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The hydrogeologist in the environment

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Groundwater is that portion of water held in rock strata beneath the earth's surface which can be gained from boreholes or springs. Strata yielding water in usable quantities are referred to as aquifers; these are usually bounded by clays and marls which inhibit water movement underground. Statistics show that whereas about 95 per cent of the earth's water supply is contained in the oceans and roughly 4 per cent is bound in glaciers, icebergs and biomass, the next largest percentage of around 0.6 per cent occurs as groundwater and accounted for between 20 and 30 times more water than lakes or rivers.

Two controls act on the amount of water held in strata:

a. the climate regulates the amount gained by precipitation and that lost by evaporation and,

b. the geology of the region dictates how much water is retained.

Within the United Kingdom, the positions of major aquifers reflect the geology of the regions. Aquifers are mainly found in the sands and silts of the Crag region of East Anglia, the band of chalk in southern England, the sands of the Kent and Sussex Weald, Jurassic limestones of Central England and the Cotswolds and the underlying Permo-Triassic sandstones of South Wales and Devon, as well as the older Carboniferous limestone strata of South Wales and the Pennines, and the Magnesian Limestone of Durham.

Groundwater is, therefore, readily available over much of the United Kingdom. Large companies such as the Central Electricity Generating Board and Health Authorities have found it to be economic in certain circumstances to sink their own boreholes to recover water at an average cost of less than 1 pence per 1,000 gallons against the Water Authorities' average charge of £1 for the same quantity.

Hydrogeological consultants are thus contracted by such companies as well as the Water Authorities. Skilled hydrogeologists maximise the probability of finding water; large diameter boreholes cost up to £20,000 and thus failures can be very expensive.

The hydrogeologist has many techniques available to him. Firstly studies are made of readily available geological information to pinpoint probable areas for successful drilling. Field studies are then carried out. Anomalies in readings of electromagnetic surveying over a wide area pinpoints positions of rock fissures which may contain water. Resistivity surveying, a technique utilising the passing of electric current through the ground between sets of electrodes, identifies underlying strata and can also indicate fault structures. These techniques can be used successfully to indicate optimum drilling positions.

Most of the main aquifers in the UK have been known for over a century. It has been estimated that the amount of water extracted from the chalk in Southern England exceeds rainfall, thus the groundwater level is dropping. However in other parts of the country, such as Merseyside, industry closures have meant less water being extracted from aquifers and groundwater levels are rising. There is concern that should this happen in London also; the London Clay may swell causing subsidence and there is a danger that deeper Underground lines may flood.

Aquifers can be used as a storage medium. In winter surface water can be tapped and excesses pumped into aquifers to be used in the summer.

Recently new EEC standards have been issued covering water quality, and stringent controls have existed in the UK under the Control of

Pollution Act. A licence must be obtained before anything other than water can be discharged into underground strata. However two areas have been causing concern:

1. Tips and land-fill sites may exude pollutants which are carried into aquifers by rainwater infiltration.

2. Increased use of fertilisers increases the amount of nitrates and phosphates that are washed into aquifers.

Hydrogeologists are consulted on prevention of aquifer pollution, and solutions to waste disposal problems. Most water pollution by waste disposal can be controlled and new techniques included lining old quarries to be used as tips with clays. Unfortunately, the nitrate problem may already be larger than indicated, as rainwater moves through rocks faster than the nitrates it carries, especially in chalk, and thus concentrations of nitrates in water supplies may rise dramatically as the nitrates held in rocks reach saturation point.

Another problem in coastal areas occurs where aquifers pass beneath the sea. If the groundwater sinks below sea level, saline water may then migrate to pollute the aquifer.

The largest amount of work undertaken by hydrogeologists is overseas, especially in the Middle East and Third World countries. Local expertise in these regions is usually low and work for the consultants falls into three categories:

1. Rural groundwater schemes, particularly in drought-smitten areas of Africa.

2. Major schemes for towns, mining and other industrial enterprises.

3. Middle Eastern surveying of overall water resources.

The same techniques of water divining as discussed previously are still appropriate. The author showed slides of work in Zimbabwe, where the underlying rocks are Precambrian granites and gneisses which provide a soil of highly weathered granite called the 'regolith'. The deeper the regolith, the more chance of finding water reserves contained within it; such areas are found by resistivity surveying. Where the regolith is thin, electromagnetic surveying is used to try to find fissures in the granite basement rocks.

In a desert region of northwestern Pakistan, a copper mine is being developed in andesitic volcanic rocks. Large quantities of water are needed for the mining and industrial processes. Resistivity surveying showed that the occurrence of fissures in the andesites were too low and nearby alluvial gravels yielded water of an extremely high salinity. However, a region between two mountain ridges provided groundwater at depth, and test boreholes provided evidence that there was sufficient water of usable quality that would far outlive the life of the mine.

At Abu Dhabi in the Middle East, consultants have water drilling rigs based on the Shell oil well type and these are sunk to a depth of 1000 m or so. In this area water is considered a finite resource and is mined as such.

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