Ver thrust (WSJVT – west branch; ESJVT – east branch), Porto–Coimbra–Tomar shear zone (WPT – west branch; EPT – east branch).

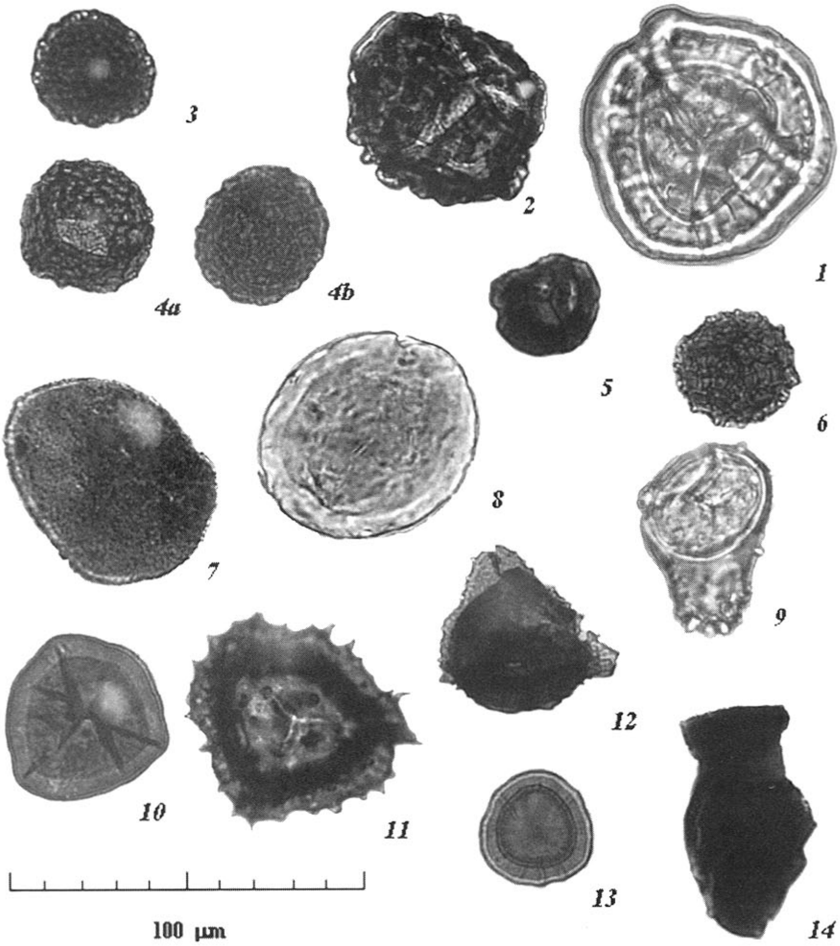


Fig. 5. Early Carboniferous palynomorph assemblage from Albergaria-a-Velha/Sernada do Vouga black shales (Ossa-Morena Zone, NW Portugal).
*Namurian association*: 1 – *Reticulatisporites carnosus*; 2 – *Savitrisporites nux*; 3 – *Microreticulatisporites punctatus*; 4a,b – *M. microreticulatus*; 5 – *Densosporites anulatus*; 6 – *Dictyotriletes* sp.; 7 – *Spelaeotriletes* cf. *arenaceus*; 8 – *Tasmanites* sp.
*Reworked:* (a) Famennian/Tournaisian: 9 – *Cyrtospora cristifer*; 10 – *Discernispotites micromanifestus*; (b) Middle Devonian: 11 – *Densosporites devonicus*; 12 – *Cristatisporites triangulatus*; 13 – *Emphanisporites annulatus*; (c) Early Palaeozoic: 14 – Chitinozoan.

are thermally affected and consequently their identification and classification is very difficult. They may be classified as 'vitrinite-like' organoclasts. The coalification degree is always very high, corresponding to the upper epizone (low-grade metamorphism). These conclusions are in agreement with previous metamorphic petrology studies, which place these materials in lower- to middle-greenschist facies, i.e., white micas + quartz + chlorite ± chloritoid ± garnet ± tourmaline ± apatite ± zircon (Severo Gonçalves, 1974; Chaminé, 2000).

*Clay mineralogy*

The mineralogical study of the samples, particularly of clay minerals, was based mainly on X-ray diffraction (XRD) analyses, carried out using a Philips X'Pert PW3040/60 powder diffractometer with Cu$K\alpha$ radiation at the Aveiro University Laboratories. The mineralogical study, particularly of the clay components, was based mainly on X-ray diffraction (XRD) determinations following the analytical methods described by Thorez (1976). Organic maturation data ($R_r$, %) were compared with mineralogical data, namely Kubler's Illite Crystallinity Index (KI), Esquevin's Illite Index (EI) and Chlorite Crystallinity Index (CI).

Quartz, micas, chlorites and feldspars dominate the bulk mineral composition of the studied samples. Illite, chlorite and kaolinite dominate the clay fraction composition. The distribution of these clay minerals (Fig. 6) shows a clear differentiation between the studied materials (i.e., Upper Paleozoic black shales and Upper Proterozoic black-greenish phyllites). Actually, Lower Carboniferous samples are richer in chlorite whereas Upper Proterozoic ones are richer in illite.

Lower Carboniferous samples exhibit KI values (Fig. 6) indicating low anchizone (KI 0.42–0.30) conditions, whereas those from Upper Proterozoic samplels (e.g., Arada Unit; Chaminé, 2000) indicate epizone conditions (KI <0.25). Most studied sam-

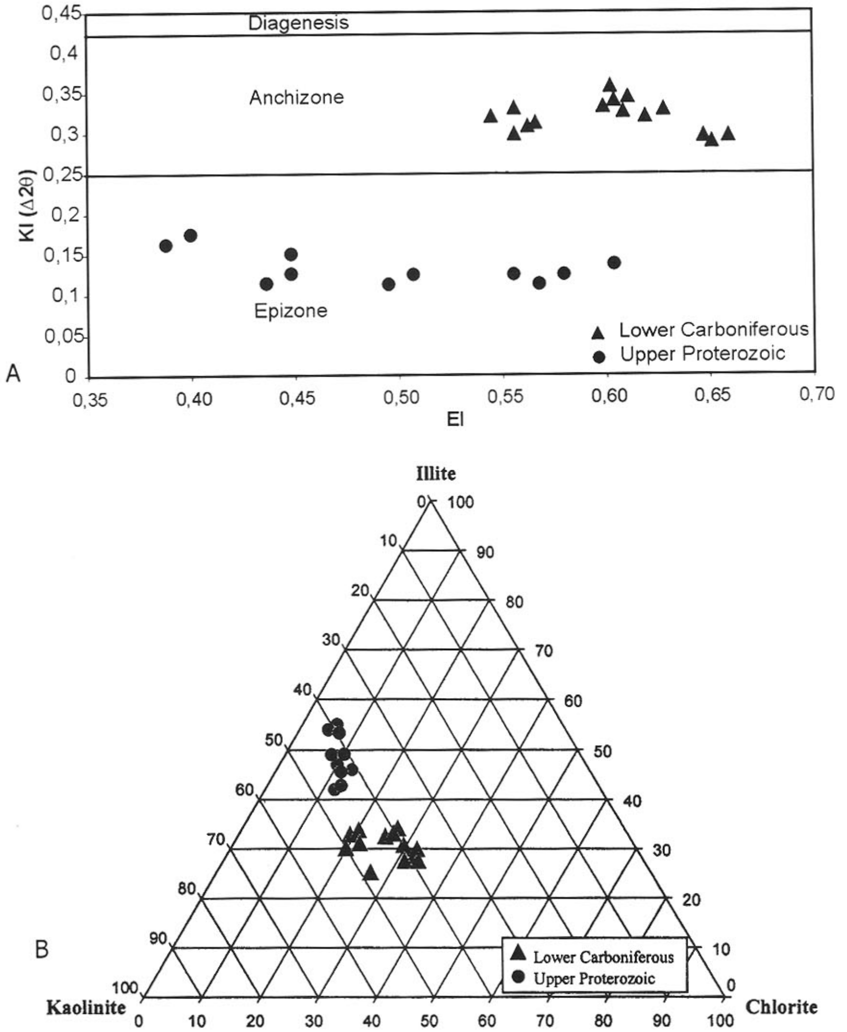


Fig. 6. KI/EI scatter diagram from the age groups studied (Lower Carboniferous and Upper Proterozoic metapelitic materials) and mineralogical composition of the clay fractions.

ples show EI values (Fig. 6) corresponding to Al-rich (phengitic and muscovitic) illites (0.40 to 0.65), in particular those samples with an Early Carboniferous age (0.55 to 0.65, clearly muscovitic). The distribution of KI values along the outcrops points out to a high-degree of structural order, although the samples of the substratum (of Late Proterozoic age, according to Beetsma, 1995) show higher-structural order than those belonging to the Upper Palaeozoic material. CI distribution is in good agreement with KI trend, in all samples.

## Concluding discussion and remarks

During the Early Carboniferous, many plant distributions were climatologically dominated and the northern margin of Africa was apparently a barrier for plant migration. Accordingly, the observed miospore associations show strong latitudinal correlation (McKerrow et al., 2000, and references therein).

Palynological and organic petrology studies performed on Early Carboniferous Albergaria-a-Velha black shales suggest the presence of marine, littoral, paleoenvironments. Petrographically, a relative abundance of plant debris with small amounts of faunal remains can be observed, also indicating marine, near-shore conditionsly. The observation of a large proportion of plant tissues and debris in the palynological residues, as well as the characteristics of the palynomorph associations, support the hypothesis of sediment deposition in a marine basin with a strong continental contribution.

The paleothermal history, inferred from mineral paragenesis, reveals very low-grade metamorphic conditions for the Lower Carboniferous section and low-grade metamorphism (lower- to middle-greenschist facies) for the Upper Proterozoic basement. An identical conclusion could be reached if relevant outcrops or petro-structural characteristics are analysed (Severo Gonçalves, 1974; Chaminé, 2000). Paleothermal history deduced from clay crystallochemical, or-

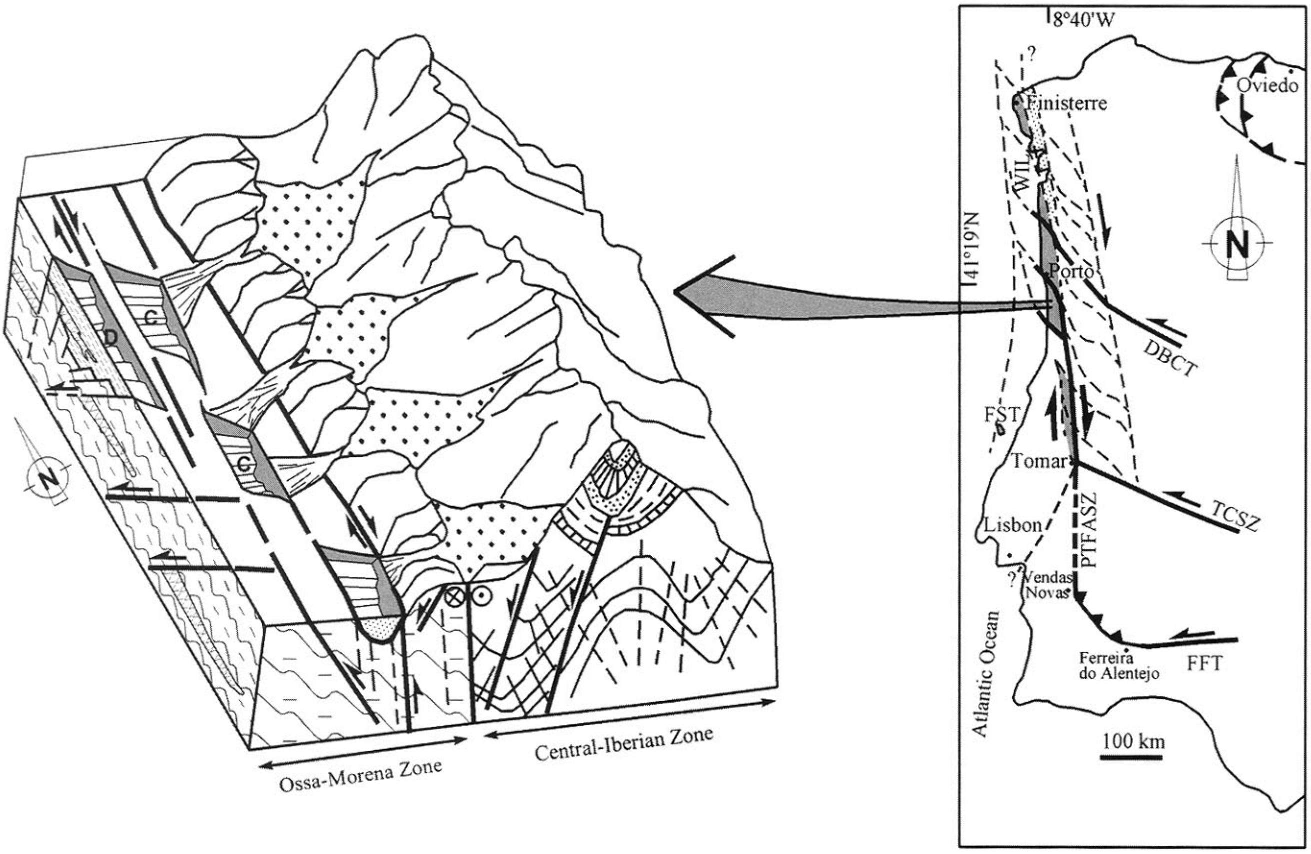


Fig. 7. 3D Block diagram illustrating the relationship of Upper Palaeozoic basins *vs.* Proterozoic basement fracture patterns on the northernmost Ossa-Morena Zone geodynamic framework during the Early Carboniferous (C: Carboniferous basins; D: Late Devonian basins). *Shear zones and terranes*: Western Iberian Line (WIL), PTFASZ: Porto–Tomar–Ferreira do Alentejo shear zone, FFT: Ferreira do Alentejo–Ficalho thrust, TCSZ: Tomar–Córdoba shear zone, DBCT: Douro–Beira Carboniferous trough, FST: Farilhões suspect terrane.

ganic and metamorphic petrology data reflects very low-grade metamorphic conditions (ca. 200°–250°C) for Early Carboniferous samples, and low-grade metamorphism (i.e., lower- to middle-greenschist facies, ca. 300°–350°C; cf. Merriman & Frey, 1999) for the Upper Proterozoic substratum.

The results of our analyses along the Porto–Albergaria-a-Velha metamorphic belt have implications for the geodynamic evolution of the Porto–Coimbra–Tomar shear zone (Fig. 7). The occurrence of Upper Paleozoic strike-slip basins in the Albergaria-a-Velha region, suggest the presence of a right stepping dextral regime along the Porto–Coimbra–Tomar shear zone, thus typifying a relevant issue to pursuit. Indeed, the discrete Middle/Late Paleozoic (Late Devonian–Early Carboniferous) metapelitic organic-rich materials, which filled ancient small troughs, have also been observed systematically along a rough strip subparallel to the Porto–Coimbra–Tomar shear zone (Chaminé et al., 2003a). A, moderate to high-angle, normal fault border is present. These Middle/Late Paleozoic NNW-SSE-trending internal basins, of low- to high-anchizone metamorphism, have been interpreted as remnants of overlaying units. The deposition occurred essentially over a pre-Early Paleozoic Ossa-Morena Zone, comprising of a deformed substratum of greenschist facies (chloritoid zone) metamorphic rocks. The field tectonostratigraphic relationships and analytical data, as previously suggested, clearly demonstrate the imbrication of organic-rich shales of Namurian age into Late Proterozoic metamorphic basement (Beetsma, 1995). Moreover, the occurrence of scattered tectonic slices suggests the existence of tectonostratigraphic imbrications of variable metamorphic grade, bearing a very characteristic regional geotectonic signature.

The Upper Paleozoic basins are consequently considered to be key structures for geodynamical and paleobiogeographical modelling of the Variscan Belt in SW Europe. Interestingly, Devonian–Carboniferous tectonic basins have been recognised in the Armorican Massif (Brittany, France) in dextral major shear zones (Rolet et al., 1994; Paris & Robardet, 1994; McKerrow et al., 2000, and references therein) associated with great lithospheric depths (Judenherc et al., 2002), namely, the North-Armorican Shear Zone (Châteaulin and Laval basins) and the South-Armorican Shear Zone (Ancenis Basin). Indeed, recent data suggest that, during pre-Variscan time, the Mid-North Armorican formed a direct extension of the West-Iberian region (Robardet, 2002). This hypothesis is based mainly on faunal and sedimentary evidence. According to this model, the transfer (rotation and translation) in the Variscan orogeny would have been achieved, most probably, during the Early Carboniferous (Robardet, 2002).

The nearby tectonic imbrications related with major faults, some of them probably with a deep-root zone, highlighted the presence of main corridors with deep-fluid circulation of metasomatic features, namely a very intense carbonatisation of some neighbouring rocks (Chaminé et al., 2003b). In conclusion, the Porto–Coimbra–Tomar shear zone is located in the Western Iberian Line (Chaminé et al., 2003a) and it delineates a major tectonic corridor extending for more than 520 km in a NNW–SSE direction across the NW part of the Iberian Massif. In addition, this lineament is probably the major structure with potential to yield further insight, at lithospheric-scale, about the basement reactivation and orientation of the regional stress field.

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