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Muon Attenuation Radiography and Tomography in the Polymetallic St. Christoph Skarn Deposit, Ertzgebirge, SE Germany

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Attenuation muography, an innovative astroparticle geophysical technique, uses cosmic-ray muons to image the internal structures of objects based on the attenuation of muon intensity due to density. We applied it in the St. Christoph mine, a tourist attraction in western Erzgebirge, SE Germany. Mining of the local polymetallic ore containing Sn, Zn, Cu, Fe, In, and Ag began as early as 1558. Our measurements were conducted as part of the Horizon 2020-funded Mine.the.Gap project.

Muography was conducted at two depths of approximately 40 and 60 m within the mine using an MWPC-type muon telescope. At the first adit, the telescope was initially positioned vertically 2 m from the shaft axis, and subsequently tilted 30° toward the shaft at a second point 19 m away. Polar plot muon radiography images from both positions distinctly revealed the shaft. Furthermore, a two-point inversion tomography was developed for the rock volume around the shaft.

The third measurement was conducted in a complex underground gallery, producing a muon radiographic density image. Given the location's nature, we employed detailed laser scanning to account for known voids and detect potential unknown ones. The gallery also contained historical supports made of bricks and stones. Our results indicated that the extraction of the dense polymetallic ore horizon was incomplete during historical mining operations.

Our measurements demonstrate that muons can be successfully applied to scan rock densities for various purposes. These include the detection of drilling targets or additional resources for extraction. Muography can also be used to detect voids, like past mine infrastructures and collapsed adits and shafts. In conclusion, our study highlights the efficacy and potential of muon attenuation tomography in contributing to the broader aim of integrating cutting-edge science and innovative technologies across the mining industry supply chain.