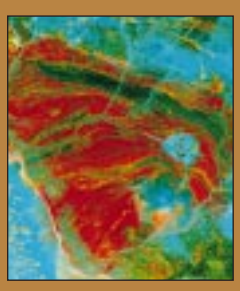
issues

DFID Department for International Development

Earthworks

ISSUE 8 May 1999

Cover picture: Small-scale mining of gemstones, Zambia (courtesy of Kevin D'Souza)



EDITORIAL

This, the eighth, issue of Earthworks includes articles on both current and recently completed projects in the Geoscience sector of the Infrastructure and Urban Development Department's (formerly Engineering Division) Knowledge and Research (KAR) programme. The KAR programme is strongly directed towards solutions that contribute towards poverty alleviation. In broad terms, the strategic aims are to:

- improve the livelihoods of poorer people;
- provide better education, health and employment opportunities, and
- protect people from natural and man-made hazards.

Appropriate small-scale technologies can play an important part. They are often well suited to the use of local materials and may create employment opportunities for poor people, either through the delivery of services or new productive enterprises. Equally important are measures to help develop the necessary policy environment and institutional framework to encourage these opportunities and to protect population. Priorities in the Geoscience sector are as follows:

Theme G1: Promote environmentally sensitive mineral resource development

Theme G2: Improve geological, geochemical and geotechnical hazard avoidance strategies in development planning

Theme G4: Improve understanding of the engineering properties of geological materials in developing countries and develop new engineering and environmental applications for their use

Theme G5: Develop strategies and systems for maintaining and improving national geoscience information services

Geoscience website

World Wide Web sites have been established for each of the KAR sectors. The Geoscience site may be found at: www.bgs.ac.uk/dfid-kar-geoscience. Direct links are provided from this to the other sector websites (addresses on the back page). The Geoscience site provides summaries of many projects, will be added to over time and will include downloadable versions of many of the full reports. The site also provides on-line access to this and earlier editions of Earthworks.

New post

Dr Andrew McDonald, sub-editor for all previous issues of Earthworks, has now left the BGS to join DERA. The Editor would like to take this opportunity to thank him for his very significant past contribution and to wish him well in his new job.

A model scheme of assistance to small-scale miners

Kevin D'Souza, Wardell Armstrong & Nigel Walls, Jay Mineral Services, Project R7181

Kevin D'Souza

Small-scale mining for minerals in Zambia.

The significance of artisanal, or small-scale mining activities, and the numbers of people involved in this sector, are often underestimated. The United Nations estimated that approximately 6 million people were involved in 1996, which is 20 per cent of the world total employed in formal mining activities. With a worker dependence of 4 – 5 this equates to some 24 – 30 million people worldwide dependent on this sector for their survival. With such numbers of people in such informal and unregulated activities, it is easy to understand why donor agencies such as DFID are keen to fund poverty alleviation projects in this sector.

DFID have commissioned Wardell Armstrong as lead consultants together with Jay Minerals Services to design and implement a small-scale mining (SSM) pilot scheme. The team also includes the BGS who provide specific geological expertise and Bugnosen Minerals Engineering who have particular experience of SSM activities around the world.

The aim of this project is to contribute to poverty alleviation via a model scheme that addresses all technological, environmental, social and economic issues that can assist miners, their dependants, and the local community. The model scheme may involve the mining or processing of precious metals, industrial minerals or gemstones. It is planned to establish a pilot scheme in one or more countries as the second phase of the study.

The initial phase of the project has involved researching published reports and visiting numerous countries in order to gain an international perspective of the problems and potential solutions in the SSM sector. This has included a broad-based examination conducted principally by mining engineers and environmentalists. Data has been gathered on SSM projects undertaken in around 90 countries worldwide, including information on the institutional framework, legislation, marketing and other salient factors that govern the sector. This research has involved country visits, library and database searches, and an analysis of detailed questionnaires returned by mines department officials within each country. The result of this exhaustive first phase will be documented for use by international governments to help them implement a formal and structured regime in which to develop their own SSM operations.

The research results will also be used to identify a suitable host country with a substantial SSM sector for a pilot scheme. From this scheme, a generic handbook will be prepared which can be used by mines departments to implement a formal and structured regime to develop and oversee effectively their own country's SSM operations and thereby improve the social and economic status of this important labour-intensive sector.

There is limited literature on small-scale mining and none is available on institutional assistance programmes. If you have any information, suggestions, questions comments or can assist in this project in any form, please do contact us *(address on p8)*.

Congratulations

Congratulations go to Dr Roger Key of the BGS who was awarded the MBE in the New Year Honours list. Roger joined BGS in 1974 and has spent much of his career overseas, principally in Africa where he has worked in Botswana, Kenya and Zambia. The award acknowledges his important contribution to the geology of Botswana where he worked from 1972-1974, 1975-1980 and 1992-1997.

The 1999 award of William Smith Fund by the Geological Society has been made to Dr Simon Young of the BGS. The medal is awarded for excellence in contributions to applied and economic aspects of the science and is intended for those under 40. The citation emphasised the value of the work done in Montserrat which reflected well on the entire project, the many British volcanologists involved, as well as Dr Young's leading part in the project.

Red rice or a red herring? Diet and goitre in Sri Lanka

Don Appleton, Fiona Fordyce & Chris Johnson, British Geological Survey, Project R6227

Goitre is one of a number of health disorders associated with iodine deficiency. Indeed, the discovery of the link between iodine deficiency and goitre probably represents the first recognised association between a trace element's concentration in the environment and human health. Sea water is the main source of iodine in its geochemical cycle so it is rather surprising that so many people are affected by goitre in the high rainfall, coastal zone of Sri Lanka where the maritime influence is likely to be strongest. Recent biochemical and nutritional research has indicated that selenium deficiency also has an important role in thyroid hormone metabolism. Since very little information was available on environmental selenium or iodine concentrations in Sri Lanka, a study was carried out to investigate possible links between these elements in the environment and goitre incidence. The investigation formed part of the KAR project 'Prediction and remediation of human selenium imbalances' and was carried out in consultation with environmental geochemists, biochemists and medical specialists from the Institute of Fundamental Studies and the University of Peradeniya in Sri Lanka.

The concentrations of selenium and iodine in soils, rice grain, and drinking water, as well as human selenium status (indicated by hair analysis), were determined for villages characterised by different goitre incidence rates. Analytical data indicate that the amount of organic matter, secondary iron oxides and clay minerals in the soil, as well soil pH, appear to control the total concentration of selenium and iodine as well as the availability of these elements to food crops. Whereas soil selenium and iodine in the areas with the highest goitre rates are not particularly low, geochemical factors appear to severely restrict their uptake by rice plants. No major differences were detected between the amounts of selenium and iodine in rice consumed in areas with high and low goitre incidence. However, iodine in drinking water is much higher in the villages with low goitre incidence and forms a significant source of dietary iodine to the people living in these villages – all of which are located in the low rainfall zone of Sri Lanka. Hair analysis indicates that a significant proportion of the Sri Lankan population is selenium deficient, although no correlation was detected between selenium status and goitre incidence. It was concluded that selenium and iodine deficiency may both be implicated in the etiopathogenesis of goitre, though neither factor appears to play a dominant role in Sri Lanka.

Whereas iodine deficiency is accepted as the main environmental determinant in the etiology of endemic goitre, there are a large number of naturally occurring agents, called goitrogens, that are known to adversely affect the function of the thyroid gland and interfere with the process of hormone synthesis. Some staple foodstuffs, such as cassava and millet, contain goitrogenic substances that can exacerbate the effects of iodine deficiency. Previous studies in Sri Lanka indicated that foods potentially high in goitrogenic substances, including cabbage and cassava, are not consumed in larger amounts in those areas where goitre is more prevalent. However, during the current investigations, it was observed that red rice is cultivated and consumed mainly in those areas with high goitre incidence. This may be important insofar that red rice is likely to contain flavonoids, which are known to be goitrogenic. Thus, goitrogenic substances in red rice may be a contributory factor and this, along with other potential factors, such as nutritional status, clearly require further investigation.

Woman suffering from goitre, one of the primary health effects of iodine deficiency.

Ongoing projects

R7115, G1 Best practice in small-scale gemstone mining. (Daniel Start, Intermediate Technology)

R7116, G1 Evaluating possible uses of Zimbabwean phosphate based wastes. (Ottos Ruskulis, Intermediate Technology)

R7120, G1 Recovering the lost gold of the developing world. (Mike Styles, British Geological Survey)

R7181, G1 Design and pilot implementation of a model scheme of assistance to small-scale miners. (Jeffrey Smith, Wardell Armstrong)

R6491, G2 Environmental arsenic exposure: health risks and geochemical solutions. (Barry Rawlins & Pauline Smedley, British Geological Survey)

R7118, G2 Cost-effective evaluation of hazards from mine waste. (Ben Klinck, British Geological Survey)

R7117, G4 New hydroponoic and construction uses for porous volcanics (VOLCON). (Steve Mathers, British Geological Survey)

R6839, G5 Implementation strategy for landslide hazard preparedness. (David Greenbaum, British Geological Survey)

R7198, G5 Appropriate technology for low-cost geological mapping. (Eugene O'Connor, British Geological Survey)

R7199, G5 Strategies and systems for maximising geoscience data value. (John Laxton, British Geological Survey)

R7200, G5 The societal value of geoscience information in LDCs. (Tony Reedman, British Geological Survey)

New projects

G1 Low-cost lime for small-scale farming (FARMLIME). (Clive Mitchell, British Geological Survey)

R7354, G1 Mercury-free coal-gold agglomeration (CGA) process for gold. (Professor Michael Mingos, Imperial College of Science Technology and Medicine)

G1 Local phosphate resources for sustainable agriculture. (Don Appleton, British Geological Survey)

G1 Sustaining communities through mine waste reclamation. (David Harrison, British Geological Survey)

G2 Environmental controls in iodine deficiency disorders. (Chris Johnson, British Geological Survey)

G4 Bentonite-enhanced soils technology transfer. (Tony Di Stefano, Knight Piesold Ltd (KP))

G5 Protecting vulnerable small islands by improved forecasting and warning. (Professor Bill McGuire, Benfield Greig Hazard Research Centre)

Appropriate technology for low-cost geological mapping

David Greenbaum, British Geological Survey, Project R7198

Although the skills needed for systematic geological and geochemical data gathering often exist locally within national geological survey organisations (GSOs), traditional approaches tend to be slow and expensive. More rapid techniques are needed if the deficiency in geoscience information in developing countries worldwide is to be redressed within a reasonable time frame and cost. Modern technologies can, when applied in an appropriate manner, help to achieve this. The aim of this project is to develop practical systems that can provide geological surveys with the information needed for them to make decisions on, and implement, cost-effective, appropriate and sustainable technology solutions.

Various affordable technologies now exist that can contribute towards increased data gathering efficiency and quality. These include the use of satellite and aerial remote sensing, global positioning systems (GPS), geographic information systems (GIS) and digital mapping. Other recent advances, such as the use of total-station binoculars which can be linked to GPS, may also be appropriate under special circumstances. The technologies can be used individually or in various combinations and at different levels of sophistication. At an entry level, for example, GSOs may choose simply to purchase bulk-processed optical or radar satellite imagery to provide an up-to-date topographic base map and basic geological interpretation. At a higher level, they may decide to develop a full in-house image processing capability and/or adopt GPS for locational control in both mapping and geochemical surveys. Such decisions will depend upon individual country circumstances, and it is essential that such decisions are made in the full knowledge of both the likely benefits and costs. This project will try to show how such technologies can be integrated with conventional approaches to improve the rate of coverage and data accuracy. The move to digital techniques will further mean that data are held in a form that is more amenable to modern exploration and development needs.

In order to ensure that take-up is sustainable, it is important that developing countries are provided with the right information to enable them to make decisions. Appropriateness is a key issue in take up and must be measured in relation to a country's data gathering needs, skills base, infrastructure, budgets, geological setting, climate etc. The project will attempt to establish decision rules on how to approach such choices. This will be provided via an interactive World Wide Web system capable of generating country-specific reports containing only information that is relevant to local circumstances. In effect, this will act as an expert system providing free consultancy-style advice.

The design of any system of this sort requires a clear understanding of the types of local problems faced by GSOs. In order to ensure that the system provides meaningful, comprehensive and understandable information presented in the best possible way, the BGS is working with collaborators in the GSOs of Mongolia and Guyana to look at these issues and to decide how such approaches should be implemented. Initial studies will involve field trials to try to model these decision processes so that the systems eventually developed can more effectively match real needs.

Collaboration with the Mineral Resources Authority of Mongolia. The author is pictured with its Director, Dr O Chuluun.

GEOSCIENCE INFORMATION

National geological survey organisations (GSOs) are responsible for collecting, archiving, processing and making available data concerning that unique portion of the Earth's crust which forms the foundation of their nation's territory. In doing so they provide a national geoscience information service available to the nation's public and private sectors, to governmental and non-governmental organisations and to individuals within the population at large. Such information is fundamental to the sustainable development of their nation's earth resources and the protection of its peoples from a wide variety of natural hazards. A recent meeting at the British Geological Survey of the heads of 27 Commonwealth country geological survey organisations highlighted the difficulties many are experiencing in providing an adequate national geoscience information service. Accordingly, the BGS, in collaboration with a number of individual developing country GSOs and regional geoscience organisations, has commenced three DFID-sponsored KAR projects aimed at developing more cost-effective methodologies for collecting basic geoscience data in the field and at storing, processing and disseminating such data. These projects (R7198, R7199 and R7200) are described on these pages.

Strategies and systems for maximising geoscience data value

John Laxton, British Geological Survey, Project R7199

Access to geoscience information is essential to the decision making process in many key areas such as inward investment, resource development, environmental protection, urban planning, and the development of water, mineral and hydrocarbon resources. However, the information must be in a form that is readily available, both to national policy makers and to potential international investors.

The cost of developing a geoscience information system from first principles is large and the skills and

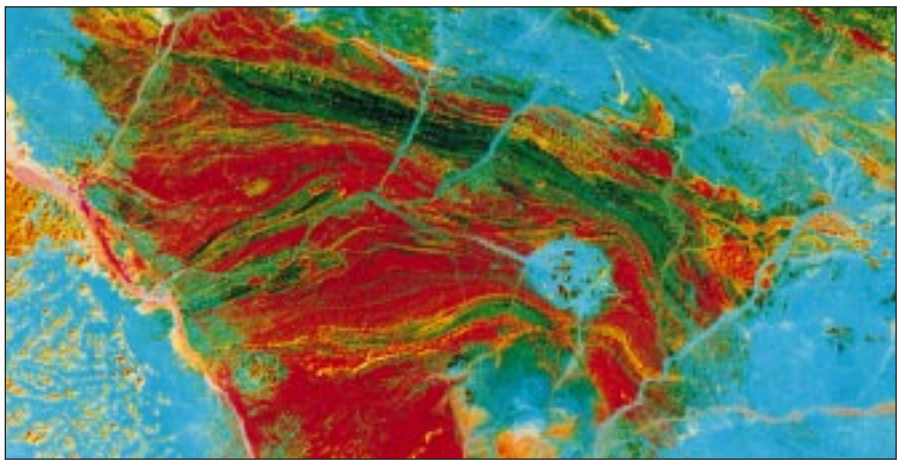
experience required are scarce. This project aims to assist in the organisation of geoscience data by developing data handling, validation and management procedures, as well as high-level metadata indices. The project also aims to provide a standard data structure along with a GIS interface to facilitate data access, querying and integration, and a World Wide Web (WWW) site for data dissemination and sharing.

No two geological survey organisations (GSOs) will have identical requirements and it is therefore not possible to provide a complete IT solution that will fully meet the requirements of all GSOs. The aim of the project is rather to provide a generalised core template which individual GSOs can develop further to meet their own specific requirements. It is not therefore intended to provide a single package which has to be adopted in its entirety or not at all, but rather a set of integrated guidelines, procedures and applications which link together but nevertheless can be adopted selectively as GSOs deem appropriate. Different GSOs will therefore be able to come into the system at different levels, for example some may be primarily concerned with the organisation of their data prior to any IT implementation, whereas others may have digital data at project level and be interested in guidelines on how to link these together to form a corporate database.

If the systems and strategies developed are to be utilised it is essential that they are firmly rooted in the reality of GSOs' requirements. The project will work closely with the GSOs of Botswana, Malawi, Indonesia and Malaysia to define the requirements and to test the systems using real data and real problems. It is considered that these GSOs, along with BGS experience in working in many other countries, will provide a representative picture of GSOs more generally, both in terms of geographic distribution and level of IT development.

As the project aims to develop techniques with a wide applicability, it is essential that the project results be widely disseminated. To achieve this it is proposed to use the WWW to allow access to an online implementation of the system, using trial data provided by our partner GSOs, and to allow the download of applications and documentation. It is also intended to use the WWW to train users in the strategies and systems developed in the project, and distance learning methods will be developed by the project to enable self-tuition. It is further hoped that the use of the WWW will ensure that the results of the project continue to be readily available after the project has finished and will provide the means by which countries can collaborate directly with one another and pool experience.

The use of the strategies and systems developed by the project will facilitate the exchange of information, as common data standards will exist across national boundaries. This in turn will aid the building of regional geological models and provide easier access to the data by outside organisations, thus increasing the likelihood of inward investment.



Ophiolite rocks in the Precambrian basement complex of the Eastern Desert, Egypt. Remotely sensed images can reduce costs and improve the efficiency and information content of geological mapping.

The societal value of geoscience information in less developed countries

Tony Reedman, British Geological Survey, Project R7200

The two companion KAR projects described here are concerned with methodologies for the more efficient and cost-effective provision of a national geoscience information service. A clear assumption is that such a service achieves significant and diverse economic and social benefits and represents value for money to the national exchequer.

While few would doubt that such benefits exist, little attempt has been made to evaluate the programmes that contribute to the national geoscience knowledge base in cost-benefit terms. There are good reasons for this. Firstly, there are methodological difficulties associated with the measurement of benefits and secondly, few scientists or public institutions have had to justify their work by measurable indicators. This situation is changing, however, with those in charge of public finances increasingly keen to ensure better spend targeting and efficiency.

During the course of the DFID-KAR project 'Geological Surveys in Developing Countries: Strategies for Assistance' (R6229), many developing country geological survey organisations (GSOs) and regional organisations representing geological surveys highlighted a need to evaluate mapping programmes, and other work, in cost-benefit terms. From the GSO perspective, there is a clear belief that such programmes represent excellent long-term value for money because of their potential contribution to economic development. However, they argue, with some justification, that value could be highlighted and communicated with more authority if it could be demonstrated quantitatively. From government and donor perspectives too, there is a clear demand for better evaluation; both face competing demands for scarce finances, and establishing priorities is difficult when alternatives cannot be compared in common and consistent terms. Assigning monetary values to at least some of the programmes of geoscience institutions would make for more balanced appraisals, narrowing the field for pure judgement and providing a more secure and transparent basis for policy development.

The current project will explore the feasibility of applying cost-benefit analysis to the types of surveying programmes that are common to most GSOs. The methodologies developed need to be relatively simple and amenable to application at low-cost by organisations in developing countries who do not have routine access to expertise in economic analysis.

Having reviewed and identified the main costs and likely benefits of a variety of GSO surveying programmes, a more detailed and quantitative analysis of two major projects, one in Zimbabwe and a second in Indonesia, is being attempted. The projects selected (a systematic regional geological and geochemical mapping programme covering the whole of Sumatra, Indonesia, and a structural mapping programme of the Midlands goldfield in Zimbabwe) are ones which focused on a specific purpose. This purpose was the provision of information likely to stimulate increased investment in mineral exploration and mine development by the private sector, a policy imperative of the governments of both countries concerned.

Depending on the success of the two case studies, it is hoped to collaborate with other developing country GSOs in a qualitative test of our methodologies on some of their other programmes that could potentially illustrate the costs and benefits of the geoscience information that they provide as part of their national geoscience information service.

Appropriate landfilling of solid waste

Mansoor Ali & Andrew Cotton, Water, Engineering, and Development Centre, Loughborough University, Project R6842

The purpose of this project is to contribute towards improving the current, largely inadequate, practices of municipal solid waste disposal which prevail in low-income countries. The final output of the research project will be a framework for considering options for the disposal of municipal solid waste in developing countries together with a review of guidelines for landfilling. Solid waste management has received little attention. It is a complex topic embracing waste collection, transfer, haulage and disposal. Its impacts are wide, encompassing, for example, environmental health, quality of environment, municipal finance, municipal management, waste reuse, and informal sector employment. It is therefore important to take a broad view of the issues raised and not to consider disposal options only within the narrow confines of a particular technology. Whilst investigating landfill sites in low-income developing countries we found a number of common key issues:

- Institutional capacity in low-income countries is limited to planning, operating and managing landfill sites to acceptable standards.
- Development of a disposal site requires a large capital investment which may not be available locally.
- Cost recovery for the centralised facilities such as landfills is an issue when many waste management authorities are struggling to collect charges for the waste collection and transportation.
- Existing standards for disposal sites are generally borrowed from high-income countries and may not be appropriate for low-income countries due to available resources, institutional capacity and differences in waste composition and climates.

The landfill practices at the study sites are at an early stage of development. The common practice in all of the cities studied is to remove the waste from major commercial and residential areas and transport it to the open areas. In Addis Ababa, Ethiopia, there is an officially demarcated waste site but there is no practice of environmentally safe landfill operation as defined in high-income countries.

Landfill design guidelines for low-income developing countries must be appropriate and affordable keeping in view the local factors. To develop guidelines for the selection of disposal options it is important to fully understand the technical, institutional, financial, environmental and social framework. A detailed analysis of these factors for Karachi, Pakistan, for example, revealed that although the Karachi Metropolitan Corporation is moving towards designing a landfill site on a selected piece of land, there are still many factors to be considered to make the changes work. The findings support our presumptions about the technical factors; however, the institutional, environmental and social factors are not favourable to support any landfill development in a sustainable manner.

Dr Mansoor Ali

Solid waste disposal sites are a source of livelihood for a number of poor and weaker sections of the society. Here, waste pickers are sorting out paper and plastics from the collected waste.

The research provides a review of practices from which detailed design guidelines will be developed. Since landfill planning is currently underway in a number of developing countries, it is important to encourage their early use in such projects. We have found considerable interest in the findings from municipal corporations, environmental NGOs and international experts, and some authorities have already contacted us. Additionally it is hoped that the research findings will be applied in developing a pilot-scale landfill site.

Local development of affordable lime in southern africa

Clive Mitchell, British Geological Survey, Project R6492

An often overlooked basic requirement in food production is the need for agricultural lime (aglime) which is used to maintain the soil at the correct pH. Aglime is usually ground dolomite and limestone, although hydrated burnt lime is occasionally used. In many less developed countries, such as Zambia, soil conditions have in some areas been allowed to deteriorate. In northern Zambia, for example, high rainfall actively leaches out soil nutrients which, coupled with the use of substantial amounts of artificial fertilisers, has resulted in highly acidic soils. This has led to reduced crop yields, significantly affecting the livelihood of small-scale farmers. The use of aglime would quickly remedy this situation. However, the centralised nature of aglime production, the high cost of transportation and a lack of awareness of its benefits have constrained its use. It was estimated that in 1995 the potential demand for aglime in Zambia was 140 000 tonnes per annum, but actual consumption was only 37 000 tonnes.

This project, completed in March 1998, focused on Zambia, following the recommendations of a survey of the lime industry in the Southern African Development Community (SADC) region. It was carried out by the BGS in collaboration with the Zambian Geological Survey Department and Intermediate Technology Zimbabwe. An initial market survey found that local demand for aglime was suppressed especially in the more remote northern provinces and in those provinces which are heavily cultivated. It also confirmed that poor availability and relatively high cost were the main constraints on aglime consumption.

A review of the carbonate resources of Zambia indicated that limestone and dolomite, potentially suitable for aglime production, occur in all the main

agricultural areas. Appropriate laboratory test methods were identified to evaluate the suitability of local limestone and dolomite for use as aglime. Limestone and dolomite samples collected from 20 sites across Zambia were tested to determine the following properties:

- plant nutrient content;
- neutralising ability (or value, NV);
- particle-size distribution;
- agronomic effectiveness, the rate at which aglime neutralises soil acidity, and, ease of pulverisation (or grindability).

Eight samples, from prominent farming districts, were identified as being suitable for use as aglime. Research was also undertaken to identify a low-cost method for the small-scale production of aglime. A review of existing lime operations in Zimbabwe determined that the most appropriate method involved contract stone extraction, manual crushing and stone dressing, mechanical milling and manual bagging. A basic requirement was for a simple, cost-effective mill to grind the limestone to a fine powder. The Technology Development Advisory Unit at the University of Zambia carried out small-scale production trials on a Zambian built hammer mill designed and normally used for the milling of maize. Bulk samples of dolomitic limestone from Mkushi in Central Province were successfully milled and the resulting product was sufficiently fine-grained to be used as aglime.

This work will be further developed under a new KAR project 'Low cost lime for small-scale farming (FARMLIME)' due to start in September 1999 which aims to demonstrate the effectiveness of appropriate lime production technology by establishing a small-scale lime plant in Mkushi, central Zambia. This project will also involve crop trials as a means of demonstrating to sceptical farmers the benefits of using agricultural lime.

Industrial minerals workshops

David Morgan, British Geological Survey, Project R7119

The last ten months have seen an intense period of activity, with eight workshops conducted in three continents. Most of these were in Africa – Tanzania, Mozambique, Angola, Ethiopia and Cameroon – and the remaining three in Thailand, Jamaica and Colombia.

Three of the workshops, in Tanzania, Colombia and Thailand, were also attended by participants from surrounding countries. They covered not only exploration, laboratory assessment and use-related testing of industrial minerals, but the use of this information for formulating responsible long-term strategies for resource management and land-use planning. Applications of industrial minerals in environmental protection, and environmental impact assessment of extraction operations, also featured strongly. The country-specific workshops concentrated more on assessment procedures for aggregates and building materials and other basic industrial minerals that are essential for infrastructure development and economic growth in developing countries. As well as the usual visual aids, the workshops were supported by video presentations and computer displays, and extensive literature on laboratory testing and field evaluation of industrial minerals, together with reports of industrial minerals projects carried out by the BGS both in the UK and internationally.

Core funding for the workshops was provided by the DFID KAR programme and the World Bank Information for Development (InfoDev) programme, with extra resources being provided by the United Nations Industrial Development Organization (UNIDO), the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP), the Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP), the Korean Government and, of course, geoscience organisations in the host countries

In all, over 250 people attended this series of workshops, these being drawn from senior levels in government, geological surveys and mines departments, the private sector (producers, users and consultants) and academia. Discussions confirmed that lack of adequate funding for investment is probably the major constraint on the development of industrial minerals in emerging economies. This is mainly because the importance of industrial minerals to the economic development of a country is still not clearly understood. Many developing countries lack a comprehensive databank of industrial mineral deposits which ideally should contain information on resources and reserves, quality, production, demand, and information on imports vs. exports for each commodity. Information on commercially important specifications, is not generally available, often as a result of the lack of proper equipment for testing. In many countries there is a dearth of modern mineral processing equipment, including that for laboratory, pilot-plant and industrial work. Similarly, much mining equipment may be old and poorly maintained. A continuing problem is the lack of sufficient expertise within a country to design and carry out exploration projects in the non-metallics and construction sectors. Other problems, which increasingly apply to development of both metallic and industrial minerals globally, are restrictions on land use resulting from national and regional government policies, and ever-increasing environmental legislation and pollution control measures. There was general agreement that these problems were common to most developing countries and that they were best approached on a regional basis. A very positive step was taken at the Tanzanian workshop, held at the Southern and Eastern African Mineral Centre, Dar es Salaam, where the African Industrial Minerals Network was conceived and inaugurated. The aims of AIMnet are to enlighten governments of the importance of the industrial minerals sector to the development of a diverse industrial economy, to foster regional cooperation in industrial minerals ventures, and to promote local private sector entrepreneurs, including small-scale miners.

Participants in the workshop that took place in Ethopia in December 1998. Inset picture *The author pictured with the Chief Geologist of the Ethopian Institute of Geological Surveys.*

Topics dealt with in regional industrial minerals workshops

- **The importance of industrial minerals to developing countries**
- **Exploration for industrial minerals: methodologies and models**
- **Minerals for markets: evaluation strategies**
- **Reserves vs. resources — the importance of correct terminology**
- **Raw materials for construction, including waste and recycled materials**
- **Industrial minerals for environmental applications**
- **The environmental impact of mining and processing industrial minerals**
- **Maps and databases for mineral development planning**
- **Industrial mineral inventories and investment promotion exercises**

Offshore aggregates in south-east Asia

Chris Evans, Ceri James & Dave Harrison, British Geological Survey, Project R6840

Most of the major cities in south-east Asia are built along the coast and there is consequently an ever increasing pressure for land, and protection of the existing low-lying land. The demand for the land is met by reclamation, the creation of new land by building up areas susceptible to flooding, or extending the existing land out into the sea. Increased protection of the low-lying land is afforded by constructing sea defences or beach renourishment schemes. The largest example is the new airport in Hong Kong, but similar developments may be found across south-east Asia. The materials for this construction commonly come from offshore, since the available resources onshore are in limited supply, the infrastructure is not in place to deliver such volumes, and the supply from offshore may be, on balance, an environmentally more sensitive option. This project aims to describe the necessary steps to proceed from a reconnaissance survey for the location of such resources through to the environmental impact assessment necessary to evaluate the consequences of the extraction.

The location and extraction of these materials, collectively known as aggregates, from offshore requires a range of approaches which have been used extensively in north-west Europe over the past two decades, and more recently in Hong Kong waters. Different uses require different type of sediment; aggregate to be used for concrete has a tightly specified grain size, as has that used for beach recharge, but the grain size of sediment used as reclamation fill is less rigidly specified though the volumes required are very much higher. Experience around the world has identified offshore aggregate resources from three main geological environments: (1) valleys incised and filled during or after the last period of low global sea level which reached a maximum about 18 000 years ago; (2) sand sheets and banks now moribund, left when sea level was rising during the period from about 10 000 to about 5000 years ago; and (3) the sediments moved and formed by the modern tidal regime. The geologist can identify these different environments by interpreting seismic profiles and side-scan sonar records which may then be ground-truthed by sea bed sampling or coring. An initial reconnaissance survey of an area is based on a wide sampling grid with a subsequent tighter grid for the prospecting study focused onto areas of real resource potential. From this data a geological model of the resource block is created, the volume of reserves calculated, a classification of the sediment made, and an extraction strategy worked out.

The economics of extraction depend on many factors including the scale of the exercise, the type of dredgers available, the water depth and the logistical restrictions. To be economic, the distance from the extraction to landing site must be minimal, and a smooth turn around of vessels planned.

Great care must be taken that marine aggregate extraction does not damage the environment. Potential problems include the impacts of the suspended sediment plume generated by the dredging on aquaculture, such as shrimp farms; the destruction of the seabed environment; and the change in sea-bed morphology possibly leading to enhanced erosion of the adjacent coastline. In order to limit such effects an environmental impact assessment is essential prior to the issuing of a dredging licence by the local government. The project report sets out the topics to be included in such an assessment.

The main message of the report is that careful planning of offshore aggregate extraction is essential to develop the most economic approach with minimal associated environmental impact.

Earthworks is published by:

The British Geological Survey on behalf of the Department for International Development.

The views expressed are not necessarily those of DFID.

Editor: Dr David Greenbaum
Sub Editor: Dr Joanna Thomas
Design: Adrian Minks
Production John Stevenson
Printed by: Lithgo Press Ltd, Leicester
PRINTED ON RECYCLED PAPER

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