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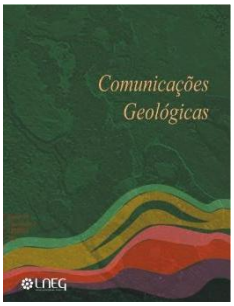
Is the Rosario Antiform, Iberian Pyrite Belt, a Variscan tectonic window?: a tectono-stratigraphic interpretation based on the geology of the Neves-Corvo mine region



É a antiforma de Rosário, Faixa Piritosa Ibérica, uma janela tectónica Varisca?: uma interpretação tectono-estratigráfica baseada na geologia da região da mina de Neves-Corvo

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Abstract: This work suggests a new structural interpretation for the Rosario Antiform, Portuguese Pyrite Belt. This is based on the following successive developments: 1 - deposition of an upper Visean flysch succession, designated by CMt2, which conformably overlaid the autochthon represented in ascending order by the clastic succession of the Phyllite-Quartzite Formation (PQ) followed by the lower Volcano-Sedimentary Complex (VSC, CVS in the geological map annex) dominated by felsic volcanism and black shale sediments, all of late Devonian age, and the upper VSC composed by shales, volcanoclastic sediments, including cherts and jaspers, and mafic volcanic and igneous rocks of late Tournaisian – late Visean ages; 2 - the reinterpretation of fifteen selected drill hole logs previously carried out by Somincor and LNEG geologists and recovered from the region west of the Neves-Corvo mine proved that below the CMt2 flysch succession the upper VSC is absent in many places and the unit is in direct fault contact with the lower VSC, in a position similar to that recognized in the mine. This abnormal contact is inferred to represent the trace of an extensional fault that locally erased the upper VSC lithologies. A sub-autochthon block composed of remnants of the lower VSC and the overlying CMt2 sediments was then formed above the extensional fault, as discussed below; 3 - a SW directed tangential transport, well documented in the Neves-Corvo mine region, placed a distinct flysch succession (CMt1) and the underlying clastic dominated upper VSC units, all of late Visean age, both forming the allochthon, upon the CMt2 succession. The allochthon is organized as a thin-skinned package moving southwestward upon the subautochthon developing a large overthrust. All the package units were folded by a second episode of pervasive regional tectonic compression. 4 – a second tectonic reverse fault at the west limb of the antiform caused the uplifting of the autochthon and the subautochthon which after the regional erosion became a true tectonic window according to this interpretation.

Keywords: Iberian Pyrite Belt, Rosario Antiform, Neves-Corvo mine, tectonostratigraphy, overthrust.

Resumo: A cartografia geológica realizada na antiforma do Rosário e, em particular na área da mina de Neves-Corvo, conjugada com a investigação estratigráfica realizada com base em miosporos e datações U/Pb em zircões, mostra que a sucessão litoestratigráfica é constituída por um substrato detrítico clástico, tradicionalmente designado por Grupo Filito-Quartzítico (PQ), de idade Givetiano-Famenniano, a que se sobrepõe o Complexo Vulcano-sedimentar (CVS), este dividido na Sequência Inferior do Complexo de idade Famenniano (CVS inferior) e na Sequência Superior do Complexo (CVS superior) de idade Tournaisiano superior-Viseano superior. No presente trabalho sugere-se que a antiforma de Rosário é uma janela tectónica com base nos seguintes desenvolvimentos: 1 - deposição de uma sucessão sedimentar do tipo flysch, do Viseano superior, designada por CMt2, sobre a sucessão litológica autóctone constituída pelo conjunto PQ e Complexo Vulcano-sedimentar; 2 - a revisão dos logs relativos a 15 sondagens, realizadas na região a oeste da mina, provou que a sucessão CMt2 está em contacto com o Complexo Vulcano-sedimentar inferior, faltando portanto o CVS superior, numa posição equivalente à que ocorre no interior da mina. Este contacto anormal é atribuído à existência de uma falha de descolamento que provocou a erosão de partes do CVS superior, de que resultou um bloco subautóctone constituído pela sucessão CMt2 e restos da sucessão do CVS que resistiram à erosão provocada pelo descolamento, assunto discutido no texto; 3 - um episódio tectónico tangencial com transporte para SO originou o empilhamento pelicular de um conjunto constituído por uma sucessão sedimentar tipo flysch distinta, designada por CMt1, e as unidades subjacentes do CVS superior, conjunto este identificado como alóctone. Na mina e em grande parte da região o alóctone está tectonicamente sobreposto aos turbiditos sucessão CMt2, que por sua vez também estão em contacto tectónico com o CVS inferior subjacente, este constituindo o bloco autóctone, bem documentado na região da mina. O contacto entre o bloco alóctone e o subautóctone sublinha um carreamento com larga expressão regional, que na mina é designado por “corredor de deformação" Por sua vez, o contacto entre a sucessão CMt2 e o bloco autóctone sublinha outro acidente tectónico de grande relevância na região; 4 – um segundo episódio tectónico compressivo de âmbito regional, também vergente para SW, provocou o dobramento de todo o empilhamento desenhando larga antiforma. Finalmente uma falha inversa tardia no bordo ocidental desta antiforma provocou o levantamento crustal do conjunto autóctone/ subautóctone, e a erosão subsequente pôs em evidência a janela tectónica sugerida neste trabalho.

Palavras-chave: Faixa Piritosa Ibérica, Antiforma de Rosario, Mina de Neves-Corvo, tectonoestratigrafia, carreamento.

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1. Historical Introduction

The Rosário antiform is situated in the south branch of the Portuguese sector of the Iberian Pyrite Belt (Fig. 1). The southeast termination of this antiform, which incorporates the Neves-Corvo mine region, has been the aim of several mapping programs, particularly by Leca *et al*. (1983) at a 1: 10.000 scale (Fig. 2), unpublished work by Ribeiro *et al*. (1984) and exploration maps by SOMINCOR geologists and private companies. Leca *et al*. (1983) recognized the main units of the lithostratigraphic sequence, composed in ascending order by the Phyllite-Quartzite Unit (PQ) of upper Devonian age, a Volcano-Sedimentary Complex (VSC) of Lower Carboniferous age and a Culm-type sedimentary sequence of Visean age. They also erected the local structural style composed of stacked sheets of the stratigraphic sequence with tectonic transport to SW (Fig. 2).

The stratigraphic succession, the tectonic structure and the best definition of the ore masses were performed by mine geologists based on several dozens of drill holes (Carvalho, Ferreira, 1994; Carvalho, *et al*., 1996; Carvalho, *et al*., 1998). The advent of paleontological research based on ammonoids and miospores allowed the division of the stratigraphic succession into a lower sequence represented by shales, siltstones, quartzite beds and minor limestone lenses at the top, of Givetian-Famennian age (PQ), overlain by shales, felsic and minor mafic volcanic rocks (lower VSC) of latest Famennian age (Strunian), and an upper sequence (upper VSC) of late Tournaisian-late Visean age where fine clastic sedimentation prevails (Oliveira *et al*., 1997; Oliveira *at al*., 2004; Oliveira *et al*., 2006; Oliveira *et al*., 2013; Mendes *et al*., 2020; Pereira *et al*., 2023). Miospore biozones indicate that a hiatus of the Lower-Midlle Tournaisian age separates the lower and the upper VSC sequences (Fig 3), but a volcanic event appears to

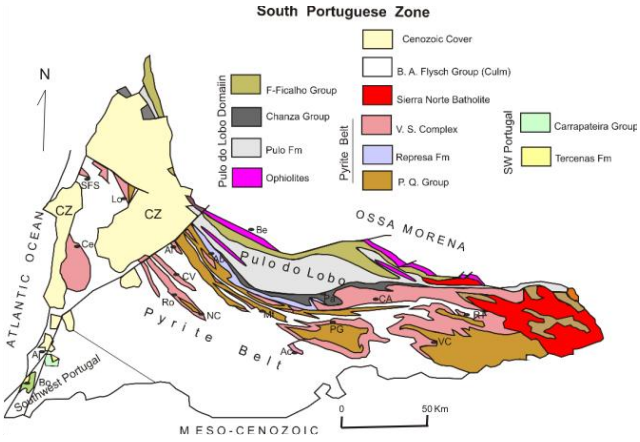

Figure 1. The Rosário antiform location in the Iberian Pyrite Belt (Oliveira *et al*., 2019).

Figura1. Localização da antiforma de Rosário na Faixa Piritosa Ibérica Belt (Oliveira *et al*., 2019).

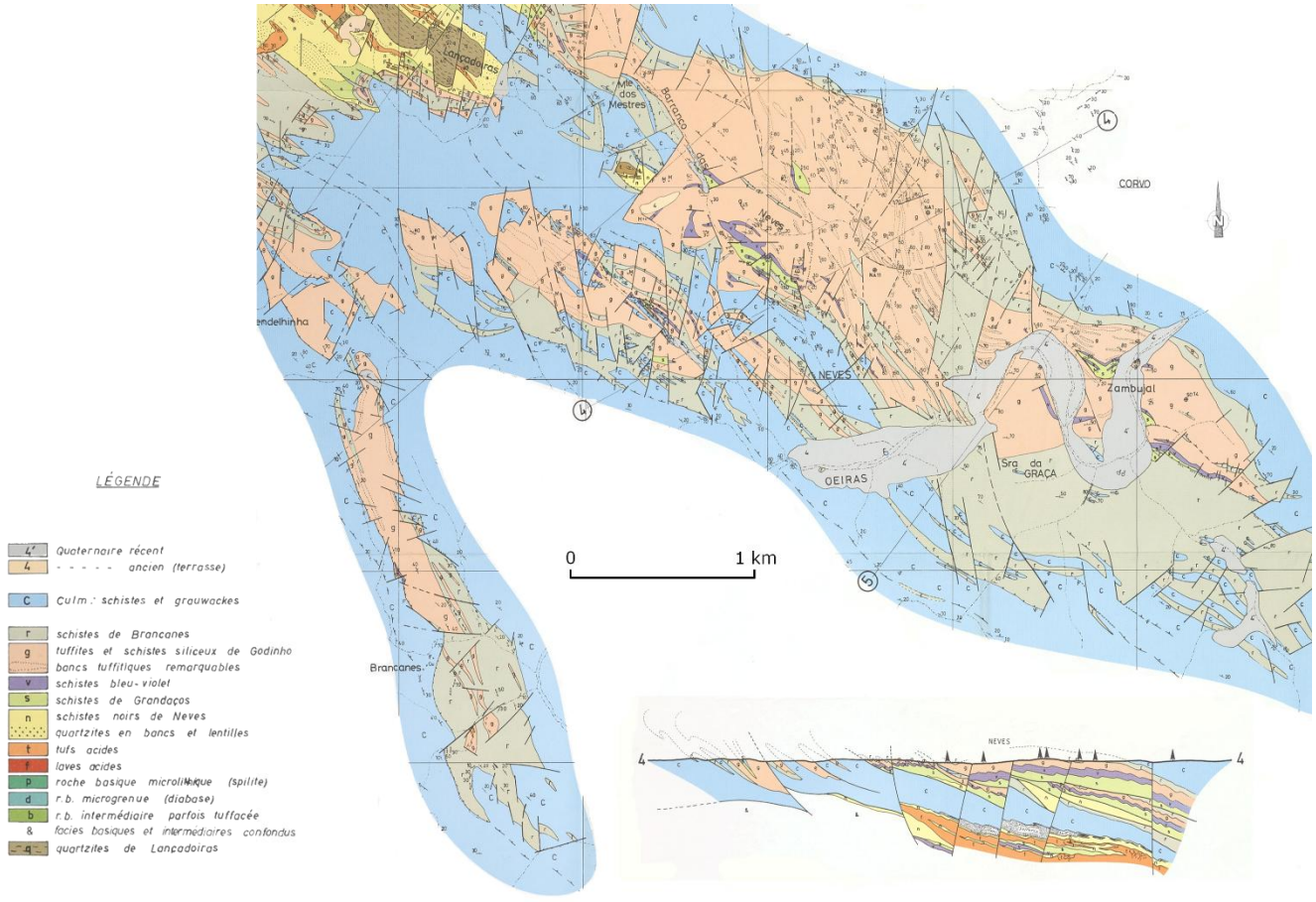

Figure 2. Geological map of the Neves-Corvo mine region (Leca *et al*., 1983)

Figura 2. Mapa geológico da região da mina de Neves-Corvo (Leca *et al*., 1983).

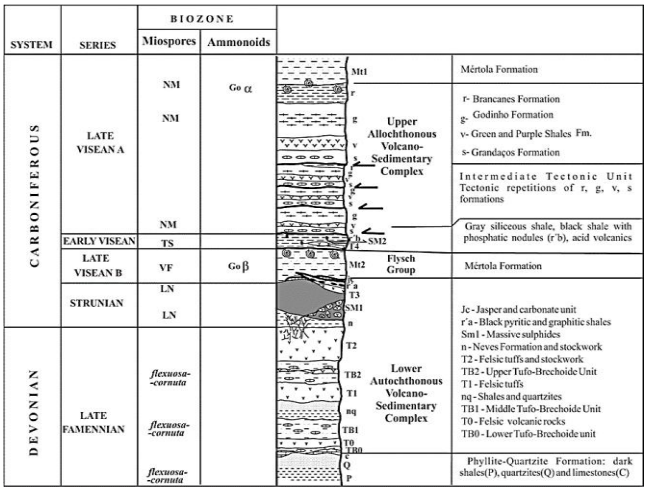

Figure 3. Lithostratigraphic units recognized in the Neves-Corvo mine region (Carvalho and Ferreira, 1993; Oliveira *et al.*, 1997; Oliveira *et al.*, 2004). Units lithological composition: SM1/SM2-massive sulfide ores; n-Neves Formation, composed of black pyritic shales; s- Grandaços Formation, represented by dark green shales, siltstones with interbedded siliceous lenses, nodules and lenses of manganese oxides and volcanoclastic sediments; g-Godinho Formation, composed of siliceous shales and volcanoclastic beds; r-Brancanes Formation, with black shales, siltstones and fine-grained greywackes; Mt1, Mt2 Mértola Formation flysch sequences. The remaining symbols are easily self-explained.

Figura 3. Unidades litoestratigráficas reconhecidas na região da mina de Neves-Corvo (Carvalho e Ferreira, 1993; Oliveira *et al.*, 1997; Oliveira *et al.*, 2004). Composição litológica das unidades: SM1/SM2-jazigos de sulfuretos maciços; n-Formação de Neves constituída por xistos negros piritosos; s- Formação de Grandaços representada por xistos verdes, siltitos com intercalações siliciosas lenticulares, nódulos e lentículas de óxidos de manganês e sedimentos vulcanoclásticos; s- Formação de Godinho composta por xistos siliciosos e leitos vulcanoclásticos; r- Formação de Brancanes com xistos negros, siltitos e grauvaques finamente estratificados; MT1, MT2- sequências de flysch atribuídas à Formação de Mértola. Os símbolos restantes são facilmente explicáveis.

have taken place during the Lower Tournaisian (Solá *et al*., 2015; Albardeiro *et al*., 2020; Matos *et al*., 2020). The Culm-type sediments were renamed Mértola Formation (Oliveira *et al*., 1997) and were locally divided into three lithological sequences, labelled CMt1, CMt2 and CMt3 (Oliveira *et al*., 2013; Oliveira *et al*., 2016). The tectono-stratigraphic meaning of these sequences is a key for the regional tectono-stratigraphic interpretation discussed below. Further geochronological dating based on U/Pb ages in zircons are in general concordant with the ages given by miospores (Oliveira *et al*., 2013; Solá *et al*., 2015; Albardeiro *et al*., 2020).

Exploration work for the Neves-Corvo mine development led to the first modern structural interpretation (Fig. 4) since then taken as the leading edge for further research. A recent cross section traced from Corvo to Rosa Magra confirmed this interpretation (Pereira *et al*., 2020) (Fig. 5).

The mine region was mapped in the context of the publication of the Geological Map Sheet 46-C, Almodôvar, scale 1:50.000 (Oliveira *et al*., 2016). A somewhat distinct structural interpretation was then proposed suggesting that the stacked stratigraphic sheets recognized in the mine are part of a folded overthrust with tectonic transport to SW (Fig. 6).

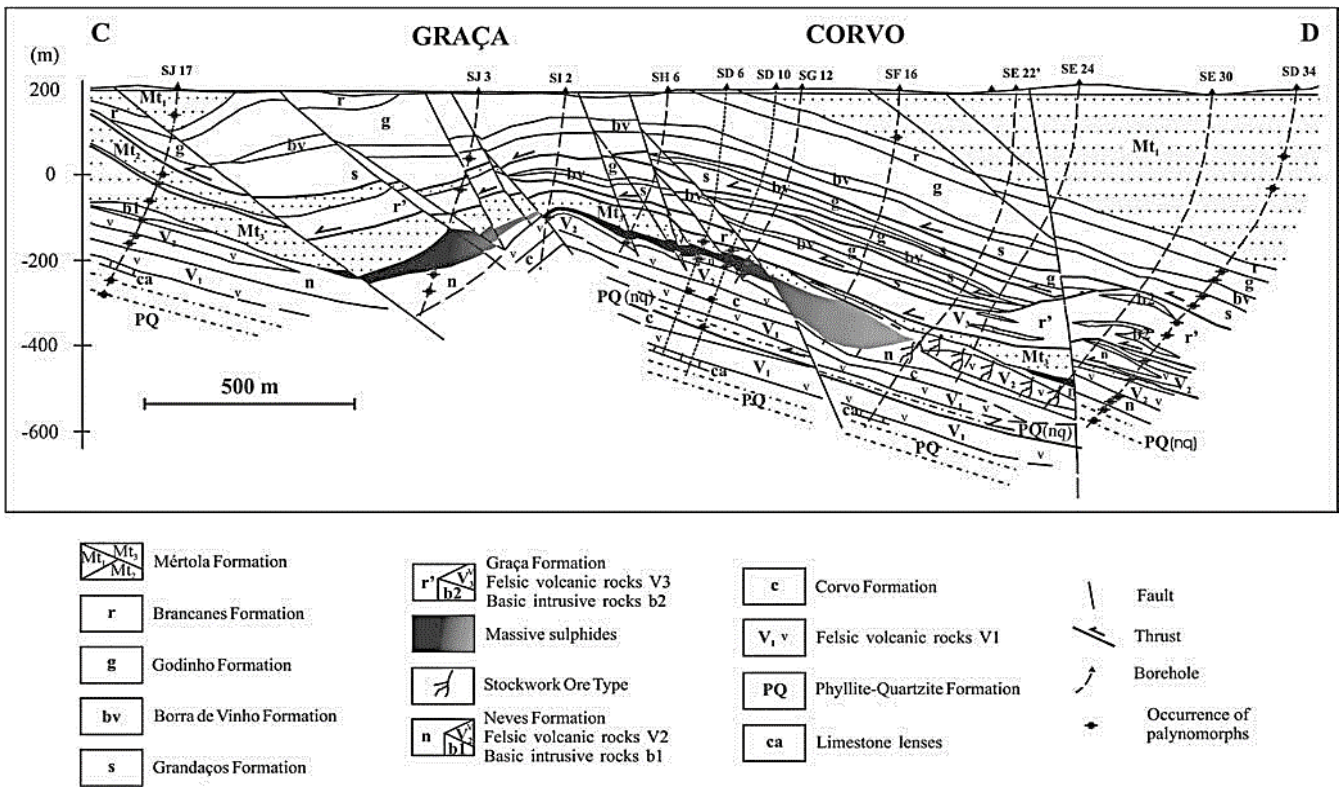

Figure 4. Structural interpretation of the Neves-Corvo mine based on logging data (Carvalho and Ferreira, 1993; Oliveira *et al.*,1997; Oliveira *et al.*, 2004). Symbols as in figure 2

Figura 4. Interpretação estrutural da mina de Neves-Corvo baseada em perfis (Carvalho e Ferreira, 1993; Oliveira *et al.*, 1997; Oliveira *et al*., 2004). Símbolos da figura 2.

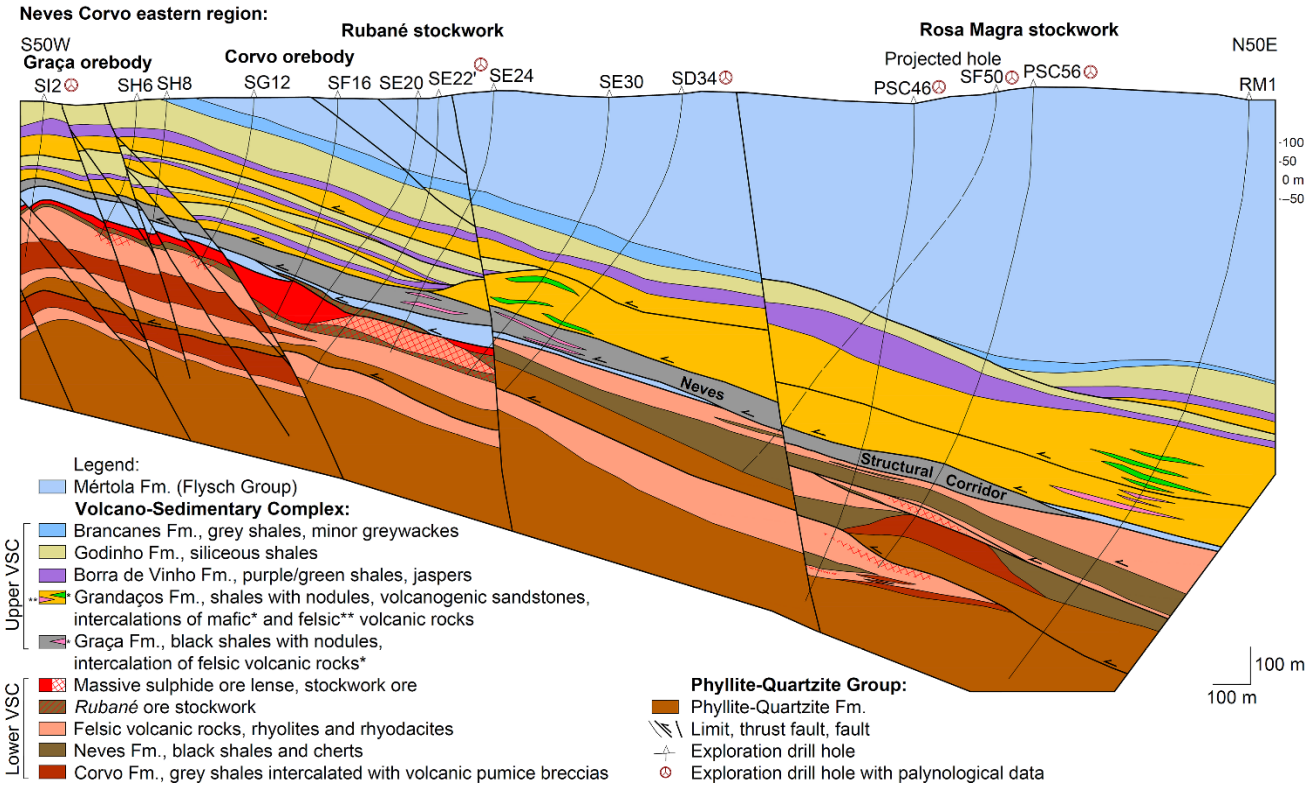

Figure 5. Cross section across the Rosa Magra, Corvo and Graça orebodies illustrating the tectonic style associated to the east limb of the overthrust (Pereira *et al*., 2020).

Figura 5. Corte geológico traçado através dos jazigos de Rosa Magra, Corvo e Graça ilustrando o estilo tectónico associado ao flanco oriental do carreamento (Pereira *et al*., 2020).

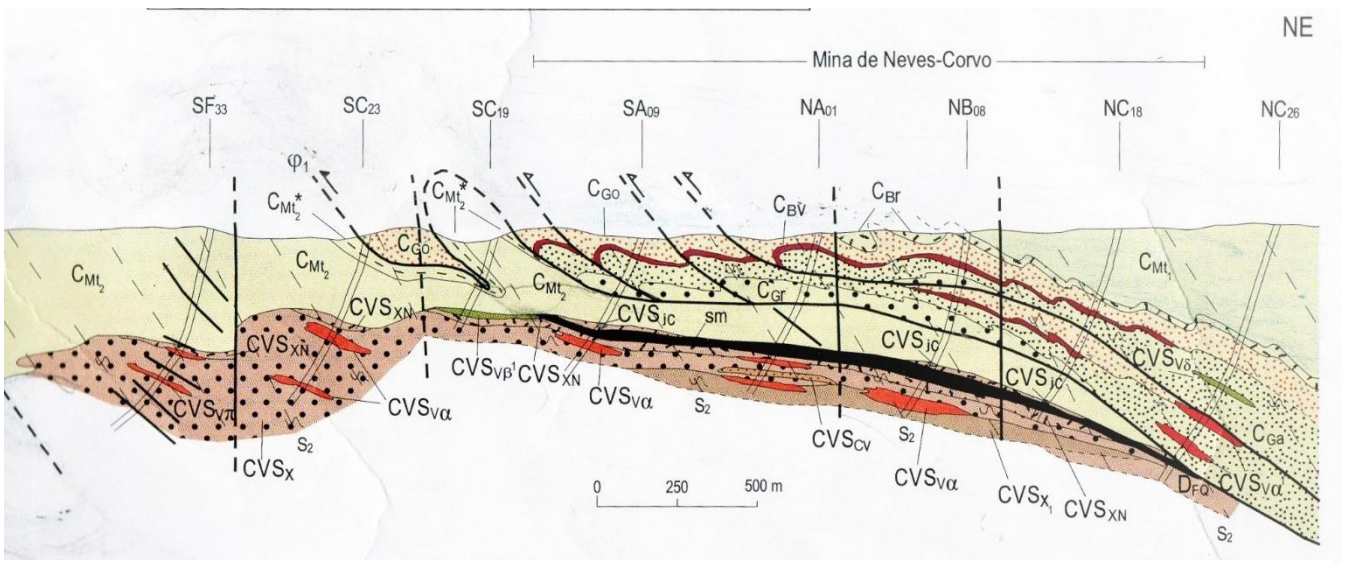

Figure 6. Reviewed section across the Neves-Corvo mine region (Oliveira *et al*., 2016). Symbols: DFq - shales, siltstones, thin quartzite beds and minor limestone lenses; CVSX1 - shales and siltstones; CVSXN - black shales; CVSvα - felsic volcanic rocks; CVSCV - Corvo-tuff-breccia unit; CVSVß - mafic intrusive body; CVSjc - jaspers; CVSVδ - dolerite; CGr - Graça unit; CGa - Grandaços fm.; CBV - Borra de Vinho fm.; CGo - Godinho fm.; CBr - Brancanes fm.; CMt1/ CMt2 - Mértola fm. sequences.

Figura 6. Corte geológico revisto através da mina de Neves-Corvo (Oliveira *et al*., 2016). Símbolos: DFq - xistos argilosos, siltitos, leitos finamente estratificados de quartzito; CVSX1 - xistos argilosos e siltitos; CVSXN - xistos negros; CVSvα - rochas vulcânicas félsicas; CVSCV - unidade de tufo-brecha Corvo; CVSVß - intrusão máfica; CVSjc - jaspes; CVSVδ - dolerito; CGr - unidade da Graça; CGa - formação de Grandaços; CBV - formação Borra de Vinho; CGo - formação de Godinho; CBr - formação de Brancanes; CMt1/ CMt2 - sucessões litológicas da formação de Mértola.

2. The new regional tectono-stratigraphic interpretation

In order to understand the regional expression of the overthrust identified in the mine area a recent and detailed regional mapping revision was undertaken (Annex 1). The geological mapping was complemented by the selection and logging review of fifteen boreholes kindly made available by SOMINCOR (Figs. 7a, b, c; Fig. 8).

Notes on the structural data recovered from the logging review:

Figure 7a-MM01-shearing in the black shales below the CMt2 flysch sediments; Mm02-gradual change from black shales of Famennian age to felsic volcanic rocks; MM09001-faulted black shales at the transition to the CMt2 flysch sediments.

Figure 7b-SF33-10 cm thick quartz-mylonite breccia; Sc23-shearing at the base of CMt2 flysch sediments; Sj21-shearing at the base of CMt2 flysch sediments; Sc19-fault at the base of CMt2 flysch sediments.

Figure 7c-BR4-CMt2 sediments tectonically overlaid by upper VSC units; Hr01- below the CMt2 flysch sediments black shales are ascribed to the Brancanes Formation (?). Fault at the transition to the felsic volcanic rocks; SE09001-shales, siltstones and fine quartzites (?) below the CMt2 sediments; Hf01- below the CMt2 sediments about 50 m of shales and siltstones affected by faults related to shearing; Sx2-gradual transition between the CMt2 sediments and the felsic volcanic rocks?; SR16- CMt2 flysch sediments tectonically overlaid the upper VSC units (Neves-Corvo allochthon).

The borehole logging made by mine geologists consists mostly of lithology descriptions, faults and cleavage orientation. From the present revision, no other cinematic data could be obtained.

These stratigraphic correlations clearly show that the upper VSC units are tectonically superposed on the CMt2 unit (Figs. 7a, c). This tectonic contact is interpreted as the southwest continuation of the structural corridor recognized in the mine at the base of the allochthon (Figs. 5 and 6). On the other hand, the CMt2 flysch sediments are tectonically placed above the lower VSC units (Figs. 7a, b, c), in a tectono-stratigraphic position which is similar to that observed in the mine (Figs. 4, 5 and 6). It has been suggested that the CMt2 flysch sediments conformably overlie the lower VSC units in the mine sections (Oliveira *et al*., 1997; Oliveira *et al*., 2004). The trace of this abnormal contact is now inferred to represent a pre-orogenic extensional fault, as discussed below.

Careful mapping of the SE closure of the Lançadoiras block (Annex 1) indicates that, despite the poor outcrop exposure, the PQ Formation and the lower VSC units are subjacent to the upper VSC units and these are conformably overlaid by the CMt2 flysch sediments. A profile from the Lançadoiras block to boreholes MM09001-SF33-SE0900 (Fig. 8) shows the partial disappearance of the upper VSC units below the CMt2 flysch sediments which is ascribed to tectonic erosion caused by an extensional fault, whose trace is marked at the CMt2/ lower VSC boundary. A tectonic disconformity between these sediments and the lower VSC was therefore generated (Figs. 5 and 6). Due to the poor outcrop exposure, the trace of this fault below the upper VSC units in the Lançadoiras block is inferred. The block above the extensional fault is here named subautochthon (Fig. 9). This block was previously interpreted as an autochthon (Ribeiro *et al*., 1984).

The global tectonic structure of the SE termination of the Rosário Antiform is also reviewed. The geological section A-B (Fig. 9) across the Lançadoiras block illustrates the structural relationship between the autochthon (PQ and lower VSC), the subautochthon (upper VSC units plus CMt2 flysch sediments) and the Neves-Corvo allochthon (upper VSC units plus the CMt1 flysch sediments.

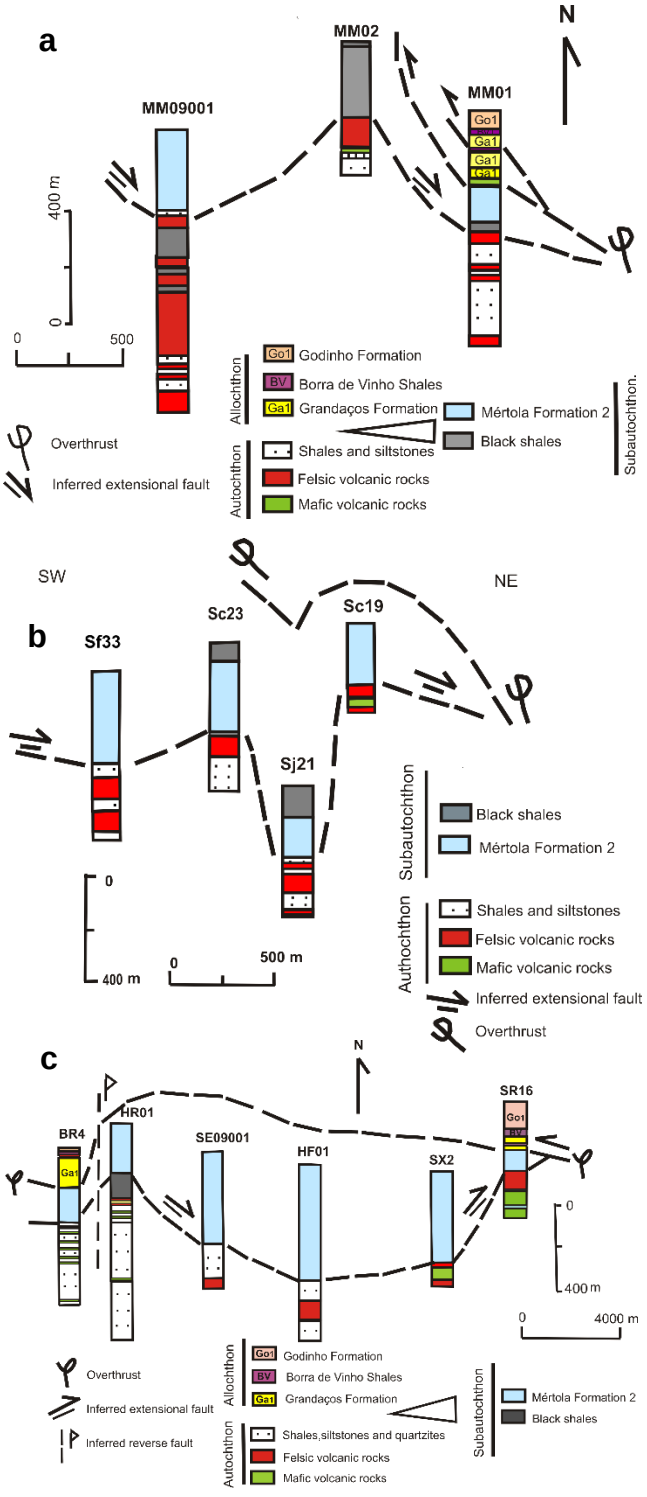

Figure 7 a, b, c. Simplified logging of selected boreholes and their stratigraphic correlation across the area. Locations in annex 1 and figure 12.

Figura 7 a, b, c. Perfis estratigráficos de sondagens selecionadas e respetiva correlação através da área estudada. Localizações no anexo 1 e figura 12.

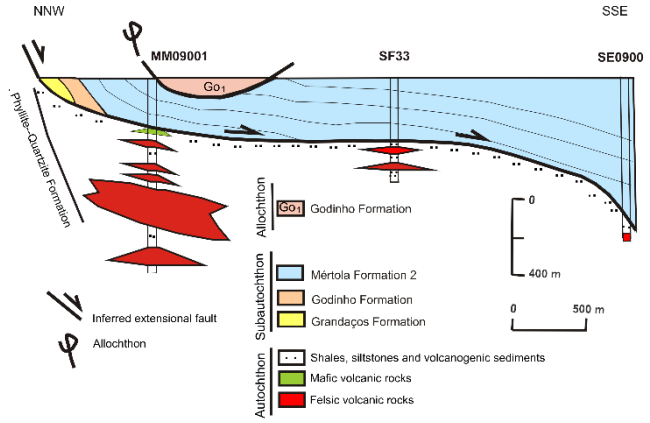

Figure 8. The tectono-stratigraphic interpretation of the subautochthon in the regional geological context.

Figura 8. Interpretação tectono-estratigráfica do sub-autóctone no contexto da geologia regional.

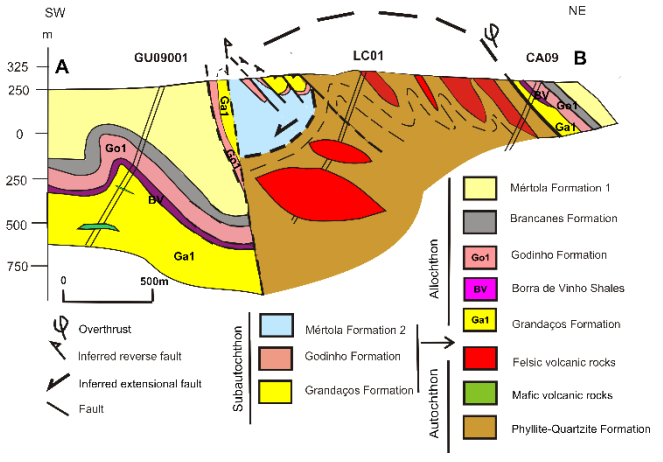

Figure 9. Geological cross section across the Lançadoiras block.

Figura 9. Corte geológico através do bloco de Lançadoiras.

The Ca09 borehole intersects the northwestern continuation of the Neves-Corvo allochthon. The borehole Gu09 depicts a flysch succession (named as CMt3 Member in the Almodôvar map sheet, Oliveira *et al.*, 2016), now interpreted as a lateral equivalent of the CMt1 flysch sediments) overlying upper CVS units. From these the 450 m thick black shales and thin-bedded siltstones ascribed to the Grandaços Fm. needs better support in terms of age and thickness. The latter is considered abnormal in the regional context and tectonic thrusting may have occurred. Borehole LC01 also deserves some comments. From above, the 400 m thick succession represented by the felsic volcanic rocks and the underlying PQ thin-bedded quartzites, black shales and siltstones with miospores of Famennian age is common across the antiform (Pereira *et al.*, 2023). The following 600 meters are composed of pyritic black shales and rhyolite domes with no age data. However similar lithological sequences are not uncommon in the region (see Fig. 7a, above). In the cross-section (Fig. 9) it is also suggested that the Neves-Corvo allochthon is extended to the western side of the Lançadoiras block. This suggestion is based on the occurrence of two meters large greywacke outcrop (a CMt2 flysch intercalation?) bellow the Borra de Vinho shales near Monte Pardieiro and the overthrust carrying the upper VSC units upon the autochthon shown by the interpretation of boreholes PMR1and PMR2 located 800

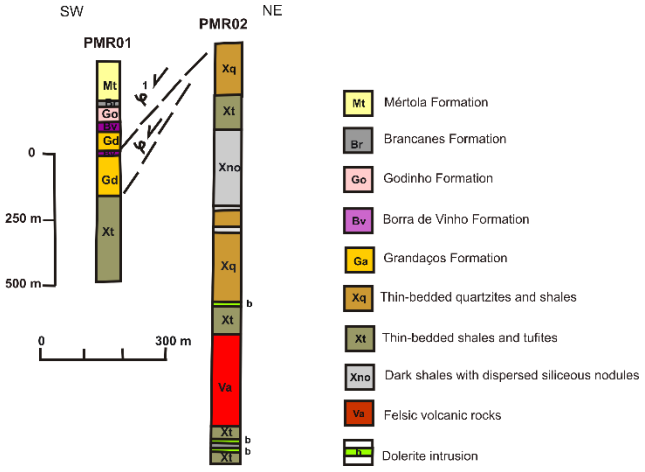

Figure 10. Tectono-stratigraphic interpretation of boreholes PMR01 and PMR02 during the overthrust episode

Figura 10. Interpretação tectono-estratigráfica das sondagens PMR01 e PMR02 no contexto do episódio de carreamento.

meters NW of Monte Pardieiro near the Oeiras river margin, kindly provided by Lundin Mining (Fig. 8).

The upper VSC stacked sheets formations are interpreted as representing the west continuation of the Neves-Corvo allochthon carried upon the autochthon, represented by all the units below the overthrust (see also Pereira *et al.*, 2023). The late Variscan reverse fault (Figs. 9 and 11) inverted this structural relationship placing the autochthon over the allochthonous stacked sheets. The northwestward prolongation of this thrust along the west limb of the antiform is interpreted as the reworking of the overthrust trace generated during the F_1 compressional episode.

The cross-section C-D (location in Annex 1 and Fig. 11) represents the Brancanes complex antiformal structure and its relationship with the uplifted block encompassing the autochthon (PQ plus lower VSC), the CMt2 flysch sediments and a klippe of the

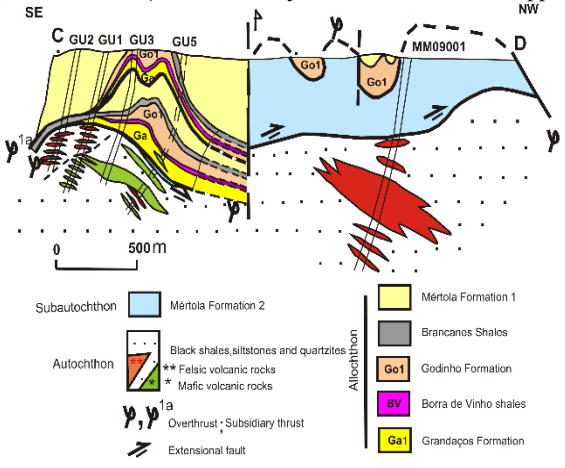

Figure 11. Cross-section illustrating the Brancanes complex antiformal horse-like structure and its boundary with the uplifted block encompassing the autochthon, the subautochthon Mt2 flysch sediments and klippes of the Neves-Corvo allochthon. The Brancanes structure is the reinterpretation of that represented in the Almodôvar map sheet, cross-section C-D (Oliveira *et al.*, 2016).

Figura 11. Corte geológico ilustrativo da complexa estrutura antiformal de estilo "horse" e respectivo contacto com o bloco elevado compreendendo o autóctone, o sub-autóctome MT2 representado por sedimentos tipo "flysch" e "klipes" do alóctone de Neves-Corvo. The Brancanes structure is the reinterpretation of that represented in the Almodôvar map sheet, cross-section C-D (Oliveira *et al.*, 2016).

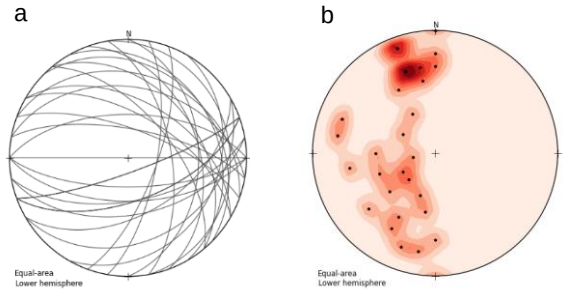

Figure 12. Lower hemisphere equal area projection of 31 measures of S_1 cleavage (a) and the corresponding poles (b) in the VSC units, across the autochthon.

Figura 12. Estereogramas de 31 medições da clivagem S_1 (a) e dos respetivos polos (b) em unidades do CVS, através do autóctone.

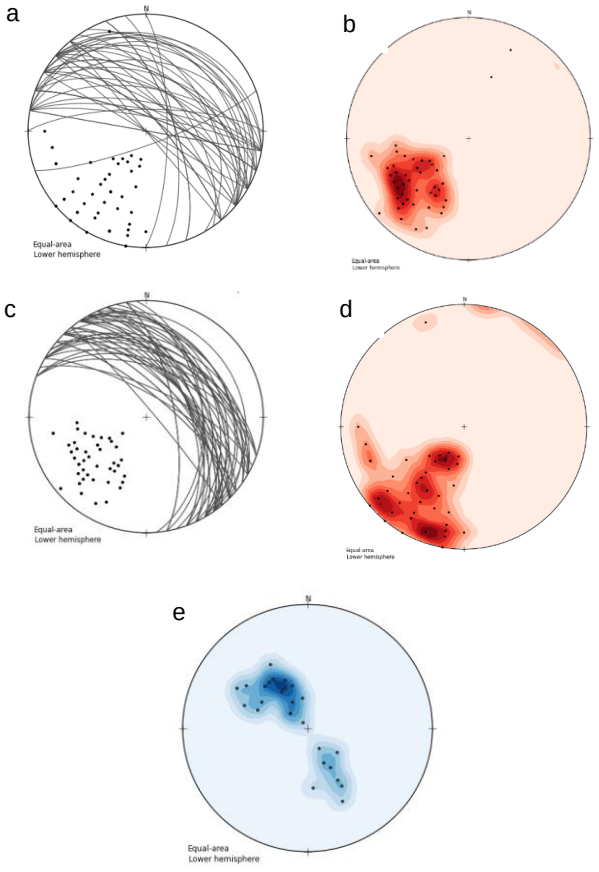

Figure 13. Lower hemisphere equal area projection of S_2 cleavage measures and the corresponding poles: a, and b, 48 measurements in VSC units; c and d, 49 measurements in flysch beds. Figure e represents the S_2^S_0 intersection lineation of 26 measurements in flysch beds. All the measurements were recovered from the entire antiform and the Mértola Formation.

Figura 13. Estereogramas da clivagem S_2 e respetivos polos: (a) e (b) relativos a medições efetuadas em unidades do CVS; (c) e (d) em bancadas de "flych". A figura (e) representa a lineação de interceção (S_2^S_0), com medições em bancadas de "flysch". Os dados foram recolhidos em toda a antiforma e na Formação de Mértola.

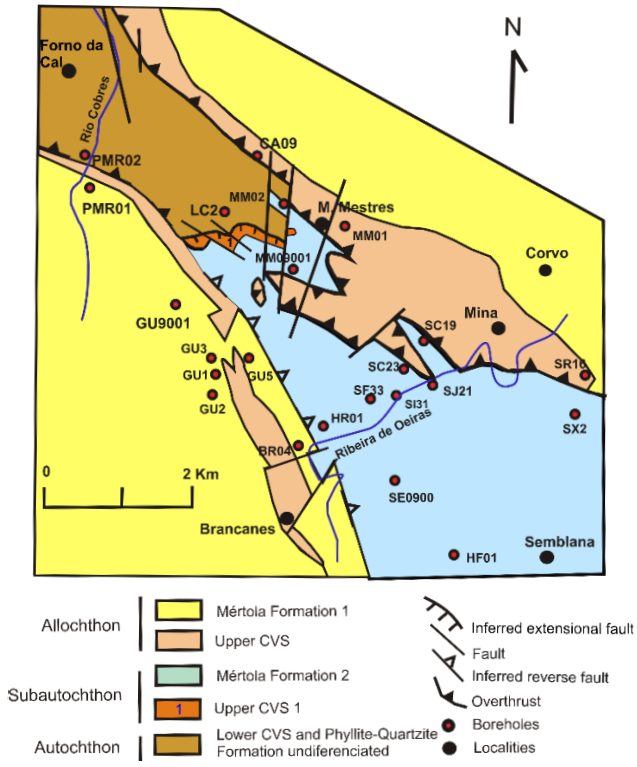

Figure 14. Tectonic structure of Monte Forno da Cal-Semblana region.

Figura 14. Estrutura tectónica da região de Monte Forno da Cal-Semblana.

Neves-Corvo allochthon represented by the CMt1 flysch sediments on top of the Godinho Formation. The borehole Gu5 (location in Fig. 11) has been projected in the cross-section plane to point out the existence of 10 m thick flysch sediments ascribed to the CMt2 flysch on top of the autochthon sequence. This is indicative of the presence of the extensional fault (Fig. 8) in the Brancanes antiform. The uplifting is attributed to the late Variscan reverse fault that occurs at the boundary between the Brancanes structure and the CMt2 succession (Annex 1 and Fig. 12).

The available data suggests that before the uplifting, the Neves-Corvo allochthon was extended to the Brancanes region forming a large SW-directed overthrust (nappe) on top of the CMt2 flysch sediments (Annex 1). The Lançadoiras block lithological sequence comprising the PQ + the lower and upper VSC units + CMt2 sediments represents the regional basin development. A first tectonic extensional episode is marked by the pre-orogenic down-dip décollement (Fig. 8). This was followed by a compressional episode (F_1) that generated the nappe. The allochthon composed of the upper VSC units and the CMt1 flysch moved southwestward upon a sole plan situated at the top of the CMt2 flysch (the Neves Corridor) in a thin-skinned structural style. This episode may have generated a weak S_1 cleavage mostly observed the PQ and the VSC units (Fig. 12).

A second compressional episode (F_2) caused the SW vergent nappe folding, thrusting and associated cleavage (S_2) (Fig. 13). All the autochthon, subautochthon and allochthon composing units were pervasively affected by this episode (Fig. 14).

The boundary between the CMt2 flysch and the lower VSC units was then reworked (sheared). The SW nappe boundary between the Lançadoiras block and the allochthon sequence became reversed by a late high-angle out-of-sequence fault causing the thrusting of the autochthon upon the allochthon (Fig. 12).

3. Discussion and conclusions

As pointed out the Monte Forno da Cal-Semblana region is situated at the Rosário antiform SE sector (Annex 1). The VSC stratigraphic units in this area have marked lithological differences related to facies changes. In the northeastern branch of the allochthon, the Ribeira de Cobres Formation is only recognized SW of Misericordia Nova farm, the Graça formation was not identified, and the Grandaços, Borra de Vinho and Godinho formations are well represented. A marked difference exists with respect to the southwestern branch of the allochthon where all the classical upper VSC units (Grandaços, Borra de Vinho and Godinho formations) are represented.

Extending the discussion to the entire antiform (Fig. 15), all along the southwest limb of the antiform the allochthon keeps the lithological characteristics except for the Godinho Formation which progressively becomes thinner and disappears northwestward of Monte do Testa below the Brancanes Formation. In the northeast limb of the antiform, the allochthon becomes reduced to the Godinho Formation and the overlying CMt1 flysch, 500 m north of Misericordia Nova farm. Here the allochthon is thrusted upon a flysch succession designated CMt (see below). Assuming the continuation of this thrust plane further northeast, a situation is generated by which the allochthon now reduced to the CMt1 flysch is thrusted upon the CMt flysch of the northeast limb of the antiform (Fig. 16).

Between Misericórdia Nova and Zambujeira farms, the upper VSC is only represented by the Grandaços Formation, in this case with the presence of metric-scale jasper outcrops in the Ferragudo Mn old mine and SE of Zambujeira farm. In the isolated outcrop surrounded by the CMt flysch,1 km east of Zambujeira farm, the jasper outcrops are overlaid by weathered reddish shales followed by metric-thick volcanoclastic sediments ascribed to the Godinho Formation. The outcrop is interpreted as a probable olistrostome which indicates the occurrence of gravity sliding in this limb of the antiform. Gravity slidings (probably related to extensional faults?) are not uncommon in

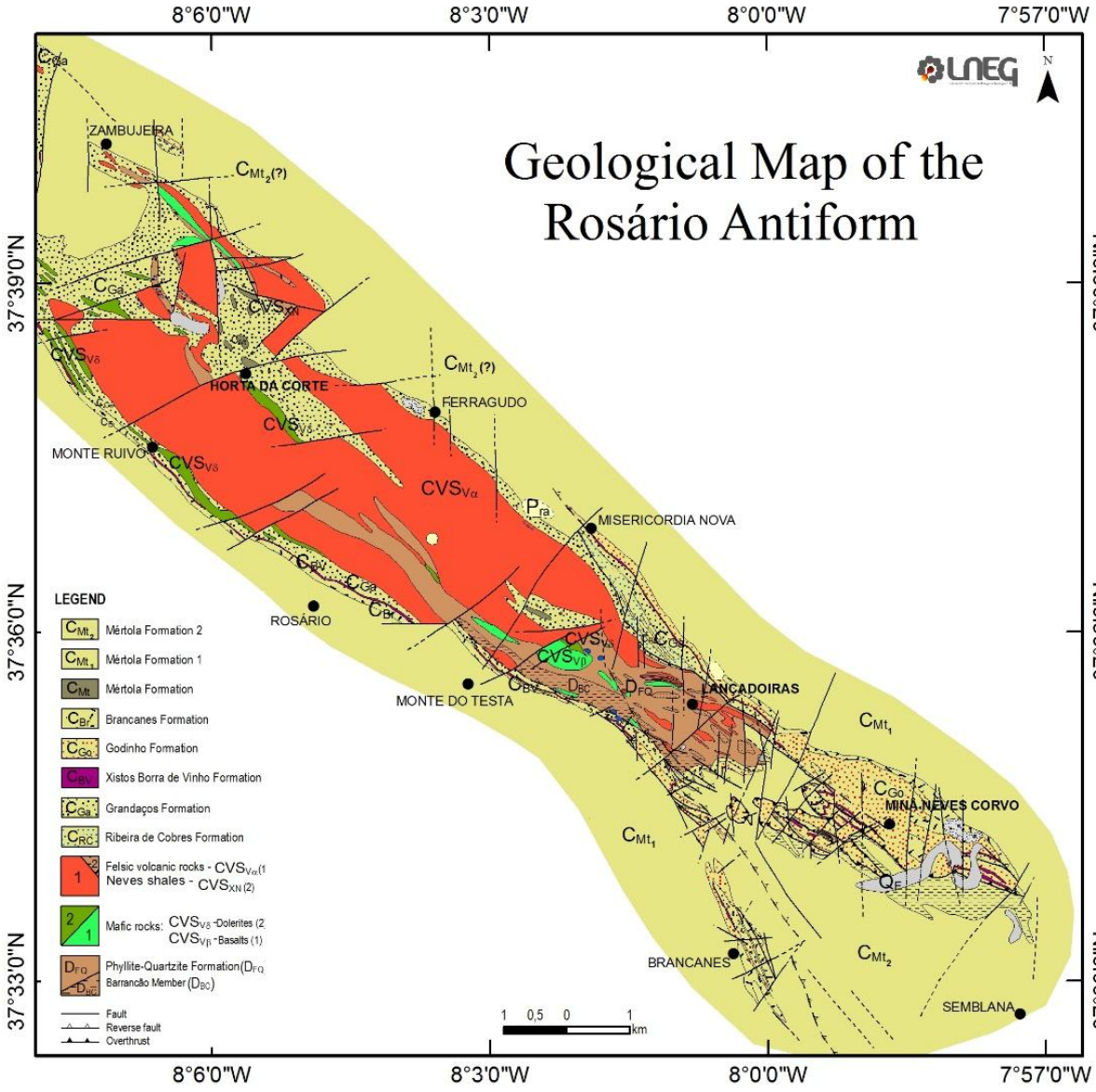

Figure 15. The Rosário antiform geological map, Sheet 46-C, scale 1:50.000 (Oliveira *et al*., 2016).

Figura 15. Mapa geológico da antiforma do Rosário, Folha 46-C, escala 1: 50 000 (Oliveira *et al.*, 2016).

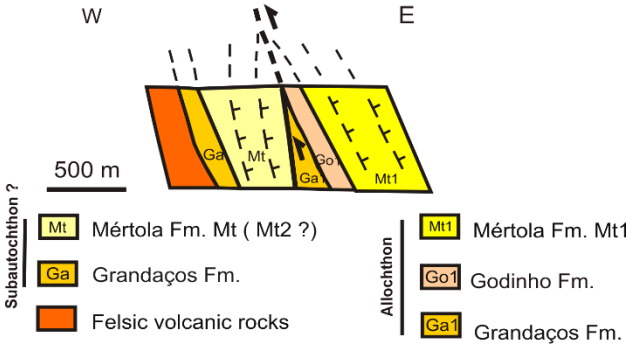

Figure 16. Structural interpretation of Misericórdia Nova region (schematic).

Figura 16. Interpretação estrutural esquemática da região do monte de Misericórdia Nova.

the Pyrite Belt, and well-documented in Mértola region (Oliveira and Quesada, 2019). Furthermore, the Duque unit in Spain (Geological Sheet Paymogo) is considered a tectonic mélange with associated gravity sliding episodes. This unit prolongation to Portugal was recently accepted (Diez-Montes and Matos, 2020). The CMt flysch succession overlies the Grandaços Formation and apparently progressed westward across the autochthon, as shown by the isolated and poorly exposed outcrops of shales and greywackes (flysch) overlying the Grandaços Formation north of Forno da Cal farm (location in Annex 1), in the Horta da Corte farm area and in the northwest synclinal closure (Fig. 15).

Taking all the things together, figure 17 summarizes the new structural interpretation proposed for the Rosário Antiform. This is based on detailed mapping and reinterpretation for the Neves-Corvo Mine region exploration drill holes which were extended to the entire antiform. The identification of a subautochthon block placed above an extensional fault plane at the antiform closure resolves the long-lasting question related to the occurrence of Mértola Formation flysch (CMt2 sequence) directly upon the lower VSC and even above the ore in the mine. The stratigraphic succession of the northeast limb of the antiform, between Misericordia Nova and Zambujeira farms shows similarities with that of the subautochthon, including the flysch sequence, named CMt. As seen above, the latter is thrusted by the Neves-Corvo branch of the allochthonin in the Misericórdia Nova region, suggesting so a stratigraphic correlation with the CMt2 flysch. Consequently, it is admitted that the northeast limb of the antiform may be seen as the northeast continuation of the subautochthon (Fig. 17). However, this proposal needs to be confirmed by new research, particularly the identification of an extensional fault at the base of the upper VSC close to the NE limb of the antiform, complemented by a deep borehole to check the disappearance of the upper VSC the units below the CMt flysch sequence.

The southwestern branch of the allochthon identified in the Brancanes-Monte Pardieiro area was recognized along the southwest limb of the antiform.

In conclusion, the Rosário Antiform is interpreted as a tectonic window composed of an autochthon represented by the Phyllite-Quartzite Formation overlaid by the lower Volcano-Sedimentary Complex (VSC) and a flysch succession designated CMt2. A southeastward-directed extensional fault (*décollement*) tectonically eroded part of the VSC causing the tectonic emplacement of the CMt2 flysch above the lower VSC units, generating so a subautochthon block. This pre-orogenic extensional episode was followed by a compressive southward-directed tectonic transport that generated the allochthon represented by the upper VSC units and the overlying Mértola Formation flysch CMt1.

This new structural interpretation for the Rosario antiform is different from any other published so far in Portugal (see for example Matos *et al*., 2020).

If correct, the tectonostratigraphic interpretation described in the present work should imply the structural revision of this branch of the Iberian Pyrite Belt.

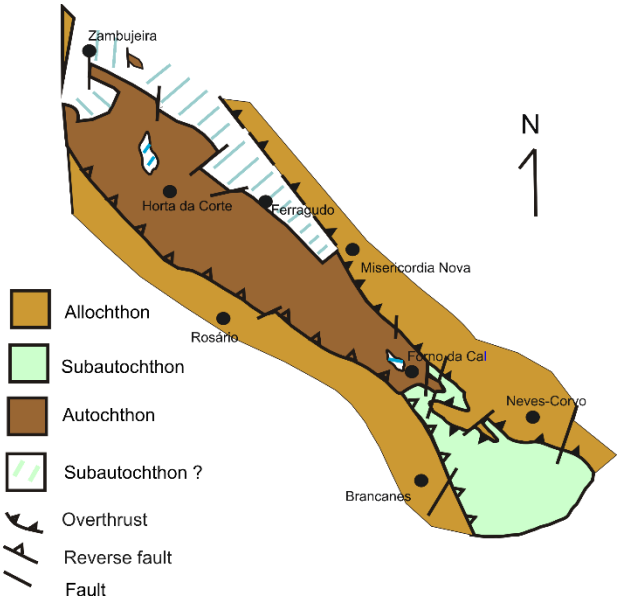

Figure 17. Re-interpreted tectonic structure of the Rosário antiform (schematic).

Figura 17. A antiforma de Rosario reinterpretada (esquemática).

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Annex 1. Geological map of Monte Forno da Cal-Semblana region and location of the studied boreholes.

Anexo 1. Mapa geológico da região de Monte Forno da Cal-Semblana e localização das sondagens estudadas.