Sediment-matrix igneous breccias at the top contacts of felsic units in the IPB: implications for VHMS exploration

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Abstract. The Volcanic Sedimentary Complex of the Iberian Pyrite Belt is dominated by mudstone units and comprises felsic lavas/domes and pyroclastic units that define lava-cryptodome-pumice cone volcanoes. Sediment-matrix igneous breccias may outline the contacts of volcanic units, occur within them, or lie laterally to the volcanic centres. These breccias can form by several processes, each with its genetic implications, having nevertheless very similar final aspect. We have distinguished and characterized several sediment-matrix breccia types. The most abundant types are sediment-infill volcanic breccia and peperite; however other types of sediment-matrix breccia were also identified. The correct identification of these breccias is crucial to reconstruct the volcanic centres and to define the stratigraphy, which in mineralized volcanic provinces is a major issue both for metallogenic and mineral exploration models.

Keywords. Sediment-matrix igneous breccias; Iberian Pyrite Belt; VHMS exploration

1 Introduction

The Iberian Pyrite Belt (IPB) in the south of Portugal and Spain hosts more than 92 massive sulfide deposits amounting to more than 1850 million metric tonnes of sulfide ore (Tornos, 2006). The deposits are hosted by the Upper Devonian to Lower Carboniferous Volcanic-Sedimentary Complex (VSC). The VSC comprises a volcanic and sedimentary succession, of which the depositional environment is considered to be submarine, due to the widespread presence of marine fossils, abundant massive sulfide deposits, thick intervals of black mudstone and sandstone and mudstone turbidites. The abundant turbidites suggest that much of the submarine environment was below wave base. The VSC overlies the Phyllite-Quartzite Group (PQ) (Upper Devonian, base unknown) and is overlain by the Baixo Alentejo Flysch Group - BAFG (Lower to Upper Carboniferous). Disruption of the IPB stratigraphy by low-angle thrust faults, and subsequent folding of these structures to form NW-SE or W-E trending anticlines occurred during the Variscan orogeny in the Upper Devonian-Carboniferous (Silva et al. 1990).

2 The felsic volcanic centres of the Iberian Pyrite Belt

The volcanic centres of the IPB have emplaced over mudstone units, and typically consist of thick (up to 400 m) felsic lavas/domes that may have intercalated thick, normally graded felsic pyroclastic units (Rosa et al., 2010), reflecting the alternation of effusive and neptunian eruptions (Allen and McPhie, 2009). Syn-volcanic intrusions are also relatively abundant. These volcanoes are mainly rhyolitic to dacitic-rhyolitic and formed lava-cryptodome-pumice cone volcanoes (Rosa et al., 2010) from intrabasinal submarine vents. The lavas or domes probably constructed topographic highs and the collapse of unstable parts formed aprons of resedimented autoclastic breccia. The number of volcanic events and volume of felsic lavas, intrusions and pyroclastic units, varies significantly within the IPB. The VHMS deposits are hosted by felsic units, black mudstone or both, and typically occur in a proximal setting, but laterally to the volcanic centres.

3 Contact relationships of the felsic units

The upper contacts of the felsic units are typically irregular and gradational to bedded volcaniclastic units or mudstone and consist of sediment-matrix igneous breccias. These breccias are typically monomictic comprising igneous clasts, with the space between them occupied by a sedimentary component. The two most abundant types of sediment-matrix igneous breccia that occur in the IPB are sediment-infill volcanic breccias and Peperite (Rosa et al., submitted to Bulletin of Volcanology). However, other sediment-matrix igneous breccias containing pyroclasts formed by neptunian eruptions (Allen and McPhie, 2009) but with different origins are also abundant. These breccias have formed on the sea floor and typically occur laterally to lavas and domes, whereas sediment-infill volcanic breccias and peperite may outline the top contacts of the felsic units. Therefore, sediment-infill volcanic breccias and peperite are the focus of this paper.

3.1 Sediment-infill volcanic breccias

Sediment-infill volcanic breccias comprise volcanic clasts organized in a dense clast-supported framework and massive or laminated sedimentary component between the volcanic clasts (Fig. 1) (Rosa et al., submitted to Bulletin of Volcanology). The breccia matrix typically consists of massive or planar laminated mudstone, but locally it can be of jasper with spheroidal texture or crystal-rich fine sandstone. The mudstone in the matrix grades to overlying mudstone units and where laminated, the lamination is parallel in adjacent matrix domains of the breccia, and parallel and conformable with the regional bedding. Locally, the lamination drape the volcanic clasts.

The jigsaw-fit texture of the clastic framework, shown by groups of volcanic clasts, indicates that the clasts remained in situ after fragmentation. The clast have irregular shapes with planar and curviplanar margins and perlitic groundmass. These characteristics are consistent with quench fragmentation (Pichler, 1965) and the clastic framework of these breccias is hyaloclastite. The undisturbed and conformable bedding in the breccia matrix indicates that the sedimentary components have occupied and infilled the void spaces of a pre-existing clastic framework, preserving finely parallel laminae in the mudstone and the delicate spheroidal textures in the jasper. These breccias form in subaqueous environment at the top contact of volcanic units, their correct identification is key to determine the extrusive nature of the volcanic units to which they are associated.

Figure 1. Sediment-infill volcanic breccia at Albernoa, Portugal. Clast-supported framework of rhyodacite clasts showing parallel laminated purple mudstone in the matrix. The lamination in the mudstone is parallel to the bedding in the overlying sedimentary sequence.

3.2 Peperite

Peperite is common in submarine settings where volcanism and sedimentation are concomitant and consists of mixed igneous and sedimentary domains that have resulted from the interaction between magma and unconsolidated sediment (Fig. 2) (Kokelaar, 1982; Busby-Spera and White, 1987; Skilling et al., 2002). Sediment-matrix breccias, interpreted as peperite have been widely identified at the top and basal contacts of felsic units in the IPB (Boulter, 1993; Boulter et al., 2001; Soriano and Marti, 1999; Donaire et al., 2002; Valenzuela et al., 2002; Tornos, 2006; Rosa et al., 2010).

In the IPB, peperite outlines the basal contacts of felsic lavas or domes with mudstone. Locally, the upper contact of felsic cryptodomes and partly extrusive cryptodomes is discordant with the overlying sedimentary units and marked by peperite. The peperites show abundant domains of igneous clasts scattered in a sedimentary matrix, however clast-supported domains can also be abundant. The clasts have phenocryst populations and groundmass textures identical to the coherent or monomictic breccia facies of felsic lavas and domes to which they are associated. These clasts range from 0.5 mm to 10 cm across and have quenched margins. They are blocky with planar margins, or ragged or fluidal in shape and typically occur scattered in mudstone matrix. Quartz and feldspar crystal fragments (1-2 mm) are also abundant in the mudstone matrix. The igneous clasts can show short (1 cm long) wisps and seams of mudstone inside thin fractures.

The mudstone in the matrix grades to beds of mudstone. The mudstone matrix is massive or can show contorted and disrupted laminae and is in places more silicified than the bedded mudstone. The silicified mudstone domains, and disruption of the lamination are consistent with intrusion of hot volcanic units and baking of the mudstone during their emplacement.

Figure 2. Peperite showing massive black mudstone matrix and blocky and fluidal rhyodacite clasts, at Serra Branca, Portugal.

4 Conclusions

Several different processes have formed sediment-matrix igneous breccias at the top contacts of the felsic lavas and domes in the IPB (Rosa et al., submitted to Bulletin of Volcanology). The two most abundant types of breccias are sediment-infill volcanic breccias and peperite; however other types of sediment-matrix breccias are also abundant. Sediment-infill volcanic breccias formed by infiltration of fine sediment into the clastic carapace of the effusive units, are abundant and have only recently been identified (Rosa et al., 2010). These breccias occur at the top contact of the felsic units and some occurrences may have been misinterpreted as peperite. Therefore, sediment-matrix igneous breccia should be interpreted with care, especially examples that occur at the top contacts of igneous units. In the IPB, peperite mainly occurs at the basal contacts of felsic lavas and domes and only locally at their top contacts.

Discriminating between sediment-infill volcanic breccias and peperite relies mainly on the characteristics of the sedimentary component the arrangement of the volcanic clasts and contact relationships with adjacent facies. Distinctive features of each type of these breccias are:

- The matrix of the sediment-infill volcanic breccias have undisturbed and parallel lamination that is not baked and are conformable with the regional bedding. Jasper matrix shows preserved spheroidal texture.
- The matrix in the peperite is massive, or shows disturbed and contorted lamination, and can be baked, being more silicified than the original mudstone.
- The clastic components of the sediment-infill volcanic breccias define a dense clast-supported framework.
- The clasts in peperite can be fluidal and occur scattered in the sedimentary matrix.

Distinguishing sediment-infill volcanic breccias from peperite at the top contacts of the volcanic units is crucial for determining the timing of sedimentary, volcanic, intrusive and hydrothermal events and for the recognition of seafloor positions. In VHMS hosting successions, recognition of seafloor positions is important for massive sulfide exploration and also for defining metallogenetic models. In opposition to lavas, intrusions do not mark seafloor positions, are older than the host succession, and disrupt and complicate the stratigraphic sequences.

Acknowledgements

The authors would like to acknowledge the Fundação para a Ciência e Tecnologia (FCT), Portugal; the ARC Centre of Excelence in Ore Deposits (CODES) at the University of Tasmania; the Centre for Research on Mineral Resources, Mineralogy and Crystallography (CREMINER/LA-ISR) at the University of Lisbon, and the Mineral Resources Department of Laboratório Nacional de Energia e Geologia (ex-IGM) for the financial and logistic support. The study was also funded by research project ARCHYMEDES II (FCT - POCTI/CTA/45873/2002). We also would like to thank Fernando Barriga, Isabel Costa, Víctor Oliveira, Diogo Rosa, Zélia Pereira, Tomás Oliveira, João Matos and Raul Jorge for the discussions on the geology of the IPB.

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