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Volcanics for Construction (VOLCON) Summary Report

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Summary Report

Introduction

The Volcanics for Construction (VOLCON) project commenced in September 1998 and finished in August 2001. The goal of the project was to improve understanding of the engineering properties of geological materials in developing countries and to develop new engineering and environmental applications for their use. The project purpose was to stimulate local industry to invest in developing new construction and other uses for volcanic raw materials. The outputs that have achieved these aims are

- Strategies to evaluate volcanic rocks
- Recommendations and advice on suitable raw materials and potential uses
- Field and laboratory studies in collaboration to develop a local capacity to evaluate volcanic raw materials
- Workshops, a strategy forum and seminars to train collaborators and disseminate advice and project results
- A comprehensive manual on the evaluation and end-uses of volcanic rocks as industrial raw materials, supported by more detailed technical reports on specific investigations

The VOLCON project has been led by a team at the British Geological Survey comprising Steve Mathers (Project Manager), David Harrison, Peter Dunkley, Clive Mitchell, Simon Inglethorpe, Ellie Steadman (nee Evans) and Claire Cotton. Other UK-based collaborators have included Ted Sibbick of the Buildings Research Establishment (BRE); Martin Woodbridge from the Transport Research Laboratory (TRL) and Mike Allen of Mike Allen Associates. The other key participants have been John Kagasi (Department of Mines and Geology, Nairobi, Kenya), Zacharia Bongole (Ministry of Energy and Minerals, Dodoma, Tanzania) Fernando Alvarado (ICE, San José, Costa Rica), Mario Maya (INGEOMINAS, Bogota, Colombia), José Gómez and Bolivar Flores (DINAGE - formerly CODIGEM, Quito, Ecuador). The overall project budget was £230K.
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The VOLCON project has sought to increase awareness of the many potential uses to which volcanic raw materials can be put. These include construction applications such as aggregate, building and dimension stone, and pozzolanic additives. Other more specialized uses can be found for products such as expanded perlite which forms a useful loose fill material with good fire retarding and sound insulation properties, whilst many zeolite-rich rocks are pozzolans and possess a host of potential environmental and agricultural applications utilizing their ability to exchange cations and act as sieves at the molecular scale. This account is structured following the eight defined activities-phases in the project documentation.

Desk study and Strategy Forum

A thorough literature search and desk study of methods for the field and laboratory evaluation of volcanic rocks was undertaken and published. Based on the literature a field test kit for zeolite identification based on the Culfraz heat of hydration method was assembled, and then refined during fieldwork. A relatively new piece of equipment the Portable Infrared Mineral Analyser (PIMA) was evaluated successfully in the laboratory on zeolite and perlite samples for which it gives diagnostic signals. It was then deployed for field studies.

The VOLCON Strategy Forum was held at BGS Keyworth from 17-23 May 1999. The aim of this forum early in the project was to enable the entire project team to meet each other, to discuss and review initial progress, and plan the succeeding phases of the project. The 12 participants included 7 BGS scientists together with the key participant from each of the other five collaborating nations (Costa Rica, Colombia, Ecuador, Tanzania and Kenya). To ensure effective transfer of knowledge and skills a full programme of training lectures, demonstrations and field visits was mounted by the BGS team. Teaching slide collections, technical data and extensive training literature (much from past DFID-BGS KAR projects) were also distributed to enable the five visitors to return home well equipped to further disseminate the aims and initial results of the project together with DFID-funded industrial minerals work in general.

Presentations were made at the Forum by all of the visiting scientists covering varied aspects of the volcanic industrial minerals in their home countries. Two of these collaborators reported the results of independent research following take-up of suggestions from BGS team members. Because these presentations are of high calibre they have been translated (from Spanish) and disseminated as an additional project technical report.
**Field Investigations**

The philosophy adopted by the project was to try where possible to evaluate the potential of volcanic raw materials *in situ* rather than try to systematically sample the rocks and dispatch vast volumes of material for laboratory identification and testing. In simple terms we have tried to take the laboratory to the rocks rather than the rocks to the laboratory. The advantage of this approach, when successful, is the considerable savings in shipment costs and the ability to focus detailed laboratory work on only the most promising raw materials. With this in mind we utilized and refined the zeolite identification test and deployed the recently developed Portable Infrared Minerals Analyzer (PIMA) in order to identify zeolite-bearing rocks, and hydrated volcanic glasses that are prospective perlites.

During the field investigations, pumice, zeolite and prospective perlite, and pozzolanic materials were located. Demonstrations of the zeolite field test and the PIMA were given to counterpart staff in the field and repeated in Ecuador for all the geological staff of DINAGE at their offices in Quito. At their Director’s request we have donated a zeolite identification kit to DINAGE to enable them to progress this work further under their own initiative.

In Kenya and Tanzania fieldwork took place in September-October 1998 and October 1999 in collaboration with the Mines and Geology Department. This included locating, sampling and mapping of selected deposits of pumice, scoria, pozzolanic ashes, volcanic lavas and tuffs for use as aggregate and building stone. In Kenya the Naivasha area close to Nairobi (the main market) was selected and in northern Tanzania the Arusha area was examined because of the rapid expansion of construction fuelled by tourism. Meetings were held with local industries that utilise these materials to evaluate their requirements.

Fieldwork in Ecuador took place in February 1999 and January 2000 in collaboration with DINAGE - the national geoscience institute (formerly CODIGEM). Deposits of natural zeolites were located in several parts of the country. The areas that are most prospective are the late Miocene intermontane basins, except the basin around Loja - Vilcabamba which is filled entirely with coarse sediments of metamorphic provenance. However the Nabon Basin north of Saraguro, and the Tarqui Formation around Saraguro itself contain fine volcanogenic sediments of acid composition in which we have located zeolite-rich deposits. In addition, the Grupo Saraguro has some potential. In particular the Fm. Plancharumi west of Cuenca, which consists of zeolitised rhyolitic tuffs - pumice lapilli tuffs of lacustrine origin. Some of the early Miocene ash-flow tuffs at the top of the Grupo Saraguro - such as the Fm. Jubones or
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Fm. La Paz also contain zeolites. Deposits of prospective perlites were also located near Quito and farther south these were also sampled and shipped to the UK for testing.

In Costa Rica more limited fieldwork was carried out in February 1999 and April 2000. Extensive consultations with local industry and government institutions were conducted and much advice and literature provided on testing methods for aggregates. Fieldwork was carried out in the northwest of the country in Guanacaste province where a series of rhyolite domes were sampled as prospective perlites. Other commodities studied included pumice and scoria.

**Laboratory Investigations**

Routine chemical and physical characterisation of prospective perlites, pumice, scoria, potential pozzolans and zeolite samples from the two fieldwork phases was completed and written up on schedule. This has involved were appropriate X-Ray Diffraction, Differential Thermal Analysis, X-Ray Fluorescence, and the determination of density, particle size distribution and water absorption. Many of these results obtained validate those obtained using the portable field methods and the data provided useful case histories and examples for the VOLCON manual. The detailed results are contained in the technical reports and were communicated to the counterpart organizations and interested companies. The results show the suitability of many of the materials sampled for various construction uses including aggregate, lightweight aggregate, insulation, for use as a pozzolan, and dimension stone.

The use of a Portable Infrared Minerals Analyser (PIMA) for determining useful properties (mineralogy, water content etc.) of volcanic materials and the field test kit for zeolite identification were initially evaluated in the BGS laboratories. Some of this work was carried out by a visiting student sponsored by the Nuffield Fellowship scheme.

**End-use testing**

Perlites are hydrated volcanic glasses that on flash heating to about 900 degrees Centigrade expand to form a popcorn like product which is valued in construction for its fire retardation and acoustic insulating properties.

A small-scale expansion furnace was designed, commissioned and constructed in consultation with local consultants Mike Allen Associates to ensure effective expansion testing of perlite deposits. Samples from both the first and second phases of fieldwork have all been tested and several samples have yielded promising expansion characteristics, most notably some of those from the south of Ecuador.
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The construction properties of large representative sample of ash from the recent eruptions in Montserrat has also been examined as an additional project initiative in view of the relevance of this project to the current situation on the island. The studies conducted mainly at BRE show that the material lacks pozzolanic properties for use as an additive in cement based products. The ash is however a potential source of fine aggregate. This information has been relayed to DFID and BHC staff on Montserrat for local dissemination.

Technical Reports

Some 11 reports describing the field investigations and laboratory testing have been produced and the results disseminated to counterpart organizations and local industry.

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Two major technical reviews have also been produced: the first on Alkali-silica reactivity by Ted Sibbick of the Buildings Research Establishment (BRE) at Garston, UK, the second on the use of Volcanic rocks in infrastructure construction is by Martin Woodbridge from the Transport Research Laboratory (TRL) based at Crowthorne, UK.

Full references are

The proceedings of the Costa Rican Workshop have also been published
Reference
Alvarado, F. (ed). 2001 Rocas volcanicas como agregado en Construccicion, BGS-ICE

Manual and factsheets.

The project manual describes the exploration, evaluation and applications of volcanic raw materials in construction and is the key project deliverable and dissemination tool. The manual comprises 116 pages designed with facing pages of text and colour illustration to try and be user-friendly. The manual was published in December 2000, it has been very well received by collaborators and workshop participants. Of the 500 print run over half have already been given, or sent, to interested professionals in developing countries.

Seven technical factsheets describing the construction potential and uses of volcanic raw materials have also been published with a print run of 1000 and these have also been widely disseminated.

Dissemination and Workshops

The factsheets and manual have been supplied to many professionals in Developing Countries, many requests followed an article profiling the project’s progress in the DFID Earthworks magazine. Many requests for these documents were also received whilst the project manager was in the Dominican Republic recently to present a general industrial minerals workshop funded by the local government. All of the 174 attendees at the 3 VOLCON workshops have received the manual and the factsheets.

Steve Mathers also attended the Geological Society of Tanzania’s 30th annual meeting Geotech 99 in Arusha October 1999 where, in order to ensure dissemination, a paper detailing the results of the initial phase of project fieldwork in Kenya and Tanzania was presented on
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behalf of VOLCON by our Tanzanian collaborator Zacharia Bongole (Ministry of Energy and Minerals). Following the presentation requests were received for VOLCON information and publications from other DFID funded work from over 60 of the conference participants including a substantial private sector contingent. These requests have all been met.

Exploration models for volcanic environments have also been developed and displayed in poster form at the Extractive Industry Groups annual meeting in Bath in May 2000, a scientific paper on this topic by Steve Mathers and Professor Scott of the Camborne School of Mines is in-press.

Regional workshops were held in Nairobi, Kenya (Jan 2001) and San Jose, Costa Rica (Feb 2001) and Quito, Ecuador (May 2001). These workshops included formal presentations, practical equipment demonstrations and provision of technical information (factsheets, manual, abstracts of presentations) and advice by project staff. Strong local industry and government participation was secured in each case to ensure take-up and many presentations were given by local experts in each location to accompany those of the BGS scientists. UNESCO sponsored 6 additional delegates from provincial Kenya, Tanzania and Uganda to attend the Nairobi workshop. Some 42 delegates attended the Nairobi workshop whilst 72 were present in San Jose Costa Rica and 60 in Quito. Government ministers were invited to open each workshop securing widespread media coverage of the events. Field trips followed each workshop to enable interesting deposits to be visited and informal discussions with the participants.

Advice, Monitor take-up

Throughout the project BGS staff have provided advice to the host government, national geological surveys, industry, academics and students. Some of the more notable requests are outlined below. This process is continuing beyond the timescale of the project.

Some of the Tanzanian results on scoria and pumice from the Arusha area have been provided to Danish consultants working for DANIDA (the Danish Government Aid Agency) to help them assess their suitability as a foundation material for the new Dar es Salaam-Mlandizi trunk road. This is being constructed with Danish funding. Advice on field identification of perlites and zeolites was also provided to the National Cement Company in Ecuador who are undertaking exploration for these materials. Advice was also provided to most of the national institutions in Costa Rica that are responsible for the evaluation and testing of aggregate raw materials.
Conclusions

- The VOLCON project has been completed on-schedule and within budget

- Methods appropriate for the field testing of volcanic rocks have been developed and deployed successfully especially with regard to exploration for zeolites and perlite.

- Field investigations have identified suitable sources of aggregates, lightweight aggregates, zeolites, and pozzolans. In Ecuador perlites have been located but their expansion is below that needed for commercial production.

- Extensive training has been provided to counterpart organizations in field exploration methods

- A zeolite identification kit has been donated to DINAGE to enable them to progress this work further under their own initiative

- Eleven technical reports describe the fieldwork and laboratory testing, two reviews have also been prepared one on alkali-silica reactivity the other on use of volcanic materials in construction of transport infrastructure.

- The project manual and seven factsheets have been published and widely disseminated

- Three regional workshops have been held with a total attendance of 174.

- Advice on the use of volcanic materials in construction has been provided to the host governments, their national geological surveys, local industry, academics and students.