Utilizing exploration tunnels for in-mine seismic imaging via novel GPS-time transmitter system and a broadband *e*-vibe

Bojan Brodic[1], Alireza Malehmir[1], Nelson Pecheco[2], Lars Dynesius[1], Jens van den Berg[3], Richard de Kunder[4], Joao Carvahlo[5], George Donoso[1], Tord Sjölund[6], and Vitor Araujo[2]

[1]Uppsala University, Sweden, [2]Somincor (Lundin Mining Corporation), Neves-Corvo Mine, Portugal, [3]Delft University of Technology, The Netherlands, [4]Seismic Mechatronics, The Netherlands, [5]Laboratório Nacional de Energia e Geologia, Portugal, [6]MIC Nordic AB, Sweden.

To test the feasibility of utilizing exploration tunnels in an active mine for active-source seismic survey, a novel data acquisition was conducted at the Neves-Corvo mine in southern Portugal. The survey was conducted using a combination of cabled geophones and MEMS-based (MicroElectro-Mechanical system) sensors coupled with wireless seismic nodes operating in autonomous mode. All the receivers (454) were deployed with a 2 to 4 m receiver spacing along four profiles in four exploration tunnels at ca. 650 m below the surface, and positioned above the world-class Lombador ore body. The spread design was driven by 3D forward modeling of reflection points using the known ore body shapes enabling the most optimal pseudo-3D subsurface illumination. As both cabled and nodal units used require GPS signal to operate, the novelty of the survey is particularly reflected in a GPS-time synchronization system that enabled GPS signal to be fed to the central recoding system and individual wireless nodes. An additional component, important for in-mine seismic surveys, was the use of a newly developed broadband, electromagnetically based, electrically driven ("e-vibe") vibroseis seismic source. The source was used along one of the profiles with source points spaced every 4 m and four repeated sweeps per source point. It operated with a peak force of 6.7 kN and a 20 s long sweep within the frequency range of 2-200 Hz. Apart from the subsurface portion of the seismic spread, 315 wireless recorders were also distributed along two perpendicular seismic profiles on the surface directly above the four underground profiles. The GPS-time transmitter (microsecond accuracy) hence enabled a full synchronization between the underground and surface receivers. This provided a comprehensive and unique dataset for imaging the structures both between the surface and exploration tunnels, and those deeper seated below the tunnels.

Due to being in an active mine, the cross-correlated data shows rather noisy nature, however, first arrivals are clearly notable on over 70% of the dataset. Additionally, a portion of the cross-correlated data, with only a bandpass filter applied, shows clear hyperbolic events. Here we discuss the challenges, steps undertaken and developments necessary to enable the acquisition of this challenging and comprehensive dataset. We present the results of first-break 3D traveltime tomography for the structures between the exploration tunnels and the surface and 2D reflection seismic result of one of the underground seismic profiles. Reflection seismic data from the exploration tunnel suggests the presence of strong reflections corresponding to the known Lombador ore body, as well as additional events whose nature needs further investigations. The results are encouraging and open up possibilities for large-scale underground active-source seismic surveys in operational mines thanks to the developments presented in this study.

This study was sponsored by Smart Exploration™ project. Smart Exploration™ has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement no.775971.