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# Reconstructing Estuarine Palaeo-Environments using 3D Ground Penetrating Radar Imaging

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During the last two decades, Ground-Penetrating Radar (GPR) methods have grown in popularity for acquiring high-resolution images of the buried stratigraphy and internal structure of geomorphologic features. GPR provides an effective complement to established techniques, including sediment core-logging and in-field mapping of exposures, which typically provide relatively sparse 2D insight into subsurface architecture. In geomorphological settings, GPR surveys typically complement core sampling by linking borehole data along 2D transects but cannot reveal full subsurface morphology. More comprehensive GPR surveys offer rapid, non-invasive 3D characterisation of the shallow surface ($\sim$10 m maximum depth), with data interpretable in terms of the thickness, lithology, structure and extent of subsurface depositional environments (e.g. coastal, aeolian and deltaic deposits).

The wider uptake of 3D GPR is enabled by recent advances in GPR systems technology – the development of robust equipment and GPS-coupled antennas being particularly advantageous. 3D methodologies and their dedicated processing algorithms are now commonplace within the engineering and archaeological sectors, and are able to reveal the full structure of complex targets. Equivalent advantages can now be realised for geomorphological characterisation, for assessing the true size and extent of buried coastal landscapes.

This paper highlights the potential of 3D GPR methodologies using a 500 MHz GPR dataset collected over a buried Holocene estuarine environment in Llanbedr, Gwyendd, North Wales, which has since been reclaimed for use as an airport. The complexity of the buried estuarine structures, including small, meandering, salt-marsh channels, motivates a 3D GPR survey, given that i) the channel geometry is too complex to appreciate from individual 2D transects and ii) their narrow size suggests they could easily be missed in a core logging programme. When viewed in a top-down "depth-slice" view, the 3D architecture of the subsurface is easily appraised, and can furthermore be interpreted as a palaeo-record of the evolution of the site. The deepest palaeo channels (2.9 m depth) are small and sparsely distributed, but are both more densely spaced and complex at shallower depth (1.4 m). When combined with regional models of sea-level change and associated sedimentation, these data provide a valuable model for the evolution of Holocene estuarine environments and present-day analogues.