

■ TDR GEOSCIENCE
PROJECTS

New projects and
continuing research
for 1997 *Page 3*

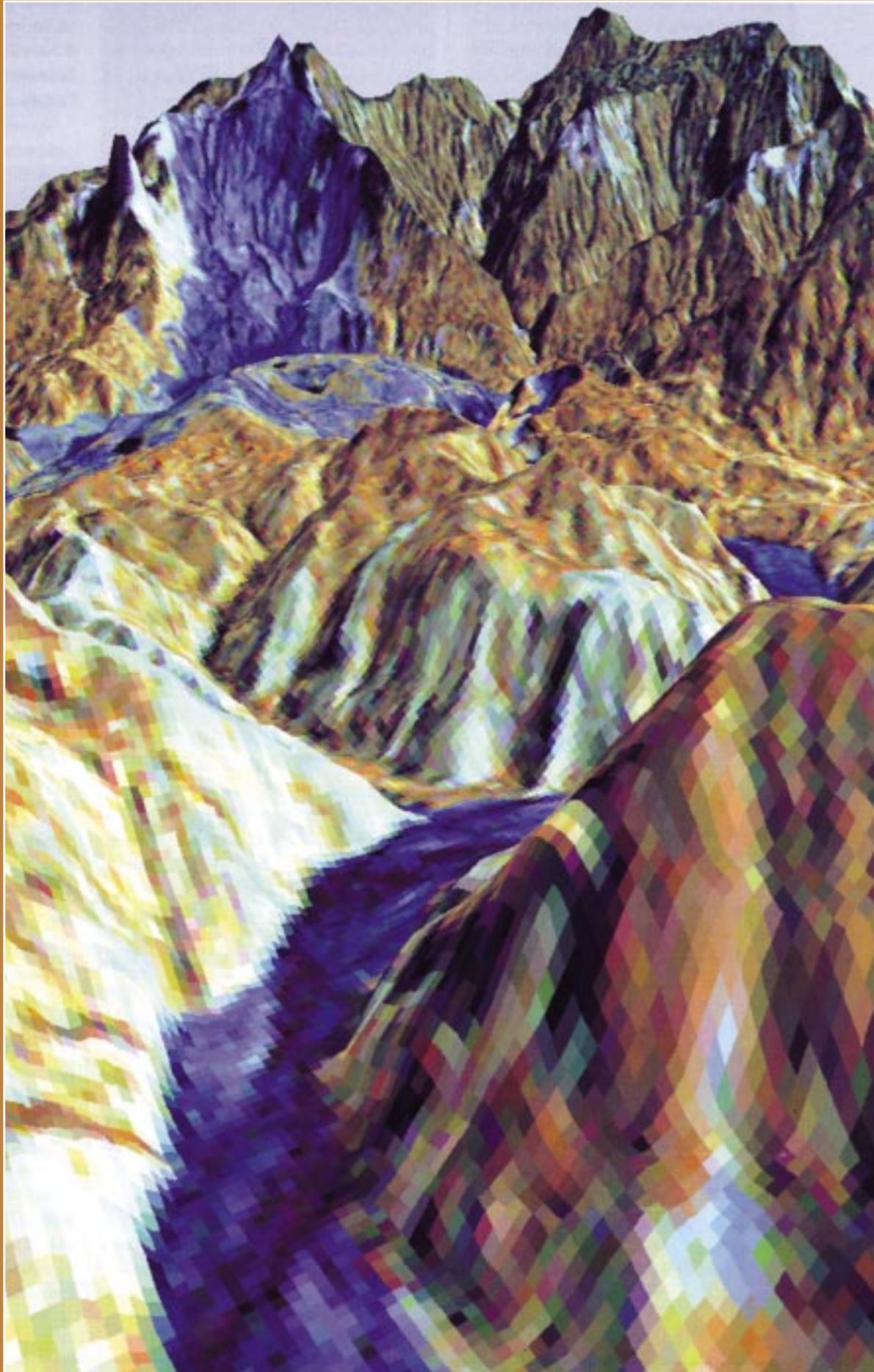
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*Picture right: Computer
generated view of Papua
New Guinea landslide using
satellite and terrain
information*

EDITORIAL

We are asked to inform our readers that the Department for International Development (DFID) replaces the Overseas Development Administration (ODA) on 2 May 1997. We are also delighted to report that *Earthworks* lives-on. After a review of Issues 1 to 3, and the positive responses that *Earthworks* and its sister newsletters in the other sectors of the Technology Development and Research (TDR) programme have elicited, the DFID is continuing to support further issues.

For the benefit of new readers, and as a gentle reminder, perhaps, for those who are not so new, *Earthworks* is the newsletter for the Geoscience sector of the TDR programme which is managed by the DFID Engineering Division. The TDR programme seeks to apply science and technology practically to problems constraining development in developing and emerging countries. *Earthworks* aims primarily to disseminate information on the work in the Geoscience sector, to encourage further enquiry and interest, and to help promote the take-up of project results and methodologies in the developing world.

This issue lists three new Geoscience TDR projects as well as all the continuing projects. However, it highlights current projects which develop the applications of geoscience, particularly geochemistry, to environmental and health-related problems in the developing world. In implementing these investigations, the project staff are collaborating not only with sister geoscience organisations but also with environmental health and medical research organisations in the UK and the developing countries. This collaboration exemplifies TDR in action in the best sense of the term and is bringing together disciplines which have more in common than might be imagined.

DFID and TDR on the Internet

The text of the TDR newsletters is accessible on the Internet through One World Online, which is supported by the DFID. The One World Online address is: <http://www.oneworld.org/> and the DFID homepage can be found at:

<http://www.oneworld.org/dfid.index.html>.

Enquiries about specific articles and project information featured in *Earthworks* should be addressed to the named contributor or to the Editor, for onward transmission.

Your help please

To be effective in its aim of providing information about the DFID TDR Programme, *Earthworks* must reach the correct people. If you no longer wish to receive *Earthworks* or you receive surplus copies, please inform the Editor. This will allow the mailing list to be updated and so optimise the dissemination of information.

The Princess Royal visits BGS

Volcanic monitoring, the contribution of geochemistry to health and groundwater exploration were among the subjects described to the Princess Royal during her visit to the headquarters of the British Geological Survey in January. The visit emphasised the role of geology in development and emergency aid by focussing on a number of DFID funded projects. The continuing volcanic crisis on Montserrat and its effects on the island's population were described by a

member of the Montserrat Volcano Observatory monitoring team. The Princess was shown how selenium affects the health of regional populations in China (see centre pages). Aspects of the search for groundwater resources in Africa were described and the use of satellite imagery for landslide hazard assessment demonstrated. To mark her visit BGS staff presented the Princess with a donation for Save the Children Fund, the charity of which she is the President.



The role of geochemistry and health being shown to the Princess Royal.

Credit: Newark Advertiser

Geological Society of Africa (GSA)

The GSA was established in the early 1970's to promote geoscience development and collaboration throughout the continent. It supports national and regional geoscience organisations in arranging meetings, workshops and training courses and holds its own triennial conference, the next in 1998. In 1997 it is supporting, among other events, a workshop in Harare, Zimbabwe on geoscience education (see under *Forthcoming Meetings*, page 8 this issue). A fuller account of the Society appears in *Episodes* (vol.19 no.3, September 1996). GSA welcomes new members, individuals and institutional, who are working or have worked in Africa and have interest in the development of geoscience in the continent. Details may be obtained from the Editor.

Technology take-up in Kenya

ARESCAN resistivity imaging system, donated through the TDR programme by DFID funding, has been used successfully in local geotechnical site investigations by the Materials Testing and Research Department (MTRD) of the Ministry of Public Works and Housing, Kenya. Used at the site of a proposed earthwork dam, the system located a number of underground cavities. Similar cavities have caused leakage at an existing dam near by. The results of the survey helped in the siting of investigative boreholes. MTRD has also used RESCAN in the Nairobi area to find areas suitable for siting new power pylons. RESCAN was first used in Kenya during a BGS/DFID TDR project looking to prevent the collapse of road embankments (Project R5558, *Earthworks*, March 1995).

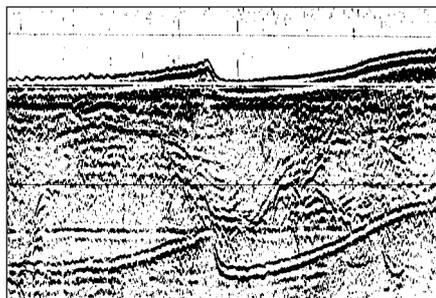
NEW PROJECTS FOR 1997

Effective development of offshore aggregates

*Dr Chris Evans,
British Geological Survey,
Project Ref. R6840, Theme G1.*

Much of the growth of southeast Asia is taking place in coastal cities, leading to increased demand for marine aggregate, both for construction and fill purposes. Badly planned extraction of these offshore resources can damage the offshore and coastal environments, and mis-uses a non-renewable resource. This project combines the geological expertise of the BGS and the commercial skills of DEMAS in the exploitation of offshore aggregate resources.

BGS will address the geological setting of the resources and develop conceptual models to assist with resource exploration. DEMAS will describe the data required to calculate reserves and the practical problems that need consideration when a resource body is evaluated. Together they will address the issues of licensing offshore aggregate extraction and subsequent monitoring. Present practice will be evaluated in Malaysia, Indonesia and Thailand.



Sparker seismic trace of the north coast of Sarawak showing sandwaves with infilled channels beneath.

The results of the project will be published as a report setting out best practice guidelines for the region, drawing also on experience in the UK, the Netherlands and Hong Kong.

Implementation strategy for landslip hazard preparedness

*Dr David Greenbaum,
British Geological Survey,
Project Ref. R6839, Theme G3.*

Each year landslides cause significant damage in developing countries. Here the effect of landslides on the local population and economy is proportionally greater than in the developed world. Although the risk is known to be high in these areas,



Papua New Guinea village destroyed by landslide following an earthquake. The only building left standing is the church at the edge of the landslide scar.

often very little information exists on the extent of landslide hazard. Consequently, avoidance planning is almost non-existent.

A previous project (*Rapid methods of landslide hazard mapping*, R5554, Earthworks, March 1994) established a simple, robust technique for assessing regional landslide hazard in mountainous tropical terrain. Landslide susceptibility zones can be mapped quickly by the combined analysis of remote sensing imagery and existing geological, topographical and land-use information. The technique relies on Geographic Information System (GIS) computers for data analysis and result presentation. The new project will develop the method by exploring how the different parameters interact, by examining the tests used to assess the validity of the model and determining how best to quantify the degree of hazard, thereby defining a generally applicable technique.

Dissemination of the results is an important part of this project. Information will be given to geological surveys, local government, emergency planning authorities and NGOs, all of which are involved in the reduction of natural hazards. The main output will be an implementation guide understandable by planners and geotechnical specialists. Training workshops will be held in the regions in which the technique is developed and tested.

Other Projects

Appropriate landfilling of solid waste Dr A P Cotton, Institute of Development Engineering, Project Reference R6842, Theme G1.

CONTINUING GEOSCIENCE PROJECTS

Unbound granular materials (M J O'Connell, Transport Research Laboratory), Project reference R5605, Theme G4.

Natural gravels for road building (P A K Greening, Transport Research Laboratory), Project reference R6020, Theme G3.

Slope maintenance and protection (J Beavan, Transport Research Laboratory), Project reference R6025, Theme G3.

Minerals for development workshops (D J Morgan, British Geological Survey), Project reference R6224, Theme G1.

Procedures for the rapid assessment of limestone resources (D J Harrison, British Geological Survey), Project reference R6225, Theme G1.

Mitigation of mining-related mercury pollution hazards (T M Williams, British Geological Survey), Project reference R6226, Theme G2.

Prediction and remediation of human selenium imbalances (J D Appleton, British Geological Survey), Project reference R6227, Theme G2.

Cerium and endomyocardial fibrosis in tropical terrains (B Smith, British Geological Survey), Project reference R6228, Theme G2.

Training and policy guidelines for artisanal quarrying (N L Hall, Intermediate Technology), Project reference R6487, Theme G1.

Treatment of contaminated land using diatomite (K Atkinson, Camborne School of Mines), Project reference R6488, Theme G2.

Development of bentonites for use in urban waste disposal (M Cambridge, Knight Piesold), Project reference R6489, Theme G4.

Environmental arsenic exposure: health risks and geochemical solutions (T M Williams and P L Smedley, British Geological Survey), Project reference R6491, Theme G2.

Local development of affordable lime in southern Africa (C J Mitchell, British Geological Survey), Project reference R6492, Theme G1.

Geoscience information system for mineral development (J S Coats, British Geological Survey), Project reference R6635, Theme G5.

GEOCHEMISTRY AND HEALTH

Using geochemistry to investigate selenium deficiency diseases

Dr Don Appleton, British Geological Survey, Project Ref. R6227

Selenium (Se) is an essential trace element for human, animal and plant health. It is important in many metabolic functions and some biological enzymes which remove chemicals believed to impair cell membrane structure and function, promote hardening of major arteries, and activate carcinogens.

diation of human selenium imbalances (R6227). This project will develop a methodology for delineating areas where selenium deficiency or toxicity may pose a health risk. The environmental geochemical controls on the distribution of Se-responsive diseases are also being evaluated.



Collecting soil samples for selenium analysis.

In China, endemic incidences of Keshan disease, a heart muscle disease, and osteoarthritis, which causes deformity of affected joints, are associated with areas with extremely low environmental selenium concentrations. The causes of Keshan disease are not well understood but may be linked to an infectious virus. Experiments show that the virulence of these viruses is enhanced by the low selenium nutritional status of the population. The trace mineral status of rural populations in developing countries closely reflects that of their local environment. Geochemical studies may be able to identify those areas at greatest risk and help the investigation of the causes of diseases for which trace mineral status is thought to be a factor.

BGS is collaborating with the Institute of Rock and Mineral Analysis, Beijing, and the county Public Health Bureaux and Endemic Disease Prevention Department in a project entitled *Prediction and reme-*

Over the last two years, the project has analysed samples of soil, grain, human hair and drinking water from five villages with low disease incidence, five with moderate and five with high disease incidence. The sampling procedure involved collecting a human hair sample, then a sample of grain which was the person's staple dietary intake, and then a sample of soil from the field in which the grain had been grown.

People living in the relatively isolated rural areas of China where Keshan disease is most prevalent obtain most of their selenium intake from cereals grown on Se deficient soils. The relationship between Se levels and Keshan disease incidence in the Zhangjiakou area, Hebei Province follows the expected trend in hair, water and grain (i.e. the lowest levels of Se occur in the villages with the highest Keshan disease incidence rate). However, total Se in soils is highest in those villages with the highest incidence of Keshan disease, which is

the reverse of what would be expected. Total Se in the soils is controlled by the amount of organic matter which retains the Se so making it not readily available to plants. All the villages are characterised by very low water soluble Se concentrations in soil so this information can not be used to discriminate between low and high disease incidence villages. Selenium concentrations in hair are broadly related to the environmental Se status of an area but are very variable. In general, it appears that grain Se appears to be the most reliable indicator of local environmental concentrations of Se and Keshan disease incidence.

The methodologies developed by the project are being used to study other Se-related diseases in Sri Lanka in collaboration with the Institute of Fundamental Studies, Kandy and the University of Peradeniya.

Cerium and infantile heart disease

Dr Barry Smith, British Geological Survey, Project Ref. R6228

Cerium (Ce) is the most abundant of the rare earth group of chemical elements and is commonly found throughout the world. Environmental levels of cerium have been considered, in the past, to be non-toxic. In the late 1980's however, medical workers from India noted a strong link between endomyocardial fibrosis (EMF), a fatal coronary condition in children throughout the tropics, and increased environmental levels of cerium in Kerala province. Subsequent laboratory studies have substantiated that cerium is potentially toxic at a cellular level but have not adequately established the relative importance of exposure pathways or the relationship between EMF and cerium in other similarly affected communities. Collaborative research undertaken by BGS, the Mulago Hospital, The Institute for Child Health (Gt. Ormond Street) and Makerere University is investigating whether similar environmental exposure to cerium can account for the occurrence of endemic EMF in Uganda where it is a major cause of coronary disease amongst those aged 3 to 35 years.

Case control studies performed at the Mulago Hospital, Kampala, indicate a high prevalence of EMF amongst patients from Mukono and Luwero districts of Uganda. Initial investigations focused on assessing the concentrations and type of cerium present within the local environment of these areas. A variety of analysis techniques had to be used due to the large variation in cerium abundance between soil, water, food and biological samples. The results confirmed that long-term weathering of basement rocks in Mukono and Luwero districts have both enriched the



Drying cassava directly on soil leads to increased cerium in flour produced.

well drained fertile soils in cerium and depleted them with respect to magnesium, which enhances cerium uptake in mammals. Whereas typical staple crops grown on such soils (cassava, sweet potato, matooke (bananas) and maize) show no signs of significant enrichment there is evidence of elevated concentrations of cerium in water supplies subject to particulate contamination from the soil zone and regolith (typically drainage pits and hand dug wells used by the poorest or more rural communities). Model calculations, based on the collected data, indicate that the most important exposure route is by oral ingestion of soil-bound cerium either inadvertently or through the habitual eating of soil during which it has been shown that 10 to 30% of children in a rural African community typically eat up to 10g of soil a day.

Establishing environmental levels of cerium and evaluating the relative importance of exposure pathways based on the total mass of cerium ingested is relatively simple. It is more difficult to estimate the potential bio-assimilation and resulting "dose" from each pathway. Further studies are examining whether readily available biological materials can be used to confirm the occurrence of related exposures to cerium within the affected population, and if tissues from EMF patients exhibit similarly elevated levels. In the former case, levels of cerium in deciduous teeth from the United Kingdom are being compared with those from the Mukono District, Uganda. The data show a greater exposure in Ugandan children with a much wider range, from 2 to 10 times that of the concentration found in teeth from the United Kingdom. Bulk chemical analysis of a limited number of post-mortum tissue samples has indicated a four fold increase in Ce levels in EMF hearts compared to control samples from accidental and cardiac non-EMF cases. Whilst this is encouraging and consistent with observations made in India, additional samples are required to prove this observation statistically.

Mercury pollution by mining activities on the island of Palawan, Philippines: Fact or fiction?

Dr Martin Williams, British Geological Survey, Project Ref. R6226

Research into the environmental impact of mining-related mercury (Hg) contamination in the Philippines was started by BGS in 1995 as part of a DFID-TDR project *Mitigation of Mining-Related Mercury Pollution Hazards* (R6226). At the outset, BGS and the Philippines Mines, and Geosciences Bureau (MGB) targeted areas which in the past decade have experienced artisanal gold-rushes, and in which the use of Hg for gold recovery has been widespread. In August 1995 the MGB were, however, forced to revise their priorities following national media reports of human mercury poisoning in the vicinity of Honda Bay, an area of former mercury mining on the island of Palawan. In response to a directive from the Office of the President, the MGB commissioned an inter-agency investigation and issued a formal request for BGS assistance under the ongoing TDR agreement. This request was viewed by BGS and the DFID as a genuine case for demand-led TDR expenditure, and a preliminary investigation was carried out in December 1995.

The BGS survey of Honda Bay was designed to assess the true extent of human Hg exposure via two discrete pathways: (i) consumption of Honda Bay fish contaminated by Hg emanating from a coastal jetty built of mine waste; and (ii) residential exposure among population living on, or near, the jetty.

The distribution of mercury in Honda Bay was measured by collecting and analysing marine sediment cores. These showed the average Hg concentration in the top layers of sediment in the bay to be well within the global background range. Mercury con-

centrations in deeper sediments showed that no significant changes had occurred over the past 100 years. The construction of the Sitio Honda Bay jetty, therefore, had had no major impact.

The total concentration and bioavailability of mercury was established by geochemical and mineralogical analyses of mine waste from the jetty. These observations showed that most of the mercury present had low bioavailability. Human Hg exposure through particulate inhalation or hand-mouth ingestion was unlikely to be a major health risk.

Mercury concentrations in fish from Honda Bay fall within the ranges typically encountered for analogous species worldwide. Concentrations in green mussels close to the jetty were increased but similar samples offshore fall within the global background range.

Analysis of hair samples from Palawan subjects showed that all Palawan residents are subject to high Hg exposure, relative to a control population from Manila. Statistical analysis of data for five Palawan sub-groups failed, however, to discriminate those living on mine-waste from other populations. High mercury concentrations are typical of populations eating fish. There is virtually no evidence of appreciable toxicological risk at blood concentrations of this magnitude.

The survey results were presented to the Office of the President and to government representatives. All have now recognised that the earlier press reports were ill-founded, and that there is no need for expensive remediation or population re-settlement.



Sorting of fish recovered from Honda Bay for assessment of levels of Hg in tissue.

Developing Mineral Resources in Angola

Tim Colman,
British Geological Survey

The British Geological Survey has been helping the Angolan Ministry of Geology and Mines to develop the indigenous mineral resources. Funded through the World Bank, this Technical Assistance Institutional Strengthening project was led by the BGS Mining Advisor to the DFID and included collaboration with the Portuguese Instituto Geológico e Mineiro and other consultants.

The BGS component of the project examined the current functions and organisational structure of the MGM and suggested ways in which it may be strengthened. These include the development of information systems, establishing health and safety and environmental regimes and encouraging private investment in the small mines sector. Specific elements included specification and installation of hardware and software for a new mining cadastre Geographical Information System (GIS), provision of database and GIS training, prioritising mineral resource potential, assessing the availability of local investment and skills and publishing a promotional brochure to encourage private investment in the minerals sector.

Angola is a large country, about twice the size of France, with major oil and surficial diamond resources and production. There is virtually no other mineral production despite the varied geology, which shows great potential for the discovery of significant deposits of metalliferous and other minerals. For example, over 700 kimberlite pipes, many of which contain diamonds, are known and other prospective areas of ancient altered igneous rocks have been identified by reconnaissance geological mapping. Modern mineral exploration in Angola has been limited, except in some diamond areas, due to a lack of basic geological information, a lack of investment and intermittent internal unrest since independence in 1975. The security situation has now improved. Recent developments in mineral legislation, including a new Mining Law, are creating a good legal framework within which mineral exploration and development can thrive. This World Bank project provides the basis for further collaboration and the development of Angola's immense mineral potential.

Groundwater management in drought prone areas of Africa

Roger Calow and Nick Robins, British Geological Survey

Project Ref: R6233

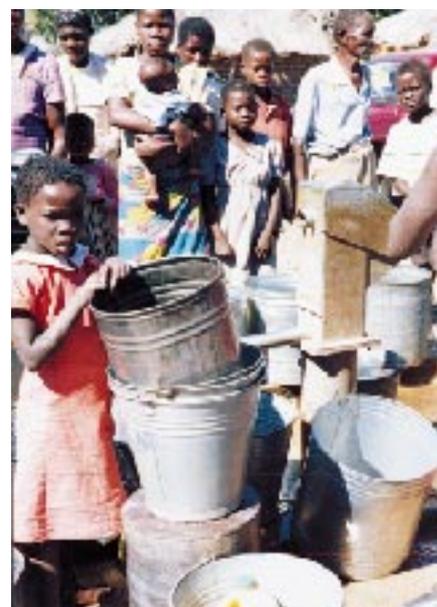
Droughts are recurrent events in many parts of Africa. Understanding of the processes which create drought crises has improved significantly over the last two decades particularly with respect to food security. This is reflected in the development of numerous drought early warning systems. However, the impact of drought on water security has received relatively little attention. In the dryland regions of Africa, groundwater is typically the only perennial source of water supply. Recent experience of 'groundwater drought' has demonstrated that these supplies may fail, with the result that water scarcity may quickly supplant crop failure as the single most important and politically visible issue.

Changes in the approach to the management of groundwater may help prevent or mitigate groundwater droughts. Different management strategies have been investigated by an international team led by the British Geological Survey at Wallingford. These emphasise the advantages of pre-drought planning over short term, crisis management. A key contention of the project is that some wells, and some areas, are much more vulnerable to groundwater drought than others, and that potentially predictable variations should be planned for and acted upon.

In February of this year, project partners from the UK, Malawi, Ghana and South Africa held an international workshop in Lilongwe to discuss findings and make recommendations. Over 60 government, donor and NGO delegates from eight African countries took part, and discussions were animated and productive.

Some of the key issues raised are listed below. Recommendations are perhaps most relevant to donors who, in many African countries, fund the majority of water supply developments and relief programmes.

1. Emergency water supply programmes are often poorly targeted, may fail to relieve immediate water stress, and may put in place unsustainable infrastructure. Typical constraints include: lack of data on status of water supplies; poor coordination of different organisations involved; dependence on the international relief system and external politics; rushed planning; lack of scope for community mobilisation; and inappropriate technical choices.
2. Funding should be geared more towards crisis avoidance. Management strategies could include the development and use of groundwater drought vulnerability maps to identify sensitive areas. Such maps could inform technical choices in pre-drought periods, help identify critical monitoring zones, and identify areas where pre-positioning of relief resources might be prudent. Groundwater drought vulnerability maps have been developed for Ghana, Malawi and South Africa during the course of the project.
3. Long term tracking of rainfall, surface flows and groundwater conditions is vital, as predictive indicators can be used to trigger timely, preventative actions. Symptoms of water stress, including migrations, long queues at water points and ill health, need to trigger different actions aimed at relieving immediate water stress. There are many options, but at this stage infrastructural programmes (e.g. drilling programmes) may be inappropriate. There is a strong case for joint government-donor funding of monitoring programmes and early warning systems.
4. Reliable and timely monitoring information is a necessary but not sufficient condition for timely action. If crises are to be avoided, wider institutional and political obstacles to the use of early warning information need to be addressed.



Queuing for scarce groundwater at a village borehole in Malawi.

International Volcanology

In January this year the General Assembly of IAVCEI, the International Association of Volcanology and Chemistry of the Earth's Interior, met in Puerto Vallarta, Mexico. IAVCEI is the primary international focus for research in volcanology. Its objectives are to study volcanic processes; to promote international collaboration; to promote efforts in mitigating volcanic disasters and to disseminate research results.

Entitled *Volcanic Activity and the Environment*, the assembly attempted to focus on topics complementary to the International Decade for Natural Disaster Reduction. Stimulated by the eruption on Montserrat, the mechanics and effects of dome forming eruptions formed a major topic of discussion throughout the assembly. The results of a number of projects funded by the DFID were presented as papers and posters. These included a description of the operations and procedures at the Montserrat Volcano Observatory (MVO) by Dr. Simon Young of the BGS. The results of scientific research on the eruption were presented by Prof. Steve Sparks, Senior Scientific Advisor to the MVO, and members of his team. This research contributes to the management of the volcanic crisis by improving the understanding of the Soufriere Hills volcano. Other work presented included the use of satellites for volcanic monitoring.

Volcano monitoring using thermal images from satellites

*David Rothery, Department of Earth Sciences, The Open University,
Project Ref: R5989.*

Studies at the Open University, partly funded by DFID, have demonstrated that cheaply available thermal images at low resolution (1 km pixels) can provide valuable information about active volcanoes. We have used data with 1 km pixels from the NOAA Polar Orbiter AVHRR instrument and the ERS-1 and ERS-2 ATSR instruments. We can now use time-series observations of infrared radiation to determine the effusion rate of lava, and have worked on Etna (Sicily), Cerro Negro (Nicaragua), Fogo (Cape Verde Islands) and Fernandina (Galapagos). By monitoring changes in the total infrared flux from volcanoes containing active lava domes we can determine the stability of the dome and relate this to eruptive behaviour; we have examples from Lascar (Chile) and Unzen (Japan) but use of similar data for the Soufriere Hills volcano on Montserrat is badly inhibited by cloud. Techniques for distinguishing wildfires from volcanic lava on satellite thermal images have also been developed.

Ecuadorians Focus on Industrial Minerals

*Dr David Morgan and Steve Mathers,
British Geological Survey, Project Ref: R6224*

Thirty five senior Ecuadorian Government officials, university lecturers and Industrialists attended a DFID-funded workshop aimed at technology transfer and raising the profile of Industrial Minerals in Ecuador. The workshop took place mainly in the capital Quito on the 17- 21st February 1997 and was organised locally by CODIGEM - the Ecuadorian Government agency with responsibility for the minerals sector and the implementation of environmentally sensitive extraction policies.

The course tutors were Dr David Morgan and Steve Mathers from the British Geological Survey (BGS) together with guest lecturer Fernando Alvarado, an acknowledged regional expert on the environmental aspects of quarry design and bulk mineral extraction employed by the Costa Rican electricity generating authority- Instituto Costarricense de Electricidad (ICE).

The workshop began with three days of formal presentations and interactive discussions held at the spacious modern training facilities of the Ecuadorian Ministry of Agriculture in the heart of Quito. The majority of presentations were given in Spanish, with additional simultaneous translation facilities as required. The full range of industrial mineral commodities likely to be present in Ecuador were considered together with detailed accounts of how to test the raw materials to determine their suitability

for industrial applications. All participants were supplied with full and appropriate course documentation.

Following the presentations a two day field excursion was organised by CODIGEM with industrial sponsorship from the National Cement Corporation and PRODEMICA. This enabled tutors and participants to see at first hand important industrial mineral sources and processing plants. Heading south from Quito on the first day large pumice deposits were examined at Latacunga followed by marble dimension stone and diatomite deposits near Galte before descending from the Cordillera to overnight in Guayaquil, Ecuador's second city and principal port. On the final day visits were made to the National Cement Corporation and local producers of carbonate rock and refractory bricks.

The level of interest generated by the workshop was unprecedented with countless participants requesting considerable further technical information in particular the laboratory manuals and other publications resulting from the previous DFID-BGS TDR Project Minerals for Development (R 5541). Others requested details of UK-based suppliers of plant and machinery. Strong representations were also made for a repeat of the course, to give an opportunity to the many professionals unable to attend the event, since it was more than two times oversubscribed.



Course participants and tutors at Covitan SA, Guayaquil.

Recent reports

BGS reports

WC/96/17 A groundwater hazard assessment scheme for solid waste disposal: Summary report. (Project R5564). B A Klinck. £18

WC/96/25 Groundwater management in drought prone areas of Africa: northern Ghana inception report. (Project R6233). A M MacDonald, R C Calow, A J Andrews and S Appiah. £17

WC/96/28 Groundwater management in drought prone areas of Africa: Malawi inception report. (Project R6233). R C Calow, B R Gibbs, A J Andrews and P Mtembezeka. £21

WC/96/39 Unconsolidated sedimentary aquifers: Review No 12 – Groundwater quality management in unconsolidated sedimentary aquifers. (Project R5561). P J Chilton, M E Stewart, W M Edmunds, H K Jones, A R Lawrence, P Shand and T R Shearer. £40

WC/96/42 Contaminant transport and storage in the estuarine creek systems of Mombasa, Kenya. (Project R6191). J G Rees, T M Williams, M M Nguli, K K Kairu and A C Yobe. £27

WC/96/56 Groundwater management in drought prone areas of Africa: South Africa inception report. (Project R6233). A M MacDonald, R C Calow, A J Andrews and S Appiah. Price on application

WC/96/64 Unconsolidated sedimentary aquifers: Review No 14 – Groundwater modelling in aquifer management. (Project R5561). J A Barker, D G Kinniburgh with contributions by T R Shearer. £36

WC/97/1 Simple modelling to illustrate the impact of drought on groundwater availability. (Project R6233). A M MacDonald and D M J Macdonald. £10

WC/97/9 Groundwater data management by the Malawian Ministry of Irrigation and Water development – a case study. (Project R5973). A A McKenzie. £12

WC/97/10 Groundwater data management by the Ghana Water and Sewage Corporation, Northern District – a case study. (Project R5973). A A McKenzie. £12

WC/97/14 A review of gold particle-size and recovery methods. (Project R6226). C J Mitchell, E J Evans and M T Styles. £12

WC/97/17 Gypsum geohazards: Their impact on development-project summary report. (R6490) A H Cooper and R Calow. Price on application

WC/97/19 Land-derived contaminant, influx to Jakarta Bay, Indonesia. Volume 1: Geochemistry of marine water and sediment. (Project R6191). T M Williams, J Rees and D Setiapermana. Price on application

Other reports

Harris, A. J. L., Rothery, D. A., Carlton, R. W., Langaas, S., and Mannstein, H., 1995, Non-zero saturation of the AVHRR thermal channels over high temperature targets: evidence from volcano data and a possible explanation, *Int. J. Remote Sensing*, 16, 189-196.

Dennis, A. M., Harris, A. J. L., Carlton, R. W., Francis, P. W., and Rothery, D. A., 1996, The 1993 Lascar pyroclastic flows imaged by JERS-1, *Int. J. Remote Sensing*, 17, 1975-1980.

Rothery, D. A., Babbs, T. L., Harris, A. J. L., and Wooster, M. J., 1996, Colored lava flows on the Earth: a warning to Io volcanologists, *J. Geophys. Res.*, 101, 26131-6.

Intermediate Technology 1997. Calculating the energy efficiency of a lime burning process? World Cement March, Palladian Publications Ltd.

No charge is made for single copies of TDR reports for use by government and educational establishments, research institutions and non-profit making organisations in countries eligible for British Aid. Free copies can normally be addressed to individuals under official titles, not by name.

Reports can also be purchased by organisations and individuals not eligible to receive free copies. Contact should be made directly with the organisation concerned. UK Value Added Tax (VAT) may be chargeable in addition and the prices quoted exclude postage and packing.

Forthcoming meetings

Interplate magmatism and tectonics of southern Africa, to be held in Harare, Zimbabwe from 8-12 September 1997. The meeting is being organised by the Geological Society of Zimbabwe and the Department of Geology at the University of Zimbabwe. Details are available from: The Conference Secretary, Geological Society of Zimbabwe, P O Box CW1719, Harare, Zimbabwe.

The conference will be preceded by a Workshop on 8-9 September to address Geoscience education and training in Africa.

The International Association of Hydrogeologists XXVII Congress, *Groundwater in the urban environment*, to be held in Nottingham, UK from 21-27 September 1997. In developing economies the rapid expansion of urban areas has been accompanied by uncontrolled groundwater exploitation and by indiscriminate waste disposal. The Congress will discuss issues of urbanisation and groundwater from various perspectives and draw lessons for the sustainable use of water supplies and waste disposal. Contact address for further details: Conference Nottingham, Regent House, Clinton Avenue, Nottingham, NG5 1AZ, UK.

Other DFID Newsletters in the same series

ENERGY EFFICIENCY

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