Appendix 1

Edited Abstracts of other oral and poster presentations from the 17th Extractive Industry Geology Conference

held at Edge Hill University 5th to 8th September 2012

(Edited abstracts are given in alphabetical order of the first author)

EDITED ABSTRACTS

DEFINING SAND AND GRAVEL DEPOSITS: THE USE OF ELECTRICAL RESISTIVITY IMAGING (ERI) AND OTHER GEOPHYSICAL TOOLS

B. Balding[1], D. Hanratty[2] & C. Phillips[2]

[1]Golder Associates (UK) Ltd,
[2]Golder Associates Ltd, Canada.

The evaluation of sand and gravel deposits has traditionally been undertaken by carrying out a sampling program using test pits and/or various drilling techniques. Based on the sampling results, the quality of the resource is estimated and the overburden and resource volumes are calculated assuming a simple geometry for the resource. In some cases this approach is adequate. However in the case of complex deposits it has a number of limitations that may prove costly to the producer as the property is mined. Methods such as percussion or rotary type drilling do not always yield representative samples due to the nature of the technique (i.e., pulverizing, grinding and/or introduction of drilling fluids). This can lead to an erroneous interpretation of the geometry of the resource and overburden, or of the resource quality. Whilst test pits are a 'cleaner' approach to visually examining a resource and obtaining appropriate samples, a large limitation related to test pitting is the depth which is usually limited to about 6m (less than 25ft). Boreholes and test pits are point samples, providing information on resource deposits at the immediate location of the sample location. Assuming there is continuity between sample locations can lead to either overestimation or underestimation of the resource present within a given property. In addition, modelling tools to calculate overburden and resource volumes have traditionally been very simple and are not usually able to depict the spatial distribution of a complex resource and/or overburden deposit at a given property.

The limitations described show the need for additional tools to define complex sand and gravel deposits.

Electrical Resistivity Imaging (ERI) is a geophysical method used to map variations in the resistivity of the subsurface. This method has been used by the authors to define complex sand and gravel deposits on numerous sites, and this work is the focus of the presentation. The use of other geophysical methods that have potential applications for sand and gravel and stone deposits are also reviewed.

A NEW SAND AND GRAVEL MAP FOR THE UK CONTINENTAL SHELF TO SUPPORT SUSTAINABLE PLANNING

T. Bide[1], P. Balson[1] & I. Selby[2]

[1]British Geological Survey, [2]The Crown Estate.

The UK is well endowed with marine sand and gravel resources and has one of the largest marine aggregate dredging industries in the world. These minerals are vital for the UK economy, supplying raw materials for both the construction sector and for coastal protection and reclamation.

As a result of new legislation passed in the UK Marine and Coastal Access Act 2009, the planning framework for the UK Continental Shelf (UKCS) is to undergo significant change. An integrated plan-led process, similar to that undertaken onshore, is being applied offshore. It is vital that sand and gravel resources are adequately considered in this process. The British Geological Survey, funded by The Crown Estate, is undertaking a project to produce a map representing the sand and gravel resources of the UKCS.

Resources have been defined using geological mapping data and BGS's extensive collection of core, seabed samples and geophysical records. Map compilation for the Southern North Sea has been completed and the shelf-wide survey is due for completion in March 2013.

Identifying the distribution of known sand and gravel resources and presenting them in a consistent fashion and on a national scale allows planners to adequately consider minerals in the planning process, avoid sterilisation from development of this non-renewable natural resource and permits more effective and sustainable management strategies to be developed.

APPLICATION OF HYDRO-ECOLOGICAL RELATIONSHIPS FOR ASSESSING QUARRY IMPACTS

D. C. Bradley[1] & M. Streetly[2]

[1]APEM Ltd, [2]ESI Ltd

The Water Framework Directive requires a more holistic approach to assessing impacts of development on the water environment. In particular, the focus of impact assessment has shifted towards the biological elements of aquatic ecosystems that are supported by the conditions provided by hydrology and geomorphology. There is a requirement for hydrogeologists to work closely together with ecologists in applying the rapidly developing science of hydroecology. This also provides a focus on the interaction between many different pressures (water abstraction, diffuse pollution, sedimentation etc.) on the outcome of ecological status.

This presentation provides some examples of how this approach is being applied in other industries (principally the water industry) and shows how this will be of increasing relevance to the extractive industries. Key findings to date are that in many cases the standard guidance on the amount of impact on stream flows that is acceptable may be overly precautionary. This is of great significance to many current quarry impact assessments.

PETROGRAPHIC CHARACTERISATION OF POTENTIALLY DELETERIOUS SULPHIDE-BEARING AGGREGATES

A. Bromley

Alan Bromley Consultant Ltd.

Alan was unable to present this work at the EIG conference due to illness.

In southwest England the accelerated degradation of concrete made with metalliferous mine waste aggregate has been recognised for at least eighty years. The use of unstable mine waste aggregates ceased about fifty years ago but many domestic and small commercial properties in the region are still suffering the consequences. Degradation was recognised as a result of the *in-situ* oxidation of sulphide minerals, mainly pyrite, but it became apparent many years ago that the degradation potential of concrete products could not be reliably assessed on the basis of residual sulphide mineral concentration alone. Petrographic investigations, using conventional transmitted and reflected light polarizing microscopy and scanning electron microscopy have demonstrated that pyrite morphology, grain size distribution and bulk mineralogy of the aggregate are more important factors than total sulphide

mineral content in assessing the degradation potential of particular aggregates.

In southwest England two quite different degradation mechanisms are associated with particular types of mine waste aggregate. In concrete made with waste from hypothermal tin – copper mineralisation, degradation results mainly from oxidation of liberated pyrite in the aggregate and direct sulphate attack on carbonated cement paste. It results from failure of cement – aggregate bonds and pore volume collapse. Initial pyrite concentrations of >1% are usually required before major degradation can occur. Lead mining wastes, usually conveniently graded jig tailings, carry little liberated sulphide but have abundant altered wall rock with fine, disseminated pyrite. Degradation results from oxidation of this fine pyrite and bulk expansion of the aggregate. Initial pyrite concentrations of less than 0.2% may be enough to cause major damage.

More recently, the use of pyrite-bearing calcareous mudstones and siltstones as inert fill and concrete aggregate in the Dublin area, Republic of Ireland, has resulted in widespread rapid degradation. Economic prosperity during the 1990's and early 2000's led to major road construction and housing development. In many new housing estates early displacement of ground floor slabs and pavements was traced to *in-situ* expansion of fill made up principally from pyrite-bearing calcareous mudstone and siltstone. Very rapid deterioration results from pyrite oxidation and the reaction of soluble sulphur species with calcite in the aggregate. Growth of secondary gypsum close to oxidation sites causes exfoliation and expansion of individual aggregate particles while secondary gypsum and aragonite growth in interstitial voids leads bulk expansion of the fill as a whole.

As in southwest England, petrographic studies of the Irish aggregates shows that pyrite distribution, morphology and grain size, and associated minerals are more critical in assessing degradation potential than total sulphide content alone.

RIVER TERRACE SAND AND GRAVEL VOLUME DETERMINATION USING THREE-DIMENSIONAL ELECTRICAL RESISTIVITY TOMOGRAPHY

J. E. Chambers[1], P.B. Wilkinson[1], D. Wardrop[2], A. Hameed[3], I. Hill[4], C. Jeffrey[3], P. I. Meldrum[1], O. Kuras[1], M. Cave[1], D.A. Gunn[1]

[1]British Geological Survey,
[2]Lafarge Aggregates at the time of the conference and now Wardrop Minerals Management Ltd.,
[3]University of Leicester at the time of the conference and now Camborne School of Mines, University of Exeter,
[4]University of Leicester.

The use of a fully volumetric geophysical imaging approach, namely, three-dimensional electrical resistivity (3D ERT), for the purpose of detecting bedrock beneath mixed sand and gravel deposits, typical of fluvial valley-fill terraces is described. The method is illustrated through an analysis of terrace deposits of the Great Ouse River (UK), where up to 4m of sand and gravel have filled the valley bottom during the latest Pleistocene. The approach provides an estimate of bedrock depth (verified by drilling) to a precision better than 0.2m (average) and 0.4m (standard deviation). Comparison of a range of drilling techniques at the site has revealed that borehole derived interface depths suffered from levels of uncertainty similar to those associated with the 3D ERT, indicating that the reliability of bedrock interface depths determined using these two approaches is comparable in this case. The 3D ERT method provides a high spatial resolution that enabled a previously unknown erosional bedrock structure, associated with the change from deeper first terrace to second terrace deposits, to be identified. The method provides a relatively quick method of quantifying the fill volume of river terraces over large sites to a high degree of precision.

UK SHALE GAS EXPLORATION AND MONITORING SOLUTIONS

H. Clarke

Cuadrilla Resources Ltd.

In 2010 Cuadrilla Resources commenced an exploration drilling programme in the county of Lancashire. The focus was to evaluate the shale gas potential of the Bowland Basin, northwest England. With three exploration wells drilled and initial results proving positive the next phase of exploration can begin. This will include a 100 square kilometre 3D seismic survey, hydraulic stimulation of the Bowland shales along with micro seismic monitoring and fracture mapping, and plans to drill and complete a lateral well bore within the most productive shale strata.

Media attention has focused on ground water pollution and trigger seismicity leaving the UK shale industry on the back foot. But with industry best practices and thorough transparent monitoring of ground water and fracture evolution, negative stories can be replaced with the positive benefits of jobs, secure 'greener' domestic gas, and the possible tax revenue to the UK government.

THE BUSINESS OF GEODIVERSITY

T. Clifford

Aggregate Industries at the time of the conference and now at Atkins.

Much of the history of our planet is known only through human activities that expose the rocks. Indeed quarries have often been described as windows into our past, offering glimpses out over ancient worlds and environments through the incredible array of rocks, fossils and structures which are revealed. With the extractive industry being in control of arguably of some of the great geodiversity assets in the UK there is a need to develop a managed approach to enhance those assets whilst avoiding any environmental or operational conflict and whilst being commercially viable.

The business and management approach to geodiversity at excavation sites was examined in this project and recognition of planning, Corporate Social Responsibility and stakeholder gain was illustrated through case studies. It was also possible to demonstrate how a mineral extension within a geological SSSI can be a viable operation, through an appropriately managed geo-restoration scheme. With increasing pressures on operational management, the ability to accommodate and maintain geodiversity requires new holistic concepts and several examples showing how geological value was maintained without compromising operational requirements were illustrated in this project.

EFFECTS OF MINE WORKINGS ON BRICK PIT SLOPES

A. Cobb

GWP Consultants LLP.

This paper considers the effects of underground abandoned coal mine workings on the strength and permeability of rocks forming the slopes of a number of UK brick pits. Over several years the author has investigated a number of incidents in brick pit slopes that have been undermined by longwall workings.

That the stability of Coal Measure rocks forming the over and interburden in Opencast Coal mines can be seriously impaired by the effects of the old coal mine workings within those rocks has long been appreciated by opencast mine designers. Although less well known, long term deterioration of mudstone rocks forming natural slopes, undermined by longwall workings at considerable depth (420m) also occurs. This was demonstrated by the Bolsover landslide of 1991.

Longwall workings create a void into which the ground above is let down as the workings progress. The subsidence extends beyond the working area. Over the edge (ribside) of the working, the rocks are stretched, resulting in the opening up of joints, and sometimes limited breakage of the rock blocks. This disturbance results in greatly increased permeability. There are also accommodation movements along bedding planes, which can lead to reduction in strength. These effects remain even when workings cease. The increased permeability allows water to percolate through the previously impermeable rock mass, with consequent softening of the strata. The consequences of this on the stability of a number of brick pit slopes are demonstrated.

RECENT DUST SAMPLING DEVELOPMENTS

H. Datson & G. Walton

Dustscan Ltd.

The monitoring of dust movements and dust settlement is often necessary where quarrying and mineral processing raise environmental or nuisance concerns for nearby receptors, especially when multiple dust sources are present within and beyond the limits of mineral working. Health and safety issues may also arise; monitoring, therefore, needs to address both concerns. This paper explores recent developments of passive dust monitoring systems to sample deposited dust and dust in flux. Early methods to provide directional data on moving dust included cylindrical pads that collected dust on an acrylic adhesive. Whilst excellent data were obtained on dust source directions in terms of coverage and colour, dust could not be readily removed from the sticky pads for geochemical or other analyses. A system for 'acid digestion' of segments of sticky pads with dust and equivalent blank pads allowed the development of a method by which distinctive elemental ratios and proportions could be determined. By this means the proportion of key indicator elements consistent with dust from a specific quarry or other source could be studied and this distribution further refined by the use of geostatistics.

Recent developments have concentrated on the use of hot-melt adhesives that allow for the removal of dust following the standard scanning for dust coverage and colour. A dust disc sampler, using the same adhesive, was developed to collect settled dust. Field trials have indicated a good correlation between the dust disc and the Frisbee-type dust deposition sampler, but avoiding the collection of rain water. A mass detection limit of 0.5gm^{-2} has been established and the technique also applied to directional dust samples from sticky pads. Examples are shown of these methods in use in quarries and open-pit mines in the UK and elsewhere. The ability to separate dust from the sampling media allows the preparation of samples for grading analyses, and chemical and mineralogical testing using ICP-MS and SEM-EDX (including QEMSCAN) as well as gravimetry. Health risk dust is generally taken to be <10 microns in size and may be measured by a variety of techniques, however directional PM10 can now be sampled using sticky pads. Interesting variations have been identified in PM10 levels prior to initial excavations at a site where conditions are geochemically and geomorphologically consistent but where the variations in PM10 levels are not necessarily consistent with variations in weather. The ability to characterise and quantify dust using simple sticky pad equipment may help in apportioning responsibility for nuisance and health risk concerns associated with mineral workings.

QUARRYING AND KARSTIC HYDROGEOLOGY; THE CHALLENGES OF CONCEPTUALISATION, ASSESSMENT AND MITIGATION

A. J. Edwards

SLR Consulting Ltd.

Karstic hydrogeological environments can be both complex and difficult to easily conceptualise. Under these circumstances, it can also be difficult to precisely assess the potential impacts that a quarry may have on the hydrogeological environment, and the extent of the mitigating measures that might be required. Practically, it may also be difficult to estimate how much groundwater might actually enter into a quarry, with significant inflows of water entering via caves on quarry benches that are actually located above the surrounding water table. This could have significant implications for issues such as the management of water volumes and suspended sediment.

This presentation considers various points:

- What are the steps to conceptualising a karstic environment? What is important and how can you make an initial estimation to the level of complexity that actually exists? When does this complexity materially exist?
- What techniques are available for both aquifer investigation and impact assessment? What are the particular impacts that are particular to karst and how do you deal with what often is imperfect information? and finally
- What mitigation measures are most appropriate to karst? What are the specific measures that should be considered in this environment? Again, how do you deal with the unknowns?

INDUSTRIAL WASTE MATERIALS: A RARE EARTH ELEMENT RESOURCE?

A. Finlay, J. Gluyas, F. Worrall & C. Greenwell

Department of Earth Sciences, Durham University.

World demand for Rare Earth Elements (REE) has been growing year on year with the consequence that they are rated as being the 5th most at risk element/group of elements in the British Geological survey 2011 risk list. New technologies, including green renewable energy have led this surge in demand as they rely heavily upon the properties of the REEs. At the same time China is the dominant supplier of REEs, producing around 97% of the global supply. However, in 2010 China's export quota was easily outstripped by a world demand. Therefore, to enable the green revolution to continue, it is imperative, for economically developed countries to find new, accessible sources of these elements.

The authors believe we are on the cusp of a paradigm change in delivering REE resources which could help meet expanding demand. Importantly, the authors are not advocating wholesale destruction of the environment but rather suggest REE recycling through the reclamation from previously unconsidered industrial waste products such as shale from coal mining and oil retorting. Despite only a limited range of samples being analysed, waste shale that contain heavy REE concentrations (the more valuable Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu), have already been identified and the concentrations are greater than seen in traditional ore. The authors calculate that one easily accessible UK waste dump is alone worth ~ $2 billion in terms of its REE content (2010 wholesale prices). Further research is ongoing, aimed at investigating other varieties of waste material such as a variety of slags produced by steel manufacture.

EO-MINERS: MONITORING THE ENVIRONMENTAL AND SOCIETAL IMPACT OF THE EXTRACTIVE INDUSTRY USING EARTH OBSERVATION

S. Grebby[1], F. McEvoy[1], C. Jordan[1], S. Chevrel[2], E. Ben-Dor[3], C. Fischer[4], P. Schepelmann[5], H. Hejny[6], V. Kopackova[7], H. Coetzee[8], E. Kylychbaev[9] & C. Fleming[1]

[1]British Geological Survey, UK,
[2]Bureau de Recherches Géologiques et Minières (BRGM), France,
[3]Tel Aviv University, Israel,
[4]German Aerospace Center (DLR), Germany,
[5]Wuppertal Institute for Climate, Environment and Energy, Germany,
[6]Mineral Industry Research Organisation (MIRO), UK,
[7]Czech Geological Survey, Czech Republic,
[8]Council of Geosciences, Environmental Geosciences, South Africa,
[9]Central Asian Institute for Applied Geosciences, Kyrgyzstan

The growing demand for mineral and energy resources over the last decade has placed the extractive industry under increasing pressure to monitor and reduce the environmental and societal impact throughout the life-cycle of mining operations. Despite the mounting pressure, the industry is still facing the challenge of how to define targets for, and monitor, the impact of mining.

In 2010, the EU-funded EO-MINERS project; Earth Observation for Monitoring and Observing Environmental and Societal Impacts of Mineral Resources Exploration and Exploitation, was set-up to try to help address this issue. The project aims to define criteria and indicators associated with environmental and societal issues and then demonstrate the capability of Earth Observation (EO) in helping to monitor and reduce their impact, from the exploration phase through extraction and remediation.

To implement this, three case study areas have been chosen: the Witbank coalfield in South Africa, the Sokolov lignite opencast mine in Czech Republic and the Makmal gold mine in Kyrgyzstan. For each study area, a list of indicators of mining-related issues was compiled following discussions with stakeholders (e.g. mining companies, governmental organisations, civil society representatives). Currently, an array of EO data (i.e. satellite, airborne and in-situ) amassed during this project is being utilised to develop tools, methods and products that can help ascertain and monitor the status of the site-specific indicators. A selection of such products was presented, including maps showing the distribution of iron oxide minerals and surface drainage maps, essential for monitoring the acid mine drainage potential, as well as multi-temporal landcover maps, important for determining the re-cultivation success. From the results to date, it is clear that EO can play a key role in providing more efficient and comprehensive assessments of mining-related impacts on both the environment and society.

ENHANCING WASHING PLANT EFFICIENCY THROUGH THE INTRODUCTION OF EFFECTIVE WATER AND SLUDGE MANAGEMENT TECHNOLOGIES

S. Hunger

CDE Global Ltd.

With a growing requirement for washing of materials due to the nature of the raw material being processed, operators are faced with a unique set of challenges. Traditionally, washing plants required a large amount of space in order to facilitate the large settling ponds required for the waste water from the washing plant, and, large volumes of water were required to ensure that the material was effectively washed. With the development of more efficient processing systems in recent years equipment manufacturers have developed systems which succeed in significantly reducing the space required to accommodate a washing plant while also reducing the volume of water required to feed the plant. There have been several phases to this process including systems which integrate the feeding, screening, sand washing and stockpiling capability onto a single chassis. Following this, effective water recycling systems and sludge management technologies have been specifically developed to cope with the harsh operating environments seen by operators in the extractive industries. This presentation focuses on the significant developments of recent years in this area and the benefits that this offers operators considering the introduction of washing technologies.

GEOLOGY IN HIGH PLACES: HOW DO GEOLOGISTS AND GOVERNMENT INTERACT?

F. McEvoy & A. Bloodworth

British Geological Survey.

The relationship between government and the extractive geosciences community is complex and continuously evolving. In reality, 'government' is a multi-layered institution (from EU to parish) which operates using a variety of mechanisms to address diverse priorities. These priorities are driven by economics, environment, geopolitics and societal attitudes. For the extractive sector, this largely translates into conflicting government concerns regarding security of mineral supply to maintain economic growth and the need to protect the environment. Many of the issues associated with mineral development are contentious, and our democratic system requires that everyone have their say. This debate must be informed by objective geoscience. Debate and decision-making are a function of government and geoscientists contribute to this process by providing baseline information, expert advice and horizon-scanning. For a variety of reasons, interaction with government can be very challenging. In Whitehall and elsewhere, lines of communication can be long and corporate memory can be short. This situation means that geoscientists must move beyond their discipline and develop an understanding of both policy priorities and process. Examples of different types of interaction with various levels of government will be presented and contributions from delegates

regarding their own experiences will be sought. Lessons learned should strengthen the quality of future relationships between the extractive geoscience community and government.

AN ASSESSMENT OF THE POTENTIAL RESPIRATORY HEALTH HAZARD OF QUARRYING VOLCANIC DEPOSITS

S.A.K. Michnowicz & C.J. Horwell

Durham University.

Volcanic deposits are extensively quarried for a variety of uses ranging from building materials to specialist industrial applications. Many studies have investigated exposure to dust from quarrying sedimentary rocks such as sandstone and coal; however, the specific hazard posed by quarrying volcanic material has hitherto not been investigated. Recent work on volcanic ash has revealed that 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 investigates whether quarrying volcanic deposits generates dusts with a comparable, or even enhanced, risk through the generation of freshly fragmented particles during the quarrying processes.

Samples were collected from a dozen quarries in Greece, Montserrat and New Zealand representing a variety of magma types (from mafic to felsic). Grain size analyses of dusts indicated that the finest particles were produced as a result of drilling (carried out prior to blasting), although some finished product also contained significant concentrations of respirable dust. Scanning electron microscope analyses confirm that the morphology of particles can be altered by the method of processing and were often comprised of aggregates of smaller particles. Crystalline silica quantification was determined by X-ray diffraction and reveals a link between deposit type and amount of crystalline silica. The mafic samples contained low levels, whereas intermediate and many felsic samples contained greater quantities, some at ~20 wt.%. Surface reactivity analyses indicate a trend between magma type and hydroxyl radical generation, with magmas richer in iron generally generating more radicals. Toxicological experiments (using red blood cells) are currently in progress. To provide a holistic assessment, personal exposure monitoring and background monitoring of dust concentrations allow for the determination of differing exposure based on quarry workers' roles. Risk-perception questionnaires were also carried out with the workers to ensure that any recommendations arising from this study are useful and practical for the people they aim to serve.

METAL MINING IN SOUTH-WEST ENGLAND: PAST PRODUCTION, CURRENT ACTIVITY AND FUTURE PROSPECTS

R. C. Scrivener

Consultant Geologist.

Current high metal prices and the perceived need to achieve security of supply has led to renewed interest and activity in metal mining in Cornwall and Devon. The southwest England orefield extends from the Isles of Scilly to Dartmoor and is delimited by the granite plutons of the Cornubian Batholith and their enclosing rocks. This presentation will review the past production of tin, copper, tungsten and other commodities and will briefly describe the various types of deposit. Most of the historic production has been from hydrothermal veins, worked via an infrastructure of shafts and galleries with tracked haulage and skip hoists. In view of the high cost of this type of mining and its labour-intensive nature, it is likely that future exploration for tin, tungsten and other commodities may be directed to high-tonnage deposits of low to moderate grade, such as sheeted vein deposits, 'stockworks' and disseminated ores amenable to modern mining methods and trackless haulage. The world class Hemerdon tungsten/tin deposit in south Devon, acquired by Wolf Minerals in 2007, is a paradigm for this approach: the deposit, its setting and resources will be described together with a timetable leading to full production in 2014.

SUSTAINABILITY AND ECONOMIC DRIVERS IN THE UK BRICK MANUFACTURING SECTOR; PAST, PRESENT AND FUTURE

A. Smith

Ceram Ltd.

The past 10 years has seen some major changes in the field of sustainability within the construction materials sector. The UK brick manufacturing sector has also seen some major changes over this time period, both in structure and in production volume. Overarching all of this has been the adoption of sustainability, both in concept and action, as a primary business driver.

The paper will present, through case studies and industry initiatives, the past and current situation regarding what sustainability means to the UK brick manufacturing sector, what is measured and reported, and more importantly why and how such a process can be turned from a chore to a business development tool.

Sustainability is an ever changing landscape, and is no longer dominated by carbon issues. In the near future new standard ways of measuring and reporting will be introduced through the development of;

- Harmonised pan European (EN's) and Global (ISO) standards for the declaration of environmental performance of construction products (Environmental Product Declaration, or EPD).
- Product or material specific Product Category Rules (PCR's).
- The European Commission's Resource Efficiency Roadmap.

The aim is transparency and consistency of information, however it does present the construction materials sector with a challenge; more paperwork, more measuring, more reporting, but also an opportunity to continually improve not only environmental performance, but also fiscal performance, by better understanding of everyday business decisions and process modifications.

THE GEOLOGY AND MINERAL RESOURCES OF NORTH WEST ENGLAND

G. Thomas[1] & A. Thompson[2]

[1]University of Liverpool (retired), Cuesta Consulting Ltd[2].

Northwest England, extending from Cumbria and the Isle of Man in the north to the Cheshire Basin in the south, contains a wide variety of commercial mineral resources. The oldest rocks are those of Ordovician and Silurian age within the Lake District. These include the granites, volcanic rocks and metamorphosed sediments within the National Park, some of which are still worked for roofing slates, together with a similar

range of rocks outside the National Park, some of which provide important sources of construction aggregate. The latter include a small area of the Borrowdale Volcanic Group rocks around Millom and more extensive turbidite sediments in southeast Cumbria which both form important sources of High Specification (skid-resistant) aggregates for use in road construction.

Carboniferous limestone, which almost encircles the National Park is extensively worked for crushed rock aggregates and more locally as a source of high purity lime for the steel industry (at Shap Fell) or for building stone. Further south, around Clitheroe in Lancashire, the limestones and associated shales are exploited for cement manufacture. Carboniferous sandstone outcrops within the eastern parts of Lancashire, Greater Manchester and Cheshire are traditional sources of building and roofing stone as well as lower-grade aggregates; whilst the Permo-Triassic Sandstones of Cumbria are also important sources of distinctive red building stone.

Carboniferous coal measures occur extensively at shallow depth within northwest Cumbria, southern Lancashire, much of Greater Manchester, and the eastern parts of Merseyside and Cheshire, but are not currently worked on any significant scale. In all of these areas, there are associated fireclay deposits which are locally utilised for brick making. Deeper coal deposits extend beyond these areas, throughout the rest of the Cheshire basin and in the north of Cumbria, but again are not currently worked.

Permian gypsum deposits within the shales beneath the Eden Valley are worked by underground mining at Kirkby Thore, near Penrith; and Triassic salt within the Mercia Mudstone Group underlies much of the Cheshire Basin, where it continues to be worked by controlled brine pumping and rock salt mining. In the past, 'wild' brine pumping has given rise to spectacular subsidence, though this is now controlled far more effectively.

Quaternary glacial sands and gravels occur extensively within Cheshire and Greater Manchester. The deposits are worked for construction aggregates, especially in the Delamere Forest area, but elsewhere, around Chelford, they are important sources of high purity silica sands, which continue to be used for glass-making in St Helens. More recent superficial deposits include the river terrace and sub-alluvial sands and gravels of the major river valleys, exploited for construction aggregates; the wind-blown Shirdley Hill sand deposits of east Lancashire, which were the original source of silica sand for the glass industry in St Helens; and the inter-tidal sediments of the Ribble, Mersey and Dee Estuaries, which have been exploited at times as a source of building sand.

TOPLEY PIKE QUARRY: A GEOTECHNICAL CASE STUDY

I. Thomas

Aggregate Industries.

On 25th June 2010 following a blast at Topley Pike Quarry a substantial rotational failure occurred within a historical restoration landscape located just beyond the limit of working and immediately behind the face that was blasted. The quantity of material involved was approximately 2,700 tonnes of limestone waste which was heavily vegetated, and at the time of failure was relatively dry. The failure was deep seated, rapid and damaged a power line and public footpath along the valley floor. Extraction from the working face had to continue to the limit of working, to maximise the deposit, and it was imperative that further failures did not occur. By calculating the seismic loading (using vibrograph information, material properties and the slope geometry) a back analysis of the failure was carried out using 2D limit equilibrium analysis software. This work allowed a revised Maximum Instantaneous Charge (MIC) to be determined from the sites regression line, allowing the remainder of the face to be worked with some confidence. This would have been impossible without accurate blast vibrograph records showing both the frequency and peak vibration levels.

The determination of the actual seismic loading and having accurate vibrograph records also provided an economic advantage, as it was possible to minimise the number of explosive decks needed, allowing a normal drill pattern to be used. The back analysis also showed the advantage of using Eurocode 7 for short term loadings, allowing accuracy in future predictions.

WHAT LURKS BENEATH? - THE APPLICATION OF PART 2A OF THE ENVIRONMENTAL PROTECTION ACT 1990 TO LEGACY SITES.

M. Uttley

Hanson UK.

Part 2A of the Environmental Protection Act 1990 came into force in 1995. Following the 'polluter pays' principle, it gave powers to regulators (local councils and the Environment Agency) to serve notice on appropriate persons requiring them to clean-up contaminated land.

Part 2A attempts to find the persons responsible for causing the contamination. There is no limit on how far back in time a regulator can look to find the original polluter, but they can only serve a notice if they or a successor still exist today. The regulator can also serve notice on the current owner / occupier of the land, and / or any intervening owners / occupiers who may have 'knowingly permitted' the contamination to be present and taken no action to prevent it. Many large extractive companies control sizeable portfolios of land acquired over many years often through large acquisitions and mergers. It is possible that some of this land may have been contaminated by 'industrial' processes, past or present. Modern due diligence will normally pick these issues up, but it has not always been the case, resulting in a potential transfer of liabilities.

The paper explores some of the technical complexity involved in identifying contaminated land, much of which may be unfamiliar to an extractive company geologist. The paper also highlights some of the legal complexity involved in properly allocating liabilities under the legislation, and provides some simple recommendations to help make sense of it all.

SETARMS – SUSTAINABLE ENVIRONMENTAL TREATMENT AND RE-USE OF MARINE SEDIMENTS

E. van Veen, J. Coggan & J. Anderson

Camborne School of Mines, University of Exeter.

The English Channel is one of the busiest shipping areas in the world, with many important ports located on both the English and French sides. Both maintenance and capital dredging are undertaken in these ports in order to maintain navigable water depths and develop the port facilities with the consequent economic benefits to the port and surrounding areas. The responsibility for dredging and the regulatory framework in the two countries is very different; however both are faced with large volumes of dredged materials requiring disposal. Whilst for the majority of sediments immersion at sea is the most cost effective solution, where concentrations of

contaminants render them unsuitable for immersion at sea according to nationally defined levels, disposal is more problematic. The SETARMS project was setup with the intention of identifying treatment and re-use solutions for these difficult to dispose of sediments. Options explored have included electrokinetic treatment of the sediments and the use of stabilised sediments in road sub-layers.

The results of the chemical and mineralogical analysis using the techniques of XRF, XRD and QEMSCAN on sediments from 13 ports located on the French and English side of the Channel are presented. Since the project involves a certain degree of anonymity the ports are codified, however ports are identified by country. The implication of the different guidelines for the disposal of the sediments is discussed in terms of the metal content. The mineralogy of the samples is revealed and associations between different phases in the sediment samples from different ports discussed.

EDITED POSTER ABSTRACTS

QUARRY LIFE AWARD: PADESWOOD BIODIVERSITY PARK, MOLD, NORTH WALES, HANSON CEMENT

K. Neal, K. Jackson & G. Lucas

Edge Hill University.

This project, entered for the Quarry Life Award sponsored by HeidelbergCement investigates the feasibility of converting a redundant CKD (Cement Kiln Dust) landfill cell constructed in 2007, and its immediate environs (c.3.5ha), into a biologically diverse haven for wildlife as well as providing a facility for the local community to enjoy. The prime objective of the survey work is to generate an educational (primary school to doctoral), scientific and relaxational resource from an abandoned industrial site, whilst maintaining the benefits of the site's existing biodiversity. The aim is to follow the principles of restoration ecology where any modification or diversification of anthropogenic habitats supports a greater range of species without compromising land use. This is a different approach than previously applied as it does not attempt to re-create or simulate a previous ecosystem state or condition. Although the project is adjacent to a cement plant, the principles have direct application to quarry restoration.

PULVERISED FLY ASH (PFA) - A POTENTIAL SOURCE OF CRITICAL METALS?

R. A Shaw[1] & S. Wood[2]

[1]British Geological Survey (BGS),
[2]Camborne School of Mines (CSM), University of Exeter.

Heightened concerns surrounding the security of mineral supply have led many countries to re-assess indigenous resources, particularly resources of the 'critical' metals. These metals are defined as 'critical' because the risks of supply shortage and their impacts on the economy are higher when compared with most other raw materials. In addition to improving knowledge of primary mineral deposits, resource recovery from waste materials is attracting considerable attention. Pulverised Fly Ash (PFA) is a coal combustion waste product primarily consisting of very fine particles of silicon dioxide (up to 60 %), aluminium oxide (up to 35 %), and iron oxide (up to 40 %). In meeting domestic energy demand the United Kingdom annually produces about five million tonnes of PFA. Approximately 65 % of this material is utilised in applications such as concrete production, highway construction, and ground stabilisation. The remaining 35 % is sent to landfill.

Numerous metallic elements are known to occur in PFA, in concentrations ranging from a few parts per billion up to a several weight per cent; depending on the specific composition of the feedstock coal.. Existing UK-based research is heavily focussed on the environmental impacts of PFA, with a large amount of data reported for the Potentially Harmful Elements (PHEs), such as arsenic, selenium, tellurium, lead, mercury, and chromium present in PFA. However, the potential for recovery of economic concentrations of critical metals from PFA, originating from UK power stations has received limited attention. New research by the BGS and CSM, incorporating new geochemical and mineralogical data, is assessing the feasibility of recovering critical metals, including Rare Earth Elements (REE); gallium, germanium, indium, and niobium, from PFA produced by UK power stations.

GEOLOGICAL FACTORS CONTROLLING IRON OXIDE DISTRIBUTION IN HIGH PURITY LIMESTONE USED FOR GLASS MANUFACTURE

A. Smith

NSG Pilkington.

Pilkington-NSG manufactures glass of consistently high quality and its quality control procedures involve monitoring the geological supply chain of silica sand and other additives to ensure that tolerance limits are maintained. This project, which formed an undergraduate dissertation, aimed to investigate the geological factors controlling iron oxide distribution at one of the limestone additive suppliers; Grange Mill limestone quarry, Derbyshire.

Iron oxide can have deleterious effects in the production of glass. The maximum iron oxide level in limestone for glass intended for low iron applications is 200ppm. Higher levels can have a detrimental effect on the light transmission of glass produced for applications such as solar panel glass.

Geological field work established varying lithologies within and between benches in the quarry. This was followed by detailed geochemical (including XRF) and mineralogical (XRD and SEM and transmitted light thin section microscopy) analysis. A chemical and mineralogical profile map of the deposit was created based on the findings and an attempt to explain the iron variation has been made.

Five possibilities were considered to explain the variation of iron oxide in the limestone received from the quarry. They were:

- Localised ferro-dolomitisation.
- Jointing and fracture patterns controlling the movement of iron oxide enriched groundwater.
- Clay wayboards resulting from the alteration of intervening Carboniferous basaltic pyroclastic activity contaminating the limestone blast piles.
- Fault controlled mineralisation.
- Groundwater contamination from overlying late Carboniferous/Permo-Triassic redbeds.

It was concluded that the main geological factor controlling the iron oxide distribution is contamination from the interbedded iron oxide enriched clay wayboards. To mitigate the potentially problematic iron oxide distribution within the quarry which could affect Pilkington's quality specification, a dilution factor based on bench geochemistry has been devised.