

Nottingham Trent Geohazards Group Professorial Lectures

Edited by Mike Rosenbaum

The delivery of an Inaugural Lecture by a newly appointed incumbent is a long standing tradition for those awarded a Chair in a British university. Nottingham Trent has upheld this tradition through its Professorial Lecture series, publishing those delivered in the period 1989-1996 as a compendium entitled 'Thinkers and Shapers in the Modern University' (Watson, 1997).

There has never been a Geology Department as such in the University or its predecessors. Nevertheless interest in the ground has been encouraged, particularly the issues facing the built environment. The ground-related research has been led by the Geohazards Group. This has helped maintain a vibrant and active research culture, enhancing the University's distinctiveness and quality through the appointment of professors, four of whom have joined in the past three years. Each has delivered an Inaugural Lecture, so providing an insight to the range of geohazards that affect our society - Mike Rosenbaum on 24th May 1999, Ian Smalley on 11th October 1999, Martin Culshaw on 30th January 2001 and David Butcher on 1st March 2001.

The Geohazards Group

Geohazards are a danger, or source of danger, arising from the ground conditions. They may be a danger to mankind, may damage the environment or may cause excessive cost and disruption. They may cause ground failure, often precipitated by human activity. Their study requires expertise in the key areas of geotechnical engineering, engineering geology, hydrogeology, risk management and planning. The Geohazards Group at the Nottingham Trent University is investigating the reactions of the ground to natural and manmade processes, and their engineering implications relating the outcomes to the user community. In most instances these require attention to be concentrated on near surface processes rather than on the deep rock profile. This involves quantification of the processes rather than classification of their products.

Four foci of activity have developed within the Geohazards Group:

a. Ground Engineering - investigating new technologies appropriate to sustainable development and remediation strategies for earthworks, slope instability and foundation engineering.

b. Ground Investigation - developing the identification of geohazards and assessment of their impact on land value, residential development and

use of derelict land, and developing spatial analysis techniques and decision support systems appropriate to the evaluation of ground performance in the built environment.

c. Geo-environmental Management - furthering our understanding of the natural environment with particular emphasis upon the management of current issues, notably wetland restoration, pollution travel times, reservoir sedimentation and sediment controls on catchments.

d. Public Policy and Awareness - raising professional consciousness and developing a general public awareness of ground engineering science in relation to the built environment, dealing with social applications and the outcomes for society, and thus with policy. The focus is investigating how the ground has been recognised and depicted through history, in the geological map, and how ground has been perceived through statutory processes.

The Geohazards Group has its own web site at: construction.ntu.ac.uk/graduate_school/Research

Professor Mike Rosenbaum - The ground beneath our feet: geohazards in the built environment

Geologically active processes, leading to volcanism and rapid crustal movement, have obvious consequences for those who live in the vicinity, but such a model enables the geologically-related hazards to be recognised and the consequent risks assessed across the globe. Remote from a modern plate boundary, the heat and stress effects of former zones of plate collision have become locked into the rock fabric. With unloading and reduction of temperature, rock materials become brittle, and with loss of confinement they expand leading to cracking, effects exaggerated by ice. Man's activities can change the rock condition still further. Conceptual models are developed to help our understanding of how the ground might influence site behaviour.

Geohazards are adverse events arising from processes acting within the ground. Causes are of scientific interest, but it is the consequences which are of greatest concern to the public. Current attitudes for dealing with hazards are discussed in the context of dealing with consequence as well as dealing with cause. The properties of the geological profile and the processes operating within it determine where and when an adverse combination of circumstances might become linked together, quite possibly induced by human action, so bringing about an imbalance that triggers failure. Taking into

account the likelihood of geohazards occurring, together with an assessment of the vulnerability of people, property and environment in the vicinity, provides support for decisions as to what should be done to mitigate the consequences. As important is the need to enhance public perception, increasing education, awareness and information.

Man's activities must next be considered alongside natural geological processes to investigate whether these might change the stress state still further. Additional energy release will lead to rebound, cracking and raveling. But how much will occur, and how deep will it extend? The ground can, and has been, changed for the benefit of Man: changing the shape of the surface, decreasing settlement by reaching down to less compressible layers, or increasing the ground's ability to carry load by spreading the foundations or taking them deeper. Around Nottingham there are the consequences of mining in rock, from coal, gypsum, limestone and sandstone, the 'caves' in the latter having been comprehensively described by Tony Waltham (1996), with direct effects on the built environment. Water exerts an important influence, weakening the rock in the roof, walls and pillars.

There are weak rocks elsewhere too, such as the Chalk, a soluble rock that develops karst, along with its natural cavities, and also contains mines, which are often forgotten over time. An example is from Pinner in North London. This mine was only detected when a depression developed in a footpath, but clues as to the presence of a former mine were in the form of chalk fill on terrain where chalk does not outcrop at the surface, and the occurrence of

London & Birmingham Railway sleepers indicating a very old rail link to the former workings. Such cavities can have seriously adverse effects on the built environment, as on the reduced load bearing capacity of piles driven into a similar old mine in Norwich (Fig. 1).

The ground is significantly affected by the climate. The first lectures as to how geology influences engineering behaviour were given by Herbert Lapworth at Imperial College, whose similar presentations to the Institution of Civil Engineers were later published. However, the relationship between geology and engineering was already well established, notably helped by William Smith, the canal engineer who produced the first comprehensive map of the geology of England and Wales in 1815, giving a framework for understanding the likely ground conditions at any given location.

The climate not only physically alters the rock but chemically alters it too, leading to weathering, the importance of which is to progressively rot the ground from exposed surfaces (from the ground surface itself or from the surfaces of fractures), thereby weakening the ground. However, these processes also enable new substances to grow, even in contact with artificial materials such as the growth of silica gel as the result of alkali silica reaction concrete between aggregate and cement which has even led to building collapse.

The keys to tackling ground-related hazards lie with understanding the processes, and effectively communicating their consequences. The processes may be considered in terms of those that occur naturally and those that are due to the influence of Man. The natural geological processes may be considered in terms of:

- active processes, that could make the ground unstable
- dormant processes, that might be re-activated (notably those active during the Quaternary)
- fossil processes, which have left the ground in an unstable condition.

The natural geological processes of greatest concern to engineering are essentially those that are active or have been active during the Quaternary. Processes respond to change, leading to reactions to restore a state of equilibrium. Most engineering works in the built environment thus need to incorporate a consideration of the geological profile, tempered with anthropogenic stratigraphy and identification of active processes, to fully appreciate the potential geohazards.

Biographical Note

Professor Rosenbaum has been involved with engineering geology for most of his career. Having studied at Imperial College, he started work at Soil Mechanics Ltd (first in Site Investigation and then in the Foundations Division), learning on site about how engineering is influenced by

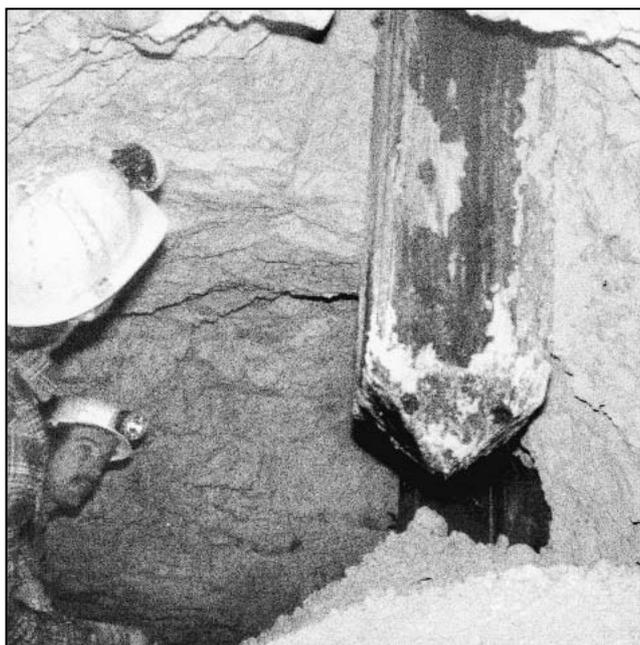


Figure 1. A driven pile loses all its end-bearing load capacity when it breaks through the roof of an old chalk mine in Norwich.

the ground, including a spirited discussion about whether or not solifluction had affected a 7° hillslope in London Clay – this started to move when the new motorway was being constructed, conclusively proving the point! He then returned to Imperial College, to pursue research for his PhD concerning the ‘laboratory simulation of burial diagenesis of sediments’, before taking up an academic appointment in engineering geology, still at Imperial College. Mike Rosenbaum is now Professor in Geological Engineering at the Nottingham Trent University and Head of the Geohazards Group.

Professor Ian Smalley - Loess: the yellow earth

What have the following in common: Buckingham Palace; the collapse of the Teton Dam in Idaho in 1976; the origins of the Chinese civilisation; the ‘dustbowl’ of the 1930s in middle America; the economy of New Zealand; and the great 1920 earthquake in Gansu Province, China? The common factor is loess, a yellow soil or sediment that is essentially silt sized (20-60 µm) and deposited by the wind. It used to be said that everybody who had survived a high school geography course knew three things about loess: it was yellow, it was deposited by the wind and it was found in China (Fig. 2).

Loess grows good crops (Iowa is virtually covered in loess) and makes good bricks. Buckingham Palace is made of bricks from the loess deposits in North Kent. The locals call it brickearth, but it is true loess. The 90 m high Teton Dam in Idaho was made of loess, which is not good dam construction material, and the dam failed as the reservoir was being filled. The Chinese civilisation, the only one of the ancient civilisations to survive until today, developed in the loess lands of northern China. Loess suits simple agriculture, and 4000 years ago the loess lands were wetter than now and grew good crops. The loess, having blown into position, can blow away again and this is what happened across the Mid-West USA in the 1930s. Desperately dry conditions and less than perfect farming practices allowed the surface of some of the valuable land to blow away; luckily much remained, as a major national resource. New Zealand has loess and rain in abundance, and as a result it grows sheep and grapes and trees and survives in a difficult trading world. The great 1920 earthquake in Gansu mobilised the loess ground into huge flowslide movements; the total area in motion was about the size of Ireland. Many thousands of people, who lived in the easily excavated caves in the loess, were killed. In terms of loss of life, it was the worst natural disaster ever to occur.

We need to look at two beginnings of the loess story, an ancient beginning and a comparatively recent beginning. The ancient Chinese were well aware of the loess and its remarkable properties. They observed the Yellow River with its huge suspended load of loessic material (about 40% solids), and noted the vertical features and cemented

nature of the material. The Yellow Earth (huang ta) was important, and indeed yellow became the Imperial colour. But there is no record of ancient landform science; the Chinese were astronomers and engineers, but not, apparently, geomorphologists. The poets took note of the material. In the Imperial capital at Chang-an, the Tang poets of the 8th century wrote often of dust, which was everywhere.

The recent beginning takes place in Heidelberg, around 1830. Karl Caesar von Leonhard named the material Loess. This was a great scientific leap; once the material was named, its nature, and mode of formation, could be investigated. An interesting coincidence occurred at this point: Charles Lyell, who was then engaged in writing one of the seminal works in the earth sciences *The Principles of Geology*, set out for a honeymoon trip down the Rhine. He met von Leonhard in Heidelberg, was shown the loess, and was so impressed by it that he included a loess section in Volume 3 of the *Principles*. The Lyell book proved to be a huge success and its wide distribution meant that news of loess spread around the world. The ‘loess problem’ for 19th century scholars was ‘how was the material deposited’ and a range of opinions was proffered.

By 1880, a theory of loess deposition was well in place. Baron Ferdinand von Richthofen had successfully promoted the idea that loess material was transported by aeolian mechanisms, i.e. that the wind blew the loess into place. This theory was soon widely accepted, particularly in North America.

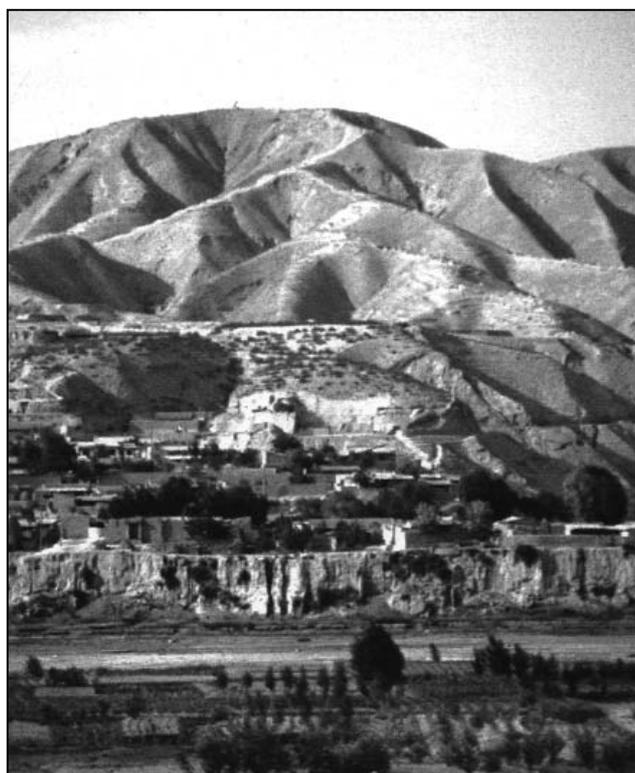


Figure 2. Gullied slopes in thick loess in the Yellow River basin near Lanzhou, central China.

There is only one major maverick diversion that needs to be identified: L.S. Berg, in the early days of the Soviet Union, promoted the idea that loess formed in situ by a sort of 'loessification' process. He especially denied any validity to the aeolian hypothesis. The Berg hypothesis can now be seen to derive directly from the basic soil forming ideas formulated by V.V. Dokuchaev in the late 19th century. The in situ theory was a truly Russian theory, and in the chauvinistic days of the early Soviet state was inevitably accepted. As might be expected in the hierarchical structure of Soviet science, a theory, once accepted, became very difficult to adjust and correct. The Berg theory, operating between about 1920 and 1960, was echoed by R.J. Russell in Louisiana in the mid-1940s, but he was probably the only influential western supporter.

Today we recognise that those particles in finer-grained detrital sediments are usually composed of quartz. Most particles fall into two size grades: sand (2 mm-62 μm) and silt (62 μm -2 μm). These size gradings conceal important processes, since there are geological controls on both the sand and the silt populations of quartz.

Sand nature is largely controlled by geochemical reactions, for example in cooling granite from which it is eventually released by weathering action. The quartz is among the last part of the rock system to solidify and the eutectic-like reaction which occurs ensures that the quartz exists as small crystalline units, each suffering cooling and recrystallisation stresses on a significant scale.

Silt production

Silt is broken quartz, and has traditionally been considered to lack a specific geological control. The situation is confused by the large range of materials that fall into the size category, but there do seem to be distinguishable modes and possibly comminution limits within the 60 μm span. The controls operating in this size range are probably the critical concentration of 'Moss defects' in the quartz particles. Moss postulated the formation of specific crystal defects in the quartz that formed in granites. These affect sand formation, and it is possible that they also control the modal size of silt particles. Within the silt range there may be several usefully definable populations, as Moss proposed for sand. The Quaternary appears to be a silt-rich period due to tectonic and glacial activity, but silt production is apparent throughout the sedimentary record. Very long-term silt producing processes are required.

To produce silt in nature on a large scale, very energetic processes are required. Many processes that are believed to generate silt particles have been listed. However, large-scale production is essentially due to glacial grinding, or to intense weathering processes in high, cold, tectonically active mountain

regions. The heart of High Asia is a major generator of silt particles. These form the productive alluvial soils of northern India, most of Bangladesh, the loess deposits of the Syr-darya and Amu-darya rivers in Central Asia, and the great loess deposits of North China. Some claims have been made for silt production in hot deserts. Large amounts of very fine aerosolic dust are produced, but in terms of loess-sized particles this is a small-scale process and leads to modest, disputed deposits. The loess deposits around the Sahara usually have smaller mode sizes (in Nigeria) or larger mode sizes (in Libya and Tunisia) than the true Chinese mode at 25 μm .

The silt particles were formed by late Tertiary and Quaternary processes, and reflect the expenditure of a considerable amount of geo-energy. Deposits of loess underlie much of the most productive agricultural land in the world, and suffer the worst erosion problems. Silt also presents a series of conventional geotechnical problems. For example, it has the ability to form very open, metastable structures that collapse when loaded and wetted, thus causing continued foundation problems. The steep slopes in the loess of northwestern China are vulnerable to landslide failure, and these slides may become very destructive flowslides, resulting in large loss of life and infrastructure. The Teton dam, on the Teton River, above Rexburg, Idaho, failed in 1976 largely because it was built of silt, a material not well understood by engineers. Sowers (1993) has described the Teton Dam collapse as the worst civil engineering construction failure of the 20th century, not because it did vast damage or caused large loss of life (it did not) but because of the loss of confidence it caused in the civil engineering profession (Fig. 3).

Loess consists essentially of silt-sized (typically 20-30 μm) primary quartz particles that form as a result of high energy earth-surface processes such as glacial grinding or cold climate weathering. These particles are transported from their source by great rivers - notably from the tectonically active mountains of the Himalayan and Alpine ranges by the Huang He, Danube and Rhine. Subsequent flooding of these rivers allows the quartz silt particles to be deposited on flood plains. On drying out, these particles are detached and transported by the prevailing winds until deposition leeward at distances ranging from tens to thousands of kilometres. This process has resulted in the almost continuous deposit of loess from the North China plain to southeastern England. The major loess deposits underlie highly populated areas and major infrastructure links, and are prone to collapse and ground subsidence. The areas of most widespread concern are concentrated in Eastern Europe and Russia and to a growing extent in China (Derbyshire *et al.* 1995a), although serious problems of potential collapse exist wherever loess is found.

Figure 3. Failure of the Teton Falls Dam in Idaho, USA. The face of the loess dam is on the right, with the rock canyon wall on the left. The core of the dam has just totally collapsed into the piping cavity that had progressively enlarged along the original line of seepage through the permeable loess. (With thanks to the unknown photographer)



Metastability and subsidence

The particles that make up loess, although principally of quartz, consist also of feldspars and micas. Clay-sized particles within the loess structure consist of quartz, feldspar, carbonates and some true clay minerals. This compositional picture is complicated further by differences in (particularly the mineralogy of) the clay-sized fraction in loess and palaeosols, both between different climatic regions and between loess units and buried palaeosol horizons within the same climate environment. These differences are a fundamental cause of variation in metastability, and hence the potential collapse that may result after a loess soil is loaded and/or wetted. In addition, the primary quartz particles are irregular in shape (Rogers and Smalley, 1993). As a result of their genesis and constitution, loess deposits form remarkably open structures with the interstitial clay-sized particles congregating at the quartz particle contacts. This open structure is maintained by a process of bonding, the strength of which increases with time.

Natural loess typically has an open structure with a voids ratio of 0.8-1.0 or more, and is found in three main forms: sandy-, silty- or clayey- loess. The primary quartz particles are held in this condition by bonding, the nature of which is variously attributed by researchers world-wide. It has been shown (Jefferson and Smalley 1995) that loess has a bond-weight ratio of approximately unity, making the bonding a crucial element of natural loess behaviour.

Bonds break down progressively as increased stresses are applied at the natural water content, but more importantly the structure undergoes immediate and considerable collapse (up to about 15%) if saturated. The structure is therefore metastable in its natural condition. Such collapse has resulted in catastrophic failures that, in some cases, have caused considerable loss of life.

Although this bonding can maintain a relatively open (i.e. high voids ratio) structure underneath considerable thicknesses of overburden (e.g. the upper 10 to 38 m Malan loess of the 400 m thick sequence in China), it is still metastable and the structure will collapse under conditions of additional loading and/or wetting (Derbyshire *et al.* 1995b). It is this metastability that results in the most widespread and costly problem of engineering geology of loess: hydroconsolidation subsidence. The impacts of this process are enormous on infrastructure, urban and rural developments in China (which is the fastest growing construction market in the world) and Eastern Europe, and pose considerable problems in all other countries where loess is found. In one small district of Lanzhou in China, 101 out of the 168 buildings have been damaged or destroyed as result of loess hydroconsolidation in the last 10 years. In Britain, engineers face this problem on the loess up to 8 m thick in Essex and on similar deposits elsewhere in the south of England (Dibben *et al.* 1998).

Clearly, a treatment process is required that can safeguard any structures built on these deposits - which include possible radioactive waste repositories constructed in the loess of northern Bulgaria. Before a safe, effective and economical technique can be established, it is vital that the mechanisms of loess metastability and subsequent collapse potential are fully understood.

Biographical Note

Professor Smalley took his PhD at City University, London, on packing and cohesion in particulate sediments and soils, whilst a lecturer in chemistry. He subsequently held academic posts at Leeds, Leicester and Loughborough, at City University of New York in the USA and at the University of Waterloo in Canada, and for 5 years was a research scientist at the New Zealand Soil

Bureau. He has held numerous senior posts in national and international learned societies, and is currently President of the INQUA Loess Commission. Perhaps Ian's most famous contribution to our understanding of the ground has been his realisation (reported in *Nature* in the mid 1960s) that Britain was sinking in the southeast, but rising in the northwest, due to isostatic recovery following the melting of the great Pleistocene ice sheets. Ian Smalley is now Visiting Professor in Quaternary Engineering Geomorphology at the Nottingham Trent University.

Professor Martin Culshaw - From dig-it-all to digital: the rise and fall and rise again of the geological map

Topographic maps provide a scaled-down *representation* of (usually) part of the earth's surface whereas the geological map is an *interpretation* of what is in the Earth. The lecture described how geological maps were first produced to help the exploitation of minerals and assist engineers in construction. However, once Geological Surveys began systematic national geological mapping and geology became an academic subject in our universities, the practical origins of the geological map were somewhat forgotten. For almost 150 years geological maps were interpretations by geologists, for geologists. Only in the last 30 years, or so, have geological maps begun to return to their practical roots. This period has seen an explosion in the types of geological maps produced and the range of users. The increased power of desktop computers and the continuing development of software that allows map data to be manipulated are now accelerating this process. Examples of some of the new digital maps that provide information for a variety of uses were presented using the *MapInfo* software on a laptop PC.

Geological maps were created for essentially practical purposes but then became, to some extent, an end in themselves. Only as the user became more demanding, in the latter part of the 20th century, did the geological map return to its applied beginnings. With the rapid development of digital technology, the geological map is now on the verge of a new golden age that will reach into the lives of everyone.

A map is like a portrait - it provides a representation of something, the accuracy of which depends on the skill, and the intention, of the creator. Like a portrait, the map can be at a variety of scales, in a variety of styles, and in full colour or in monochrome. Maps of the Earth's surface (topographic maps) are those with which we are most familiar - where the information to create them is almost wholly observable, and the position of each point on the Earth's surface can be measured relative to any other point.

The geological map is different. Unlike a topographic map, which is a scaled down representation of a part of the Earth's surface, the

geological map is a two dimensional representation of a three dimensional object - the ground beneath the surface. Furthermore, only a tiny amount of the subsurface is observable by the geological mapmaker. Consequently, the map is not a representation, but an interpretation of what is in the ground.

The study of the Earth has many aspects to it. Some geologists look at the composition of rocks (petrologists and mineralogists), some are concerned to understand the way life has evolved through examination of the fossil record (palaeontologists), while others seek to classify the rocks in terms of their age and how they came to be where they are today (stratigraphers). It could be argued that these geologists are mainly interested in geology for its own sake, and are less concerned with whether what they do has any practical application. Their work is often described as pure geology, in the sense that it is not influenced by considerations other than the pursuit of knowledge.

Geohazard mapping

Other geologists are more concerned with the relevance of geology to improving people's lives. Such scientists are usually referred to as *applied* geologists. Unfortunately, some 'pure' geologists also see them as being the opposite of pure, by implication being partial, insincere, shallow and corrupted by all the usual influences of society. There may also be the implication that they are somehow less worthy than 'pure' geologists; to put it more simply, they are second-rate!

However, while it is clear that geology is of key importance in wealth creation, it is also very relevant to the improvement of the quality of life. The industrial revolution, which the availability of geological materials helped to fuel, also produced an environmental legacy with which we are only just starting to come to terms. As we move into an era in which future development will have to be increasingly sustainable, so geologists are having to provide society with the information needed to achieve this. Society needs to be assured that our groundwater is safe to drink, that our buildings and infrastructure are safely constructed, that the ground that we use for building, recreation and cultivation is not contaminated and that we do not exacerbate natural geological hazards.

The geological map was a major tool in assisting geologists in the discovery of mineral resources. In Britain, where we have exhausted many of these minerals, the use of the geological map for this purpose has declined. However, our increasing environmental concerns are giving a new impetus to the need to record and present geological information.

Geohazard maps for the insurance industry provide an illustration of the applicability of the geological map. The late 1980s and early 1990s was a period of abnormally low rainfall across many parts

of the UK but particularly in south east England. This area is underlain by a number of stratigraphic units that consist mainly of clay, in particular the London Clay that underlies large parts of London and its hinterland. Clays tend to swell (increase in volume) during wet weather and shrink (reduce in volume) during dry periods. As a result of the prolonged period of dry weather the clays in southeastern England shrank more than usual. The shrinkage was exacerbated by the increased moisture requirement of trees and shrubs during the dry weather. The excess shrinkage of the ground removed support to the foundations of lightweight structures, particularly houses, causing damage to both foundations and super-structure. In the period 1989 to 1991, insurance companies lost around £1.5 billion in paying out claims.

Swelling and shrinkage of clay soils are not the only hazards that cause damage to property and financial loss. Dissolution of gypsum in the Ripon area has caused losses of several million pounds, while the Holbeck Hall landslide on the coast just south of Scarborough destroyed a hotel worth about £2M (Fig. 5). Landsliding at Nefyn, on the north coast of North Wales killed one person, injured another and destroyed two houses on 2nd January 2001. Collapse of abandoned mines has damaged houses in Reading, Newcastle and Edinburgh in the last few months, while long-abandoned mine shafts

are regularly discovered, adding to the cost of development by the need to safely cap them.

These losses led insurance companies to demand an information system that could help them reduce losses by enabling them to set premiums at an appropriate level for the geological hazards found in each part of the country. The principle by which insurance largely operates is that the many pay for the misfortunes of the few. The system is based on the idea of social justice. However, the principles of natural justice suggest that those who are at higher risk should pay more than those at lower risk. Consequently, the premium paid by an individual is based on the exposure to risk of a group of individuals. The problem is to group together individuals so that the premiums paid reflect that level of risk, requiring a system that identifies the degree of susceptibility of geological hazards for defined geographical areas. This was done by using geological data, knowledge and experience to identify the local ground conditions within each postcode sector. Each geohazard could then be analysed separately, and the results of the analysis combined to produce the final ratings, taking into account possible interactions between geohazards.

There is a certain irony that, just when many national geological surveys are completing the stratigraphic mapping of their territories, when there

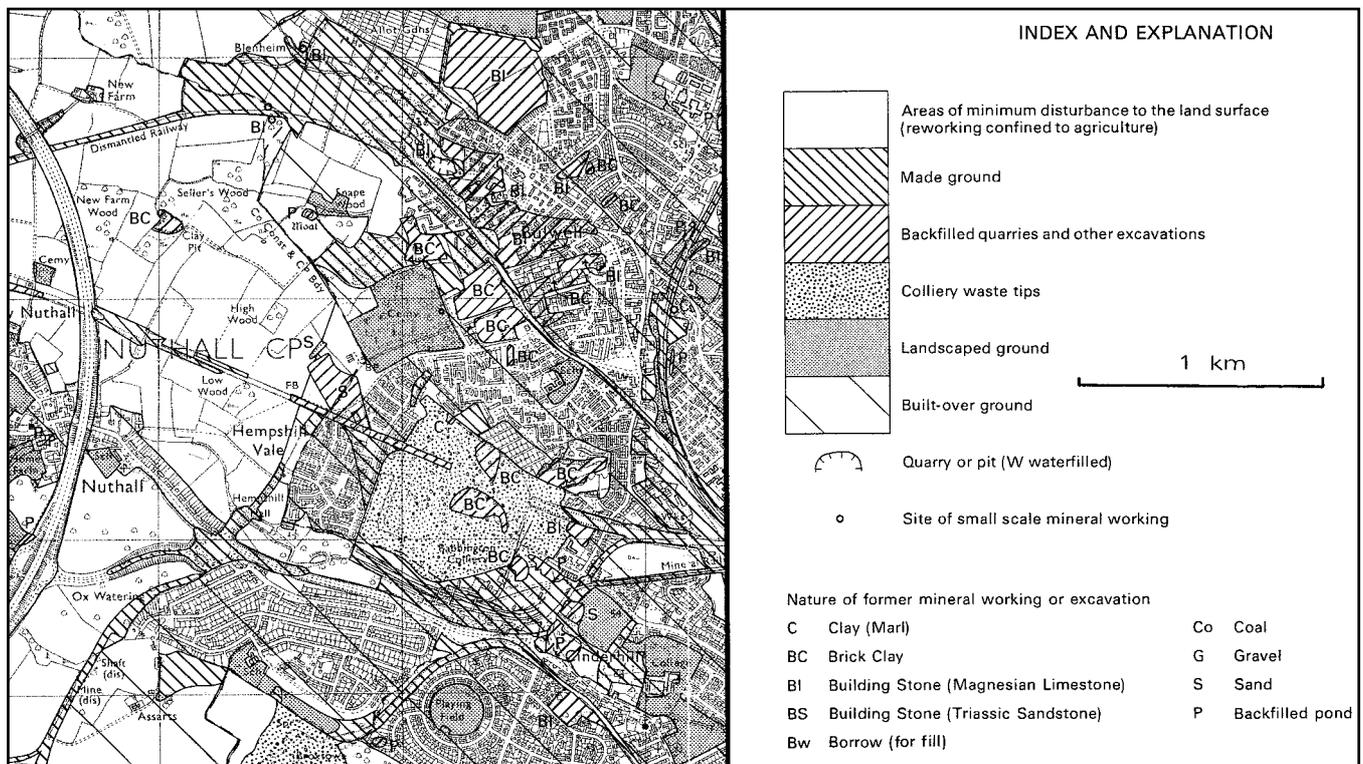


Figure 4. Extract from map 4A, *Distribution of made and disturbed ground*, in the BGS report on the applied geology of the Nottingham area (Charsley *et al*, 1990). This shows the area between Bulwell and the motorway on the west side of Nottingham, with the backfilled quarries in the Permian brick clays and Bulwell Stone and the waste heap from the old Cinderhill colliery.

is a greater awareness than ever of the requirement to meet diverse user needs and when the information technology revolution will enable the former to become easily available to the latter, the relevance of the geological survey as an active and dynamic service organisation is being questioned. It is almost as if the realisation that the paper-based geological map, as we knew it, is an anachronism which has made decision-makers believe that, maybe, the geological survey, too, is outdated. Nothing could be further from the truth.

The realisation that the paper map is the medium and not the message has liberated geological surveys from the so-called 'postage stamp collection' phase of their activity. Instead, a new phase has begun, in which the end is not the map itself but the collection and interpretation of data using the latest methods, models and theories. In other words, we are



Figure 5. Wreckage of the Holbeck Hall Hotel is strewn down the headscar of the landslide that destroyed it at Scarborough in 1993.

returning to the original intention of geological mapping but without the limitations placed upon it by paper sizes and printing technology. Scale is no longer a constraint; detail does not need to be at the same level across the whole country; the types of data collected can be more easily related to the needs of the geological and non-geological user. The geological map is on the brink of a momentous digital revolution similar to the revolution that initiated geological mapping over 200 years ago. William Smith and his contemporaries must be spinning in their graves, not in anger over what has happened to the geological map but in frustration that they can't be a part of it!

Biographical Note

Professor Culshaw's early geological career was inspired by Fred Shotton, while a student at Birmingham. Postgraduate training followed at Leeds, and he then joined the British Geological Survey, progressing to his current position as Manager of the Urban Geoscience and Geological Hazards Programme. He has published over 70 papers and articles, co-authored over 100 technical reports and edited eight conference proceedings, as well as organising meetings and conferences. Although Nottingham doesn't have a university geology department, the East Midlands does have on its doorstep the country's principal custodian of geological knowledge - the BGS. Martin Culshaw is now Visiting Professor in Engineering Geology at the Nottingham Trent University.

Professor David Butcher - The protection of drinking water supplies in Britain

In recent years, considerable concern has been expressed that the existing infrastructure of water supply in Britain may be insufficient to maintain an adequate response to demand. This concern has been primarily related to issues of variation in supply associated with climate change scenarios, but latterly an increasing awareness of two other issues has emerged - the loss of reservoir capacity caused by sedimentation and the disruption of river extraction caused by pollution incidents.

Until recently reservoir sedimentation has not been perceived as a major problem in Britain, and there have been only a limited number of studies into the subject area. However, the cost of replacing lost capacity and the need for greater storage has caused both the government and the water companies to consider rates of capacity loss and the costs of sediment removal. British reservoirs tend to be rather old, on a global scale, and have high capacities relative to their catchment areas; they are therefore very efficient at trapping sediment. Key investigations now being pursued include measurement of the rates of sedimentation, and research into how the sediment may be removed. This is requiring a detailed survey of reservoir floor profiles and sampling of the sediments.



Figure 6. Sediment-rich water released on opening the bottom scour valve at Blakeley Reservoir, Yorkshire

There is also an issue concerning what might happen should a dam fail. The consequent increase in water velocity could cause significant additional erosion, and the dispersion of mud slurry could well cause major difficulties downstream.

River waters already account for over 55% of the potable abstraction in Britain, and are increasingly being utilised to address the escalating demand for water supplies. This brings with it a need for increased awareness about the sources of pollution that may threaten these resources. The duty of the water supply companies for the provision of 'wholesome' water to the consumer's tap is offset with the necessity to maintain the traditional use of river channels for irrigation, waste disposal and recreation.

The increasing pressure on the fluvial environment has led to a steady increase in the number and severity of pollution incidents. Current research focuses on the travel and dispersion of pollution in rivers. Notable is the significance of enhanced surface run-off in urban areas and the increased sediment load of rivers in regions hosting intensive farming practices.

Drinking water is a crucial issue of life or death significance to many people. The issues of its supply are of great importance in Britain, but are of vital importance in countries where water resources are scarce. To address them requires a multi-disciplinary approach, which is being consolidated through the Geohazards Group, addressing the problems caused by reservoir sedimentation, the cost of replacing lost capacity and the need for greater storage of water.



Figure 7. Channel cut through sediments in Wessenden Old Reservoir, Yorkshire, when it was drained for repair works.

Biographical Note

Professor Butcher began his career in Higher Education studying for a BA in Geography and a PGCE at Hull University. David clinched his first position as senior tutor at the Field Studies Council, before moving to Slapton Ley Field Studies Centre as Deputy Director of Studies. He subsequently lectured at Huddersfield Polytechnic, where he also gained his PhD, studying soil water movement, before spending a period at the Peak National Park. David's next career step brought him back to Huddersfield as an academic, and then to the University of Central Lancashire. David Butcher is now Professor in Engineering Hydrology at the Nottingham Trent University, and Head of the newly formed Department of Land-Based Studies, located at its Brackenhurst College Campus in Southwell.

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References

- Charsley, T. J., Rathbone, P. A. and Lowe, D. J., 1990. Nottingham: a geological background for planning and development. *British Geological Survey Technical Report WA/90/1*, 82pp + folder of 16 maps.
- Derbyshire, E., Dijkstra, T.A., Billard, A., Muxart, T., Smalley, I.J. & Li, Y.-J., 1995a. Thresholds in a sensitive landscape: the loess region of Central China. In: Thomas, D.S.G. & Allison, R.J. (Eds.) *Landscape Sensitivity*. Belhaven, London, 97-127.
- Derbyshire, E., Dijkstra, T.A., & Smalley, I.J., 1995b. *Genesis and Properties of Collapsible Soils*. Kluwer, Dordrecht, 424pp. NATO ASI Series.
- Dibben, S.C., Jefferson, I.F. & Smalley, I.J., 1998. The "Loughborough Loess" Monte Carlo model of soil structure. *Computers & Geosciences*, **24**, 345-352.
- Jefferson, I.F. & Smalley, I.J., 1995. *Six definable particle types in engineering soils and their participation in collapse events: proposals and discussions*. In: Derbyshire, E., Dijkstra, T.A., & Smalley, I.J., *Genesis and Properties of Collapsible Soils*. Kluwer, Dordrecht, 19-32. NATO ASI Series.
- Rogers, C.D.F. & Smalley, I.J., 1993. The shape of loess particles. *Naturwissenschaften*, **80**, 461-462.
- Sowers, G.F., 1993. Human factors in civil and geotechnical engineering failures. *Journal of Geotechnical Engineering, ASCE*, **119**, 238-256.
- Waltham, T., 1996. *Sandstone caves of Nottingham*. East Midlands Geological Society, Nottingham, 55pp.
- Watson, A.J., 1997. *Professorial Papers 1984-1996: Thinkers and Shapers in the Modern University*. The Sherwood Press, Nottingham, 309 pp.

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