D'Arcy McGee Beacon Fellowship Lecture Series

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Geoforensics in Nova Scotia: Application of GPR for the study of Graveyards and Criminal Investigations

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Abstract

The achievements of Thomas D'Arcy McGee are a significant contribution to the long, intertwined history of Canada and Ireland. His vision for Canada to be built on a foundation of tolerance, inclusivity and diversity, along with his support for minority rights, can be viewed by Irish and Canadian contemporaries as modern and progressive for his time. The D'Arcy McGee lecture fellowship is the latest in a long history of collaboration and research connection between Professor Wach and the Irish geological community. This talk will showcase geoforensics work in Nova Scotia, Canada.

Ground-penetrating radar (GPR) is an established, non-invasive, and non-destructive remote sensing geophysical technique used extensively for the accurate reconstruction of the shallow (< 10 m) subsurface, and has been successfully utilised in numerous disciplines and environments including locating utilities, engineering, forensics and law enforcement, infrastructure, mining and quarrying, geotechnical and environmental work, archaeology, military, agriculture and forestry, and in imaging through ice and snow. Detecting foreign objects or anomalies in the subsurface has a near endless range of applications if the accuracy of data collection and modelling can be optimised. Reconstructions have largely been completed and presented as 2D vertical and horizontal planes, limiting visualization of subsurface 3D shapes and their spatial relationships. With technological advancements, including the availability and integration of various software platforms, 3D modelling of GPR data is now emerging as the new standard. However, with these advances, robust examination and testing of these techniques is required to discern if their application is beneficial and warranted.

This 2019 study was completed in a church graveyard near Halifax, Nova Scotia, Canada. Tombstones and plot plans indicate locations and ages of burial sites, as well as the different types of burial sites and practices (single-casket, multi-casket, and urns). The plot plans indicated unmarked, known burial sites, confirmed by the cemetery warden, but have no tombstones, or indication of a burial site in the graveyard. A GPR grid survey was conducted in the graveyard to generate 2D and 3D model reconstructions of the burial sites. Data collection and processing was completed using a Sensors and Software Incorporated PulseEKKO™ Pro SmartCart GPR system and

EKKO_Project™ software, with modelling completed using Schlumberger's Petrel™ software platform. The soil in the study area is characterized as light brown to yellowish-brown sandy loam derived from glacial boulder clay.

The subsurface patterns present in the 2D and 3D reconstructions closely matched the graveyard plot plan, validating our collection, processing, and modelling methods. The 2D model was adequate for 2D horizontal visualisation of reflection patterns at specific depths. However, the 3D model provided enhanced subsurface visualisation with identification of a companion burial plot (stacked caskets) and possible leachate plumes below and encircling burial sites, both of which were not evident in the 2D model, highlighting the benefits of 3D modelling for discerning subsurface objects. Application of these techniques was completed in Autumn 2019 and Spring 2020 to aid law enforcement in criminal investigations in Nova Scotia. We expect this work to be of value to future GPR studies, with particular significance to geoforensics and criminal investigations.