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Characterising the structural heterogeneity of Irish hard rock aquifers: insights from field-scale geophysical investigations

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In spite of extending over 65% of the Irish land surface, fluid movement in Irish hard rock aquifers, and the interaction between ground- and surface-water bodies, is poorly understood. Their management and protection is required under the Water Framework Directive, yet there have been few studies to date and conceptual models have not been developed specifically for an Irish context.

Conceptualising flow in such aquifers requires a comprehensive, three-dimensional understanding of the structure and zonation of the overburden and bedrock units. Four general zones are recognised, extending from the (1) unconsolidated overburden, through a physically and chemically weathered (2) transition zone into the (3) shallow and (4) deep fractured bedrock. Beyond this simple, layered categorisation, however, little research has been undertaken to investigate the 3D continuity and possible variations of this model at the catchment-scale. In particular the roles played by bedrock lithology and the depositional history of the region (including the influence of the recent glaciation) with regard to the development of the weathered units, are of importance for the generalisation of the conceptual understanding for this region.

Although providing accurate information at point locations in an aquifer, borehole (hydraulic, geophysical or hydrochemical) investigations are often insufficient to account for the catchment-scale variability in fractured rock and must be put in context within a larger scale of investigation. Surface geophysical methods provide a valuable tool in this respect, as the range of scales over which they can be applied provides a means of identifying relevant structural features across the relevant hydrogeological scales.

A suite of geophysical methods were applied to the characterisation of aquifer structure at 3 sites, covering low- to high-grade metamorphic units in the North and West of Ireland. Electrical resistivity tomography along kilometre-scale transects provided large-scale information on geological contacts, discontinuities and the depth and extent of the weathered zone, to depths of up to 60 m. Seismic refraction was applied to the delineation of the overburden from the transition zone and shallow weathered zone, to approximately 20 m depth. At depths of 0 - 10m ground penetrating radar provided indications of hydraulically active zones in the subsoil and transition zones, although limited to localities in which clay content was minimal. Borehole geophysical logging was undertaken at each site and provided measurements for comparison and groundtruthing of the surface profiles.

In combination the results provide essential spatial information for the interpretation of borehole-based hydrodynamics and geochemical data, and have been integral in the development of groundwater conceptual models of the sites.