# Appendix 1

## Edited Abstracts of other oral and poster presentations from the 16th Extractive Industry Geology Conference

held at
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# EDITED ABSTRACTS

## CARBON REDUCTION INITIATIVES FOR THE EXTRACTIVE INDUSTRIES

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Since 2001 the Carbon Trust has been working with the extractive industries to assist organisations identify and implement low carbon solutions. The Trust has worked with aggregates, cement, lime, china clay, sand, bricks and gypsum; delivery solutions as diverse as improving drive systems on conveyor systems; designing turbo systems for dump trucks; running behaviour change programmes; and providing business tools to make it easier to adopt and sustain energy efficient practices.

This paper will review some of the projects and programmes that the Carbon Trust has delivered to the Extractive Industries and suggests that Managing Carbon emissions of extraction and processing operations, along with the emissions associated with product use and disposal, is an increasingly important business function for which many of the answers are already available. These technologies can be applied today as economic solutions and simply need a little renewed commitment from us all to make a step change the sector's carbon performance.

## ASSESSING AND IMPROVING ENERGY AND CARBON PERFORMANCE IN THE MARINE AGGREGATES BUSINESS

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Resource development activities are increasingly being scrutinised by regulators, industry and customers for environmental performance and efficiency. This forces consideration of how sustainable an activity is and where improvements can be realised. Importantly for business, these improvements in environmental performance often lead to economic benefits. The extraction processes associated with marine aggregate dredging including dredging, transit, and discharging result in a range of energy and carbon impacts which are examined and assessed. Processing at the wharf and downstream distribution of aggregates from the wharf are also reviewed. Mitigation of these impacts has been developing over the last few years and currently a series of initiatives including a ship performance analysis, a carbon assessment and a review of dredging and resource management are underway as part of continuous improvement in the sector. The value of the progress to date is estimated, together with a view on development directions for the future.

## ASSESSMENT OF ROCKFALL RISKS ASSOCIATED WITH THE CONTINUED USE OF WHEELED LOADERS TO LOAD OUT BLAST PILES AT HOPE LIMESTONE QUARRY

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This paper presents a case study completed at Hope Limestone Quarry which has assessed the risks associated with the continued use of wheel loaders to load out blast piles compared with the possible use of backhoe excavators. Operational benefit is associated with the use of wheel loaders, given that they can relocate rapidly within the quarry to load out blast pile material from different locations in the quarry, thereby blending limestone with varying chemical compositions required as feed stock mix for cement clinker manufacture. The study has completed a series of detailed analyses to assess the rockfall risk associated with the operation of wheel loaders and backhoe excavators to load out blast piles. This has involved generating and analysing thousands of rockfall trajectories using site specific parameters, assessing residence time of plant in rockfall hazard zones, and rockfall hazard probability and considers the tolerability of risk having regard to HSE documentation and guidance. The paper examines existing control measures and reviews some of the problems encountered with machine selection. The study recognises that health and safety implications of plant selection are of paramount importance rather than operational benefit.

## ROCK AND SOIL SLOPE STABILISATION AND PROTECTION BEST PRACTICE INCLUDING INTERNATIONAL CASE HISTORIES

*D. Gibson*

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This talk, which draws on some world wide experience, covers a wide variety of relevant topics, relating to rock and soil slope stabilisation, with particular reference to the quarrying industry and the 1999 Quarry Regulations including:-

- Inspection and Assessment
- Rock and Soil Slope Stabilisation Best Practice including rock bolting, ground anchors and rock bolting, facings, drainage and pre-split blasting
- Rock and Soil Slope Stabilisation Standards and Guidelines including the new ETAG 027 and Swiss BAFU guidelines
- Rock and Soil Slope Protection Best Practice including drape netting, attenuation meshes, rock fall barriers, landslide barriers and debris flow barriers including the recent A83 Rest and be Thankful landslide barriers
- Rock and Soil Slope Protection System Guidelines
- Methods of Work including risk mitigation, access, drilling plant, equipment, rope access, materials showing recent project work providing illustration
- Design Issues and Testing with reference to British Standards and CIRIA Soil Nailing Guidance
- Project Examples from the UK and Overseas including Rock Fall protection in UK quarries, soil nailing to slopes to maximize reserve exploitation, protection measures in open cast and deep mines in overseas countries such as Namibia and Australia.

## ROCK MASS CHARACTERISATION USING THE COMBINED FRACMAN/ELFEN APPROACH

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This paper demonstrates how the combined use of a discrete fracture network tool (FracMan) and a combined continuum-discrete element tool (ELFEN) has resulted in significant improvements in the understanding of the fundamental mechanisms contributing to rock mass behaviour allowing geotechnical risks to be better understood and managed. This paper gives an overview of a number of case studies using this technique.

FracMan enables the generation of a rock mass model based on geotechnical data obtained from boreholes, geophysics and outcrop mapping. It then permits the creation of integrated three dimensional stochastic models using a Discrete Fracture Network (DFN) description. The stability of excavations can be analysed using FracMan. This allows for the identification of completely defined rock blocks formed by finite fractures and allows for the factor of safety of these blocks to be determined in both supported and unsupported ground. The underlying Monte Carlo technique enables sensitivities to ground variability and the quantification of the geotechnical risk for an excavation to be determined.

The resulting DFN can be exported to the combined continuum-discrete element software ELFEN. ELFEN can be used to examine the fundamental mechanisms contributing to rock fragmentation and movement, this approach enables the rock mass performance to be predicted with confidence.

The use of FracMan modelling and ELFEN to determine the geotechnical risk is a relatively new approach and provides a more powerful tool than traditional methods of rock mass assessment, allowing greater confidence in calculating geotechnical risk during the process of mining method selection and design.

## THE AVOCA MINES - ASSESSING THE RISK FROM AN OLD IRISH MINE

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The Avoca mines are reputedly the oldest and most extensive in Ireland. Worked underground and opencut at various times for copper, iron and lead, they were also for a while, the principal source of sulphur in the British Isles. Finally abandoned in 1982, the centuries of workings have left a barren landscape of tips and excavations. There are remains of many shafts and adits, along with numerous buildings. There is some 8.5Mm$^3$ of waste above ground.

On behalf of the Geological Survey of Ireland, a detailed appraisal was undertaken of the many physical hazards and risks associated with these old mine workings. All accessible sites were inspected and measured. Comprehensive hazard appraisals and risk assessments were undertaken, leading to recommendations for remedial actions of varying urgency.

Migrating voids, adits, buildings, tips and lagoons present many hazards, but the most severe are due to the high rock faces and shafts. Shaft caps are very variable in quality. The risks are heavily influenced by the ability of the public to gain access to the old workings. Determined individuals repeatedly damage fences to gain access to what are, in some cases, extremely dangerous sites.

Following prolonged heavy rain in November 2009, water levels rose in the East Avoca mine, issuing from a previously dry adit. The possibility of such events had been predicted. An unusual rockfall incident resulted from the new flow routes.

## A CASE STUDY ON DEVELOPING THE OPERATIONAL STANDARDS OF A LIBYAN QUARRY

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This case study illustrates the operations of a limestone quarry (and cement works) in Benghazi, Libya. The previously nationalised, Libyan Cement Company worked under embargo restrictions, meaning that few improvements or modern methods of working were implemented over the last decade or so. In 2008 Libyan Cement Company was taken over by the Austrian quarrying company Asamer. Asamer implemented a quarry optimisation scheme aimed at making the operation safer, raising the working standards, improving production and increasing efficiency. This study shows the previous working methods, including blasting techniques, attitudes toward health and safety and regulatory restrictions imposed upon the quarry operation before the optimisation project started and the measures taken to try to optimise the quarry, to try to bring it in line with standards found in the UK.

## AGGREGATES AND ARCHAEOLOGY

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In 2005 a Minerals and Historic Environment Forum was set up with senior representatives from the minerals industry, mineral planning and historic environment sectors. This was in response to the growing concerns of the minerals industry about escalating costs, inconsistency and uncertainty with archaeological practice. After much constructive dialogue, in 2008 the Forum published *Mineral Extraction and Archaeology: A Practice Guide* according to set of agreed principles in order to capture and define good practice.

Archaeological investigation can sometimes be regarded by the world of development as 'high risk - low opportunity' - but, perhaps not surprisingly, most archaeologists believe it can and should be a 'low risk - high opportunity' exercise. This paper will examine the relationship between archaeology and mineral extraction when compared with archaeological investigations required by other forms of development.

## MINERALS POLICY IN BRITAIN: A METALLIC MINERALS PERSPECTIVE

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Exploration and mining companies have a greater incentive to invest in countries with an efficient regulatory environment that expedites the exploration and development process. Britain has a varied geological environment with significant prospectivity for a range of metals. It has systematic geological data coverage, a history of mineral exploration and discovery and low financial and sovereign risk, all of which resource companies find attractive. A survey conducted by Resource Stocks (2009) ranked the UK twelfth in a global assessment of countries' risk profiles for resource sector investment. Despite this generally positive outlook and an unprecedented surge in metal prices in recent years, mineral exploration activity in Britain has not kept pace with other European countries. This review appraises the underlying reasons for this including the relatively complex regulatory environment in Britain, necessitated by demographic pressures and competition for land use, and mineral ownership rights. These issues are likely to become more prominent given security of supply concerns and growing interest in indigenous mineral resources, particularly those required for environmental technologies. The study compares and contrasts Britain with Northern Ireland and other jurisdictions, which have been successful in attracting significant mineral exploration expenditure. The analysis also considers the views of companies actively exploring, or who have recently considered exploring, for metals in Britain.

## IMPLEMENTING THE MINING WASTE DIRECTIVE - MINIMISING THE BURDEN AND KEEPING THE FOCUS

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The implementation of the Mining Waste Directive in the UK should have been a swift, simple and straightforward tightening of existing legislation. All of the elements necessary to ensure that the principal objectives of the Directive could be satisfied were in place throughout the UK. Many of the specific requirements of the Directive were already addressed through the existing planning, health and safety and environmental legislative and regulatory regimes. The requirements of these regimes were already clearly understood by industry and regulators alike.

The decision to implement the Directive through Environmental Permitting, with the Environment Agency as competent authority has meant that, instead of focussing on the objectives of the Directive, both industry and regulator have been faced with a much more significant challenge. For the Environment Agency it has meant developing whole new systems to bolt onto a rapidly evolving system of permitting to regulate an industry with which it has, until now, had very little substantive contact. For industry it has meant having to try to understand the full complexity of the Environmental Permitting regime and how it applies to what are for the most part already well managed and well controlled activities.

In developing its approach to permitting, the Environment Agency initially missed many opportunities to engage in a meaningful way with the extractive industry. When industry was finally consulted, ideas and approaches had already become entrenched. The drive to ensure that the burden of regulation falls with a 'light touch' has continued for much of the last two years.

## THE ENVIRONMENT AGENCY – PROTECTING THE ENVIRONMENT OR REGULATING WHAT CAN EASILY BE REGULATED?

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There is a view increasingly being expressed by quarry operators, whose sites also have Environmental Permits for landfilling with inert waste, that the inert landfill industry is over-regulated and that the Environment Agency seem, on occasions, to be less interested in protecting the environment and more interested in ticking boxes and disproportionately applying "regulation" without having due regard to environmental risk. Pragmatic approaches would seem to be thin on the ground, especially amongst Environment Agency staff having responsibility for the day to day regulation of inert sites. By way of a series of case studies this paper presents examples of the over regulated approach, poor decision making and inconsistencies across regions of the Environment Agency which all increase the burden of regulation on operators with little or no return in terms of environmental protection.

## EVALUATING DECISIONS FOR AGGREGATES WORKING IN DESIGNATED AREAS SINCE THE INTRODUCTION OF MPS1

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Policy on planning for minerals in England is set out primarily in Minerals Planning Statement 1 (MPS1), issued in November 2006. A recent MIRO funded study examined all significant proposals for aggregate working in England (taken as being accompanied by an Environmental Statement(ES)) decided by either the Mineral Planning Authority or Secretary of State between the issue of MPS1 and the end of July 2009. This comprised 60 cases, four of which were wholly, or partly within the designated areas considered in the study (Special Protection Areas, Special Areas for Conservation, World Heritage Sites, National Parks and Areas of Outstanding Natural Beauty). The environmental impacts of these 60 permissions were examined and a comparison made between the approaches taken towards mitigation and afteruse at sites inside and outside designated areas. The overall analysis suggests, with regard to aggregate extraction, that current legislation and policy on the protection of designated areas in England is meeting its objectives.

The study also conducted a desk based literature review of public perceptions and degree of acceptance of quarrying, with particular reference to designated areas. This identified only a few relevant studies, which often focused on controversial cases, favoured qualitative methods and rarely captured public attitudes directly. Nevertheless, the literature is useful in suggesting several key conclusions about public attitudes towards mineral extraction, not just in terms of the content of such attitudes but also regarding their determinants and consequences. An analysis of culture influence on the mineral planning application process supported these findings. The overwhelming issue accounting for why application decisions were overturned by councillors was deemed to be local perception of the impact of the application on the local amenity, suggesting a degree of cultural resistance to mineral working. The perceived poor performance of the applicant at existing sites was also deemed to influence Councillors decisions.

## ORDNANCE STORAGE AT THE FAULD GYPSUM MINE, STAFFORDSHIRE

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The neglect of Britain's defences during the interwar years and increasing threat of hostilities resulted in rapid expansion of investment in military infrastructure. The development of aerial warfare required the development of hidden storage facilities for ordnance for all of the services. During the 1930's the Air Ministry hastily acquired interests in room and pillar mines with a view to adapting them for ordnance storage and maintenance operations. Three sites were eventually established and for the northern depot the former Peter Ford gypsum mine at Fauld in Staffordshire was purchased that later became RAF Fauld.

Most of the of the facilities were purchased with little consideration for their geological suitability for storage nevertheless the site at Fauld became one of the most important by virtue of its geographical location.

On the 27th November 1944 at the height of the German bombing campaign some of the munitions stored in the mine exploded causing the death of some 70 people. This explosion caused considerable damage and left a crater covering 5 ha and

50 metres deep and is believed to represent the largest none nuclear explosion. Nevertheless the robustness of the facility allowed it to be rebuilt and operated until 1966 finally closing in 1973.

The geological setting of the RAF Fauld is described including some of the difficulties that hampered the underground operations and the influence of site geology on the explosion.

## MILITARY GEOLOGY IN THE BRITISH ARMY: 1980 TO PRESENT DAY

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During the past 30 years the pool of geologists of the British Army has drawn its expertise from a variety of civilian geological fields and has supported both peacetime and war fighting operations in a series of diverse theatres around the world.

Geological support may be provided throughout the Spectrum of Conflict and may have a direct or indirect contribution to each phase of an operation: from planning, preparation and training through to the operation itself and the subsequent reconstruction and stabilisation phases that have been seen in more recent years in operations in Iraq and Afghanistan.

Three key applications of geological support are in the Intelligence Preparation of the Battlefield (IPB), quarrying and the application of geological expertise to support effects based operational strategies.

IPB is a critical component within the operational planning cycle and in modern times has made full use of the advances in computing and GIS as well as ever growing sources of geospatial data. Geology and geomorphology are important layers within the IPB analysis and may impact dramatically on the courses of action available to a commander and his final plan. The provision of materials for fortifications, construction and roads continues to be of critical importance to an army which whilst deployed on more expeditionary and enduring operations must therefore build and maintain its own logistics and real estate without the benefits host nation infrastructure and support.

Finally, the ability to employ non kinetic operational support effects, namely Military Assistance to Civilian Effect (MACE), to 'win the hearts and minds' of a population has been proven to be an invaluable application of geological support.

## RESTORATION OF EASTGATE QUARRY, COUNTY DURHAM

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Lafarge Cement's Weardale Cement Works in County Durham closed in 2002, following closure a scheme was prepared and submitted to Durham County Council to restore the large quarry site (~1,200 acres). This paper presents as a case study: the restoration scheme, it will illustrate the substantial restoration work undertaken during two seasons of earthmoving involving the movement of over 1.2 million tonnes of material from both former overburden tips and quarry/overburden faces, it will demonstrate how safe(r) final faces have been achieved, the paper will be illustrated with before and after plans/photos and cross sections. The focus will be on the difficulties faced and the practical ways that geotechnical issues were addressed during the restoration work and how a flexible pragmatic approach from the planning authority resulted in a great landform for nature to re-colonise and to help blend the workings back into the sensitive landscape adjoining the North Pennine AONB. History of removal, studies/investigations of and remediation of Fairy Hole cave SSSI will also be described.

## MAKING BIG PROFITS FROM QUARRY REDEVELOPMENT

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The entrepreneurial culture of the land developer is to see opportunities where others only see problems. Land from which the minerals industry has walked away and others have further despoiled can be a spectre of dereliction and blight on the industries' reputations. This negative view can be changed to a positive one with developers, land owners, mineral and waste clients. Examples of projects undertaken include the creation of substantial settlements such as the 8,000 house mixed use development at Hampton Township near Peterborough on the "Fletton" brickfields and planning permissions for projects such as the 6,000+ houses in the 310 hectare Eastern Quarry (as well as the commercial, retail and leisure space, a public transport network and other services this entails). The recent political "spotlight" of the Ecotowns has highlighted a number of potential redevelopments of mineral land including the largest candidate for the process, Marston Vale, which remains a viable proposal for a town between Milton Keynes and Bedford for some 30,000 people.

By examining a number of case studies it is intended to show how value can be realised through re-development of mineral sites to create sustainable developments.

## A CASE STUDY IN SAND AND GRAVEL ASSESSMENT AND EXTRACTION: WE CAN DO BETTER – YES WE CAN!

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As a component part of the MIST Project "Deposit Knowledge for Efficient Production" the authors have studied the extraction of a small area of an existing sand and gravel deposit in the valley of the Great Ouse, Central England. Our objective was to detail the potential benefits which could be gained during the extraction and production process, resulting from more detailed characterisation of the deposit prior to extraction. The study area of the deposit is a thin, 0.5 to 3m, and highly variable alluvial sand and gravel covering an area of about 4 hectares. Exploration drilling by the company comprised a grid of holes at nominal 100m spacing. This drilling revealed wide variations in both the thickness and the quality of the deposit. Correlation between boreholes was difficult.

The area was investigated prior to extraction using geophysical techniques and a detailed multi-method borehole survey. Initial results from the geophysics showed a very complex structure to the deposit. Detailed borehole sampling was guided by the geophysical results. The area has now been completely worked, and the working faces have been regularly sampled during extraction.

The comprehensive sampling of the deposit allows an interesting comparison with the predictions based on (a) the exploration drilling, (b) the geophysics, and (c) the detailed drilling program. Our results allow a comparison of the limitations and bias produced by each of these exploration methods. These in turn lead to a consideration of what the optimum exploration program might have been, its operational benefits, and potential cost savings.

## DEVELOPING A LONG TERM MINERALS PLANNING STRATEGY FOR THE MENDIP HILLS: AN ECOSYSTEMS APPROACH

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The Mendip Hills are one of the most important sources of hard rock construction aggregates in England. This is partly because of the suitability of the geological resources which they contain (Carboniferous Limestone and Silurian volcanic rocks), but is also because these outcrops are the closest of their kind to the major development markets in London and South East England.

National and regional supply strategies are such that the Mendips are required to supply around 13 million tonnes of aggregate per year. This scale of extraction will inevitably change the landscape, transforming the affected areas into a disjointed pattern of deep, steep-sided, waterfilled holes. By taking a more strategic, longer-term approach, this piecemeal scenario could be replaced by a more beneficial, community-driven strategy which focuses on and works towards larger-scale restoration options that are designed, from the outset, to make more positive contributions to the landscape, biodiversity, geodiversity, the water environment, amenity, tourism and the economic well-being of the area. This paper describes how the "Ecosystems Approach" has helped to develop pointers for such an integrated strategy - one which achieves the required level of aggregate provision whilst also delivering an optimum balance of other ecosystem services.

## THE APPLICATION OF ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT) FOR UK SAND AND GRAVEL DEPOSIT ASSESSMENT AND QUARRY PLANNING

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ERT is a ground imaging technique that is sensitive to compositional variations in the subsurface. It can be used to distinguish different lithologies, e.g. clean gravels and clay bedrock, and to identify quality variations within mineral deposits. Because it is non-invasive and can provide volumetric information on the subsurface, it is particularly well suited to the investigation of complex deposits or deposits that are difficult to drill. Although research has begun into the use of ERT for sand and gravel deposit evaluation, it has yet to be tested in many economically important geological settings in the UK. Moreover, there is still much work to be done to quantify the performance and resolution of ERT, and to assess the economic and environmental benefits of integrating ERT into the deposit investigation process.

Here we present one of a number of case studies from the UK, illustrating the use of ERT for sand and gravel deposit investigation. Together with the other case studies, we will assess survey costs, evaluate the performance of ERT, and illustrate good practice in the application of ERT to deposit investigation.

3D ERT was used to image river terrace deposits within a quarry extension area, in the Trent Valley, Newark, UK. The survey covered an area of 2.25 hectares, and was designed to achieve a depth of investigation of approximately 20 m. Contrasting resistivities allowed the mineral, bedrock and overburden to be distinguished within the 3D image. Calibration of the model was achieved using a single borehole from within the survey area, by which a 3D bedrock surface was determined from the image. Subsequent sand and gravel extraction from the area revealed the bedrock surface at a depths of between 8.5 and 9.6 m below ground level. The height of the bedrock surface was mapped using differential GPS, with centimetric or better resolution, and the results were compared to the bedrock surface generated from the ERT survey. Good agreement between the measured and predicted bedrock surface was observed, as indicated by a mean absolute height difference of 0.4 m.

These results confirm that non-invasive 3D ERT can contribute valuable additional spatial and volumetric subsurface information, which has the potential to significantly improve sand and gravel reserve estimates. We propose that ERT has a role to play as a component of an integrated approach to site investigation incorporating both non-invasive and conventional intrusive methods.

## AN UPDATE ON STUDIES INTO THE ACCURACY OF SAND AND GRAVEL RESERVE CALCULATIONS

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In 1999 the author reported the results of an 18 year study into the accuracy of sand and gravel reserve calculations. Since that time some changes have been made in the company's resource investigation practices in certain types of deposit, and the data gathering has continued. The paper presents the results of almost double the data available in 1999, considered on its own and in combination with the first exercise.

The analysis shows closely similar outcomes in respect of accuracies, the distribution of results, and the magnitude of excursions from the bulk of results. Conclusions and the statistics from the 1999 study are supported by the greater volume of data, and it can be suggested that attempting to improve accuracy by the last few percent could be disproportionately expensive.

## THE POTENTIAL RESPIRATORY HAZARD OF QUARRYING AND PROCESSING RHYOLITIC VOLCANIC DEPOSITS

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Volcanic deposits are extensively quarried around the world for both domestic and industrial use. Work on volcanic ash has identified potential health hazards of inhaling the dust; it may contain respirable crystalline silica (a human carcinogen also implicated in the fatal disease silicosis) and reactive iron species which generate the hydroxyl free radical (a lung inflammation and carcinogenic factor). This project aims to discover, for the first time, whether quarrying volcanic deposits generates dusts with a comparable, or even enhanced, risk due to the generation of freshly fragmented particles through mining processes. Research into rhyolitic (high SiO2 content) samples is highly relevant to the UK quarrying industry as the UK is a major importer and processor of crude perlite and pumice, and economically-viable perlite deposits exist in the northwest of the UK and on Arran. There has been no research on the health effects of perlite dusts in over 20 years and techniques have developed significantly during this time.

Samples from a variety of quarries have been collected, representing basaltic (low silica, high iron), andesitic (medium silica) and rhyolitic (high silica, low iron) magma types. Collection of rhyolitic samples from Greece and processed material from UK will take place in July and August 2010 with the aid of an EIG bursary. The latest analyses will be presented at the EIG conference. However, limited sampling from rhyolite quarries also took place in New Zealand (in Feb. 2009), along with the basaltic quarry sampling. Grain size analysis revealed that the finest dusts were those produced by drilling and processing material (for all magma types). Surface reactivity tests showed a clear correlation between the quantity of available iron on particle surfaces and the quantity of hydroxyl radicals produced, with iron-rich, basaltic samples producing greater numbers of hydroxyl radicals that iron-poor, andesitic and rhyolitic ones. Exposure (aerosol monitor), morphological (scanning electron microscope) and compositional tests (using X-ray diffraction and X-ray fluorescence) are in progress; the latter will reveal the quantity of crystalline silica in the samples as well as bulk composition. Future work will involve in vitro toxicological assays based on the known pathological sequence elicited by both quartz and metal-rich particles in the lungs. This trans-disciplinary research will provide results contributing to improved knowledge of the potential risks of inhaling quarried volcanic materials and show how this dust compares to volcanic ash.

## UNMANNED AERIAL VEHICLES (UAVS): GEOSPATIAL DATA ACQUISITION IN MINERAL EXPLORATION AND MINING INDUSTRY

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Unmanned Aerial Vehicles (UAVs) are steadily becoming the mainstay of military geospatial data acquisition and have evolved rapidly in recent years with the current high tempo of operations in the Middle East and Central Asia. As is often the case there has been a steady transition of military technology and expertise across to the civilian world where it is already contributing to several industries including that of minerals exploration and mining.

UAVs are capable of safely operating in hazardous environments such as offshore or at extremely low altitudes which removes the aircraft crew from potential risk and can significantly improve the quality of data collected. They can also provide a more cost effective and timely solution when compared to manned systems.

A variety of UAV or Unmanned Aerial Systems (UAS) exist which employ both fixed wing and rotary airframes with ground control stations and a range of payloads that can be configured to suit the survey requirements for the collection of geospatial data types (magnetic, radiometric, LiDAR, multi spectral, imagery, video).

A rotary UAS has been developed for applications in the mineral exploration and mining industry. The UAV has a range of payload configurations that have been developed and tested since the start of 2010. It is expected that the new UAV will commence commercial data acquisition in the final quarter of 2010.

## INNOVATIVE APPROACHES TO ENGAGING THE PUBLIC WITH QUARRIES AND QUARRYING ACTIVITIES

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Since 2003 the Yorkshire Quarry Arts Project has involved quarry companies, communities and academics in innovative and imaginative activities with the aim of changing public perception of landscapes that include quarries and the active quarrying industry. It has also undertaken research into the restoration and after use of quarries and projects that capture the imagination of young people to encourage them to learn about geology.

This presentation will give examples of how academics from Earth Sciences, Civil Engineering, Food Science, Biological Sciences, Contemporary Art and Music at the University of Leeds became involved with a number of aggregate quarries through seven projects funded through Defra's Aggregate Levy Sustainability Fund.

The author is currently working with a number of different interdisciplinary groups to research sound in quarries and quarried materials and biodiversity issues in quarries and surrounding landscapes to develop research proposals. Stakeholders include many aggregate companies and other organisations such as Opera North, Grassington Festival, Yorkshire Wildlife Trust, the National Trust and local councillors.

The two projects will be featured as case studies: the MEng students' Architectural Engineering designs for the after use of a quarry and the Ruskin Rocks project to excite young peoples' interest in geology through a 21st century rock instrument.

# EDITED POSTER ABSTRACTS

## PREDICTION OF MINE WATER OUTBURSTS USING 3D MODELS

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Pollution from abandoned mines has been identified, under the characterisation process of the Water Framework Directive, as being likely to impede the achievement of good ecological status for ground and surface waters in a number of areas in UK. Mine adits, spoil heaps and tailings together with contaminated sediments and floodplain soils represent point and diffuse sources of contamination in mine-impacted catchments. Understanding of the risks posed by these sources is needed to inform remediation strategies for surface waters and impacted ecosystems. This includes assessing the risk of minewater outbreaks, due for example to blockages or roof falls in underground mines. Outbursts of this type are known to have occurred in the UK in the Rookhope catchment, North Pennines, the Wye catchment, Derbyshire (Magpie Mine) and Wheal Jane, Cornwall. Prediction of the location of mine water surface emergence is, however, difficult. This paper describes ongoing research to explore methodologies, using 3-D geological modelling as a platform for the identification of zones of mine instability with a potential to cause pore pressure build-up and consequential outbursts.

## THE USE OF WET RESTORED MINERAL WORKINGS FOR ENERGY RECOVERY

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This paper will examine and discuss the technical and financial merits and engineering considerations of obtaining low grade heating and cooling from wet restored quarries.

"Wet" restoration may be popular with local residents and environmentalists; and well-planned lake environments create varied and important wetland habitats for many species and recreation facilities for the nearby population. Artificial lakes may also provide a magnet for commercial and residential developments around the edges of the excavation. While "wet" restoration may be attractive to third parties, those parties are often unwilling to pay hard cash for the aesthetic value of the restored void. The flooded pit can therefore remain "economically sterile" from the point of view of the minerals operator. Indeed, before transferring ownership for a nominal sum to a wetland trust or local authority, the minerals operator may need to underwrite management costs for a substantial future period.

Any large body of water is an enormous reservoir of reliable and sustainable environmental heat and "coolth". Thus a flooded quarry represents a very significant energy source. The energy source can be used to attract commercial and residential development. Such businesses increasingly require low carbon energy sources to overcome planning restrictions and buildings regulations. There therefore exists a potential customer base for low-carbon space heating and cooling around restored mineral workings. The energy locked into the wet restoration is extracted using a groundwater sourced Heat Pump (GSHP) which gives a minerals operator or site owner the potential to support a district heating / cooling utility and to convert an environmentally sterile asset into a source of revenue.

The minerals industry spends a significant amount of development cost in restoring sites, which are usually delivered back to a landowner or to an environmental trust, such as a county wildlife trust, for long term management. This management costs money, and it is not uncommon that the most difficult part of the "walkaway solution" is agreeing the long term aftercare costs.

Installation of the means necessary to extract or dump heat to the restoration provides either a long term potential revenue, or makes the site attractive as a commercial development opportunity (as well as an environmental benefit). By designing the energy system into the restoration and installing it when the pit bottom is easily accessible, the operator leaves an asset rather than a liability.

## WHAT WE DO NOT KNOW DURING A SAND AND GRAVEL DEPOSIT ASSESSMENT

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Greenfield site sand & gravel deposit assessments are rarely undertaken in the UK without the benefit of significant knowledge of likely deposit composition and geometry. The UK hosts a range of well-defined deposit types. Most companies have archives of site data, BGS maps, reports and mineral assessment information. The geologist undertaking the survey also has their own personal experience to call upon.

So what is there that we do not know? Surprisingly quite a lot! We do not for instance fully understand which drilling techniques best recover a particular deposit type, how this changes downhole, and what corrections to the grading results are appropriate for this. We have custom and practice about how far our boreholes should be apart but what is the basis of this and is it valid? Have we over or under-drilled the deposit? Is the sample recovered large enough to be statistically representative of the deposit and how can we tell any of this before the grading analyses are returned? We generally recover around 0.0003 % of the deposit and base our assessment on this material. Perhaps most obviously we also generally do not know what is in the 99.99% of the area between the boreholes we drill or trial pits we excavate. We do however have anecdotal information, examples and personal professional experience to help.

The industry has developed and adopted new techniques but where is the strategic view? The demands of enhanced planning controls, environmental conditions, stock exchange reserve declarations, carbon quotas and energy efficient production combined with new technological opportunities mean that it is a good time to look at the process more carefully.

We can envisage rapid, integrated, multi-technique geological and land characterisation assessments that can provide detailed 3D quality related data throughout the deposit, calibrated by direct sampling, and all at a cost lower than or comparable to current investigations. We are not there yet but can demonstrate that we are well on the way. Sand and gravels represent the most commonly worked mineral deposit type. A new assessment methodology is perhaps overdue.