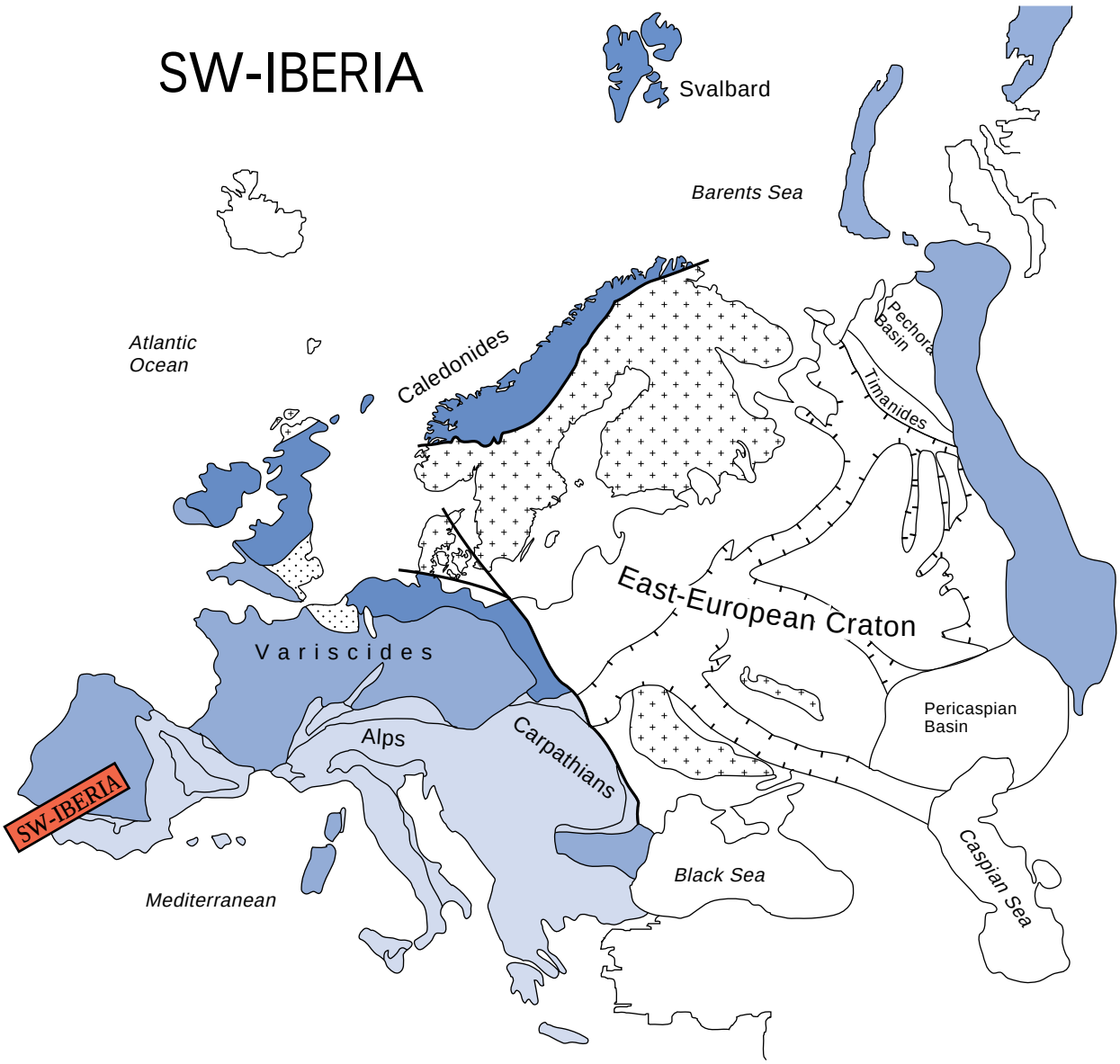
SW-IBERIA
Svalbard
Barents Sea
Atlantic Ocean
Caledonides
Pechora Basin
Timanides
East-European Craton
Variscides
Alps
Carpathians
Pericaspian Basin
SW-IBERIA
Black Sea
Caspian Sea
Mediterranean

SW-IBERIA

Transpressional Orogeny in the Variscides

by Antonio Ribeiro (Lisbon), David Sanderson (Southampton) and SW-Iberia colleagues

The Variscan orogen in southwestern Iberia offers a unique opportunity to image and study a transpressional orogen and to examine the partitioning of deformation in 3-dimensional space and time. The region consists of a series of zones representing different tectonostratigraphic units exposed at a variety of structural levels. Varying components of shortening and left-lateral strike-slip deformation have been recognised from field studies and from geodynamic models, such as the indentor model of the Ibero-Armorican arc. Studies of the structure, stratigraphy, metamorphism, magmatism and palaeogeography will allow a reconstruction of the geometry and history of this important class of orogens produced by oblique collision of lithospheric plates.

The principal aim of this multidisciplinary project is to better understand orogeny resulting from oblique collision. This will be achieved by imaging the crust at different structural levels through collaborative work on existing data, geological and geophysical investigations of critical areas and acquisition of new seismic reflection profiles through the orogen. The seismic profiles will be fully integrated with the surface geology and provide images deep into the mantle, thus, providing a critical 'missing link' in the imaging of the Variscan orogen in Europe.

Within the Variscan of SW-IBERIA are some of Europe's most important Volcanic Massive Sulphide ore deposits (Rio Tinto, Neves-Corvo, etc.). The tectonic setting and reconstruction of the ore bodies requires detailed stratigraphical and structural studies; this project will provide new concepts for further exploration.

The SW-IBERIA project will focus on the following main goals:

1) Imaging of the lithosphere using deep seismic reflection profiling, wide-angle studies, magnetotelluric and other geophysical experiments.
2) Testing of transpressional models through mapping of strain variation through the different structural zones. This, together with the geophysical imaging will allow testing of thick-skinned versus thin-skinned models of deformation, and constrain estimates of shortening and displacement at crustal and lithospheric scales.
3) Reconstruction of the pre-collisional (North Gondwanan) and syn-collisional palaeogeography of the crustal units using sedimentary, faunal and palaeomagnetic studies to constrain the timing and position of orogenic processes.
4) Examination of the boundaries (sutures) and associated rocks (high grade metamorphics and ophiolites), in order to constrain the processes of continental collision.
5) Examination of the origin, setting and timing of magmatism and metallogenesis to constrain emplacement mechanisms and crustal evolution.

Introduction

The Variscan Fold Belt in Europe is strongly arcuate, contrasting with the linear pattern of other Palaeozoic fold belts in the continent, such as the Caledonides and Uralides (Fig. 8.1). Tectonic and palaeomagnetic analysis shows that the Ibero-Armorican Arc is due, in part, to oroclinal bending, which is expressed in southwestern Iberia as transpressive deformation. Field studies have provided a large range of kinematic criteria, but deep seismic imaging experiments are required to more fully evaluate their significance. Thus, the SW-IBERIA Variscides provide a unique opportunity to study the dynamics of transpression at the lithospheric scale, not only to know more about this important part of the European continent, but to provide new insight into an important, but poorly understood, class of orogens. In plate tectonics, oblique convergence is the rule rather than the exception.

Development of the Research Plan

The SW-IBERIA project developed from the Uralides-Variscides Main Theme in a number of Europrobe workshops, including Perlora (1993), Évora (1994), Lisbon (1995) and Granada (1996). Geoscientists from Bulgaria, France, Germany, Ireland, Italy, Morocco, the Netherlands, Norway, Portugal, Russia, Spain, Sweden and United Kingdom have attended those meetings. The project now involves research institutes from 15 countries.

Geological Framework

The Iberian Massif is a well exposed fragment of Variscan basement that has escaped significant Alpine rejuvenation except along its margins (Matte, 1986). It affords the most complete geotraverse through the Variscan Fold Belt in Europe (Fig. 8.2).
The spectacular Ibero-Armorican Arc has been known for more than a century and its connection to Armorica was proposed by Argand (1924) and later explained by the opening of the Bay of Biscay (Carey, 1958).
The subdivision of the Iberian Massif into several zones with specific palaeogeography, tectonics, pre- and syn-orogenic magmatism, and metamorphism was established by Lotze (1945), with minor modification afterwards (Julivert et al., 1974; Farias et al., 1987; Dallmayer and Martínez García, 1991).
Much progress has been made in the Iberian Variscides in the last decades. Recent studies of geochronology, petrology and tectonics have contributed to a better understanding of the geodynamic evolution of the Iberian Variscides, allowing the definition of suture zones. A model has been developed for the generation of the Ibero-Armorican Arc by indentation of a Cantabrian Block (Ribeiro et al., 1991); palaeogeographic and palaeomagnetic studies (Bachtadse and Van der Voo, 1986) have shown the latter to be a part of the Gondwanan margin. Key problems of interpretation remain to be solved, such as the role of transpression in the generation of the present structure, and its variability in space (particularly depth) and time.
The general trend of Variscan structures in southwestern Iberia is NW-SE or slightly arcuate between NS and EW. Thus, from northeast to southwest the following zones are distinguished (Fig. 8.2):

Central Iberian Zone (CIZ)

The oldest rocks exposed are Upper Proterozoic metasediments affected by the Cadomian orogeny, with moderate deformation and low-grade regional metamorphism. The latest Precambrian-Cambrian sequence consists of metasediments and volcanics. The Ordovician-Devonian is mainly composed of siliciclastic rocks, including the lower Ordovician Armorican quartzite. The Lower Carboniferous is unconformable over older rocks.
The structure comprises NE-verging thrusts and recumbent folds, synchronous with low-grade metamorphism. To the northeast, the folds become upright. This early deformation event is pre-Carboniferous and slightly modified by a second deformation event. Late synorogenic and post-orogenic granitoids occur widely.

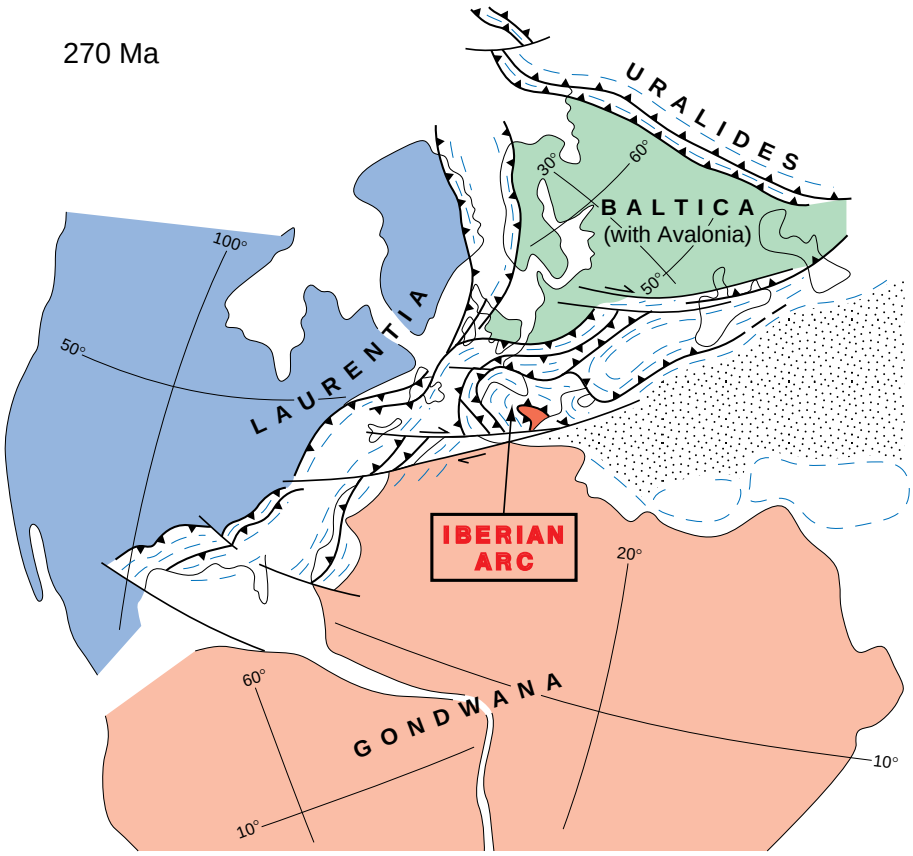

Figure 8.1: Palaeozoic peri-Atlantic orogens in the Permian (from Matte, 1991). Highlighted in red is the Cantabrian indenter, responsible for the Variscan structures in the Iberian peninsula.

Tomar-Badajoz-Cordoba Shear Zone (TBCZ)

This 2 - 15 km wide, 350 km long zone is composed of metasediments, amphibolites, migmatites and orthogneisses. It is affected by very intense left-lateral ductile shearing passing to late, more brittle, faulting with reverse and normal components of movement in different areas. The orthogneisses correspond to Upper Cambrian-Ordovician granitoids, sometimes with peralkaline tendencies, that cut previously deformed country rocks. Eclogites and garnet amphibolites occur as lens-shaped bodies within migmatites and metasediments. The shearing occurred at amphibolite to greenschist facies during the late Devonian and Carboniferous. This unit marks one of the sutures of the southwestern part of the Iberian Massif.

Ossa-Morena Zone (OMZ)

The oldest rocks are metasediments and metavolcanics of Neoproterozoic age, possibly deformed during Cadomian events. The Upper Vendian-Lower Cambrian consists of acid volcanics and arkosic sandstones and conglomerates, passing up into Lower Cambrian limestones. Pelites and greywackes with interbedded mafic volcanics occur in the Middle and Upper Cambrian. The Lower Ordovician consist of pelites passing up into Silurian quartzites, overlain by a condensed sequence of shales of Silurian and Early Devonian age. The Upper Devonian is flyschoid and unconformable on older rocks. Lower and Middle Carboniferous, sometimes with coal, occupies intramontane basins. To the southwest, a volcanic detrital series of Early Silurian age unconformably overlies Lower Cambrian dolomites.

The structure of the OMZ is dominated by recumbent folds and thrusts verging to the SW and later upright folds; a component of sinistral strike-slip is predominant over most of the area. Variscan metamorphism varies from chlorite to sillimanite grade and is of low pressure type. Magmatism is represented by several small plutons of uncertain age, whose composition changes from bimodal gabbro-peralkaline syenite in the northwest, through a gabbro-granite series, to calc-alkaline tonalite-granite associations in the southeast.

Southern Ophiolite Terrane and related sequences (BAOC)

The boundary between the Ossa-Morena and South-Portuguese zones is marked by the presence of a dismembered ophiolite sequence of mafic cumulates, gabbros, a sheeted-dyke complex and lavas, forming the so-called Beja-Acebuches Ophiolite Complex (BAOC).

A complex of obducted ophiolites and roof-imbricates with high-pressure metamorphic rocks (eclogites and blueschists) has been discovered along the southwestern boundary of the Ossa-Morena Zone. Early thrusting to the NE has been proposed and interpreted to predate Dl folding in the footwall of the Ossa-Morena Zone.

A major thrust with SW-directed transport marks the southwestern boundary of the OMZ, putting it on top

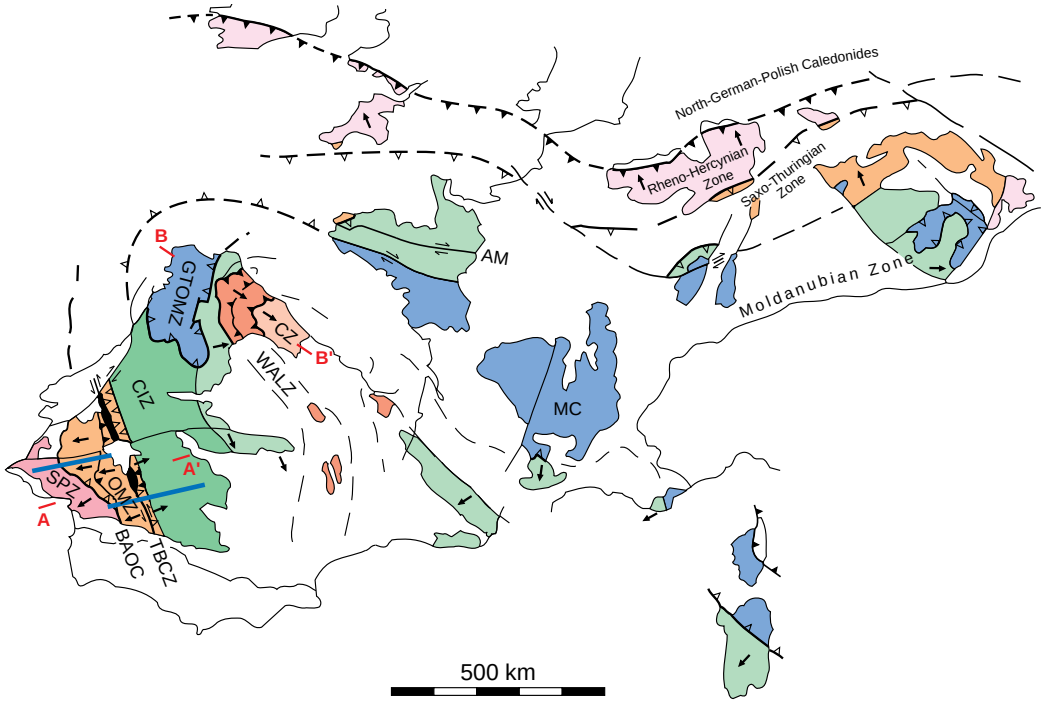

Figure 8.2: Main structural elements of the Variscides during the early Carboniferous (after Franke, 1989). Blue lines in southwestern Iberia mark the planned seismic profiles. Red marks indicate the positions of the cross-sections represented in figure 8.3. AM, Armorican Massif; BAOC, Southern Ophiolite Terrane; CIZ, Central Iberian Zone; CZ, Cantabrian Zone; GTOMZ, Galicia-Tras-Os-Montes Zone; MC, Massif Central; OMZ, Ossa Morena Zone; SPZ, South Portuguese Zone; TBCZ, Tomar-Badajoz-Cordoba Shear Zone; WALZ, West-Asturian Leonese Zone.

of deformed metasediments (Pulo do Lobo), which pass up into Upper Devonian quartzites and phyllites. Three major deformation events, with vergence to SW affect these rocks.

South Portuguese Zone (SPZ)

The SPZ shows a strong sedimentary and tectonic polarity with syntectonic sedimentation migrating to the southwest. The older rocks are pelites and quartzites of Upper Devonian age. Bimodal volcanics of Tournaisian to Lower Visean age occur in the northeast, forming the 'Pyrite Belt', with its associated important massive sulphide ore-bodies. Condensed shoal facies with black shales occur to the southwest. Thick flysch units of Upper Visean and Namurian age prograde to the southwest, where limestones and black shales are deposited in the Visean and Namurian, respectively. Finally, Westphalian flysch was deposited in the southwest, with intramontane continental deposits to the northeast.

The tectonics of the SPZ is dominated by a thin-skinned, fold-and-thrust belt with vergence to the SW. Regional metamorphism of low grade changes from chlorite, via prehnite-pumpellyite facies, to anchimetamorphism towards the southwest.

General Evolutionary Model

The Variscan Fold Belt in Iberia can be divided into tectonostratigraphic terranes, which incorporate the classical zonal description of the belt (Fig. 8.2), sumarized above.

The southwestern Iberia terranes (the Southern Portuguese, Southern Ophiolite and Ossa-Morena Terranes) were apparently assembled in a transpressive regime, generally with SW-vergence, along the southern margin of the Central Iberian Terrane. To the north, vergence is to the NE and E (Fig. 8.3). Platform successions of the Cantabrian Zone and deeper-water sediments of the West-Asturian Leonese Zone form a foreland fold-and-thrust belt onto which the major Variscan allochthons of northern Iberia were emplaced, including the Northern Ophiolite and uppermost, continentally derived terranes of the Galicia-Tras-os-Montes Zone (Fig. 8.2).

Two models have been proposed to juxtapose the Ossa-Morena and Central Iberian Zones. In the one model, the Tomar-Badajoz-Cordoba shear zone marks an Eo-Variscan suture (Azor et al., 1994). In the other, a Cadomian suture is inferred, reactivated as an intracontinental sinistral shear zone generated from lateral expulsion away from the Cantabrian indentor.

Ribeiro et al. (1991) propose the following geodynamic evolution. The Armorican Plate was separated from Gondwana by rifting in Cambrian to Silurian times. A southern ocean (Palaeotethys), bifurcating toward the north into the main Rheic ocean and the minor Massif Central-Galicia ocean, closed producing the Southern Ophiolite terrane. Closure of Palaeotethys started after the Silurian by subduction to the ENE of the Ossa-Morena Zone, where typical calc-alkaline magmatism dominates until the Early Carboniferous. This was followed diachronously by continental collision (Middle Devonian in the north and Early Devonian in the south). Thus, the polarity of the main subduction was towards the Ibero-Armorican Arc with production of a tectonic flake. In the outer arc, divergent (outward) thrusting predominated and in the inner arc, convergent (inward) back-thrusting was predominant. The crustal shortening increases from southwest to northeast around the arc. On the southwestern side of the Cantabrian block, a sinistral transpressive regime was established, with dextral transpression on the northeastern side (Armorica). This fact shows that oblique collision produced a general dextral regime between Laurasia and Gondwana, also expressed by late Variscan strike-slip faults (Arthaud and Matte 1977; Pérez Estaún et al., 1988; Ribeiro et al., 1995).

Outstanding Features

The Variscan belt in southwestern Iberia forms an important part of the Ibero-Armorican Arc and shows many features diagnostic of transpressional orogens. The outstanding features which form the basis of this proposal for an interdisciplinary SW-IBERIA study are:

1) A number of kinematic criteria show that transpression (Sanderson and Marchini, 1984) was operative during various stages of orogeny, but there is little known about the dynamic processes involved in this sort of kinematic regime.
2) The transpressive deformation is expressed at different structural levels and in a variety of palaeogeographical settings. Thus inferences made from this study may be used to interpret a range of other orogens. Seismic imaging will allow differentiation of shear zones operating at crustal and lithospheric scales, strain partitioning occurring at depth and the overall resolution of thin-skinned versus thick-skinned components of the deformation.
3) A complete section can be made through the orogen from one foreland region to the other, allowing changes in stratigraphy and structure to be fully documented. Seismic data will allow construction of the most complete profile at crustal and lithospheric scale in the Variscan belt of Europe.
4) Large volumes of igneous rocks exist which allow examination of the timing and mechanics of intrusion during transpressive orogeny.
5) There is potential to comprehensively date deformation and uplift events using stratigraphical and magmatic relationships.
6) The project will fill an important 'missing link' in the deep imaging of the Variscan belt in Europe, being complementary to previous DEKORP, ECORS and BIRPS sudies further to the north.

SW-IBERIA RESEARCH

1. Deep normal incidence, 3-D upper crustal imaging and wide-angle seismic reflection profiling: Southern Variscan Transects *(Barcelona [ICTJA], Madrid [ITGE], Granada [U], Salamanca [U], Lisbon [U], Uppsala [U], DEKORP, Scheelit [BGE], Wyoming [U]).*

A combined vibroseis and coincident explosive experiment along two NE-SW transects has been designed to investigate the internal architecture of the lithosphere of the southern Variscan zones (Fig. 8.3). The vibroseis will provide a high resolution image of the upper crust, whereas the explosive part will give information at deeper levels. Detailed 3-D reflection seismic profiling has been designed to image the crustal structure of the SPZ and OMZ and the transition zone. In addition, three component wide-angle recording will supply velocity information along crossline and in-line directions, with special emphasis on the lateral continuity between the profiles for a primary three-dimensional lithospheric model. In order to constrain the geometry and nature of the crustal boundaries, the transect covers the major structural features recognised from the surface geology. The most relevant targets of the multi-seismic experiment include: 1) defining the internal architecture of the orogen, 2) imaging suture zones and their lateral variation, 3) addressing the structure and physical properties of the lower crust, 4) mapping the Moho topography, and 5) obtaining information on mantle structure and reflectivity.

2. Potential field studies and modelling *(Uppsala [U], Lisbon [U], Oviedo [U], Madrid [ICN], Ekaterinburg [RAS], Keyworth [BGS]).*

The good existing potential field coverage of southwestern Iberia will be augmented with new gravity and aeromagnetic data to provide 3D imaging of crustal structures in order to determine terrane boundary positions and remnants of Variscan suturing. Initially, the Portuguese and Spanish data sets have to be integrated. Anomalies and lineaments will be defined and interpreted in relation to surface geology. Structures will be extended to depth, focusing mainly on the position and dip of Variscan structures, including fault (thrust) zones, ophiolite bodies and magmatic intrusions. Measurements of densities and magnetizations will be carried out. Further constraints on this modelling are expected from existing DSS profiles, as well as from the planned multi-seismic profiles.

3. Magnetotelluric studies across major Variscan boundaries *(Barcelona [U], Lisbon [U], Berlin [FU], ITGE, Ekaterinburg).*

This project involves two main magnetotelluric profiles along the two deep seismic reflection lines referred to above. The five magnetotelluric components will be recorded at periods sufficiently long to be able to determine the electrical conductivity distribution of the whole lithosphere. Furthermore, short profiles perpendicular to the main ones will be carried out in

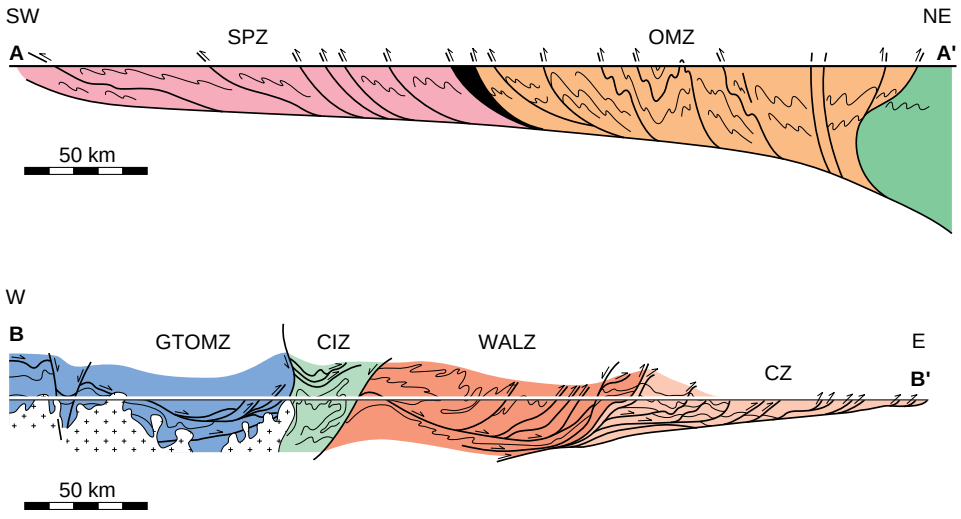

Figure 8.3: Simplified cross-sections of the Iberian Variscide Belt (ophiolites black). A-A': southwestern profile (redrawn from Ribeiro et al., 1995), B-B': northwestern profile (redrawn from Pérez-Estaún et al., 1991). Positions and abbreviations see Fig. 8.2.

order to obtain a 3D image of this transpressive orogen. With these measurements, the main units, i.e. the CIZ, OMZ and SPZ will be covered as well as the major structural features. The main goals are: 1) determination of the electrical conductivity distribution (crust and upper mantle) of each geological province, 2) detection of the faults and sole detachments as well as their continuity at depth, and 3) survey of the suture zones.

4. Investigation of seismic anisotropy in southwestern Iberia in relation to a transpressive lithospheric regime *(Barcelona [ICTJA], Lisbon [U, INM], Scheelit [BGE], Wyoming [U]).*
This project aims at providing complementary seismic constraints to the reflection transects. A passive seismic experiment is designed to record for an extended time period (several months) the regional and teleseismic activity in a band-broadened, portable network covering the three main Variscan domains in southwestern Iberia. 3-D lithospheric tomographic inversions will be carried out after analysis of P and S wave travel-time residuals, complemented by existing crustal refraction data. Additional investigations of 3-D structure by shear-wave polarization and splitting will provide a key for understanding the main stress directions in the lithosphere and the possible existence of anisotropy related to major lithospheric shear zones and other tectonic phenomena.

5. Early Palaeozoic palaeogeography of southwestern European Variscides *(Brest [U], Rennes [U], Lyon [U], Granada [U], Madrid [U, CSIC, ITGE], Oviedo [U], Zaragoza [U], Porto [U], Lisbon [IGM], Pisa [U], Caglari [U], Berlin [TU], Rabat [U], Sofia [BAS], Prague [CAS], Toronto [U]).*
The geodynamic evolution of the different parts of the Iberian Variscides can be investigated through sedimentological and faunal studies. Those studies allow: 1) recognition and delimitation of different domains with distinct faunal, sedimentological and palaeoenvironmental characteristics and 2) evaluation of their relative positions and mutual relations through time, within the pre-orogenic palaeogeography. The project will provide a more complete analysis of the domains of this part of the North-Gondwanan Province margin and of their relations with surrounding areas (especially Morocco and southeastern Europe), the palaeogeography providing essential constraints on the amount of movement involved in the transpressive terrane assemblage.

6. Palaeomagnetic constraints for the geodynamic evolution of the Iberian Variscides *(München [U], Barcelona [ICTJA], St. Petersburg [VNIGRI]).*
The pre- and syn-orogenic framework of the various terranes involved during the Lower Palaeozoic evolution of the Iberian Variscides will be investigated using palaeomagnetic techniques. Detailed palaeomagnetic studies of Ordovician to Carboniferous sedimentary and volcanic sequences from the CIZ, OMZ and SPZ will provide constraints on the palaeodrift history of these units. This work will be carried out in close collaboration with other subprojects concerned with structural, stratigraphical and faunal data. Special attention will be paid to the Lower Carboniferous basins of southwestern Iberia. Combining palaeomagnetic and structural studies with investigations of the anisotropy of magnetic susceptibility, it will be possible to determine the rotational component of deformation related to transpressional movement along the TBCZ.

7. Sedimentary and tectonic evolution of the forelands of the European Variscan belt: South-Portuguese and Rhenohercynian zones *(Porto [U], Lisbon [U, IGM], Aveiro [U], Madrid [ITGE], Dublin [TCD], Aachen [RWTH], Southampton [U], Ufa [RAS], Wroclaw [PGI], Sofia [BAS]).*
Detailed analysis of the SPZ will elucidate the geological evolution of the foreland successions. This will include the economically important rocks of the Pyrite Belt and evaluation of the hydrocarbon potential of the zone. Collaborative teams will investigate: 1) basin filling and thermal history, including biostratigraphy and sedimentology, 2) volcanism and hydrothermal activity, and 3) tectonic evolution. This investigation will allow palaeogeographic and geodynamic reconstruction of the region for comparison with other parts of the Rhenohercynian zone, where a more comprehensive database already exists.

8. Suture related rocks: High grade terranes and ophiolites in the Iberian Variscides *(Lisbon [U, IGM], Aveiro [U], Évora [U], Madrid [U], Salamanca [U], Granada [U], Paris [UPMC], São Paulo [U], Sofia [BAS], Moscow [GIN], Ekaterinburg [RAS]).*
This project involves tectonic, petrological, geochemical and geochronological studies of the Iberian allochthonous terranes of the Variscan oceanic suture. Attention will be focused on the high-grade granulitic/peridotitic rocks, eclogites/blueshists and ophiolites of southwestern Iberia. The principal objective is to define the tectonometamorphic evolution of the main suture of the Iberian Variscan chain. Specific research topics will include: 1) protolith identification, definition of P-T-t metamorphic paths (including radiometric dating) and characterisation of emplacement processes for Variscan blueschist/eclogite units from the Galicia-Tras-os-Montes and the Ossa-Morena Zones and 2) characterisation and comparative analysis of the genesis and obduction processes of ophiolites in these zones. New work will also be necessary on the petrological, geochemical, tectonic and metamorphic evolution of the high-grade continental allochthonous terranes within Galicia-Tras-Os-Montes. By integrating structural, petrological and geochemical data with that derived from the geophysical

experiments, this project will contribute to a better understanding of the deep processes acting during lithospheric oblique collision.

9. The Southwestern Transect *(Madrid [ITGE], Lisbon [U, IGM], Granada [U], Southampton [U], Somincor, Évora [U], Bilbao [U]).*
A major goal of the SW-IBERIA project is the acquisition of deep seismic reflection profiles. As a pre-requisite to these experiments, this subgroup will prepare geological transects from available data. The profiles are oriented NE-SW, sub-perpendicular to Variscan structures, avoiding transverse structures and Tertiary basins. The eastern segment will cross the CIZ, OMZ and part of the SPZ. ITGE will co-ordinate the compilation of geological maps and cross-sections along this line. The western segment will cross the OMZ and the SPZ. University of Lisbon will compile the corresponding geological data and, in co-operation with IGM and Somincor, shallow geophysical data. Both transects will be interpreted jointly by all groups in order to define the optimum position of the seismic transects.

10. Testing transpressional models by acquisition and modelling of field data *(Southampton [U], Madrid [ITGE], Lisbon [U], Granada [U], Évora [U], Potsdam [GFZ], Fribourg [U]).*
Surface mapping of trajectories of foliation, stretching lineations, vorticity (shear-sense) indicators, cleavage transection, vein orientations, etc. will be combined with strain data to produce strain maps. These will allow identification of differing domains into which strain has been partitioned, both in space (structural level) and time. Detailed comparison of finite strain, vorticity and incremental strain along the Spanish sector of the seismic experiment will provide a quantitative constraint on the interpretation of the deeper structures and crustal strain partitioning in the CIZ, OMZ and SPZ. Modelling of the strain and fabric distributions will be undertaken to determine the translation vectors predicted by application of the transpression hypothesis to southwestern Iberia. In the high-level thrust terrain of the SPZ, translation vectors of thrust sheets will be constrained by analysis of small-scale folds and veins, and by the mapping of lateral ramps. Analysis of strain gradients into lateral ramps may also constrain directions of thrust transport. An essential constraint on modelling will be the integration with the deep structures identified by seismic profiling.

11. Thermal regime during the Variscan Orogeny *(Granada [U], Barcelona [ICTJA], Uppsala [U], Ekaterinburg [RAS], St. Petersburg [IPGG]).*
Abundance of granitoid bodies and gabbro-granite complexes of variable age and typology is one of the outstanding features of the Iberian Variscides. The study of these rocks and their potential protoliths will give tight constraints on the lithospheric thermal regime during orogeny and is essential for understanding the orogen dynamics. Modelling potential fields will help to delimit the actual size of the intrusions. Structural field studies as well as petrographic, petrofabric and geochemical characterisation of the rocks will define the timing, P-T conditions and relations to protoliths and country rocks during emplacement. A good knowledge of heat producing element distribution and thermal rock properties will give further boundary conditions for numerical modelling of partial melting and emplacement of the plutonic rocks. The actual thermal field will be investigated to further constrain the temperature field during the final phase of the Variscan orogeny. Finally, comparison with plutonism in the Uralides is expected to shed new light on the reasons for the strong differences observed between these orogens.

12. Ore forming processes during transpressional tectonics *(Madrid [ITGE], Lisbon [U], Ekaterinburg [RAS], Aachen [RWTH], Granada [U], Keyworth [NERC]).*
Southwestern Iberia hosts a wealth of mineral deposits, not commonly matched in other parts of Europe. Many of these deposits, including massive sulphides, skarn deposits, base metals in basic rocks, vein-type gold deposits and Sn mineralization in pull-apart basins, were formed during the transpressional stage of the Variscan orogeny. In contrast, this variety of ore deposits was not formed during the compressional phase of the Uralide orogeny. The aim of this project is to investigate the control that transpressional tectonics has on ore-forming processes. It is intended to achieve this goal by 1) investigating the structural setting and control of mineralization, 2) determination of the origin of mineralising fluids and the timing of ore-forming processes, 3) understanding the effect that the particular tectonomagmatic evolution has on ore-forming processes, and 4) investigation of the palaeogeographic setting of the massive sulphides.

13. Alpine reactivation of the Variscan crust and recent tectonics *(Barcelona [ICTJA], Lisbon [U], Évora [U]).*
This proposal gives complementary information, regarding the Alpine reactivation of the Variscan crust and will influence the interpretation of the seismic profiling. The available data indicate that seismicity originates at very shallow depths (in the upper 5-10 km). An initial Portuguese-Spanish collaborative action is proposed, focusing on: 1) analysis of actual seismicity, 2) neotectonics studies, and 3) recent movements, which may show reactivation of the Variscan crust.

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