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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 two client imaging programs over the summer of 2021: the first with multi-national uranium exploration company Orano at McClean Lake, Saskatchewan, and the second with Canadian mining junior Fireweed Zinc at Macmillan Pass, Yukon Territory.

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 above the sensors can be determined, within a wide field of view. 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 15 milliradians), low power consumption (approximately 10W) and operational robustness (high hydrostatic pressure, continuous data uplink). In June, 2021, we deployed four HQ-sized borehole muon detectors in a single chain within a drillhole down to depths of 240m at the McClean Lake mine site in the Athabasca Basin

in Saskatchewan, Canada. This field trial aimed to image a known but poorly characterized, compact, unconformity-related uranium deposit at approximately 150m – 200m depth.

In August 2021, Ideon Technologies deployed four more detectors in a 400m deep hole at the Macmillan Pass property with Fireweed Zinc, to explore a region around a known lead-zinc-silver deposit, both to map the extension of the deposit and to search for additional density anomalies nearby.

In both cases, 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 Fireweed Zinc and McClean Lake 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.

Additive Information

Global demand for metals and minerals is doubling every 20-30 years, as the world transitions to clean energy. Production of minerals needs to increase by nearly 500% over the next 30 years, with more than 3 billion tons required to deploy technologies such as wind, solar, geothermal power, and electrification. With most near-surface deposits already discovered, the mining industry is searching deeper underground at both new and existing mine sites. Without suitable tools available, discovery rates have fallen sharply while exploration costs continue to skyrocket.

Muon tomography has the potential to transform subsurface exploration, reducing exploration drilling activity while identifying exploration targets with quantified certainty. Users will be able to drill less and discover more – reducing cost and risk, saving time, and minimizing environmental impact. This breakthrough Canadian innovation has the potential to generate significant value for the global mineral exploration market, among others, while dramatically reducing environmental impact.