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Recharge velocity and geochemical evolution for the Permo-Triassic Sherwood Sandstone, Northern Ireland

A.A. Cronin[a,*], J.A.C. Barth[b,c,1], T. Elliot[d,2], R.M. Kalin[d,2]

[a]*Robens Centre for Public and Environmental Health, University of Surrey, Building AW, Guildford GU2 7XH, UK*
[b]*University of Tübingen Institute of applied Geosciences (ZAG), Sigwartstr. 10, 72076 Tübingen, Germany*
[c]*Scottish Universities Environmental Research Centre—SUERC, Rankine Avenue, East Kilbride G75 0QF, UK*
[d]*School of Civil Engineering, Queen's University Belfast, David Keir Building, Belfast BT9 5AG, Northern Ireland*

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Abstract

The Triassic Sherwood Sandstone Group is a major European aquifer system. It is also the principal groundwater source in Northern Ireland. However, key aspects of its regional hydrogeology, such as age distribution and geochemical evolution, remain largely unknown. Here the groundwater geochemistry and isotopic composition were investigated in order to evaluate groundwater recharge and flow processes in a complex regional hydrogeological setting. The dominant geochemical processes, such as dissolution of carbonate cements were determined from the major and trace element chemistry. Stable and radio-isotope measurements were taken as residence time and flow path indicators and, together with physical and geochemical groundwater modelling, revealed groundwater ages of up to 9000 years. The importance of infiltration from overland flow from springs deriving water from the adjacent Cretaceous chalk aquifer and subsequently re-infiltrating into the Sherwood Sandstone was confirmed. In addition, evidence was found of a slow recharge component through low conductivity mudstones that yielded significant groundwater resident times throughout the Lagan Valley. These findings provide improved understanding of groundwater flow processes in Northern Ireland and serve as an example of methods that can be applied to water management elsewhere.

Keywords: Aquifer; Groundwater; NETPATH; Permo-Triassic Sandstone; Water quality

1. Introduction

1.1. The study area

The Permo-Triassic red-bed sandstones are comprised of soft, compact, weakly cemented sediments and form regionally important aquifers throughout Western Europe. The Permo-Trias is usually a high yielding aquifer with groundwater flow through

* Corresponding author. Tel.: +44 1483 689931; fax: +44 1483 689971.
E-mail addresses: a.a.cronin@surrey.ac.uk (A.A. Cronin), j.barth@suerc.gla.ac.uk (J.A.C. Barth), t.elliot@qub.ac.uk (T. Elliot), r.kalin@qub.ac.uk (R.M. Kalin).
[1] Tel.: +44 1355 270146, fax: +44 1355 229898.
[2] Tel.: +44 28 90274006, fax: +44 28 90663754.

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the matrix being enhanced by the presence of fractures (Price et al., 1982). Groundwater flowing in these sandstone aquifers has played an important role in the development of several major UK cities (e.g. Birmingham, Nottingham, Liverpool and Belfast) through supplying water for industrial and potable use. However, recharge sources and pathways in many such sandstone aquifers remain poorly resolved and are the subject of active research (e.g. Cronin et al., 2003; Taylor et al., 2003).

In Northern Ireland, the Triassic Sherwood Sandstone Group covers an area of ~150 km^2 and forms the principal aquifer underlying the most populated and industrialised region around Belfast (Manning et al., 1970; Kalin and Roberts, 1997). The vulnerability and potential for mining of this aquifer is already a concern and local licensing of major groundwater abstractions is being considered (Robins, 1996). Clearly, this would require adequate knowledge of the renewable resources within the aquifer unit.

The thickness of the Sherwood Sandstone Group ranges from ~300 to 400 m in the Belfast area, thinning to the SW and dipping generally at about 14° to the NW beneath the Antrim basalts (Manning et al., 1970; Fig. 1). The Lagan Valley (Fig. 1) has little exposed rock and thick Quaternary deposits cover the majority of the area (GSNI, 1997). This complex overburden, together with the presence of dolerite dykes, introduces heterogeneity in hydraulic conductivity. The Sherwood Sandstone Group grades up conformably into a series of overlying low-permeability argillaceous sediments, collectively known as the Mercia Mudstone Group. To the east of the Lagan Valley, the base of the aquifer is underlain by Permian marls, which overlie a minor Permian Sandstone aquifer. East of Belfast the aquifer narrows before widening again into the Enler Valley. Groundwaters from the Enler Valley sandstone are also extensively abstracted and exhibit important differences to the Lagan Valley. These differences are discussed below.

X-ray diffraction analyses and thin section petrography on Sherwood Sandstone samples from the Enler Valley show that the detrital mineralogy is dominated by quartz and feldspar (McKinley et al., 2001), similar to equivalent samples in Great Britain (Edmunds et al., 1982). The sandstones contain a variety of cements including quartz, K-feldspar, dolomite, calcite, iron oxide, clay minerals, hydroxyapatite and hematite (McKinley et al., 2001). A typical mineralogical composition of the Mercia

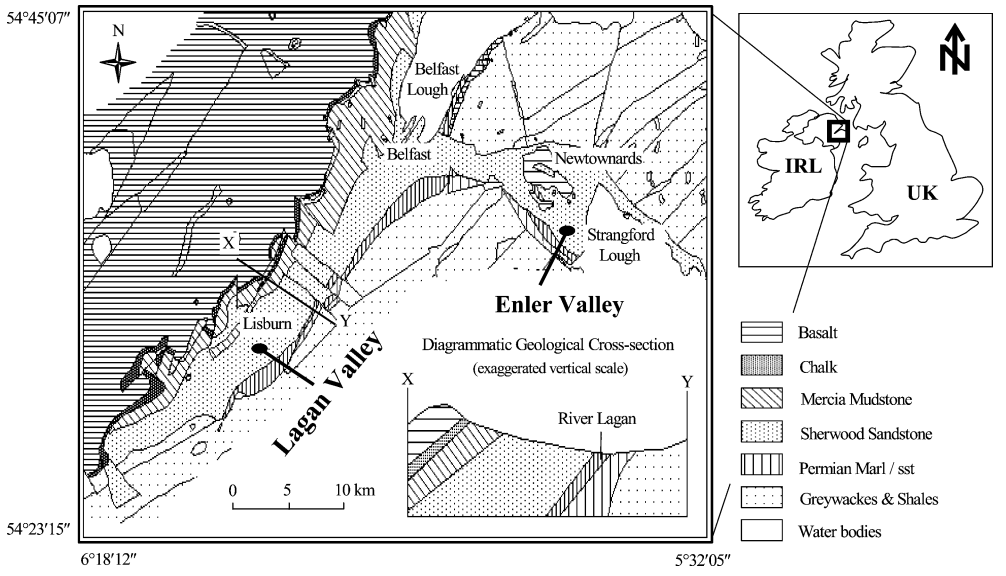

Fig. 1. The study area is shown by the black square in the smaller inset map. The larger map shows the Lagan Valley Permo-Triassic aquifer underlying the Belfast region, Northern Ireland (after GSNI, 1997).