BGS Technical Cooperation in Latin America (1965–90)
TECHNICAL REPORT WC/91/25

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S J Mathers (Compiler)
International Division

Cover illustration
Top right, a BGS geologist studying molybdenum mineralization at an altitude of 4900 m in the Andes near Jacabamba, Peru; Bottom right, Peruvian counterpart geoscientists preparing geochemical samples in the Cordillera Blanca, central Peru; Left, map of Latin America, red dots indicate locations of host countries.

Bibliographic reference
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<td>Geophysical Survey of the Valentines Iron Deposits</td>
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Introduction

This report summarizes work undertaken in Mexico, the seven small republics of Central America and the 13 nations on the continent of South America by the British Geological Survey (BGS) formerly the Institute of Geological Sciences (IGS), during the period 1965 - 1990. Most of the work was carried out as bilateral technical co-operation with the British contribution funded by the Overseas Development Administration (ODA). Several small projects in which BGS served as consultants for international aid agencies and development banks are also included.

The BGS has made a significant contribution to geological surveying and mineral exploration in Latin America (Fig.1). The Andean countries of Bolivia, Colombia, Ecuador and Peru have in particular benefited from the cooperation with several regional surveys providing the geological framework for a total area about 2.5 times the size of Britain (Fig.2). Such projects identify economic potential worthy of the more detailed evaluations that are subsequently carried out by mining enterprises, oil companies and public service authorities.

Other substantial projects have included regional geological surveys in Belize and Guyana; mineral exploration in Chile, Colombia, Costa Rica and Peru; hydrogeological work in Costa Rica, Honduras and Peru and geothermal energy investigations in Panama.

In all the programme of 36 separate projects has involved 14 of the 21 Latin American countries. An index of projects and participating countries is provided at the end of the report. The information contained in this report is also stored in a BGS database of international activities.

Review of Projects

The 36 projects are summarized under the countries with which they were concerned.

Argentina

In 1973 four geologists provided training courses and advice to the Argentinian Government for an anticipated regional mineral exploration survey of Patagonia. In 1983 a small geophysical project assisted a United Nations investigation of the Huemules precious and base metal prospect helping to identify the extent of the ore-body.

Belize (formerly British Honduras)

A regional survey of the Maya Mountains in southern Belize enabled a detailed geological map and account of the geology of this area to be published. Synchronous geochemical sampling revealed limited potential although a promising area with high Molybdenum concentrations was identified and subsequently became the focus of exploration effort by a Canadian mining enterprise.

Bolivia

Regional geological surveying and mineral exploration of about a third of Bolivia was undertaken by BGS between 1974 - 1986 (Fig.2). The majority of the work was carried out in eastern Bolivia where some 250,000 km² of previously poorly known Precambrian shield terrain was surveyed and its mineral potential evaluated.

Geological maps, numerous scientific and economic articles and a comprehensive geochemical atlas of the region were published. The considerable mineral potential, which includes occurrences of gold, platinum, silver, uranium and rare earth elements was publicised at several international conferences. Follow-up exploration studies are being undertaken by multi-national companies including Rio Tinto Zinc. The success of this endeavour was highlighted by an ODA review of the project and an ODA sponsored conference in Bolivia in 1989 helped to attract interest from international mining companies.

Project List
Brazil

Between 1970 and 1974 assistance in assessing mineral resources in the states of Para and Piaui in northern Brazil was provided; a telemetered array of seismic stations was installed on the Brazilian Plateau and advice on the interpretation of radar images and the setting up of courses at the university of Bahia was given. In Piaui State new areas likely to contain diamonds and opal were identified and schemes for working these materials were devised. Northern Brazil was the starting point for a BBC hovercraft expedition to Georgetown, Guyana which included an IGS geologist as navigator.

Chile

A geochemical exploration programme in southern Chile - the Magellan Project - identified molybdenum, copper, nickel, lead and zinc anomalies worthy of follow-up exploration by mining enterprises. Subsequently resident advisors helped establish a geochemistry division in the Chilean Government's geological institute and provided hydrogeological advice in designing water supply schemes for copper processing in arid parts of northern Chile.

Colombia

During the 1980’s regional geological surveying and mineral exploration was carried out in the departments of Cauca and Vale in southwest Colombia (Fig. 2). The surveys elucidated and geology of large segments of the Central and Western Cordilleras together with parts of the Pacific coastal plain. Porphyry-copper mineralization was discovered in the Central Cordillera whilst a fresh understanding of the origin and derivation of the alluvial gold deposits in the Western Cordillera and Pacific coastal plain should enable new occurrences to be found. A geochemical laboratory enabling analysis for a dozen key elements has been installed at INGEOMINAS - the counterpart organization - and on the job training and several scholarships have been provided to try to ensure that the work of these projects will continue with local endeavour.

Costa Rica

Five projects have been mounted in Costa Rica over the past 15 years, three concerned with mineral potential and two with hydrogeology.

Photogeological mapping and field reconnaissance enabled geological maps of part of the Talamanca Cordillera to be produced. The area is thought to have potential for porphyry-copper deposits because of the discovery of a large deposit within the Cordillera in neighbouring Panama.

The Tilaran-Aguacate mountains were the subject of a multidisciplinary study involving surveying, photogeology, geochemistry and geophysics which successfully provided advice on geochemical sampling methods and identified new targets for gold exploration.

The largest of the projects was the recently completed national industrial minerals survey. This 3 year project was divided into two phases. The first involved the compilation of a systematic inventory of known occurrences of industrial minerals together with an analysis of local markets and potential. The second phase followed with the detailed appraisal of economically valuable deposits of diatomite and high-purity limestone together with an exploration programme for bentonite. On the job training, seminars and study visits to the UK for counterpart staff were designed to ensure that the work continues successfully.

Two separate sources of funding enabled advice and technical support to be provided to the Costa Rican water authorities. Studies were focused on the densely populated Valle Central which includes the capital San Jose and other principal cities. Specific advice on the siting of production wells, safe abstraction rates and aquifer management was provided. A detailed study of the key Colima Aquifer was also undertaken with a view of its further development. It concluded that an additional wellfield could safely extract further water resources.
Ecuador

In the 1970’s cooperation with Ecuador enabled some 40% of her national territory to be surveyed geologically and the mineral potential identified (Fig.2). The work covered most of the Ecuadorian Andes and the Pacific Coastal Plain. Geological maps have been produced for this entire region including more detailed editions for the major cities of Quito and Cuenca. The total area covered was approximately half the size of Britain. Important discoveries of copper and phosphate resources were made and geotechnical problems around the capital Quito was studied. Strengthening the national geological body DGGM (now INEMIN) involved the installation of a geochemical laboratory, training in cartography and field geology and the provision of 15 awards for counterpart staff to study in the UK.

An on-going study is seeking to elucidate the geology and mineral potential of the Cordillera Real in Eastern Ecuador, the area is believed to contain gold and base metal mineralization. Several areas with potential have been identified and these are the subject of current investigation.

Guyana (formerly British Guiana)

Between 1966 and 1971 the region south of latitude 4°N, which comprises more than a third of Guyana, was studied using photogeology and field traverses. The results were published as geological maps and accounts and include a comprehensive geological memoir on the area published in 1977. A subsequent short advisory visit helped establish a lapidary for the production of decorative stones and ornaments. The Manaus-Georgetown hovercraft expedition featured in a BBC documentary film terminated in Georgetown, Guyana.

Honduras

Four distinct projects have been carried out in Honduras. One concerned with regional development, two with hydrogeology and one involving geophysical studies for minerals.

The Mosquitia Project comprised an ODA-sponsored mission of experts to evaluate the natural and renewable resource potential of the Mosquitia part of Honduras. As part of this study a BGS geologist revised the geological framework of the area and made recommendations on the type of follow-up programme that would be necessary to establish the areas mineral potential.

Hydrogeological advice has been provided to the various national water organizations since 1982, initially by advisory visits and lately with the provision of two resident experts. Numerous hydrogeological projects and schemes have benefited from these arrangements including the improved provision of water to the capital city of Tegucigalpa.

A short geophysical study mainly comprising Induced Polarization measurements was undertaken for the United Nations at a mineral prospect they are helping to develop near Yuscaran in southern Honduras. The study pin-pointed targets for future UN drilling programmes.

Mexico

In the early 1970’s IGS provided a resident expert at the National University in Mexico City to help train Mexican students in petrology and volcanology. The collaboration resulted in the publication of geological maps of the volcanoes Nevado de Toluca and Popocatepetl, together with the supervision of the theses of a dozen post-graduate students.

Panama

Multidisciplinary studies involving geological surveying, geophysics and geochemistry were carried out in order to assess the potential energy producing capacity of the Cerro Pando Geothermal Field in Panama. Recommendations were made to concentrate further exploration effort to the area farther north, the source of deep thermal waters.
Peru

Some severe projects have been mounted in collaboration with the Peruvian Government marking an almost continual input from 1963 to 1986.

Regional geological surveying and follow-up mineral exploration was conducted in the Pacific coastal part of Peru together with the Altiplano around Lake Titicaca comprising a combined area broadly the size of Britain (Fig. 2). Important finds of copper and molybdenum mineralization were made during these studies. Additional advisory services in the fields of hydrogeology and engineering geology were also provided.

Another project studied possible problems of pollution that might result from recycling of wastewater in the drainage basin above the Peruvian capital city of Lima. The study identified pollutants including excessive nitrate concentrations and showed that the water recharging the aquifer was unsuitable for drinking.

In 1985 a short geophysical study was made for the United Nations on a gold concession at Ananea on the Altiplano near Lake Titicaca. The study helped elucidate the complex structure of gold bearing glacial moraines and enabled the cost-effective siting of boreholes subsequently drilled as part of the UN exploration effort.

In 1984 a BGS geologist undertook a brief review of the coal resources of Peru and made detailed recommendations for the studies necessary to develop the potential of this important sector.

Uruguay

In 1975 a short geophysical survey for the UN was conducted on the Valentines Iron ore-body in northeastern Uruguay. The survey revealed large magnetic anomalies related to the deposit which enabled its extent to be defined and helped guide a subsequent UN-funded exploratory drilling programme.
Figure 1. Map of Latin America showing the locations of collaborating nations
NOTE ON PROJECT SIZE

On the Project Summary Forms the size of individual projects is given on a scale of 1 (very large) - 5 (small). Broad descriptions of these five categories are as follows:

Size 1  Large multidisciplinary studies carried out by sizeable residential teams with considerable specialist support; usually running for 5 - 10 years; making a major contribution to the development of geological knowledge and potential of the host country.

Size 2  Important regional studies carried out by residential teams with specialist support usually up to 5 years in duration, making a significant contribution to geological knowledge of the host country.

Size 3  Residential projects undertaken by 2 - 3 staff with some specialist support, generally about 3 years duration often concerned with particular themes or topics.

Size 4  Small projects on specific topics usually involving nonresidential input from a small group of specialists or an individual.

Size 5  Short minor consultancies, training and advisory visits carried out by 1 - 2 staff usually with specific objectives.
## PROJECT COMPLETION FORM

### PROJECT NO: 1

**TITLE:** ADVISORS TO "PLAN PATAGONIA"

**LOCATIONS:** Argentina  
**PROJECT SIZE:** 5  
**DATES:** 1973

### COLLABORATING ORGANISATIONS

Ministerio de Industria y Minería, Argentina

### PROJECT OBJECTIVES

The overall aim of Plan Patagonia was the geological survey and mineral exploration of southern Argentina (Argentinian Patagonia). The UK contribution was to assist in the design of the Plan by:

a) Providing consulting expertise in Geochemistry to design the mineral exploration strategy for Plan Patagonia

b) Installing and training staff to operate an ODA donated Atomic Absorption Spectrophotometer

c) Providing a short course in Photogeology

### PROJECT RESULTS

The consultancies, courses and training were completed as planned contributing significantly to the strengthening of the 'Plan Patagonia' team's scientific capability.

### OUTPUT (Reports, Papers, & etc)

### WORKSHOPS AND PRESENTATIONS

Photogeology Course

Training in the use of Atomic Absorption Spectrophotometer

### PROJECT STAFF

Dr B G N Page
Dr J W Aucott
J L Roberts
Dr E J Cobbing

### FUNDING

ODA Technical Cooperation
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<th><strong>TITLE</strong>: MINERAL EXPLORATION IN CHUBUT PROVINCE</th>
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**COLLABORATING ORGANISATIONS**

**PROJECT OBJECTIVES**
A Geophysicist contributed to the UNRFNRE study of the Huemules precious and base metal prospect in Chubut Province, Argentina.

**PROJECT RESULTS**
Included Polarization, Resistivity and Electromagnetic surveys were employed. The surveys helped define the structure of the long sulphide-bearing deposit and its transverse dislocations. Targets for detailed exploration were identified and recommendations made for the type of on-going investigation.

**OUTPUT (Reports, Papers, & etc)**
Confidential Report to UNRFNRE

**WORKSHOPS AND PRESENTATIONS**

**PROJECT STAFF**
R B Evans

**FUNDING** United Nations Revolving Fund for Natural Resources Exploration (JNRFNRE)
### PROJECT COMPLETION FORM

**PROJECT NO:** 3  
**TITLE:** GEOLOGY OF THE MAYA MOUNTAINS

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**COLLABORATING ORGANISATIONS**

**PROJECT OBJECTIVES**

Remapping and Geochemical Prospecting of the Maya Mountains

**PROJECT RESULTS**

The 5200 km² area of the Maya Mountains in Belize has been remapped and its Economic Potential evaluated.

The Stratigraphy of the area has been completely revised.

Geochemical studies on the whole were disappointing with the exception of one area with high molybdenum values, this anomaly was followed up by a Canadian mining company.
OUTPUT (Reports, Papers, & etc)


Rouse, J, Snelling, N J and Bateson, 7 H. 1975. Age Determinations on Igneous rocks from the Maya Mountains, Belize. IGS Isotope Geology Unit Report No 75.


WORKSHOPS AND PRESENTATIONS

PROJECT STAFF

J H Bateson
I H S Hall
N J Snelling
J Rouse

FUNDING ODA Technical Cooperation
**Title:** Regional Geology, Central Bolivia

**Locations:** Bolivia

**Project Size:** 3

**Dates:** 1974-5

**Collaborating Organisations**

Servicio Geologico de Bolivia (GEOBOL) La Paz

**Project Objectives**

Regional Photogeological Mapping in the sub-Andean belt of Bolivia south west of Santa Cruz (one-degree Square 18-19°S 64-65°W)

**Project Results**

The designated area was mapped by Photogeology and field checking; a 1:250 000 geological map and explanatory text of the area were produced.

**Output (Reports, Papers, & etc)**

1:250 000 Geological map of the Vallegrande Region GEOBOL 1979

**Workshops and Presentations**

Informal presentation made to GEOBOL staff in La Paz at termination of fieldwork - main theme - the value of satellite imagery and interpretation in regional mapping.

**Project Staff**

J H Bateson

P J Strange

**Funding**

ODA Technical Cooperation
**PROJECT COMPLETION FORM**

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**COLLABORATING ORGANISATIONS**

Servicio Geologico de Bolivia (GEOBOL), Santa Cruz

**PROJECT OBJECTIVES**

To conduct a major regional survey of the geology and mineral potential of the Precambrian Shield terrain of Eastern Bolivia. The area involved is about 250,000 km² (roughly the same size as Great Britain) much of which is remote and relatively inaccessible.

To publicise any Economic/Mineral Potential found within the region.

**PROJECT RESULTS**

Geological maps covering the entire region have been published.

A Geochemical Atlas showing the distribution of 22 elements has been published for the region as a guide to mineral exploration.

A substantial number of reports and scientific articles have been written and published by BGS and science journals.

The considerable mineral potential of the region identified by the project has been published at an ODA sponsored International Conference in Santa Cruz, Bolivia, 1989 generating exploration interest from major mining companies.

Potentially-economic occurrences of many metallic minerals have been detected; these include gold, platinum, silver, copper, lead, zinc, tin, rare earths, uranium and nickel together with a variety of industrial minerals.

An ODA review of the project concluded the project was a major success, quoting independent observers who believe it to be outstanding and the best geological study in Bolivia in the last 25 years.
OUTPUT (Reports, Papers, & etc)

Attached is a copy of a catalogue of documentary products from the Project compiled in 1986 at the end of Phase III of the project.

Subsequent output is listed below:


WORKSHOPS AND PRESENTATIONS

PROJECT STAFF

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<thead>
<tr>
<th>Dr K Bloomfield</th>
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<th>D P F Darbyshire</th>
<th>R B Evans</th>
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<tr>
<td>Dr J Berrange</td>
<td>(Project Manager 1980-3) Phase II</td>
<td>J A T Smellie</td>
<td>N Grant</td>
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<tr>
<td>C C J Burton</td>
<td>(Project Manager 1983-6) Phase III (Independent Consultant)</td>
<td>M T Styles</td>
<td>C Halls</td>
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<tr>
<td>Dr R N Annells</td>
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<td>R R Harding</td>
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<tr>
<td>Dr M Litherland</td>
<td>Dr C J N Fletcher</td>
<td>A G Gunn</td>
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<tr>
<td>Dr J D Appleton</td>
<td>Dr W I Mitchell</td>
<td>N J Snelling</td>
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<tr>
<td>Dr B A Klinck</td>
<td>Dr B C Webb</td>
<td>M Bennett</td>
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<tr>
<td>Dr E A O'Connor</td>
<td>Dr G Power</td>
<td>A J Shaw</td>
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<td>P E J Pitfield</td>
<td>M P Hawkins</td>
<td>W I Mitchell</td>
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FUNDING ODA Technical Cooperation
PROYECTO PRECAMBRICO

Catalogue of Documentary Products

Compiled by

C C J Burton, BSc., C. Eng.
Preface

The listings cover all the documentary products of 'Proyecto Precambrico' and are grouped into

A. External Publications covering papers published in scientific journals and conference proceedings;
B. Open-File Reports and Published Maps
C. BGS Publications.

Copies of Open-File Reports may be obtained at reproduction and carriage costs from:

Information and Central Services Directorate
British Geological Survey
Keyworth
NG12 5GG
United Kingdom

or

Servicio Geologico de Bolivia
Casilla 2729
La Paz
Bolivia

Published Maps may also be obtained at cost from the above addresses.

BGS Publications may be obtained at cost from the above BGS address.
REFERENCES

These refer to the final twenty-one reports covering Phase I and Phase II of the Project and listed below. The reports are on open file at BGS, Kevworth, and GEOBOL, La Paz, (in Spanish). Accompanying published maps may be purchased.

Phase I reports (1979):

1. Summary of the geology and mineral potential of the Project area—Southern Zone (two maps at 1:1 000 000), compiled by K. Bloomfield and M. Litherland.
2. The geology and mineral potential of the Concepción area (Quad. SE 20-3 with part of SE 20-2) (map at 1:250 000), compiled by C. J. N. Pitfield.
3. The geology and mineral potential of the San Ignacio de Velasco area (Part of Quad. SE 20-4) (map at 1:250 000), compiled by M. Litherland.
4. The geology and mineral potential of the Las Petas-San Matías area (Parts of Quads. SE 21-1 and SE 21-2) (map at 1:250 000), compiled by P. E. J. Pitfield.
5. The geology and mineral potential of the San José de Chiquitos area (Quad. SE 20-8 with part of SE 20-7) (map at 1:250 000), compiled by E. A. O’Connor.
6. The geology and mineral potential of the Santo Corazón-Rincón del Tigre area (Quads. SE 21-5 with part of SE 21-9, and SE 21-6 with part of SE 21-10) (two maps at 1:250 000), compiled by W. I. Mitchell.
7. The geology and mineral potential of the Rincón del Tigre Igneous Complex (map at 1:100 000), compiled by R. N. Anellns.
8. The geology and mineral potential of the Velasco Alkaline Province and Cerro Manomó (three maps at 1:100 000 and four at 1:20 000), compiled by C. J. N. Fletcher.
9. Results of the age determination programme (map at 1:1 000 000), compiled by D. P. F. Darbyshire.

Phase II reports (1982):

10. The geology and mineral potential of the Huanchaca area (Parts of Quads. SD 20-12 and SD 20-8) (map at 1:250 000), compiled by M. Litherland.
11. The geology and mineral potential of the Perseverancia and Monte Verde areas (Quads. SD 20-11 and SD 20-15) (2 maps at 1:250 000), compiled by B. A. Klinck and E. A. O’Connor.
12. The geology and mineral potential of the Huachi and Ascensión de Guayaros areas (Parts of Quads. SD 20-10 and SD 20-14) (2 maps at 1:250 000), compiled by R. N. Anellns and M. P. Hawkins.
13. The geology and mineral potential of the Manomó area (Part of Quad. SD 20-16) (map at 1:250 000), compiled by M. P. Hawkins.
14. The geology and mineral potential of the Magdalena area (Parts of Quads. SD 20-6 and SD 20-2) (map at 1:250 000), compiled by P. E. J. Pitfield and G. Power.
15. The geology and mineral potential of the Puerto Villazón area (Parts of Quads. SD 20-7 and SD 20-3) (map at 1:250 000 and at 1:100 000), compiled by P. E. J. Pitfield.
16. Geochemical prospecting for base metals in the San José de Chiquitos inlier (various maps), compiled by J. D. Appleton and A. Llanos.
17. Prospecting for tin in the Ascensión de Guayaros and Concepción areas (various maps), compiled by J. D. Appleton and A. Llanos.
18. Pegmatites, quartz veins and quartz breccia reefs in the Precambrian Shield of eastern Bolivia (map at 1:500 000), compiled by J. D. Appleton, C. C. J. Burton and A. Llanos.
19. The geology and mineral resources of Cerro Manomó (6 maps at 1:10 000), compiled by C. C. J. Burton.
20. The mineral resources of the Rincón del Tigre Igneous Complex (various maps), compiled by R. N. Anellns and C. C. J. Burton.
21. Synopsis of the geology and mineral potential of the Proyecto Precámbrico area—Southern and Northern Zones (2 maps at 1:1 000 000), compiled by J. P. Berrangé and M. Litherland.

NAME REFERENCES

AHLFELD, F. 1954. Los yacimientos minerales de Bolivia. 277pp. (La Paz: Banco Minero de Bolivia y Corporación Minera de Bolivia.)


— — — — In press c. The Rincón del Tigre Igneous Complex: a layered ultramafic-mafic intrusion of Upper Proterozoic age in the Precambrian Shield of eastern Bolivia. Part I:
B. Open File reports and published maps

Project reports, published and on open file at the libraries of the British Geological Survey, Keyworth, Nottingham, UK. Also available for inspection at the offices of the Servicio Geologico de Bolivia (GEOBOL), Santa Cruz, La Paz, Bolivia.

For location see map.

**Phase 1 1976-1979**


2. Bloomfield, K. and Litherland, M., 1979. Summary of the geology and mineral potential of the Project area - Southern Zone. 2 Maps at 1:1,000,000.


**Phase 2 1980-1983**


Phase 111 1983-1986


C. BGS Publications


A. List of Publications

External publications


<table>
<thead>
<tr>
<th><strong>PROJECT COMPLETION FORM</strong></th>
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<tbody>
<tr>
<td><strong>TITLE:</strong> MINERAL RESOURCES AND GEOLOGICAL ADVISORS</td>
</tr>
<tr>
<td><strong>LOCATIONS:</strong> Brazil</td>
</tr>
<tr>
<td><strong>DATES:</strong> 1970-74</td>
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<table>
<thead>
<tr>
<th><strong>COLLABORATING ORGANISATIONS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Instituto do Desenvolvimento Economico-Social do Para, (IDESP) Belem</td>
</tr>
<tr>
<td>Instituto de Geosciences, Federal University of Bahia</td>
</tr>
<tr>
<td>University of Brasilia</td>
</tr>
<tr>
<td>Departamenio Nacional de Produção Mineral (Proyecto RADAM)</td>
</tr>
<tr>
<td>State of Piaui</td>
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</table>

<table>
<thead>
<tr>
<th><strong>PROJECT OBJECTIVES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>To provide assistance in assessing limestone and other mineral resources in the states of Para. To act as consultant on the geology of the Roraima Territory in NW Brazil and to assist in the interpretation of side look radar imagery of the region (Proyecto RADAM)</td>
</tr>
<tr>
<td>To advise on setting-up a photogeology and remote sensing department at the Federal University of Bahia.</td>
</tr>
<tr>
<td>To install and monitor a telemetered array of seismic stations on the Brazilian Plateau to provide a more complete coverage along the Andean Chain.</td>
</tr>
<tr>
<td>To provide a three month course in photogeology and geological surveying for IDESP.</td>
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<tr>
<td>To assess and survey opal and diamond deposits in the state of Piaui, to identify new resources and extraction schemes.</td>
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<tr>
<th><strong>PROJECT RESULTS</strong></th>
</tr>
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<tbody>
<tr>
<td>The project objectives were fully realized.</td>
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<thead>
<tr>
<th><strong>OUTPUT (Reports, Papers, &amp; etc)</strong></th>
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</table>
**WORKSHOPS AND PRESENTATIONS**

Photogeology course, (IDESP) Belem, Brazil 1972 (10 geologists instructed)

Presentation at Brazilian Geological Conference, Belem 1972

**PROJECT STAFF**

Dr J P Berrangé  
Dr B N Fletcher  
N R Cameron  
P G Linzell (Independent Consultant)  
Dr I McReath  
E A Jobbins

**FUNDING** ODA Technical Cooperation
<table>
<thead>
<tr>
<th><strong>TITLE:</strong> &quot;MAGELLAN PROJECT&quot;, SOUTHERN CHILE</th>
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| **LOCATIONS:** Chile | **PROJECT SIZE:** 3 |

| **DATES:** 1969-70 |

| **COLLABORATING ORGANISATIONS** |

| Instituto de Investigaciones Geologicas, Santiago |

| **PROJECT OBJECTIVES** |

| Reconnaissance Mineral Exploration of southern Chile (Navarino and Western sectors) |

| Training of counterpart geologists in field techniques, geochemical sampling and laboratory analysis. |

| **PROJECT RESULTS** |

| The reconnaissance mineral exploration was completed for the Navarino and Western sectors (54°52'-55°24'S, 66°-25'-68°30'W), the maps and reports listed overleaf describe the findings. |

| A dozen geochemical anomalies with high values of either molybdenum, copper, nickel, lead or zinc were identified. |

| **OUTPUT (Reports, Papers, & etc)** |


| Stewart, J W, Cruzat, A, Page, B, Suarez, M, Stambuk, V. 1971. Estudio Geologico Economico de la Cordillera Patagonia entre los parallelos 51°00'-53°30'S, Provincia de Magallanes |

| **WORKSHOPS AND PRESENTATIONS** |

| **PROJECT STAFF** |

| Dr B G N Page |

| Dr J W Stewart |

| **FUNDING** ODA Technical Cooperation |
**PROJECT COMPLETION FORM**  
**PROJECT NO:** 8

<table>
<thead>
<tr>
<th><strong>TITLE:</strong></th>
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<tr>
<td><strong>LOCATIONS:</strong></td>
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<tr>
<td><strong>PROJECT SIZE:</strong></td>
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</tr>
<tr>
<td><strong>DATES:</strong></td>
<td>1970-74</td>
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</table>

**COLLABORATING ORGANISATIONS**
Instituto de Investigaciones Geologicas (IIG)  
Empresa Nacional de Mineria

**PROJECT OBJECTIVES**
To provide geological advisors to Chilean parastatal bodies in the fields of geochemistry and hydrogeology.

To assist with national plans for mineral exploration and development.

Slope stability studies at the El Teniente Mine.

**PROJECT RESULTS**
Two resident advisors were provided, in Geochemistry (1971-74) and in Hydrogeology (1972) plus short-term advisory visits in the fields of Engineering Geology and Geophysics.

The geochemical advisor helped to establish a Geochemistry Division at IIG comprising 13 professional staff and support workers equipment was donated by ODA and studies conducted involved exploration for copper, nickel and coal.

The hydrogeological advisor assisted studies of water supply schemes for copper processing in arid N Chile including well siting and drilling.

**OUTPUT (Reports, Papers, & etc)**

**WORKSHOPS AND PRESENTATIONS**
Course in geochemical prospecting, University of Chile 1972
**PROJECT STAFF**

Dr B G N Page (Geochemist)
J W Lloyd (Hydrogeologist)
C B Campbell
P J Moore
B Denness

**FUNDING** ODA Technical Cooperation
# Project Completion Form

**Title:** REGIONAL GEOLOGY, VALLE, SOUTHWEST COLOMBIA

**Locations:** Colombia

**Project Size:** 2

**Dates:** 1980-4

**Collaborating Organisations**
Instituto Nacional de Geología y Minas (INGEOMINAS) Cali

**Project Objectives**

Regional geological mapping and mineral exploration of 16,500 km² of the Western and Central Cordilleras and the Cauca valley around Cali, SW Colombia, supported by age-determination and geophysical studies from BGS.

To help establish a new regional office of INGEOMINAS in Cali and the installation of a geochemical laboratory.

To train counterpart geologists in field mapping and mineral exploration techniques.

**Project Results**

The area identified was surveyed geologically supported by geochemical, isotope and geophysical studies. Geological maps and accounts of the area were published (detailed overleaf) and several fundamental advances in the geology and structure of the area were achieved.

Porphyry-copper mineralization was discovered in the Central Cordillera whilst Tertiary alluvial gold deposits comprise the main potential of the Western Cordillera.

A geochemical laboratory enabling routine analysis for a dozen elements was installed in INGEOMINAS, Cali to enable the work to be extended.
OUTPUT (Reports, Papers, & etc)

List of Map Reports (In Spanish) presented to INGEOMINAS for publication:-

McCourt, W J, Mosquera, D, Nivia, A and Nunez, A. Armenia, Sheet 243.
Armas de, M, Tulua, Sheet 261.
McCourt, W J. Genova, Sheet 262.
Aspden, J A and Nivia, A. Bahia de Buenaventura, Sheet 278.
McCourt, W J, Millward, D of Espinosa, A. Palmira, Sheet 280.
Verdugo, G and Aspden, J A. Jamundi, Sheet 299.
McCourt, W J and Verdugo, G. Cali, Sheet 300.
McCourt, W J. Generalized Geology, Departamento del Valle de Cauca (in English).

Project Reports:-

Vergara, H and Aucott, J W. Geochemical prospection in the La Marina area, Department of Valle del Cauca. Report No 1 (English and Spanish).
Vergara, H and Aucott, J W. Preliminary Soil Geochemistry and Electrochemistry of the El Pisno Area, Department of Valle del Cauca. Report No 2 (English and Spanish).
Aucott, J W. Regional geochemistry and economic potential of base metal mineralization in the Department of Valle del Cauca. Report No 4 (English and Spanish).
Aspden, J A. The geology of the Western Cordillera and Pacific Coastal Plain in the Department of Valle del Cauca (Sheets 261, 278, 279, 280 and 299). Report No 7 (English).
McCourt, W J. The geology of the Central Cordillera in the Department of Valle del Cauca, Quindio and (NW) Tolima (Sheets 243, 261, 262, 280 and 300). Report No 8 (English).
Brook, M. New radiometric age data from SW Colombia. Report No 10 (English).

Scientific Publications:-


<table>
<thead>
<tr>
<th>WORKSHOPS AND PRESENTATIONS</th>
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<tbody>
<tr>
<td>Presentations at:</td>
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<tr>
<td>4\textsuperscript{th} Congress of Colombian Geology, Cali, Colombia 1982</td>
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<tr>
<td>11\textsuperscript{th} International Geochemical Exploration Symposium, Toronto 1985</td>
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<tr>
<td>10\textsuperscript{th} Caribbean Geology Congress Cartagena, Colombia 1983</td>
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<tr>
<th>PROJECT STAFF</th>
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<tbody>
<tr>
<td>Dr J W Aucott (Project Manger)</td>
</tr>
<tr>
<td>Dr J Aspden</td>
</tr>
<tr>
<td>Dr McCourt</td>
</tr>
<tr>
<td>Dr D Millward</td>
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<p>| FUNDING | ODA Technical Cooperation |</p>
<table>
<thead>
<tr>
<th><strong>Title:</strong> PACIFIC PRECIOUS METALS PROJECT</th>
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<tr>
<td><strong>Locations:</strong> Colombia</td>
</tr>
<tr>
<td><strong>Project Size:</strong> 3</td>
</tr>
<tr>
<td><strong>Dates:</strong> 1986-90</td>
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</tbody>
</table>

**Collaborating Organisations**

Instituto Nacional de Investigaciones Geológico y Mineras (INGEOMINAS)

**Project Objectives**

Gold exploration and evaluation in the Pacific coast and Western flank of Colombia's Western Cordillera, SW Colombia

On the job training of counterpart staff.

**Project Results**

A new model to explain the gold mineralization in the Pacific coast area was developed, relating the gold to Tertiary subvolcanic intrusive rocks.

The richest gold deposits are found where mudflows have preserved old river deposits in ancient valleys.

This fresh understanding of the occurrence of the gold deposits will guide future exploration efforts.

Two counterpart geologists have completed MSc courses at British Universities funded by the British Council, others are proposed.

**Output (Reports, Papers, & etc)**

1:60 000 Geological Map & Report.


WORKSHOPS AND PRESENTATIONS

Lectures and Course provided by BGS staff in:

Remote Sensing INGEOMINAS Cali 1989

Mineral Processing Technology INGEOMINAS Cali and Bogota 1988

Geochemistry in Gold Exploration INGEOMINAS Cali 1989.

PROJECT STAFF

Dr R N Annells (Project Manager Phase 1, 1986-88)
Dr W J McCourt (Project Manager Phase 2, 1988-90)
Dr I R Basham
Dr B Beddoe-Stephens
D A Briggs
R B Evans
R C Jones
J L Roberts
Dr B J Amos
Dr J D Appleton
D Entwhistle

FUNDING ODA Technical Cooperation
**PROJECT COMPLETION FORM**

**PROJECT NO: 11**

<table>
<thead>
<tr>
<th>TITLE: TALAMANCA CORDILLERA REGIONAL GEOLOGY</th>
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<tbody>
<tr>
<td>LOCATIONS: Costa Rica</td>
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<tr>
<td>PROJECT SIZE: 4</td>
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<tr>
<td>DATES: 1975-7</td>
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</tbody>
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**COLLABORATING ORGANISATIONS**

Dirección de Geología, Minas y Petroleo (DGMP), Costa Rica  
British Museum (Natural History)

**PROJECT OBJECTIVES**

Photogeological study and field checking to produce geological maps of 3,000 km² of the Talamanca Cordillera which was thought to contain major porphyry copper mineralization. Training of Costa Rican counterpart geologists in photogeology and field mapping. One counterpart geologist was sent to the UK for post-graduate training.

**PROJECT RESULTS**

One geological map covering 500 km² and five photo-geological maps covering 2,500 km² of the Talamanca Cordillera were produced.

These provide the basis for future more detailed mapping and exploration for gold and porphyry copper deposits by Costa Rican geologists.

The stratigraphy of a key area in the Talamanca Cordillera was sorted out by field mapping and palaeontological studies.

One Costa Rican counterpart geologist (A Monge) gained a PhD in Mineral Economics from University of Leicester. He subsequently became Director of Costa Rica's state mining enterprise MINASA.

**OUTPUT (Reports, Papers, & etc)**


Berrangé, J P. 1977. Geological Map  
Photogeological Maps  
Tapantí Sheet 1:100 000  
Pejibaye Sheet 1:50 000  
Vueltas Sheet  
Cuerici Sheet  
Savegre Sheet  
San Isidro Sheet
<table>
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<th>WORKSHOPS AND PRESENTATIONS</th>
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<th>PROJECT STAFF</th>
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</table>
Dr J P Berrangé  
Dr J E Whittaker (British Museum)  

| FUNDING ODA Technical Cooperation |
**TITLE:** TILARAN-AGUACATE GOLD PROJECT

**LOCATIONS:** Costa Rica

**PROJECT SIZE:** 4

**DATES:** 1981-83

**COLLABORATING ORGANISATIONS**
Corporacion Costarricense de Desarrollo (CODESA)

**PROJECT OBJECTIVES**
Geological mapping and gold exploration in the Tilaran-Aguacate mountains involving photogeology, field studies. Geochemistry and geophysical inputs.

Provide advice on training in gold exploration and related laboratory techniques

**PROJECT RESULTS**
A geological map, report and geochemical analyses were published covering the Tilaran-Aguacate area (3500km²).

This will help guide future exploration for gold in the area, recommendations are made for geochemical sampling procedures and exploration targets are identified.

Two short advisory visits were undertaken to CODESA laboratories in San Jose to advise on instrument calibration, laboratory environment, procedures, methodology, techniques, etc.

The report (listed) provided an input to USGS “Mineral Resource Assessment of the Republic of Costa Rica”.

**OUTPUT (Reports, Papers, & etc)**
WORKSHOPS AND PRESENTATIONS

PROJECT STAFF
Dr B J Amos
Dr P Rodgers
J Roberts

FUNDING ODA Technical Cooperation
**Title:** VALLE CENTRAL HYDROGEOLOGY

**Locations:** Costa Rica

**Project Size:** 4

**Dates:** 1975-1984 (Intermittent)

**Collaborating Organisations**
- Servicio Nacional de Aguas Subterráneas, Riego, y Avenamiento (SENASA)
- Instituto Costarricense de Acueductos y Alcantarillados (ICAyA)

**Project Objectives**
- Intermittent short-term advisory support to SENARA and ICAyA on groundwater abstraction in the Valle Central.
- Construction of a preliminary aquifer mathematical model to simulate and evaluate future abstraction plans.
- Preparation of a hydrogeological map of the Valle Central.

**Project Results**
- Considerable advice and technical know-how has been provided to SENARA and ICAyA, on production borehole siting, design and protection, resource evaluation and modelling.
- A hydrogeological map of the Valle Central has been published.
- The work resulted in a World Bank Commonwealth Development Corporation-funded project (No.13 this volume) to investigate groundwater resource development and protection in greater detail.
**OUTPUT (Reports, Papers, & etc)**

Losilla, M and Rodriguez, H 1978 Consideraciones sobre recarga y descarga del acuífero de Colima en el área del Campo de Pozos de Santo Domingo. SENAS, informe tecnico 102:


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**WORKSHOPS AND PRESENTATIONS**

**PROJECT STAFF**

Dr S S D Foster  
J M Parker  
Dr R Kitching  
R A Monkhouse  
A Williams

**FUNDING** ODA Technical Cooperation
**TITLE:** VALLE CENTRAL GROUNDWATER RESOURCES

**LOCATIONS:** Costa Rica

**PROJECT SIZE:** 4

**DATES:** 1984-87

**COLLABORATING ORGANISATIONS**

Servicio Nacional de Aguas Subterráneas Riego y Avenamiento (SENARA)
Instituto Costarricense de Acueductos y Alcantarillados (ICAyA)

**PROJECT OBJECTIVES**

To carry out hydrogeological studies to enable ICAyA and SENARA to exploit more rationally the groundwater resources of the Valle Central (the major populated part of Costa Rica).

To extend knowledge of the recharge and discharge of deep and superficial aquifers in the Valle Central, especially the key Colima Aquifer System.

To assess the potential for further development of groundwater supplies on the northern side of the Valle Central.

**PROJECT RESULTS**

It is concluded that the Colima aquifer could yield a further 1000-1500 litres/sec with the construction of new wellfields.

Whilst groundwater quality is excellent some aquifers are at risk of serious contamination, preventive measures are identified.

Recommendations are made for future groundwater development, and management, further investigation requirements are identified.
OUTPUT (Reports, Papers, & etc)


WORKSHOPS AND PRESENTATIONS

Presentations at:

Regional Seminar for Latin America on the use of isotope techniques in hydrology, Salazar, Mexico 1987


PROJECT STAFF

Dr S S D Foster
J M Parker
Dr R Kitching
G Darling
A Williams
J A M Cook
M Perkins

FUNDING World Bank and Commonwealth Development Corporation
## Project Completion Form

### Title:
INDUSTRIAL MINERALS SURVEY (PACOMI)

### Locations:
Costa Rica

### Project Size:
3

### Dates:
1987-91

### Collaborating Organisations
- Direcccion de Geologia, Minas y Hidrocarburos (DGMH) 1987-89
- Recope S A 1989-91
- Ministerio de Recursos Natales Energia y Minas (MIRENEM)

### Project Objectives
- To complete a systematic inventory of Industrial Mineral occurrences in Costa Rica (Phase 1).
- To undertake more detailed follow-up studies of selected commodities (Phase II).
- To identify opportunities for import substitution and export of industrial minerals, to study regional markets.
- To train counterpart staff to continue the work.

### Project Results
- A comprehensive 181-page inventory of industrial minerals in Costa Rica has been published, production and import/export statistics are included, opportunities for import substitution and export are identified.
- Detailed follow-up studies identified 3 million tonnes of diatomite reserves suitable for filtration, thin beds of bentonite-rich clay and the very high purity Barra Honda Limestone resource which has export potential.
- A post-graduate course on industrial minerals was developed at the University of Costa Rica; two counterpart staff have been given training in the UK - funded by the British Council.
- High-technology applications related testing of several commodities was performed at BGS Keyworth. Some 20 publications listed overleaf describe the detailed work of the project.
- A short consulting visit was made to Nicaragua to investigate the industrial mineral capacity.
OUTPUT (Reports, Papers, & etc)


# OUTPUT (Reports, Papers, & etc)


# WORKSHOPS AND PRESENTATIONS

Post-graduate University course in Industrial Minerals presented at the University of Costa Rica, 1990.

Two 'on the job' working seminars provided in limestone and bentonite assessment.

Papers read at:

- 1st National Symposium on Mining, San José 1988
- Circum - Pacific Conference, San José 1990
- 2nd National Symposium on Mining San José 1990

# PROJECT STAFF

Dr J P Berrangé (Project Manager 1987-89) Phase I
S J Mathers (Project Manager 1989-91) Phase II
D J Harrison
C J Mitchell
A J Bloodworth
S D J Inglethorpe

# FUNDING

ODA Technical Cooperation
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<th><strong>PROJECT COMPLETION FORM</strong></th>
<th><strong>PROJECT NO: 16</strong></th>
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<tr>
<td><strong>TITLE:</strong> REGIONAL GEOLOGY - LOJA &amp; LLANGANATES</td>
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<tr>
<td><strong>LOCATIONS:</strong> Ecuador</td>
<td><strong>PROJECT SIZE:</strong> 3</td>
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<td><strong>DATES:</strong> 1969-70</td>
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<td><strong>COLLABORATING ORGANISATIONS</strong></td>
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<tr>
<td>United Nations Development Programme (UNDP)</td>
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<tr>
<td>Servicio Nacional de Geologia y Minería</td>
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<tr>
<td><strong>PROJECT OBJECTIVES</strong></td>
<td></td>
</tr>
<tr>
<td>UK-based photogeological interpretation, followed by field checking, to produce 1:1 000 000 geological maps of 17.500 km² of terrain in the Loja and Llanganates areas of Ecuador.</td>
<td></td>
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<tr>
<td>Training Counterpart staff in Photogeology</td>
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<tr>
<td>Publication of 1:100 000 Geological Maps of the areas identified</td>
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<tr>
<td><strong>PROJECT RESULTS</strong></td>
<td></td>
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<tr>
<td>The six 1:100 000 geological maps planned were produced and published</td>
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<tr>
<td>Samples were collected in the Loja area for a UNDP Mineral Survey Project - these were analyzed in UNDP Laboratories in Ecuador.</td>
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<tr>
<td>A counterpart Ecuadorian geologist was given 5 months training in Photogeology in the UK</td>
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<td>OUTPUT (Reports, Papers, &amp; etc)</td>
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<tr>
<td>Maps</td>
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<tr>
<td>1 ¼ ° Sheet Llanganates Area 1:100 000</td>
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<tr>
<td>5 ¼ ° Sheets Loja Area 1:100 000</td>
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<tbody>
<tr>
<td>J B Kennerley</td>
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**PROJECT COMPLETION FORM**

**TITLE:** REGIONAL GEOLOGY AND MINERAL EXPLORATION

**LOCATIONS:** Ecuador  
**PROJECT SIZE:** 1  
**DATES:** 1972-80

**COLLABORATING ORGANISATIONS**
- Direccion General de Geologia y Minas (DGGM)  
- Instituto Geografico Militar (IGM) (for pre printing of all maps)  
- British Museum

**PROJECT OBJECTIVES**
- Regional Geological Mapping of extensive areas of the Andean Chain and Pacific Coastal Plain of Ecuador; involving photogeological interpretation and fieldwork.
- Production of 1:100 000 geological maps and a revised 1:1M geological map of Ecuador, with explanation.
- Associated exploration for metallic and industrial minerals
- Engineering geology studies especially around the capital, Quito.
- Training counterpart staff in laboratory techniques, drafting and production of computer databases. Institution Building.

**PROJECT RESULTS**
- 61 ¼° Sheets covering in area of 125,000 km² (half the size of Britain) were surveyed geologically, the geological maps were published at 1:100 000 scale.
- The survey remapped about 40% of Ecuador, and a new National Geological map at 1:1 million scale and geological explanation were produced using the findings.
- Several zones of copper mineralization were discovered in the Western Cordillera, and important occurrences of phosphate in the Napo area (sub-Andean belt).
- A Geochemical laboratory including atomic absorption spectrometry equipment and associated computing facilities donated and installed.
- Engineering geology and geotechnical studies were carried out around Quito.
- Cartographic training and supervision in geological map making, were provided.
- 15 training awards were provided for Ecuadorian staff to receive MSc courses and training in the UK.
OUTPUT (Reports, Papers, & etc)

Maps

61 1:100 000 scale geological maps of ¼° sheets covering 40% of Ecuador (not listed in detail)


Other publications


Baker, M C and Francis, P. 1978. Upper Cenozoic volcanism in the central Andes. Isotope Geology Unit, No 78.6, 5pp.

Atkin, D. 1979. XRD examination of phosphate samples from Ecuador. File 87.25/1, No 8474.


WORKSHOPS AND PRESENTATIONS

Photogeology Course, Escuela Politecnica Nacional Quito 1975
Geochemistry in Mineral Exploration, Politecnica Nacional Quito 1978
### PROJECT STAFF

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Position</th>
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<tbody>
<tr>
<td>J B Kennerley</td>
<td>Project Manager</td>
<td>1972-6</td>
</tr>
<tr>
<td>Dr J W Baldock</td>
<td>Project Manager</td>
<td>1977-80</td>
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<tr>
<td>Dr C R Bristow</td>
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<td>R F Randel</td>
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<td>Dr J W Aucott</td>
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<td>Dr A F Wilkinson</td>
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<td>Dr C Mortimer OBE</td>
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<td>Dr J E Whittaker (British Museum)</td>
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<td>R M Carruthers</td>
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<td>R I Johnson</td>
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<td>S Tucker</td>
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### FUNDING

ODA Technical Cooperation
<table>
<thead>
<tr>
<th><strong>TITLE:</strong> GEOLOGY OF THE CORDILLERA REAL</th>
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<table>
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<tr>
<th><strong>LOCATIONS:</strong> Ecuador</th>
<th><strong>PROJECT SIZE:</strong> 2</th>
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<tr>
<td></td>
<td><strong>DATES:</strong> 1986 - On Going</td>
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<thead>
<tr>
<th><strong>COLLABORATING ORGANISATIONS</strong></th>
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<tr>
<td>Instituto Nacional Ecuatoriano de Minería (INEMIN)</td>
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<table>
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<tr>
<th><strong>PROJECT OBJECTIVES</strong></th>
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<tbody>
<tr>
<td>Regional geology and mineral studies supported by geochronology and geochemical programme to elucidate the mineral potential of the poorly understood Cordillera Real of eastern Ecuador.</td>
</tr>
<tr>
<td>In particular to identify the source of gold deposits found for many centuries in this region, and to identify zones of base metal mineralization by undertaking traverses across the Cordillera Real.</td>
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<tr>
<td>Training of counterpart staff.</td>
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<tr>
<th><strong>PROJECT RESULTS</strong></th>
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<tbody>
<tr>
<td>To-date the geology of the Cordillera Real has been defined by a series of geotraverses.</td>
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<tr>
<td>Areas of potential mineralization of several distinct types have been identified.</td>
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<tr>
<td>The on-going project (Phase 3) now has three main components:</td>
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<tr>
<td>1) Studying polymetallic veins and breccias with mineral potential.</td>
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<tr>
<td>2) Reconnaissance of the geological basement in SW Ecuador to reveal mineral potential.</td>
</tr>
<tr>
<td>3) National Map Programme, compiling geologic, tectonic and metallogenic maps of Ecuador.</td>
</tr>
</tbody>
</table>
OUTPUT (Reports, Papers, & etc)


Harrison, S M. 1990. Radiometric Ages (Rb-Sr, K-Ar and Sm-Nd) for rocks from the Cordillera Real Ecuador. BGS Technical Report WC/90/12.


WORKSHOPS AND PRESENTATIONS

Training courses provided at INEMIN

a) Economic Geology (with emphasis on gold)

b) Petrography

PROJECT STAFF

Dr M Litherland (Project Manager)  Dr N J Fortey
Dr J Aspden  Dr M C G Clarke
Dr R Jemielita  S M Harrison
Dr B Beddoe-Stephens
C C Rundel
Dr T J Shepherd

FUNDING ODA Technical Cooperation
Title: Regional Geology, Southern Guyana

Locations: Guyana

Project Size: 2

Dates: 1966-71

Collaborating Organisations

Geological Survey of Guyana

Project Objectives

Reconnaissance photogeological and field mapping of Guyana south of 4°N covering about 64,000 km² of territory to produce geological maps and an account of the geology of the area; and to identify its mineral potential.

Project Results

The first systematic geological maps of 64,000 km² of southern Guyana (S of 4°N) were produced as follows:

Nine degree square geological maps at 1:200,000
One tectonic/geological map of southern Guyana at 1:500,000
One geomorphological map of southern Guyana at 1:500,000

These primary maps were subsequently utilised for the construction of a revised 1:1 M geological map of Guyana.

A memoir describing the geology of the region was produced. Nine substantive scientific papers on the Geology, geomorphology and archaeology of the region were published.

Recommendations on the disused Marudi Gold Mine led to renewed interest in it by North American mining companies. It is at present being drilled by Sutton Resources Ltd with promising assay results.

The North Savannas Rift Valley was first identified and subsequently investigated by North American petroleum companies as a possible source of oil and gas.

Recommendations led to the agate nodules in the North Savannas Rift Valley being utilised for a lapidary workshop subsequently set up by ODA/BGS in Georgetown.


**WORKSHOPS AND PRESENTATIONS**

Results presented at:


**PROJECT STAFF**

Dr J P Berrangé
Dr R L Johnson

**FUNDING** ODA Technical Cooperation
**Title:** GEOLOGICAL ADVISORS

**Locations:** Guyana

**Project Size:** 5

**Dates:** 1973

**Collaborating Organisations**
- Geological Survey of Guyana
- Land Resources Division, ODA

**Project Objectives**
Establishing a lapidary to enable local craftsmen to cut and fashion decorative stone.

**Project Results**
The lapidary which was attached to the Geological Survey of Guyana was set-up and equipped by ODA. It operated very successfully for at least a decade.

**Output (Reports, Papers, & etc)**

**Workshops and Presentations**

**Project Staff**
- E A Jobbins

**Funding** ODA Technical Cooperation
### MOSQUITIA PROJECT

**LOCATIONS:** Honduras  
**PROJECT SIZE:** 4  
**DATES:** 1981

**COLLABORATING ORGANISATIONS**  
Land Resources Development Centre (LRDC)  
Crown Agents  
Overseas Development Administration

**PROJECT OBJECTIVES**  
To report on the possible mineral potential of the Mosquitia region of Honduras (east of 85°30'W) the area is heavily forested and poorly understood geologically. (Part of a multi-disciplinary, natural and renewable resources survey for development of Mosquitia).

**PROJECT RESULTS**  
The general geological framework of the area was revised and recommendations made on the nature of a detailed follow-up programme that is essential to establish mineral potential.

Proposals made for a UNDP - or ODA-funded mineral exploration/photogeology/remote sensing programme and the establishment of alluvial-gold co-operatives.

**OUTPUT (Reports, Papers, & etc)**  

**WORKSHOPS AND PRESENTATIONS**
<table>
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<th>PROJECT STAFF</th>
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<td>Dr J W Baldock</td>
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**PROJECT COMPLETION FORM**

**PROJECT NO:** 22  

**TITLE:** HYDROGEOLOGY OF INTERMONTANE BASINS

**LOCATIONS:** Honduras  
**PROJECT SIZE:** 4  
**DATES:** 1982-84

**COLLABORATING ORGANISATIONS**

Direccion de Recursos Hidricos  
Directorate Hydrological Resources (DRH)

**PROJECT OBJECTIVES**

Evaluation of groundwater resources for irrigation in several isolated intermontane sedimentary basins.  
Quantifying costs involved in developing the resources

**PROJECT RESULTS**

A hydrogeological and Agro-economic appraisal was undertaken for several basins.  
Two were selected for detailed assessment, involving drilling, geophysics.

**OUTPUT (Reports, Papers, & etc)**


**WORKSHOPS AND PRESENTATIONS**

**PROJECT STAFF**

B L Morris

**FUNDING** ODA Technical Cooperation
**Title:** Hydrogeological Advisors  

**Locations:** Honduras  

**Project Size:** 3  

**Dates:** 1984-90  

**Collaborating Organisations**  

Servicio Autonomo Nacional de Acueducos y Alcantarillados (SANAA)  

**Project Objectives**  

To advise the Honduran Government and SANAA on varied hydrogeological and organizational matters, mainly dealing with the capital, Tegucigalpa.  

**Project Results**  

Advice was given on many diverse hydrogeological projects and problems, including the construction of a pipeline linking 16 supply wells to Tegucigalpa, the capital city.  

Advice was also given on reorganizing the management of groundwater resources and questions related to rural and urban water supply.  

**Output (Reports, Papers, & etc)**  


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Project List


<table>
<thead>
<tr>
<th>WORKSHOPS AND PRESENTATIONS</th>
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<tbody>
<tr>
<td>International Workshop on Groundwater Chemistry, Tegucigalpa, Honduras 1990</td>
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<td>R J Marks</td>
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<td>B L Morris</td>
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**PROJECT COMPLETION FORM**

**PROJECT NO:** 24

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<th><strong>TITLE:</strong></th>
<th>GEOPHYSICAL STUDY FOR MINERALS, YUSCARAN</th>
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<td>Honduras</td>
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<tr>
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<tr>
<td><strong>DATES:</strong></td>
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</table>

**COLLABORATING ORGANISATIONS**

**PROJECT OBJECTIVES**

To investigate the further potential of a precious/base-metal prospect in rugged terrain, at Yuscaran, Southern Honduras.

The study forms part of UNRFNRE Mineral Exploration Project.

**PROJECT RESULTS**

Magnetic, electromagnetic and induced polarization (IP) measurements were initially made over known mineralization at Yuscaran, southern Honduras. IP was found to be the only method to give a positive response related to the mineralization and so was selected as the geophysical method for a more extensive survey at Yuscaran.

A large number of chargeability anomalies were found and were often associated with a resistivity anomaly of high values. Several east-north east trends and an east-west trend have been identified. Some anomalies have also been found over the unmineralized tuffs and may be related to mineralization in the underlying andesites. The sources of the anomalies are either thin steeply dipping linear zones or more extensive areas of silicification and propylitisation.

Based upon the IP results 11 sites have been recommended for drill holes. The anomalies are caused by disseminated sulphides and it is not possible to ascertain from the IP data whether precious metals are associated with the base metals.

**OUTPUT (Reports, Papers, & etc)**

## WORKSHOPS AND PRESENTATIONS

### PROJECT STAFF

- J P Busby
- A S D Walker

### FUNDING

**UN Revolving Fund for Natural Resources Exploration (UNRFNRE)**
**TITLE:** GROUNDWATER INVESTIGATION AND DEVELOPMENT

**LOCATIONS:** Honduras  
**PROJECT SIZE:** 3  
**DATES:** 1988-1995

**COLLABORATING ORGANISATIONS**  
Servico Antonomo Nacional de Acueducos y Alcantarillados (SANAA)

**PROJECT OBJECTIVES**  
To advise the Honduranian Government and SANAA on varied hydrogeological and organizational matters, mainly areas outside the capital city.

**PROJECT RESULTS**  
Hydrogeological studies investigating individual proposals for groundwater development in Honduras.  
Hydrogeological assessments of well drilling and pump tests within Honduras, Development of a groundwater database for Honduras

**OUTPUT (Reports, Papers, & etc)**

**WORKSHOPS AND PRESENTATIONS**

**PROJECT STAFF**  
A A Mackenzie  
D F Ball

**FUNDING** ODA Technical Cooperation
**TITLE:** VOLCANOLOGICAL RESEARCH AND TRAINING

**LOCATIONS:** Mexico  
**PROJECT SIZE:** 3  
**DATES:** 1971-4

**COLLABORATING ORGANISATIONS**

Instituto de Geologia, Universidad Nacional Autonoma de Mexico  
Departamento de Prehistoria, Instituto Nacional de Antropologia e Historia

**PROJECT OBJECTIVES**

To provide advice and training in mineralogy, petrology and geochemistry at the National University and to the Mexican Government.

To stimulate volcanological research in Mexico and train counterpart geologists.

To supervise post-graduate research students.

**PROJECT RESULTS**

A volcanic studies group was set up.

A detailed study of the development of the Nevado de Toluca volcano was undertaken, a 1:100 000 geological map of the area was published.

Up to 12 post-graduate research students were supervised.

A study of Popocatepetl Volcano was also mounted.
**OUTPUT (Reports, Papers, & etc)**


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**WORKSHOPS AND PRESENTATIONS**

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**PROJECT STAFF**

Dr K Bloomfield

**FUNDING** ODA Technical Cooperation
**PROJECT COMPLETION FORM**

| PROJECT NO: 27 |

| **TITLE:** CERRO PANDO GEOTHERMAL FIELD |
| **LOCATIONS:** Panama | **PROJECT SIZE:** 4 |
| **DATES:** 1977-81 |

**COLLABORATING ORGANISATIONS**

Corporación de Desarrollo Minero Cerro Colorado (CODEMIN)

**PROJECT OBJECTIVES**

Investigation of the Cerro Pando Geothermal area, Western Panama involving geological mapping, remote sensing, geophysical, geochemical and hydrogeological studies to detect zones of active faults around the geothermal system, which may act as pathways for the migration of thermal groundwaters.

**PROJECT RESULTS**

Detailed geological mapping of 500 km² involving aerial photography and satellite imagery interpretation together with geophysics (microseismic survey) and temperature, conductivity and chemical analyses of streams and springs show the geothermal zone is more extensive than previously known, the hot springs are controlled by insecting faults that cut the local Tertiary volcanic rocks, there is no active vulcanicity in the area.

Hydrothermal mineralogy from deep drill cores indicates a former higher temperature geothermal regime.

Recommendations were made to concentrate further exploration in the area immediately to the north since deep thermal waters were detected migrating southwards into the area.
OUTPUT (Reports, Papers, & etc)


Forster, A. 1977. Density, porosity, magnetic susceptibility and resistivity determinations on nine rock samples from Panama. IGS-Engineering Geology Unit Report 106.


Lee, M K and Parker, M E. 1977. Electrical, magnetic and radiometric surveys for geothermal resources in the Cerro Pando area of Panama. IGS, Applied Geophysics Unit Report 50.


WORKSHOPS AND PRESENTATIONS

PROJECT STAFF
Dr C Mortimer OBE
Dr E P Wright
Dr K H Williamson
Dr M K Lee
M E Parker
P G Greenwood
C W A Browitt
A Forster
Dr A H Bath

FUNDING ODA Technical Cooperation
**TITLE:** GEOLOGY OF THE WESTERN CORDILLERA

**LOCATIONS:** Peru  
**PROJECT SIZE:** 1  
**DATES:** 1963-71

**COLLABORATING ORGANISATIONS**

Comision Carta Geologica Nacional (to 1967)  
Servicio Nacional de Investigacion y Fomento Mineros (from 1967)

**PROJECT OBJECTIVES**

Geological mapping, principally of the Pacific coastal belt of Peru.

Training counterpart staff in geological mapping and laboratory techniques, installation of ODA-donated equipment.

Geochemical and field studies to identify zones of mineralization.

**PROJECT RESULTS**

Photogeological and regional geological map at 1:100 000 of 48¼° sheets, an area of approximately 130,000 km² was accomplished.

A geochemical survey of Northern Peru was undertaken and disclosed several areas of potential commercial interest including several porphyry copper ore-bodies.

Considerable effort was put into training counterpart staff in geological mapping and operation of ODA donated laboratory equipment, several training awards for UK study were also made.

Advice on hydrogeology, mining and engineering geology was provided for a number of civil engineering Projects.
OUTPUT (Reports, Papers, & etc)

Maps, 48 1:100 000 scale maps each covering a ¼° sheet (130.000 km² in all).


## WORKSHOPS AND PRESENTATIONS
International Geological Congress, Montreal, Canada 1972

### PROJECT STAFF
- Dr J J Wilson (Project Manager)
- Dr B J Amos
- Dr J W Baldock
- Dr J H Bean
- Dr E J Cobbing
- Dr F J Sawkins
- Dr J W Stewart
- R B Evans
- P G Greenwood
- J E G W Greenwood

### FUNDING
ODA Technical Cooperation
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<tr>
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<tr>
<td>Geology Department, University of Liverpool</td>
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<tr>
<td>Instituto de Geologia y Minería del Peru</td>
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<tr>
<td><strong>PROJECT OBJECTIVES</strong></td>
<td>Contribution of specialist to Liverpool University's ODA-funded research on the Coastal Batholith of Peru.</td>
</tr>
<tr>
<td><strong>PROJECT RESULTS</strong></td>
<td>Significant Advances in understanding of the origin, mineralization and tectonics of batholiths resulted from this study.</td>
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<tr>
<td>The scientific papers produced including those contributed to by the BGS specialist (Dr E J Cobbing) are detailed overleaf.</td>
<td></td>
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</table>


Cobbing, E J. 1985. The tectonic setting of the Peruvian Andes In Magmatism at a Plate Edge. Wiley & Sons P 3-12.


WORKSHOPS AND PRESENTATIONS

PROJECT STAFF

Dr E J Cobbing

FUNDING ODA Technical Cooperation
**TITLE:** MINERAL EXPLORATION, CORDILLERAS HUAYHUASH AND BLANCA  

**LOCATIONS:** Peru  
**PROJECT SIZE:** 3  
**DATES:** 1977-82  

**COLLABORATING ORGANISATIONS**  
Direcccion de Geologia Minera, Instituto Geologico Minero y Metalurgico, Peru  

**PROJECT OBJECTIVES**  
Geochemical exploration and mineral prospection of about 6,300 km² of the eastern flanks of the Cordillera Huayhuash and Cordillera Blanca, North-Central Peru.  
This study is a more detailed follow-up of potential mineralization indicated by Project 28 (this volume).  
On job training of Counterpart staff  

**PROJECT RESULTS**  
Molybdenum-rich anomalies were revealed by geochemical exploration north west of Huari, follow-up field investigations located important molybdenite bearing stockwork mineralization in the contact zone of the batholith (sampling, detailed mapping) Molybdenum is a rare strategic metal used mainly in high specification types of steel.  
Disseminated stratabound sulphide mineralization was located in the Chimú Formation SSE of Chavin de Huantar.  
Numerous polymetallic sulphide vein occurrences and geochemical anomalies discovered and selected preliminary follow-up studies undertaken.
OUTPUT (Reports, Papers, & etc)


WORKSHOPS AND PRESENTATIONS

PROJECT STAFF

Dr J D Bennett (Project Manager)
Dr B D T Lynas
Dr P J Rogers

FUNDING ODA Technical Cooperation
**TITLE:** GEOLOGY OF THE PUNO REGION

**LOCATIONS:** Peru  
**PROJECT SIZE:** 3  
**DATES:** 1982-6

**COLLABORATING ORGANISATIONS**

Instituto Geologico Minero y Metalúrgico (INGEMMET) Lima

**PROJECT OBJECTIVES**

Geological mapping programme of 36,000 km² of southern Peru west of Lake Titicaca, the area was thought to have geothermal and metallic mineral potential.

**PROJECT RESULTS**

The Geological Surveying of the area was accomplished, detailed geological maps and a regional summary map were produced.

Polymetallic deposits have been identified in the area and low grade copper mineralization was identified in the Tacaza Group volcanics which are Tertiary in age. The geothermal potential of the area has also been examined.

A new regional stratigraphical and structural synthesis of the area has emerged detailing seven distinct deformation events in the evolution of this sector of the Andes, this model has widespread application to much of central and south Peru.
OUTPUT (Reports, Papers, & etc)

15 1:100 000 ¼° sheets were produced covering the area together with accompanying geological notes
1 1:500 000 regional summary geological map


WORKSHOPS AND PRESENTATIONS

Presentations at:

a) Andean Workshop, Oxford Polytechnic 1987
b) South American Geological Congress, Lima, Peru 1987
c) 8th Bolivian Geological Congress, La Paz, Bolivia 1986 (Contribution to IGCP Project 242)
d) 6th Peruvian Geological Congress, Lima, Peru 1987

PROJECT STAFF

Dr B Klinck
R A Ellison
M P Hawkins
W Burgess

FUNDING ODA Technical Cooperation
# Project Completion Form

**Project No:** 32  

**Title:** GROUNDWATER POLLUTION AND RECHARGE, LIMA  

**Locations:** Peru  

**Project Size:** 4  

**Dates:** 1984-6  

## Collaborating Organisations

- Servicio de Agua Potable y Alcantarillado de Lima (SEDAPAL)  
- Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente (CEPIS)  
- University of Surrey, UK  

## Project Objectives

To investigate the influence of man-made aquifer recharge mechanisms in arid zones, especially wastewater reuse at San Juan de Miraflores and la Molina Alta near Lima, on groundwater.

## Project Results

It was proven that mains leakage and over-irrigation of both amenity areas and farmed land are important aquifer recharge mechanisms and these were quantified. The latter can be by either riverwater or wastewater. The infiltrating wastewater undergoes considerable quality improvements during infiltration but does not reach potable quality even with a 20 m thick unsaturated zone. The residual pollution is largely excessive nitrate concentrations and traces of organic carbon, including some chlorinated toxic compounds.

## Output (Reports, Papers, & etc)


## Workshops and Presentations

Project List
**PROJECT STAFF**

- Dr S S D Foster
- A K Geake
- L R Bridge
- D J Miles
- J M Trafford
- W G Darling
- R Shearer
- D J Wheeler (University of Surrey)
- H E Skilton (University of Surrey)

**FUNDING** ODA, Pan-American Health Organisation (PAHO)
TITLE: GEOPHYSICAL STUDY, ANANEA GOLD CONCESSION

LOCATIONS: Peru

PROJECT SIZE: 5

DATES: 1985

COLLABORATING ORGANISATIONS

Minero, Peru

PROJECT OBJECTIVES

To conduct a resistivity survey over the Ananea concession to determine the thickness and extent of the gold bearing moraine formation.

The study forms part of a United Nations backed mineral exploration survey in southern Peru.

PROJECT RESULTS

Resistivity, gravity and altimeter measurements were taken over the 300 km² concession detecting the important physical characteristics of the glacial deposits.

The variations in thickness of the gold-bearing moraines were mapped by electrical soundings and confirmed by drilling; the gravity data indicate important variations in the structure of the drift deposits which are likely to relate to their gold potential.

The studies proved useful in guiding the extensive and expensive UNRFNRE drilling programme for gold.

OUTPUT (Reports, Papers, & etc)


WORKSHOPS AND PRESENTATIONS

Demonstrations of resistivity surveying to UN and Minero Peru staff.
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<th>PROJECT STAFF</th>
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<td>R B Evans</td>
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<td>J P Busby</td>
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<tr>
<td>United Nations Revolving Fund For Natural Resources Exploration (UNRFNRE)</td>
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</table>
**TITLE:** PERUVIAN COAL STUDIES

**LOCATIONS:** PERU

**PROJECT SIZE:** 5

**DATES:** 1984

**COLLABORATING ORGANISATIONS**

PROCARBON, Peru

**PROJECT OBJECTIVES**

In response to a request from ODA a short consulting visit was made to Peru to assist PROCARBON in the assessment of the proven, probable and possible coal reserves of Peru.

To comment on the quality of the coals present and whether they met international specifications.

**PROJECT RESULTS**

The following conclusions and recommendations were reported

Peru possess at least 1.000 million tonnes of coal resources, present data are insufficient to define reserves or targets for extraction

The following 4 stage investigation is needed

a) Collation of existing data  
b) Assessment of local markets  
c) Geological Survey of Coalfields  
d) Identification and exploration of targets identified

**OUTPUT (Reports, Papers, & etc)**

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<tr>
<td>Dr I C Burgess</td>
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<th>FUNDING</th>
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<tr>
<td>ODA Technical Cooperation</td>
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<td>TITLE</td>
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<td>LOCATIONS</td>
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**COLLABORATING ORGANISATIONS**

**PROJECT OBJECTIVES**

A Geophysicist contributed to this UNDP study in Northern Uruguay.

The objective was to identify and trace magnetic anomalies related to the Iron deposits and to train counterpart Uruguayan staff.

**PROJECT RESULTS**

The geophysical study revealed large magnetic anomalies associated with the iron deposit and identified extensions of it. The work enabled targets for drilling to be identified.

One counterpart geologist subsequently became a geophysicist.

**OUTPUT (Reports, Papers, & etc)**

Confidential Report to UNDP

**WORKSHOPS AND PRESENTATIONS**

Presentation to Uruguayan Government officials in Montevideo

**PROJECT STAFF**

R B Evans

**FUNDING** United Nations Development Programme (UNDP)
**TITLE:** THE MANAUS-GEORGETOWN HOVERCRAFT EXPEDITION

**LOCATIONS:** Brazil and Guyana

**PROJECT SIZE:** 5

**DATES:** 1971

**COLLABORATING ORGANISATIONS**
British Broadcasting Corporation  
Cushioncraft Ltd, UK  
Department of Trade and Industry

**PROJECT OBJECTIVES**
The main purpose was to make a TV feature film for "The World About Us" series of the first journey by hovercraft from Manaus (Brazil) to Georgetown (Guyana).

A subsidiary object was to demonstrate the ability of a new type of hovercraft - Cushioncraft CC7" - under varied conditions thereby promoting sales of a British invention/manufacture.

**PROJECT RESULTS**
After trials and demonstrations on the Amazon around Manaus hovercraft successfully made the 900 mile river/overland journey to Georgetown. The route was: Rio Negro - Rio Branco Rio Takutu - overland across N Savannas in Guyana to Rupununi River - Essequito River to mouth Caribbean Sea to Georgetown.

**OUTPUT (Reports, Papers, & etc)**

**WORKSHOPS AND PRESENTATIONS**
"The Forbidden Route" - full length feature film shown on TV as part of BBCs "World About Us" series.
### PROJECT STAFF

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr R L W Saunders</td>
<td>Leader/Producer</td>
<td>BBC TV</td>
</tr>
<tr>
<td>Mr A Morrison</td>
<td>Cameraman</td>
<td>BBC TV</td>
</tr>
<tr>
<td>Mr P Smith</td>
<td>Sound Recordist</td>
<td>BBC TV</td>
</tr>
<tr>
<td>Capt C A Tomlinson</td>
<td>Pilot</td>
<td>Cushioncraft Ltd</td>
</tr>
<tr>
<td>Mr L Christophers</td>
<td>Engineer</td>
<td>Cushioncraft Ltd</td>
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<tr>
<td>Dr J P Berrangé</td>
<td>Navigator/Consultant</td>
<td>Institute of Geological Sciences</td>
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### FUNDING

ODA Technical Cooperation