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Cosmic-ray muon tomography: Current developments in how Canadian innovation is helping industry drill less and discover more

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Summary

A spin-off of TRIUMF (Canada's national particle accelerator laboratory), Ideon Technologies has been advancing cosmic-ray muon tomography technology for many years and has developed the world's first compact muon detection instrument designed to be deployed down industry-standard boreholes in mining. Our radiographic analysis algorithms and data inversion methods allow for the combination of muon data with drill assay, and gravimetry (full field and gradiometry) to enhance the characterization of subsurface geology.

In 2021, Ideon completed development of a miniaturized muon detector and undertook several field deployments with industry. This presentation will share the latest developments in cosmic-ray muon tomography as well as early learnings from our first client imaging programs.

Method

Muon tomography is a novel density measurement technique based on the absorption of cosmic-ray muons in the ground. Cosmic ray muons are charged elementary particles that arise naturally from cosmic radiation interacting with the Earth's upper atmosphere. Particle showers of muons bombard Earth steadily and are attenuated by their interaction with matter along their trajectory.

Due to their long half-life and high mass, muons can penetrate deep into the Earth's crust, up to thousands of meters. By measuring the flux through muon detectors positioned beneath the surface, the average density in the overburden within a wide field of view above the sensors can be determined. Density anomalies can be inferred from reduced or enhanced muon flux arriving at the sensors from the surface along any given direction. By combining data from multiple locations, a detailed 3D model of underground density can be constructed.

Ideon Technologies has spent years developing an HQ-sized borehole muon detector with high muon tracking resolution (approximately 20 milliradians), low power consumption (approximately 10W) and operational robustness (high hydrostatic pressure, continuous data uplink). In 2021, we deployed HQ-sized borehole muon detectors at several client sites. The detector data were collected by data aggregators located at the surface of the boreholes, and automatically uploaded via cellular and satellite link to Ideon servers.

Results, Observations

In addition to lab testing outcomes for the muon detectors, some preliminary results from the data analysis of the client surveys, including radiographic image development and 3D inversions, will be presented. Further, we will review results from recent projects using our earlier version gallery-style detectors that have been used for in-mine surveys down to depths of 800m, and which successfully imaged massive sulphide deposits with resolution at a scale of ten metres.