# 2016
# ANNUAL REPORT

***of the***

# INTERNATIONAL UNION OF GEOLOGICAL SCIENCES
# COMMISSION ON GLOBAL GEOCHEMICAL BASELINES

January 2017

# 2016 ANNUAL REPORT *of the* IUGS COMMISSION ON GLOBAL GEOCHEMICAL BASELINES

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URL: www.globalgeochemicalbaselines.eu/

## 1. TITLE OF CONSTITUENT BODY

IUGS Commission on Global Geochemical Baselines (CGGB).

**Note**: The IUGS Task Group on Global Geochemical Baselines (hereafter 'the Task Group') was upgraded to the Commission on Global Geochemical Baselines (hereafter 'the Commission') on 31 August 2016 at the 4th Ordinary Session of the IUGS-IGC Council meeting in Cape Town.

## 2. OVERALL OBJECTIVES

The mission of the Commission is to (i) prepare a global geochemical database and its representation in map form, and (ii) document the concentration and distribution of chemical elements and species in the Earth's near-surface environment. This database is urgently needed by environmental and natural resource managers throughout the world. To reach this goal, the Commission works with geochemists throughout the world to establish standards for global-scale geochemical mapping. The Commission also promotes and facilitates the implementation of harmonised sample collection, preparation, quality control, and analysis protocols for geochemical mapping programmes.

Commission activities include:

- Developing partnerships with countries conducting broad-scale geochemical mapping studies
- Providing consultation and training in the form of workshops and short courses to build the capacity for conducting geochemical mapping programmes in countries around the world
- Organising periodic international symposia and conferences to foster communication among the geochemical mapping community
- Developing standards for global-scale sampling in different morpho-climatic terranes
- Developing criteria for certifying those projects that are acceptable for inclusion in a global geochemical database
- Acting as a repository for data collected by projects meeting the standards of harmonisation
- Preparing complete metadata for the various certified projects
- Preparing a global geochemical database and atlas

## 3. RELATED GOALS TO OVERALL IUGS SCIENTIFIC OBJECTIVES

Current IUGS scientific policy objectives relate to global Earth Science issues, such as identification of mineral resources, global change, geological hazards, environmental geology and sustainable development. The work of the Commission relates directly to all of these objectives through the establishment of a land-surface global geochemical reference network, providing multi-media, multi-element baseline data for a wide variety of environmental and resource applications (Darnley et al., 1995). The project is also consistent with:

- The strategic plan published by the IUGS Strategic Planning Committee (2000)
- The International Year of Planet Earth (2007-2009) of *'Earth Sciences for Society'* (www.yearofplanetearth.org/)
- The objectives of IUGS Resourcing Future Generations initiative (iugs.org/index.php?page=resourcing-the-future-initiative)
- Work of the newly established UNESCO International Centre on Global-scale Geochemistry (www.globalgeochemistry.com/)

## 4. STRUCTURE AND ORGANISATION

The Commission is led by a Steering Committee, which coordinates the activities of four Technical Committees as well as the contributions made by regional representatives. This organisation structure, carried over from the former Task Group, will be reviewed and possibly revised in 2017, as additional countries with active geochemical mapping programmes or an interest in establishing such programmes become members.

### 4.1. STEERING COMMITTEE

| | | |
|---|---|---|
| *Co-Chairs* | David B. Smith | US Geological Survey |
| | Xueqiu Wang | ICCG[1], China |
| *Scientific Secretary* | Patrice de Caritat | Geoscience Australia |
| *Treasurer* | Alecos Demetriades | Hellas |

### 4.2. ANALYTICAL COMMITTEE

| | | |
|---|---|---|
| *Chair* | Gwendy Hall | Canada |

Coordinates the work plan for the analysis of Global Reference Network (GRN) samples, the activities of the laboratories, and the supervision of analytical quality control data.

### 4.3. SAMPLING COMMITTEE

| | | |
|---|---|---|
| *Chair* | Alecos Demetriades | Hellas |

Supervises the development and coordination of sampling protocols in the various climatic and geomorphological provinces throughout the world.

### 4.4. DATA MANAGEMENT COMMITTEE

| | | |
|---|---|---|
| *Chair* | Timo Tarvainen | Finland |

Supervises the sampling strategy and progress of the participating countries, manages the database of sample information and analytical results.

### 4.5. PUBLIC RELATIONS AND FINANCE COMMITTEE

| | | |
|---|---|---|
| *Chair* | Alecos Demetriades | Hellas |

Advertises and promotes the aims, objectives and achievements of the project worldwide, including by use of the internet, and takes responsibility for trying to secure funding for the project.

[1] UNESCO International Centre on Global-scale Geochemistry

## 4.6. REGIONAL REPRESENTATIVES

### *4.6.1. South America*

Carlos Alberto Lins, CPRM - Geological Survey of Brazil, Recife - PE, Brazil

João H. Larizzatti, CPRM – Geological Survey of Brazil, Rio de Janeiro, Brazil

Juan Pablo Lacassie Reyes, Geological and Mining Survey of Chile, Santiago, Chile

Gloria Prieto, Servicio Geológico Colombiano, Bogotá, Colombia

### *4.6.2. Africa*

Theo Davies, Mangosuthu University, Durban, South Africa

Marthinus Cloete and J.H Elsenbroek, Council for Geoscience, Pretoria, South Africa

Keith Sheppard, World Agroforestry Centre (ICRAF), Nairobi, Kenya

Alhaji Lamin Turay, Geological Survey Department, Ministry of Mineral Resources, Sierra Leone

### *4.6.3. Indian subcontinent*

Pradip Govil, National Geophysical Research Institute, Hyderabad, India

Mathew Joseph, Geological Survey of India, Kerala, India

Ashvin Wickramasooriya, South Eastern University of Sri Lanka, Sammanthurai, Sri Lanka

### *4.6.4. China*

Xueqiu Wang, Institute of Geophysical and Geochemical Exploration, Langfang, China

### *4.6.5. Australasia*

Patrice de Caritat, Geoscience Australia, Canberra

### *4.6.6. Japan*

Atsuyuki Ohta, Geological Survey of Japan, AIST, Tsukuba

### *4.6.7. Europe*

Clemens Reimann, Geological Survey of Norway, Trondheim, Norway

### *4.6.8. North America*

David Smith, United States Geological Survey, Denver, USA

Enrique Espinosa, SGM, Pachuca, Mexico

Andy Rencz, Ottawa, Ontario, Canada

# 5. INTERACTION WITH OTHER INTERNATIONAL ORGANISATIONS AND PROJECTS

## 5.1. UNESCO INTERNATIONAL CENTRE ON GLOBAL-SCALE GEOCHEMISTRY

In May 2016, the UNESCO International Centre on Global-scale Geochemistry (ICGG) opened

in Langfang, China. The Task Group (now Commission) was an active participant in preparing the successful proposal originally submitted to UNESCO in 2009.

One of the most important tasks for the new Commission is to establish formal collaboration with the UNESCO Centre.

Although there is considerable overlap in the objectives of the Commission and the Centre, the IUGS mandate is quite clear, namely that the Commission takes the lead in establishing the standards for global-scale geochemical mapping, in collaboration with the Centre; whereas, the Centre takes the lead in implementing those standards, in collaboration with the Commission. There will be close collaboration between the Centre and the Commission with respect to the initiative of the International Scientific Cooperation Project of Mapping the Chemical Earth by the Centre and the Global Geochemical Baselines coverage according to IGCP 259 specifications. It is, of course, essential that the two bodies work to support each other in the pursuit of the aforementioned objectives (Section 2). The collaboration is expected to be smooth as the Commission's Steering Committee are members of the Centre's Governing Board and Scientific Committee.

## 5.2. INTERFACE WITH OTHER INTERNATIONAL ORGANISATIONS AND PROJECTS

This project is closely associated with the work of the EuroGeoSurveys (EGS) Geochemistry Expert Group (previously the Forum of European Geological Surveys, FOREGS Geochemistry Expert Group). The project also has links with the International Atomic Energy Agency (IAEA) and potential links with the Global Terrestrial Observing System (GTOS). The EGS Geochemistry Expert Group has also established closer links with the European Soil Bureau Network (ESBN) over the past few years, and was actively involved in the European Union's (EU) Soil Thematic Strategy group for the preparation of the EU's Soil Protection Document, and the final draft of the pending Soil Protection Directive.

The EGS Secretary General has established links to other European Commission projects, such as the Global Monitoring of Environment and Security (GMES) programme, and Infrastructure for Spatial Information in Europe (INSPIRE), since the Geochemical Atlas of Europe has been produced in a harmonised manner according to IGCP 259 specifications (Darnley et al., 1995) and, therefore, compliant with INSPIRE guidelines.

In 2013, EGS became member of the United Nations Food and Agricultural Organization's (FAO) Global Soil Partnership, since the Geological Surveys of Europe are actively involved in soil geochemical mapping. A Memorandum of Understanding (MoU) has been signed by EGS and the European Commission Joint Research Centre at Ispra (northern Italy), and representatives of the two institutions met at the end of January 2014 to discuss and finalise the cooperation.

In 2014, the Task Group established links with the Young Earth Scientists Network during the 1st International Geosciences Congress organised by the Geological Survey of Iran in Tehran (February 2014). This collaboration resulted in the organisation of a two-day workshop on *"Global Geochemical Baselines"* during the 3rd YES Congress in Tanzania (August 2014) as detailed in Section 7.2. This collaboration is continuing and apart from the organisation of a workshop on the occasion of the 4th YES Congress in Iran (August 2017), there is discussion about the establishment of a YES Working Group on Applied Geochemistry.

EuroGeoSurveys also established cooperation with the Organisation of African Geological Surveys (OAGS) and developed a pan-African geological project proposal (PanAfGeo), which is financed by the European Commission. The project proposal was presented at a workshop on 14 August 2014 in Dar es Salaam (Tanzania), and the final results were presented at the OAGS Director's meeting in Gaborone (Botswana), 13-16 October 2014. The two-year joint project will cover a fairly wide range of tasks, starting from the issues of geoscientific mapping and

sustainable management of mineral resources, to human resources and training needs for OAGS members and their partners through innovative case studies. The first results of this project were presented at a dedicated session of the 35th International Geological Congress (35th IGC) in Cape Town in August 2016.

EuroGeoSurveys is participating in GEO-CRADLE (Coordinating and integRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East, and Balkans and Developing Links with GEO related initiatives towards GEOSS), a European Commission Horizon-2020 funded project. The results of both the FOREGS and GEMAS (GEochemical Mapping of Agricultural and grazing land Soil of Europe) projects are used by this project.

The Task Group submitted in August 2015 a joint proposal entitled "*Africa Global-scale Geochemical Baselines for mineral resource and environmental management: Capacity building phase*" to the Group on Earth Observations (AfriGEOSS) with the EGS Geochemistry Expert Group, the Geological Society of Africa and the Organisation of African Geological Surveys. We have been informed that the proposal is included for funding in the 2016-17 programme of AfriGEOSS. According to the Secretary General of EGS, this is the first step for the project proposal to be included for funding from the European Commission financial protocols.

In North America, the project has established links with the North American Soil Geochemical Landscapes Project involving the Geological Survey of Canada (GSC), the United States Geological Survey (USGS), and the Servicio Geológico Mexicano (SGM).

The Commission also interfaces with the National Geochemical Survey of Australia and the China Geochemical Baselines projects.

The Task Group (now Commission) contributed to the IUGS initiative's Resourcing Future Generations (RFG) by submitting comments in July 2015 on the White Paper "*Resourcing Future Generations: Mineral Resources and Future Supply*" in collaboration with the EGS Geochemistry and Mineral Resources Expert Groups. Also participated with a representative in the RFG workshop in Namibia (24-30 July 2015).

## 6. CHIEF PRODUCTS IN 2016

### 6.1. ARTHUR DARNLEY MEMORIAL DVD

Compilation of the 2nd version of the Arthur Darnley DVD, and production of 1000 copies for distribution at the 35th IGC in Cape Town, and other conferences, symposia and workshops. The DVD includes all publications and reports by the Task Group (now Commission) from 1989 to 2008, the list of all publications from 1989 to 2016, and freely available publications from 2008 to 2016. It also includes the Geochemical Atlases of Europe, United States of America and Australia.

### 6.2. ARTICLES, PAPERS, ATLASES AND BOOKS

Aloysius, A.N., Djibril, K.N.G., Arnaud, K.P., Wotchoko, P., Didero, T.W.J., Mbaringong, A.C., Anzah, A.R. & Suh, C.E., 2016. *Geochemical investigation of stream sediments from the Nlonako area, Littoral, Cameroon: implications for Au, Ag, Cu, Pb and Zn mineralization potentials*. International Journal of Advanced Geosciences, 4, 104-112. http://dx.doi.org/10.14419/ijag.v4i2.6771

Birke, M., Reimann, R., Oorts, K., Rauch, U., Demetriades, A., Dinelli, E., Ladenberger, A., Halamić, J. Gosar, M., Jähne-Klingberg, F. & the GEMAS Project Team, 2016. *Use of GEMAS data for risk assessment of cadmium in European agricultural and grazing land soil under the REACH Regulation*. Applied Geochemistry, 74, 109-121. dx.doi.org/10.1016/j.apgeochem.2016.08.014

Caritat, P. de & Cooper, M., 2016. *A continental-scale geochemical atlas for resource exploration and environmental management: the National Geochemical Survey of Australia*. Geochemistry: Exploration, Environment, Analysis, 16, 3-13. dx.doi.org/10.1144/geochem2014-322

Cudahy, T., Caccetta, M., Thomas, M., Hewson, R., Abrams, M., Kato, M., Kashimura, O., Ninomiya, Y., Yamaguchi, Y., Collings, S., Laukamp, C., Ong, C., Lau, I., Rodger, A., Chia, J., Warren, P., Woodcock, R., Fraser, R., Rankine, T., Vote, J., Caritat, P. de, English, P., Meyer, D., Doescher, C., Fu, B., Shi, P. & Mitchell, R., 2016. *Satellite-derived mineral mapping and monitoring of weathering, deposition and erosion*. Scientific Reports, 6, 23702. dx.doi.org/10.1038/srep23702

Lacassie, J.P., Vivallo, W. & Díaz, A., 2016. *Caracterización geoquímica de los yacimientos metáliferos de la región de Atacama mediante el uso de redes neuronales artificiales* [monografías]. SERNAGEOMIN, Santiago, IR-16-61, 177 pp.

Main, P.T. & Caritat, P. de, 2016. *Southern Thomson Region Geochemical Survey, Southwestern Queensland and Northwestern New South Wales - The Chemical Composition of Surface and Near-Surface Catchment Outlet Sediments*. Geoscience Australia Record, 2016/11, 136 pp. dx.doi.org/10.11636/Record.2016.011

Mann, A., Caritat, P. de & Sylvester, G., 2016a. *Degree of Geochemical Similarity (DOGS): a simple statistical method to quantify and map affinity between samples from multi-element geochemical data sets*. Australian Journal of Earth Sciences, 63, 111-122. dx.doi.org/10.1080/08120099.2016.1130744

McKinley, J.M., Hron, K., Grunsky, E.C., Reimann, C., Caritat, P. de, Filzmoser, P., Boogaart, K.G. van den & Tolosana-Delgado, R., 2016. *The single component geochemical map: fact or fiction?* Journal of Geochemical Exploration, 162, 16-28. dx.doi.org/10.1016/j.gexplo.2015.12.005

Mernagh, T.P., Bastrakov, E.N., Jaireth, S., Caritat, P. de, English, P.M. & Clarke, J.D.A., 2016. *A review of Australian salt lakes and associated mineral systems*. Australian Journal of Earth Sciences, 63, 131-157. dx.doi.org/10.1080/08120099.2016.1149517

Morris, P.A., Scheib, A.J., Souza Kovacs, N. de, 2015. *Regolith chemistry of the Balanggarra area, north Kimberley*. Geological Survey of Western Australia, Record 2015/9, 142 p. http://dmpbookshop.eruditetechnologies.com.au/product/regolith-chemistry-of-the-balanggarra-area-north-kimberley-geographical-product-n14bczp.do

Morris, P.A., Scheib, A.J., Souza Kovacs, N. de, 2016. *Regolith chemistry of the Dambimangari area, west Kimberley*. Geological Survey of Western Australia, Record 2016/15, 126 p. http://dmpbookshop.eruditetechnologies.com.au/product/regolith-chemistry-of-the-dambimangari-area-west-kimberley.do

Mukosi, N.C., Netshitungulwana, R. & Hlatshwayo, S., 2015. Airborne geochemical mapping in Namaqualand. Geoclips, 43, 1-4. http://www.geoscience.org.za/index.php/publication/geoclips

Négrel, P., Ladenberger, A., Reimann, C., Birke, M., Sadeghi, M. & the GEMAS Project Team, 2016. *GEMAS: Source, distribution patterns and geochemical behaviour of Ge in agricultural and grazing land soils at European continental scale*. Applied Geochemistry, 72, 113-124. dx.doi.org/10.1016/j.apgeochem.2016.07.004

Oorts, K., Smolders, E., McGrath, S.P., Gestel, C.A.M. van, McLaughlin, M.J. & Carey, S., 2016. *Derivation of ecological standards for risk assessment of molybdate in soil*. Environmental Chemistry, 13, 168-180. dx.doi.org/10.1071/EN15086

Reimann, C., Ladenberger, A., Birke, M. & Caritat, P. de, 2016. *Low density geochemical mapping and mineral exploration: application of the mineral system concept*. Geochemistry: Exploration, Environment, Analysis, 16, 48-61. dx.doi.org/10.1144/geochem2014-327

Reimann, C., Négrel, P., Ladenberger, A., Birke, M., Filzmoser, P., O'Connor, P. & Demetriades, A., 2016. Correspondence: *Comment on "Heavy metals in agricultural soil of the European Union with implications for food safety" by Tóth, G., Hermann, T., Da Silva, M.R. and Montanarella, L*. Environmental International, 97, 258-263.

dx.doi.org/10.1016/j.envint.2016.07.019

Reimann, C., Négrel, P., Ladenberger, A., Birke, M., Filzmoser, P., O'Connor, P. & Demetriades, A., 2016. *Comment on "Maps of heavy metals in the soils of the European Union and proposed priority areas for detailed assessment" by Tóth, G., Hermann, T., Szatmári, G., Pásztor, L*. Science of the Total Environment, 578, 236-241. dx.doi.org/10.1016/j.scitotenv.2016.07.208

Scheib, A.J., Morris, P.A., Souza Kovacs, N. de, 2016. *Regolith chemistry of the Bunuba and Yuriyangem-Taam areas, south Kimberley*. Geological Survey of Western Australia, Record 2015/15, 109 p. http://dmpbookshop.eruditetechnologies.com.au/product/regolith-chemistry-of-the-bunuba-and-yuriangem-taam-areas-south-kimberley.do

Wilford, J., Caritat, P. de & Bui, E., 2016. *Predictive geochemical mapping using environmental correlation*. Applied Geochemistry, 66, 275-288. dx.doi.org/10.1016/j.apgeochem.2015.08.012

## 6.3. ORAL AND POSTER PRESENTATIONS

***4th Australian Regolith Geoscientists Association (ARGA) Conference, Thredbo, New South Wales, Australia, 7-10 February 2016*** (http://regolith.org.au/conferences.html)

Caritat, P. de, Main, P., Grunsky, E. & Mann, A., 2016. *Recognition of geochemical footprints of mineral systems at the regional to continental scales*.

***GEO-CRADLE Kick-off Meeting*** *(Coordinating and integrating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East and Balkans and Development Links with GEO related initiatives toward GEOSS)****, Ionic Centre, 11 Lysiou Street, Athens, Hellas, 18-19 February 2016***
(geocradle.eu/geo-cradle-kick-off-meeting-in-athens-on-febuary-2016/)

Demetriades, A. & EuroGeoSurveys Geochemistry Expert Group, 2016. *FOREGS Geochemical Atlas of Europe and GEMAS - GEochemical Mapping of Agricultural and grazing land Soil of Europe*.

***12th Seminar of the Faculty of Geology and Geoenvironment, National and Kapodistrian University of Athens, Hellas, 31 March, 7 and 14 April 2016***
(http://www.geol.uoa.gr/index.php/en)

Demetriades, A., 2015. *The Geochemical atlases of Europe: Methodology and results.* (Note: A 3-part seminar using data from the FOREGS, European Groundwater Geochemistry and GEMAS atlases)

***European Geosciences Union General Assembly 2016, Vienna, Austria, 17-22 April 2016***
(egu2016.eu/home.html)

Fabian, K., Reimann, C., Kuzina, D., Kosareva,L., Fattakhova, L., Nurgaliev, D. & the GEMAS project Team, 2016. *GEMAS: Unmixing magnetic properties of European agricultural soil*.

Klug, M., Fabian, K., Reimann, C. & the GEMAS project Team, 2016. *GEMAS: Colours of dry and moist agricultural soil samples of Europe*.

***UNESCO International Centre on Global-scale Geochemistry, Opening Ceremony Workshop, Langfang, Hebei, P.R. China, 12-17 May 2016***

Caritat, P. de, 2016. *Progress of Global Geochemical Baselines in Australia*.

Caritat, P., de, 2016. *Quality control procedures used in the geochemical mapping of Australia*.

Davies, T., 2016. *An African geochemical database for Medical Geology applications*.

Dawen, L., 2016. *International cooperation on geochemical mapping, CGS*.

Demetriades, A., 2016. *Global-scale geochemical baseline mapping of Europe and potential uses*.

Demetriades, A., 2016. *Progress of Global-scale Geochemical mapping in Europe: 1986-2015*.

Demetriades, A., 2016. *Sampling and laboratory quality control in the geochemical mapping of Europe*.

Guohua, Z., 2016. *Geochemical survey on environment and agriculture in China: Application of geochemical data in land quality assessment*.

Oberhänsli, R., 2016. *Resourcing Future Generations – geochemical challenges*.

Prieto, G., 2016. *Geochemical mapping in Colombia*.

Simubuli, G.N., 2016. *Geochemical mapping in Africa*.

Smith, D.B., 2016. *Global Geochemical Baselines: Progress and challenges*.

Smith, D.B., 2016. *Global-scale geochemical mapping of the United States: Processes and opportunities*.

Spiridonov, I., Kilipko, V.A. & Morozov, A.F., 2016. *Geochemical mapping in Russia*.

Wang, X., 2016. *China Geochemical Baselines: Quantifying environmental changes*.

Wang, X., 2016. *Geochemical mapping for mineral exploration*.

Wang, X., 2016. *Initiative for the International Scientific Project on Mapping the Chemical Earth.*

Wang, X., 2016. *International training course for geochemical mapping: Concepts and procedures of geochemical mapping*

***Australian Earth Sciences Convention 2016, Adelaide, South Australia, 26-30 June 2016***
(http://aesc2016.gsa.org.au/)

Mann, A., Caritat, P. de, Lilly, R. & Sylvester, G., 2016. *Inferring lithological information from multi-element soil geochemistry*.

***Goldschmidt Conference 2016, Yokohama, Japan, 26 June-1 July 2016***
(http://goldschmidt.info/2016/)

Cracknell, M.J. & Caritat, P. de, 2016. *Catchment-scale gold prospectivity analysis from the National Geochemical Survey of Australia*.

Espinoza, F., Lacassie, J.P., Baeza, L., Astudillo, F., Ramirez, C., Carrasco, F. & Barrera, J., 2016. *Content and distribution of arsenic in surficial sediments in Atacama Desert, northern Chile*.

Furman, O.S., Caritat, P. de, Maher, W., Foster, S., Gruber, B. & Thompson, R.M., 2016. *Mercury distribution in Australian catchment outlet sediments at the continental scale*.

***Simposio Servicio Geológico Colombiano 100 años de producción científica al servicio de los colombianos, Centro Empresarial y Recreativo El Cubo, Bogotá, Colombia, 27June-1 July 2016***
(http://www2.sgc.gov.co/Noticias/General/Simposio-Servicio-Geologico-Colombiano-100-anos-de.aspx)

Demetriades, A., 2016. *Continental-scale geochemical mapping in Europe*.

Demetriades, A., 2016. *Urban geochemistry in Europe*.

Smith, D.B., 2016. *A national-scale soil geochemical and mineralogical survey of the conterminous United States*.

***ISEH 2016 & Geoinformatics 2016: Joint International Conference on Environment, Health, GIS and Agriculture: Session on Regional Geochemical Mapping – methods and challenges (sponsored by EuroGeoSurveys), Galway, Ireland, 14-20 August 2016*** (http://www.nuigalway.ie/iseh2016/)

Demetriades, A., Reimann, C., Birke, M., Mann, A., Eilu, P., De Vivo, B., Cicchella, D., Kaminari, M., Rothenbacher, K. & the GEMAS Project Team, 2106. *GEMAS: Precious metal spatial distribution patterns in European soil*.

Reimann, C., Birke, M., Fabian, K., Filzmoser, P. & the GEMAS Project Team, 2016. *GEMAS: mapping of soil properties and metal concentrations in agricultural and grazing land soil at the European scale*.

Reimann, C., Fabian, K., Flem, B. & Schilling, J., 2016. *Behaviour of potentially toxic elements (PTEs) and Pb isotopes in North-Trøndelag forest soil.*

Reimann, C., Matschullat, J., Fabian, K., Klug, M., Nurgaliev, D. & the GEMAS Project Team, 2016. *GEMAS – geochemical mapping of agricultural soil of Europe: new developments*.

***35th International Geological Congress, Workshop on Global-scale Geochemical Mapping, Cape Town, South Africa, 27-28 August 2016*** (http://www.35igc.org/)

1. Demetriades, A., 2016. *Introduction to Applied Geochemistry*.
2. Wang, X., 2016. *Geochemical mapping: Principles and methodologies*.
3. Wang, X., 2016. *China Geochemical Baselines: Quantifying environmental changes*.
4. Demetriades, A., 2016. *Sampling at the continental scale*.
5. Demetriades, A., 2016. *FOREGS laboratory scheme*.
6. Demetriades, A., 2016. *FOREGS quality control scheme*.
7. Wang, X., 2016. *Regional geochemical mapping for mineral resources: Examples from China*.
8. Demetriades, A., 2016. *Geochemical data management and map generation*.
9. Demetriades, A., 2016. *Application of geochemical mapping for mineral exploration and environmental assessment*.
10. Demetriades, A., 2016. *Application of geochemical mapping for environmental assessment*.

***35th International Geological Congress, 3rd Arthur Darnley Symposium: Mapping the geochemistry of the Earth's surface at global to local scales, Cape Town, South Africa, 30 August 2016*** (Note: abstracts of the oral and poster presentations are available on the American Geosciences Institute website http://www.americangeosciences.org/information/igc)

***Oral Presentations***

Bensid, M.L., Strauss, S.W. & Billay, A.Y., 2016. *Geochemical mapping of the Tugela terrane, Kwazulu-Natal, South Africa: Semi-regional soil survey*.

Demetriades, A., Reimann, C., Birke, M. & Tarvainen, T., 2016. *The three geochemical atlases of Europe*.

Demetriades, A., Smith, D.B., Wang, X. & Caritat, P. de, 2016. *Mapping the geochemistry of the Earth's surface at global to local scales.* (Keynote presentation)

Négrel, P., Ladenberger, A., Reimann, C., Birke, M., Sadeghi, M. & the GEMAS Project Team, 2016. *Ge-Ga-Cs in agricultural and grazing land soils at European continental scale*.

Hou, Q., Yang, Z., Gu, Z. & Yu, T., 2016. *Effect of soil erosion on soil organic carbon in Wuyuer river basin, China*.

Rattenbury, M., Christie, T., Martin, A., Cohen, D., Turnbull, R., Hoogewerff, J., Baisden, T. & Rogers, K., 2016. *The geochemical baseline survey of southern New Zealand*.

Wang, X., Nie, L., Yao, W.S. & Zhou, J., 2016. *Mapping the Chemical Earth: sustaining natural resources and environments*.

Wang, X., Nie, L. & Zhang, B., 2016. *Geochemical mapping project across the boundary area of China and Mongolia*.

Wensheng, Y., Qin, Z. & Wang, X., 2016. *Comparability and traceability in laboratory analysis of Global Geochemical Baselines mapping samples*.

***Poster Presentations***

Kilipko, V., 2016. *Methods and Results of Regional Geochemical Prospecting of petroliferous Deposits*.

Kilipko, V., 2016. *Geochemical Map of Russia in Scale 1:2 500 000*.

***IUGS Booth at the 35th IGC***

Three posters of the IUGS Task Group (now Commission) were displayed at the IUGS Booth (Figure 1).


Figure 1. IUGS/IAGC Task Group posters displayed at the IUGS booth, 35th IGC, Cape Town.

***10th International Geostatistics Congress, Geostats 2016, Valencia, Spain, 5-9 September 2016*** (http://geostats2016.webs.upv.es/)

Mueller, U., Coombes, J., Caritat, P. de, Grunsky, E., 2016. *From surface sediment geochemical surveys to prediction of major crustal blocks*.

***Servicio Geológico Mexicano, San Luis Potosí, Mexico, October 2016*** (http://www.sgm.gob.mx/Webmovil/index.html)

Woodruff, L.G., 2016. *Soil geochemistry and mineralogy for the conterminous United States: Results from the North American Soil Geochemical Landscapes Project*.

***Michigan Technological University Geoseminar, Houghton, Michigan, USA, 18 October 2016*** (http://www.geo.mtu.edu/~raman/SilverI/Geoseminar/Welcome.html)

Woodruff, L.G., 2016. *Soil geochemistry and mineralogy for the conterminous United States: Results from the North American Soil Geochemical Landscapes Project*.

***6th National Conference on Applied Geochemistry, Xi'an, China, 11-13 November 2016***

Demetriades, A., Reimann, C., Birke, M. & Tarvainen, T., 2016. *The geochemical atlases of Europe*.

Wang, X., 2016. *What sample types can be used for quantifying the geochemical changes induced by human activities and natural processes?*

## 7. CHIEF ACCOMPLISHMENTS IN 2016

### 7.1. SCIENTIFIC ACCOMPLISHMENTS

There has been continued and significant progress in a number of areas during 2016, as detailed in the following.

#### *7.1.1. The Americas*

***NORTH AMERICA (David B Smith, USGS; Juan Antonio Caballero Martínez, SGM)***

The collaboration between the US Geological Survey (USGS) and the Servicio Geológico Mexicano (SGM) for geochemical and mineralogical mapping of soil in the US and Mexico continued during 2016. In September 2016, representatives from SGM and USGS met in San Luis Potosi, Mexico to discuss issues related to sharing of data and generation of geochemical maps based on national-scale soil geochemical surveys conducted by each organisation under the North American Soil Geochemical Landscapes Project (NASGLP).

***SOUTH AMERICA***

***Brazil (João H. Larizzatti, CPRM)***

The Geological Survey of Brazil (CPRM) has been conducting Geochemical Mapping Programmes since the 1970s. The objective of Geochemistry Division (DIGEOQ) is to give support to mineral exploration, geological mapping and environmental studies. The DIGEOQ focuses on:

- Geochemical mapping projects: regional-scale (1:100K and 1:250K) and low-density surveys
- Populating the GEOBANK (CPRM Geoscientific Database) with geochemical data
- Generating geochemical maps and atlases
- Updating the geochemistry technical manuals

### Regional geochemical mapping

Since 1970, CPRM has collected and analysed more than 100,000 heavy mineral concentrates, 116,000 rock samples (including ore), 550,000 stream sediment samples, 190,000 soil samples, and 3600 marine sediment samples. Figures 2 to 6 show the current coverage by sample medium.

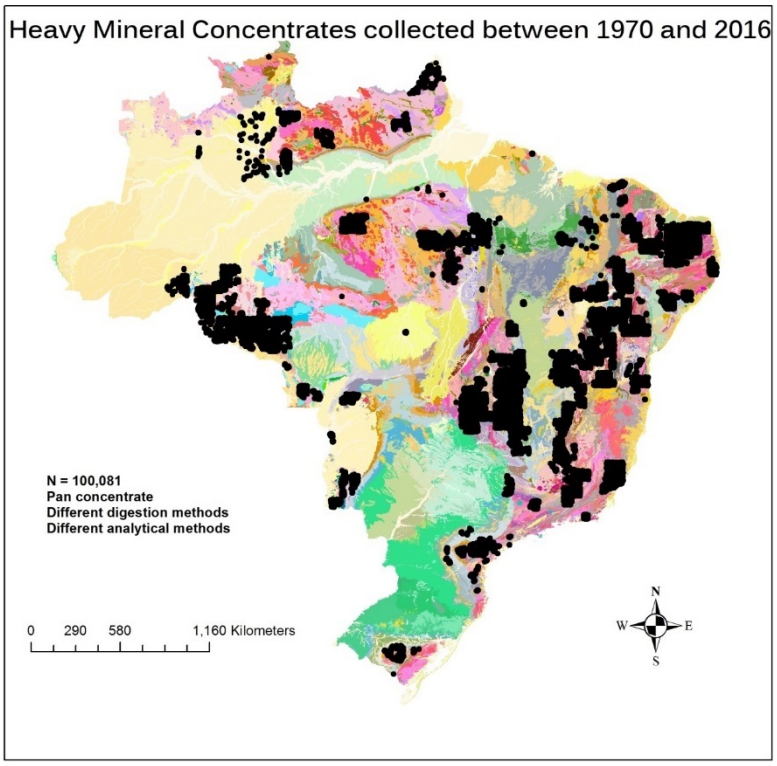


Figure 2. Samples of heavy mineral concentrates collected from 1970 to 2016, Brazil.

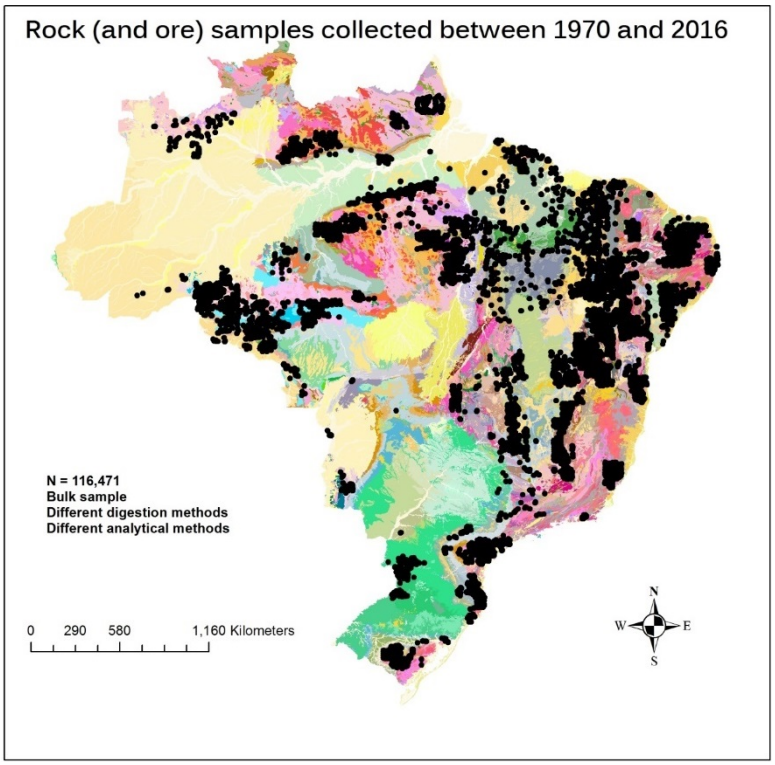


Figure 3. Rock samples collected from 1970 to 2016, Brazil.

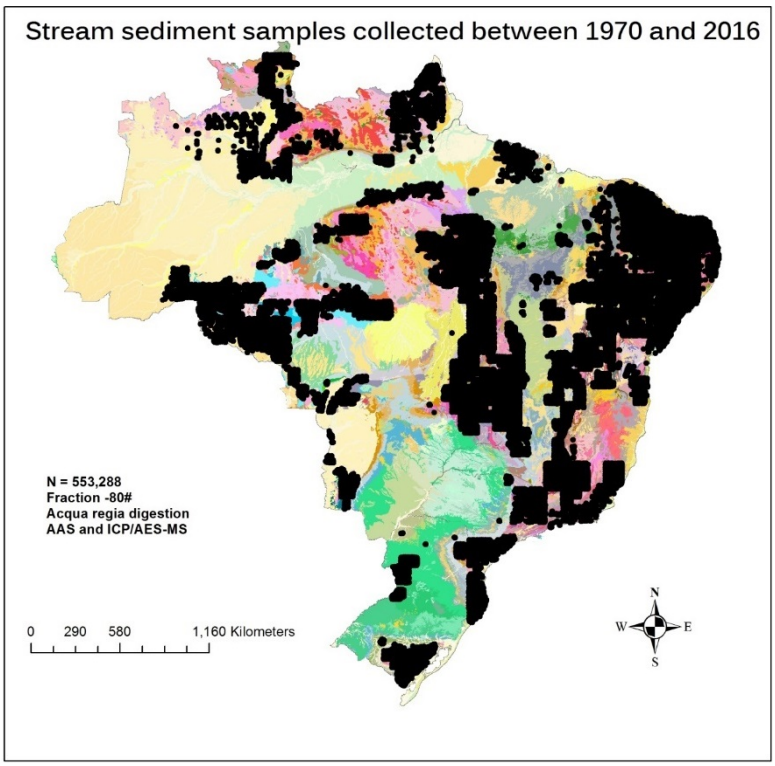


Figure 4. Stream sediment samples collected from 1970 to 2016, Brazil.

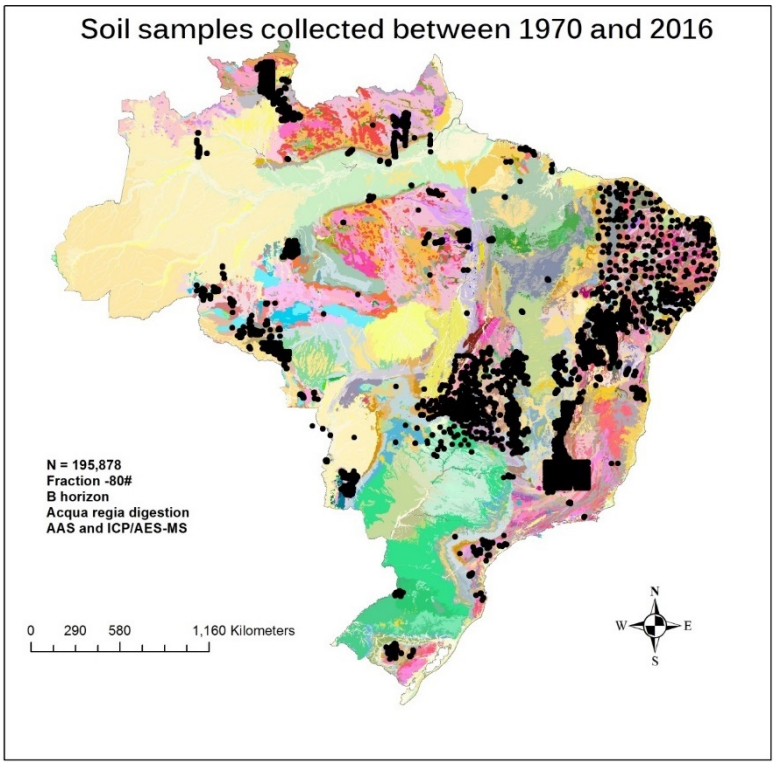


Figure 5. Soil samples collected from 1970 to 2016, Brazil.

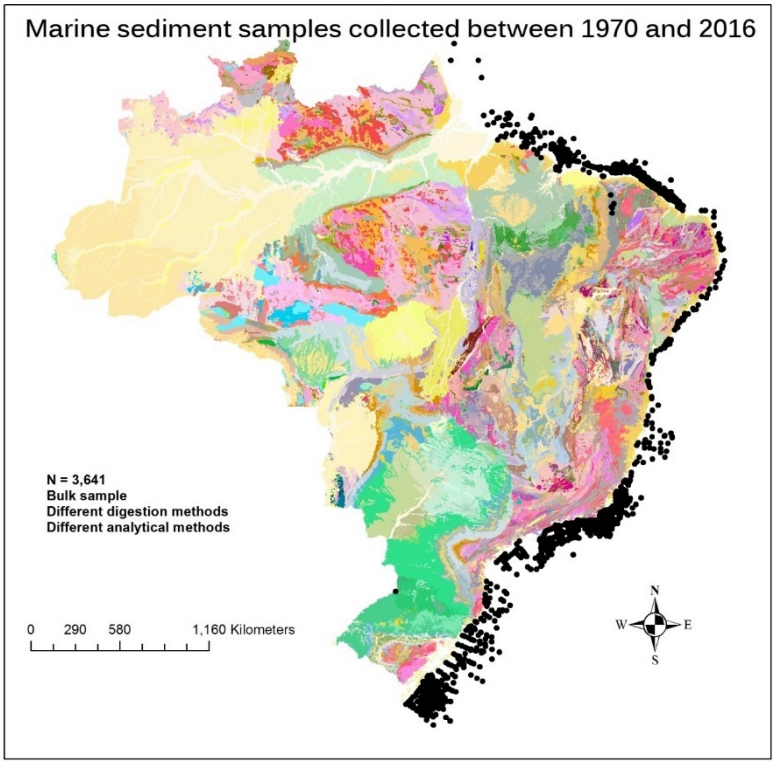


Figure 6. Marine sediment samples collected from 1970 to 2016, Brazil.

The sample density of regional surveys is about one sample/12 km$^2$. Geochemical analyses are carried out by a contracted laboratory following hot Aqua Regia digestion and Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) and Inductively Coupled

Plasma-Mass Spectrometry (ICP-MS) finish (53 elements). After initial data treatment, geochemical results and metadata are stored in the CPRM database GEOBANK.

Data processing is carried out using a variety of software packages, i.e., STATISTICA, Dell Statistica v.13, and GEOSOFT Target for ESRI ArcGIS v.10.2. Symbol maps showing the spatial distribution of element concentrations are plotted. Using the GIS environment, geological, geophysical and other geoscientific data and information are integrated in order to give a better view of the geological processes under study.

During the last three years, CPRM concentrated most of its efforts on the organisation and consistency of the Geochemical Database. Geochemical data from different sources were integrated in a uniform format and this information is available to the public at CPRM GEOBANK (op. cit.). These data are being evaluated for consistency (Figure 7).

More than 100,000 sample locations have been verified to-date. Historical projects from the 1970s, 1980s and early 1990s have been checked using original location maps, drainage maps and satellite images in a GIS environment. Recent projects with sample location determined using GPS also have been verified.

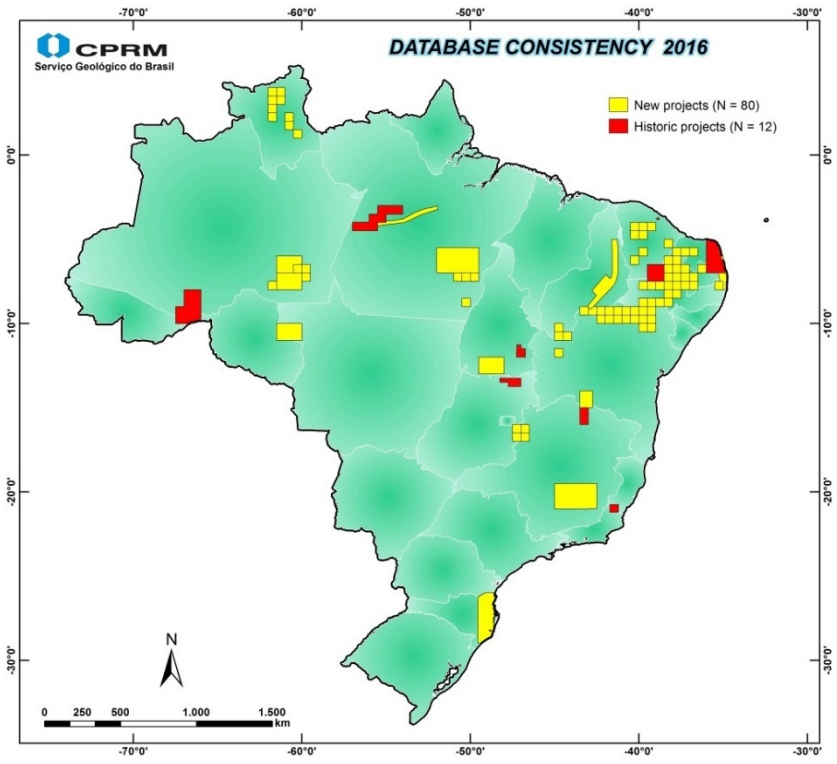


Figure 7. Geochemical database consistency work. Areas studied up to 2016.

Since 2014, CPRM and the China Geological Survey have been working together in the Piatã area, Chapada Diamantina, Bahia State, Brazil. This project includes the geochemical mapping of the Piatã 1:100K mapsheet and the collection and analysis of 3000 stream sediment/soil samples. The first field trip took place in July/August 2016. Four Chinese researchers came to Piatã and worked together with ten Brazilian researchers. Sample collection and preparation were performed by both teams. Six hundred samples were sent to China for multi-element analysis (Figures 8 and 9).

Figure 8. Brazilian and Chinese geochemists at Chapada Diamantina, Bahia, Brazil.

Figure 9. Geochemical activities at Piatã with CGS.

Due to financial restrictions, during 2015 CPRM sampling teams worked only in two areas (Figure 10). They collected 2110 stream sediment samples and 1692 heavy mineral concentrates.

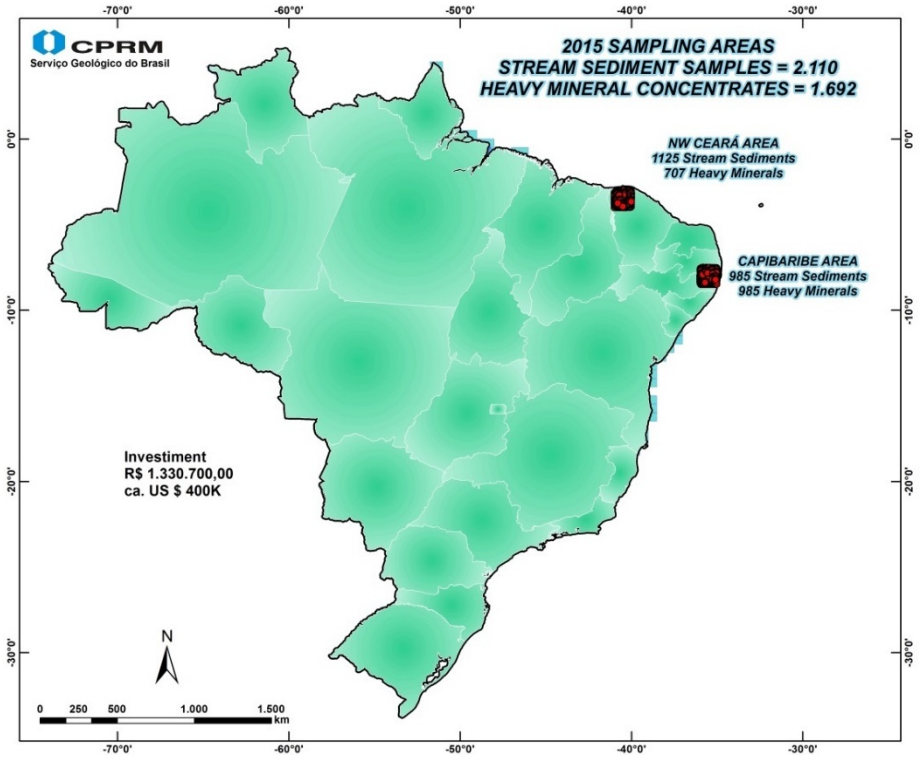


Figure 10. Stream sediment and heavy mineral concentrate samples collected during 2015 and 2016, NE Brazil.

During 2016, more than 8000 stream sediment samples were prepared and analysed at a cost of approximately US$ 216K for regional geochemical mapping projects (Figure 11).

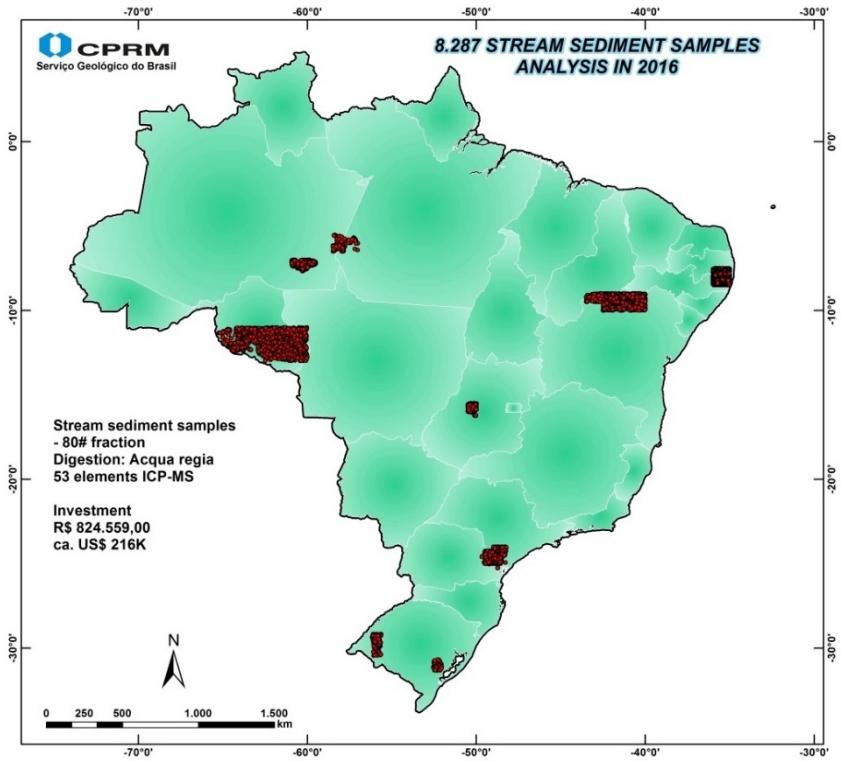


Figure 11. Stream sediment samples analysed during 2016.

Besides regional geochemical mapping projects, DIGEOQ provides analytical support to every project running under CPRM Directory of Geology and Mineral Resources. More than 1000 rock samples were analysed using different digestions and analytical methods at a cost of approximately US$ 35K.

**Low-density geochemical mapping**

Until 2016, CPRM developed low-density geochemical surveys through its Department of Environment and Land Management (DEGET). Figure 12 shows sample location for soil, and water and stream sediment.

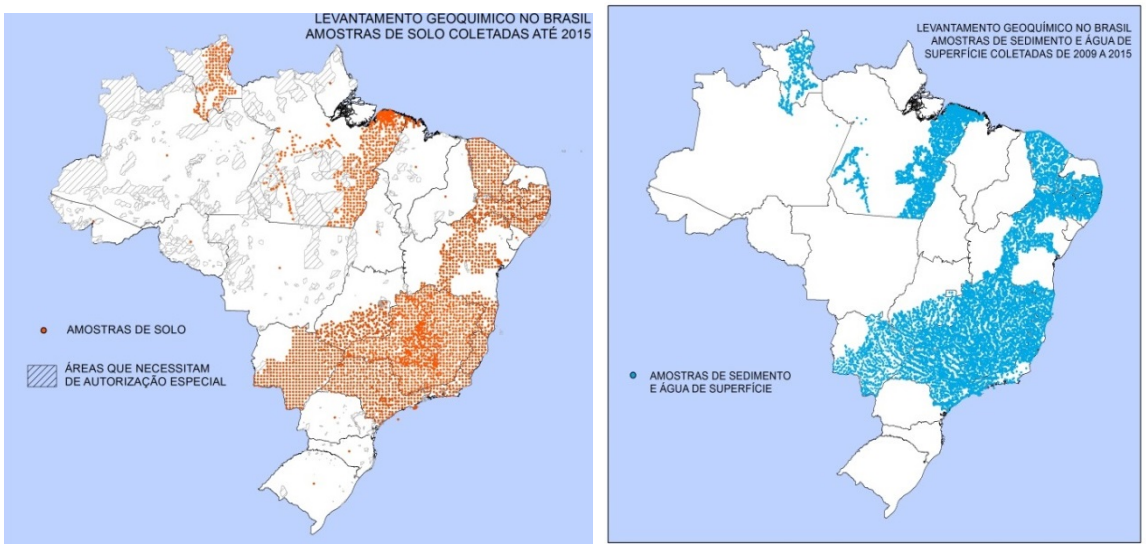


Figure 12. Low-density geochemical mapping for soil (left) and water and stream sediment (right) in Brazil up to 2015.

Today, low-density geochemical mapping projects are the responsibility of the Division of Geochemistry. During 2016, CPRM Geochemistry Division started a low-density geochemical mapping project in the north-western Amazon. The region, known as Dog Head (Cabeça do Cachorro), is one of the most remote areas in Brazil (Figure 13).

A team of geologists and geochemists went to the area in October/November 2016 to collect stream sediment, heavy mineral concentrate and water samples. The filed work will continue in 2017.

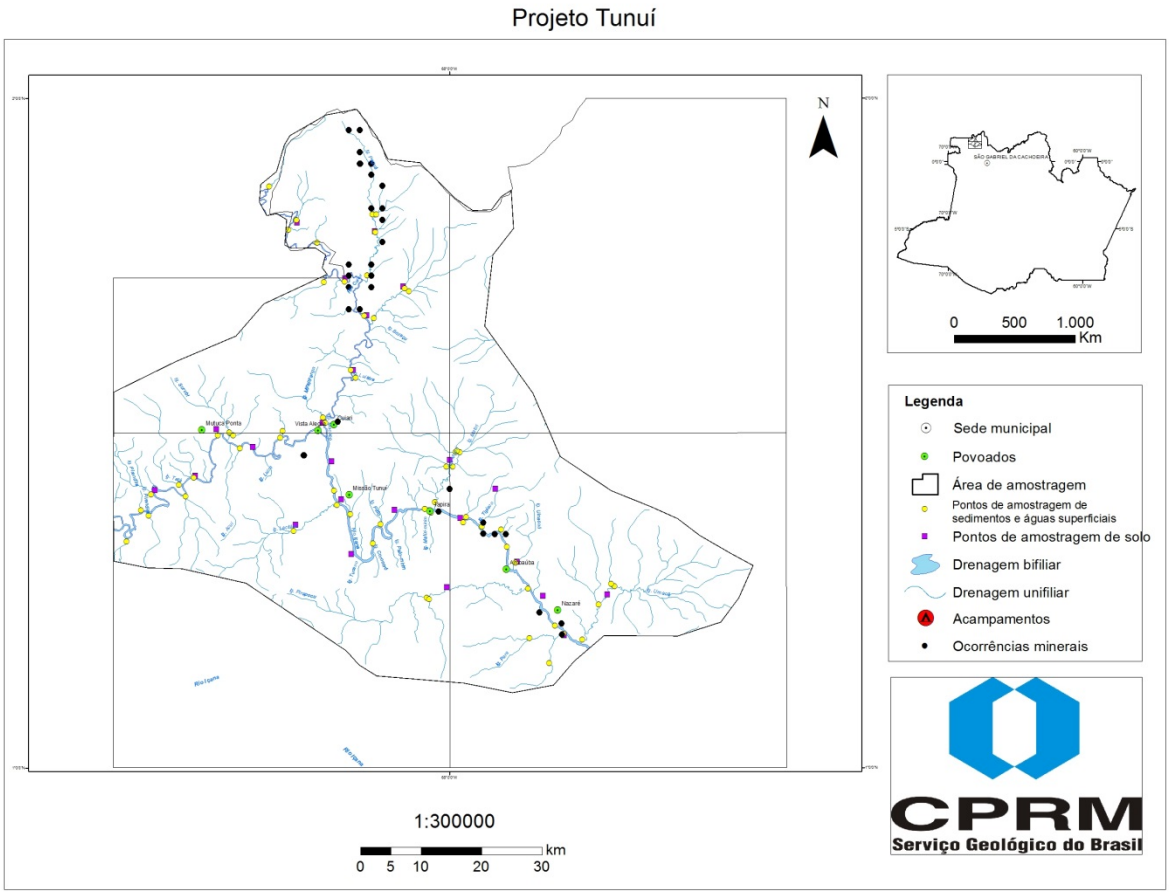


Figure 13. Low sampling density geochemical mapping project, NW Amazonas State.

***<u>Chile</u> (Juan Pablo Lacassie Reyes, SERNAGEOMIN)***

**General Information**

The Geochemical Map of Chile is a government program that is carried out by the Geological and Mining Survey of Chile (SERNAGEOMIN). The objective is to promote sustainable development of Chile by (1) defining geochemical baselines and (2) identifying mineral resources.

From 2011-2016 the Government of Chile has provided funding of approximately US$ 3M for fieldwork, sampling, sample preparation, chemical analyses and staff salaries.

**2016 Achievements**

Published products: geochemical databases for Pisagua and La Serena 1:250K mapsheets (Figure 14).

Products in press: geochemical maps for La Serena and Vallenar 1:250K mapsheets (Figure 14).

Geochemical sampling: 70% of the Taltal 1:250K mapsheets (Figure 14).


| Sheet (1:250.000) | Geochemical Map | Geochemical Database | Geochemical Samplig |
|---|---|---|---|
| Arica | Published | Published | 100% |
| Pisagua | Published | Published | 100% |
| Iquique | Published | Published | 100% |
| Quillagua | | | |
| Tocopilla | | | |
| Antofagasta | | | |
| Aguas Blancas | | | |
| Taltal | | | 70% |
| El Salvador | | | 100% |
| Copiapo | | | 100% |
| Vallenar | | In Edition | 100% |
| La Serena | In Edition | Published | 100% |

Figure 14. Location of the 1:250K mapsheets being the main targets of the geochemical program in northern Chile. The table shows detailed information concerning the production of geochemical maps, databases and sampling (2016 products in blue).

Technical reports:

- Geochemical baseline of the Valdivia Basin, in southern Chile; in press (Figure 15)
- Geochemical characterization of mineral deposits from the Atacama region, northern Chile, by using Artificial Neural Networks (see Section 6.2)

Geochemistry of fluvial basins: SERNAGEOMIN has generated geochemical baseline data for 10 large fluvial systems across Chile, including for the Valdivia Basin (Figure 16).

Geology Thesis: Miss Valentina Quitral: *Geochemistry of the Valdivia Basin, southern Chile*

(University of Chile).

New Products/Innovation:

- Geochemical map in Google Earth format (kmz file) for the Aysen Basin, southern Chile (Figure 17).
- Standardised field data collection: Excel template for collecting field data (Figure 18).
- Statistical analysis of geochemical data using Artificial Neural Networks (Figure 19).

International activities: Oral presentation at the 2016 Goldschmidt Conference, Yokohama, Japan (see Section 6.3).

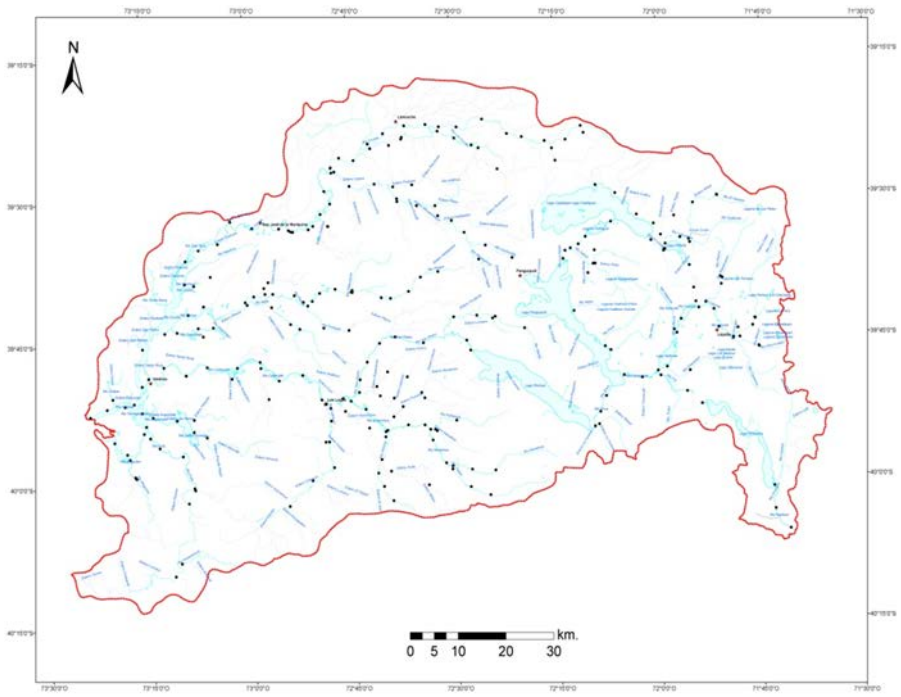


Figure 15. Location of the 262 sampling sites (black dots) of the Valdivia Basin (10,275 $km^2$) geochemical survey, southern Chile.


| Number | Fluvial Basins | Year of study | Geologists |
|---|---|---|---|
| 1 | Lluta | 2010 | Leonardo Baeza (*) |
| | Azapa-Vitor | 2013 | Francisca Espinoza (*) |
| 2 | Salado | 2015 | SERNAGEOMIN |
| | Copiapó | 2015 | SERNAGEOMIN |
| | Huasco | 2009 | Juan Pablo Lacassie / Alejandro Díaz |
| 3 | Elqui | 2013/2014 | Carolina Miralles (*) / Pablo Gómez (*) |
| | Limarí | 2011/2013 | Felipe Astudillo (*) / Felipe Carrasco (*) |
| 4 | Rapel | 2008 | Juan Pablo Lacassie |
| 5 | Aysen | 2015 | Jaime Barrera / Tania Roth (*) |
| 6 | Valdivia | **2016** | Felipe Astudillo / Valentina Quitral (*) |

(*) Associated with Thesis in Geology

Figure 16. Location of the fluvial basins survey areas studied by the Geochemical Program of SERNAGEOMIN. The frames are only schematic and do not include Argentinean, Peruvian or Bolivian territory. The table indicates the studied fluvial basins, the geologist in charge and those who have developed their Thesis in Geology.

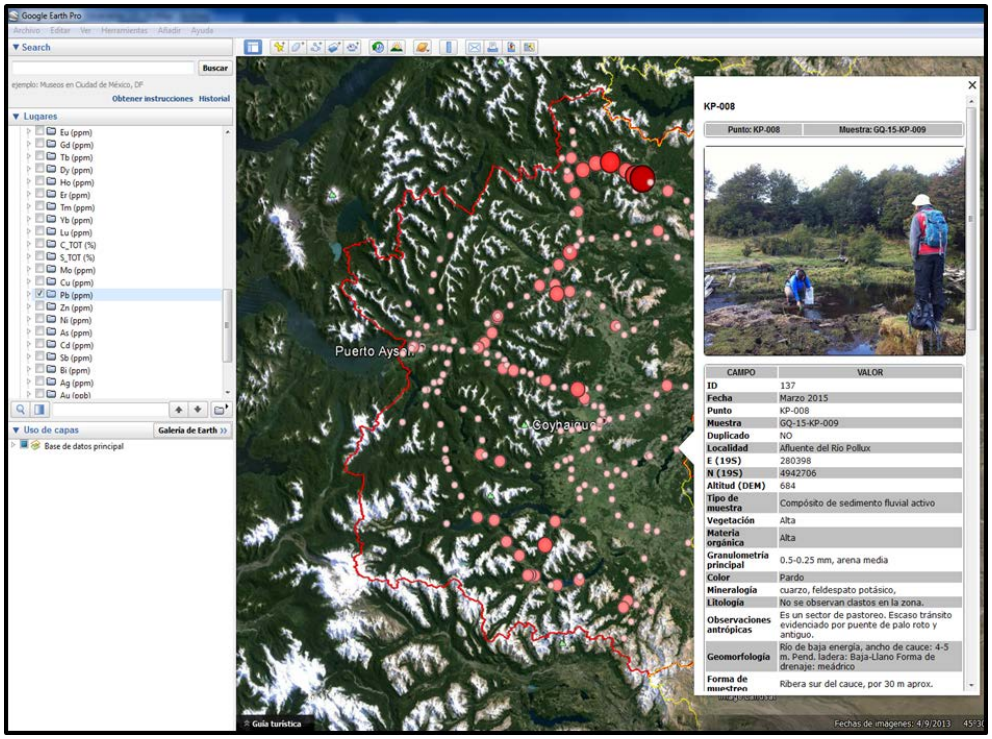


Figure 17. Google Earth representation of the geochemical map of the Aysen Basin, southern Chile. The geochemical map in kmz format was developed by Jaime Barrera (Geologist-Geochemist of SERENAGEOMIN). It uses Google Earth for detailed online representation of the geographical distribution of the concentrations of any of the 61 reported chemical elements. For each sampling point there is a dropdown box that includes a representative field picture coupled with field and chemical data.

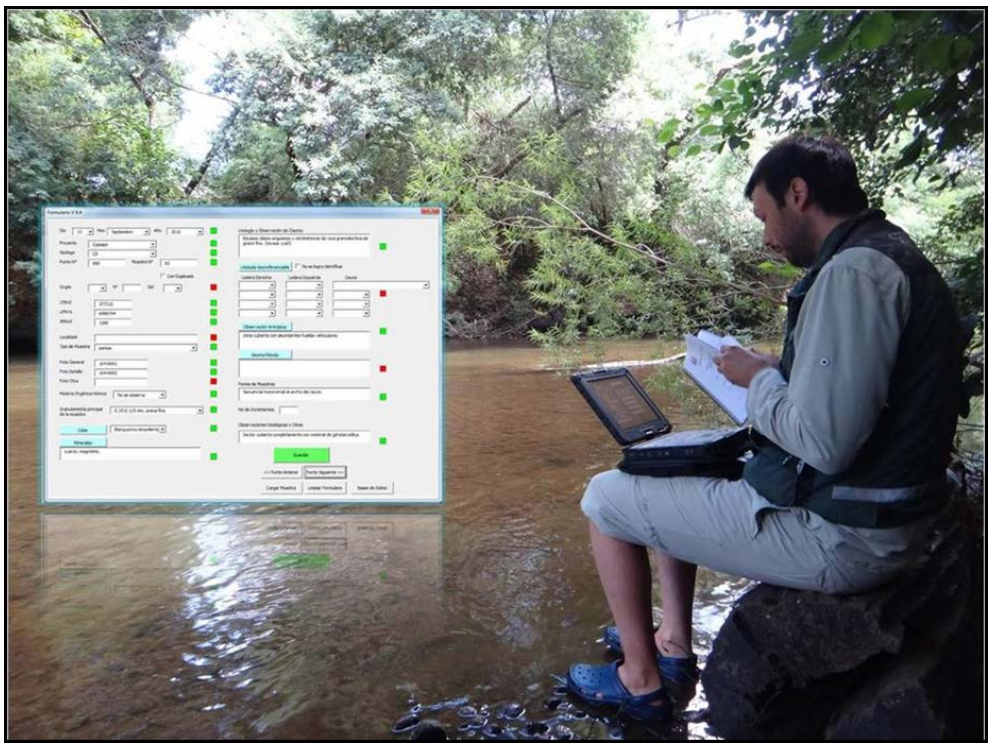

Figure 18. Since 2016 all the field data is collected using specially designed Excel file (macros), developed by Felipe Carrasco (Geologist-Geochemist of SERENAGEOMIN). It allows standardised collection of field data and automatic generation of reports.

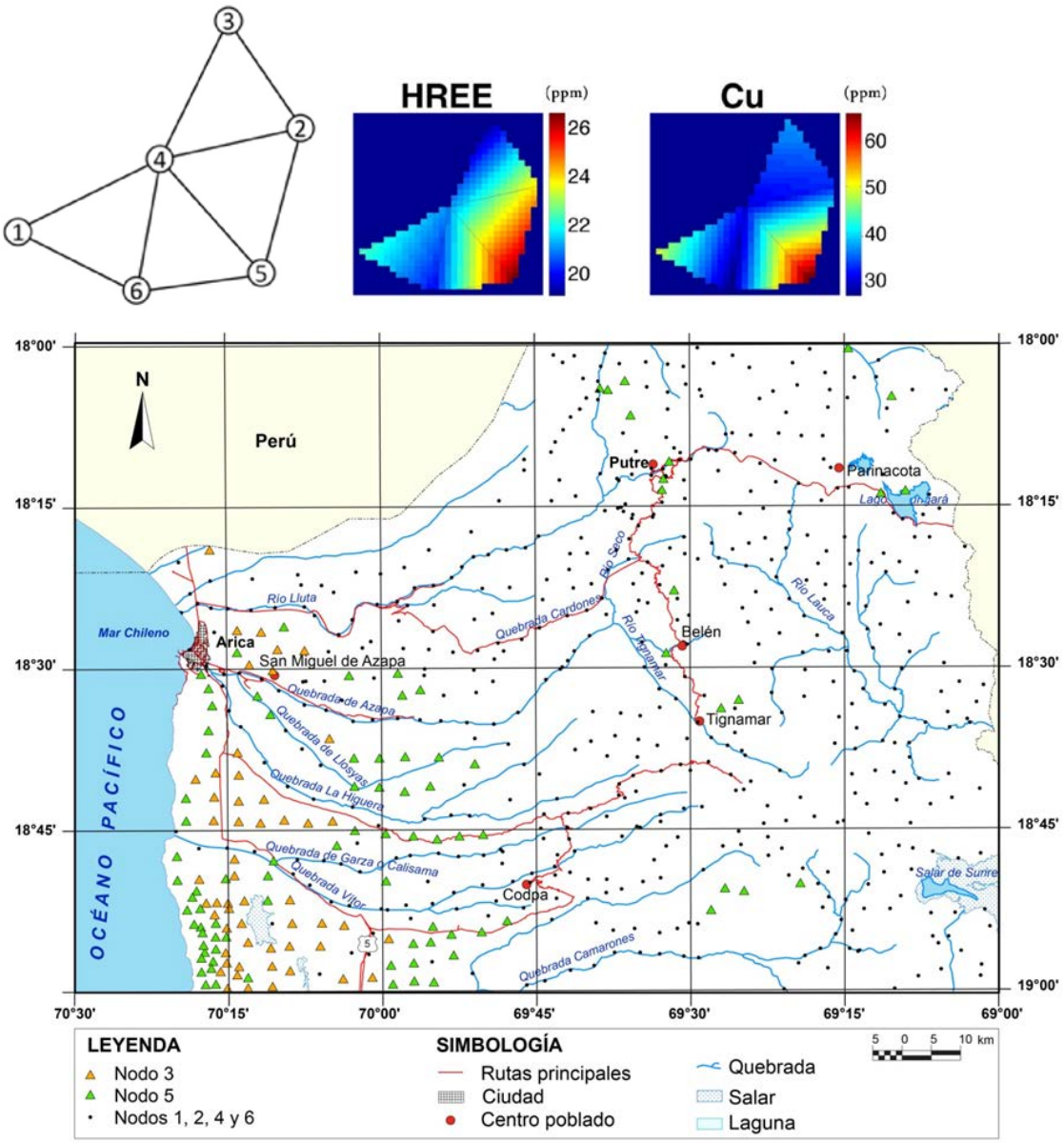


Figure 19. As part of the current methodology, the geochemical maps and technical reports include the statistical analysis of large datasets by using the K-means and/or growing cell structures Artificial Neural Networks (ANN) algorithms. As an example, the ANN analysis of the geochemical data of the Arica mapsheet, allowed the recognition of a specific group of samples (node 5 group; green triangles), characterised by high concentrations of copper (Cu) and heavy rare earth elements (HREE) among other elements. The figure shows the neural network structure coupled with the Cu and HREE distribution of concentrations (above) and the geographical distribution of node 5 samples (below), which are concentrated along the western margin of the Arica mapsheet, a possible prospective target.

### ***Colombia*** *(Gloria Prieto, Servicio Geológico Colombiano)*

The Geological Survey of Colombia is carrying out geochemical surveys at different sampling densities for mineral exploration purposes.

The geochemical programme includes collection of stream sediment, panned concentrates and rocks following standardised methodologies based on Global Geochemical Baselines recommendations adapted to the Colombian conditions and landscape. As part of the mineral exploration programme, geological mapping reconnaissance and metallogenetic studies in areas of mineral interest were carried out.

During 2016, the regional geochemical programme of the Geological Survey of Colombia covered systematically 10,000 $km^2$ and collected 3100 samples of stream sediment at density of one sample/3-5 $km^2$ (Figure 20).


Figure 20. Stream sediment sample collection in Colombia.

At the same time, a detailed geochemical sampling survey was carried out in areas of mineral interest by collecting 1085 samples (rocks, stream sediments, panned concentrates).

Geochemical analyses were performed in the geochemistry laboratories of the Geological Survey of Colombia, following standardised methodologies. Up to 60 elements were determined using analytical instrumental methods, such as ICP-MS, ICP-AES, X-Ray Fluorescence (XRF), Atomic Adsorption Spectrometry (AAS) and Graphite Furnace Atomic Adsorption Spectrometry (GFAAS), after appropriate acid leaches. For gold, mercury and mineral studies, specific methodologies were used. Selected elements in rocks and panned concentrates were analysed in commercial laboratories in Canada.

All the data generated were stored in the geodatabase that includes geochemistry, geophysics and metallogenetic information.

Data processing was performed using statistics and geostatistics software (SPSS, GEOSOFT Geochemistry, and IoGAS), and geochemical maps (dots, distribution, association) were plotted for each sampled region (Figures 21 and 22).

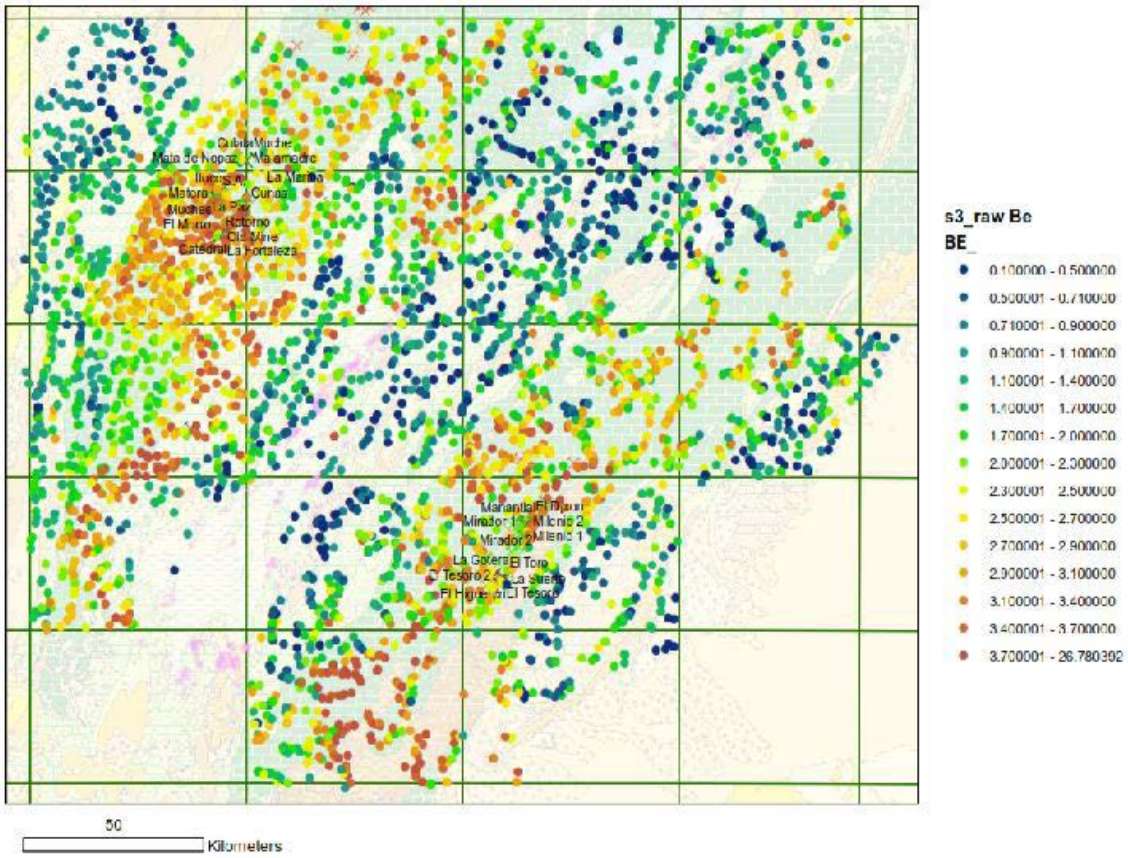


Figure 21. Geochemical map of Be (ppm), Emerald Project, Colombia.

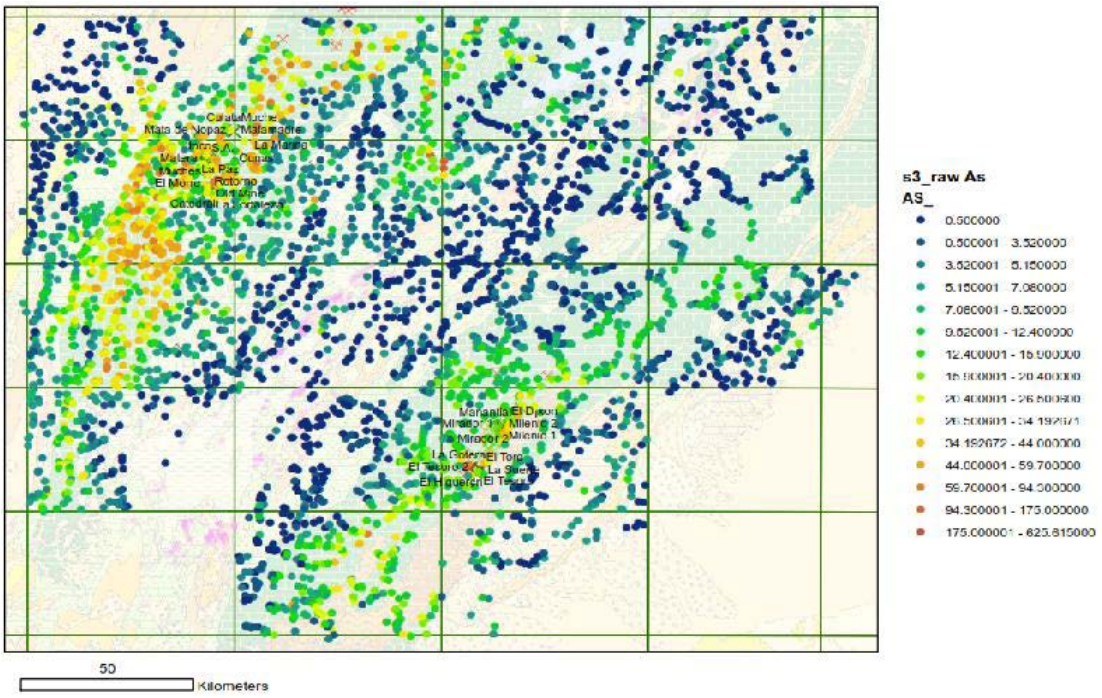


Figure 22. Geochemical map of As (ppm), Emerald Project, Colombia.

For mineral exploration purposes, geochemical anomalies were identified, and targets for detailed geochemical studies were located.

In order to have a broad view of the geochemical patterns of Colombia, old and recent geochemical data from stream sediment surveys were reviewed and processed to produce new geochemical maps of Colombia (Figures 23 and 24).

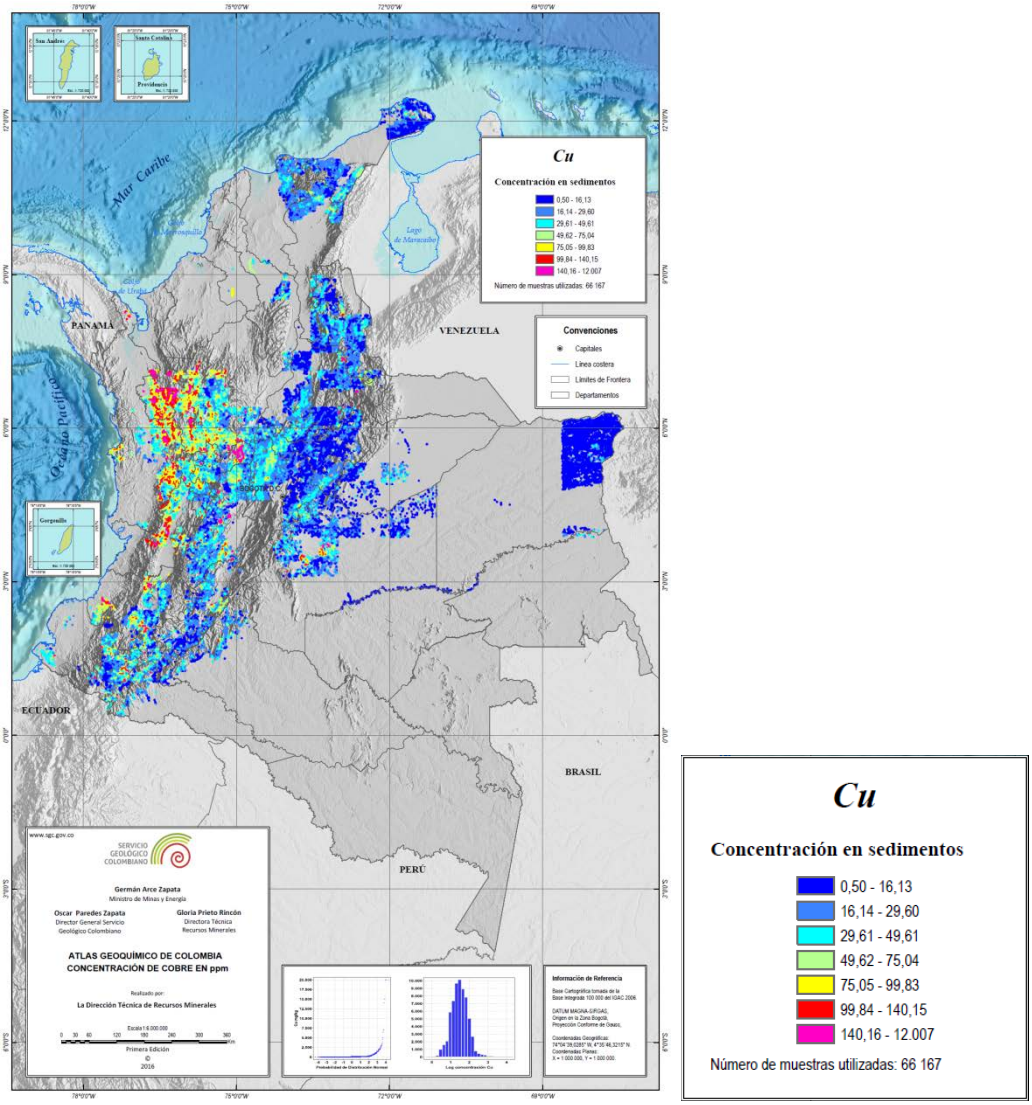





Figure 23. Geochemical map of Cu (ppm), Colombia.

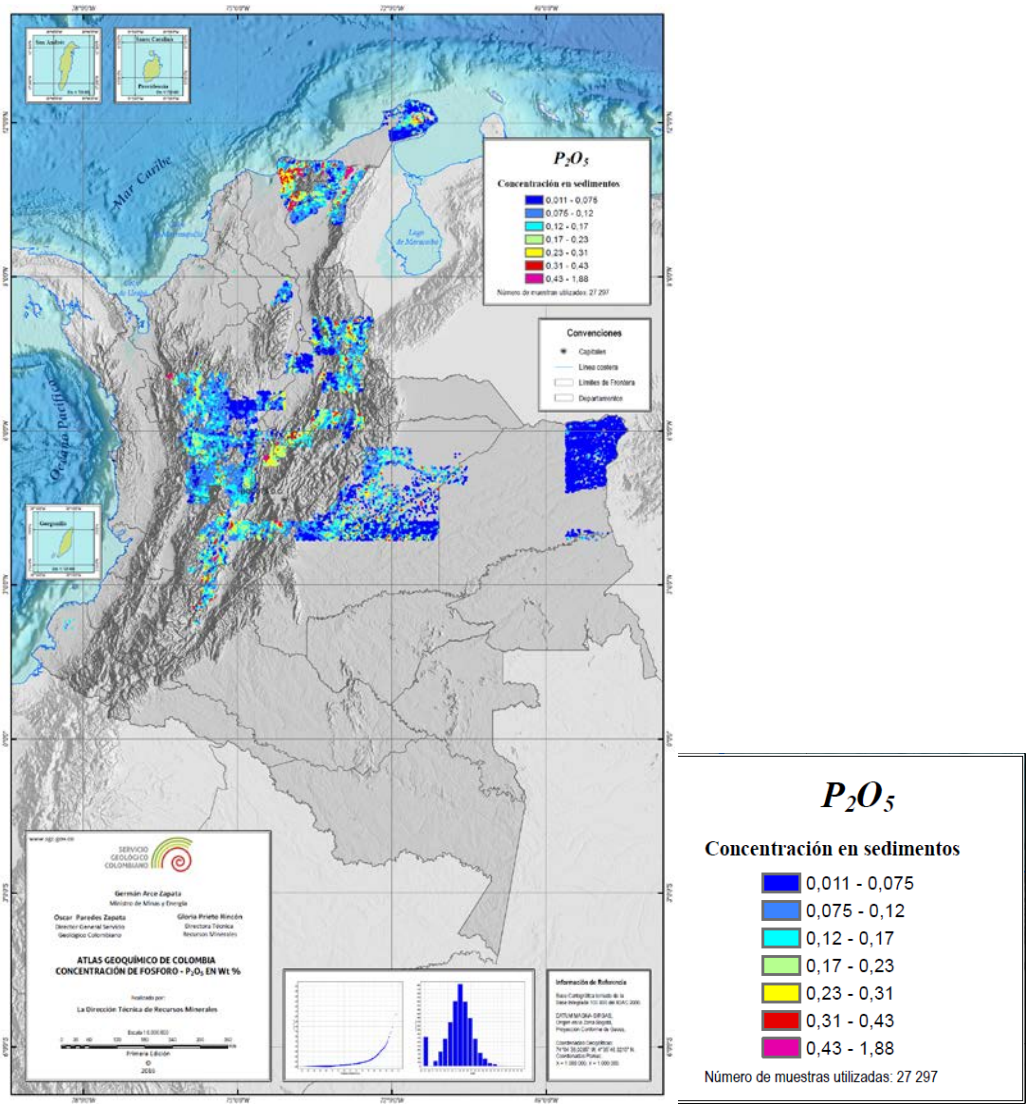


Figure 24. Geochemical map of $P_2O_5$(wt%), Colombia.

These geochemical maps are useful for delineating and identifying areas of interest for conducting detailed geochemical surveys for mineral resources exploration, as well as to environmental and health studies.

Thanks to the mineral exploration programme, and based on geological, geochemical, geophysical and metallogenetic information, 19 new areas with potential for mineral resources were identified, and detailed exploration is planned.

In relation to acid rock drainage studies, geochemical baselines for waters, soils and rocks were completed during 2016, and the acid generation potential was evaluated in Cajamarca, Tolima, a region where gold mineralisation occurs (Figure 25).

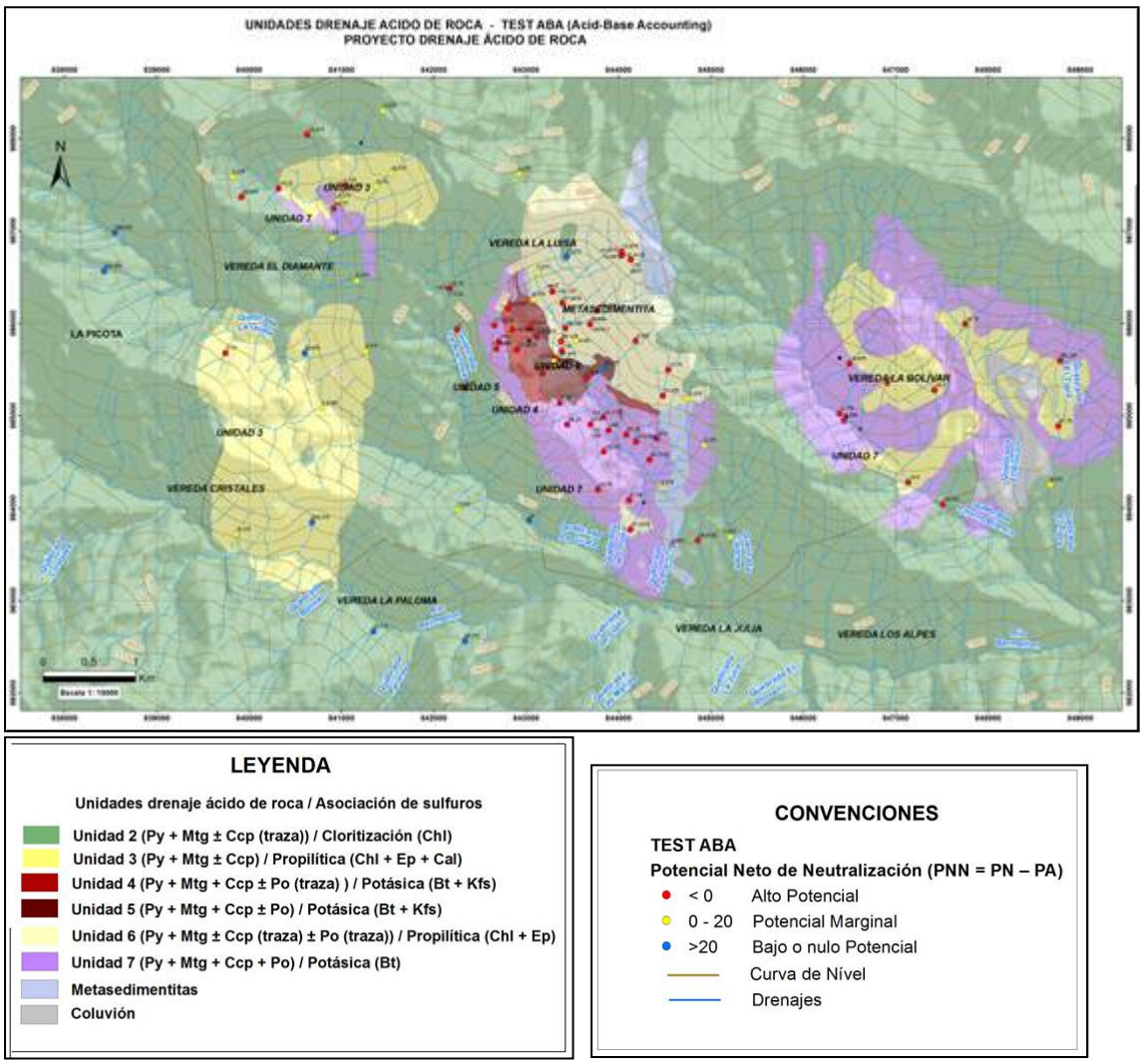


Figure 25. Acid rock drainage potential map based on Lawrence acid-base accounting method (modified Sobeck test) in the Cajamarca, Tolima, study area, Colombia.

The airborne gamma-spectrometry programme has to-date covered 800,325 km$^2$ (Figure 26). Future work will cover part of the Andes Region and the Eastern Region (Orinoquia-Amazonia) of Colombia to identify U, K, and Th anomalies. Survey parameters are: line spacing 500 m (Andes Region) to 1000 m (Eastern Region); tie line spacing 5 km (Andes Region) to10 km (Eastern Region); elevation over ground varies from100 m to 300 m depending on topography.

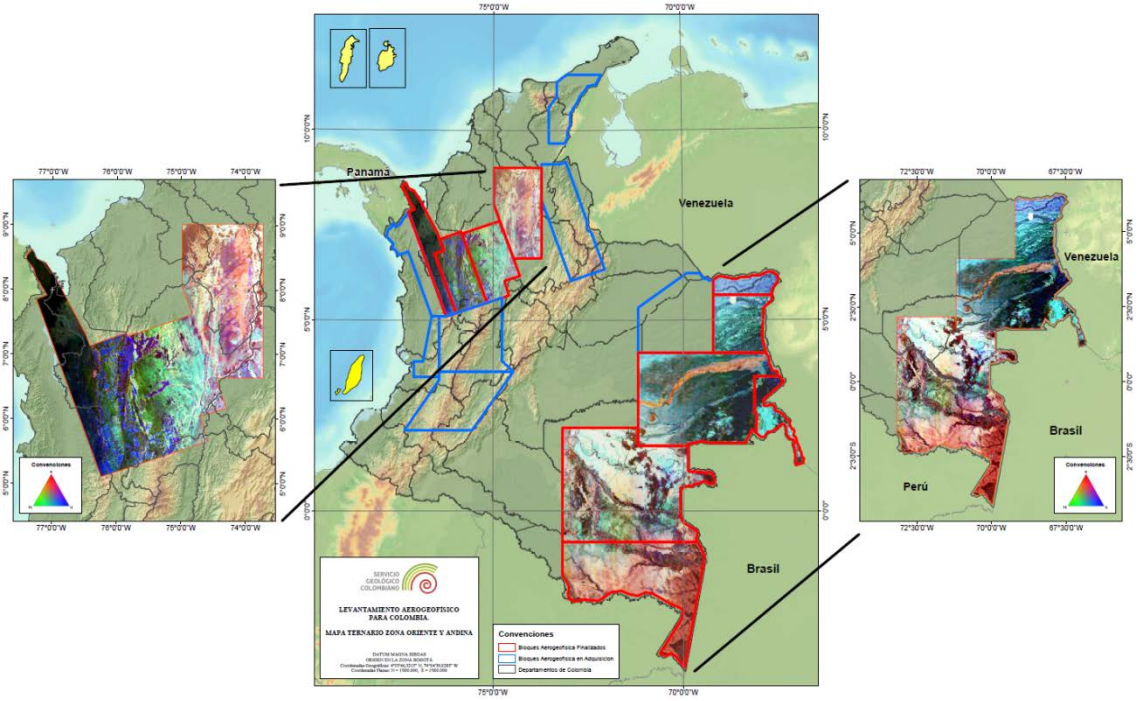


Figure 26. Airborne gamma-spectrometry programme in Colombia.

The Geological Survey of Colombia will continue its geochemical mapping programme at different sampling densities to produce the geochemical atlas of Colombia. For this purpose, the Geological Survey of Colombia is working towards the establishment of international collaboration agreements.

### *7.1.2. Africa*

***AFRICA - GENERAL* (Theo Davies, University of Nigeria at Nsukka)**

Large-scale geochemical sampling and analysis campaigns that have direct bearing to the "Africa Geochemical Database" (AGD) Programme were limited during 2016 owing to lack of funding. Activities in this direction were largely a continuation of programmes reported in last year's Annual Report, e.g., South Africa's Council for Geoscience (CGS) continued geochemical sampling and analyses in the Pofadder area and the Barberton Super Group, the Tugela area having already been completed.

Mukosi et al. (2015; see Section 6.2) reported on the continuation of the Namaqualand Airborne Geochemical Mapping Project. One of the aims of this Project is *"To aid in the acquisition of exploration geochemistry data for the generation of mineral potential target areas and the establishment of an updated geochemical database, as this will assist in providing a variety of geoscientific solutions"*. Soil samples from the top 20 cm or A-horizon (5 kg each) are taken by helicopter at the density of one sample per $km^2$ then prepared and dry sieved to <75 µm for analysis at the CGS laboratory. The samples are then analysed for more than 40 elements using the Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES).

Aloysius et al. (2016; see Section 6.2) gave the results of a stream sediment geochemical survey in the Nlonako area of the Cameroon Volcanic Line to determine the mineralisation potential of the area. Weak anomalies were reported for Au, Ag, Cu, Pb and Zn, and a relatively high input of the light rare-earth elements was found in the mineralising system.

Activities having direct relevance to the AGD consisted mainly of the capacity building

workshop that preceded the opening of the UNESCO International Centre for Global-scale Geochemistry (ICGG) in Langfang, China (12-13 May 2016; see Section 7.2), in preparation for potential approval of a proposal for funding by EGS, IUGS and others *"To develop a land base multi-element geochemical baseline database for mineral resource and environmental management"*. The project proposal for Africa is within the vision of GEO *"To realise a future wherein decisions and actions, for the benefit of humankind, are informed by coordinated, comprehensive and sustained Earth observations and information"*.

Examples of such workshops are the following:

- From funds provided by the Chinese Government, the opening ceremony of the ICGG from 12-13 May 2016, and the inaugural meeting of the ICGG Governing Board and Scientific Committee, were followed by a three-day Training Course (14-16 May 2016) on *"Global Geochemical Baselines"* (see Section 7.2). The course was attended by more than 50 geoscientists from Africa, Asia, China, Europe, and Central and South America. The African participants were from Liberia, Madagascar, Namibia, South Africa, Zambia and Zimbabwe.
- The IUGS/IAGC Task Group on Global Geochemical Baselines organised and sponsored a two-day Workshop on *"Global Geochemical Baselines"* on the occasion of the 35$^{th}$ IGC in Cape Town (27-28 August 2016). The first day was devoted to lectures, and the second to training in the field, where sampling methods used in global-scale geochemical mapping were demonstrated (see Section 7.2). All training materials were provided to participants on a memory stick. The course was attended by 19 participants, mostly from African countries.
- A Geochemical Modelling Workshop was also held during the 35$^{th}$ IGC, 26-27 August 2016. Following a fully hands-on format, participants learned to construct, trace, and interpret models of reaction in multi-component geochemical systems. Participants' reaction to the Geochemical Modelling Workshop was extremely gratifying, with some vying to take the Reactive Transport Course in the future.

Other geochemical activities carried out during 2016 that have the potential to generate data usable in the AGD Programme with reference to sampling and analytical protocols adopted, were largely by exploration firms, in locating specific mineral deposits, as described below.

On 19 September 2016, AMI Resources Inc announced the results of infill geochemical soil sampling programme over their Northern Anoura project area in Ghana. This survey was conducted on their behalf by SEMS (Accra) Exploration Services Ltd. One hundred and seventy C horizon samples (20-100 cm depth) were collected for geochemistry. A maximum assay of 210 ppb Au was obtained, with 13% of the samples above the local threshold of 40 ppb. Two further sites were cleared for additional grid sampling. Soil samples were taken from the C horizon at depths of 20-100 cm. Two zones of Au anomalies (in excess of 40 ppb) were identified.

Oklo Resources announced the commencement of the 2016-17 exploration field season, with the start of auger drilling at its Dandoko and Moussala projects in western Mali (www.okloresources.com/wp-content/uploads/2016/12/1630802.pdf; 2 MB). Over coming months, a series of early stage and advanced targets are planned for drill-testing. An initial 40,000 m auger geochemical programme is expected to be completed at both projects with six rigs on site.

On 7 November 2016, Kodal Minerals Plc Gold Project Joint Venture Exploration of Cote d'Ivoire, with lithium and gold interests in West Africa, gave the following update: (http://www.investegate.co.uk/kodal-minerals-plc--kod-/rns/gold-project-jv-exploration-update--cote-d-ivoire/20161107070009439 4O/)

At its Resolute Joint Venture – Tiebissou concession:

- 1797 surface geochemical samples collected, which has defined a gold anomalous zone extending across the concession that is interpreted to be related to a major structural zone
- 99 aircore drill holes were completed on a wide-spaced grid of 4320 m

At its Resolute JV – Nielle Concession:

- Completed surface geochemical sampling comprising 474 surface geochemical samples, 38 rock chip samples and 92 stream sediment samples
- Surface geochemical sampling has defined new regional gold anomalous zones
- Two new anomalous zones extending over 3 km x 1.5 km and 3 km x 2 km demonstrated by widely spaced infill geochemical sampling and trenching to define anomalies prior to reconnaissance drill testing, planned

At its Newcrest JV – Dabakala Concession:

- Advancement of auger drilling programme at Dabakala
- Auger geochemistry targeting surface geochemical anomalies and interpreted complex geological structural zones
- Exploration camp constructed on site and two auger drilling crews operating to complete the programme as soon as possible

***Africa** (Keith Shepherd, World Agroforestry Centre)*

The World Agroforestry Centre (ICRAF) under the Africa Soil Information Service (AfSIS) has launched the project of a Rural Soil-Plant Spectroscopy Lab (Figure 27). This consists of a portable mid-infrared diffuse reflectance spectrometer (FT-IR) coupled with a portable X-Ray Fluorescence spectrometer (pXRF). These two instruments can provide a wide range of rock, soil, plant and fertiliser analyses, and are robust enough to withstand tough conditions in rural Africa. ICRAF is deploying this technology under AfSIS to take measurements of matched soil and crop plants in a large number agronomic trials in collaboration with partners in Ethiopia, Kenya, Nigeria and Tanzania, to guide fertiliser targeting and blending decisions. The labs can provide farmers with analytical services at low costs, similar to rural public health clinics. ICRAF is working with Rothamsted Research (UK), new hosts of AfSIS, on developing a set of calibration standards for total element analysis in soil and plant samples by pXRF.

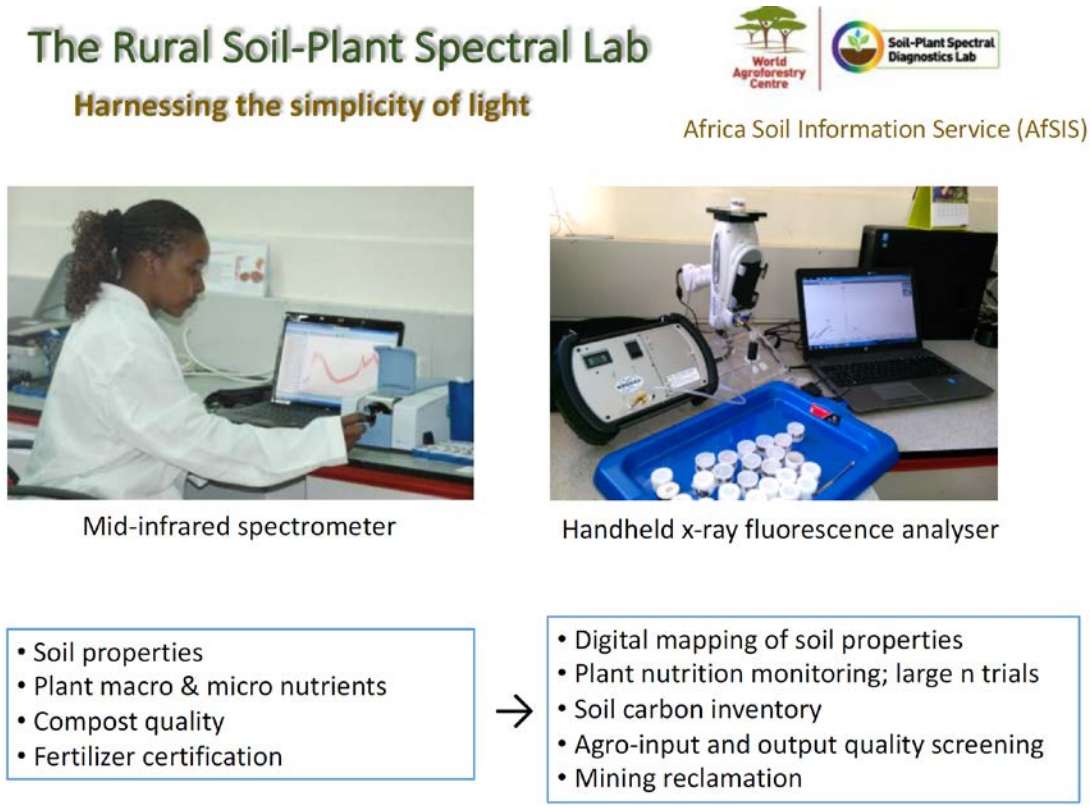


Figure 27. Mid-infrared spectrometer and portable X-Ray Fluorescence analyser used for agroforestry studies, Africa.

### *7.1.3. Asia*

***<u>CHINA AND OTHER ASIAN COUNTRIES</u> (Xueqiu Wang, IGGE)***

#### *China Geochemical Baselines Projects*

The China Geochemical Baselines Project (CGB) is a contribution to CGGB. Its purpose is to document China's nationwide geochemical baselines, spatial distribution and evolution of all elements. Each Grid Reference Network (GRN) cell is divided into 4 CGB cells. Approximately 1500 CGB cells cover the whole of China. Soil and rock samples were collected in each cell for pedosphere and lithosphere geochemical baselines, respectively. At two sampling sites from each CGB cell homogeneous samples of soil/overbank/floodplain sediments were collected. At each site, two depth samples were taken: 0-25 cm and >100 cm. Typical rock samples, representing different geological units, were concurrently collected in each CGB cell to interpret the geogenic sources of secondary geochemical patterns, and to explore the evolution of elements with geological time from Archaean to Quaternary.

A 5-year term, from 2008 to 2012, was planned for covering the whole of China's mainland, and a 2-year extension term from 2013-2014 was devoted to data interpretation and publications. A one-year pilot study was conducted in 2008 to test and refine the recommended protocols, and to optimise field logistics for the geochemical sampling. After completion of the pilot studies, a total of 6617 soil/catchment sediment samples from 3382 sites were collected at 1500 CGB grid cells across the whole of China (9.6M $km^2$), corresponding to a density of approximately one sample site per 3000 $km^2$. In addition, 11,943 rock samples were also collected to aid in the interpretation of geogenic sources of elements. Before chemical analysis, the soil and sediment samples were sieved to <2 mm and a 1 kg sample was ground to <74 µm in an agate or pure aluminium-porcelain mill. A 500 g sample was sent to the laboratory for analysis. The remaining sample was bottled and archived. Seventy six chemical elements plus 5

additional chemical parameters ($Fe^{2+}$, Organic C, $CO_2$, $H_2O+$ and pH) were determined under strict laboratory quality control.

The internet based software Digital Chemical Earth, similar to Google Earth, was developed and launched in May 2016. It can manage the geochemical database and allow everyone to access vast amounts of geochemical data and maps through the internet.

Initial results show excellent correlations of element distribution with lithology, mineral resources and mining activities, industry and urban activities, agriculture, and climate. These results were presented at the 34th IGC in Australia in August 2012, and at the 26th IAGS in New Zealand in November 2013, and published in the Journal of Geochemical Exploration. The China Geochemical Baselines Atlas has been submitted to the publishing house for publication. The data will be released after the atlas publication according to the contract with the publishing house. The simplified maps can be downloaded from the website of the UNESCO International Centre on Global-scale Geochemistry (www.globalgeochemistry.com).

***China and Mongolia Cooperation Geochemical Mapping Project***

China is cooperating with Mongolia in geochemical mapping at a scale of 1:1M covering an area of approximately one million $km^2$ across boundary regions of the two countries. The project was launched in 2008 under an agreement issued by the China Geological Survey and the Mineral Resources and Petroleum Authority of Mongolia. The Institute of Geophysical and Geochemical Exploration (IGGE) helped with training in sample collection protocols and provided free chemical analyses. The sampling methods were developed specifically for the project landscapes of Gobi desert, grassland and mountains. A total of 10,532 samples were collected across the boundary area of approximately 1,050,000 $km^2$ at a sample density of 1 per 100 $km^2$ before 2013. The project has extended into the whole of Mongolia as from 2014. In total, 2000 samples were collected in 2014, and analysed in 2015. The analytical methods were principally ICP-MS, ICP-AES and XRF combined with an additional 10 methods. High-quality data were generated under strict quality control using standard reference materials. A geochemical atlas of 69 elements and organic carbon was published. The results showed that (i) regional geochemical patterns were identified for the first time across the world's largest REE ore deposit in Inner Mongolia; (ii) regional geochemical patterns of Ag-Pb-Zn have good correlation with the polymetallic province along the east part of the boundary region; (iii) regional geochemical patterns of Cu-Au-Mo have good correlation with the porphyry metallogenic province along the middle part of the boundary region. The first phase final report, analytical data and atlas were presented to Mongolia State Authorities in August 2012. Four scientists were awarded the Mongolian Medal of Honour, which is the highest ranking honour for geologists who have made a great contribution for Mongolian Geology and Mineral Resources. The results were presented at the China Mining Conference in China in November, 2013. The first phase geochemical atlas was completed in 2014. The second phase project began in 2015, and 300 additional samples were collected in 2016.

***CCOP/ASEAN Geochemical Baseline Mapping Programme***

As detailed in the 2012 Annual Report, the China Geological Survey has approved a proposal to provide financial and technical support for a Geochemical Baseline Programme within the member countries (China, Japan, Vietnam, Indonesia, Singapore, Cambodia, Thailand, Malaysia, Papua New Guinea, Philippines and Korea) of the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP).

A CCOP/ASEAN Seminar on Geochemical Mapping took placed in Nanjing, China, in March 2012, and a Workshop entitled "CCOP-ASEAN Geochemical Mapping" took place in Nanning (Guangxi Province), China, from 3 to 8 September 2013.

A training course on field geochemical sampling took place in Papua New Guinea in 25-27 October 2014.

A training course on geochemical mapping including indoor lectures and field sampling took place in Cambodia in November 2016.

A total of 146 global-scale soil/catchment sediment samples from 73 sites were collected across the whole of Laos (approximately 200,000 $km^2$) corresponding to a density of approximately one sample site per 3000 $km^2$ in 2014 and 2015. 76 elements were determined in 2016. 900 stream sediment samples at density of 1 per 100 $km^2$ were collected in Laos in 2015 and 2016.

***JAPAN** (Atsuyuki Ohta, Geological Survey of Japan)*

A high density urban geochemical mapping project commenced in 2010 to elucidate contamination and transportation processes of elements released through anthropogenic activity to stream sediments and coastal sea sediments. Geochemical maps in the Kanto region, including nation's capital Tokyo, were published in the 2015. Subsequently, a high density geochemical mapping project in Tokai region at a scale of 1:500K started in 2015. The Tokai region includes Nagoya City, Toyota City, and Hama-matsu City where one of the best industrial areas is. In 2016, 250 stream sediment samples were collected (approximately one sample site per 10 $km^2$) for the project. The samples were air dried and sieved to <180 μm size fraction. Magnetic minerals in the fine sediment samples were removed to minimise the effect of their accumulation. Fifty three elements including toxic elements such as As, Cd, and Hg were determined using ICP-AES, ICP-MS, and AAS.

***KYRGYZTAN** (Rolf Tore Ottesen, NGU; Jim Bogen, NVE)*

The Kyrgyzstan regional geochemical mapping project was a part of the Norwegian CPEurasia programme for the period 2010-2014. The partners were KG-Asanaliev's Kyrgyz Institute of Mining Technologies; Department of Geology, University of Tromsø; Norwegian University of Science and Technology; Geological Survey of Norway (NGU); Norwegian Water Resources and Energy Directorate (NVE). The estimated cost of the four year programme was NOK4M (~US$ 0.7M). Overbank sediment samples (top and bottom) were collected from 500 sites, and were analysed for 40 elements in the ALS-laboratory in Kyrgyzstan. The Geochemical Atlas of Kyrgyzstan was presented to State Authorities in September 2014. The data are presently being processed, and the project team is working on the interpretation of results. The Geochemical Atlas of Kyrgyzstan should be ready for publication in 2017.

### *7.1.4. Australasia*

***AUSTRALIA** (Patrice de Caritat, Geoscience Australia; Paul Morris, GSWA)*

2016 saw the release of further publications on the National Geochemical Survey of Australia (NGSA) dataset; statistical analysis of the data continued, including the development of methods for analysing and representing compositional data as well as integrating it with other datasets (see Section 6.2). Presentations were made at the 3rd Australian Regolith Geoscientists Association Conference, the Australian Earth Sciences Convention, the 26th Goldschmidt Conference, the 35th IGC (see Section 6.3).

Visible-shortwave infrared, mid-infrared and thermal infrared spectroscopic analysis of the NGSA samples, which begun in 2013, was completed for the surface soil samples in 2016. The resultant data were uploaded in the publicly accessible SPECCHIO spectral database.

Opportunistic infill sampling on a grid pattern as part of a national geophysical (i.e., magneto-telluric) survey has to-date collected samples from parts of Victoria, South Australia and Western Australia, despite funding and logistical difficulties. A separate initiative funded under the 'Exploring for the Future' programme of the Australian Government (2016-2020) will see catchment-based sampling at an order of magnitude higher density compared to the NGSA take place over the Tennant Creek-Mt Isa-McArthur River region straddling the Northern Territory--Queensland border during 2017.

At the regional scale, the results of the southern Thomson geochemical survey (northern New South Wales and southern Queensland) were published this year in a report (see Section 6.2). A paper in press presenting an upscaling methodology from regional- to continental-scale survey results and their application to mineral exploration will be published next year.

The Geological Survey of Western Australia's (GSWA) assessment of regional geochemical data for 1027 samples collected at a nominal density of one sample per 25 km$^2$ from the Kimberley area of northern Western Australia has been completed, with the publication of explanatory notes for the Balanggarra, Bunuba and Yuriyangem-Taam, and Dambimangari areas (Figure 28). These publications (see Section 6.2) are available for download free of charge from the Department of Mines and Petroleum (DMP) website. Data for the fine fraction (<50 µm) of 637 regolith samples, collected at a nominal density of 1/12.5 km$^2$, have been generated for the Ngururrpa area of northeastern Western Australia (Figure 28), an area underlain by Proterozoic and Phanerozoic sedimentary rocks. Digital versions of the geochemical data from the Kimberley and Ngururrpa projects are available from the 'GeoChem Extract' portal on the DMP website.

GSWA occasionally is provided with regional geochemical datasets from exploration companies. These data are released as digital files from the Data and Software Centre. A recently released dataset consists of 262,000 analyses of surface samples generated by Western Mining Corporation, largely covering Archean greenstones of the Yilgarn Craton (Figure 28). Each sample has been analysed for up to 22 components (Ag, As, Au, Bi, Cu, Fe, Mn, Pb, Pd, Pt, Sn, Zn, Ni, Mo, Co, Cr, Sb, W, Ir, Ru, Rh, as well as pH).

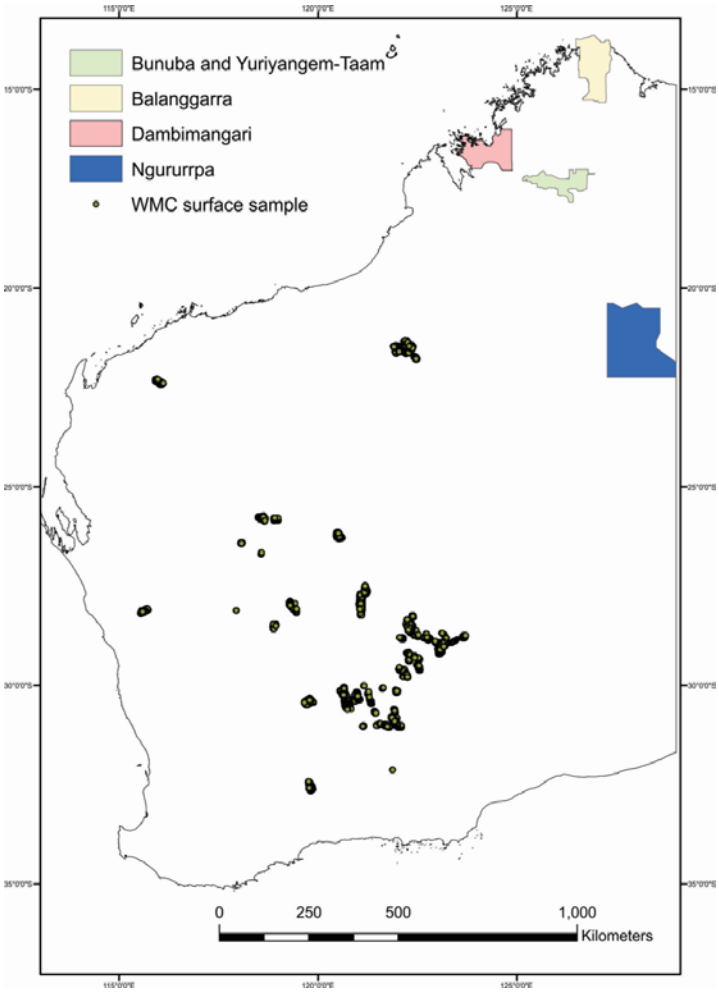


Figure 28. Location of GSWA's sampling sites and regional geochemical survey areas.

***NEW ZEALAND* (Adam Martin, GNS Science)**

GNS Science has completed a regional survey in New Zealand around the Nelson Marlborough area, which included 500 sites at a mix of 8 km and 2 km spacings. Samples were collected from 0-2 cm, 2-18 cm and 50-70 cm. They will be analysed by ICP-MS and XRF. The primary goal of the survey is to obtain background information for mineral exploration and targeted ultramafic and plutonic rock types. The results will be available through the New Zealand petroleum and minerals website in March 2017.

### *7.1.5. Europe*

***EUROPE* (Clemens Reimann, Geological Survey of Norway)**

The two volumes of the FOREGS-EGS Geochemical Atlas of Europe (Salminen et al., 2005; De Vos et al., 2006), available for free download from weppi.gtk.fi/publ/foregsatlas/, are still very popular. The complete European database of all field and geochemical data collected as part of this project and the related digital photo archive are also freely available at this website. The data of widest interest are the stream water data, since this is the only harmonised dataset in Europe and complies to the specifications of the Directive on Infrastructure for Spatial Information in the European Community (INSPIRE), and to the Water Framework Directive 2000/60/EC.

The EGS Geochemistry Expert Group published in April 2014 a two-volume set of the GEMAS project (GEochemical Mapping of Agricultural and Grazing land Soil) entitled "*Chemistry of Europe's Agricultural Soils*" at density of 1 sample site/2500 $km^2$. This was a cooperation project with industry, and was partly funded by the European Association of Metals (Eurometaux) for the provision of harmonised data compliant to the European Commission's REACH Regulation (Registration, Evaluation and Authorisation of Chemicals).

New activities during 2016 included the writing of papers on different aspects of the GEMAS project (see Section 6.2), and additional determinations on the agricultural and grazing land soil samples, which should be completed in 2017, namely (a) soil colour on dry and wet samples on both the agricultural and grazing land soil samples, and (b) Sr isotopes, total C, N and S, and magnetic measurements on agricultural soil samples only.

## 7.2. PUBLIC RELATIONS ACCOMPLISHMENTS

The main priority of the Public Relations and Finance committee is to promote the project for the purpose of attracting sponsors that may be interested to finance the Global Geochemical Baselines project in different parts of the World. This is a difficult task, and hitherto only one company (GEOINVEST Ltd), has sponsored the Commission's work, namely the floodplain sediment sampling in Cyprus in collaboration with the Hellenic Institute of Geology and Mineral Exploration and the Cyprus Geological Survey Department.

One of the main priorities at the end of 2012 and beginning of 2013 was the reorganisation and update of the website material. The website was reorganised and redesigned by a commercial company in collaboration with the public relation officer. The new website became operational in February 2013 (www.globalgeochemicalbaselines.eu/). A major update of the website will be undertaken at the beginning of 2017.

The website hosting the FOREGS Geochemical Atlas of Europe is still very important for the promotion of the Global Geochemical Baselines project. Hotlinks have been established to the FOREGS Atlas site from the sites of EGS, many European Geological Surveys, and also professional organisations, *e.g.*, the Association of Applied Geochemists, International Medical Geology Association, and the Society of Environmental Geochemistry and Health.

Another important website, which is now in operation, concerns the GEMAS project of the EGS Geochemistry Expert Group. The website is hosted by the Geological Survey of Austria

and the webmaster is Paolo Valera from Italy; the Commission is actively involved in the compilation of the material that is uploaded to the GEMAS website. A novel idea is the uploading of two photographs from each sampling site to Google Earth – work that is done by Edith Haslinger (Austria) in her own time. Thus, interested people can fly directly to the sampling site and see a landscape and a soil profile photograph.

In 2010, the EGS Geochemistry Expert Group decided to produce GEMAS calendars for 2011, 2012, 2013, and 2014 for the promotion of the project, which have been designed by Peter Hayoz (Switzerland). Each calendar has 12 photographs from different countries, which display European agricultural and grazing landscapes. As the 2014 calendar was very popular, it has been decided to continue its production as from 2017 onwards and the latest calendar can be downloaded from the GEMAS downloads website; the 2017 issue is being finalised at the time of writing.

Another recent novel idea was the design of the GEMAS Periodic Table of Elements of Agricultural Soil, and the GEMAS Periodic Table of Mineralisation and Mineral Deposits, both of which were revised in 2016. They continue to be very popular at all international events where they are presented, and are available from the GEMAS download website (op. cit.).

The CD of the FOREGS/EGS Geochemical Atlas of Europe includes the two volumes of the Atlas, the analytical data, the field manual, the IGCP 259 Report 'A *global geochemical database for environmental and resources management*' (Darnley et al., 1995). More than 2500 copies have been distributed to date (1300 copies by EGS office and over 1200 copies by the Public Relations and Finance Committee).

Another significant promotional activity has been the distribution of the memorial issue of the 2008 DVD in honour Arthur G. Darnley (1930-2006), which was still being distributed at international conferences, congresses and meetings until June 2016. The DVD includes all the material from the Geochemical Atlas of Europe CD, all publications from 1988 to 2008 of the two IGCP programmes 259 International Geochemical Mapping and 360 Global Geochemical Baselines, and copies of all papers from the Arthur Darnley Symposium - Geochemical Mapping from the Global to the Local Scale - held at the 33rd IGC in Oslo, Norway. About 1500 copies of the DVD were made, and as at end of June 2016 more than 1480 copies had been distributed at workshops, conferences, congresses and meetings, and also posted to interested university students and professionals.

As the first edition of the Arthur Darnley memorial DVD was very popular, it was decided to reproduce it on the occasion of the 35th IGC in Cape Town with the addition of new material, such as freely available publications and reports, and the geochemical atlases of the USA (http://pubs.usgs.gov/ds/801/; http://pubs.usgs.gov/of/2014/1082/) and Australia (www.ga.gov.au/ngsa).

In 2012, the Task Group (now Commission) published a paper in Earth Science Frontiers titled "*The IUGS/IAGC Task Group on Global Geochemical Baselines*." This paper provided a summary of the history and accomplishments of the Task Group.

The Task Group (now Commission) supported the travelling and part of the sustenance expenses of the Sampling Committee Chair to participate at the following events, following official invitation from the organisers:

- The 1st International Geosciences Congress and 32nd National Symposium in Tehran (Iran) held 16-19 February 2014, which were organised by the Geological Survey of Iran (http://nigc.conference.gsi.ir/en). A keynote presentation about the Global Geochemical Baselines project was delivered at the opening session of the congress, attended by more than 300 people, on 16 February 2014. A workshop on "*Global*

*Geochemical Baselines"*, attended by 12 geologists and applied geochemists, was organised on 15 February 2014 at the premises of the Geological Survey of Iran.

- The 3rd Young Earth Scientists (YES) Congress 2014, which was held in Dar es Salaam (Tanzania) 11-13 August 2014, in conjunction with the 25th Colloquium of African Geology (CAG25) (http://panafgeo.eurogeosurveys.org/?p=310). The 3rd YES Congress was organised by the Young Earth Scientists Network. The two-day training workshop (12-13/8/2014) on *"International Geochemical Mapping and African Geochemical Baselines"* was attended by 59 registered geoscientists mostly from African countries, but also participants from Peru, Brazil, Canada, China and Europe. The attendees ranged from graduate and post-graduate students, to University academics and professionals.
- The IUGS Workshop on RFG, which was held at the Gocheganas Wellness Village in Windhoek, Namibia, 24-30 July 2015. A diverse group of geoscientists, environmental and social scientists and economists, drawn from a range of institutions with diverse private and public experience in exploration, mining and mineral policy, environmental protection, and sustainable development participated in the Workshop. The report *"Resourcing Future Generations – A Global Effort to Meet the World's Future Needs Head-on"* is freely available on the internet (3 MB). In addition, a paper has been written with the title *"Sustainable Mineral Sourcing Requires International Action"* and submitted for publication in Nature.
- On the occasion of the 35th IGC and in conjunction with the 3rd Arthur Darnley Symposium, the Task Group (now Commission) organised a two-day Workshop (WK4) on *"Global-scale Geochemical Mapping"*, 27-28 August 2016, Cape Town, South Africa.

The first day was devoted to lectures, where the 19 attendees were given a comprehensive overview of the methods, tools and techniques used in global geochemical baseline mapping, and the training material was provided to all attendees. The tutors were Xueqiu Wang (Executive Director of the UNESCO International Centre on Global-scale Geochemistry and 2nd Co-Chair of the Commission), and Alecos Demetriades (Chair of Sampling Committee and Treasurer of IUGS Commission). The lectures are listed under Section 6.3.

The second day was devoted to the demonstration of sampling techniques used in global-scale geochemical mapping, described in the FOREGS/EGS *'Geochemical Mapping Field Manual'* (Salminen et al., 1998). Suitable sampling sites for sampling floodplain, overbank and stream sediments, and residual soil were found in the Cape Farms area to the north of Cape Town (Figure 29).

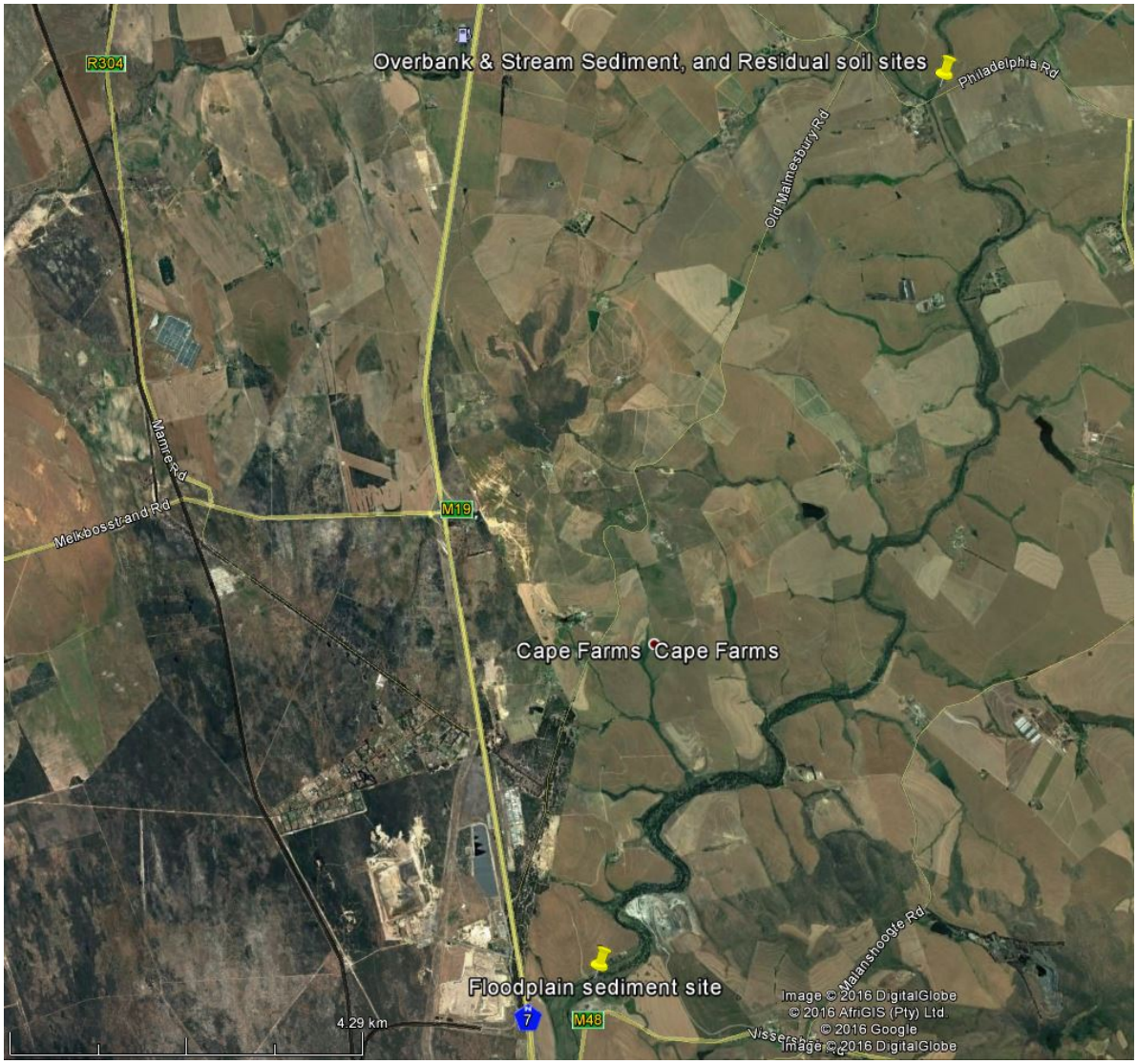


Figure 29. Google Earth image showing the location of the floodplain, overbank and stream sediment and residual soil sampling sites, Cape Farms, Cape Town, South Africa.

The sampling sites were visited on 24 August 2015 by Alecos Demetriades (Chair of Sampling Committee) and Ross Campbell (local geologist), whose help was greatly appreciated as it was necessary to purchase digging equipment, to sand blast the painted spade and mattock cutter (Figure 30), and also to obtain access permission from the land owners. The land owners of (i) the floodplain sediment sample site, Andre Brink, and (ii) overbank and stream sediment, and residual soil sampling sites, Jan van der Spuy, are thanked for giving us permission to access their land.

The transportation by coach to the field sites was sponsored by the Commission. The 35$^{th}$ IGC Organisers are thanked for providing the packed lunches. The field course was attended by 21 people (Figure 31).

Figure 30. (left) Painted spade and mattock cutter, and (right) Sandblasted spade and mattock cutter; the paint on part of the handle was left for demonstration purposes.

Figure 31. Field training course attendees.

The morphoclimatic situation in South Africa is similar to south European conditions, i.e., Mediterranean type environment. Figures 32, 33, 34 and 35 show respectively the floodplain, overbank and stream sediment, and residual soil sampling sites in the Cape Farms area, Cape Town, South Africa.


Figure 32. Floodplain sediment sampling site: (left) Landscape photograph showing the overall environmental setting, and (right) Close-up of the floodplain sediment profile showing at least 5 floodplain sediment layers.


Figure 33. Overbank sediment sampling site: (left) Landscape photograph showing the overall environmental setting, and (right) Close-up of the overbank sediment profile showing at least 5 floodplain sediment layers and one layer with stream sediment, similar in characteristics with the current active stream sediment.


Figure 34. Stream sediment sampling site: (left) Landscape photograph showing the overall environmental setting, and (right) Close-up showing the coarse-grained nature of the current active bed load of the stream, which is similar to the layer found in the overbank sediment profile.

Figure 35. Residual soil sampling site: (left) Landscape photograph showing the overall environmental setting, and (right) Close-up showing the residual soil profile; the bedrock can be seen at the bottom of the profile.

- The IUGS/IAGC Task Group (now Commission) organised the 3rd Arthur Darnley Symposium with the title *"Mapping the geochemistry of the Earth's surface at global to local scales"* at the 35th IGC in Cape Town, South Africa. The session was co-chaired by Xueqiu Wang (Executive Director of UNESCO International Centre on Global-scale Geochemistry and 2nd Co-chair of Commission) and Alecos Demetriades (Commission Treasurer and Chair of Sampling Committee). Over 60 geoscientists attended the Symposium. The Arthur Darnley Symposium was held under Theme 3 'Public Sector Geoscience and Geological Surveys' on 30 August 2016, and was attended by more than sixty people. A list of oral and poster presentations is given in Section 6.3.

***Important outcomes***

Directly after the 1st International Geosciences Congress and 32nd National Symposium in Tehran in February 2014, the development of an MoU was being discussed with the Geological Survey of Iran. Whilst the MoU was in the process of approval by the different Iranian Ministries, China Geological Survey intervened with the 'Silk Road' country project initiative, and an MoU was signed with the Geological Survey of Iran. In this case, the Task Group paved the way and, according to our information, the sampling of the GRN cells started in 2016 and will be completed in 2017, follows the 'Blue Book' (Darnley et al., 1995) and FOREGS specifications.

The text of the MoU with GSAf for training workshops in Africa was agreed to in early 2015, but has not yet been signed, because GSAf is searching for sponsors to finance the first workshop in Ethiopia. An MoU was, however, signed between China Geological Survey (CGS) and the Geological Survey of Ethiopia, and a capacity building workshop is being planned.

***Global Geochemical Mapping MoU signed between IUGS and CGS***

An MoU on Global Geochemical Mapping of five year duration was signed by the IUGS and the CGS in Tianjin (China) on 22 October 2014. The IUGS has always given vigorous support to global geochemical mapping through the IGCP 259 (1989-1993) and IGCP 360 (1994-1997) programmes, and the IUGS Task Group (now Commission) on Global Geochemical Baselines (1997 to present). According to Article 5 of the MoU, "IUGS will communicate with its adhering Organisations and encourage them to provide necessary assistance for global

sampling and experiments related to research and training projects jointly supported by CGS and IUGS under the framework of the International Research Centre on Global-scale Geochemistry and the IUGS/IAGC Task Group on Global Geochemical Baselines". The co-operation between CGS and IUGS in global geochemical mapping may be effected by:

- Launching Global Geochemical Baselines Mapping Project - Chemical Earth, and to promote the establishment of a global network for the project and to develop partnerships with countries and organisations.
- Fostering and supporting the implementation of global-scale geochemical mapping in developing countries;
- Providing consultation and training in the form of workshops and short courses for scientists, engineers and postgraduate students on the basis of up-to-date global-scale geochemical knowledge and methodology, and providing technical assistance to developing countries;
- Organising periodic international symposia to foster communication among the geochemical mapping community, for instance at International Geological Congresses; and
- Promoting equal access to basic services and knowledge sharing, and developing a bridge between the scientific community, decision-makers and the general public in the field of geochemistry.

***International Centre on Global-scale Geochemistry approved by UNESCO***

The Proposal for the establishment of the International Centre on Global-scale Geochemistry in Langfang, China, under the auspices of UNESCO as a Category 2 Centre, was approved by the 37$^{th}$ session of UNESCO in Paris on 13 November 2013, and approved by China Government in September 2015.

Since the 1980s, in light of the importance of global geochemical baselines for recognition of global environmental changes, formidable efforts have been made by applied geochemists through the International Geochemical Mapping Project (IGCP 259), the Global Geochemical Baselines Project (IGCP 360), and the IUGS/IAGC Task Group (now Commission) on Global Geochemical Baselines. However, progress has been slow and limited, as foreseen by Darnley et al. (1995) in the final report of IGCP Project 259: "*Because of the number of organizational and technical steps involved it seems highly unlikely that any group of scientists convened under a non-government organization, however enthusiastic, could sustain or manage an international sampling activity (other than as a small test project in a sympathetic jurisdiction) over the period of time required for completion... Assuming the importance of the geochemical information to be obtained is recognized by the international scientific community, there is a clear need for a single permanent agency to accept formal responsibility for securing funds, managing and coordinating these activities according to scientific guidelines determined by an external advisory committee*."

In the past twenty years, experience and lessons have made it clear that there is an urgent need for the establishment of a single permanent agency to accept formal responsibility for securing funds, managing and coordinating these activities according to scientific guidelines determined by an external advisory committee.

In September 2009, Prof. Xie Xuejing (China), Dr. David Smith (USA) and Dr. Wang Xueqiu (China), forwarded a proposal to the China IGCP National Committee for establishing an International Research Centre on Global Geochemical Mapping (The name was subsequently changed to International Centre on Global-scale Geochemistry) under the auspices of UNESCO. The proposal had also been thoroughly discussed by the participants of the Global Geochemical Mapping Symposium held in Langfang China (9-12 October 2009). All

participants expressed their support for establishment of an International Research Centre for Global Geochemical Mapping at the IGGE in Langfang, China.

The proposal was supported by the Ministry of Land and Resources of P.R. China, the International Union of Geological Sciences (IUGS), the Association of Applied Geochemists (AAG), the Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP), the IUGS/IAGC Task Group (now Commission) on Global Geochemical Baselines, the China Geological Survey (CGS), the Chinese Academy of Geological Sciences (CAGS), and the Geological Society of China.

In October 2010, the Ministry of Land and Resources formally requested the Director-General, through the Permanent Delegation of the People's Republic of China, that UNESCO carry out a feasibility study for the establishment of a Category 2 Centre in Langfang, co-located with the IGGE (State Research Institute). The IGCP Scientific Board reviewed the feasibility study report and made a resolution in support of the proposal at the 39th IGCP Scientific Board Meeting, 16-18 February 2011. The decision was adopted by the UNESCO Executive Board at its 191st session in Paris on the 3 June 2013. Finally, the proposal was approved by the General Conference at its 37th session in Paris on 13 November 2013. The Centre has been approved by the State Council-China Government (September 2015), and the final procedure authorisation for the signing of the agreement by the China Geological Survey with UNESCO was approved by the Ministry of Foreign Affairs of China.

The Centre will foster knowledge and technology for documenting global-scale geochemical data and accompanying distribution maps, sustaining development for natural resources and the environment, and act as the platform for training and transferring up-to-date knowledge and technology between the developed and developing countries, and promote equal access to basic services in the field of global-scale geochemistry.

On 12 May 2016, during the official opening ceremony in the newly constructed building within the premises of Institute of Geophysics and Geochemistry (IGGE) in Langfang, P.R. China, the Agreement between UNESCO and China for the establishment of the International Centre on Global-scale Geochemistry was signed (Figure 36).

Figure 36. Building of the UNESCO International Centre on Global-scale Geochemistry, Langfang, P.R. China.

A Global Geochemical Mapping Programme via the Centre was approved by China Government through the China Geological Survey. A six-year term financial support plan (2016-2021) for Global Geochemical Mapping was submitted by the China Geological Survey via the Ministry of Land and Resources, and a budget of approximately Yuan200M (approximately US$ 29M or € 27M) per year was approved by the Ministry of Finance.

Professor Wang Xueqiu (wangxueqiu@igge.cn, geochemistry@sina.com), as the Executive Director of the Centre and 2nd Chairperson of the Commission, is the project leader for the coordination of the programme. Any countries that are interested to participate in the programme may contact him directly.

***Establishment of an IUGS Commission on Global Geochemical Baselines***

The officers of the IUGS Executive Committee at their 68th sitting on 28 January 2015 in Vancouver, Canada, judged positively the proposal for the establishment of an IUGS CGGB (see Minutes; 250 KB).

According to the decision, the proposed upgrading of the Task Group within IUGS would need further implementation and refinement before eventual approval. The upgrading of the Task Group to Commission was discussed at the 69th meeting of the Executive Committee in January 2016.

According to the minutes of the 68th IUGS Executive Committee meeting:

- The Commission can run in parallel with the establishment of a Subcommission/Working Group on Isotopes taking advantage of the now existing isotope group (TGIG).
- The establishment and design of the new Commission is compatible and should be synergetic with the IUGS RFG Initiative.
- Also in terms of synergy with the current activities of IUGS, it seems crucial and quite suitable that One Geology serves as visualisation platform for the new geochemical database.
- Global Geochemical Baselines would be a suitable project proposal for the ICSU's Future Earth Initiative.

On 31 August 2016 at the Fourth Ordinary Session of the IUGS Council Meeting in Cape Town the establishment of an IUGS CGGB was approved.

## 7.3. CHIEF ACCOMPLISHMENTS IN 2016

- Compilation and production of the 2nd version of the Arthur Darnley memorial DVD with published material of the Global Geochemical Baselines project, and distribution of more than 80 copies, including copies of the 1st version (as at July 2016).
- Organisation of a two-day workshop on *"Global Geochemical Mapping"* (27-28 August 2016) on the occasion of the 35th IGC in Cape Town.
- Organisation of the 3rd Arthur Darnley Symposium entitled *"Mapping the geochemistry of the Earth's surface at global to local scales"* at the 35th IGC in Cape Town (30 August 2016).
- Business meeting held at the 35th IGC in Cape Town (30 August 2016).
- Collaboration with the UNESCO International Centre on Global-scale Geochemistry (ICGG) in the finalisation and editing of the (a) Governing Board Statutes, (b) Scientific Committee Statutes, (c) ICGG Statutes, (d) Six-year programme (2016-2021), and (e) compilation of the first newsletter of the ICGG (21 October-30 November 2016).

## 7.4. WORK PLAN FOR 2017

### *7.4.1. Business meeting of the Commission*

The next business meeting of the Commission will tentatively take place in Vienna (April 2017) in conjunction with the annual meeting of the EGS Geochemistry Expert Group at the European Geosciences Union (EGU) General Assembly.

### *7.4.2. Field Sampling Manuals*

The mandate of IUGS Commissions is to set standards. Hence, the IUGS Commission should set the standards for Global-scale Geochemical Baseline Mapping according to 'Blue Book' (Darnley et al., 1995) specifications in all the major terrestrial morpho-climatic terranes found on Earth.

For historical reasons it was decided to leave the FOREGS Geochemical Mapping Field Manual (Salminen et al., 1998) as it is, because it deals with sampling in Temperate and Mediterranean terranes.

An additional field manual, according to 'Blue Book' (Darnley et al., 1995) specifications, is under preparation by the Commission, and although this was planned to be published in 2016,

it was not possible due to financial constraints. This field manual will include sampling instructions in (a) Karstic terranes, prepared by Alecos Demetriades, Simon Pirc, Milan Bidovec and France Šušteršič (completed), (b) Desert terranes by Xueqiu Wang (under review), (c) Tundra terranes by Xueqiu Wang, (d) Arctic terranes by Rolf Tore Ottesen, and (e) Tropical terranes by Alecos Demetriades, Xueqiu Wang, Christopher C. Johnson, Reijo Salminen and others.

As the field sampling manuals are very important, not only for the Global Geochemical Baselines project, but also for any applied geochemical survey, they are planned to be accompanied by video films, which will be uploaded to YouTube and Facebook.

#### *7.4.3. Capacity building workshops*

In 2012, the Task Group received inquiries from Iran and Brazil about conducting training in geochemical mapping. Because of financial problems in most surveys no further action was taken during 2013-2016. New opportunities developed in 2014 with the invitation from the Geological Survey of Iran (GSI) for a one-day workshop on *"Global Geochemical Baselines"*, and a keynote presentation at the plenary session of the 1st International Conference in Iran. Field training was undertaken by the IGGE, after an MoU was signed between GSI and China Geological Survey.

Similarly, following the two-day workshop in Dar-es-Salaam (Tanzania) in 2014, the Geological Society of Africa (GSAf) would like to pursue training opportunities in African countries in Global Geochemical Baselines methods. Although the contents of the MoU have been agreed, it was not signed, because GSAf has not yet found sponsorship. Therefore, it may be possible, if GSAf finds the necessary funds from sponsors, to organise the first training workshop in 2017.

At the invitation of the Young Earth Scientists Network (YES), a two-three day capacity building workshop is planned on the occasion of the 4th YES Congress in Tehran (27-30 August 2017). The plan is for two days of lectures on Global Geochemical Mapping and one day of field training in sampling techniques.

Other capacity building workshops will be organised in collaboration with the UNESCO International Centre on Global-scale Geochemistry.

#### *7.4.4. Communication and Dissemination Plans*

The Commission, and all national- and continental-scale geochemical mapping projects being carried out in many countries, plan to continue active participation in national and international symposia, conferences and workshops for the promotion of global-scale geochemistry.

Communication will also be achieved through continued output of peer-reviewed scientific papers.

In addition, the Commission's website will be a key forum for communication and dissemination of information, and the plan is to include links to popular social media, such as Facebook, Twitter, YouTube, Linkedin, Pinterest, Google Plus+, etc.

## 8. SUMMARY OF EXPENDITURES AND PROBLEMS ENCOUNTERED IN 2016

### 8.1. USAGE OF IUGS ALLOCATION

The Task Group (now Commission) received in 2016 the sum of US$ 5K from IUGS. In 2016, the Commission had expenditures totalling US$ 7,140.83 as detailed in the table below.

| | |
|---|---|
| (1) Travel insurance, Metro fare and taxi from home to airport, food and coffee for the Treasurer and Chair of Sampling Committee to participate at the Opening Ceremony of the UNESCO International Centre on Global-scale Geochemistry, Langfang, China (May 2016) | US$ 130.38 |
| (2) Travel insurance and Metro fare from home to airport, for the Treasurer and Chair of Sampling Committee to participate at the 100th Anniversary of the Geological Survey of Colombia, Bogota (June-July 2016) | US$ 48.88 |
| (3) Production of 1000 copies of the 2nd version of the Arthur Darnley memorial DVD | US$ 800.18 |
| (4) Sponsorship of 35th IGC registration fee for two YES Network members (Putra Herianto US$ 440.31, and Bita (US$ 596.61*) | US$ 1036.92 |
| (5) Travel & hotel expenses, sustenance costs, car hire, and registration fee for the Treasurer and Chair of Sampling Committee to participate in the 35th IGC in order to organise the Workshop and Special session, Cape Town (August-September 2016) | US$ 4,353.03 |
| (6) Expenses of the field training workshop, 35th IGC (28 August 2016) – coach hire | US$ 370.78 |
| (7) Annual fee for the hosting of Commission's website | US$ 313.77 |
| (8) Postage of Arthur Darnley memorial DVDs to USA, Australia, Belgium (EGS & European Federation of Geologists) and Germany | US$ 86.89 |
| ***Total:*** | ***US$ 7,140.83*** |

*Includes late registration fee

In addition to the expenditure of funds provided to the Commission by IUGS, many of the Commission's goals are supported by various national Geological Survey organisations. The cost of the EGS GEMAS programme over the past five years is estimated to have been in excess of US$ 6.25M. The overall cost of the FOREGS/EGS activities over the past fifteen years or so is difficult to estimate, as the work has been funded independently from each of the participating countries, but a conservative estimate is in excess of US$ 12M. These funds were provided from the Geological Surveys of the participating countries within Europe. The cost of the soil geochemical mapping project in the conterminous United States during 2013 was approximately US$ 750K. There has also been considerable expenditure within a range of countries worldwide, as indicated in Section 7.

## 8.2. PROBLEMS ENCOUNTERED

With the establishment of the UNESCO International Centre on Global-scale Geochemistry, the Chinese Government will be funding global-scale geochemical projects and capacity building workshops in developing countries. Hence, the main problem still facing the Global Geochemical Baselines project is the lack of funding to cover developed countries. The geochemical baseline project in Europe was completed with funding by the participating European Geological Surveys. Work in North America, Australia, Brazil, China, Chile, Colombia, Cyprus, India, Kyrgyzstan, Nigeria, South Africa, Sweden, Uganda and Zimbabwe, for example, are similarly funded by national geological surveys or other national scientific institutions.

The UNESCO International Centre on Global-scale Geochemistry will undertake preparation and analysis of samples from developed countries on a *cost free* basis, but the sample collection costs must be borne by each country. During 2017 a database will be compiled of all developed countries that are willing to participate in the Global Geochemical Baseline project, but do not have the funds to finance the project, and are interested to be trained in the sampling techniques. As the Commission is almost entirely dependent on funds from IUGS, it is considered important for the annual grant to be increased (see Section 9.2).

## 9. BUDGET FOR NEXT YEAR AND FUNDING SOURCES OUTSIDE IUGS

### 9.1. FUNDING OF GLOBAL-SCALE GEOCHEMICAL PROJECTS

The success of the IUGS/IAGC Task Group (now Commission) has to-date been almost entirely dependent on funding from sources outside the IUGS. This funding has come primarily from national Geological Surveys and other scientific institutions in participating countries. We conservatively estimate that over the past ten years, US$ 33M has been spent on broad-scale geochemical surveys, conducted according to recommendations from the IUGS/IAGC Task Group (now Commission) and its predecessors.

### 9.2. FUNDING FROM IUGS

Funding from IUGS has consisted of US$ 1.5K per year for 2003-2008, US$ 4K for 2009 and 2010, and US$ 5K for 2011 and 2012, no funding for 2013, and US$ 5K for 2014, 2015 and 2016. The Commission currently has reserves of US$ 12,608.65.

### 9.3. FUNDING REQUEST FROM IUGS FOR 2017

Taking into account:

- the necessity to publish in 2017 the Field Manual, and accompanying video films, for all the remaining terrane types,
- the need for field training courses and workshops in African and other countries, and
- the organisation of a dedicated session on *"Global Geochemical Baselines"*, and a three-day capacity building workshop on the occasion of the 4th International YES Congress in Tehran (Iran),

it is anticipated that the expenses for 2017 could reach US$ 25K. The Commission is, therefore, requesting financial support in the order of US$ 15K from IUGS for 2017.

## 10. LINK TO IUGS WEBSITE

The Commission's website has a link to the IUGS website: www.globalgeochemicalbaselines.eu/?page_id=47.

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## REFERENCES CITED

Darnley, A.G., Björklund, A., Bølviken, B., Gustavsson, N., Koval, P.V., Plant, J.A., Steenfelt, A., Tauchid, M., Xuejing, X., Garrett, R.G. & Hall, G.E.M., 1995. *A Global Geochemical Database for Environmental and Resource Management: Recommendations for International Geochemical Mapping. Final Report of IGCP Project 259*. Earth Sciences 19, UNESCO, Paris, 122 pp. www.globalgeochemicalbaselines.eu/wp-content/uploads/2012/07/Blue_Book_GGD_IGCP259.pdf (5 MB)

De Vos, W., Tarvainen, T. (Chief Editors.), Salminen, R., Reeder, S., De Vivo. B., Demetriades, A., Pirc, S., Batista, M.J., Marsina, K., Ottesen, R.T., O'Connor, P.J., Bidovec, M., Lima, A., Siewers, U., Smith, B., Taylor, H., Shaw, R., Salpeteur, I., Gregorauskiene, V., Halamic, J., Slaninka, I., Lax, K., Gravesen, P., Birke, M., Breward, N., Ander, E.L., Jordan, G., Duris, M., Klein, P., Locutura, J., Bel-lan, A., Pasieczna, A., Lis, J., Mazreku, A., Gilucis, A., Heitzmann, P., Klaver, G. & Petersell, V., 2006. *FOREGS Geochemical Atlas of Europe: Part 2 - Interpretation of Geochemical Maps, Additional Tables, Figures, Maps, and Related Publications*. Geological Survey of Finland, 690 pp. http://weppi.gtk.fi/publ/foregsatlas/part2.php

International Union of Geological Sciences Strategic Planning Committee, 2000. *International Earth Science in the 21st Century. Science and Organisational Strategy for the International Union of Geological Sciences*. Trondheim, Norway, International Union of Geological Sciences, 49 pp. iugs.org/uploads/images/PDF/iugs_stratplan.pdf (500 KB)

Salminen, R., Batista, M.J., Bidovec, M., Demetriades, A., De Vivo, B., De Vos, W., Duris, M., Gilucis, A., Gregorauskiene, V., Halamic, J., Heitzmann, P., Lima, A., Jordan, G., Klaver, G., Klein, P., Lis, J., Locutura, J., Marsina, K., Mazreku, A., O'Connor, P.J., Olsson S.Å., Ottesen, R.T., Petersell, V., Plant, J.A., Reeder, S., Salpeteur, I., Sandström, H., Siewers, U., Steenfelt, A. & Tarvainen, T., 2005. *FOREGS Geochemical Atlas of Europe: Part 1 - Background information, Methodology and Maps*. Geological Survey of Finland, 525 pp. weppi.gtk.fi/publ/foregsatlas/

Salminen, R., Tarvainen, T., Demetriades, A., Duris, M., Fordyce, F.M., Gregorauskiene, V., Kahelin, H., Kivisilla, J., Klaver, G., Klein, H., Larson, J.O., Lis, J., Locutura, J., Marsina, K., Mjartanova, H., Mouvet, C., O'Connor, P., Odor, L., Ottonello, G., Paukola, T., Plant, J.A., Reimann, C., Schermann, O., Siewers, U., Steenfelt, A., Van der Sluys, J. and Williams, L., 1998. *FOREGS Geochemical Mapping. Field Manual*. Geological Survey of Finland, Opas - Guide 47, 42 pp. tupa.gtk.fi/julkaisu/opas/op_047.pdf (2 MB)