Evolução temporal do complexo vulcano sedimentar associado ao depósito de Neves-Corvo

Time span of the volcanic setting of the Neves-Corvo VHMS deposit

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Abstract

The crystallization/emplacement age of the felsic volcanic rocks of the Neves-Corvo mine region, occurs in the interval 363-349 Ma, and clearly marks two distinct volcanic events with a gap between them. The first volcanic episode occurred between ~ 363-358 Ma (latest Famennian-Strunian) and confirms the exploration potential of the Strunian age main ore mineralization episode in the Portuguese IPB sector. The second volcanic episode occurred at ~353-349 Ma, in Tournaisian times. The effusive volcanic rocks of this episode also present sericite hydrothermal alteration and sulphide dissemination. This hydrothermal event is probably related with a syn-deformation episode or a late (probably Tournasian age) mineralization minor stage. This new result suggests that in Neves-Corvo region, the Strunian hydrothermal system may have been "reactivated" during the Tournaisian effusive volcanism. The significant fraction of Devonian inherited zircon grains provides direct evidence that the felsic volcanic rocks derived from the successive melting of pre-existing, volcanic rocks and/or juvenile immature sediments derived from them, probable included in Phyllite–Quartzite Fm. The occurrence of Lower Devonian zircons ages of ~415 Ma in almost felsic volcanics, strongly suggests that at least locally, the magmatic activity in Neves- Corvo region was active for ~60 Ma.

Keywords: IPB-Iberian Pyrite Belt, VSC-Volcanic Sedimentary complex, zircon ages, Neves-Corvo.

Resumo

A idade de cristalização das rochas vulcânicas félsicas da região de Neves Corvo ocorreu no intervalo entre 363 e 349 Ma. Os dados de geocronologia sugerem a existência de dois episódios vulcânicos distintos, espaçados no tempo. O primeiro evento ocorreu entre ~ 363-358 Ma (Famenniano tardio-Estruniano), sincrónico do principal sistema de alteração hidrotermal, ao qual se associam os jazigos de sulfuretos. Por este motivo, este tempo geológico é considerado um bom guia de prospeção. O segundo evento vulcânico ocorreu entre ~353-349 Ma (Tournaisiano), sendo marcado por rochas félsicas finas, de caracter efusivo, com sericite hidrotermal e disseminações de sulfuretos, evidenciando um estádio hidrotermal pouco desenvolvido e possivelmente sin-tectónico. A geocronologia sugere assim que possam ter ocorrido em Neves - Corvo duas fases mineralizantes distintas, sendo as tardias associadas a remobilizações a partir das mineralizações mais importantes de idade Estruniana. Outra hipótese sugere que o sistema hidrotermal possa ter sido "reativado" durante o Tournaisiano. A fração importante de zircões herdados de idade Devónica evidencia que as rochas vulcânicas félsicas possam ter derivado da fusão sucessiva de rochas vulcânicas e/ou sedimentos juvenis preexistentes, provavelmente incluidos na Formação Filito-Quartzítica. A ocorrência de zircões de idade ~415 Ma (Devónico Inferior) na maioria das rochas vulcânicas sugere que a atividade magmática na região de Neves Corvo, ocorreu num intervalo amplo, de cerca de 60 Ma.

Palavras-chave: FPI-Faixa Piritosa Ibérica, CVS-Complexo Volcano Sedimentar, idades em zircão, Neves-Corvo.

Introduction

In Iberian Pyrite Belt (IPB), volcanic-hosted massive sulphide (VHMS) deposits and related hydrothermal systems, when present, are generally coeval and coincident with felsic volcanic rocks in close association with black shales (e.g., Leca et al., 1983). Geochronology constraints of Volcanic Sedimentary Complex (VSC) in the IPB and particularly in the Neves-Corvo mine region are given by the study of palinomorph assemblages present in the VSC shale sequences (e.g., Oliveira et al., 2004). However, contact relationships between sediments and volcanic rocks are not always clear, due to the complex tectonic structure, extrusive and intrusive volcanic facies (Rosa et al., 2008), discordances and poor exposure.

Insights into the timing of the magmatism related to the formation of VHMS deposits and its sources can be obtained through the study of zircon minerals present in the felsic volcanic rocks. The available high precision zircon U–Pb geochronology of volcanic rocks in the Portuguese IPB sector (e.g., Barrie et al., 2002; Rosa et al., 2009; Oliveira et al., 2013) has proved to be an important tool to i) precise the age of the lithostratigraphic units, ii) to constrain the timing of the volcanism on a regional and local scales and also iii) to get information about the age of the sources, indicated by the inherited zircon grains.

This work presents new geochronological data of the volcanic rocks of the Neves-Corvo region obtained during the project "IPB Vectors-Geologic, stratigraphic and litogeochemical characterization of the geological units of the Algaré structure, Rosário Antiform and Semblana massive sulphide mineralization" (Pereira et al., 2014) a research contract signed between LNEG and AGC/(Lunding Mining).

This approach, U-Pb zircon ages of the volcanic rocks, combined with biostratigraphic ages of intercalated sedimentary rocks, detail field and log studies, previous studies (Pereira et al, 2014 and Oliveira et al., 2013) allowed to: i) constrain the timing of the volcanism in Neves-Corvo mine region, ii) obtain information about the age and nature of the sources; iii) determine with precision the different sulphide ore forming events and iv) confirm the Strunian age of the main sulphide mineralization episode.

Geochronology of volcanic rocks

Samples and analytical methods

Ten exploration drill-holes located at Algaré, Semblana, Monte Branco localities and at Neves-Corvo mine (Lombador, Neves, Graça, Corvo and Zambujal ores) were selected for zircon geochronology of volcanic rocks, after detailed logging (example in Fig. 1). Zircon concentrates of 16 felsic volcanic samples (rhyolitic composition), related with sulphide mineralization were extracted and analysed for U, Th and Pb isotopes by LA-ICP-MS techniques at the Museum für Mineralogie und Geologie (Senckenberg, Dresden). Details on analytical protocol and data processing are described in Frei and Gerdes (2009).

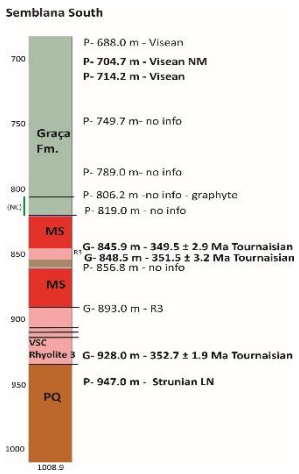

Fig. 1 – Simplified stratigraphic log of the studied Semblana PSN44 drillhole (Lundin Mining) (after Pereira et al., 2014); P - sample for palynostratigraphical study; G - sample for zircon geochronology. Graça Fm. (Upper Visean); MS – massive sulphide, VSC – felsic volcanics (rhyolite), PQ – Phyllite-Quartzite Fm (Strunian-Famennian). Bold lines – thust faults.

Results

Zircon ages are summarized in Table 1. Crystallization/emplacement ages are given by the concordia age of the youngest age fraction. Inherited ages in each sample correspond only to concordant or almost concordant ages.

Table 1 – Shyntesis of LA-ICP-Ms zircon ages obtained in the studied boreholes of Neves-Corvo mine region.

Localiz. (nº of samples)	Crystallization age (Ma)	Inherited ages
Algaré (3)	357.5 ± 3	not detected
	360.5 ± 2.1	Upper and Lower Devonian
	361.4 ± 3.2	Middle Devonian
Monte-Branco (3)	350.1 ± 1.5	Upper Devonian, Neoproterozoic and Mesoproterozoic
	358.8 ± 2.1	Lower Devonian, Neoproterozoic and Mesoproterozoic
	359.8 ± 1.9	Upper and Lower Devonian
Semblana (4)	349.5 ± 2.9	Upper Devonian
	351.5 ± 3.2	Upper Devonian
	352.7 ± 1.9	Upper Devonian
	360 ± 2.1	Upper Devonian, Middle Ordovician and Mesoproterozoic
Lombador (1)	361.1 ± 3.4	Upper, Middle and Lower Devonian; Middle Ordovician and Paleoproterozoic
Neves (1)	358.3 ± 3.6	Upper, Middle and Lower Devonian; Neoproterozoic
Graça (1)	363.4 ± 2.6	Upper, Middle and Lower Devonian; Neoproterozoic
Corvo (1)	359.3 ± 3.1	Upper, Middle and Lower Devonian; Cambrian, Neoproterozoic, Mesoproterozoic and Paleoproterozoic
Zambujal (2)	356.9 ± 3.5	not detected
	362.8 ± 4.1	Upper and Lower Devonian

Discussion and conclusions

Crystallization ages

The crystallization/emplacement age of the felsic units of the VSC of the Neves-Corvo region, occurs in the interval 363-349 Ma, and clearly marks two distinct volcanic events with a gap between them. The first volcanic episode occurred between ~ 363-358 Ma (latest Famennian-Strunian) and is coeval with the Neves Fm. (Strunian) and Corvo Fm. (Famennian). (Oliveira et al., 2013; Pereira et al., 2014).The second volcanic episode occurred at ~353-349 Ma, in the Tournaisian. The volcanic rocks of the second event have zircons slightly older than the magmatic zircon, with the age of the first event (~ 363-358 Ma). It should be noted that that along each drill-hole, the age variation within the same volcanic episode was well documented by the age of zircon crystallization. For example, in Semblana PSN 44 drill-hole the three sampled sections record of 353-349 Ma (Fig. 1).

Age of ore mineralization episodes

The zircon age of the older package of VSC volcanic rocks (~363-358 Ma) is coincident with the biostratigraphic age (Late Strunian, miospore biozone LN, 360.7 ± 0.7 Ma - 362 Ma; Pereira et al., 2008) of interbedded shales in the massive sulphide and stockwork ores (Pereira et al., 2008; 2014) and confirms the exploration potential of the Strunian age main ore mineralization episode in the IPB (Matos et al., 2011). The range of zircon ages of the younger package of felsic volcanics (~ 353-349 Ma) is undetected by fossil record because of absence of Tournaisian sedimentary sequences, in the Neves-Corvo region (Oliveira et al. 2004, 2013) or organic matter was not preserved in the sediments. It is important to underline that the Tournaisian felsic volcanic units show sericite hydrothermal alteration and

sulphide dissemination, observed along cleavage plans at Semblana and Monte Branco drillholes. This hydrothermal event is probably related with a late mineralization stage (probably Tournaisian age) and/or a syn-deformation episode. This new result suggests that in Neves-Corvo region, the Strunian hydrothermal system may have been “reactivated" during the Tournaisian effusive volcanism.

Crustal inheritance sources

In the studied volcanic rocks are identified zircons with ages older than the crystallization age (Table 1), interpreted as inherited and indicative of the existence of recycled crustal materials of various ages in the protoliths of the felsic rocks.

The majority of inherited ages are distributed along the Devonian times (~ 416-366 Ma), suggesting that the magmatic activity in the Neves-Corvo region took place roughly continuously since the Lower Devonian to Tournaisian times (~350 Ma). This is evidenced by the occurrence of zircons ages of ~415 Ma in Graça, Corvo, Lombador, Neves, Algaré and Monte Branco felsic volcanics. In Semblana volcanics the oldest zircons only record the magmatic activity of ~ 383 Ma, like also verified for the Rosario sector (Oliveira et al., 2013). Therefore, at least locally, the magmatic/volcanic activity in Neves - Corvo region was active for over a ~60 Ma. This new “time span” is the double than the ~30 Ma obtained for Rosário area by Oliveira, et al., (2013).

Such a long period of heat flow would have promoted the long-lasting hydrothermal activity, favourable to the formation of VHMS deposits. As mentioned by Rosa et al., 2009, the presence of recycled zircons in felsic volcanics should be considered a potential exploration criterium for VHMS deposits.

The significant fraction of Devonian inherited zircon grains provides direct evidence that the felsic volcanic rocks derived from the successive melting of pre-existing, volcanic rocks and/or juvenile immature sediments derived from them, probable included in Phyllite–Quartzite Fm (PQ), which is immediately beneath the VSC. The link between the PQ Fm and VSC and related massive sulfide deposits has already been suggested by Rosa et al., (2009) and Jorge et al. (2007), respectively. Older, Pre-Devonian zircon ages (Paleoproterozoic to Ordovician), were also identified, reflecting a detrital component in PQ Fm. source rocks or an older basement beneath PQ Fm.

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