

## **200 years of hydrogeology - Abstracts**

### **The hydrogeological work of William Smith (1769-1839)**

*Hugh Torrens*

Smith's Order of Strata shows that by 1799 he had a keen awareness of the importance of groundwater and how such water was released at stratigraphically controlled spring lines. This paper considers five of his water-related activities. The first was as canal engineer where one of the two branches of his first canal had to be abandoned because it could not be made to retain water as it passed over the Dolomitic Conglomerate. The next was as a water drainer which he first attempted in about 1795. Third, Smith was a significant exponent of the art of creating water meadows. Fourth, Smith was active in erecting sea defences along the east coast of England. Finally he was consulted on how to develop new water supplies.

### **Dr John Snow and an early investigation of groundwater pollution**

*Michael Price*

John Snow was a physician whose studies of the way in which cholera is spread have long attracted the interest of hydrogeologists. His investigation into the epidemiology of the outbreak around the pump in Broad Street Soho, in 1854, represents one of the first, if not the first, study of an incident of groundwater pollution in Britain. At the time of this outbreak Snow was continuing his practice as a physician and anaesthetist. His casebooks for 1854 do not even mention cholera. Yet, nearly 150 years later, he is as well known in medical circles for his work on cholera as for his pioneering work on anaesthesia, and his discoveries are still the subject of controversy.

### **William Whitaker (1836-1925) - father of English hydrogeology?**

*William George*

Whitaker was on the staff of the Geological Survey from 1857 until his retirement in 1896 when he left to work in private practice as a water engineer. For nearly sixty years he meticulously accumulated and published detailed records of wells and borings. Whitaker was described, in a recent history of the Survey published in 1985, as being undoubtedly the father of English hydrogeology. A more recent and considered review describes his contribution as being merely "worthy". This paper details Whitaker's life work and reassesses his contribution to English hydrogeology.

### **Joseph Lucas (1846-1926) - Victorian polymath and a key figure in the development of British hydrogeology**

*John Mather*

Lucas joined the Geological Survey in 1867 and spent almost 9 years mapping in Yorkshire. Forced to resign in ignominious circumstances, for the rest of his life he earned his living advising on groundwater resources. In 1874 he was the first to use the term hydrogeology in its modern context and defined this new subject in a series of papers in the 1870s. He drew the first British maps showing groundwater contours and described how to carry out a hydrogeological survey. He was an accomplished linguist translating material from a variety of European languages and wrote books on natural history and genealogy.

### **19th Century studies of the hydrogeology of the Permo-Triassic of Lancashire and Cheshire**

*John Tellam*

In the middle and latter stages of the nineteenth century, amateur hydrogeology researchers existed across the country. An example is Isaac Roberts, who was particularly active in the Liverpool Geological Society. Roberts' works of the 1860s and 70s demonstrated a sound grasp of many hydrogeological concepts, including permeability, specific yield, seawater intrusion, recharge, and the effects of faulting on flow. He discovered that flow rates were proportional to pressure differences across blocks of Triassic sandstone, completely unaware of Darcy's work, and undertook what must have been one of the first ever column breakthrough experiments in his investigations of seawater intrusion. This presentation will describe the contributions of Roberts and his contemporaries in the Liverpool/Manchester area.

### **Robert Stephenson (1803-59) - The first groundwater engineer**

*Martin Preene*

By any reasonable measure Robert Stephenson was one of the foremost civil and mechanical engineers of his time. What is not so well known is that he developed considerable expertise in the practical management of groundwater, both as a source of supply and as an obstacle to construction works. Stephenson's empirical approach to groundwater was first shaped by the years spent battling water-bearing quicksands during construction of the Kilsby Tunnel near Rugby. Later in his career he advised on water supplies from the Chalk in London and the Sherwood Sandstone in Liverpool. Stephenson's work pre-dates the theories of Darcy, yet his practical observational approach allowed development of groundwater sources in a rational way that would still be familiar to modern practitioners.

### **"Making water": the hydrogeological adventures of Britain's early mining engineers**

*Paul Younger*

The earliest technical descriptions of British mining practices (which date from the late 17th and early 18th Centuries) dedicate many paragraphs to the problems posed by the unwanted ingress of groundwater into underground workings. While the main preoccupations of the early mining engineers were utterly practical, they also speculated on the nature and origins of underground waters identifying issues which remain current to the present day. These include the role of fractures as groundwater pathways, heterogeneities in groundwater quality and discrimination between head-dependent and head-independent sources of water entering pumped voids. So successful were these early mining engineers that they bequeathed the technological basis for the development of large scale public supply abstractions from about 1820 onwards.

### **The contribution of British military geologists and engineers to the development of groundwater**

*Ted Rose*

During the nineteenth century, the British military pioneered initiatives in geological mapping and teaching, and in the operational use of Norton tube wells. During the First World War, the British army appointed its first military hydrogeologist to site boreholes and develop water-supplies in Belgium and northern France. Groundwater was extracted from deep boreholes in the Chalk and fine-grained Tertiary sands and, in coastal regions, by [drive] tube wells emplaced in the Quaternary cover. During the Second World War, British military well-drilling units were deployed more widely, notably in East and North Africa as well as Northern France. A reduced hydrogeological and well-drilling capability has been retained by the British army through the Cold War to the present day.

### **The development of groundwater in the UK between 1935 and 1965 - the role of the Geological Survey of Great Britain**

*Dick Downing*

After the drought of 1933-34 the Geological Survey became responsible, under the Inland Water Survey, for collecting and collating data on groundwater. In 1935 a Water Unit was formed for this purpose. Following the Water Act of 1945, the Survey advised the Government on aspects of the Act relating to groundwater. The act led to the introduction of quantitative hydrogeology in England and Wales. The groundwater resources of the main aquifers were assessed, well hydraulic theory was applied to British aquifers and geophysical techniques and new instrumentation introduced.

### **Exploiting groundwater - evidence from the BGS National Well Record Archive**

*Andrew Mackenzie*

The British Geological Survey is the curator of the National well Record Archive, a collection of data on over 100,000 water wells and boreholes. The data in the archive have been compiled from a wide variety of sources; from survey mapping, from systematic inventories, and, in recent decades, from statutory returns on water well drilling. Data in the collection began to be systematically collected in the 1870s, but much relates to earlier groundwater development. The data, now digitally indexed, have been used to explore spatial patterns of groundwater development, demonstrating linkages with industrial and technological development, and show how hydrogeological understanding has influenced the patterns of groundwater exploitation.

### **Bath thermal waters: 400 years in the evolution of ideas in hydrogeochemistry and hydrogeology**

*Mike Edmunds*

Fascination with mineral and thermal waters in Britain is evident from the earliest recorded history and this curiosity, notably at Bath, has driven the advancement of medical and scientific ideas since the late 16th century. Theories were developed on the source of heat and the curative properties of natural waters; early drilling and mine engineering around Bath led to early foundations of modern hydrogeology. For the past 150 years Bath has been, and still is, the test-bed for new chemical, radiochemical and isotopic analysis in the resolution of geothermometry, water-rock interaction, deep groundwater circulation and residence times.

### **Chalybeate springs near Tunbridge: site of a seventeenth-century New Town**

*John Fuller*

Among Wealden towns Tunbridge Wells is comparatively new. Before the Civil Wars of the 1640s there was no village here, nor any name on a map. Chance finding of chalybeate springs a few miles south of Tunbridge attracted attention at court and even gynaecological interest. Verifiable facts indicate that Thomas Neale (1641-1699) was the main agent in organising the nascent resort's amenities, beginning in 1676 with plans to construct a chapel or assembly room. The springs themselves issue from Lower Cretaceous Wealden beds, a few feet above the Wadhurst Clay, in a shallow valley formed by the headwaters of the River Grom. Siderite (iron carbonate or chalybite) abounds in these formations, and was the ore-material for the Wealden iron industry.

### **British hydrogeologists in North Africa and the Middle East - an historical perspective**

*John Lloyd*

Between the two world wars some limited British interest was taken in geological and hydrogeological aspects of Palestine and the western desert of Egypt. A more groundwater-

targeted approach, with shallow well drilling, occurred in North Africa and through into Jordan during the military campaigns of the second world war. After the war and the creation of Israel the main British interest concentrated upon the groundwater resources of Jordan. In the Arabian peninsula groundwater exploration only really commenced in the mid-1970's with British consultants extensively involved in the Gulf States and Saudi Arabia. In the 1980's, and subsequently, major groundwater studies have been carried out by British consulting firms in Libya and Algeria, with work still continuing in Libya.

### **British hydrogeologists in West Africa - an historical evaluation of their role and contribution**

*Robin Hazel*

The Colonial Office established and funded geological surveys in British West African colonies, from c.1908 until self government in c.1960. Provision of water supplies, at first a minor component of the services provided, later often dominated departmental activities. Understanding of the nature of groundwater mirrored the state of the art elsewhere; supply kept pace with demand. Exploration of sedimentary basins led to development of major aquifers. In the thirties innovative refinements of geophysical siting and well sinking techniques were developed. From 1980 major water borehole programmes were largely supervised by British consultants, who continued to pioneer siting and construction techniques.

### **"Hair singed off by the fires of Hell" - the development of groundwater tracing in Britain**

*Tim Atkinson*

The earliest recorded groundwater tracer test was in the time of Alexander the Great, who is said to have used horse carcasses to demonstrate the course of an underground river in Asia. The first scientific attempt at water tracing in Britain was at Malham in Yorkshire in the early eighteenth century, but real advances did not follow until the development of analytical and industrial chemistry in the nineteenth century. Salt, fluorescein dye and bacterial tracers were all introduced prior to the First World War. Methodological developments in the 20th century include various inert particulate tracers, radioactive and stable isotopes, bacteriophage, further fluorescent dyes, and dissolved gases.

### **Recollections of a golden age; the groundwater schemes of Southern Water 1970-1990**

*Howard Headworth*

The creation of the river authorities and Water Resources Board in 1965 and the water authorities, Water Research Centre and Central Water Planning Unit in 1974 led to an explosion of groundwater investigation and development in England and Wales. In Southern's region, from the Hastings Beds of the Wealden Series to the beach gravels at Dungeness, a dozen or so schemes were carried out to investigate and develop aquifers and manage their groundwater resources. Six schemes are described here, including artificial recharge in Sussex, groundwater augmentation in Hampshire and the assessment of saline contamination from minewater disposal in East Kent.

### **Developments since 1974 - bringing the story up to date**

*Rick Brassington*

The last quarter of the twentieth century saw a marked increase in the numbers of hydrogeologists, a broadening of the spheres in which they are employed and an increasing ability to collect, process and interpret field data to understand groundwater systems on a routine basis. The four main influences that brought about these developments were changes in the structure of the UK water industry; influences of EC directives on UK environmental

regulation; a growing public awareness of environmental issues and pressure on successive governments; and developments in computing power, software development and electronic instrumentation. The paper will explore these influences on the development of hydrogeology over this recent period