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Thrust tectonics of sardic age in the Rosmaninhal area (Beira Baixa, Central Portugal)

JOSÉ ROMÃO * & ANTÓNIO RIBEIRO **

Key-words: Centro-Iberian Zone; Beiras Group; lithostratigraphy; sardic phase; sardic thrusts; slickensides; geodynamic significance; aulacogene; dextral transpressive inversion.

Abstract: The Rosmaninhal area (Beira Baixa, Central Portugal) was mapped in detail. The lithostratigraphy of the Beiras Group (part of the «Xisto-Grauváquico» Complex – CXG, Cambrian to upper Proterozoic in age) was established and allowed the mapping of folds and thrusts of Sardic age (Cambrian to Ordovician), on which are superposed variscan folds and axial plane cleavage, producing interference patterns. It is proposed that the sardic deformation is due to dextral transpressive inversion of an aulacogene of upper Proterozoic to Cambrian age inside the Ibero-Armorican Terrane.

Palavras-chave: Zona Centro-Ibérica; Grupo das Beiras; litoestratigrafia; fase sarda; cavalgamentos sardos; estrias; significado geodinâmico; aulacógeno; inversão transpresssiva dextra.

Resumo: A área de Rosmaninhal (Beira Baixa, Portugal Central) foi cartografada em detalhe. A litoestratigrafia do Grupo das Beiras (parte do Complexo Xisto-Grauváquico – CXG, com idade do Câmbrico ao Proterozóico superior) foi estabelecida, o que permitiu cartografar dobras e cavalgamentos de idade sarda, entre o Ordovícico e Câmbrico, às quais são sobrepostas dobras variscas com clivagem de plano axial, produzindo estruturas de interferência. Propomos que a deformação sarda é devida à inversão dum aulacógeno em regime de transpressão dextra do Proterozóico superior ao Câmbrico no terreno Ibero-Armoricano.

INTRODUCTION

The present geological mapping study is part of Research Project 1.2 of the Geological Survey of Portugal «The Stratigraphy and Structural Study of the Xisto-Grauváquico Complex-XGC»; it covers the region of the Centro-Iberian Zone located near its SW limit (LOTZE, 1945), N of the Tejo River and W of the Erges River, being included in the so-called «Beiras Group» (SILVA *et al.*, 1988).

The main geologic units present in the area are: metasediments of the Beiras Group, included in the «Douro-Beiras Supergroup» of Cambrian and Upper Proterozoic age; quartzite, arenite and slate (Armorican Quartzite Formation) of Lower Ordovician age; continental sediments of Cenozoic age and late-syntectonic variscan granitoid plutons. Acid and basic dykes of pre-variscan and variscan age (fig. 1) are also present.

The main structural features show clearly a sardic deformation phase and superposed variscan orogenic phases. The sardic phase generated upright folds with axial trends towards 45°±15° and dominant vergence to SE and, less frequently, to NW. The first variscan phase (F_1) is caracterizated by WNW-ESE trending folds with associated penetrative vertical cleavage subparalell to the axial planes of the folds. Superposition of sardic and variscan folds (Pl. I, photo 1) originated type I and II interference patterns (RAMSAY & HUBER, 1987).

The second variscan phase (F_2) produced a flatter S_2 crenulation cleavage with NNW-SSE trend and «pitch» to SE.

The late variscan phase is expressed by conjugate NNE-SSW to ENE-WSW, sinistral and NNW-SSE to NW-SW dextral systems. These systems are compatible with a N-S stress-field in the Upper Carboniferous (RIBEIRO *et al.*, 1979). Subvertical «kink-bands» with

* Serviços Geológicos de Portugal. Rua da Academia das Ciências, 19, 2°, 1200 Lisboa

** Departamento de Geologia, Faculdade de Ciências, Universidade de Lisboa, 1200 Lisboa

N-S to NNW-SSW trend and fractures with ESE--WNW to E-W trend, filled by gabbro and microgabbro are also observed. This brittle event was produced by W-E maximum compressive stress, probably in the Lower Permian.

LITHOSTRATIGRAFY OF THE BEIRAS GROUP

The «Xisto-Grauváquico» Complex, also called «Douro-Beiras Supergroup» of pre-Ordovician age, is subdivided into the Douro Group (SOUSA, 1982) and the Beiras Group (SILVA *et al.*, 1988 and ROMÃO, in press). Both groups are composed of flyschoid sequences which are exposed in large areas of Northern (Douro Group) and Central (Beiras Group) Portugal.

The Beiras Group in the Rosmaninhal-Moradal sector has been recently subdivided from the bottom to the top into the following units (ROMÃO, 1990):

— **Malpica do Tejo Formation:** Thin (centimetric to milimetric) bands of laminated pelite and siltstone with occasional metric sized interbeds of greywacke, in the lower member, and thick sequences of greywacke with pelite and siltstone intercalations in the upper member. The lower member has a thickness of at least 150-200 metres (base not seen) and the upper one a thickness in excess of 1000 metres.

— **Rosmaninhal Formation:** Microconglomerates, conglomerates and metric layers of greywacke intercalated in a very thick pelitic sequence. This unit has a thickness in excess of 1000 meters.

— **Almaceda Formation:** A thick sequence made up predominantly of greywacke with subordinate pelite and bands of siltstone. This unit is lithologically similar to the upper member of the Malpica do Tejo Formation. The thickness of this unit is unknown, because its top is not exposed in the mapped area, but it should be in excess of 1000 meters.

Recently, SEQUEIRA (1991) has found acritarchs in the upper part of the Beiras Group near the Cabeço das Popas region, just north of our study area, which indicate a Middle to Upper Vendian age (Upper Proterozoic).

The Armorican Quartzite Formation (Lower Ordovician) is composed of quartzites with minor intercalations of pelite; it rests unconformably on the Beiras Group sediments. Between the Armorican Quartzite Formation and the Beiras Group another unit crops out. It is locally composed of conglomerate, arenite, quartzite and volcanics, and has been given diferent names: Serra Gorda Formation (SEQUEIRA, 1991), Envendos Formation (RIBEIRO *et al.*, 1991), Vale do Grou Formation (SILVA *et al.*, 1988) and «Série Intercalar» (CONDE, 1971). This unit is conformable to slightly unconformable with respect to the overlying Armorican Quartzite and is strongly unconformable on the Beiras Group.

REGIONAL STRUCTURE

In the study area, the Beiras Group has a general structure with WNW-ESE trend and the Armorican Quartzite Formation shows NW-SE trend; thus there is an unconformity between both units (fig. 2). The metasediments of the Beiras Group are deformed by sardic and variscan phases and the Armorican Quartzite only by variscan phases.

The Malhadio-Serrinha das Corgas Antiform and the Rosmaninhal Synform represent first order macroscopic structures. Both structures were generated by the interaction of the sardic upright folds with a first order variscan anticline-syncline pair, with development of axial plane cleavage (S_1). This interference originates oscillation in the strike and dip of the limbs of the major structures.

In the north limb of the Malhadio-Serrinha das Corgas Antiform the normal succession is found, i. e., upper member of the Malpica do Tejo Formation overlain by the Rosmaninhal Formation, as we walk towards the NNE. The south limb of the antiform is reversed, dipping to the NNE except near the Armorican Quartzite (rio Aravil area) where the succession is normal, dipping to SSW. This antiform verges to the NNW and its core becomes steeply plunging when it crosses a sardic syncline, with subhorizontal axis in the NE-SW direction, in the Pônsul river sector, 6 km W of Ladoeiro.

Adjacent to the S limb of the Malhadio-Serrinha das Corgas Antiform is the N limb of the Monforte da Beira-Rosmaninhal Synform defining everywhere a reverse limb, dipping to the S. Thus, the Monforte da Beira-Rosmaninhal Synform shows, from E to W, both limbs reversed or only the S limb reversed.

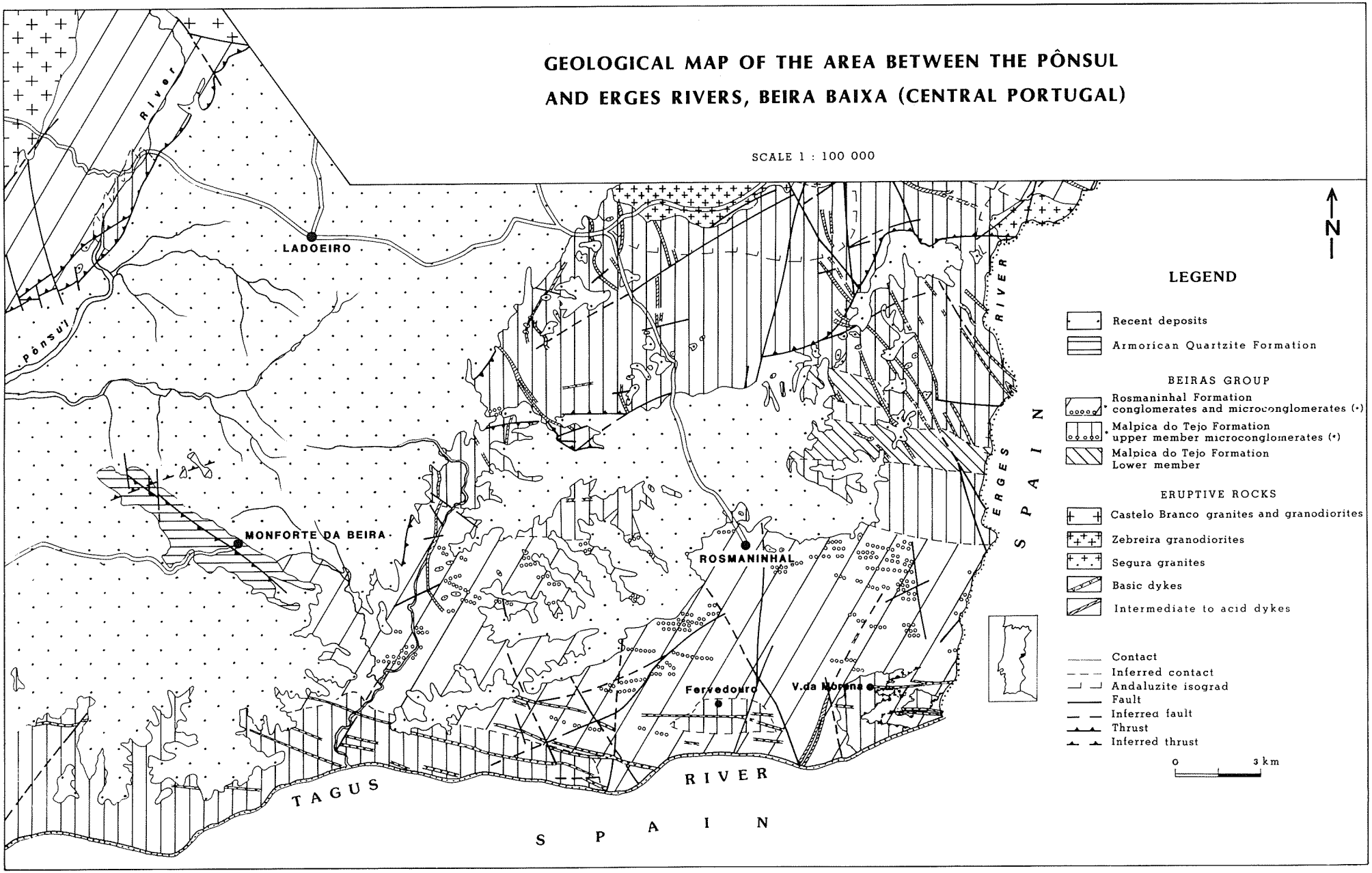


Fig. 1 — Geological map of the area between the Pônsul and Erges rivers, Beira Baixa (Central Portugal).

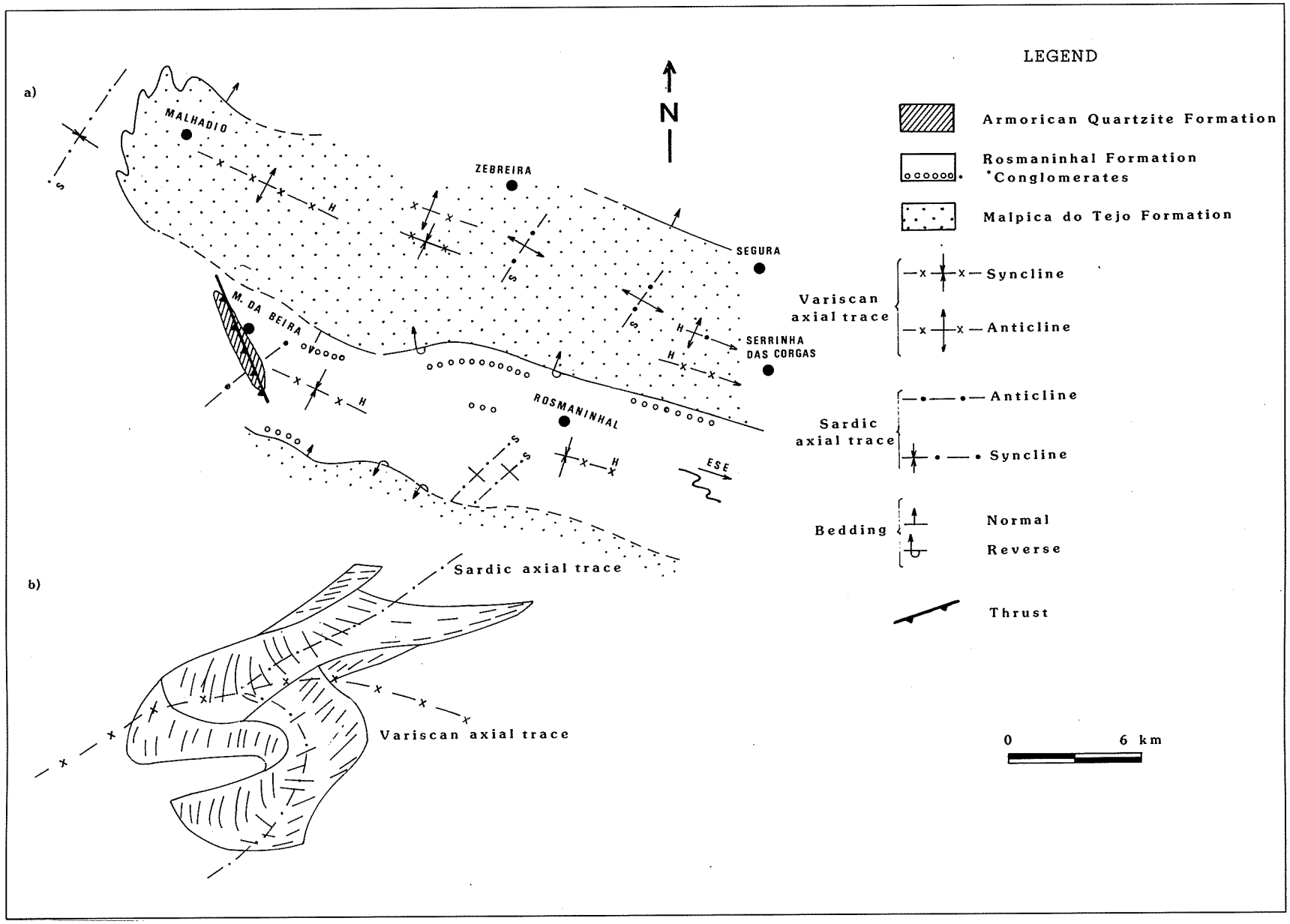


Fig. 2 — Schematic map of the regional structures (scale 1/200 000).

a – Identification of Malhadio-Serrinha das Corgas Antiform and Monforte da Beira-Rosmaninhal Synform and its relation with the Armorican Quartzite syncline of Monforte da Beira.

b – Axial zone of the Malhadio-Serrinha das Corgas Antiform.

THE VALE DA MORENA AND BOIZANA THRUSTS

Three exposures of the upper member of the Malpica do Tejo Formation, contrasting by the predominance of the greywacke component with the surrounding sequences of mainly pelitic composition, occur in the SE corner of the study area; we named them the Fervedouro, Vale da Morena and Boizana subdomains (fig. 1).

The Fervedouro structure is a brachyanticline generated by the interference of a sardic anticline of long wavelength, vergent to WNW, with shorter wavelength variscan folds (ROMÃO, in press).

The Vale da Morena structure has a NW limb younging to NW; it corresponds to the envelope of a sardic anticline cut by higher order variscan folds vergent to the SW. The SE limb shows that the younging to NW Rosmaninhal Formation is dipping below the older upper member of the Malpica do Tejo Formation, also younging to NW. This is due to the presence of the Vale da Morena thrust (fig. 3). This thrust is itself affected by the variscan folds and cleavage, causing highly variable dips in the thrust plane.

The Boizana structure is similar to the Vale da Morena one, with the Boizana thrust carrying the Malpica do Tejo upper member over the Rosmaninhal Formation situated to the SW. Both thrust planes duplicate the stratigraphic sequence from NW to SE. Thrust indicators were defined in the Vale da Morena thrust plane by quartz slickensides at the millimeter to centimeter scale oriented N60-75W, 55-65SE (Pl. I, photo 2).

An outcrop of Malpica do Tejo greywacke situated between the Vale da Morena and Boizana structures correspond, probably, to a «Klippe» of the Vale da Morena thrust but its geometry is ill defined due to lack of exposure.

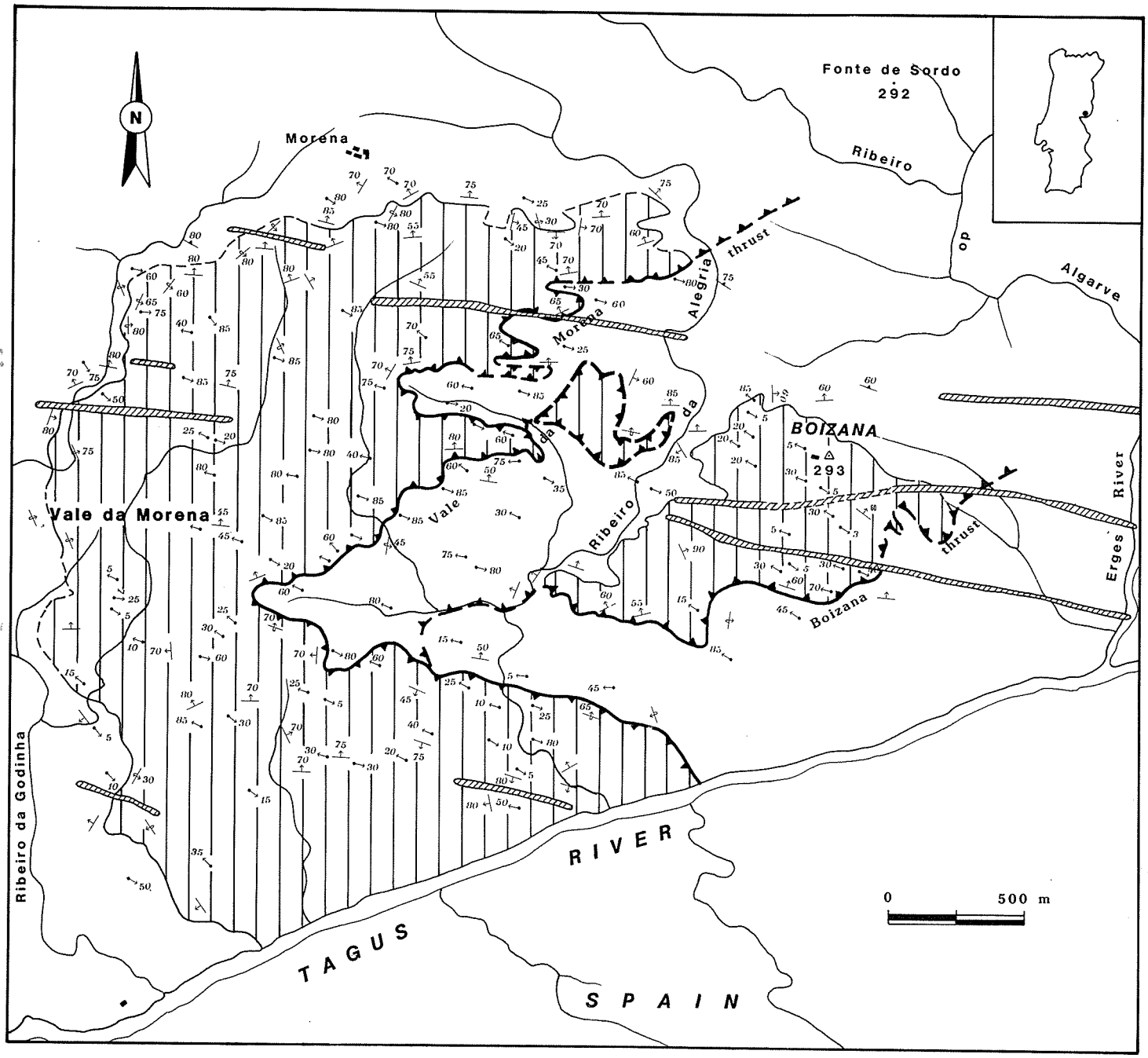
In these areas the $L_1(S_1 \wedge S_0)$ intersection lineation was systematically mapped at the 1:16 000 scale (fig. 3). By drawing dip isogons of this lineation it is possible to reconstruct the geometry of the sardic folds (fig. 4). Looking at the isogon map we notice that in the hangingwall of the Vale da Morena thrust the sardic axes strike NNE and in the footwall they strike NE, being truncated by the thrust plane. This suggest that the amount of thrusting is increasing to SSW.

A schematic block-diagram (fig. 5) of the Vale da Morena thrust was constructed from outcrop data; it shows clearly the truncation of the footwall beds by the thrust plane and also some backfolding.

GEODYNAMIC SIGNIFICANCE OF SARDIC THRUST TECTONICS

The geodynamic significance of sardic thrust tectonics observed in the Rosmaninhal area can be analysed if we put it on the larger context of the Centro-Iberian Zone of the Iberian Terrane (DALLMEYER & MARTINEZ GARCIA, 1990) and in the even larger context of the Ibero-Armorican Arc, IAA (RIBEIRO, DIAS & SILVA, in press).

In fact, some zones of the Iberian Terrane show a palaeogeographic evolution markedly similar to the corresponding zones in Armorica. The more affine zones seem to be the Centro-Iberia (CIZ) and Centro-Armorican (CAZ) Zones that form the nucleous of both variscan massifs. The palaeogeographic evolution of both zones is very similar from Cambrian to Devonian times (ROBARDET, 1976; YOUNG, 1990) and new data (RABU *et al.*, 1990) show that Brioveran, formely considered to be Upper Proterozoic in Britanny but nevertheless very similar to the «Xisto Grauváquico» Complex of CIZ, which is Cambrian (REBELO & ROMANO, 1986) at least in the upper part, is also post 540 MY in age. This is very important because the sardic unconformity of CIZ, between Upper Cambrian and Lower Ordovician is also present in Armorica, with the same age, and has been previously considered part of Cadomian cycle. We can trace a belt affected by the sardic deformation phase, disappearing to the inner side of the IAA and also, probably, to the outer side of the IAA (fig. 6). What is the geodynamic significance of this deformation event which produced thrusting and upright folding at high angle to variscan grain in the CIZ (SILVA & RIBEIRO, 1985) and spectacular recumbent and upright folding in the CAZ, also at high angle to the variscan grain? At the same time in other zones on both sides the deformation vanishes completely (West-Asturian Leonese Zone) or partially (Ossa Morena Zone) but the palaeogeographic trend of the Cambrian is nearly parallel to the variscan grain. We propose the following model, based on the comparison with transpressive



LEGEND

Beiras Group - "Xisto-grauváquico" Complex

Rosmaninhal Formation

Malpica do Tejo Formation

} Upper Proterozoic Cambrian

Mafic rocks (Lower Permian)

Gabbros and microgabbros

Contact

Inferred contact

Thrust

Inferred thrust

Normal polarity

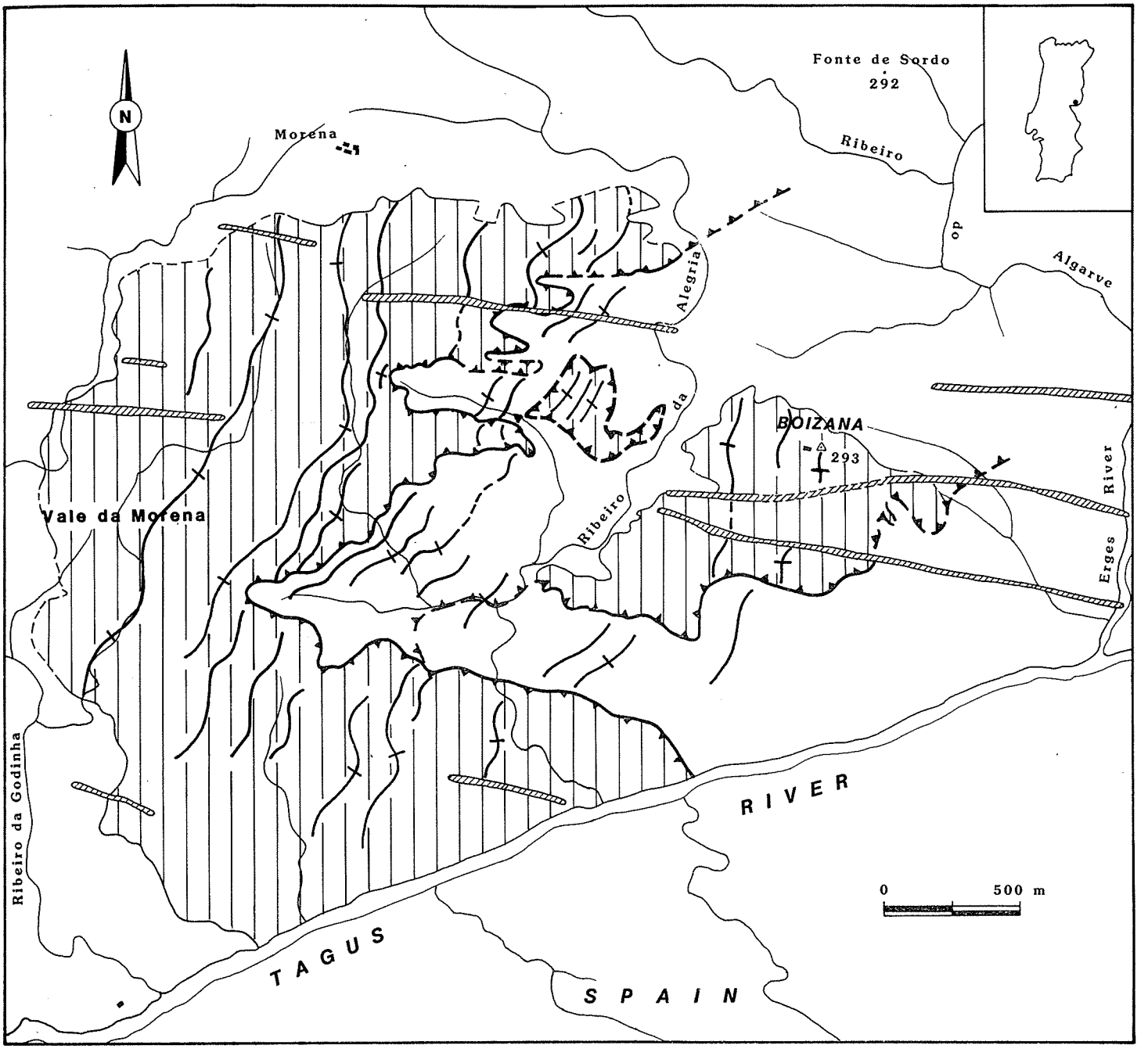
Reverse polarity

} Bedding (S0)

Primary cleavage (S1)

Lineation (L1)

Fig. 3 — Geological map of the Vale da Morena and Boizana structures (scale 1/16 000).



LEGEND

Beiras Group - "Xisto-grauváquico" Complex

Rosmaninhal Formation

Malpica do Tejo Formation

Upper Proterozoic
Cambrian

Mafic rocks (Lower Permian)

Gabbros and microgabbros

Thrust

Inferred thrust

Antiform hinge zone

Synform hinge zone

Fig. 4 — Axes of mesoscopic structures of Sardic age.

inversion of Upper Jurassic age in the High-Atlas aulacogene (SCHAER, 1986).

The CIZ-CAZ correspond to an aulacogene inside the Ibero-Armorican undisrupted Terrane that suffers at 500 MY, a very early dextral transpressive inversion (SILVA & RIBEIRO, 1985) with folding, bimodal magmatism but no cleavage – except perhaps near some local intrusions – and is later incorporated in the variscan collisional belt, since 390 MY. We can compare the difference in age between the early inversion and the beggining of collision in the High Atlas (200 and less than 100 MY, respectively) and in Iberia (500 and less than 390, respectively) and see that they are of the same order of magnitude. We conclude that the intracratonic sardic trough extended with no discontinuity from Iberia to Armorica.

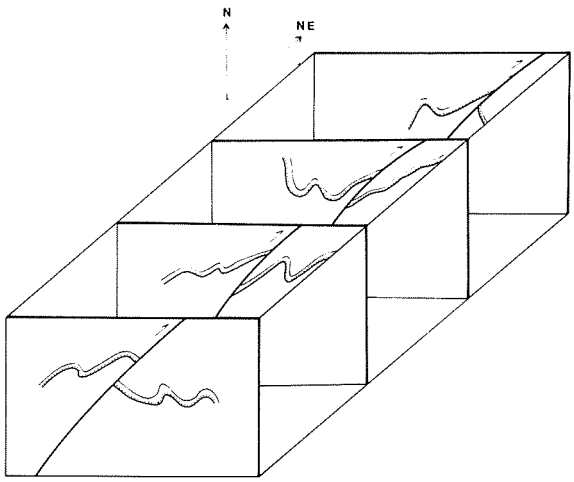


Fig. 5 — Schematic block-diagram of the Vale da Morena thrust.

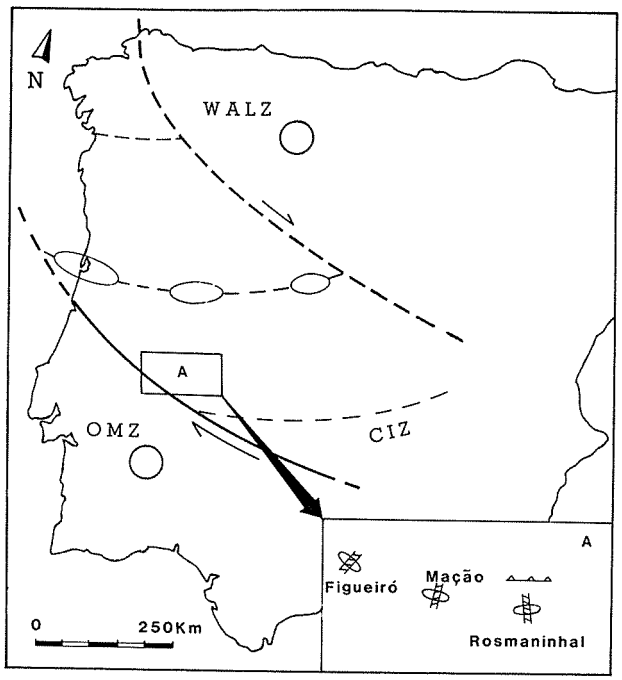


Fig. 6 — Tectonic model for the transpressive sardic inversion of the Centro-Iberian Zone aulacogene.

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