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Potential of Legacy 2D Seismic Data for Deep-Targeting and Structural Imaging at the Neves-Corvo Mining Site, Portugal

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Summary

Volcanogenic-hosted massive sulphide (VMS) deposits show a strong seismic contrast (mainly due to their density) against almost all lithological host rocks therefore justifying their direct targeting using seismic methods (Salisbury et al., 2000; Malehmir et al., 2012 and references therein; Malehmir et al., 2013) when there is adequate signal-to-noise (S/N) ratio and suitable geometry. While there are earlier published accounts illustrating the use of seismic methods for direct targeting of deep-seated VMS deposits elsewhere (Matthew, 2002; Malehmir and Bellefleur, 2009), a number of attempts were done in Europe during the early 90s for this purpose and these have been overlooked for unknown reasons.

Introduction

Volcanogenic-hosted massive sulphide (VMS) deposits show a strong seismic contrast (mainly due to their density) against almost all lithological host rocks therefore justifying their direct targeting using seismic methods (Salisbury et al., 2000; Malehmir et al., 2012 and references therein; Malehmir et al., 2013) when there is adequate signal-to-noise (S/N) ratio and suitable geometry. While there are earlier published accounts illustrating the use of seismic methods for direct targeting of deep-seated VMS deposits elsewhere (Matthew, 2002; Malehmir and Bellefleur, 2009), a number of attempts were done in Europe during the early 90s for this purpose and these have been overlooked for unknown reasons.

Focused in this work, is a number of 2D profiles acquired during 1996 in the Neves-Corvo VMS mining area of Iberian Pyrite Belt of the South Portuguese Zone showing one of the earliest attempts of employing the seismic methods for both deep targeting and also for structural imaging of their host rocks. Fortunately, these data are recoverable as raw shot records with adequate level of documentation to be revisited for a number of purposes. In particular, legacy seismic data as such can be reprocessed using today's current processing standards and experience gained in processing of hardrock seismic data characterized by low S/N ratio (e.g., Ehsan et al., 2012; Koivisto et al., 2012).

Hardrock seismic data require a careful processing approach with a focus on a number of key steps to allow successful imaging of steep and sometimes low-contrast targets. The reprocessing can then bring new information that may reduce the cost for future planning of exploration and new surveys avoiding the sometimes high cost of new seismic data acquisition and also saving the complications and extra-cost of any environmental footprint; also acting as a first step toward the planning for new 2D and/or 3D seismic surveys. Such an approach was already successful at Neves-Corvo where existing 2D seismic data along with other geological and geophysical information were used to justify the acquisition of a 3D survey covering a number of targets in the area (Yavuz et al., 2015; West and Penney, 2017). In the current work, we have recovered six 2D seismic profiles over the Neves-Corvo mining area with the main objective of illustrating the potential of seismic and legacy data for deep targeting and how additional information can be extracted from these data through a careful and dedicated hardrock processing approach. We show that not only VMS deposits are remarkably distinguishable in the data but also key geological structures are imaged, which were not obvious in the earlier processing work.

Neves-Corvo geology

Geologically, Neves-Corvo sits within the world-class Iberian Pyrite Belt (Figure 1) in the South Portuguese Zone known for its numerous VMS deposits. The Neves-Corvo deposits, up to 100 m thickness, are rich in zinc and copper, and comprised of seven lenses: Neves, Corvo, Graça, Zambujal, Lombador, Semblana and Monte Branco. Strong metal zoning of copper, tin and zinc zones, as well as barren massive pyrite dominate the deposits. Neves-Corvo is considered one of the largest and richest base-metal mines in the world. The VMS deposits are typically underlain by stockwork sulphide zones within a felsic volcano-sedimentary setting (flysch-rhyolite).

Legacy 2D seismic data

The legacy 2D seismic data are comprised of six profiles totalling 25 line km. The data were acquired by Somincor (a subsidiary of Lundin Mining Corporation) through CGG seismic acquisition company during March-April of 1996. There are also five additional seismic profiles in the area acquired during 1991 by CGG, however, at present only final sections are available exhibiting poor-quality images or only large-scale features. The main seismic acquisition parameters of the 1996 data (our focus) are nominal receiver and source spacing of 15 m, explosive sources fired at 1.5 m deep holes, a total of 96-120 channels (depending on the profile) and a roll-along type acquisition setup providing low-fold data (i.e., 48 for the current data) compared to the most data acquired today (> 100 fold) for similar purposes. A record length of 2 s and sampling rate of 2 ms was used. Prior to the main data acquisition, a number of tests were conducted to optimize the survey parameters. However, these tests apparently led only to increase the number of recording channels from 96 to 120 (Somincor, 1996).

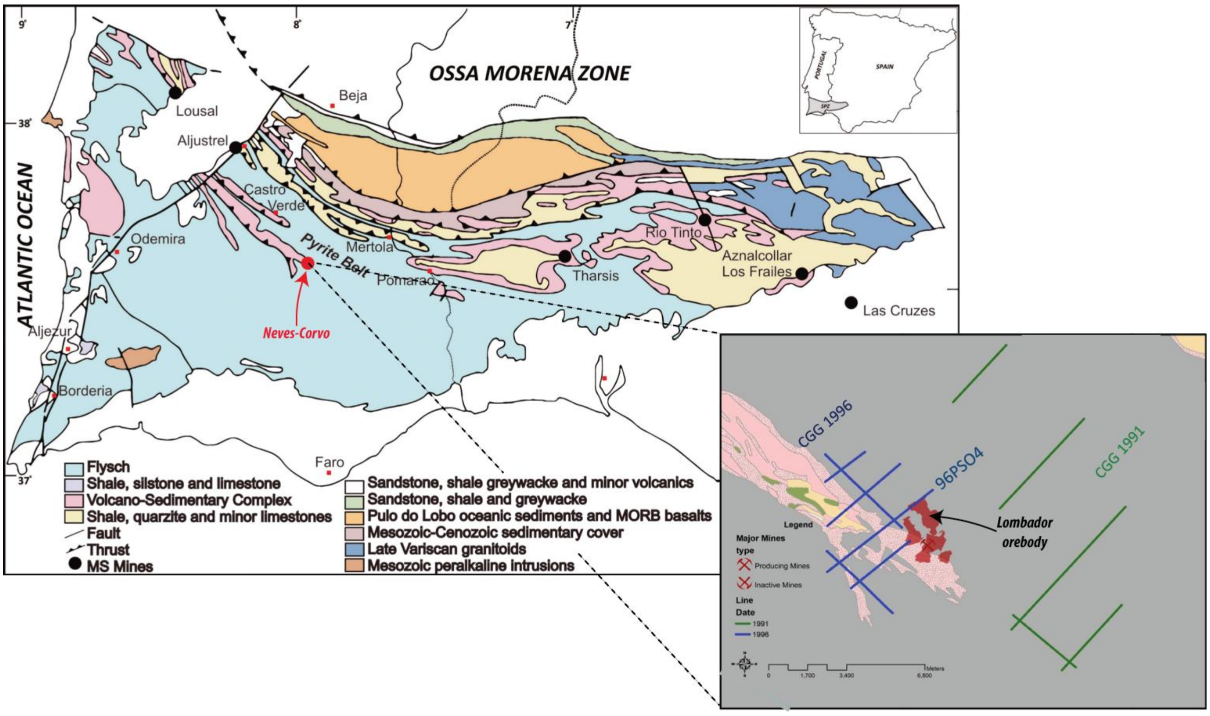

Figure 1 *Geological map of the Iberian Pyrite Belt over the South Portuguese Zone showing the location of the study area, the 1996 legacy seismic data and orebodies in the Neves-Corvo (adopted from Yavuz et al., 2015). Seismic data along 96PS04 are presented in this study.*

Reprocessing work

The reprocessing work started with a careful studying of existing reports on the acquisition parameters to make sure that the recovered geometry was as accurate as possible. Fortunately, we were able to recover most of the key information from the existing headers and the published reports (e.g., Somincor, 1996). After assigning a CDP processing line, first breaks were picked and used to obtain refraction static corrections to compensate traveltime delays due to the effect of near surface low-velocity overburden. Strong ground-roll and source-generated noise dominates most of the shot records (Figure 2a), however, this was attenuated through a set of bandpass filtering, spectral balancing and top-mute. Upon these steps of the processing, a number of steep reflections were recognized in the shot records around 200-300 ms and a strong one around 500 ms (Figure 2b). This observation was encouraging and helped to preserve these reflections through the remaining processing steps involving velocity analysis, coherence noise removal, a careful design of the stretch mute and post-stack data enhancement involving FX-deconvolution and low-frequency noise removal. The processing work will continue to include more advanced imaging techniques such as a prestack time and/or depth imaging algorithm. However the potential of the data for imaging mineralization and its host rock and provide a first-hand comparison with the existing sections made available from the earlier works has already been illustrated.

Figure 3a shows a partial stacked section along one of the six profiles for the shots that illuminated the target of interest more favourably. Figure 3b shows a similar portion of the line as Figure 3a but processed during the earlier works (likely in 2007 through a new attempt). The strongest reflection observed around 400-500 ms is originating from the Lombador orebody and can remarkably be seen in the data. Moreover, a set of north-dipping reflections is imaged in the new processing work that is totally absent in the earlier work.

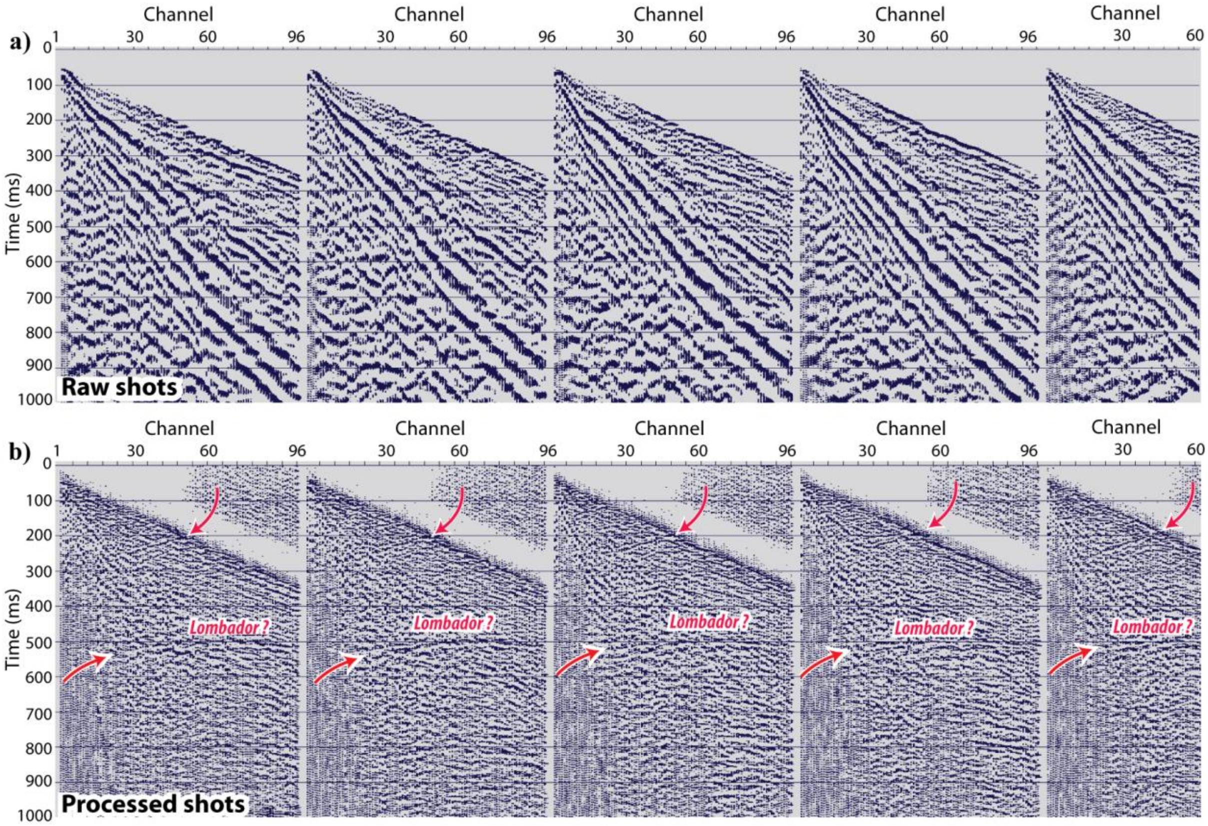

Figure 2 *(a) Example raw shot gathers from profile 96PS04 showing how ground-roll dominates the records. (b) Processed shot gathers showing a set of notable reflections around 200-300 ms and a higher-amplitude one around 500 ms. The reflection around 500 ms time is generated by the Lombador VMS orebody.*

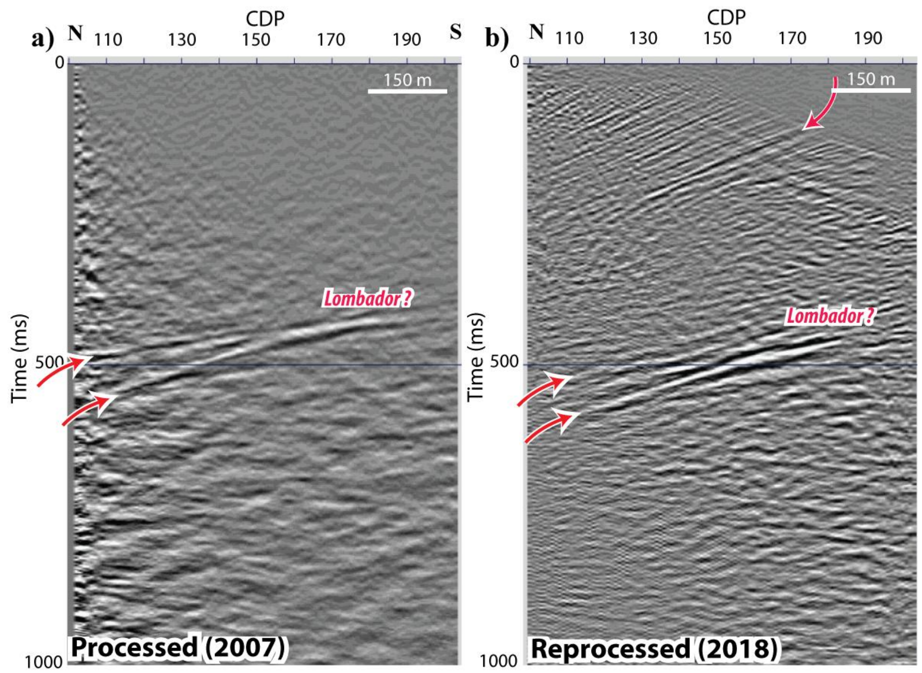

Figure 3 *Comparison between (a) available stacked section (an earlier processing work) and (b) reprocessed stacked section (this work) from profile 96PS04 intersecting the Lombador orebody. Note the higher signal-to-noise ratio in the reprocessed work and steeply north-dipping reflections imaged around 200-300 m. The strongest reflection is generated from the Lombador VMS ore.*

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